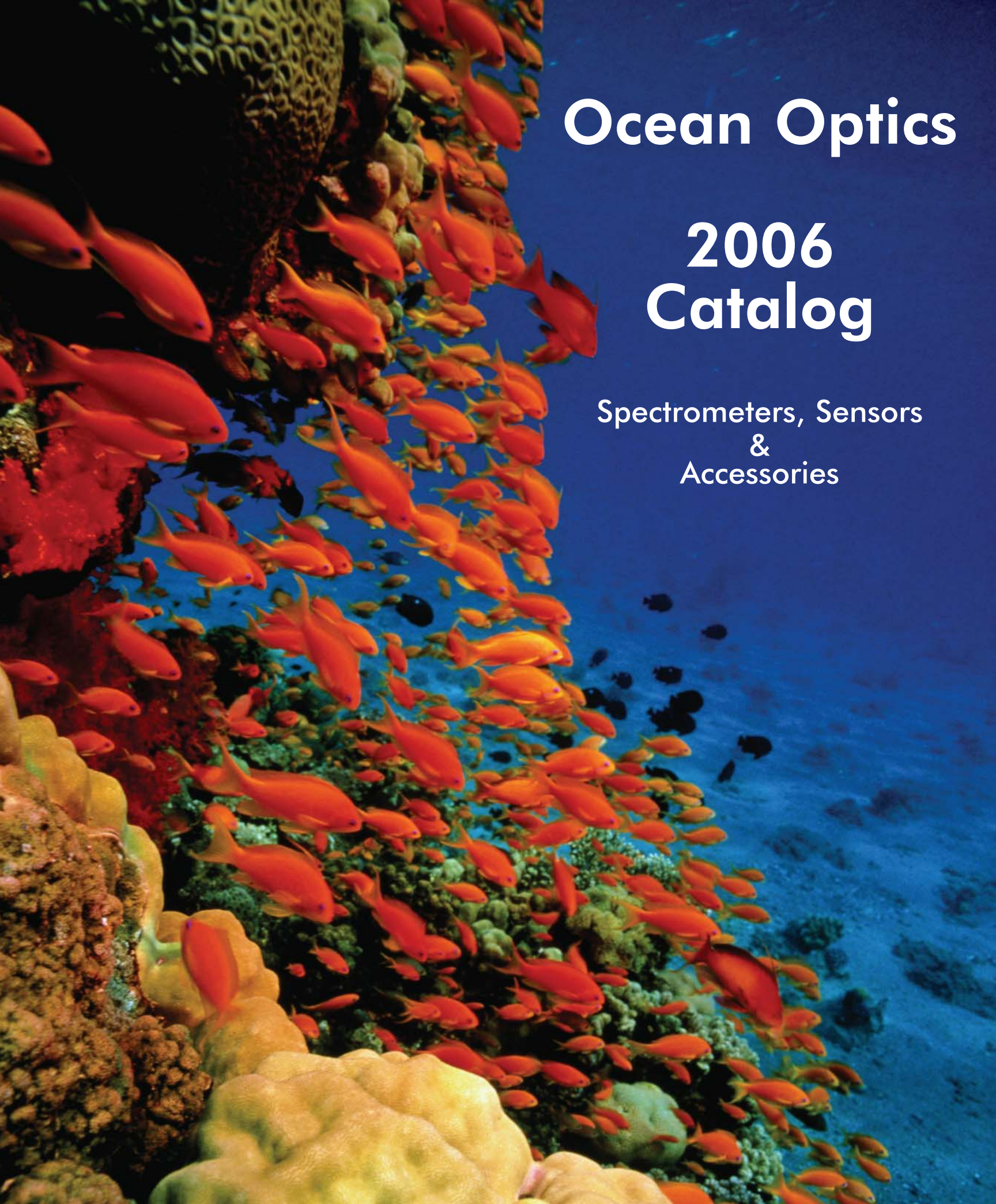
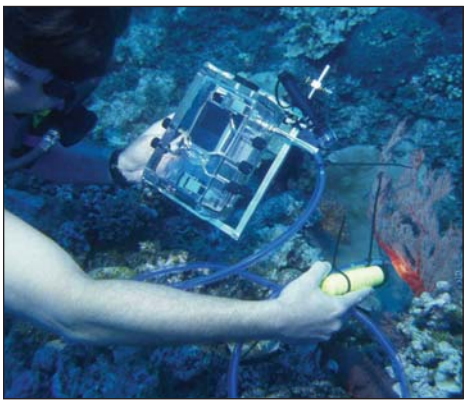


Ocean Optics

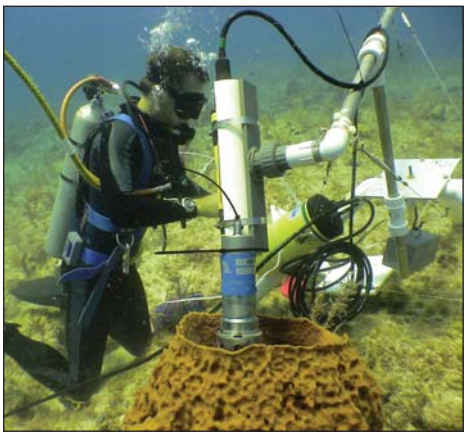
2006 Catalog

Spectrometers, Sensors
&
Accessories

Ocean Optics spectrometers have been used inside human bodies, in space and on Mars, in research labs and process streams, atop forest canopies and alongside active volcanoes. And, of course, in water, where it all began for us 15 years ago. A sample of ocean applications gives a snapshot of what Ocean Optics spectrometers can do in just one of the many challenging environments our customers face -- the sea.

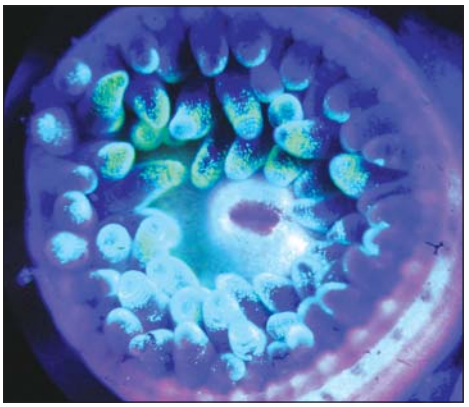


Eric Hochberg from the Hawaii Institute of Marine Biology measures reflectance from a soft coral near Okinawa, Japan. Here he uses an entirely self-contained, diver-operated system, which includes a USB2000 Spectrometer and a handheld computer, to acquire spectra. A colleague of Hochberg's designed and built the water-proof housing. Hochberg also has taken his custom-built system down 110 feet to study light ecology of an octocoral off Waikiki. For more details, visit www.soest.hawaii.edu/marlin/hochberg/.



Chris Martens, professor at the University of North Carolina at Chapel Hill, is measuring sponge consumption of oxygen and sponge production and recycling of new nitrogen in coral-reef ecosystems. The health of the Florida coral-reef ecosystem has declined in recent years and one cause could be the excessive nutrient fluxes brought on by sponges. He is conducting his research from Aquarius, a NOAA Undersea Research Center in the Florida Keys. For details, visit www.uncw.edu/aquarius/2005/08_2005/expd.htm.

Alexander Cheroske was a Ph.D. candidate when he used the USB2000 Spectrometer and a CC-3 Cosine Corrector to study how light intensity in the ocean affects the color vision and communication of marine animals. Diving near Lizard Island, Australia, Cheroske measured irradiance at 1-meter intervals from the water's surface to its floor, 18 meters below. Cheroske is now a biology professor with Moorpark College.



Dana Riddle of Riddle Aquatic Laboratories, Hawaii, is working on a NOAA grant to investigate how to manipulate reflective and fluorescent pigment production in corals, and how to maintain the vivid coloration in artificial environments. Riddle researched how narrow-bandwidth light sources promote (or destroy) reflective and/or fluorescing pigments. He measured both the color and fluorescence of coral in response to artificial light sources, specifically the LEDs we offer.

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Duiven
The Netherlands
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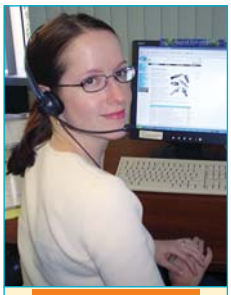
Info@OceanOpticsBV.com

Application Assistance
Our experienced staff of Applications Scientists can assist you with pre-sale product or application questions, and provide post-sale support.



Real People, Real Answers

Call Ocean Optics and talk over your optical sensing needs with one of our knowledgeable Applications Scientists.

Expanded Service Hours
(EST)
8 a.m to 8 p.m.
Mondays - Thursdays
8 a.m. to 6 p.m.
Fridays

Ask us about our new order-processing hours and late-day shipping option!

727.733.2447

Ordering Information

Pricing:
All prices are subject to change without notice. For the most up-to-date pricing, contact Ocean Optics. For information on pricing in Europe, please contact our office in Duiven, The Netherlands.

Terms:
Net 30 days with credit approval. Contact us for futher information. All shipments are delivered EXWORKS, Dunedin, Florida, USA. For all shipments into California and Florida, we are required to charge sales tax unless a valid resale certificate is received prior to shipment. Fax resale certificates to our Accounting Department at 727.734.0957. Specifications, descriptions, ordering information and item codes described herein are subject to change without notice.

Credit Cards:
Ocean Optics accepts American Express, MasterCard and VISA credit cards.

Shipping:
Shipping charges are the responsibility of the customer. Orders are shipped UPS Ground, unless otherwise requested. Customers may reverse shipping charges to use the carrier of their choice.

What's Inside & What's New

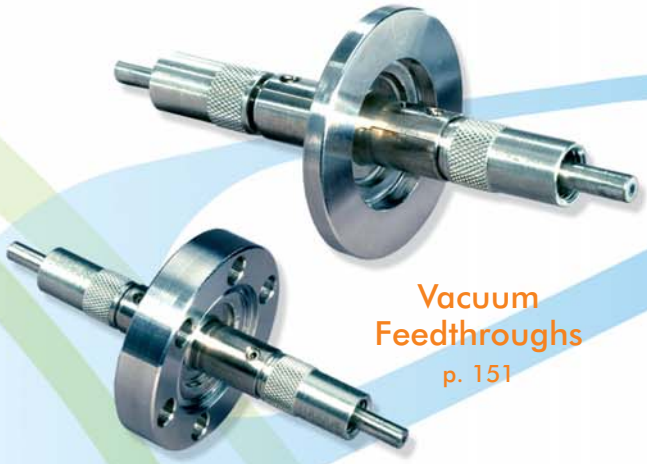
LIBS-ELITE Laser Ablation Sampling System
p. 22

QE65000 Scientific-grade Spectrometer
p. 54

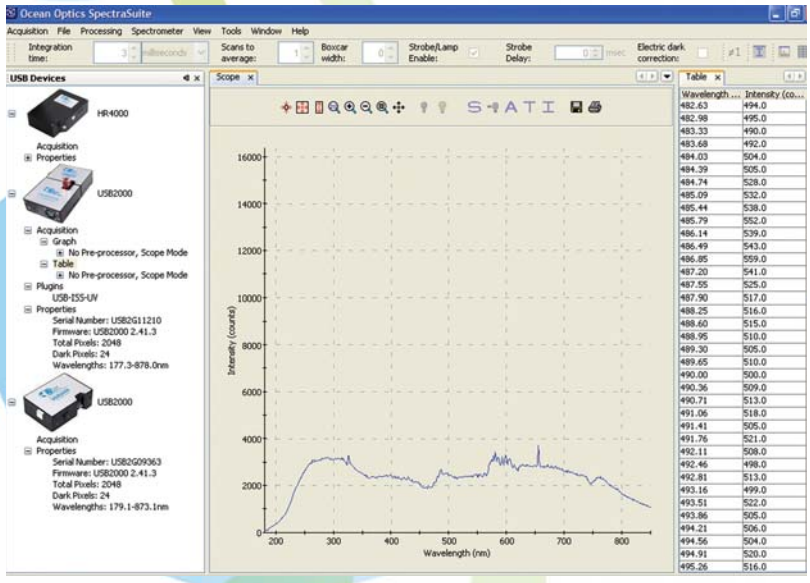
HR2000+ High-speed, High-res Spectrometer
p. 49

The Sentry Air Monitoring System
p. 24

What's Inside & What's New



Vacuum Feedthroughs
p. 151



SpectraSuite Spectroscopy Platform Software
p. 76

USB-DT Deuterium Tungsten Halogen Source
p. 123

Our Value Proposition

PARTNERSHIPS

To expand the frontiers of
optical sensing and make it
the foundation on which innovative,
life-changing ideas are built.
-- Ocean Optics Vision Statement

What Really Matters

We value the opportunities to learn and to grow -- and to expand the frontiers of optical sensing -- that come from partnership. Recognizing and seizing these opportunities is what Ocean Optics is all about -- and is reflected in an open, collaborative approach that appeals to everyone from the innovators and early adopters to the skeptics and the traditionalists.

The Partnership Proposition

Partners come in many types:

- **Original Equipment Manufacturers (OEMs)** integrate our components into their own analytical devices. Our spectrometers in particular are ideal for embedding into other devices. One such OEM is NanoDrop (nanodrop.com), a Delaware-based supplier of UV-Vis spectrophotometers for extremely small-volume sampling. NanoDrop is a sort of poster child of the customer-innovator: a small team of researchers with an exciting application, the passion and know-how to make it happen, and an appreciation for the advantages of size, cost and flexibility that our spectrometers provide.

- **"One-off" customers** typically collaborate with us on a specific application need. In fact, our flexible, modular product line is designed especially for the researcher with a custom application. One-off customers often become OEMs and distributors.

- **Distributors** purchase products from us and resell those products to their own customers. We have more than 40 distributors worldwide and offer them competitive pricing, marketing and training support. (See our list of distributors at OceanOptics.com/Distributors.asp).

- **Value-added Resellers** and **Private Labelers** typically repackage and add value to our products -- and then market those products under their own brand names.

- **Vendors** and **Suppliers** provide us with fun, interesting and useful products that we resell. We're always on the lookout for cool stuff that complements our line of 900+ products.

- **Grant Seekers** and **Proposal Writers** collaborate with us on grants and proposals seeking funding for the development of new technologies. Ocean Optics got its start as the result of a Small Business Innovation Research grant for a pH sensor. We've worked with both corporate and institutional innovators and developers.

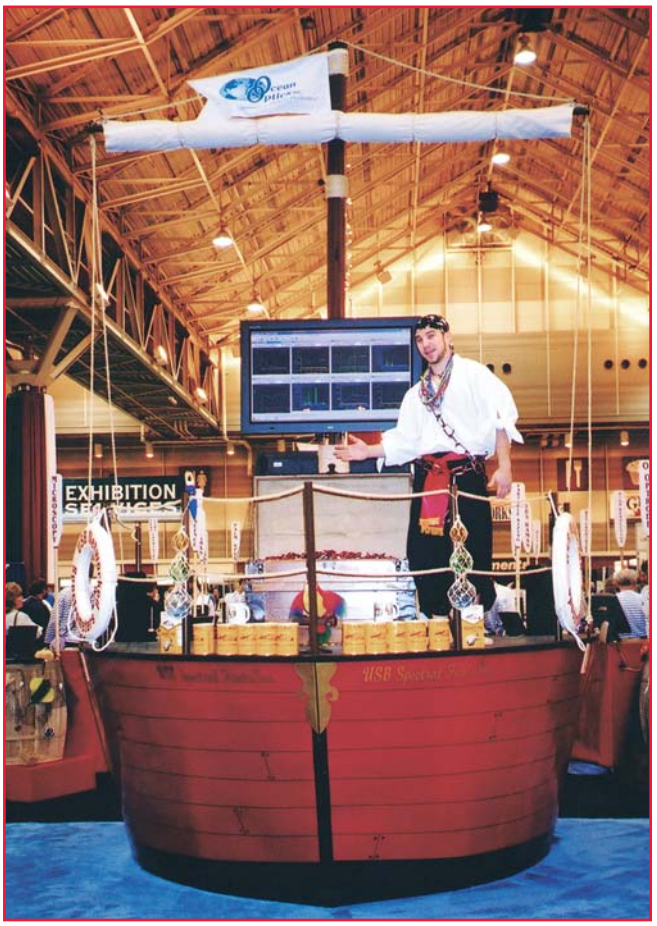
- **Grant Program Winners** earn cost-sharing rewards for promoting science in high school and undergraduate curricula. Additional information on the Innovations in *Educational Spectroscopy Grant Program* is available on page 8.

Our Online Distributor Partners

Ocean Optics products are now available for purchase online at VWR.com and FiberOpticStuff.com.

VWR is one of the leading suppliers of scientific equipment, labware and chemicals in the world, and offers a remarkable catalog of 750,000 products, including virtually every item in our product line. VWR.com is a nice option for customers who are familiar with our product line, have a credit card, and don't require sales consultation.

FiberOpticStuff.com provides low-cost fiber optic products for researchers, experimenters and tinkerers. In addition to fiber assembly-making kits and components, FiberOpticStuff.com offers discounted "scratch & dent" patch cords and probes, plus sampling fixtures, lab accessories and optical standards.



We often invite our partners to share trade show space with us. Funny pirate shirts are just a bonus. Nick Sebastian, now our Worldwide Distribution Sales Associate, will never live down Pittcon 2001.

Original Equipment Manufacturers

We Treat Our OEMs Like "Star Partners"

The inherent size, cost and modularity of Ocean Optics spectrometers and accessories make them ideal for OEMs and product developers. With our OEM Star Partner Program, the benefits of our flexible approach -- including savings associated in start-up and engineering expenses -- are significant.

OEMs profit from our vertical manufacturing structure. We assemble optoelectronic systems, grind and polish optics, add coatings, develop optical sensors, and make our own optical fiber assemblies. And, with more than 55,000 spectroscopy systems sold, we're light years ahead of our competitors in applications know-how.

Getting Started

Prospective OEMs purchase an evaluation unit at retail price to determine technical feasibility. If the application is viable, the prospective OEM purchases an OEM Developer's Agreement for $999. This agreement entitles the OEM Developer to discounts on equipment purchased during the first year of the OEM agreement, regardless of quantity. The OEM Agreement must be renewed annually, at $599, to ensure discounts and benefits:

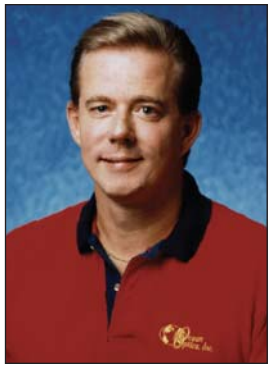
- Limited access to our proprietary technical information
- OEM Interface Guide, wiring diagrams, register maps and spectrometer pin-out information
- Hands-on support from our OEM Sales Manager, who is a trained engineer with nearly a decade of experience designing and working with Ocean Optics spectrometers

Discounts & Savings

Once the OEM's product development cycle is complete, sizeable savings on spectrometers and other components are possible. We offer volume discounts on gross margin for spectrometers, based on annual blanket purchase orders. The chart (below, right) shows savings based on the number of units per year for a USB2000-UV-VIS Spectrometer. After the first 12 months of the OEM Developer's Agreement, we request quarterly volume updates to ensure that production needs are met, and to manage our inventory accordingly.

Modular Components

We offer a comprehensive toolkit of optical-sensing components that can be configured in an amazing number of variations. For example, by mixing and matching optical bench components such as gratings and slits, the "S" Optical Bench alone can be configured more than 500 different ways.



OEM Manager, Rob Waterbury

Full-service Support

OEMs have at their disposal an array of R&D services, from optical design and software engineering to prototype development and testing and validation. As with our modular hardware, R&D services are available on an à la carte basis. In addition, some OEMs take advantage of cooperative marketing services such as shared booth space at trade shows and postings on our website.

CEREX Environmental Services, Inc. is an OEM that uses one of our high-resolution spectrometers in its Sentry and Hound Monitoring Systems, advanced, EPA-approved detection methods for conducting real-time parts-per-trillion analysis of toxins in the air. See pages 24-25 for details.

Partnership Opportunities

To reap benefits such as volume pricing, customers aren't strictly limited to OEM partnerships. We're willing to work with you on a private label or value-added reseller basis, or even act as both your OEM supplier and as a reseller of your products. The latter option can be attractive to smaller companies lacking the sales and marketing resources that we bring to the table.

Contact Information

For more information on OEM opportunities, call us at 727.733.2447 or e-mail us at Info@OceanOptics.com.

Number of Units per Year	Discount	USB2000-UV-VIS with OEM Discount*
1	Gross Margin	$2,649
5	10%	$2,384 per unit
10	15%	$2,251 per unit
20	20%	$2,119 per unit
35	25%	$1,986 per unit
50	30%	$1,854 per unit
75	35%	$1,721 per unit
100	40%	$1,589 per unit
150	45%	$1,456 per unit
200	50%	$1,324 per unit
250	53%	$1,245 per unit
500	55%	$1,192 per unit

** OEM Discount Price does not include the OEM Developer's fee of $999 in the first year and the $599 renewal fee each year thereafter.*

Worldwide Distribution

Worldwide Distribution Network

Our distributors are distinguished by their applications expertise and extensive knowledge of our product line. Many are scientists and engineers with significant hands-on experience using our products. For an up-to-date list of Ocean Optics distributors, click on the "Worldwide Distribution" link at OceanOptics.com.

Sales & Service in Europe

We operate a full-service sales office, Ocean Optics B.V., in Duiven, The Netherlands. Ocean Optics B.V. carries the full array of Ocean Optics inventory and is equipped to handle sales consultation, customer service, technical support and engineering services. A network of sub-distributors covers areas such as Germany, France and the United Kingdom.

Distributors from around the globe meet at Ocean Optics headquarters in Florida for training.

Distributors Add Value

There are two compelling reasons to work with a distributor: convenience and service. Around the world, there is wide variation in the rules of business. We use distributors who are experienced in local regulations to help our customers avoid the inconvenience of customs documents, payment details and shipping issues. Also, our distributors provide pre- and post-sales application assistance, and offer a level of support that, for logistical reasons, Ocean Optics may not be able to provide.

Worldwide Pricing Ensures Fairness

Our distributors abide by our "Worldwide Pricing" policy, which ensures that a single, universal price applies to every Ocean Optics product. Extra costs due to currency exchange, customs duties and shipping charges should not be confused with a product's selling price. We originated this policy to provide clients with relief from excessive add-on costs that many manufacturers and distributors pass on to overseas customers. Worldwide pricing is prominently displayed on our website and in our print catalog. We adhere to fair business practices and employ these principles in the Ocean Optics worldwide distributor agreement.

Progressive Distributor Program

We are always looking for companies with skilled sales engineers to add to our family of distributors. If you're interested in becoming a distributor, we'd love to hear from you. Ocean Optics distributors enjoy a number of benefits:

Discounted Pricing

Depending on sales volume and other qualifications, distributors enjoy deep discounts on most products. Discounts are based on the gross margin of the product as well as volume purchasing. The latter is reviewed at year's end so that the next year's rate is adjusted to reward top performers. Also, top-tier distributors enjoy sales prospect-generation and market-support benefits to promote Ocean Optics products in their regions.

Lead Sharing

Ocean Optics marketing efforts generate thousands of prospects. Top-tier distributors qualify for lead sharing, an exchange of leads between Ocean Optics and the distributor. Lead sharing ensures that our overseas prospects receive rapid response to their sales and technical needs.

Sales & Marketing Support

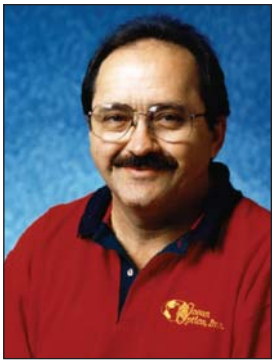
Ocean Optics makes available to distributors various promotional items, and encourages distributor participation at major trade shows. For top-tier distributors we offer a marketing matching funds program -- i.e., a dollar-for-dollar match -- for the purpose of promoting Ocean Optics through advertising, trade shows and other marketing vehicles. Top-tier distributor support also includes sales prospect lead-sharing and market-coordination programs designed for greater territorial coverage and customer sales support.

OEM Client Development

Our spectrometers are used in thousands of OEM devices in various industries worldwide. We offer special pricing for distributors who prospect and manage OEM clients within their territories. Under this unique margin-sharing program, OEM client development offers a premium profit advantage for both Ocean Optics and the distributor.

Technical Training

Because selling Ocean Optics products requires skilled applications engineers who perform a significant consultative role, we provide distributors with regular technical training. Also, Gary Manche, our Worldwide Distribution Manager, makes frequent site visits to provide sales and technical support for new programs and products.



Worldwide Distribution Manager, Gary Manche

Contact Information

To find a distributor, visit OceanOptics.com/Distributors.asp. For information on distributing our products, contact Gary Manche at DistributorSupport@OceanOptics.com.

Pricing: Open, Fair, Honest

Published Prices Please Prospects

Our philosophy is simple: If a prospect takes the time to check us out, we're not going to make him or her jump through hoops to find pricing. And so, we continue to publish prices on our website, in our catalog, and in other materials. For up-to-date pricing, contact an Applications Scientist at 727.733.2447 or Info@OceanOptics.com, or visit our website at OceanOptics.com.

Worldwide Pricing Policy

Worldwide pricing ensures that a single, universal price applies to every Ocean Optics product, regardless of where it's sold. While extra costs due to currency exchange, and customs, shipping and other costs are borne by the customer, they should not be confused with a product's selling price. We adopted this policy – which our distributors observe -- to provide clients with relief from the occasionally excessive add-on costs that many manufacturers and distributors pass on to overseas customers.

Price Changes

There are a few things to keep in mind about prices. First, we try not to raise prices too often. In 1992, our S1000 Spectrometer, the flagship of the product line, retailed for $1,800, plus another $500 or so for an analog-to-digital converter. Today, our most popular spectrometer, the USB2000, is just $2,199, and doesn't need an external A/D converter. Second, prices are subject to change without notice. It would be nice if prices never changed, but things happen – material and production costs increase, exchange rates change, and so on. In any event, here are some tips about pricing:

- Prices are subject to change without notice.
- For accurate pricing, check with an Applications Scientist at 727.733.2447, e-mail us at Info@OceanOptics.com our visit our website at OceanOptics.com.
- We resell some popular light sources and accessories from our European partner Mikropack. Pricing for these products is subject to the vagaries of exchange rates, and can vary frequently.
- We honor the pricing cited in a quotation for 30 days.
- Discounts are available on volume orders, for qualifying distributors and OEMs, via cost sharing for qualified educators and researchers, and through our trade-in program. Ask an Applications Scientist for details.

Volume Discounts & Other Options for the Savvy Shopper

- **Become an OEM or qualify as a distributor.**
  OEMs and distributors earn discounts based on volume purchases and other commitments.

- **Buy in volume.**
  You don't have to be an OEM to enjoy volume pricing. Volume discounts are available on most every product, and apply to orders of 5 or more of a particular item.

- **Visit FiberOpticStuff.com for "scratch & dent" items.**
  Discounted optical fibers, probes and more are available for purchase online at FiberOpticStuff.com. We also keep a limited number of scratch & dent items on our main website at OceanOptics.com/Products/Scratchdent.asp. All scratch & dent items are in good working order; any wear-and-tear is primarily cosmetic.

- **Apply for an educational grant.**
  We do not offer so-called educational discounts. Instead, we provide cost-sharing support to qualified educators toward the purchase of Ocean Optics products to be used in science curricula. For more, see page 8 or visit OceanOptics.com/Corporate/Grantprogram.asp.

- **Take advantage of our trade-in program.**
  We offer all sorts of trade-in options: Educators can trade in old spectrometers to earn discounts worth up to $2,000 on the purchase of CHEM2-series Spectrophotometers. Anyone with an Avantes or StellarNet spectrometer can trade it in and earn $1,000 off a new Ocean Optics spectrometer; anyone with any kind of spectrometer will earn a $500 discount with their trade-in. Customers also can trade in their old Ocean Optics A/D cards and FOXY-24G Probes for additional savings. For trade-in program details, visit our website at: OceanOptics.com/Tradeins.asp.

Ocean Optics has several trade-in offers. You may remember this eye-catching mailer from a few months ago.

Innovations in Educational Spectroscopy Grants

Innovations in Educational Spectroscopy Grant Program

Today's students are the most tech-savvy generation in history. Tap their enthusiasm by bringing the power of optical sensing to the modern teaching lab. The *Innovations in Educational Spectroscopy Grant Program* provides cost-sharing resources to educators and researchers to promote the use of fiber optic spectroscopy in curricula and research. This is a great option for educators on a limited budget, or for those who are outfitting an entire lab.

Cost Sharing on Proposals for Extramural Funding

We provide cost-sharing support for proposals to federal, state or private institutions for the express purpose of purchasing our products to be used in science or engineering teaching. Cost sharing varies according to the product, but can be as much as 50% of the equipment's retail value. There is no limit to the total cost-sharing amount.

Cost Sharing for Ocean Optics Equipment Used in Curricula

We provide cost sharing for purchasing products used to develop new science and engineering curricula. Cost sharing varies according to the product, but can be as much as 50% of the equipment's retail value. Funding may come from any source, including an organization's internal funds; however, awards are based on the strength of the applicant's technical proposal and the novelty of the proposed curricula. The developed materials must be made available for publication at OceanOptics.com, so that other educators may have access to the information.

Trade-in Savings

Our trade-in programs provide discounts for all educational institutions on the purchase of CHEM2-series Spectrophotometers for the purpose of setting up a lab. Institutions qualify for discounts of up to 50% on CHEM2 units provided the institution trades in an old spectrometer, regardless of its condition.

Eligibility

Cost sharing is available to any qualified non-profit learning institution. For more information, or to request an application, visit OceanOptics.com/Corporate/Grantprogram.asp or contact an Applications Scientist at 727.733.2447 or Education@OceanOptics.com.

$1,000,000 Worth of Grant Winners

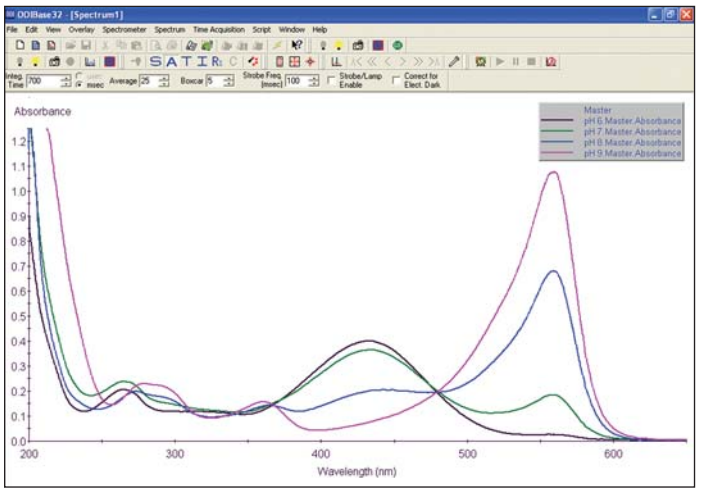
Since 1999, we have awarded over $1 million to learning institutions for funding spectroscopic applications such as:

- Analysis of surface water samples
- Identification of organic dyes in textiles
- Chlorophyll absorbance and its relationship to photosynthesis
- High school-level introduction to principles of nanotechnology
- Visible tissue reflectance as a diagnostic tool in studies of the use of laser therapy for dermatological lesions
- Raman spectroscopy to analyze atmospheric pollutants
- Luminescence of mineral crystals to determine the histories of components in sedimentary rocks
- Metabolic rate, oxygen tension and hemoglobin concentration in fish
- Detection and identification of atomic emission lines from gas discharge tubes
- Measurement of ionization constants in acids and pH dyes
- Study of seaweed photosynthesis and animal respiration in aquatic chambers and under various water velocities
- Determination of DNA concentration using absorbance spectroscopy
- Fluorescence measurements of luminescent semiconductor-nanocrystal quantum dots
- Analysis of stellar and planetary absorption spectra
- Identification of organic dyes in Peruvian textiles for archaeological and ethnographic origin
- Measuring photosynthetic radiation through leaf reflectance
- Theoretical functioning and the effects of different variables on the ability of glow discharge plasmas to destroy pollutants
- Color perception of bees
- High temporal resolution measurements of volcanic degassing
- NIR analysis of the nutritional content of (yikes!) feces of various grazing animals

Spectrometers:
Systems & Setups

Systems and Setups are either turnkey systems in one enclosure or a review of all the tools necessary for a specific application.

The Maxwell Absorbance Spectrophotometer



Titration of phenol red: Spectra are of a single solution of phenol red at 4 levels of pH. The spectra are overlaid to demonstrate the isobestic point at 480 nm.

Specifications	
SYSTEM	
Wavelength range:	200-1100 nm
Optical resolution:	~0.75 nm FWHM
Dynamic range:	2 x 10^9 (system); 1300:1 for a single acquisition
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Photometric range:	0.0-3.0 absorbance units; 0-100% transmission
Photometric accuracy:	99.9%
Wavelength accuracy:	1.0 pixel (~0.27 nm)
Dimensions:	33 cm x 24.9 cm x 12.2 cm
Weight:	7.65 kg
Temperature limits:	0-60 °C
Humidity limits:	0-90%, non-condensing
DETECTOR & OPTICAL BENCH	
Detector:	Linear silicon CCD array, UV-enhanced
Pixels:	3648 pixels; pixel size of 8 µm x 200 µm
Signal-to-noise ratio:	300:1 (at full signal)
Optical bench design:	f/4, crossed Czerny-Turner, 101.6 mm focal length
ELECTRONICS & COMPUTER	
Power consumption:	2.3 A @ 5 VDC
Data transfer speed:	Full scans to memory every 4 ms with USB 2.0 port
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux using USB port; any 32-bit Windows OS using serial port
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible
LIGHT SOURCE	
Light source:	Deuterium and tungsten halogen
Bulb life (hours):	800 hours
Warm-up time:	30 minutes to stabilized output
SAMPLE CHAMBER	
Pathlength:	1-cm standard
Cuvette shape:	Square
"Z" dimension:	15 mm (from bottom of chamber to center of light path)

Fully Integrated System

The Maxwell Absorbance System is a complete turnkey lab spectrophotometer for full spectral analysis of solutions. This fully integrated system offers the quality, convenience and accuracy of more expensive systems, and provides an attractive, affordable alternative to outdated monochromators and spectrophotometers.

0.75 nm Resolution from 200-1100 nm

At the heart of the Maxwell Absorbance System is a 3648-element CCD-array detector inside a high-resolution optical bench. This design yields full spectral analysis -- i.e., 3648 wavelengths over the 200-1100 nm spectral range -- and optical resolution of 0.75 nm (FWHM), stray light of <0.05% and photometric linearity ~99.9%.

Easy-to-Use Software

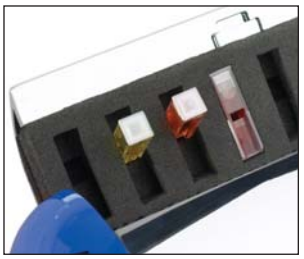
The Maxwell's easy-to-use operating software displays and logs real-time absorbance units, percent transmission and concentration values, as well as graphical spectra. Users can set timed data acquisition and set and lock experimental procedures. The software also includes streamlined features such as kinetics and Beer's Law plots.

PC-based System with USB 2.0 Interface

The Maxwell interfaces to a PC via a USB port (USB cable included). The Maxwell is compatible with USB 2.0 and USB 1.1. All system parameters are set via the included operating software.

Versatile Sample Chamber

The Maxwell's sample chamber is designed for standard 1-cm square cuvettes, and has a retractable cover to block ambient light. Illumination is provided by a novel miniature light source that combines the continuous spectrum of an RF-excited deuterium source and a tungsten-halogen source in a single optical path.



Cuvettes & Other Accessories

We offer both quartz and disposable cuvettes (page 93), as well as a cuvette-shaped adapter that connects to a mercury argon source for performing spectrometer wavelength calibration (at left, and page 133).

OOI-MAX: $7,499

The Curie Emission Spectrofluorometer

Filtering Technology -- No Monochromator!

The Curie Emission Spectrofluorometer is a high-sensitivity system for detecting picomolar-range concentration of fluorophores in solutions from 200-850 nm. The Curie is a versatile lab system distinguished by internal filtering technology that helps to discriminate between powerful pulsed xenon excitation source wavelengths and the weak spectral emissions from samples. The Curie is the only spectrofluorometer with built-in Linear Variable Filters (LVFs). These filters are ideal for spectrally shaping the excitation energy from the onboard pulsed xenon source, and eliminate the need for scanning monochromators. This makes additional correction for excitation and emission wavelengths unnecessary and data more reliable.

Filtering Options

You have several filtering options with the Curie. You can use the built-in LVFs to adjust the excitation wavelength of the xenon source by moving each filter's transmission or blocking band throughout the 230-500 nm or 300-750 nm wavelengths. You could also use your own filter or no filter to get the maximum response from your fluorophore. The Curie has a built-in filter slot for the excitation side and one for the emission side. Included with the Curie are three bandpass or excitation-shaping filters and four longpass or emission-shaping filters, all of which are removable.

Gated Mode

The Curie has a high-sensitivity CCD-array detector that provides full spectral analysis -- i.e., 2048 wavelengths over the 200-850 nm spectral range -- and is preloaded with microcode that allows users to select a delay (from 5-500 microseconds) between activation of the excitation source and the start of the spectrofluorometer's integration time. This gated-mode operation is ideal for measuring fluorophores that have long fluorescence lifetimes, such as lanthanides.

Cold & Standard Mirrors

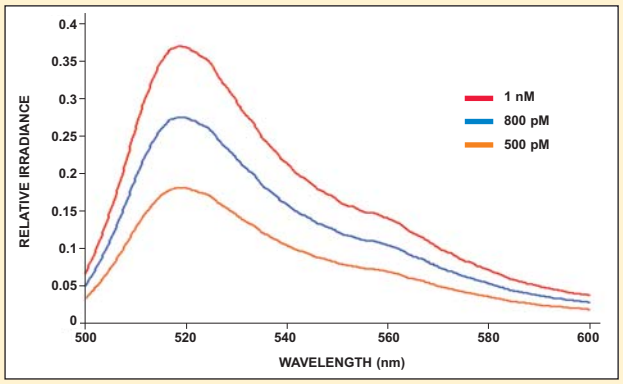
The Curie system also includes a knob for selecting a cold or standard mirror (at right). The cold mirror has a proprietary Ag coating to increase ultraviolet reflectance, which increases the sensitivity of the spectrometer. This cold mirror absorbs nearly all visible light, virtually eliminating the excitation source's spectra from interfering with the sample spectra.

Sample Chamber

The Curie's sample chamber accepts 1-cm square cuvettes, and has a retractable cover to block ambient light. A nifty storage compartment is great for spare filters and cuvettes. (One quartz cuvette is included. Disposable plastic cuvettes are available at prices beginning as low as $10. See page 93.)

OOI-CURIE: $8,499

Sample Spectra of Fluorescein Levels



With the Curie, you can detect picomolar-range concentration of fluorophores. Above shows three different levels of fluorescein concentration.

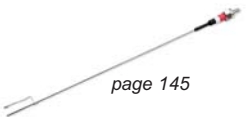
Specifications	
SYSTEM	
Emission wavelength range:	200-850 nm
Excitation wavelength range:	220-700 nm
Optical resolution:	10.0 nm FWHM
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Wavelength accuracy:	1 pixel (~0.35 nm)
Photometric accuracy:	99.9%
Dimensions:	33 cm x 24.9 cm x 12.8 cm
Weight:	6.75 kg
Temperature limits:	0-60 °C
Humidity limits:	0-90%, non-condensing
DETECTOR & OPTICAL BENCH	
Detector:	linear silicon CCD array
Pixels:	2048 pixels, pixel size of 14 µm x 200 µm
Signal-to-noise ratio:	250:1 (at full signal)
Optical bench design:	f/4, crossed Czerny-Turner, 101.6 mm focal length
ELECTRONICS & COMPUTER	
Power consumption:	90 mA @ 5 VDC + 0.2 A @ 12 VDC = 2.9 W
Data transfer speed:	Full scans to memory every 13 ms with USB 2.0 or USB 1.1 port
Operating systems:	Windows 98/Me/2000/XP, Mac OS X, Linux using USB port
Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible)
LIGHT SOURCE	
Light source:	Pulsed xenon
Bulb life:	>1 x 10^8 flashes
SAMPLE CHAMBER	
Pathlength:	1-cm; standard 1-cm square cuvettes required
Bandpass filters:	526 nm, 330 nm, 407 nm
Longpass filters:	610 nm, 550 nm, 420 nm, 530 nm
"Z" dimension:	15 mm (from bottom of chamber to light path)

CHEM2 Systems for Education

More Tools for Teaching Labs

The CHEM2's range of applications can be expanded by purchasing a few additional accessories:

The FL-400 Flame Loop takes the guesswork out of visual flame analysis by providing real-time atomic emission lines of Na, K, Cu, Ca and more when heated in a Bunsen burner flame.



page 145

Our Transmission Dip Probes bring the spectrometer to the sample. To measure absorbance, just dip the probe into a beaker, flask or reaction vessel, or immerse it in a stream or pond in the field.

pages 148-150

The R400 Reflection Probe turns the spectrophotometer into a reflectometer. Add our color software to demonstrate the science of visual perception and colorspace.

page 146

We offer several types of 1-cm pathlength disposable cuvettes. Prices start at $10 for a pack of 8 cuvettes.

page 93

Photometric Standards for Absorbance are used to check the accuracy of spectrometer systems. The kits consist of a reference and low, medium and high absorbance solutions.

page 93

Unique Teaching Tool = More Data, Faster

Our CHEM2-series Spectrophotometers for Education are small-footprint, PC-based systems designed for chemistry professors, teachers and others who use spectroscopy as a teaching tool. These fully integrated systems -- including spectrometer, light source, cuvette holder and operating software -- are available at dramatic discounts with the trade-in of an old lab instrument. Acquire and display data -- 2048 wavelengths -- in <1 second with our convenient, PC-based systems.

Sampling Optics: Direct-attach or Fiber

Each CHEM2 system comes with a fully integrated light source and cuvette holder that attaches to the spectrometer for a remarkably small-footprint system. The cuvette holders for all of the systems are designed for standard 1-cm square cuvettes.

Direct Attach:
The CHEMUSB2-VIS has a direct-attach combination tungsten and blue LED source. The CHEMUSB2-UV-VIS has a state-of-the-art, miniature RF-excited deuterium tungsten source. You can separate each spectrometer from its integrated light source to couple the spectrometer to any of our fiber optic accessories and light sources.

Fiber:
The CHEM2-UV-FIBER and CHEM2-VIS-FIBER include a light source and cuvette assembly that attaches to the spectrometer with an optical fiber. The advantage of this design is that the light source can be easily coupled to other fiber optic accessories such as reflection probes or transmission dip probes. The CHEM2-VIS-FIBER comes with a tungsten source and the CHEM2-UV-FIBER uses a deuterium tungsten source.

USB Interface for Easy Startup

All of our CHEM2 systems interface to a PC via USB. All you need is to install the software and connect the included USB cable to your PC to be up and running. Wavelength calibration data are loaded automatically upon startup, and spectrometer power is supplied through the USB.

Software for Linux, Macintosh & Windows

All CHEM2 systems come with student-friendly software, which includes functions for absorbance, transmission, relative irradiance and kinetics measurements. The systems also work with our new cross-platform SpectraSuite Spectroscopy Software (pages 76-77), which works in Linux, Macintosh and Windows operating systems.

Discount Pricing & Cost Sharing

Any learning institution qualifies for trade-in prices for CHEM2 systems. Save $1,500 by trading in your old monochromator or spectrometer. See the facing page for trade-in savings. Our *Innovations in Education Spectroscopy Grant Program* rewards educators and researchers for utilizing fiber optic spectroscopy in curricula or in research. See page 8 for details.

CHEMUSB2-UV-VIS:	$3,999 or $2,499 with trade-in
CHEMUSB2-VIS-NIR:	$2,999 or $1,499 with trade-in
CHEM2-UV-FIBER:	$3,999 or $2,499 with trade-in
CHEM2-VIS-FIBER:	$2,999 or $1,499 with trade-in

CHEM2 Systems for Education

	Spectrometer & A/D Converter	Wavelength Range	Light Source & Sample Holder	Optical Fiber	Retail Price	Trade-in Price
CHEMUSB2-UV-VIS 	USB2000-UV-VIS	200-850 nm	USB-ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$3,999	$2,499 (save $1,500)
CHEMUSB2-VIS-NIR 	USB2000-VIS-NIR	390-950 nm	USB-ISS-VIS integrated tungsten bulb with a violet LED and cuvette holder for 1-cm square cuvettes	None -- integrated light source and sample holder directly attaches to spectrometer	$2,999	$1,499 (save $1,500)
CHEM2-UV-FIBER 	USB2000-UV-VIS	200-850 nm	ISS-UV-VIS integrated deuterium tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 1-meter long P300-1-SR assembly with 300 µm diameter solarization-resistant fiber	$3,999	$2.499 (save $1,500)
CHEM2-VIS-FIBER 	USB2000-VIS-NIR	400-850 nm	ISS-2 integrated tungsten halogen light source and cuvette holder for 1-cm square cuvettes	Lamp and sample holder attach to spectrometer via 2-meter long P400-2-UV-VIS assembly with 400 µm diameter fiber	$2,999	$1,499 (save $1,500)

Specifications

	CHEMUSB2-UV-VIS	CHEMUSB2-VIS-NIR	CHEM2-UV-FIBER	CHEM2-VIS-FIBER
SYSTEM				
Wavelength range:	200-850 nm	390-950 nm	200-850 nm	400-850 nm
Optical resolution:	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM	~1.0 nm FWHM
Integration time:	3 ms to 65 seconds	3 ms to 65 seconds	3 ms to 65 seconds	3 ms to 65 seconds
Dimensions (in mm):	89.1 x 63.3 x 34.4 (USB2000) 198 x 105.1 x 40.6 (USB-ISS-UV)	89.1 x 63.3 x 34.4 (USB2000) 40.7 x 88.8 x 34.1 (USB-ISS-VIS)	89.1 x 63.3 x 34.4 (USB2000) 198 x 104.9 x 40.9 (ISS-UV-VIS)	89.1 x 63.3 x 34.4(USB2000) 155 x 50 x 53.3 (ISS-2)
DETECTOR & OPTICAL BENCH				
Detector:	Sony CCD array (page 43)	Sony CCD array (page 43)	Sony CCD array (page 43)	Sony CCD array (page 43)
Pixels:	2048 pixels	2048 pixels	2048 pixels	2048 pixels
Optical bench design:	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner	f/4, crossed Czerny-Turner
Entrance aperture:	25 µm wide slit (page 42)	25 µm wide slit (page 42)	25 µm wide slit (page 42)	25 µm wide slit (page 42)
Grating:	Grating #1 (page 44)	Grating #2 (page 44)	Grating #1 (page 44)	Grating #2 (page 44)
Order-sorting filters:	OFLV-200-850 (page 43)	OFLV-350-1000 (page 43)	OFLV-200-850 (page 43)	OFLV-350-1000 (page 43)
LIGHT SOURCE/SAMPLE CHAMBER				
Bulb(s):	Deuterium and tungsten halogen	Tungsten halogen and violet LED	Deuterium and tungsten halogen	Tungsten halogen
Bulb lifetime:	800 hours	45,000 hours	800 hours	900 hours
Cuvette pathlength:	1 cm	1 cm	1 cm	1 cm
Optical fiber:	N/A	N/A	300 µm solarization-resistant, 1 m	400 µm diameter fiber, 2 m
ELECTRONICS & COMPUTER				
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; any 32-bit Windows OS when using the serial port			
Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 57.6 K baud			

FLOW2000 Flow-through Absorbance System

In-line Monitoring

Designed for measuring ozonated water, the FLOW2000 Flow-through Absorbance System combines a miniature spectrometer, UV light source, flexible tubing with Swagelok fittings, and a 1-cm quartz flow cell to measure absorbance of solutions from ~220-850 nm. The FLOW2000 can be used for most any type of on-line absorbance measurement, but is particularly handy for monitoring ozone concentration in potable water and in water used in spoilage control, environmental remediation, semiconductor cleaning processes, and aquaculture. (The FLOW2000 is not a good choice for applications where observation of very small absorbance changes -- to 0.00001 AU -- is necessary. For those applications, consider the S1024DW Deep Well Detector Spectrometer on page 41.)

Example Application: Ozone

Ozone is a naturally occurring gas that is used in dozens of industries for oxidizing, bleaching and disinfecting. Ozone concentration can be monitored with a system like the FLOW2000 by observing changes in the absorbance spectrum of ozone in water; as ozone concentration increases, a peak at 254 nm increases in intensity.

What's Included

The FLOW2000 consists of a USB2000-UV-VIS Spectrometer (200-850 nm), a miniature pulsed xexon source and a 1-cm quartz flow cell that are packaged in a single housing, with connectors that accept flexible tubing with Swagelok fittings. Operating software is included. Also, you will need a pump. Consult an Ocean Optics Applications Engineer for help choosing the correct pump.

Operating Interface

Operate the FLOW2000 via its USB or serial port. The latter is especially versatile, since it can be used to interface to desktop or portable PCs, PLCs and other devices that support the RS-232 communication protocol. Operation via RS-232 allows the spectrometer to store up to 16 spectra (2048 points for each spectrum) in the spectral data section. When used in its default configuration, the FLOW2000 provides ozone concentration values at predefined calibration coefficients. If some other analyte is to be measured, the user must perform a calibration routine in our operating software to determine the optimum calibration wavelengths. To then operate via RS-232 mode, the user stores those calibration values in the EEPROM. Acquisition parameters such as integration time and flash rate also can be stored on the EEPROM.

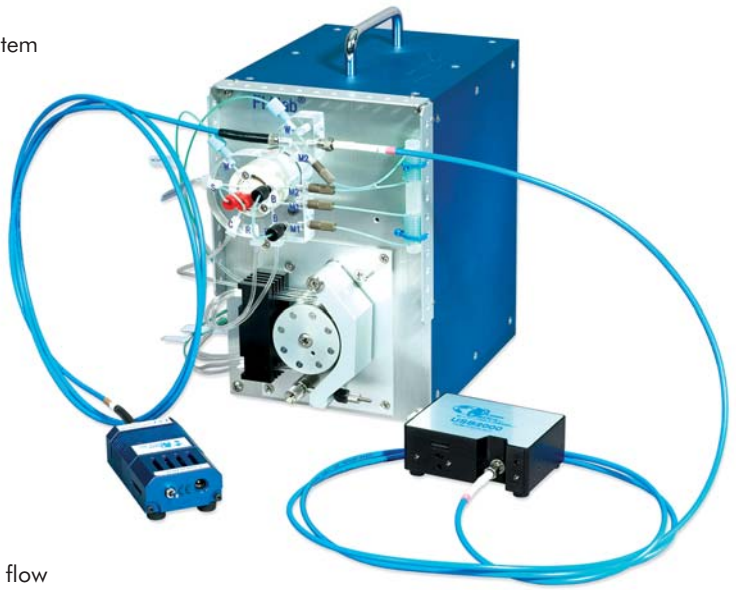
FLOW2000: $7,199

Specifications	
SYSTEM	
Optical resolution:	1.02 nm FWHM
Wavelength range:	200-850 nm
Stray light:	<0.05% @ 600 nm; <0.10% @ 435 nm
Dynamic range:	2 x 10^8 (system); 1300:1 for single acquisition
Dimensions:	155 mm x 145 mm x 75 mm
Weight:	451 g
Integration time:	3 milliseconds to 65 seconds
Temperature limits:	-0 °C to +60 °C
Humidity limits:	0% - 90% non-condensing
Sample flow rate:	1 liter per minute
DETECTOR & OPTICAL BENCH	
Detector:	2048-element linear silicon CCD array (page 42)
Signal-to-noise ratio:	250:1 (at full signal)
Dark noise:	3.2 RMS counts
Optical bench design:	f/4, crossed Czerny-Turner
Entrance aperture:	10 µm wide slit (page 42)
Grating:	Grating 1, 600 lines per mm (page 44)
Order-sorting filter:	OFLV-200-850 (page 43)
ELECTRONICS & COMPUTER	
Power consumption:	90 mA @ 5 VDC + 0.2 A @ 12 VDc = 2.9 W
Data transfer speed:	Full scans to memory every 13 ms with USB 2.0 or USB 1.1 port
Operating systems:	Windows 98/Me/2000/XP, Mac OS X, Linux using the USB port; any 32-bit Windows OS using the serial port
Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 @ 57.6 K baud with limited command set
LIGHT SOURCE & SAMPLE CHAMBER	
Light source:	Pulsed xenon
Bulb life:	>1 x 10^8 flashes
Pathlength:	1-cm quartz flow-through cuvette
FITTINGS	
Fittings:	1/4" OD standard tube fittings
Maximum pressure:	3 bar

FIA-LAB-2500 Flow Injection Analysis System

Automated System for Assays

The FIA-LAB-2500 is a flow injection analysis (FIA) system for automation of common environmental and agricultural assays such as nitrate, nitrite and ammonia. A complete, automated FIA-LAB-2500 system -- including a USB2000 Spectrometer, light source, flow cell, accessories and optional XYZ autosampler -- can be configured for about $16,000. Affordability and flexibility make the system ideal for teaching, research and commercial labs, especially where routine analyses demand a robust, easy-to-use system. Commonly measured analytes include ammonia, chloride, copper, iron, nitrate, nitrite and phosphate. (For information on other FIA systems, see pages 101-102.)



Built-in Flexibility, Affordability

The standard FIA-LAB-2500 consists of an automated flow injection system with four-channel peristaltic pump, six-port injector valve, fittings and tubing; a flow cell and optical fibers; a light source and spectrometer; and software. A range of accessories is available, including the FIA-ASX260 Autosampler with 180-sample capacity, the flow-through FIA-HEATER for elevated-temperature assays, and flow cells of varying optical pathlengths. Long-path flow cells are available for ultra-low concentration assays.

Assay	Throughput	Working Range
Nitrate	180 samples/hour	0.03 mg-200 mg/liter
Nitrite	220 samples/hour	0.005 mg-100 mg/liter
Ammonia	120 samples/hour	0.5 mg-200 mg/liter
Phosphate	120 samples/hour	0.1 mg-25 mg/liter
Chloride	120 samples/hour	1.0 mg-50 mg/liter
Iron	140 samples/hour	0.1 ppm-100 ppm

Example Applications

Nitrate/Nitrite Assay. This method performs FIA assays for soil testing and analysis of potable water and ground, surface, domestic and industrial wastewaters.

Phosphate Assay. A phosphate measurement method based on USEPA protocols, best suited for agricultural and environmental testing.

Ammonia Assay. An FIA assay for low ammonia concentrations using the salicylate method. Ideal for agricultural and environmental testing.

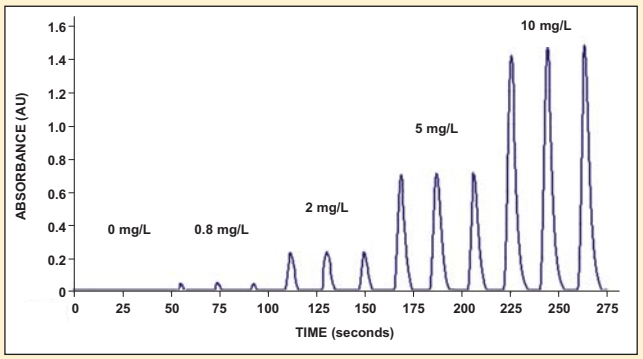
Ease of Use Tops List of Benefits

The FIA-LAB-2500 automates the handling of sample and reagent solutions, so that messy, awkward and inexact manual handling of solutions is unnecessary. Ease of operation is one of several benefits:

1) There is no need to purchase separate expensive manifolds for each type of analytical method.
2) Wavelength selections are made through software; no additional filters or lamps are required when switching among methods.
3) Monitoring multiple wavelengths (up to four) substantially extends the system's dynamic range.
4) Reference wavelengths are utilized for compensation of colored matrices and index of refraction effects.
5) The system provides automatic correction for response drift.

FIA-LAB-2500: $8,995
FIA-ASX260: $5,800
FIA-HEATER: $450

Nitrate Run: Raw Data of Triple Injections



Specifications

Spectrometer setup:	200-850 nm, 25 µm slit, UV2 upgrade, order-sorting filter
Accuracy (typical):	2%-3%
Precision (typical):	1%-2%
Pump:	4-channel standard, 6-channel available
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Dimensions:	24 cm height x 24 cm depth x 16.5 cm width
Weight:	6.75 kg
Dynamic range:	2 x 10^8 (system); 2000:1 for a single acquisition
A/D resolution:	12 bit
Board architecture:	USB 1.1
Power consumption:	90 mA @ 5 VDC and 0.2 A @ 12 VDC; total of 2.9 W
Wavelength accuracy:	1.0 pixel (~0.35 nm)
Optical fibers:	(2) 200 µm SMA 905-terminated patch cords
Light source:	Tungsten halogen (360-2000 nm)
Autosampler (optional):	180, 270 or 360 samples; 10 standards
Flow-through heater:	Ambient up to 50 °C (accuracy is +/- 0.5 °C)

LED Measurement Tools

When coupled with the optimum sampling accessories, the USB2000 Spectrometer is a highly accurate spectroradiometer for measuring the color, relative power and absolute spectral intensity of LEDs.

Miniature Fiber Optic Spectrometer

A USB2000 Spectrometer optimized for LED measurements is configured with a 350-1000 nm wavelength range, a 25 µm entrance aperture and an L2 Collection Lens to increase light efficiency. With this configuration, optical resolution is ~1.33 nm (FWHM).

LED Power Supply: Secures, Powers & Drives LED

The LED-PS Power Supply provides three useful functions: securing the LED in place, powering the LED, and displaying the LED's drive current. Use the adjustable drive current feature to increase or decrease an LED's current up to 50 mA. We offer a standard LED-PS and a NIST-traceable version.

Integrating Sphere: 360° Energy Collection

The LED is powered by the LED-PS and is inserted into the 9.5-mm diameter port of the FOIS-1 Fiber Optic Integrating Sphere, which has a 360° field of view. The P400-2-VIS-NIR Optical Fiber collects the light from the FOIS-1 and funnels it to the USB2000 Spectrometer.

Light Source: Radiometric Reference Source

The LS-1-CAL-INT is a NIST-traceable light source designed specifically to calibrate the spectral response of a spectroradiometric system that uses the FOIS-1 as the sampling device. It provides known absolute intensity values at several wavelengths. The LS-1 is used as a reference for relative power measurements.

Spectral & Color Measurement

Our software provides absolute spectral intensities for LEDs, and calculates L*a*b*, XYZ, xyz, u'v'w', hue, RGB, chroma, saturation and more. See page 81 for details.

Before measuring the absolute irradiance of your LED, you need to take a reference spectrum of a calibrated blackbody energy source. The LS-1-CAL-INT Radiometric Reference Source was designed for the FOIS-1 Integrating Sphere, our sample chamber for LEDs. The LS-1-CAL-INT is inserted into the sample port of the FOIS-1 (at right); optical fiber collects the light from the FOIS-1 and funnels it to the USB2000 Spectrometer.

After taking a reference and a dark spectrum, insert an LED into the LED-PS Power Supply, which holds and powers the LED, displays the LED drive current, and allows you adjust the current. The LED-PS is placed over the FOIS-1, so that the LED is inserted into the sample port of the FOIS-1.

In this setup, the LED-PS is on top of the FOIS-1 Integrating Sphere and a P400-2-VIS-NIR Optical Fiber collects the light energy from the FOIS-1 and sends it to the USB2000 Spectrometer. Our software reports the absolute spectral intensities for the LED as well as color values, photopic data and more.

Spectrometer Specifications	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g (without cable)
Power consumption:	90 mA @ 5 VDC
Wavelength range:	350-1000 nm
Detector:	2048-element CCD array (page 43) with L2 Collection Lens
Grating:	Grating #2, 600 lines per mm blazed at 300 nm (page 44)
Entrance aperture:	25 µm wide slit (page 42)
Order-sorting filters:	OFLV-350-1100 (page 43)
Optical resolution:	~1.33 nm FWHM
Board architecture:	USB and RS-232 interface
Dynamic range:	2 x 10^8 (system); 2000:1 for a single acquisition
Stray light:	<0.05% at 600 nm
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port

Item	Description	Page	Price
USB2000	Spectrometer with 25 µm slit, L2 Lens, OFLV-350-1100	38	$2,649
LS-1-CAL-INT	Radiometrically calibrated LS-1	131	$749
FOIS-1	Fiber Optic Integrating Sphere	108	$499
LED-PS-NIST	NIST-traceable LED power supply	107	$749
OOIIrrad-C	Software for Color and Irradiance	81	$399
P400-2-VIS-NIR	Optical fiber for connecting FOIS-1 to USB2000	138	$120
P200-2-VIS-NIR	Optical fiber for connecting LS-1-CAL-INT to USB2000	138	$100

Transmission of Optics Tools

We offer all of the components you need for measuring the transmission of optics. Listed below is a sample order that specifies an HR4000 High-resolution Spectrometer configured with our novel HC-1 Composite Grating, which provides a 200-1100 nm wavelength range. In addition, we suggest a DT-MINI-2 Deuterium Tungsten Halogen Source, plus fibers, collimating lenses and a lens fixture for sampling.

HR4000 with 200-1100 nm Wavelength Range

The HR4000 configuration we recommend for this application includes a new 3648-element CCD-array detector, the proprietary HC-1 Composite Grating and an order-sorting filter to provide a 200-1100 nm wavelength range and optical resolution better than 1.0 nm (FWHM). We also suggest a 25 µm entrance slit and a UV2 Detector Upgrade to enhance performance in the UV. The HR4000 interfaces to a PC via a USB 2.0 port.

Broad Spectral Range Light Source

The DT-MINI-2 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of a deuterium UV light source and a tungsten halogen VIS-NIR light source in a single optical path. The combined-spectrum source produces stable spectral output from ~200-2000 nm in a compact package.

Holder for a Variety of Samples

The 74-ACH Adjustable Collimating Lens Holder consists of adjustable bars with several threaded holes for collimating lenses. The bars can be set to accept samples up to ~100 mm thick, making the 74-ACH a convenient option for transmission measurements of large samples.

Collimating Lenses

The 74-UV Collimating Lenses screw into the threaded holes of the 74-ACH to collimate light. The lenses have an inner barrel threaded for attaching to optical fibers. When focused for collimation, beam divergence is 2° or less. The inner barrel can slide relative to the lens fixture to adjust the focus.

Optical Fiber

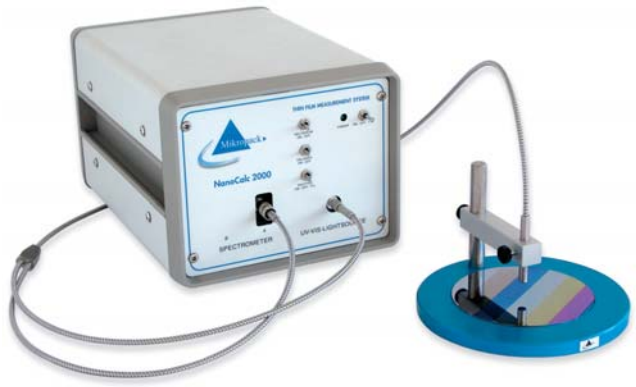
Our fiber assemblies can act as both illumination and read fibers. The two 600 µm diameter optical fibers recommended are 1 meter in length and connect easily from the collimating lenses installed in the 74-ACH to the HR4000 Spectrometer and the light source.

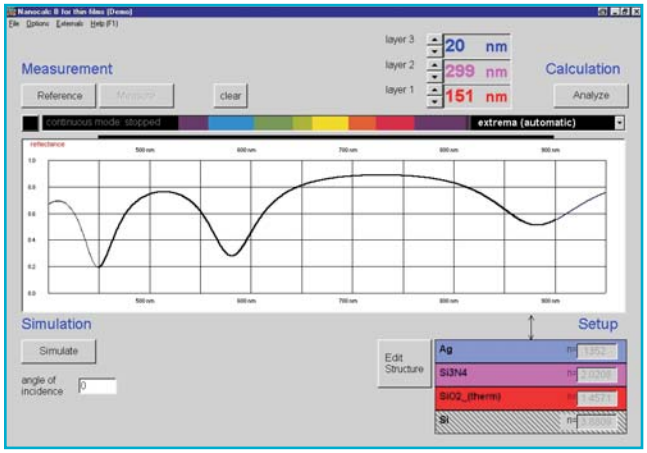
Spectrometer Specifications	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Power consumption:	450 mA @ 5 VDC
Detector:	3648-element linear CCD array (page 51)
Wavelength range:	200-1100 nm
Optical resolution:	~1.0 nm FWHM
Grating:	HC-1, 300 lines per mm grating (page 52)
Entrance aperture:	25 µm wide slit (page 50)
Order-sorting filters:	Installed OFLV-200-1100 (page 51)
Focal length:	f/4, 101 mm
Dynamic range:	2 x 10^9 (system); 2000:1 for a single acquisition
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Data transfer rate:	Full scans into memory every 4 ms with USB 2.0; 18 ms with USB 1.1; 600 ms with the serial port
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; any 32-bit Windows operating system when using the serial port
Inputs/outputs:	10 digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input and one 9-bit analog output

** Programming the GPIOs requires SpectraSuite Software, OmniDriver or another one of our device drivers. See pages 76-79 for details.*

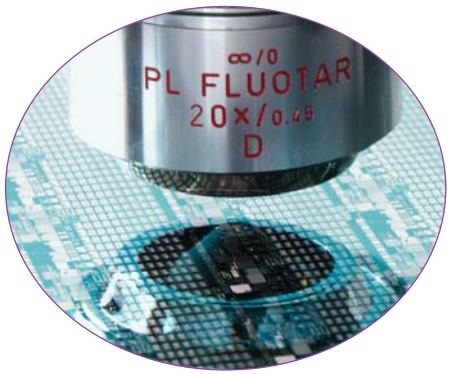
Quantity	Item	Description	Page	Price
1	HR4000	HR4000 ($3,999) with HC-1 Composite Grating ($600); 25 µm slit ($150); OFLV-H4 Order-sorting Filter ($250); UV4 Detector Upgrade ($150)	46	$5,149
1	DT-MINI-2	Miniature Deuterium Tungsten Halogen Light Source	122	$1,499
1	74-ACH	Adjustable Collimating Lens Holder	89	$299
2	74-UV	Collimating Lens	88	$318
2	P600-1-SR	600 µm diameter optical fiber in 1-meter length	139	$238
			TOTAL:	**$7,503**

NanoCalc Thin Film Reflectometry System





NanoCalc Software displays a sample interference spectrum, predicted spectra and up to four layers.



Analyze Layers from 10 nm in Thickness

The optical properties of thin films arise from reflection and interference. The NanoCalc Thin Film Reflectometry System allows you to analyze the thickness of optical layers from 10 nm to ~250 µm. You can observe a single thickness with a resolution of 0.1 nm. Depending on your software choice, you can analyze single-layer or multilayer films in less than one second and can measure the thickness and removal rates of semiconductor process films or anti-scratch coatings, hard coatings and anti-reflection coatings.

Theory of Operation

The two most common ways to measure thin film characteristics are spectral reflectance/transmission and ellipsometry. NanoCalc utilizes the reflectance method and measures the amount of light reflected from a thin film over a range of wavelengths, with the incident light normal to the sample surface.

Search by *n* and *k*

As many as four layers can be specified in a film stack. The various films and substrate materials can be metallic, dielectric, amorphous or crystalline semiconductors. The NanoCalc Software includes a large library of *n* and *k* values for the most common materials. You can edit and add to this library. Also, you can define material types by equation or dispersion formulas.

Applications

NanoCalc Thin Film Reflectometry Systems are ideal for in situ, on-line thickness measurements and removal rate applications, and can be used to measure the thickness of oxides, SiNx, photoresist and other semiconductor process films. NanoCalc Systems measure anti-reflection coatings, anti-scratch coatings and rough layers on substrates such as steel, aluminum, brass, copper, ceramics and plastics.

Item	Wavelength	Thickness	Light Source Included
NC-UV-VIS-NIR	250-1100 nm	10 nm-70 µm	Deuterium and Tungsten Halogen
NC-UV-VIS	250-850 nm	10 nm-20 µm	Deuterium and Tungsten Halogen
NC-VIS-NIR	400-1100 nm	50 nm-100 µm (optional 1 µm-250 µm)	Tungsten Halogen
NC-VIS	400-850 nm	50 nm-20 µm	Tungsten Halogen
NC-NIR	650-1100 nm	70 nm-70 µm	Tungsten Halogen
NC-NIR-HR	700-978 nm	1 µm-250 µm	Tungsten Halogen
NC-512-NIR	900-1700 nm	50 nm-200 µm	High-power Tungsten Halogen

Specifications			
Angle of incidence:	90°	On-line possibilities:	Yes
Number of layers:	4 or fewer	Mechanical tolerance (height):	With new reference or collimation (74-UV)
Reference measurement needed:	Yes (bare substrate)	Mechanical tolerance (angle):	Yes, with new reference
Transparent materials:	Yes	Microspot option:	Yes, with microscope
Transmission mode:	Yes	Vision option:	Yes, with microscope
Rough materials:	Yes	Mapping option:	6" and 12" XYZ mapping tables
Measurement speed:	100 milliseconds to 1 second	Vacuum possibilities:	Yes

SpecEl Ellipsometer System

Full Spectral Range in Easy-to-use System

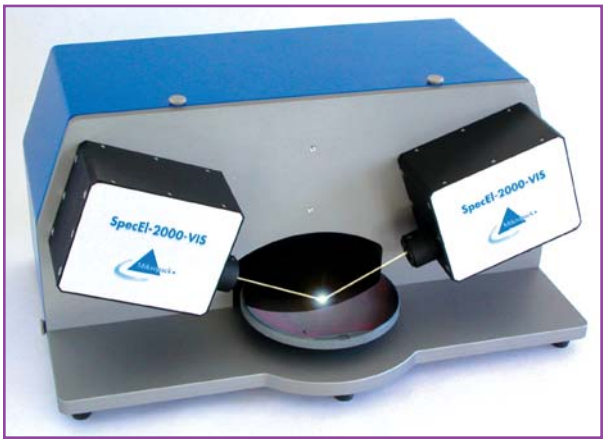
Measure refractive index, absorbance and thickness of substrates with the touch of a button! The SpecEl-2000-VIS Ellipsometer from Mikropack measures polarized light reflected from the surface of a substrate to determine the thickness and refractive index of the material as a function of wavelength. The SpecEl is controlled via a PC.

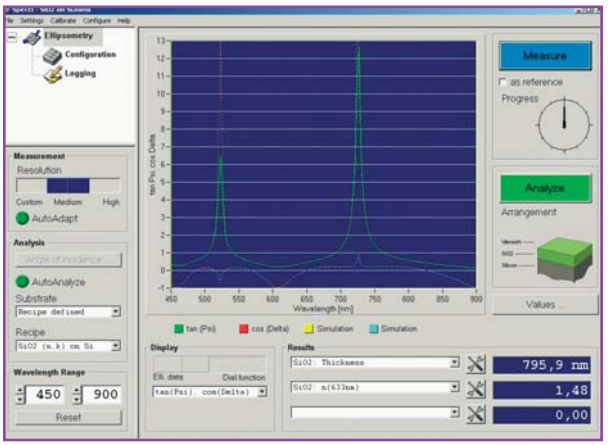
All-in-one Accurate System

The SpecEl houses an integrated light source, a spectrometer and two polarizers fixed to 70°. It also includes a PC with a 32-bit Windows operating system. The SpecEl can detect a single layer as thin as 0.1 nm and up to 5 µm thick. In addition, it can provide refractive indices to 0.005° over lambda.

SpecEl Software and "Recipe" Files

In SpecEl Software, you can configure and save experiment method files for one-step analysis. After creating a "recipe," you can select the recipe to execute the experiment.





This screen from the SpecEl Software demonstrates the Psi and Delta values you can calculate for thickness, refractive index and absorbance.

Specifications	
Wavelength range:	450-900 nm
Optical resolution:	4.0 nm FWHM
Accuracy:	0.1 nm thickness; 0.005% refractive index
Angle of incidence:	70°
Film thickness:	from 0.1 to 8000 nm for single transparent film
Spot size:	2 mm x 4 mm (standard) or 200 µm x 400 µm (optional)
Sampling time:	5-15 seconds (minimum)
Kinetic logging:	5 seconds
Mechanical tolerance:	Height ± 1 mm, angle ± 1.0°
Number of layers:	Up to 32 layers
Reference:	Not applicable

PlasCalc Plasma Monitoring & Control

Real-time, Full-spectral Plasma Monitoring

PlasCalc-UV-NIR measures plasma emission from 200-1100 nm in only 3 milliseconds. The PlasCalc benefits from advanced process control systems and sophisticated algorithms for data acquisition.

Recipe Editor

The Recipe Editor tool allows you to easily and rapidly configure, build and save experiment methods. It is easy to build robust recipes for the most difficult plasma processes such as measuring film deposition, monitoring plasma etching, examining surface cleaning, analyzing plasma chamber health control, and monitoring abnormal pollution or discharge phenomena.

Multiple Tools for Easy Plasma Diagnosis

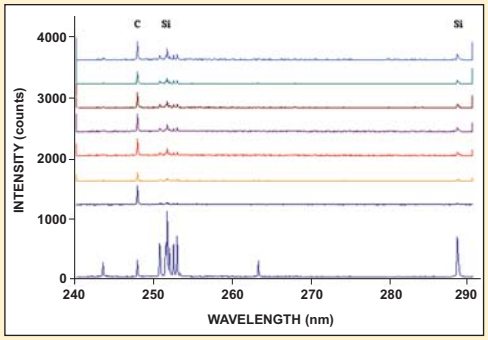
The Integrated Formula Editor provides easy access to a full range of mathematical and algorithmic functions. An Emission Wavelength Library provides species identification, while the Wavelength Editor allows you to optimize signal-to-noise. A dual-window interface shows the actual spectrum and all process control information.

Specifications	
Spectral range:	200-1100 nm
Optical resolution:	1.0 nm FWHM
D/A-converter:	14 bit
Digital input/output:	8 x TTL digital input/output
Analog output:	4 x [0-10V]
Interface:	USB 1.1
Power consumption:	12 VDC @ 1.25 A
Power requirements:	90-240 VAC 50/60 Hz
Dimensions:	257 mm x 152 mm x 263 mm
Weight:	5 kg

Laser-induced Breakdown Spectrometer

A LIBS system often includes the LIBS-LASER (page 21) as the excitation source, which includes the laser power supply (left) and the laser head that sits on top of the sample chamber. The LIBS-SC Sample Chamber (page 21, and shown above center) includes a stage and probe. The LIBS2000+ Spectrometer System is above right.

LIBS2000+ Spectra of Silicon



LIBS spectra for silicon surface contamination ranging from 0 to 2%. The LIBS spectrum for a silicon-rich sample is shown at the bottom of the graph for comparison.

Spectrometer Specifications	
Dimensions:	133 mm x 267 mm x 450 mm (spectrometer system)
Weight:	13 kg (spectrometer system only)
Power consumption:	1 A @ 5 VDC (spectrometer system only)
Detector:	(7) 2048-element linear silicon CCD arrays
Wavelength range:	200-980 nm
Optical resolution:	~0.1 nm (FWHM)
Frame rate:	10 Hz capability (PC-controlled)
Integration time:	2.1 ms; variable in free-run mode
Trigger delay:	-121 µs to +135 µs in 500 ns steps (PC-controlled)
Trigger jitter:	± 250 ns
Trigger level:	TTL not to exceed 5.5 volts

Instant Elemental Analysis from 200-980 nm

We offer a full range of systems and components for laser-induced breakdown spectroscopy, a technique for real-time, qualitative spectral analysis of elements in solids, solutions and gases. The LIBS2000+ is a broadband (200-980 nm), high-resolution detection system with optical resolution of ~0.1 nm (FWHM). Sensitivity to parts-per-billion and picogram levels is possible.

How the LIBS Works

A high-intensity, pulsed laser beam is focused on the sample area. A single 10 nanosecond-wide laser pulse ablates the sample and generates a plasma. As the plasma decays or cools, excited atoms in the plasma emit light at wavelengths that are distinct to each element. The emission is collected by a probe and sent to the spectrometer system. Each scan provides full spectral analysis from 200-980 nm -- the region in which all elements emit energy. This emission is collected by a probe and sent to a high-resolution, spectrometer system for analysis.

Diverse Applications

The LIBS2000+ is noninvasive so users can perform real-time measurements in hostile environments with little or no sample preparation. LIBS2000+ Systems are being used in these areas:

- Environmental monitoring: soil, particulates, sediments
- Materials analysis: metals, metal alloys, slag, plastics, glass
- Forensics and biomedical: teeth, bones
- Metrology: silicone wafers
- Bioresearch: plants, grains
- Safety & military applications: explosive particles, chemical and biological warfare agents
- Art restoration/conservation: pigments, paints
- Gemology: precious metals, gems

High-resolution Spectrometers

Our LIBS2000+ Spectrometer uses seven linear CCD-array detectors for broadband analysis. All spectrometers are triggered to acquire and read out data simultaneously. The detection system is portable and can be interfaced to a PC via a USB port.

Operating Software

OOILIBS Software includes a library of elemental emission lines and enables automatic identification of all elements present in the sample. Other software features allow tracking emission intensities over multiple scans and correlation of analysis routines.

LIBS2000+: $30,000
OOILIBS: $500

Advantages of LIBS over other Technologies

Parameter	LIBS	SEM/EDS	XRF	LA-ICP-MS	EPMA
Sample depth:	~50-100 µm	~5 µm	~100 µm	~80 µm	<1 µm
Sensitivity:	10-50 ppm	1000 ppm	100 ppm	<1 ppm	100 ppm
Precision:	Fair-good	Poor	Fair-good	Excellent	Fair
Accuracy:	Semi-quantitative	Qualitative	Semi-quantitative	Quantitative	Semi-quantitative
Analysis time:	Fast	Slow	Very slow	Slow	Slow
Sample consump:	almost non-destructive	non-destructive	non-destructive	almost non-destructive	non-destructive
Complexity:	Easy to use	Easy to use	Easy to use	Complicated	Complicated
Cost:	$60,000	$120,000	$120,000	$250,000	$600,000
Discrimination:	Good	Poor	Good	Excellent	Fair

Custom Setups

As lower-cost options, lab and field systems are available with fewer than seven spectrometer channels, with a narrower wavelength range for element-specific analyses.

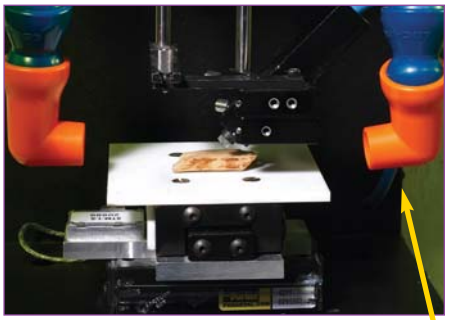
Additional LIBS Components

LIBS Sample Chamber

The eye-safe LIBS-SC Sample Chamber is a key component of a LIBS system and is designed to perform various functions safely and in clear view. The chamber accommodates a sample up to 6.5 cm x 6.5 cm x 6 cm and houses a manually controlled x-y stage. The chamber is made of an eye-protective polymer that provides a clear view of a sample. The chamber has a safety-interlock so the laser will not fire when the door is open. It is magnetically latched and interacts with a laser safety cutoff switch.

LIBS-SC: $9,800

Specifications	
Stages:	Manual x-y stage, z axis controlled manually via the focusing lens
Sample size:	6.5 cm x 6.5 cm x 6 cm maximum
Laser safety shield:	OD - 6 for 1.064 mm laser energy (call for other wavelengths)
Internal optics:	25 mm diameter lenses, 75 mm focal length supplied



The chamber includes a blower and an evacuation system that removes material from the sample area. You also can feed gases, such as Argon, into the sample chamber. Flooding the chamber with an inert gas provides greater sensitivity for a variety of elements.

LIBS Imaging Modules for Pinpoint Analysis

The LIBS-IM and LIBS-IM-C Imaging Modules directly attach to the LIBS-SC Sample Chamber to enable users to magnify a sample image and to establish precisely a laser ablation target on the sample. The cameras used in the imaging modules provide frame rates of up to 12.7 frames-per-second at 1280 x 1024 pixel resolution. Both are well suited to a variety of application areas that include forensics, semiconductor analysis, botany, biomedical analysis, gemology and metallurgy.

The imaging modules allow a user to see a magnified image of a sample via a CCD camera and PixeLINK image-capture software. PixeLINK lets you capture an image, annotate it and archive it on your PC.

The LIBS-IM produces black and white images with image resolution to 40 microns; the LIBS-IM-C provides color images at resolution to 60 microns. We recommend an imaging module for those purchasing the LIBS-SC Sample Chamber because an imaging module will provide rapid and convenient laser focus. The modules connect to a PC via a FireWire cable and FireWire PCI or PCMCIA card.

This image -- taken with a LIBS-IM -- is the "O" in the text, "Quarter Dollar" on a U.S. quarter.

Item	Description	Resolution	Price
LIBS-IM	B&W Imaging Module for the LIBS-SC	to 40 µm	$7,500
LIBS-IM-C	Color Imaging Module for the LIBS-SC	to 60 µm	$8,000
LIBS-IM-PCI	FireWire PCI card for desktop PC	N/A	$30
LIBS-IM-MCIA	FireWire PCMCIA card for notebook PC	N/A	$56

LIBS Laser Options

We offer multiple laser power options as sources for the LIBS2000+. Most all LIBS laser ablation is performed with a Q-switched 1064 nm Nd:YAG laser with variable repetition rates from 1-20 Hz, and a pulse stability of +/-3%. The choice of laser depends on your sample and its moisture content. For metals and compressed dry materials, select the 50 mJ ULTRA CFR Nd:YAG laser from Big Sky Laser Technologies (LIBS-LASER). For glass and high OH content materials, or for measuring a variety of materials, we recommend a 200 mJ Nd:YAG laser from New Wave Research (LIBS-LAS200MJ).

Though you can supply your own Q-switched pulsed laser for excitation as long as its energy is 30 mJ or above, please consult with our Ocean Analytics division before considering a laser not listed here. We offer other laser options; contact us for details.

LIBS-LASER: $14,500
LIBS-LAS200MJ: $22,500

The LIBS-LAS200MJ is a 200 mJ Nd:YAG laser from New Wave Research called the Tempest.

LIBS-ELITE Laser Ablation Sampling System

Highly Refined Sampling System for LIBS

The LIBS-ELITE, developed by New Wave Research and Ocean Optics, is a high-quality, high-precision LIBS sampling system platform with unparalleled sample imaging and control. The LIBS-ELITE consists of a laser head, sample chamber, software-controlled X-Y positioner and a high-resolution imaging system combined in a single housing. New Wave Research partnered with Ocean Optics to develop the LIBS-ELITE to work with the LIBS2000+ Laser-induced Breakdown Spectrometer System.

200 mJ Nd:YAG Laser

The LIBS-ELITE-200 comes with New Wave Research's Tempest 200 mJ Nd:YAG laser. The Tempest delivers high-energy densities to the sample to create plasma from even the most challenging materials. The accuracy and precision of the LIBS-ELITE-200 relies on the 98% pulse-to-pulse stability of the Tempest. A laser power meter located adjacent to the sample and a software-controlled attenuator are standard features that help enable quantitative sample analysis. Others laser options are available; the LIBS-ELITE-90 comes with a 90 mJ laser.

Sample Chamber: Unprecedented Control

The open architecture of the sample chamber allows the sample and ablation plume to be viewed easily through its Class 1 shield. The sample chamber includes a quick-loading sample drawer, and can accommodate samples up to 2 inches in diameter. A gas port on the rear of the housing enables the chamber to be purged with argon, which is useful for increasing sampling sensitivity, or with nitrogen or helium, which is useful when measuring emissions of elements like oxygen that are found in ambient environments. An integrated rotometer regulates the gas flow in the chamber.

Exact Positioning & High Resolution Imaging

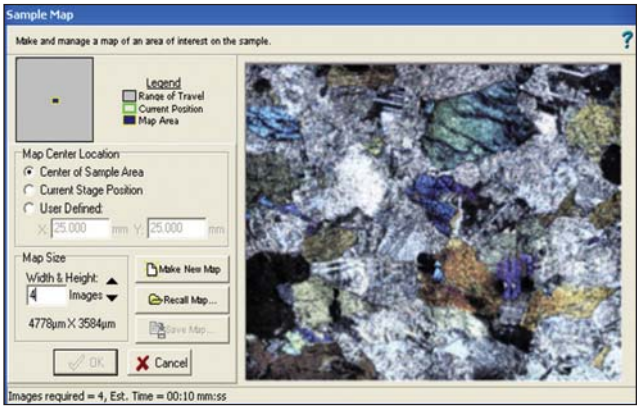
The system's software-controlled X-Y stage allows you to precisely control the target location, to create reproducible maps, and to automate sample mapping, patterning and rastering for testing sample homogeneity or for bulk analysis. The spot size controller can be used to set the ablation spot size from 20 μm to 1200 μm. The LIBS-ELITE's high-resolution sample magnification capability (see software screen capture at right) allows you to view an exact spot of the sample before and after the ablation event.

Software with Spectral Library

The LIBS-ELITE comes with intuitive operating software and a library of elemental emission lines, which enables automatic identification of all elements present in a sample. The software includes controls for ablation mode, laser repetition rate, laser power, sample spot size selection, X-Y positioning, sample viewing, sample mapping, gas routing, spectrometer system triggering and automating sampling processes. Pricing does not include the spectrometers.

LIBS-ELITE-200: $68,000
LIBS-ELITE-90: $65,000

The LIBS-ELITE works with the Ocean Optics LIBS2000+ Spectrometer System (see page 20) to provide full spectral analysis from 200-980 nm, with optical resolution of 0.1 nm and sensitivity to parts-per-billion. Below is a magnification of the sampling area where the ablation plume is produced behind the orange Class 1 shield. The sample compartment itself contains a quarter.



View an exact spot of the sample before, during and after the ablation process. The LIBS-ELITE provides real-time, high-resolution qualitative analysis of trace elements in diverse materials such as metals, biological tissues, soils, optics, semiconductors, gems, and other geological, biological and environmental specimens.

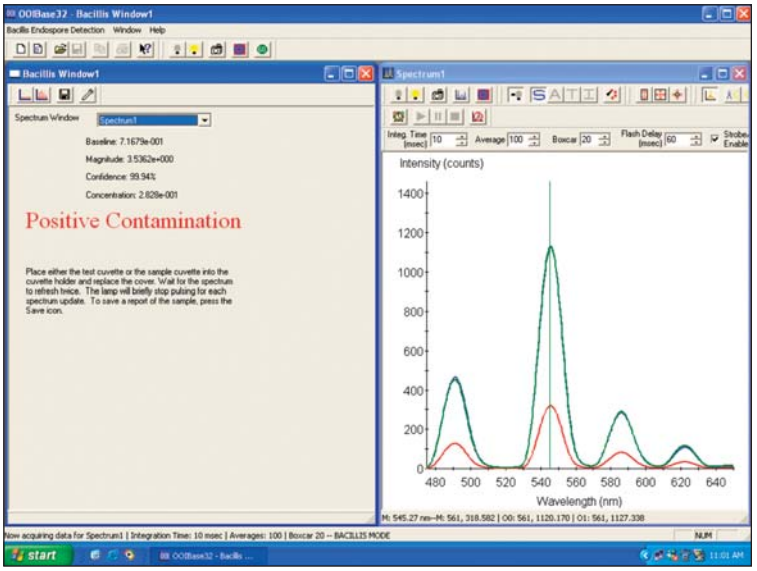
EDS2000 Endospore Detection System

Instant Endospore Detection

The EDS2000 Endospore Detection System is a field-deployable system that offers rapid front-end screening to instantly indicate the presence of *Bacillus* and *Clostridium* endospores, which include *Bacillus anthracis* (anthrax). The EDS2000 has a detection level of 100,000 spores, making it ideal for screening suspicious powders encountered by first-response teams. The entire system fits into a rugged carrying case for field use.

Principle of Operation

Analysis begins with swabbing of the potentially infected surface. The swab is swirled in a disposable plastic cuvette containing special reagents. (The EDS-TEST endospore detection reagent is available in a box of 100 reagent-filled cuvettes.) The cuvette is placed into the system's cuvette holder and exposed to ultraviolet pulsed xenon light. We use our USB2000-FLG Spectrofluorometer in gated fluorescence mode to detect and quantify the fluorescence from bacterial endospores in suspect samples.



Gated Fluorescence

The USB2000-FLG is preloaded with variable-delay gating microcode. This gated mode adds 5-500 microseconds between the excitation source firing and the start of the spectrometer's integration time, or the amount of time the detector "sees" the sample. In this mode, the spectrometer only detects the sample light when the source is off. The USB2000-FLG in gated fluorescence mode detects and quantifies the fluorescence of the sample; software then compares the sample with a standard for endospores. The software displays the comparative results -- positive, possible or below limits of detection -- within seconds of the analysis.

Special Mirrors Prevent Scattered Light

In addition to detecting fluorescence from a sample, a spectrofluorometer will also detect scattered excitation light from the light source and the sampling compartment. Another feature helps avoid detecting scattered light: special mirrors in the bench absorb UV light and improve sensitivity.

What's Been Tested

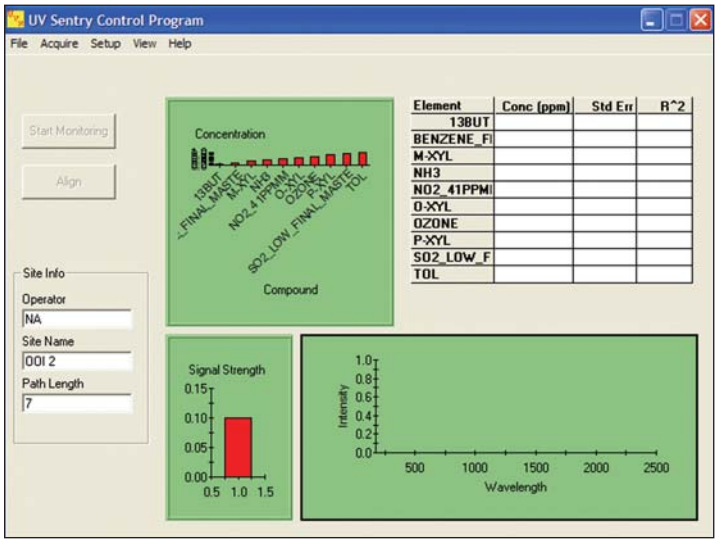
We are collaborating with other organizations to optimize the reagents now being used to detect bacterial endospores, in an effort to lower detection limits. In earlier tests, the system reported positive contamination when two anthrax strains were used as the sample: the Sterne strain (gamma-killed anthrax) and the Pasteur strain (an avirulent form of anthrax).

EDS2000: $5,000
EDS-TEST: $300

Specifications	
SYSTEM	
Dimensions:	17.5 cm x 14.5 cm x 6 cm
Weight:	1.10 kg (without battery)
Photometric accuracy:	<0.1%
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Dynamic range:	2 x 10^8 (system); 2000:1 for a single acquisition
A/D resolution:	12 bit
Board architecture:	USB 1.1
Power consumption:	90 mA @ 5 VDC and 0.2 A @ 12 VDC for a total of 2.9 W
OPTICAL BENCH & DETECTOR	
Detector:	Linear silicon CCD array
Pixels:	2048
Pixel size:	14 µm x 200 µm
Well depth:	~62,500 electrons
LIGHT SOURCE	
Light source:	Pulsed xenon
Bulb life:	>1 x 10^8 flashes
SAMPLE CHAMBER	
Pathlength:	1-cm standard
Cuvette shape:	Square
"Z" dimension:	15 mm (distance from bottom of chamber to center of light path)

Sentry System for Open-Path Air Monitoring

The SENTRY-5000 is ideal for fenceline monitoring applications of up to 850 meters. The SENTRY-STAN (at right, being inserted into the optical path of the SENTRY-5000) is a NIST-traceable calibration cell that comes with the SENTRY-5000.



The Sentry's software allows for continuous automated monitoring of compounds.

Item	Description	Price
SENTRY-5000	Open-Path Air Monitoring System with Deuterium Optical Transmitter, Integrated Spectrometer Optical Receiver, 2 Detachable Sighting Scopes, 2 power cables, 1 USB cable, Software, Spectral Library, and Calibration cell	$63,000
SENTRY-SUR-MT	Heavy duty surface mount (2 required)	$3,080
SENTRY-TRIPOD	Heavy duty tripod mounts, used for portable long distance applications (2 required)	$3,960
SENTRY-STAN	NIST-traceable Replacement Calibration Cell for Sentry	$910
SENTRY-CASE	Transit Case for Sentry	$1,999
SENTRY-DEUT	Replacement Deuterium Source for Sentry	$1,074

Innovative Open-Path Air Monitor

The Sentry is a fully automated, low-cost, open-path air monitoring system that detects and quantifies multiple atmospheric toxic compounds in real time, with a single analyzer. The Sentry senses dangerous chemicals at parts-per-trillion levels in wide-area environments (up to 850 meters in length), and is especially useful for community groups, environmental regulators, industrial corporations and government agencies in mapping hazardous emissions from pollution sources.

Partnership with Cerex

Developed by Cerex Environmental Services of Atlanta, Georgia, the portable Sentry is equipped with an integrated Ocean Optics HR2000 High-resolution Spectrometer that can resolve the fine spectral features of dangerous air-borne toxins including benzene, butadiene, toluene and xylene. (See the facing page for a list of the 20 compounds included in the current Sentry Software. If the compound you wish to monitor is not on the list, contact Ocean Optics. Additional compounds may be added to the software's library.)

Detects Airborne Toxins in Real Time

The Sentry includes a UV deuterium optical transmitter unit and a UV optical receiver unit. The transmitter projects a continuous collimated beam of UV light through the sample area to an optical receiving unit using telescope optics. The receiver, which contains the Ocean Optics HR2000 High-resolution Spectrometer, collects the light. Because each compound has a unique absorption spectral "fingerprint," the software is able to determine and specify the presence of airborne toxins along the beam's path. A release of a chemical anywhere along the beam is immediately detected and quantified. By comparison, traditional "point sampling" monitors may report only the part of a toxic plume that reaches the sensor's input port.

Used at Industrial Sites

In a highly publicized investigation, Hillsborough County, Florida, officials reported using the Sentry to monitor the air around Coronet Industries in Plant City, Florida. In the Coronet tests, the Sentry detected the presence of sulphur dioxide and nitric oxide near the plant but that the pollution levels were within legal standards. Sentry systems are being used to monitor the atmosphere for BTEX, SO_2 and other compounds at oil refineries, airports, animal feed operations, rubber manufacturing plants and more. In Durban, South Africa, for example, the Sentry differentiated between emissions that the refinery is responsible for and those produced by other sources.

The Portable Hound Sniffs Out Toxic Gas

Portable Air Monitor

The Hound is a portable point sampling air monitor that can simultaneously detect, quantify and identify up to 20 toxic airborne compounds at parts-per-billion concentration levels. The Hound instantly resolves the fine spectral features of hazardous air toxins including acrolein, benzene, sulfur dioxide, mercury, ozone and formaldehyde -- at concentrations below regulatory threshold levels.

Easy to Set Up & Deploy

The Hound is a self-contained, compact system that's just 33" long and weighs less than 25 pounds. In minutes, you can deploy the Hound on to a vehicle for emergency response monitoring, or place it in a fixed location for industrial hygiene or survey monitoring. All you need to operate the Hound is a notebook or desktop PC. The Hound interfaces very easily to the PC via a USB port and comes with a power cord (battery operation is also possible). In addition, the Hound can be operated around the clock, unmanned.

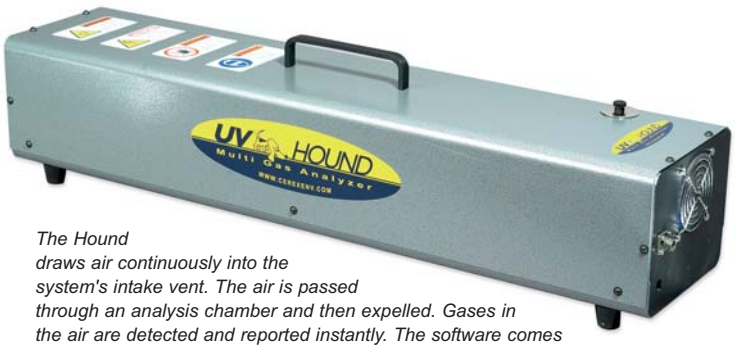
Spectroscopy Method Used for Detection

Using the Hound's software, you select the target gas you wish to monitor. Once you switch on the Hound, it begins to draw in and expel ambient air continuously. The air travels through a unique folded-path optical design, providing a 25-meter sample pathlength. At the heart of the Hound is an Ocean Optics HR2000 High-resolution Spectrometer optimized for the UV. As the gas passes through deuterium light, it will absorb light at wavelengths that are characteristic of that gas, creating an absorption spectrum.

Spectral Library Used for Matching

The Hound's software matches the measured spectrum against a library of stored reference absorption spectra for the 20 compounds listed at right. Each compound can absorb only certain wavelengths of energy; each has its own absorption spectral "fingerprint" unique to that compound. All of this analysis and reporting takes place in just milliseconds.

HOUND-7000:	$49,000
HOUND-CASE:	$1,999
HOUND-DEUT:	$1,074
HOUND-STAN:	$910



The Hound draws air continuously into the system's intake vent. The air is passed through an analysis chamber and then expelled. Gases in the air are detected and reported instantly. The software comes with a spectral library of chemicals and allows for compound selection and data logging.

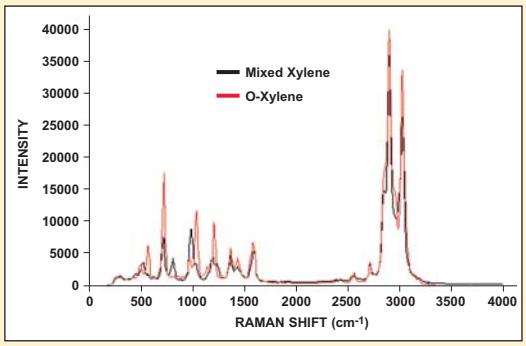
Sentry & Hound
20 Detectable Compounds

Acetaldehyde
Acrolein
Ammonia
Benzene
1,3-Butadiene
Carbon Disulfide
Chlorine
Ethyl Benzene
Formaldehyde
Hydrogen Sulfide
Isoprene
Mercury
Nitric Oxide
Nitrogen Dioxide
Ozone
Sulfur Dioxide
Toluene
m-Xylene
o-Xylene
p-Xylene

Raman Measurement Tools

Above, the QE65000 is configured for use with a LASER-785 and an RIP-RPB probe (see facing page for details). At left is the STAN-RAM785 for determining the absolute spectral intensity of your Raman system.

Comparing Xylenes Using Raman



We used the QE65000 Sample Configuration #3 (described in the table at lower right), and an InPhotonics probe to acquire Raman spectra of xylene samples.

Specifications	
Dimensions:	182 x 110 x 47
Weight:	1050 grams
Detector:	Hamamatsu back-thinned CCD (page 55)
Pixels:	1024 x 58 (1044 x 64 total pixels)
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	3 RMS counts
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input and 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 56)
Gratings:	14 gratings UV through Shortwave NIR (page 56)
Integration time:	7 milliseconds to 15 minutes
Dynamic range:	7.5 x 10^9 (system); 25000:1 for one acquisition
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber
Power consumption:	3 A @ 5 VDC with TE cooling
Data transfer speed	Full scans to memory every 4 ms with USB 2.0
Inputs/outputs	10 onboard digital user-programmable GPIOs
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port
Temperature limits:	0 °C to 50 °C
Temperature range:	13 °C maximum range between high and low
Set point:	Software controlled
Lowest Set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes

New Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one package.

Demanding Low Light-level Applications

The QE65000 was designed for low-light level applications such as Raman spectroscopy. The detector is TE-cooled, resulting in virtually no dark noise, which allows you to set the integration time of the spectrometer (analogous to a camera's shutter speed) at up to 15 minutes with little spectral distortion.

Quantum Efficiency to 90%

With the scientific-grade detector, the QE65000 achieves up to 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). With this "2D" detector in the QE65000, we bin a vertical row of 64 pixels, which increases the signal-to-noise ratio to 1200:1. (See page 54 for all specifications on the QE65000.)

Increased System Sensitivity

QE65000 system sensitivity is improved because the 2D detector allows us to take advantage of the height of the entrance slit. In our spectrometers, you regulate the light entering the bench according to the slit's width. Most of our other spectrometers use linear detectors; in those spectrometers, slit height doesn't matter because linear detectors cannot efficiently collect the light from the entire height of the slit. But with the 2D detector in the QE65000, we can better take advantage of this additional light.

NIST-traceable Raman Standards

The STAN-RAM785 and STAN-RAM532 are NIST-certified standards for determining the absolute spectral intensity of your Raman system. They consist of an optical glass that emits a broadband luminescence spectrum when excited with a laser. (Select the STAN-RAM785 when using a 785 nm laser as your excitation source; select the STAN-RAM532 when using a 532 nm laser.) The shape of this luminescence spectrum is expressed by a polynomial equation that relates the relative spectral intensity to the wavenumber from the excitation wavelength. Determining the absolute spectral intensity of your Raman system is essential for those performing peak-to-peak height analysis and those collecting a spectral library.

QE65000:	$9,999
STAN-RAM532:	$1,015
STAN-RAM785:	$1,015

Examples of QE65000 Configurations for Raman

Sample Config.	Spectral Range	Excitation Source	Grating p. 56	Slit p. 56	Resolution (approx.)
1	150-4000 cm^{-1}	532 nm laser	H6	10 µm	~8 cm^{-1}
2	150-4000 cm^{-1}	532 nm laser	H6	25 µm	~10 cm^{-1}
3	150-7500 cm^{-1}	532 nm laser	H14	10 µm	~16 cm^{-1}
4	150-7500 cm^{-1}	532 nm laser	H14	25 µm	~19 cm^{-1}
5	150-2100 cm^{-1}	785 nm laser	H6	50 µm	~6 cm^{-1}
6	150-2100 cm^{-1}	785 nm laser	H6	100 µm	~8 cm^{-1}
7	150-3950 cm^{-1}	785 nm laser	H14	50 µm	~13 cm^{-1}
8	150-3950 cm^{-1}	785 nm laser	H14	100 µm	~18 cm^{-1}

785 nm Excitation Laser for Raman

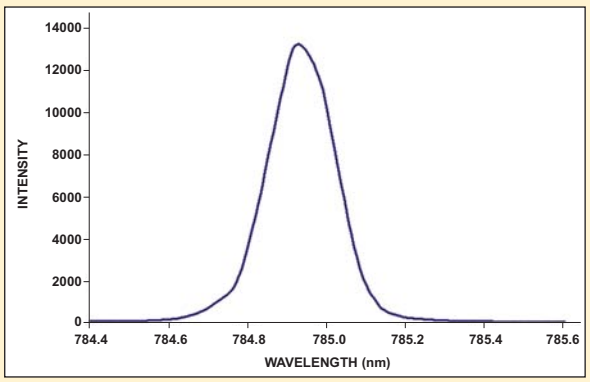
The LASER-785 is a 500-milliwatt, continuous-wave laser specifically developed for Raman spectroscopy. The high-power excitation source has an integrated laser driver, a thermoelectric cooler, a TEC controller and a TTL modulation port for controlling the input up to 100 kHz. The LASER-785 has a narrow spectral line width of only 0.2 nm (see spectrum below). Its compact and rugged design and its hermetically sealed laser component make it optimal for various industrial and medical applications.

LASER-785: $6,499

Specifications

Dimensions:	110 mm x 89 mm x 53 mm	Laser life:	10,000 hours
Weight:	600 grams	Power consumption:	3.0 A @ 5 VDC
Noise:	<0.5% RMS	Power output (CW):	>500 mW
Output fiber:	100 µm @ 0.22 NA	Peak wavelengths:	785 +/- 0.3 nm
Warm-up:	15 minutes	Spectral line width:	0.2 nm (typical)
Temperature:	-10 °C to 40 °C	Rise time:	<500 msec
Stability:	<3% peak-to-peak in 8 hours	Control:	TTL modulation -- 0 to 100 kHz
Humidity:	5-95% non-condensing	Connector:	SMA 905

HR4000 Spectrum of LASER-785



Fiber Optic Probes for Raman Applications

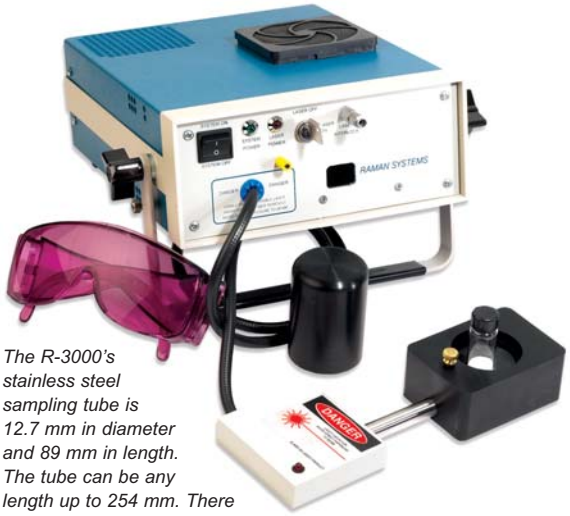
We offer several fiber optic probes for Raman spectroscopy from our corporate partner InPhotonics. Each probe provides complete optical filtering of the Rayleigh line and high signal collection in a compact, rugged probe design. Several probe models are available for laboratory, industrial and environmental applications.

The probes listed below are available for several excitation wavelengths. Please contact Ocean Optics for details.

RPB Laboratory Probe

Item	Description	Probe Size (in mm)	Fiber Length	Price
RIP-RPB	Laboratory probe for use with lasers up to 3 nm from specified operating wavelength; has 7.5-mm focal length	114 x 38 x 12.7	1.5 meter	$2,750
RIP-RPS	Stainless-steel focused probe for lab and field use; has 5-mm focal length (7.5 mm or 10 mm also available)	12.7 OD x 101 length	5 meters	$4,950
RIP-RP2	Stainless-steel immersion probe is immersible up to 200 °C and has adjustable working distance	15.87 OD x 203 length	5 meters	$6,745
RIP-RPR-H	Hastelloy C immersion probe with gold gasket for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$9,200
RIP-RPR-S	Stainless-steel immersion probe with elastomeric O-ring seal for use in process control applications up to 200 °C and 1500 psi; comes with sapphire window and has adjustable working distance	15.87 OD x 330 length	5 meters	$8,200
RIP-RPP	Stainless-steel probe with external optics for process control applications up to 500 °C and 3000 psi; comes with sapphire lens and has short working distance	9.52 OD x 300 length	5 meters	$10,200
RIP-PA-SH	Sample holder, with inserts for round vials, square cuvettes, and cups	not applicable	not applicable	$850

Low-resolution Raman Measurement Systems



The R-3000's stainless steel sampling tube is 12.7 mm in diameter and 89 mm in length. The tube can be any length up to 254 mm. There are two focusing caps: one for direct contact with a sample; the other for use with a sample container.

Specifications	
Lasers:	Solid-state 785 nm or 532 nm diode
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~10 cm^{-1}
Detector:	Linear CCD-array; optional cooled detector available
Stability:	1 cm^{-1} wavelength, 4% output stability
Power output:	125 mW and 250 mW; software-controlled
Sampling via:	Fiber optic probe for solutions, solids, gels
Remote sampling:	Up to 200 meters using optical fibers
PC interface:	USB
Data storage:	SPC or ASCII format
Calibration:	One-touch calibration
Laser safety:	Class 3b laser requires use of safety eyewear
Tolerances:	Up to 1500 psi and up to 200 ºC for tube and caps
Temperature limit:	Up to 80 ºC for probe head and fiber

Great Resolution & Stability in a Versatile Package

The Raman Systems R-3000 is a fully integrated analyzer for real-time qualitative and quantitative analysis of solutions, powders, tablets, gels and surface media from ~200-2700 cm^{-1}. The R-3000's high-performance laser provides resolution better than 10 cm^{-1} and achieves better than 1 cm^{-1} wavelength stability and 4% output stability. The R-3000 is used in pharmaceutical monitoring, petrochemical process control, drug and explosives detection, and water-quality analysis.

Fully Integrated System with New Software

The R-3000 comes with a 785 nm or 532 nm solid-state diode laser; a fiber optic spectrometer with optional TE cooling; a multi-purpose fiber optic probe for solutions, solids and powders; focusing and calibration caps; a software-controlled laser shutter; operating software; a sample holder; and safety goggles. In addition, the R-3000 has new software features that include fingerprinting and quantification capabilities, control of integration times of up to several minutes, and a multiple-spectrum display function.

Versatile Sampling Optics Add Value

The sample tubes and probe "caps" that come with the R-3000 provide easy transferability between samples in transparent containers and in immersion applications. The probe head is coupled to the spectrometer and laser via two 1-meter fibers (200 μm and 100 μm in diameter). Fibers come with PVC monocoil or stainless steel sheathing.

R-3000-785: $14,950
R-3000-532: $18,300

Handheld Raman System

Specifications	
Dimensions:	305 mm x 52 mm x 76 mm
Weight:	1.72 kg
Raman shift range:	~200-2700 cm^{-1}
Resolution:	~15 cm^{-1}
Laser:	Solid-state 785 nm diode
Output power:	500 mW
Detection via:	Linear CCD-array detector spectrometer
Sampling via:	Shuttered probe for solutions, solids, gels, etc.
Remote sampling:	Up to 200 meters using optical fibers
Battery:	2-hour rechargeable battery
Computer:	Embedded PC with spectral-matching software
Calibration:	Self-calibration and automated validation
Compliance:	Compliant with 21CFR Part 11

Small Footprint

The RSL-1 Handheld Raman Spectrometer is a 12" x 6" system for performing low-resolution Raman spectroscopy for on-site materials analysis. Although a high-resolution Raman spectrum gives detailed information about the vibrational fine structure of sample molecules, most routine applications need only ~15 cm^{-1} resolution for quantitative or qualitative analysis. As a result, a system such as the RSL-1 can be assembled using less expensive optics and lasers -- without sacrificing the power of Raman analysis.

Compact Spectral Matching System

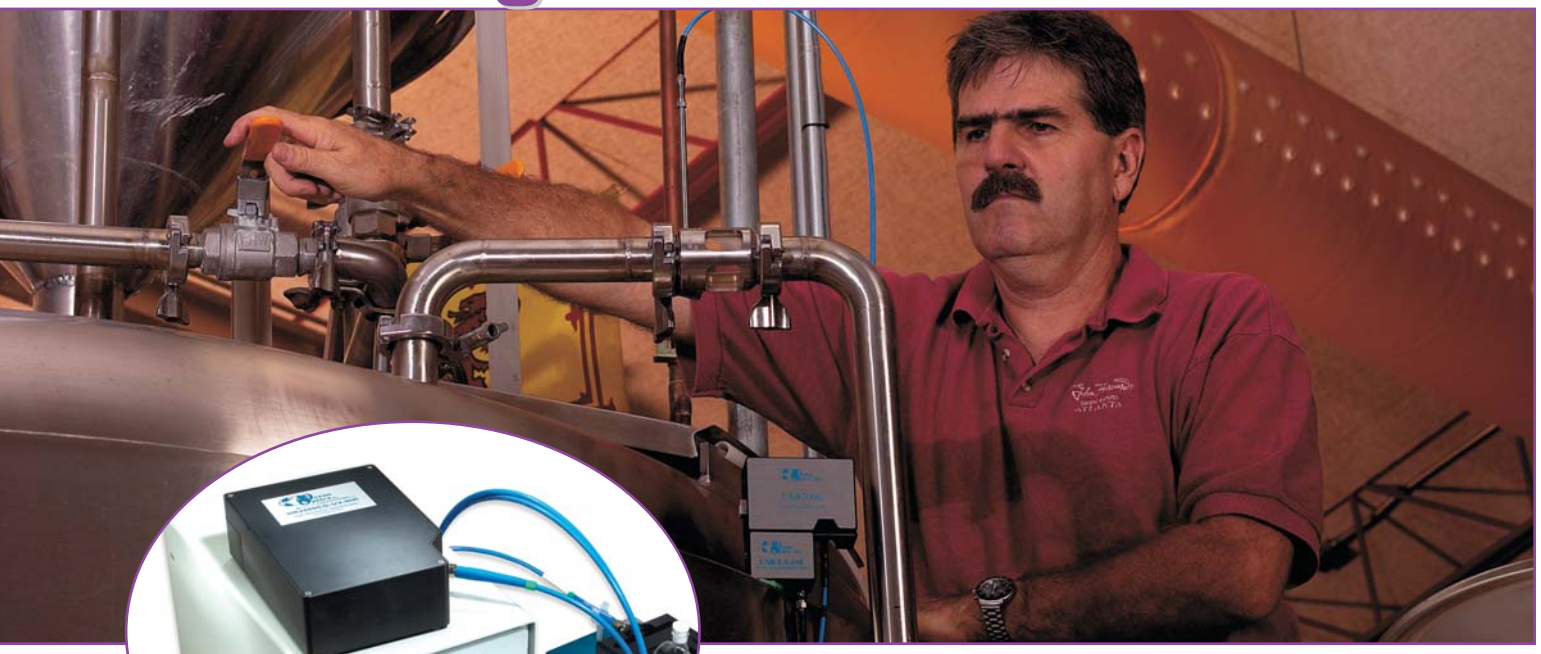
The RSL-1 consists of an embedded computer with spectral matching software for quality control, verification and validation routines. The system includes a linear CCD-array spectrometer, a 785 nm diode laser, a fiber optic probe, and a 2-hour rechargeable battery.

FDA Compliance

The operating software of the RSL-1 is compliant with the Food and Drug Administration's 21CFR Part 11, and includes features such as audit logging, database creation, spectral matching, and automatic detection of data tampering.

RSL-1: $25,000

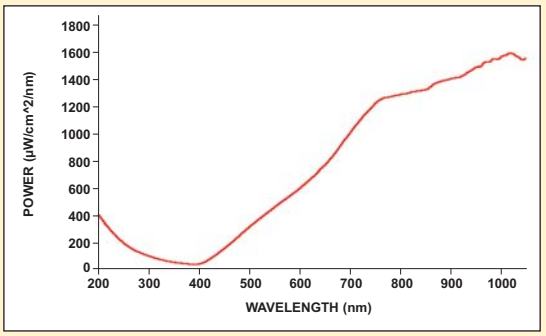
Spectrometers:
Preconfigured



Spectrometers that are configured -- with grating, wavelength range and other preselected optical bench options -- for specific applications. Not included is the light source or sampling system needed for a complete setup.

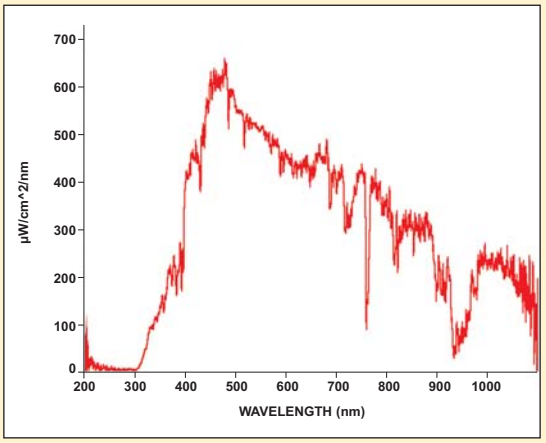
HR4000CG Spectrometer: 200-1100 nm

Sample Spectrum



An irradiance spectrum of the DH2000 Deuterium Tungsten Halogen Light Source taken with the HR4000CG-UV-NIR.

Sample Spectrum



Above is a solar irradiance spectrum taken with the HR4000CG-UV-NIR.

200-1100 nm Range, 0.75 nm Resolution

The HR4000CG Composite-grating Spectrometer utilizes a new proprietary grating and order-sorting filter to provide a 200-1100 nm wavelength range and 0.75 nm optical resolution (FWHM) in one spectrometer. The revolutionary HR4000CG is a preconfigured HR4000 Spectrometer -- where all of the optical bench options are already selected.

Composite-grating & Variable Order-sorting Filter

The HR4000CG uses the HC-1 grating, which is a revolutionary and proprietary variable blazed grating designed to provide a 200-1100 nm wavelength range. (See the grating efficiency curve for the HC-1 on the opposite page.) In addition to this new composite grating, the HR4000CG has an OFLV-H4 variable longpass order-sorting filter to eliminate second- and third-order effects. Both are installed at the time of manufacture and are fixed in place.

3648-element Detector

The HR4000CG is an upgrade from the HR2000CG. The HR4000CG comes with a 3648-element linear-array CCD detector that not only provides better optical resolution throughout the 200-1100 nm range, but also provides improved sensitivity in the 1070-1100 nm region.

Optical Bench

The HR4000CG Spectrometer uses the "HR" Optical Bench, comes with a 5 µm entrance slit, and has a UV4 Detector Upgrade to enhance the performance of the spectrometer in the UV.

USB 2.0 Compatibility and New Digital I/Os

The HR4000CG interfaces to a PC via a USB port or RS-232 port. Software reads programmed data unique to each spectrometer for easy setup. The HR4000CG also offers 10 user-programmable digital input/outputs, 1 analog input and 1 analog output.

HR4000CG-UV-NIR: $4,999

Specifications

Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Power consumption:	450 mA @ 5 VDC
Detector:	3648-element linear silicon CCD array (page 51)
Wavelength range:	200-1100 nm
Optical resolution:	0.75 nm FWHM
Grating:	HC-1, 300 lines per mm grating (page 52)
Entrance aperture:	5 µm wide slit (page 50)
Order-sorting filters:	Installed OFLV-H4 (page 51)
Focal length:	f/4, 101 mm
Dynamic range:	2 x 10^9 (system); 1300:1 for a single acquisition
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Data transfer rate:	Full scans into memory every 4 milliseconds with USB 2.0; every 18 milliseconds with USB 1.1; every 300 milliseconds with the serial port
Integration time:	Continuous -- 4 milliseconds to 20 seconds Shutter -- 10 microseconds to 4 milliseconds
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port Any 32-bit Windows operating system when using the serial port
Inputs/outputs:	10 onboard digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input one 9-bit analog output

**Programming the GPIOs requires SpectraSuite Software, OmniDriver or one of our other device drivers. See pages 76-79 for details.*

HR2000+CG High-speed + Broadband

Dynamic Electronics

The HR2000+CG Spectrometer integrates a powerful analog-to-digital (A/D) converter, programmable electronics and a high-resolution optical bench. This innovative combination produced our fastest spectrometer yet -- one scan every millisecond -- and achieves optical resolution to 1.0 nm (FWHM) over the entire 200-1100 nm wavelength range.

1,000 Full Spectral Scans Every Second

The HR2000+CG utilizes an onboard, 2-MHz A/D converter to capture and store one full spectral scan into memory every millisecond, when the spectrometer is interfaced to a PC via the USB 2.0 port (a serial port is also available). The HR2000+CG is ideal for applications where fast reactions need to be monitored and high resolution is necessary, such as certain chemistry and biochemistry applications.

Programmable Microcontroller

The HR2000+CG has an onboard programmable microcontroller that provides flexibility in controlling the spectrometer and accessories. By using a new 30-pin connector, you can implement numerous operating parameters in the software, including controlling external light sources and retrieving data on external objects. You have access to 10 programmable digital I/Os for interfacing to other equipment; one analog input and one analog output; and a pulse generator for triggering devices.

"HR" Optical Bench

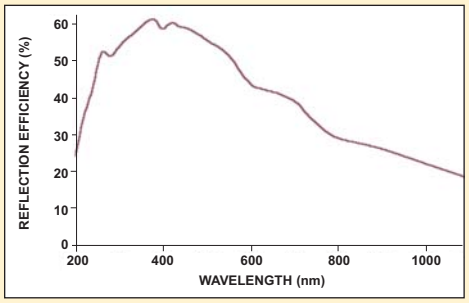
The excellent resolution of the HR2000+CG over its broadband range of 200-1100 nm is achieved by using the "HR" Optical Bench -- a 25.4-mm diameter, 101.6-mm focal length (f/4), crossed Czerny-Turner optical design.

Plug-and-Play Operation

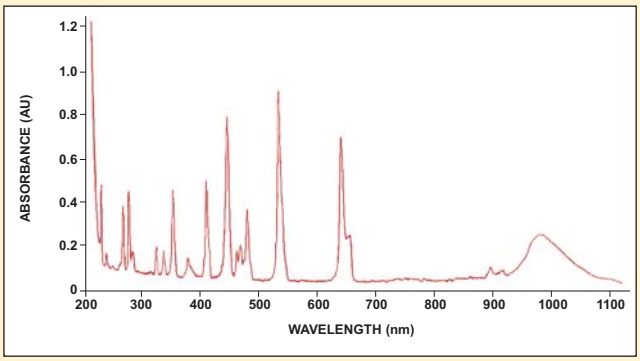
The HR2000+ interfaces to a PC via USB 2.0 or RS-232 serial port. When interfaced to a PC via the USB port, it draws its power from the PC. Data unique to each spectrometer are programmed into EEPROM on the HR2000+CG; software reads these values for easy setup and hot swapping among PCs.

HR2000+CG: $4,499

HC-1 Grating Efficiency Curve



Spectrum of Holmium Oxide



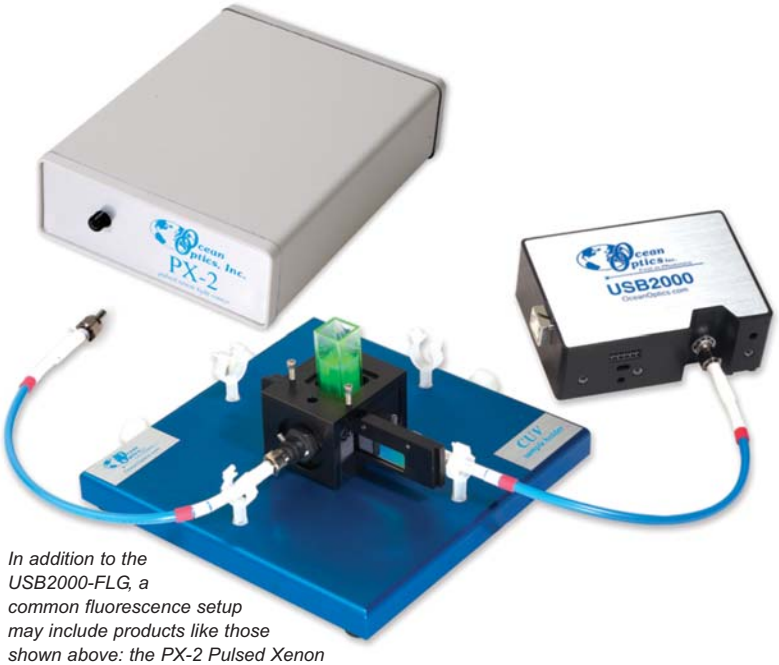
HR2000+CG absorbance spectrum of holmium oxide-impregnated glass.

Specifications

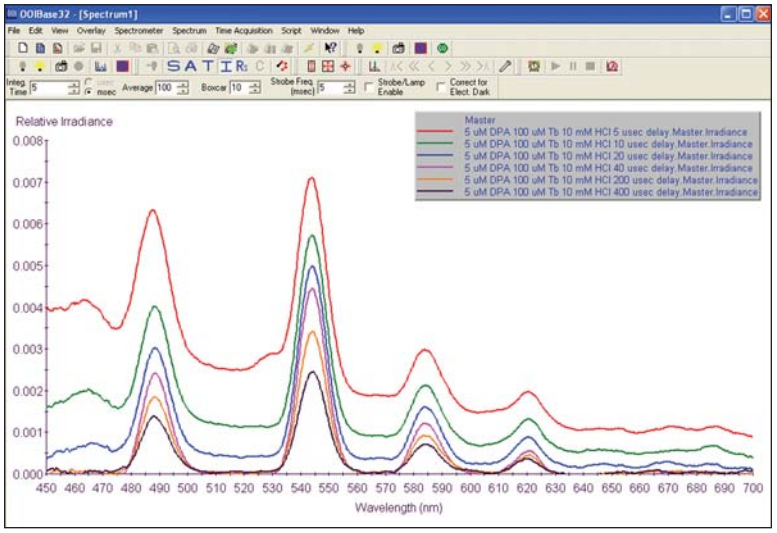
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Weight:	570 g	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Power consumption:	450 mA @ 5 VDC	Data transfer rate:	Full scans into memory every 1 ms with USB 2.0, every 15 ms with USB 1.1, every 200 milliseconds with the serial port
Detector:	2048-element linear silicon CCD array (page 51)		
Wavelength range:	200-1100 nm		
Optical resolution:	1.0 nm FWHM	Integration time:	Continuous -- 1 millisecond to 60 seconds
Grating:	HC-1, 300 lines per mm grating (page 52)	Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port Any 32-bit Windows OS when using the serial port
Entrance aperture:	5 µm wide slit (page 50)		
Order-sorting filters:	Installed OFLV-200-1100 (page 51)		
Focal length:	f/4, 101 mm	Analog channels:	One 13-bit analog input and one 9-bit analog output
Inputs/outputs:	10 onboard digital user-programmable GPIOs*	Dynamic range:	2 x 10^9 (system); 1300:1 for a single acquisition

**Programming the GPIOs requires SpectraSuite Software, OmniDriver or one of our other device drivers. See pages 76-79 for details.*

Gated Spectrometer for Fluorescence



In addition to the USB2000-FLG, a common fluorescence setup may include products like those shown above: the PX-2 Pulsed Xenon Source, the CUV-ALL-UV Cuvette Holder, LVF Linear Variable Filters, and optical fibers.



Terbium-dipicolinic acid (Tb-DPA) photoluminescence spectra acquired with the USB2000-FLG while in the Gated Mode, with the data acquisition delay set at a range of values. Analysis of samples with long emission lifetimes such as Tb-DPA improves when data acquisition is delayed until the energy from the lamp pulse is no longer observed in the spectrum, resulting in a cleaner, more resolved Tb-DPA spectrum -- achieved without using optical filters. At delay times below 40 microseconds, lingering excitation energy and background fluorescence overlap the Tb-DPA photoluminescence spectrum.

Specifications	
Dimensions:	89.1 mm x 63.3 mm x 34.4 mm
Weight:	190 g
Power consumption:	90 mA @ 5 VDC
Wavelength range:	380-1050 nm
Detector:	2048-element linear silicon CCD array (page 43)
Grating:	Grating #3 -- 600 lines per millimeter, blazed at 500 nm
Entrance aperture:	200 µm wide slit (page 42)
Optical resolution:	~10.0 nm FWHM
Stray light:	~0.05% at 600 nm, <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Integration time:	Gated mode - 5 milliseconds, normal mode - 3 milliseconds to 60 seconds
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port; any 32-bit Windows OS when using the serial port

Ultimate Fluorescence Spectrometer

The USB2000-FLG Spectrofluorometer is a preconfigured spectrometer for fluorescence applications from 380-1050 nm. We utilize a proprietary thin film technology and a time-gated spectrometer to provide a spectro-fluorometer that is 20 percent more sensitive than the standard USB2000 Spectrometer.

Avoiding Scattered Light

In addition to detecting fluorescence from a sample, a spectrofluorometer will also detect scattered excitation light from the light source and the sampling compartment. (Scattering is especially prevalent in turbid samples.) The USB2000-FLG uses two features to avoid detecting scattered light: special mirrors in the optical bench to absorb ultraviolet light and improve sensitivity and -- for fluorophores with long fluorescence lifetimes -- a time-gated mode that delays the start of spectral data acquisition by 5-500 microseconds after the excitation source is turned on (or pulses).

Gated Fluorescence Mode

The USB2000-FLG is preloaded with variable-delay gating microcode, which allows you to select a delay (from 5-500 microseconds) in our software between the light turning on and the start of the spectrometer's integration time, when the detector "sees" the sample. In this Gated Mode, the spectrometer only detects the sample light when the source is off. In order to use the Gated Mode, your fluorophore must have a long fluorescence lifetime. Those working with lanthanides and photoluminescent materials will find this mode very useful. The best excitation source to use with the Gated Mode is our PX-2 Pulsed Xenon Source.

SAG+ High-reflectivity Mirrors

In the USB2000-FLG, we replaced our standard mirrors with proprietary Ag-coated mirrors to increase reflectance, which increases the sensitivity of the spectrometer by more than 20 percent. They also absorb nearly all ultraviolet light, virtually eliminating the excitation source's spectra from interfering with the sample spectra.

Application Flexibility

The USB2000-FLG can detect fluorophores in solutions and powders, and from surfaces. We use the USB2000-FLG in our EDS2000 Endo-spore Detection System, and the USB2000-FLG has been used to measure fluorescence in coral, fruit and other flora and fauna.

USB2000-FLG: $2,999

Fluorescence Spectrometers

High Sensitivity for Fluorescence

The USB2000-FL and USB2000-FL-450 are high-sensitivity, preconfigured spectrometers -- originally conceived for use with our fluorescence-based sensors -- that can be used for general fluorescence applications. Each fluorescence unit is set to 360-1000 nm and comes with a 200-µm slit and an L2 Detector Collection Lens for increased sensitivity.

Select an Excitation Source

The difference between the USB2000-FL and USB2000-FL-450 is that the latter comes with the USB-LS-450 LED Module, which is an LED that produces either pulsed or continuous output centered at 470 nm -- the blue region -- for fluorescence measurements. The USB-LS-450 directly attaches to the spectrometer to provide you with a fully integrated spectrofluorometer. The USB2000-FL does not come with an excitation source and is the more appropriate choice if you wish to use one of the LEDs on pages 128-129.

Benefit for FOXY Users

The USB-LS-450 features a built-in, 24-bit analog-to-digital converter that is configured for a 100 ohm platinum temperature probe (USB-LS-450-TP). The USB-LS-450's onboard memory can be programmed to store temperature and oxygen calibration coefficients.

USB2000-FL: $2,499
USB2000-FL-450: $3,049

Specifications

	USB2000-FL	USB2000-FL-450
Dimensions:	63.34 mm x 89.10 mm x 34.37 mm	89.1 mm x 120.3 mm x 34.4 mm
Weight:	180 grams	310 grams
Power consumption:	90 mA @ 5 VDC	150 mA @ 5 VDC
Wavelength range:	~360-1000 nm for spectrometer	~360-1000 nm for spectrometer
Detector:	2048-element linear silicon CCD array (page 43)	2048-element linear silicon CCD array (page 43)
Grating:	Grating #3 -- groove density of 600 lines per millimeter, set to 360-1000 nm, blazed at 500 nm	Grating #3 -- groove density of 600 lines per millimeter, set to 360-1000 nm, blazed at 500 nm
Entrance aperture:	200 µm wide slit (page 42)	200 µm wide slit (page 42)
Focal length:	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)
Optical resolution:	~10.0 nm FWHM	~10.0 nm FWHM
Stray light:	<0.05% at 600 nm; <0.10% at 435 nm	<0.05% at 600 nm; <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber
Excitation source:	Not applicable; see pages 120-129 to select excitation source	USB-LS-450; see page 129 for full specifications

Temperature-regulated Spectrometers

Who Needs a Temperature Regulator?

When temperature changes occur over time in the optical bench and light source, the stored reference spectrum becomes invalid. Taking a new reference spectrum corrects for the drift; however, there are times when frequent reference-taking is impractical. For these applications, we created the preconfigured SD2000-TR-UV and SD2000-TR-VIS. Each unit has two spectrometer channels, with each channel connected to its own TR-2 Temperature Regulator to regulate the spectrometer's temperature. The master channel monitors the sample; the second channel monitors the light source.

The SD2000-TR Spectrometers come with the unit shown. Optical fiber and sampling chambers or probes are additional.

SD2000-TR-UV or SD2000-TR-VIS

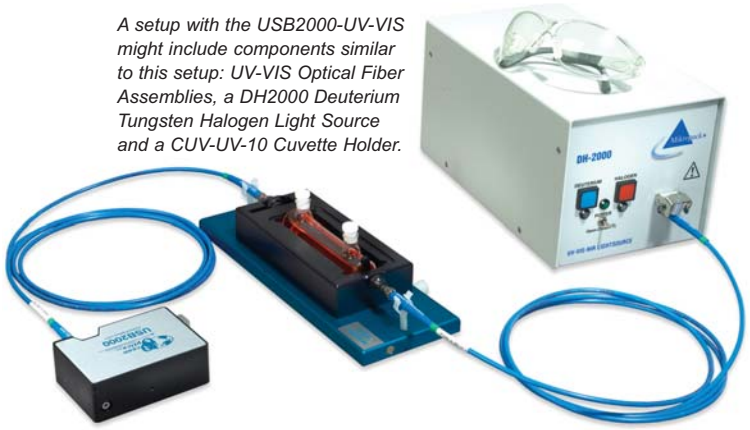
Each spectrometer channel in the SD2000-TR-UV has a 200-850 nm wavelength range. The unit comes with the DT-MINI Deuterium Tungsten Halogen Light Source. In the SD2000-TR, each spectrometer channel has a 350-1000 nm wavelength range. It comes with the R-LS-1 Tungsten Halogen Light Source. For complete details and specifications on the SD2000-TR-UV and SD2000-TR-VIS, please visit our website.

SD2000-TR-UV: $7,999
SD2000-TR-VIS: $6,999
TR-2: $999

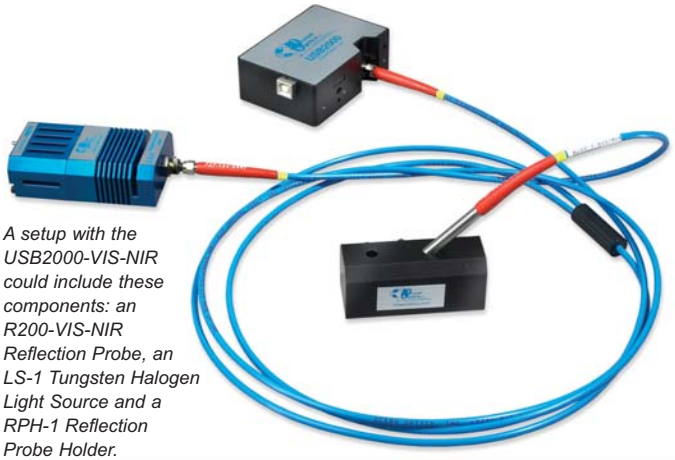
Specifications

Temperature regulator type:	Peltier thermoelectric device
Temperature set-point range:	15 °C below ambient to +37 °C
Temperature set-point default:	User-programmable; set to 20 °C
Temperature of optical bench:	± 0.1 °C of set temperature
Baseline and spectral stability:	± 0.001 absorbance units measured over 24-hour period

General Purpose: 200-850 nm or 350-1000 nm



A setup with the USB2000-UV-VIS might include components similar to this setup: UV-VIS Optical Fiber Assemblies, a DH2000 Deuterium Tungsten Halogen Light Source and a CUV-UV-10 Cuvette Holder.



A setup with the USB2000-VIS-NIR could include these components: an R200-VIS-NIR Reflection Probe, an LS-1 Tungsten Halogen Light Source and a RPH-1 Reflection Probe Holder.

Great Versatility

We offer a preconfigured UV-VIS and VIS-NIR spectrometer -- where all of the optical bench options are already selected -- to use as general-purpose instruments. By switching out light sources and sampling accessories, these spectrometers can measure absorbance in solutions or reflectance of solids.

UV-VIS Preconfigured Spectrometers

The USB2000-UV-VIS utilizes the "S" Optical Bench. It has a 200-850 nm wavelength range and comes with a detector upgrade for working in the UV, a variable longpass detector filter for second- and third-order rejection, and a 25-µm slit as the entrance aperture. Optical resolution is ~1.5 nm (FWHM).

VIS-NIR Preconfigured Spectrometers

The USB2000-VIS-NIR spectrometer also utilizes the "S" Optical Bench. It has a 350-1000 nm wavelength range and comes with a 25-µm entrance slit and a variable longpass detector filter for second- and third-order rejection. With this optical bench configuration, the USB2000-VIS-NIR achieves ~1.5 nm optical resolution (FWHM).

Accessorize

To complete your spectrometer system, select from our comprehensive line of fiber optic accessories -- light sources, sensors and probes, sample holders, flow cells, optical fiber assemblies and more.

Interfacing to your PC

With the USB2000-UV-VIS and the USB2000-VIS-NIR, the A/D converter is built into the spectrometers' electronic boards, so that external A/D converters or power supplies are unnecessary. The spectrometers interface to PCs via USB 1.1 or serial ports.

USB2000-UV-VIS: $2,649
USB2000-VIS-NIR: $2,499

Specifications

	USB2000-UV-VIS	USB2000-VIS-NIR
Wavelength range:	200-850 nm	350-1000 nm
Detector:	2048-element linear silicon CCD array (page 43)	2048-element linear silicon CCD array (page 43)
Grating:	Grating #1, 600 lines per mm grating, blazed at 300 nm	Grating #3, 600 lines per mm grating, blazed at 500 nm
Entrance aperture:	25 µm wide slit (page 42)	25 µm wide slit (page 42)
Order-sorting filters:	OFLV-200-850 (page 43)	OFLV-350-1000 (page 43)
Focal length:	42 mm (input); 68 mm (output)	42 mm (input); 68 mm (output)
Optical resolution:	~1.5 nm FWHM	~1.5 nm FWHM
Stray light:	<0.10% at 250 nm; <0.10% at 435 nm; <0.05% at 600 nm	<0.10% at 435 nm; <0.05% at 600 nm
Dynamic range:	2 x 10^8 (system); 1300:1 for a single scan	2 x 10^8 (system); 1300:1 for a single scan
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux operating systems when using the USB port Any 32-bit Windows operating system when using serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using systems when using the USB port Any 32-bit Windows operating system when using serial port

Spectrometers:
User-Configured

User-configured Spectrometers are for those who wish to select components and options in their spectrometer, from the wavelength range and grating type to the size of the entrance aperture and coating on the detector.

Overview: User-configured Spectrometers

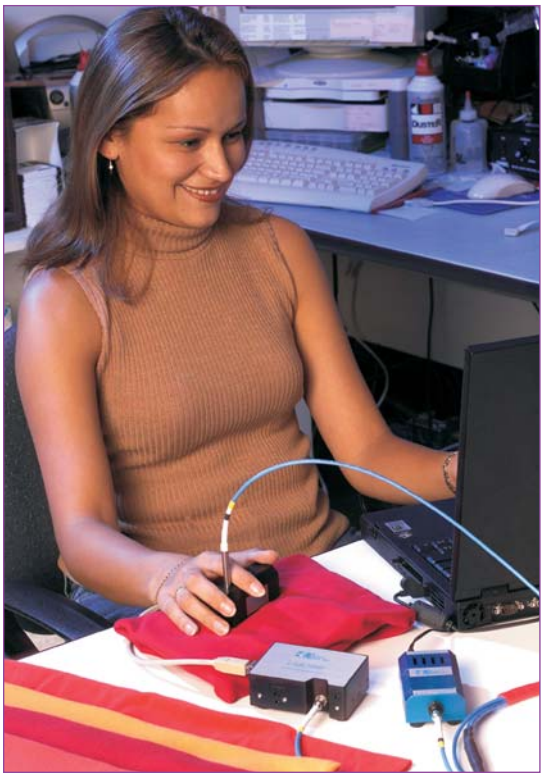
We Have Your Spectrometer!

Since we introduced the world's first miniature fiber optic spectrometer over 12 years ago, we've sold more than 55,000 spectrometers and enabled nearly as many applications. We pioneered the notion of flexible, modular spectroscopy, making it possible for users in many industries to configure systems for very different applications.

For those who wish to select the components in their spectrometer, we offer a complete range of options. You can make it your way.

- The size of your entrance aperture helps determine how much light enters your optical bench and your resolution. We have 6 sizes.
- Our filters block second- and third-order effects or balance color.
- You can opt to install standard collimating and focusing mirrors or SAG+ mirrors, which increase reflectance and increase sensitivity.
- We offer 14 different gratings, and your choice helps determine your resolution and wavelength range.
- An optional collection lens increases light-collection efficiency.
- Our OFLV filters precisely block second- and third-order light from reaching specific detector elements.
- A UV upgrade enhances the spectrometer's performance in the UV.

Our Applications Scientists have configured thousands of setups, so whatever your need, our consultative selling approach guarantees you a partner in solving your application challenge.



Detector Type

CCD Detectors
The Sony ILX511 is a 2048-pixel linear CCD-array detector that is ideal for general-purpose applications. It's used in our "S" optical bench as well as in our high-resolution "HR" bench. We also use a 3648-pixel CCD-array detector from Toshiba in our "HR" optical bench as it provides better resolution than the Sony.

Photodiode Detectors
Less-sensitive photodiode detectors provide a high signal-to-noise ratio for applications with high light levels. We use Hamamatsu's S3903 and S3904 photodiode silicon linear arrays. They can be specified only for an "S" bench.

Back-thinned TE-cooled Detector
The Hamamatsu S7031-1006 detector in the "QE" optical bench provides high quantum efficiency, fast signal processing speed and a high signal-to-noise ratio. This TE-cooled detector generates virtually no dark noise.

InGaAs Detectors
We use three different Hamamatsu linear array InGaAs detectors in our "NIR" optical bench for general-purpose NIR applications.

Bench Type

General-purpose "S" Bench
The "S" optical bench is ideal for absorbance, reflectance, fluorescence and color measurements. It's a versatile bench that is used in tens of thousands of spectrometers around the world.

High-resolution "HR" Bench
The "HR" optical bench is designed for applications requiring angstrom and sub-angstrom resolution, such as laser characterization and atomic emission spectroscopy.

Scientific-grade "QE" Bench
The "QE" optical bench is designed for demanding applications with low light levels such as Raman spectroscopy and fluorescence.

Near-Infrared "NIR" Bench
The "NIR" optical bench is designed for applications that require sensitivity in the NIR region, such as moisture analysis, tunable laser wavelength characterization and general NIR spectroscopy.

Spectrometer Type

Spectrometer Systems & Setups
Systems are turnkey spectrophotometers where all the components are included in one integrated enclosure. Setups provide a list of tools necessary for an application. Both Systems and Setups include a spectrometer, the necessary sampling accessories, a light source and software.

Preconfigured Spectrometers
A preconfigured spectrometer is preset with a grating, wavelength range and other bench accessories. You still specify other components, such as light sources and sampling accessories.

User-configured Spectrometers
You select the optical bench options, such as the grating, entrance aperture size, detector, wavelength range and more to create the optimum spectrometer for your application.

Overview: Spectrometer Comparison Chart

This table outlines the specifications of our most popular user-configured spectrometers.
Please refer to specific product pages for more detailed information.

Specifications	USB2000 p. 38	HR2000 p. 48	HR2000+ p. 49	HR4000 p. 46	QE65000 p. 54
PHYSICAL					
Dimensions (in mm):	89.1 x 63.3 x 34.4	148.6 x 104.8 x 45.1	148.6 x 104.8 x 45.1	148.6 x 104.8 x 45.1	182 x 110 x 47
Weight:	190 grams	570 grams	570 grams	570 grams	1050 grams
DETECTOR					
Detector:	Sony ILX511 linear silicon CCD array	Sony ILX511 linear silicon CCD array	Sony ILX511 linear silicon CCD array	Toshiba TCD1304AP linear CCD array	Hamamatsu S7031-1006 back-thinned area CCD
Detector range:	200-1100 nm	200-1100 nm	200-1100 nm	200-1100 nm	200-1100 nm
Pixels:	2048 pixels	2048 pixels	2048 pixels	3648 pixels	1024 x 58 (1044 x 64 total)
Pixel size:	14 µm x 200 µm	14 µm x 200 µm	14 µm x 200 µm	8 µm x 200 µm	24.6 µm square size
Pixel well depth:	~62,500 electrons	~62,500 electrons	~62,500 electrons	~100,000 electrons	300,000 electrons/well ~1.5 mill. electrons/column
Signal-to-noise ratio:	250:1 (at full signal)	250:1 (at full signal)	250:1 (at full signal)	300:1 (at full signal)	1000:1 (at full signal)
A/D resolution:	12 bit	12 bit	12 bit	14 bit	16 bit
Dark noise:	3.2 RMS counts	3.2 RMS counts	3.2 RMS counts	12 RMS counts	3 RMS counts
Corrected linearity:	>99.8%	>99.8%	>99.8%	>99.8%	>99.8%
Sensitivity:	400 nm: 75 photons/count 600 nm: 41 photons/count	400 nm: 75 photons/count 600 nm: 41 photons/count	400 nm: 75 photons/count 600 nm: 41 photons/count	400 nm: 130 photons/count 600 nm: 60 photons/count	22 electrons/count for all wavelengths 250 nm: 26 photons/count
OPTICAL BENCH					
Design:	f/4, Asymmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner	f/4, Symmetrical crossed Czerny-Turner
Focal length (input):	42 mm	101.6 mm	101.6 mm	101.6 mm	101.6 mm
Focal length (output):	68 mm	101.6 mm	101.6 mm	101.6 mm	101.6 mm
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber	5, 10, 25, 50, 100 or 200 µm wide slits or fiber
Gratings:	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR	14 gratings, UV through Shortwave NIR
HC-1 grating option:	No	provides 200-1100 nm range	provides 200-1100 nm range	provides 200-1100 nm range	provides 200-950 nm range
Detector collection lens:	Yes, L2	Yes, L2	Yes, L2	Yes, L4	No
OFLV filters:	OFLV-200-850 OFLV-350-1000	OFLV-200-1100	OFLV-200-1100	OFLV-H4	OFLV-QE
Order-sorting filters:	Longpass OF-1 filters	Longpass OF-1 filters	Longpass OF-1 filters	Longpass OF-1 filters	Longpass OF-1 filters
SPECTROSCOPIC					
Wavelength range:	Grating dependent	Grating dependent	Grating dependent	Grating dependent	Grating dependent
Optical resolution:	~0.3-10.0 nm FWHM	~0.035-6.8 nm FWHM	~0.035-6.8 nm FWHM	~0.02-8.4 nm FWHM	~0.14-7.7 nm FWHM
Integration time:	3 ms to 65 seconds	3 ms to 65 seconds	1 ms to 65 seconds	10 µs to 65 seconds	7 ms to 15 minutes
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition	2 x 10^9 (system); 1300:1 for a single acquisition	2 x 10^8 (system); 1300:1 for a single acquisition	2 x 10^9 (system); 1300:1 for a single acquisition	7.5 x 10^9 (system); 25000:1 for a single acquisition
Stray light:	<0.05% at 600 nm <0.10% at 435 nm	<0.05% at 600 nm <0.10% at 435 nm	<0.05% at 600 nm <0.10% at 435 nm	<0.05% at 600 nm <0.10% at 435 nm	<0.08% at 600 nm <0.4% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber	SMA 905 to 0.22 numerical aperture single-strand fiber
ELECTRONICS					
Power consumption:	90 mA @ 5 VDC	450 mA @ 5 VDC	450 mA @ 5 VDC	450 mA @ 5 VDC	500 mA @ 5 VDC no TE cool 3 A @ 5 VDC with TE cool
Data transfer speed:	Full scans to memory every 13 ms with USB 2.0 or USB 1.1 port, 300 ms with serial port	Full scans to memory every 13 ms with USB 2.0 or USB 1.1 port, 300 ms with serial port	Full scans to memory every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port, 200 ms with serial port	Full scans to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port, 300 ms with serial port	Full scans to memory every 7 ms with USB 2.0 port, 18 ms with USB 1.1 port, 300 ms with serial port
Inputs/Outputs:	No	No	Yes, 10 onboard digital user-programmable GPIOs	Yes, 10 onboard digital user-programmable GPIOs	Yes, 10 onboard digital user-programmable GPIOs
Analog channels:	No	No	One 13-bit analog input One 9-bit analog output	One 13-bit analog input One 9-bit analog output	No
COMPUTER					
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; Any 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 57.6 K baud	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	I^2C inter-integrated circuit	SPI (3-Wire); I^2C inter-integrated circuit	SPI (3-Wire); I^2C inter-integrated circuit	SPI (3-Wire); I^2C inter-integrated circuit	SPI (3-wire); I^2C inter-integrated circuit
OTHER					
Breakout box compat.:	No	No	Yes	Yes	Yes
Gated delay feature:	Yes	No	Yes	Yes	No
Trigger modes:	3 modes	3 modes	4 modes	4 modes	4 modes
Strobe functions:	Yes	Yes	Yes	Yes	Yes

USB2000 Plug-and-Play Spectrometer

Voted Most Popular

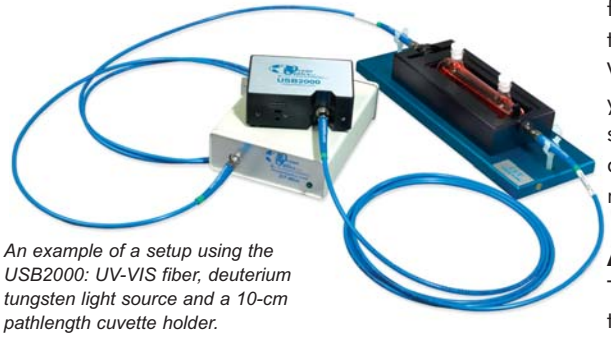
With its small-footprint design and plug-and-play convenience -- its onboard A/D converter ensures a hassle-free instrument-to-PC interface -- the USB2000 has become the most frequently specified miniature fiber optic spectrometer in the world.

Streamlined Start-up Software & Hot Swapping

The USB2000 plugs directly into the USB or serial port of any desktop or notebook PC. Interfacing the USB2000 to a PC via the USB port supports hot swapping of the spectrometer. Our software recognizes and reads data programmed on the USB2000 -- such as calibration coefficients -- saving time and reducing configuration errors. When connected to a PC via USB, the USB2000 draws its power from the computer.

User-configured Setup

The "S" Optical Bench is used in the world's first, and still the best miniature spectrometer. We've sold over 55,000 spectrometer channels for thousands of applications, and we've used that experience to make the most flexible, versatile and cost-effective spectrometer ever built. What makes the "S" bench so special are several options that allow you to optimize the bench for your application. Choose from options such as the size of the entrance slit, the type of grating and detector add-ons for the Sony ILX511 linear CCD array. (See pages 42-45 for more information on the detector and "S" Optical Bench.)



An example of a setup using the USB2000: UV-VIS fiber, deuterium tungsten light source and a 10-cm pathlength cuvette holder.

Accessories

Though all of our spectroscopic accessories work with the USB2000, the accessories on the next page directly attach to the front of the USB2000 for added convenience, ease of use and software control.

USB2000: $2,199

Cable	Description	Price
USB-CBL-1	Cable connects from USB port on USB2000 to USB port on PC; comes with USB2000	$25
USB-ADP-PC	Cable and adapter block connect from serial port on USB2000 to serial port on desktop or notebook PC; comes with USB-CBL-PS power supply	$75
USB-CBL-PS	Spare 5 VDC power supply	$25
USB-ADP-PX2	Adapter block and cable to connect PX-2 Pulsed Xenon Lamp (page 125), DT-MINI (page 122) or LS-450 Blue LED (page 128) to the USB2000	$50
USB-ADP-DT2	Adapter for directly attaching the USB-DT Deuterium Tungsten Light Source (page 123) to the USB2000	$75
ACC-CON-US2	Accessory connector for external triggering	Free

USB-CBL-PS Power Supply

USB-ADP-DT2 Adapter Block

ACC-CON-US2

USB-ADP-PX2 Adapter Block

Specifications

Dimensions:	89.1 mm x 63.3 mm x 34.4 mm	Order-sorting filters:	OFLV filters and longpass OF-1 filters (page 43)
Weight:	190 g	Wavelength range:	Grating dependent
Detector:	Sony ILX511 linear silicon CCD array (page 43)	Optical resolution:	~0.3-10.0 nm FWHM
Detector range:	200-1100 nm	Integration time:	3 ms to 65 seconds
Pixels:	2048 pixels, pixel size of 14 µm x 200 µm	Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Pixel well depth:	~62,500 electrons	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Signal-to-noise ratio:	250:1 (at full signal)	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Dark noise:	3.2 RMS counts	Power consumption:	90 mA @ 5 VDC
Sensitivity:	400 nm: 75 photons/count, 600 nm: 41 photons/count	Data transfer speed:	Full scans to memory every 13 ms with USB 2.0 or 1.1 port, 300 ms with serial port
Optical bench design:	f/4, Asymmetrical crossed Czerny-Turner	Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using USB port; any 32-bit Windows OS when using serial port
Focal length:	42 mm input, 68 mm output	Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 57.6 K baud
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 42) or fiber (no slit)		
Gratings:	14 gratings; UV through Shortwave NIR (page 44)		

USB2000 Direct-attach Accessories

USB-DT Deuterium Tungsten Light Source

The USB-DT Deuterium Tungsten Light Source is our most versatile combination UV-VIS lamp. Use the USB-DT as a stand-alone unit with any spectrometer, stack it with a USB2000 Spectrometer, or combine it with a "breakout box" accessory and an "HR"-series or QE65000 Spectrometer for software control of lamp functions. This compact source is about the size of a deck of cards, provides stable, broadband output from 200-2000 nm, and requires a simple 5-volt wall transformer to operate. See page 123 for details.

USB-DT: $1,499

USB-ISS-UV-VIS Integrated Sampling System for Cuvettes

The USB-ISS-UV-VIS is a direct-attach sample holder and deuterium tungsten light source (200-1100 nm) for measuring absorbance. This sampling system allows you to control both the intensity of the tungsten bulb and the shutter via software. The USB-ISS-UV-VIS requires an external power supply (included). See page 92 for more.

USB-ISS-UV-VIS: $1,499

USB-ISS-VIS Integrated Sampling System for Cuvettes

The USB-ISS-VIS is a direct-attach sample holder and violet LED-boosted tungsten light source (390-900 nm) combination for measuring relative absorbance. The light source boosts signal in the blue and provides over 10,000 hours of use. See page 92 for full specifications.

USB-ISS-VIS: $499

USB-ISS-T Integrated Sampling System for Test Tubes

The USB-ISS-T is a direct-attach sample holder and violet LED-boosted tungsten light source (390-900 nm) combination for measuring absorbance in 12-mm outer diameter test tubes. The sampling optics combine a diffuse source with a collimated input to the spectrometer to eliminate optical artifacts in the test tubes. See page 92 for specifications.

USB-ISS-T: $499

USB-FHS Filter Holder System

The USB-FHS is a filter holder and violet LED-boosted tungsten light source for measuring filters and other samples up to 18-mm thick. The USB-FHS is optimized for 390-900 nm and attaches to the USB2000 via a mounting plate. See page 97 for more.

USB-FHS: $499

USB-LS-450 Pulsed Blue LED Module

The USB-LS-450 is an LED module designed for fluorescence measurements in the lab or field, or as part of a FOXY Oxygen Sensor system. In addition, the USB-LS-450 has a port for attaching a 100 ohm RTD temperature sensor and onboard memory for storing temperature and oxygen calibration coefficients. See page 129 for details.

USB-LS-450: $549

USB-BP Portable Lithium Ion Battery Pack

The USB-BP provides eight hours of power to a USB2000 and to any direct-attach accessory except for the USB-ISS-UV-VIS or the USB-DT. The USB-BP measures 108 mm x 86 mm and delivers two amp-hours at 5 volts by utilizing two lithium ion cells. The battery charges in three hours with the included charger.

USB-BP: $499

S2000 & PC2000 Miniature Spectrometers

Before purchasing a PC2000, be sure that your PC has an available ISA-bus slot. ISA-bus slots are becoming obsolete.

Flexible & Modular

The S2000 and PC2000 Miniature Fiber Optic Spectrometers are high-performance spectrometers that are easily configured for thousands of applications. They have high sensitivity and provide excellent optical resolution -- for a fraction of the cost of larger, less flexible systems. S2000s and PC2000s have been used in more applications than any other miniature spectrometers in the world.

User-configured Spectrometers = Optimized Applications

With the user-configured S2000 and PC2000, you select from 14 gratings, six slits and other optical bench accessories to configure application-specific spectrometers. (See pages 42-45 for "S" Optical Bench options.) Like all of our fiber optic spectrometers, the S2000 and PC2000 couple via an SMA 905 Connector to our extensive line of fiber optic light sources, probes, sensors and other accessories.

S2000 is Stackable for Multiple-sample Measurements

You have the option of connecting multiple spectrometers for simultaneous multipoint sampling and reference monitoring or to expand the wavelength range of the system. With the S2000, you can select a master spectrometer channel and up to seven additional spectrometer channels -- hard-wired together and in one housing. (The single box is upper left. For other housing options, see page 62.) The S2000 interfaces to a PC via an A/D Converter (not included). See page 84 for A/D Converter options.

PC2000 Takes No Bench Space

The PC2000 Plug-in Miniature Spectrometer (at left) consists of a spectrometer mounted onto an A/D Converter that fits inside your desktop PC. You can add up to seven spectrometer channels to a master PC2000. (A master PC2000 comes in ISA-bus architecture only.) Each additional PC2000 channel (available in ISA-bus and PCI-bus) connects to the master channel, occupies its own slot in a PC's motherboard, and has its own optics and detector. Be aware that ISA-bus slots are becoming obsolete.

Item	Description	Power Consump.	A/D Converter	Price
S2000 (master)	Master spectrometer channel with housing	110 mA @ 5 VDC	not included	$1,800
S2000 (additional)	Additional spectrometer channel, no housing*	60 mA @ 5 VDC	not included	$799
SD2000	Two spectrometer channels in dual housing	170 mA @ 5 VDC	not included	$2,599
PC2000	Master spectrometer channel on A/D converter to insert in PC	250 mA @ 5 VDC	1 MHz ISA-bus	$1,999
PC2000-S-ISA	Additional spectrometer channel on A/D converter to insert in PC	70 mA @ 5 VDC	1 MHz ISA-bus	$799
PCI2000-S	Additional spectrometer channel on A/D converter to insert in PC	70 mA @ 5 VDC	1 MHz PCI-bus	$799
PC2000-PC104	Master spectrometer mounted onto a PC/104 A/D converter, for OEM customers only	250 mA @ 5 VDC	1 MHz PC/104	$2,199

** A system with more than two channels requires the separate purchase of a housing.*

Specifications			
Detector:	Sony ILX511 linear silicon CCD array (page 43)	Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 42) or fiber (no slit)
Detector range:	200-1100 nm		
Pixels:	2048 pixels, pixel size of 14 µm x 200 µm	Order-sorting filters:	OFLV filters and longpass OF-1 filters (page 43)
Pixel well depth:	~62,500 electrons	Wavelength range:	Grating dependent
Signal-to-noise ratio:	250:1 (at full signal)	Optical resolution:	~0.3-10.0 nm FWHM
Dark noise:	3.2 RMS counts	Integration time:	3 milliseconds to 60 seconds with 1 MHz A/D converter
Sensitivity:	400 nm: 75 photons/count, 600 nm: 41 photons/count		2 milliseconds to 60 seconds with 2 MHz A/D converter
Optical bench design:	f/4, Asymmetrical crossed Czerny-Turner	Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Focal length:	42 mm input, 68 mm output	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Gratings:	14 gratings; UV through Shortwave NIR (page 44)	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber

S1024DW Deep Well Units for High S:N

Sensitivity to 0.00001 Absorbance Units

The S1024DW Deep Well Detector Spectrometer features a 1024-element photodiode array detector for applications requiring high signal-to-noise ratio measurements. With the S1024DW, you can observe absorbance changes of less than 0.00001 absorbance units -- performance that makes the spectrometer ideal for high light-level applications.

"X" Option: Extra-deep Well Detector

The S1024DW is our standard deep well detector spectrometer. Its photodiode-array detector has a signal-to-noise ratio of 2500:1. Also available is the S1024DWX, with a detector distinguished by its deeper well depth and S:N of 8000:1.

Bench Ideal for High Light-level Applications

The S1024DW uses the "S" Optical Bench (see page 42 for slit choices and page 44 for grating choices). The S1024DW accepts light energy via an optical fiber and disperses it across a 1024-element photodiode array.

Stackable System for Multipoint Sampling

You can add up to seven S1024DW Spectrometer channels to your master S1024DW Spectrometer channel to measure multiple samples, expand your wavelength range or monitor a reference. All channels operate from a single ADC1000-USB A/D Converter, which has a channel rotator function that enables simultaneous acquisition of data from up to eight spectrometer channels. The ADC1000-USB interfaces the S1024DW to your PC via a USB or serial port. You can purchase the S1024DW and the ADC1000-USB as separate items, or buy them as one item (S1024DW-USB) and save $99. See page 84 for details on the ADC1000-USB.

S1024DW-USB:	$3,099
S1024DW (master channel):	$2,599
S2-1024DW (additional channel):	$1,399
S1024DW X (master channel):	$3,999
S2-1024DWX (additional channel):	$2,899
ADC1000-USB:	$599

Detector Options for S1024DW-series

Features	S1024DW	S1024DWX
Detector:	Hamamatsu S3903 linear photodiode array	Hamamatsu S3904 linear photodiode array
Number of Elements:	1024 pixels	1024 pixels
Pixel Size:	25 µm x 500 µm	25 µm x 2500 µm
Well Depth:	31,000,000 electrons	156,000,000 electrons
S:N (at full signal):	2500:1	8000:1
A/D Resolution:	12 bit	16 bit
Dark Noise:	2 RMS counts	2 RMS counts
Corrected Linearity:	>99%	>99%

Detector Accessories for S1024DW-series

Item	Description	Price
L2 Detector Collection Lens	Cylindrical lens placed on the detector for increased light-collection efficiency	$150
OFLV-DW	Variable longpass filter removes second- and third-order effects for systems from 200-850 nm	$150
OFLV-350-DW	Variable longpass filter removes second- and third-order effects for systems from 350-1000 nm	$150

Specifications

Dimensions:	153.4 mm x 105.2 mm x 65.6 mm (when housed with the ADC1000-USB A/D Converter)	Order-sorting filters:	Installed bandpass and longpass filters (page 43)
		Focal length:	42 mm (input); 68 mm (output)
Power consumption:	180 mA @ 5 VDC (master channels for S1024DW & DWX) 140 mA @ 5 VDC (additional channels for S1024DW & DWX)	Optical resolution:	~0.3-10.0 nm FWHM (depending on grating and size of entrance aperture)
Detector:	Linear photodiode array (see above)	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Detector range:	200-1100 nm	Relative sensitivity:	Compared to CCD detector in USB2000, S1024DW is ~30x less sensitive in the UV and ~80x less sensitive in the VIS
Gratings:	14 gratings; UV through Shortwave NIR (page 44)		
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 42) or fiber (no slit)	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
		Integration time:	31 milliseconds to 65 seconds

Options for the "S" Optical Bench

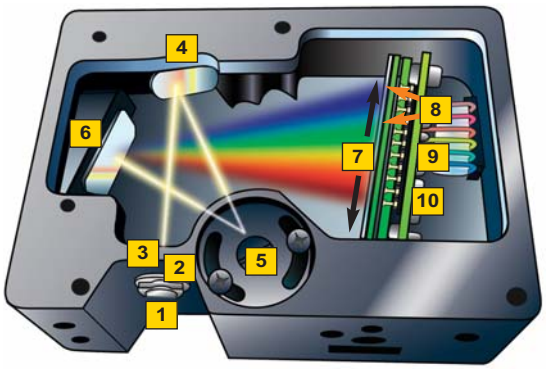
The "S" Optical Bench is used in the world's first, and still the best miniature spectrometer. We've sold over 55,000 spectrometer channels for thousands of applications, and we've used that experience to make the most flexible, versatile and cost-effective spectrometer ever built. What makes the "S" bench so special are several options that allow you to optimize the bench for your application. Our Applications Scientists can help you choose the optimum components, or you can follow this guide to pick the slit, grating, filter, lens and detector options that are best for you.

Spectrometers with the "S" Optical Bench

USB2000
S2000
PC2000
S1024DW

Components of the "S" Optical Bench

Here is a diagram of the "S" Optical Bench used in USB2000, S2000 and PC2000 Spectrometers that shows how light moves through the bench. The optical bench -- with its mechanically stable crossed Czerny-Turner design -- has no moving parts that can wear or break; all the components you specify are fixed in place at the time of manufacture.



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits come in various widths from 5 µm to 200 µm. Each is permanently fixed in the SMA 905 bulkhead to sit against the end of a fiber. (Without a slit, a fiber acts as the entrance aperture.)

3 Absorbance Filter: optional
If selected, an absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects or to balance color.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV-absorbing SAG+ mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength of your system. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt to install a standard mirror or SAG+ mirror.

7 L2 Detector Collection Lens: optional
This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency.

8 OFLV Filter: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements. We are the only miniature spectrometer manufacturer to offer "clean" first-order spectra.

9 UV2 Detector Upgrade: optional
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

10 Detector
We offer a high-sensitivity linear CCD array (or lower-sensitivity photodiode arrays). Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

Fixed Entrance Slits

Selecting the size of the entrance aperture is one option available with user-configured spectrometers. Entrance slits are rectangular apertures, 1-mm tall and various widths from 5 µm to 200 µm, with the width determining the amount of light entering the optical bench. A slit is permanent; it only can be changed by our technicians. You can opt against having a slit, in which case the diameter of the fiber connected to the spectrometer determines the size of the entrance aperture.

Slit	Description	Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	~3.0 pixels	$150
SLIT-10	10-µm wide x 1-mm high	~3.2 pixels	$150
SLIT-25	25-µm wide x 1-mm high	~4.2 pixels	$150
SLIT-50	50-µm wide x 1-mm high	~6.5 pixels	$150
SLIT-100	100-µm wide x 1-mm high	~12.0 pixels	$150
SLIT-200	200-µm wide x 1-mm high	~24.0 pixels	$150

A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

Options for the "S" Optical Bench

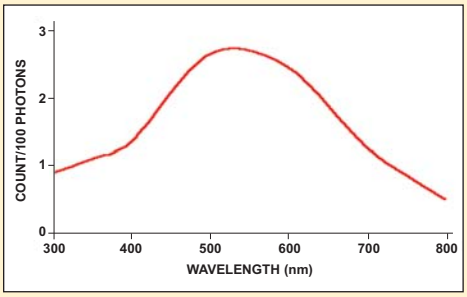
Detector & Optional Detector Accessories

In each USB2000, S2000 and PC2000 Spectrometer, we use the Sony ILX511 shallow-well linear CCD-array detector (see the specifications table below). Here are optional detector accessories available for user-configured S2000, PC2000 and USB2000 Spectrometers:

Item	Description	Price
UV2 Detector Upgrade	We replace the detector's standard BK7 window with a quartz window to enhance performance from 200-340 nm	$150
L2 Detector Collection Lens	The cylindrical lens is affixed to the detector's window (at far right) to increase light-collection efficiency and reduce stray light; it's useful with a large-diameter fiber for low light-level applications	$150
OFLV Filters	A variable longpass (order-sorting) filter is applied to the window on the detector to eliminate second- and third-order effects; see details below	$150

Detector Specifications	
Detector:	Sony ILX511 linear CCD array
No. of elements:	2048 pixels
Sensitivity:	400 nm -- 90 photons per count; 600 nm -- 41 photons per count 800 nm -- 203 photons per count; also, see graph at right
Pixel size:	14 µm x 200 µm
Well depth:	~62,500 electrons
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	12 bit
Dark noise:	2.5 RMS counts
Corrected linearity:	>99.8%

CCD Array Detector Sensitivity



Order-sorting & Blocking Filters

Our variable longpass OFLV Filters (at right) are order-sorting filters that are applied to the detector's window to eliminate second- and third-order effects. We use proprietary technology to apply the coating onto the substrate.

We also offer longpass absorbing or blocking filters (far right) that are installed permanently between the slit and the clad mode aperture in the SMA 905 bulkhead. Each filter (4.75-mm in diameter and 2-mm thick) has a transmission band and a blocking band to restrict radiation to a certain wavelength region, and is used to eliminate second- and third-order effects.

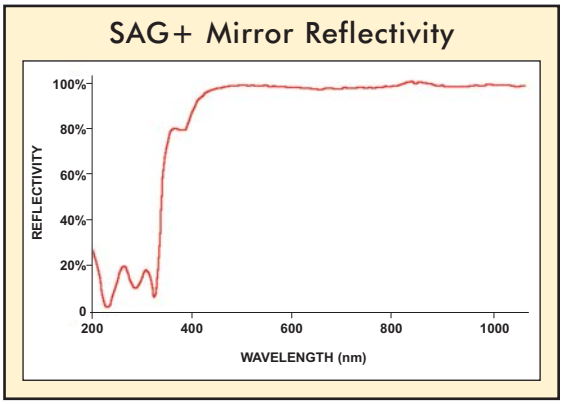
Item	Description	Price
OFLV-200-850	Variable longpass filter is applied to the detector's window to eliminate second- and third-order effects for systems from 200-850 nm (use with Gratings #1 and #2)	$150
OFLV-350-1000	Variable longpass filter is applied to the detector's window to eliminate second- and third-order effects for systems from 350-1000 nm (use with Gratings #2, #3 and #4)	$150
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

Options for the "S" Optical Bench

SAG+ Mirrors

Another optical bench option is to replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the visible and near-infrared and, in turn, increase the sensitivity of the spectrometer. These mirrors are often specified for use in spectrometers used for fluorescence applications. Not only do these mirrors create a more sensitive spectrometer, they also absorb nearly all ultraviolet light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike typical silver-coated mirrors, the SAG+ mirrors won't oxidize. They have excellent reflectivity -- more than 95% across the VIS-NIR.

SAG+UPG: $250



Choosing a Grating

Wide Selection Allows Flexibility

You choose from among 14 gratings for each spectrometer. With each grating, you consider its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the most efficient range).

Performance & Stability

Instead of the gratings rotating as they do in instruments such as scanning monochromators, our gratings are permanently fixed in place at the time of manufacture to ensure long-term performance and stability. (Gratings can only be changed at the factory.) A grating must be specified for each spectrometer channel.

Ruled & Holographic Diffraction Gratings

We offer ruled and holographic diffraction gratings. Both are polymer replicas of master gratings. There are trade-offs between these gratings: holographic gratings produce less stray light while ruled gratings are more reflective, resulting in higher sensitivity.

Grating Selection Chart

The chart below allows you -- with the help of our Applications Scientists -- to select the best grating. Terms in the column headings are:

- **Groove Density.** The groove density (mm^{-1}) of a grating determines its dispersion, while the angle of the groove determines the most efficient region of the spectrum. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range.
- **Spectral Range.** The dispersion of the grating across the linear array. The spectral range (bandwidth) is a function of the groove density and does not change. When you choose a starting wavelength for a spectrometer, you add its spectral range to the starting wavelength to determine the wavelength range.
- **Blaze Wavelength.** For ruled gratings, the peak wavelength in an efficiency curve. For holographic gratings, the most efficient wavelength region.
- **Best Efficiency (>30%).** All of our gratings optimize first-order spectra at certain wavelength regions; the most efficient region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted. For example, Grating #1 has a 650 nm spectral range, but is most efficient from 200-575 nm. In this case, wavelengths >575 nm will have lower intensity at the detector due to the the grating's reduced efficiency.

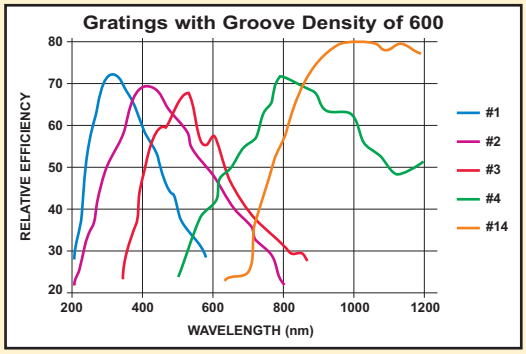
Grating Selection Chart

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
1	UV	600	650 nm	300 nm	200-575 nm
2	UV-VIS	600	650 nm	400 nm	250-800 nm
3	VIS-Color	600	650 nm	500 nm	350-850 nm
4	NIR	600	625 nm	750 nm	530-1100 nm
5	UV-VIS	1200	300 nm	Holographic UV	200-400 nm
6	NIR	1200	200-270 nm	750 nm	500-1100 nm
7	UV-VIS	2400	100-140 nm	Holographic UV	200-500 nm
8	UV	3600	50-75 nm	Holographic UV	290-340 nm
9	VIS-NIR	1200	200-270 nm	Holographic VIS	400-800 nm
10	UV-VIS	1800	100-190 nm	Holographic UV	200-635 nm
11	UV-VIS	1800	120-160 nm	Holographic VIS	320-720 nm
12	UV-VIS	2400	50-120 nm	Holographic VIS	250-575 nm
13	UV-VIS-NIR	300	1700 nm	500 nm	300-1100 nm
14	NIR	600	625 nm	1000 nm	650-1100 nm

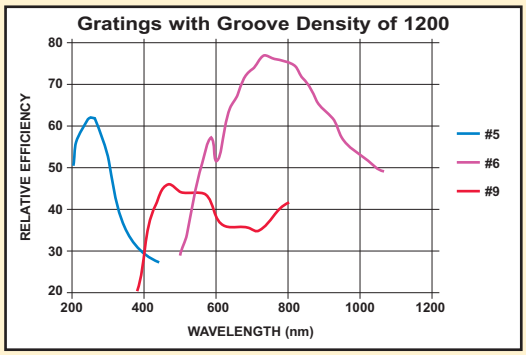
Options for the "S" Optical Bench

Grating Efficiency Curves

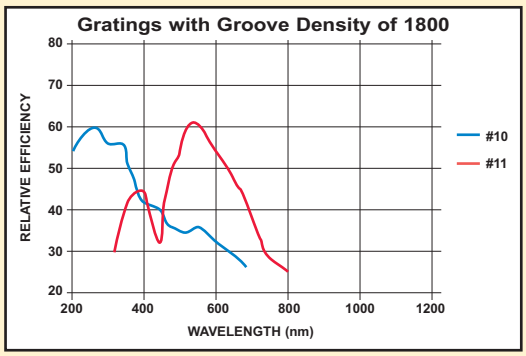
Below are the Grating Efficiency Curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. See curves for all of our gratings at OceanOptics.com/Technical/GratingCharts.asp.



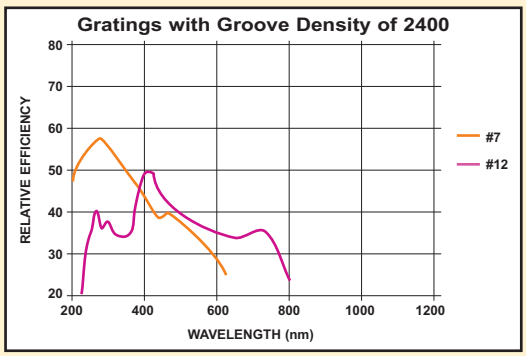
Efficiency Curves for Gratings 1, 2, 3, 4 and 14.



Efficiency Curves for Gratings 5, 6 and 9.



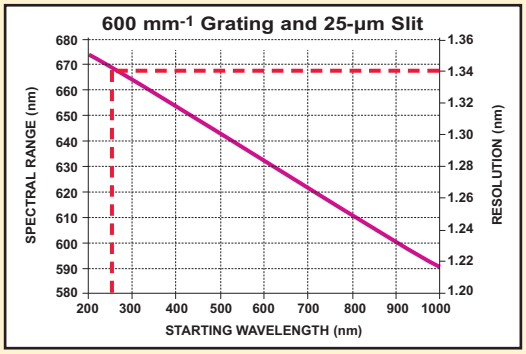
Efficiency Curves for Gratings 10 and 11.



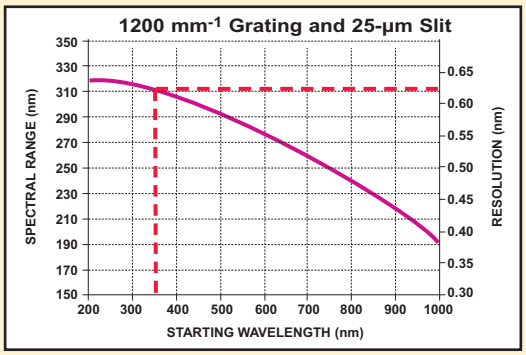
Efficiency Curves for Gratings 7 and 12.

Predicted Ranges & Resolution

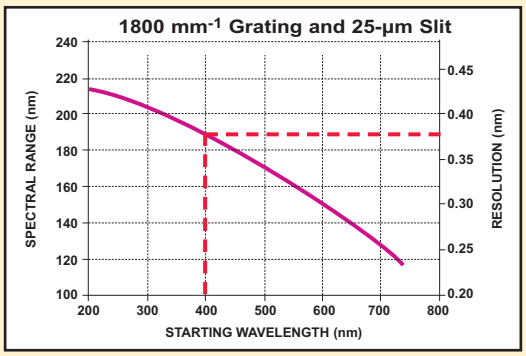
Here are a series of graphs to demonstrate the range and optical resolution (FWHM) of your "S" Bench Spectrometer with a 25 µm slit. See our website for additional graphs of ranges and resolutions for every slit size.



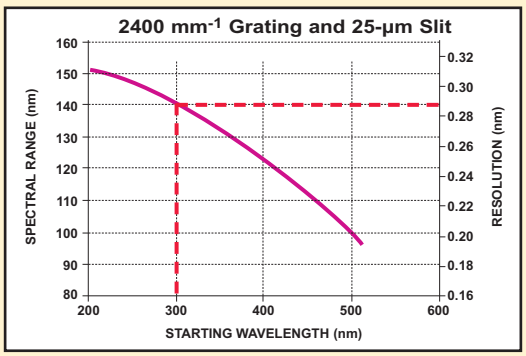
Example: *If the starting wavelength is 250 nm, then the range is ~667 nm, providing a 250-917 nm wavelength range and 1.34 nm resolution.*



Example: *If the starting wavelength is 350 nm, then the range is ~310 nm, providing a 350-660 nm wavelength range and 0.63 nm resolution.*

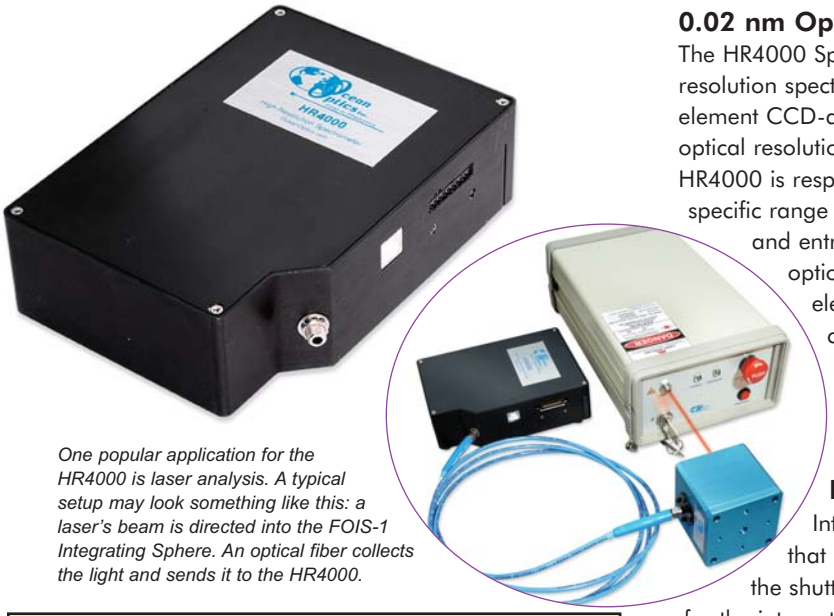


Example: *If the starting wavelength is 400 nm, then the range is ~190 nm, providing a 400-590 nm wavelength range and 0.38 nm resolution.*



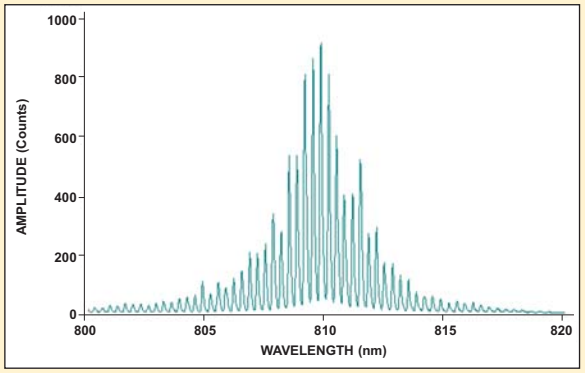
Example: *If the starting wavelength is 300 nm, then the range is ~140 nm, providing a 300-440 nm wavelength range and 0.29 nm resolution.*

HR4000 High-resolution Spectrometer



One popular application for the HR4000 is laser analysis. A typical setup may look something like this: a laser's beam is directed into the FOIS-1 Integrating Sphere. An optical fiber collects the light and sends it to the HR4000.

Sample Spectrum of Laser



We acquired this spectrum of a 810-nm Multimode Diode Laser with an HR4000, Grating H11 and a 5-µm slit.

Specifications	
Dimensions:	148.6 mm x 104.8 mm x 45.1 mm
Weight:	570 g
Detector:	Toshiba TCD1304AP linear CCD array (page 51)
Detector range:	200-1100 nm
Pixels:	3648 pixels, pixel size of 8 µm x 200 µm
Signal-to-noise ratio:	300:1 (at full signal)
Dark noise:	12 RMS counts
Sensitivity:	400 nm: 130 photons/count, 600 nm: 60 photons/count
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 50) or fiber
Gratings:	14 gratings, UV through Shortwave NIR (page 52)
Order-sorting filters:	OFLV-H4 and longpass OF-1 filters (pages 51-52)
Wavelength range:	Grating dependent
Optical resolution:	~0.02-8.4 nm FWHM
Integration time:	10 µs to 65 seconds
Dynamic range:	2 x 10^9 (system); 1300:1 for a single acquisition
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port, 300 ms with serial port
Inputs/outputs:	10 onboard digital user-programmable GPIOs
Analog channels:	One 13-bit analog input, One 9-bit analog output
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux using USB port; any 32-bit Windows OS using serial port
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-Wire), I^2C inter-integrated circuit

0.02 nm Optical Resolution (FWHM) Possible

The HR4000 Spectrometer is our next-generation high-resolution spectrometer. The HR4000 has a 3648-element CCD-array detector from Toshiba that enables optical resolution as precise as 0.02 nm (FWHM). The HR4000 is responsive from 200-1100 nm, but the specific range and resolution depend on your grating and entrance slit choices (see pages 50-53 for options). This novel combination of optics and electronics is ideal for applications such as characterizing lasers, measuring gas absorbance, and determining atomic emission lines.

Electronic Shutter: Open Detector for 10 Microseconds

Integration Time is a setting in our software that is specified by the user. It's analogous to the shutter speed of a camera: the value specified for the integration time is the amount of time the detector "looks" at the incoming photons. Because the Toshiba detector has an electronic shutter, you can specify, via software, minimum integration times as short as 10 microseconds, which allow you to measure transient events like laser pulses. Also, the ability to integrate the spectrometer for short durations eliminates saturation problems that can occur in high light-level applications such as laser analysis.

Onboard Microcontroller

The HR4000's onboard microcontroller provides you with considerable flexibility in controlling the spectrometer and accessories. Through a 30-pin connector, you can implement all operating parameters in the software: control light sources, create processes, and retrieve information on external objects. You have access to 10 user-programmable digital Inputs/outputs for interfacing to other equipment; one analog input and one analog output; and a pulse generator for triggering other devices. (Programming the GPIOs requires SpectraSuite Software, OmniDriver or one of our other device drivers. See pages 76-79 for details.)

Plug-and-Play USB Operation

The HR4000 interfaces to a PC, PLC or other embedded controllers via USB 2.0 or RS-232 serial port. When using the serial port, the HR4000 requires a single 5-volt power supply (not included). Data unique to each spectrometer are programmed into a memory chip on the HR4000; our spectrometer operating software reads these values for easy setup and hot swapping among PCs.

Using the Serial Port

If you want to interface your HR4000 to your PC via the RS-232 port, you will not be able to use our standard operating software. A serial port Command Set is included for writing your own software.

HR4000: $3,999

Spectral Hyper Adapter for Picometer Resolution

Get even higher spectral resolution from your spectrometer with the SHA-1 Spectral Hyper Adapter from Ocean Optics partner Spectral Applied Research. The SHA-1 Spectral Hyper Adapter further improves the optical resolution of the already high-performance HR4000. The Hyper Adapter provides superior resolution while retaining the entire wavelength range of the HR4000.

Increased resolution is achieved by plugging the SHA-1 into a setup between the sampling device and the HR4000. The SHA-1 plugs directly into the HR4000's 30-pin connector and connects to the HR4000's optical bench via the included 50-µm optical fiber. Commands are transmitted via the USB port and data acquisition is synchronized with the HR4000. The table below gives examples of the improvement in optical resolution the SHA-1 provides for certain HR4000 configurations.

SHA-1: $5,000

Slit	Grating	Starting Wavelength	Wavelength Range	Resolution no SHA-1	Resolution with SHA-1
5	H11 (1800 mm^{-1})	700 nm	700-791 nm	0.05 nm	0.004-0.006 nm or 4.0-6.0 pm
5	H12 (2400 mm^{-1})	550 nm	550-615 nm	0.035 nm	0.003-0.004 nm or 3.0-4.0 pm

Specifications	
Dimensions:	40.6 mm x 68.6 mm x 68.6 mm
Wavelength range:	550-900 nm
Fiber size:	50 µm
Integration time:	2 seconds (minimum)
Optical resolution:	7x-10x improvement; see table at left for examples
Optical throughput:	20-25%

Breakout Box

For easier access to a variety of functions found in the HR4000, specify the HR4-BREAKOUT, a passive module that separates the signals from its 30-pin port to an array of standard connectors and headers. The Breakout Box allows multiple interfaces to a spectrometer, such as:

- External triggering
- General Purpose Input/Output (GPIO)
- RS-232 interface
- Light sources
- Analog Input/Output

In addition to the accessory connector, the Breakout Box features a circuit board based on a neutral breadboard pattern that allows custom circuitry to be prototyped on the board itself. The Breakout Box receives its power from the spectrometer, which runs off of a PC via a USB port, or requires a separate 5-volt power supply when the spectrometer interfaces to a PC via the serial port. If you are wiring custom circuitry on the Breakout Box, you likely will need the USB-CBL-PS power supply (purchased separately).

The Breakout Box can be used with the following spectrometers:

- HR4000 Spectrometers with serial numbers beginning HR4B.
- HR2000+ High-speed, High-resolution Spectrometer (page 49)
- QE65000 Scientific-grade Spectrometer (page 54)

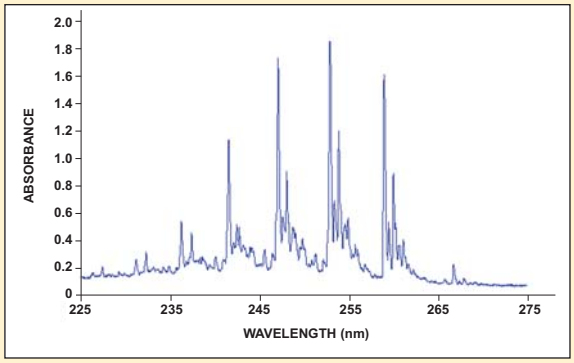
HR4-BREAKOUT: $199
USB-CBL-PS: $25

The Breakout Box includes a 30-pin HR4000-CBL-BB Ribbon Cable that connects the Box to the spectrometer.

This enlarged photo of the Breakout Box shows the connectors available. Below is an example of a setup with the HR4000 and Breakout Box.

HR2000 High-resolution Spectrometer

Vapor-phase Benzene



This absorbance spectrum of vapor-phase benzene was acquired with an HR2000 with a Grating H10 and a 5-µm slit. The setup also consisted of two 400-µm solarization-resistant fibers, a cuvette holder for 1-cm cuvettes, and a D-1000 Deuterium Light Source. This spectrum was taken with the integration time set at 500 msec.

Resolve Fine Spectral Features

Released in 2001, the HR2000 High-resolution Miniature Fiber Optic Spectrometer was the first of a line of high-resolution, "HR" Optical Bench spectrometers that today includes the HR4000 and the HR2000+. The HR2000 helped to prove that great spectrometer performance -- optical resolution to 0.035 nm (FWHM) -- is possible in a miniature spectrometer platform.

High-resolution in Small Footprint

The HR2000 measures ~149 mm x 105 mm and is ideal for applications where high resolution is necessary, such as wavelength characterization of lasers and absorbance of gases. For solution chemistry or for color measurements, the USB2000 is more likely to fill your requirements.

Modular Design Lets You Optimize Setup

The excellent resolution of the HR2000 is achieved by using the "HR" Optical Bench -- a 25.4-mm diameter, 101.6-mm focal length (f/4), symmetrical crossed Czerny-Turner optical design. The HR2000 is responsive from 200-1100 nm, but the specific range and resolution depends on your grating and entrance slit selections. With the HR2000, you select "HR" Optical Bench options such as the grating, wavelength range and entrance aperture size (see pages 50-53 for options) to optimize system setups.

Plug-and-Play Operation

The HR2000 needs no external A/D converter -- it interfaces to a PC via a USB port. Wavelength calibration coefficients unique to each spectrometer are programmed into a memory chip on the HR2000; our spectrometer operating software reads these values from the spectrometer to calibrate the wavelength of your spectrometer. The HR2000 also has a serial port for interfacing to PCs, PLCs and other devices that support the RS-232 protocol.

No External Power Requirements

When interfaced to a PC via the USB port, the HR2000 does not require an external power supply -- it draws its power from the PC to which it is connected.

HR2000: $2,999

Specifications

Dimensions:	148.6 mm x 104.8 mm x 45.1 mm	Optical resolution:	~0.035-6.8 nm FWHM
Weight:	570 grams	Integration time:	3 ms to 65 seconds
Detector:	Sony ILX511 linear silicon CCD array (page 51)	Dynamic range:	2 x 10^9 (system); 1300:1 for a single acquisition
Detector range:	200-1100 nm	Stray light:	<0.05% at 600 nm; <0.10% at 435 nm
Pixels:	2048 pixels, pixel size of 14 µm x 200 µm	Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Pixel well depth:	~62,500 electrons	Power consumption:	450 mA @ 5 VDC
Signal-to-noise ratio:	250:1 (at full signal)	Data transfer speed:	Full scans to memory every 13 ms with USB 2.0 or USB 1.1 port, 300 ms with serial port
Sensitivity:	400 nm: 75 photons/count, 600 nm: 41 photons/count		
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner	Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux using USB port; any 32-bit Windows OS using serial port
Focal length:	101.6 mm input, 101.6 mm output		
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 50) or fiber	Computer interfaces:	USB 2.0 @ 12 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud
Gratings:	14 gratings; UV through Shortwave NIR (page 52)		
Order-sorting filters:	OFLV filter and longpass OF-1 filters (pages 51-52)	Peripheral interfaces:	SPI (3-Wire); I^2C inter-integrated circuit

HR2000+: New Electronics = Speed & Control

Dynamic Electronics Gives You Control

The HR2000+ Spectrometer integrates a powerful analog-to-digital (A/D) converter, programmable electronics and a high-resolution optical bench. This innovative combination produces our fastest spectrometer yet and provides optical resolution to 0.035 nm (FWHM).

1,000 Full Spectral Scans/Second

The HR2000+ utilizes an onboard, 2-MHz A/D converter, which allows you to capture and transfer one full spectral scan into memory every millisecond when the spectrometer is interfaced to a PC via the USB port (a serial port interface is also available).

Programmable Microcontroller

The HR2000+ has an onboard programmable microcontroller that provides flexibility in controlling the spectrometer and accessories. Through a new 30-pin connector, you can implement all operating parameters in the software, such as:

- controlling external light sources
- creating processes and routines
- retrieving data from external devices

The HR2000+ gives you access to 10 user-programmable digital I/Os for interfacing to other equipment; one analog input and one analog output; and a pulse generator for triggering other devices. (Programming the I/Os requires one of our device drivers or SpectraSuite Spectroscopy Platform Software.)

"HR" Optical Bench

The HR2000+ is responsive from 200-1100 nm, but its specific range, resolution and sensitivity depend on your "HR" Optical Bench options. You select the grating, wavelength range, mirror coating, detector window and entrance aperture size. Choose from hundreds of accessories to create application-specific systems.

High-resolution Applications

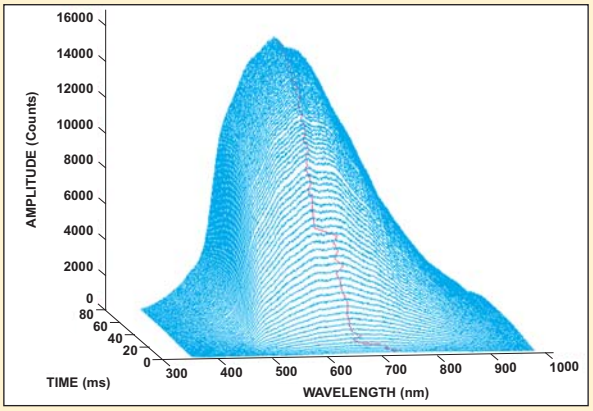
The HR2000+ is ideal for applications where fast reactions need to be monitored and high resolution is necessary, such as protein dynamics. For solution chemistry or for color measurements, the USB2000 is more likely to fill your requirements.

Plug-and-Play Operation

The HR2000+ interfaces to a PC, PLC or other embedded controllers via USB 2.0 or serial port. When connected to a PC via the USB port, the HR2000+ does not require an external power supply -- the spectrometer draws its power from the PC. When operating via the serial port, the HR2000+ requires a power supply (not included). Data unique to each spectrometer are programmed into a memory chip on the HR2000+; software reads these values for easy setup and hot swapping among PCs.

HR2000+: $3,499

Monitoring LS-1 Start-up Condition



Above is the power-up data from our LS-1 Tungsten Halogen Light Source. The data was taken at 2-millisecond increments. The graph shows the tremendous amount of data generated with the HR2000+'s acquisition rate speed of 1000 spectra/sec.

Specifications	
Dimensions (in mm):	148.6 x 104.8 x 45.1
Weight:	570 grams
Detector:	Sony ILX511 linear silicon CCD array (page 51)
Detector range:	200-1100 nm
Pixels:	2048 pixels, pixel size: of 14 µm x 200 µm
Signal-to-noise ratio:	250:1 (at full signal)
Dark noise:	3.2 RMS counts
Sensitivity:	400 nm: 75 photons/count, 600 nm: 41 photons/count
Optical bench design:	f/4, Symmetrical crossed Czerny-Turner
Entrance aperture:	5, 10, 25, 50, 100 or 200 µm wide slits (page 50) or fiber
Gratings:	14 gratings, UV through Shortwave NIR (page 52)
Order-sorting filters:	OFLV and longpass OF-1 filters (pages 51-52)
Optical resolution:	~0.035-6.8 nm FWHM
Integration time:	1 ms to 65 seconds
Dynamic range:	2 x 10^8 (system); 1300:1 for a single acquisition
Stray light:	<0.05% at 600 nm, <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
Power consumption:	450 mA @ 5 VDC
Data transfer speed:	Full scans to memory every 1 ms with USB 2.0 port, 15 ms with USB 1.1 port, 200 ms with serial port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs*
Analog channels:	One 13-bit analog input, One 9-bit analog output
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux using USB port; any 32-bit Windows OS using serial port
Computer interfaces:	USB 2.0 @ 480 Mbps (USB 1.1 compatible); RS-232 (2-wire) @ 115.2 K baud
Peripheral interfaces:	SPI (3-Wire); I^2C inter-integrated circuit

**Programming the GPIOs requires SpectraSuite Software, OmniDriver or one of our other device drivers. See pages 76-79 for details.*

Options for the "HR" Optical Bench

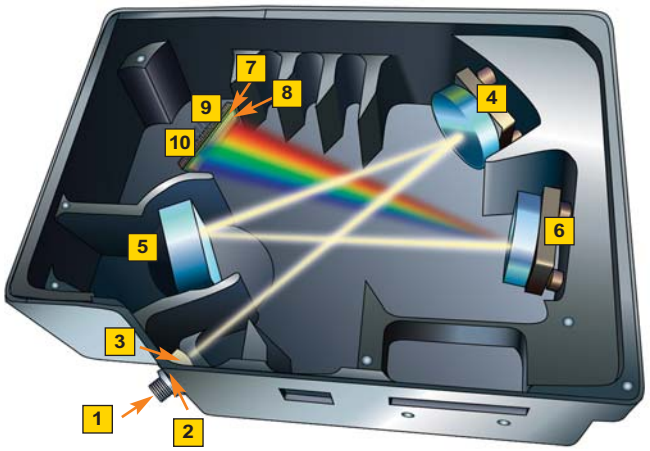
When the HR2000 debuted in 2001 to great success, it contained the same detector used in our "S" optical bench. Our next-generation high-resolution spectrometer, the HR4000, utilizes a detector that provides even better resolution than the HR2000. Not only do you have detector choices with the "HR" bench, you also have a whole host of other options when configuring your High-resolution Spectrometer. You can choose various entrance aperture sizes, detector accessories, filters, gratings and more to optimize your spectrometer.

Spectrometers with the "HR" Optical Bench

HR2000
HR2000+
HR4000

Components of the "HR" Optical Bench

Below is a diagram of the "HR" Optical Bench used in HR2000, HR2000+, and HR4000 Spectrometers. It shows how light moves through the symmetrical crossed Czerny-Turner design of the bench. All components in the bench are fixed in place during manufacturing.



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Absorbance Filter: optional
If selected, an absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects or to balance color.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. You can opt to install a standard mirror or a UV absorbing SAG+ mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. You can opt for a standard mirror or SAG+ mirror.

7 L2 and L4 Detector Collection Lenses: optional
This cylindrical lens, made in-house to ensure aberration-free performance, is fixed to the detector to focus the light from the tall slit onto the shorter detector elements. It increases light-collection efficiency.

8 OFLV Filters: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

9 UV2 and UV4 Detector Upgrades: optional
When selected, the detector's standard BK7 window is replaced with a quartz window to enhance the performance of the spectrometer for applications <340 nm.

10 Detector: specify Sony or Toshiba detector
We offer 2 detectors for the "HR" Bench; both are linear CCD arrays. Each pixel responds to the wavelength of light that strikes it. Electronics bring the complete spectrum to the software.

Fixed Entrance Slits

Another option available with "HR" User-configured Spectrometers is selecting the size of the entrance aperture. Entrance slits are rectangular apertures, 1-mm tall and various widths from 5 µm to 200 µm, with the width determining the amount of light entering the bench. A slit is fixed in place. Note that the smallest slit achieves the best optical resolution.

A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

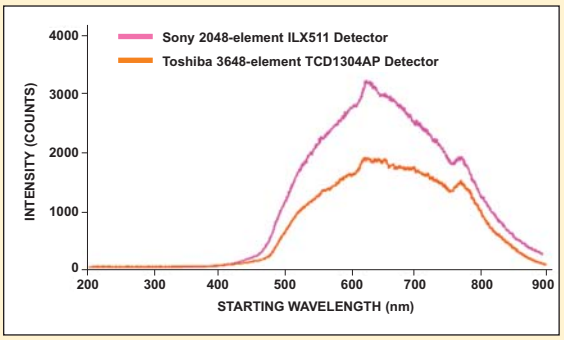
Slit	Description	HR2000 Pixel Resolution	HR2000+ Pixel Resolution	HR4000 Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	1.5 pixels	1.5 pixels	2.0 pixels	$150
SLIT-10	10-µm wide x 1-mm high	2.0 pixels	2.0 pixels	4.5 pixels	$150
SLIT-25	25-µm wide x 1-mm high	2.5 pixels	2.5 pixels	5.6 pixels	$150
SLIT-50	50-µm wide x 1-mm high	4.2 pixels	4.2 pixels	9.4 pixels	$150
SLIT-100	100-µm wide x 1-mm high	8.0 pixels	8.0 pixels	18.0 pixels	$150
SLIT-200	200-µm wide x 1-mm high	15.3 pixels	15.3 pixels	34.0 pixels	$150

Options for the "HR" Optical Bench

Detector Options

Both the HR2000 and HR2000+ utilize the Sony ILX511 linear silicon CCD array detector, the same detector used in our USB2000 Spectrometer. Our next-generation high-resolution spectrometer, the HR4000, utilizes a Toshiba detector, which has some electronic advances over the Sony, such as a user-programmable microcontroller. There are several trade-offs between the two detectors. For example, the Detector Sensitivity Comparison graph illustrates that the Sony is more sensitive than the Toshiba detector; however, the Toshiba detector achieves better optical resolution (see page 53). In addition, the Toshiba detector provides better response in the 1080-1100 nm range. Because the Toshiba detector has an electronic shutter, you can measure transient events like laser pulses and avoid saturating the detector. For a full comparison of all "HR" Spectrometers, see page 37.

Detector Sensitivity Comparison



2048-element Sony Detector

Sony ILX511 Specifications	
Detector:	Sony ILX511 linear silicon CCD array
Detector range:	200-1100 nm
Pixels:	2048 pixels
Pixel size:	14 µm x 200 µm
Pixel well depth:	~62,500 electrons
Signal-to-noise ratio:	250:1 (at full signal)
A/D resolution:	12 bit
Dark noise:	3.2 RMS counts
Corrected linearity:	>99.8%
Sensitivity:	400 nm: 75 photons/count, 600 nm: 41 photons/count
Maximum pixel rate:	Rate at which pixels are digitized is 2 MHz

3648-element Toshiba Detector

Toshiba TCD1304AP Specifications	
Detector:	Toshiba TCD1304AP linear CCD array
Detector range:	200-1100 nm
Pixels:	3648 pixels
Pixel size:	8 µm x 200 µm
Pixel well depth:	~100,000 electrons
Signal-to-noise ratio:	300:1 (at full signal)
A/D resolution:	14 bit
Dark noise:	12 RMS counts
Corrected linearity:	>99.8%
Sensitivity:	400 nm: 130 photons/count, 600 nm: 60 photons/count
Maximum pixel rate:	Rate at which pixels are digitized is 1 MHz

Optional Detector Accessories

Item	Description	Price
UV2 Detector Upgrade or UV4 Detector Upgrade	We replace the detector's standard BK7 window with a quartz window to enhance the spectrometer's performance from 200-340 nm. Use the UV2 with the Sony detector and the UV4 with the Toshiba detector.	$150
L2 Detector Collection Lens or L4 Detector Collection Lens	The cylindrical lens is affixed to the detector's window to increase light-collection efficiency and reduce stray light; it's useful with a large-diameter fiber for low light-level applications. Use the L2 with the Sony detector and the L4 with the Toshiba detector.	$150
OFLV-200-1100 or OFLV-H4	A variable longpass (order-sorting) filter is applied to the window on the detector to eliminate second- and third-order effects; it's required when using an HC-1 Grating in a 200-1100 nm wavelength range system. Use the OFLV-200-1100 with the Sony detector and the OFLV-H4 with the Toshiba detector.	$250

Order-sorting & Blocking Filters

In addition to the variable longpass OFLV Filters (in table above), we offer longpass blocking filters to restrict radiation to certain regions for eliminating second- and third-order effects. These filters are 4.75-mm in diameter and 2-mm thick and are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

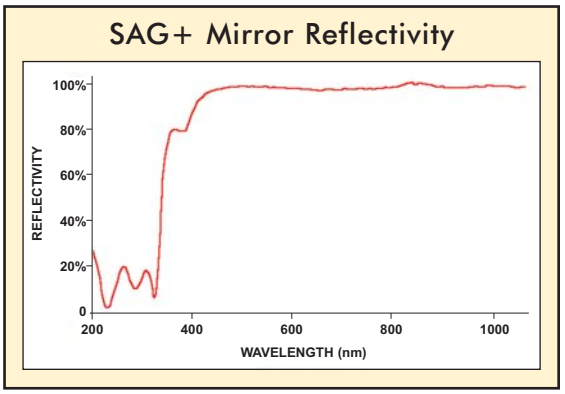
Item	Description	Price
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

Options for the "HR" Optical Bench

SAG+ Mirrors

Another optical bench option is to replace the standard aluminum-coated reflective mirrors with our proprietary, UV-absorbing SAG+ Mirrors, which increase reflectance in the visible and near-infrared and, in turn, increase the sensitivity of the spectrometer. These mirrors are often specified for use in spectrometers used for fluorescence applications. Not only do these mirrors create a more sensitive spectrometer, they also absorb nearly all ultraviolet light, which reduces the effects of excitation scattering in fluorescence measurements. Unlike typical aluminum-coated mirrors, the SAG+ mirrors won't oxidize. They have excellent reflectivity -- more than 95% across the VIS-NIR.

SAG+UPG-HR: $250

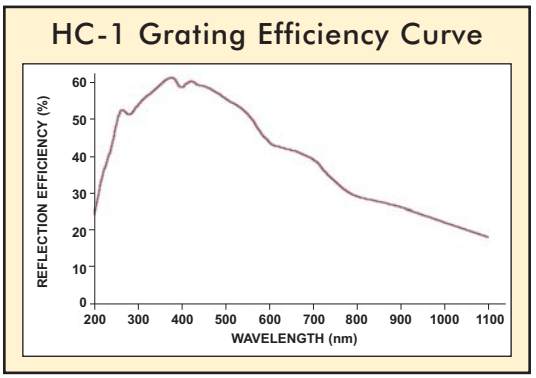


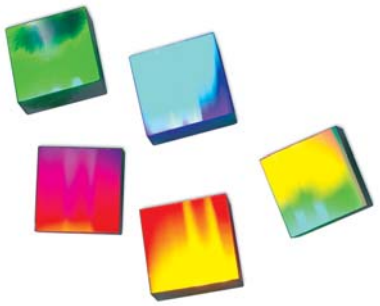
Choosing a Grating

You choose from 14 gratings for each spectrometer, giving you flexibility in configuring your system. With each grating, you know its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range) and its blaze wavelength (which helps determine the range with the most efficiency).

Instead of the gratings rotating as they do in instruments such as scanning monochromators, our gratings are permanently fixed in place to ensure long-term device performance and stability. A grating must be specified for each spectrometer. We offer ruled and holographic diffraction gratings. Both are polymer replicas of master gratings. There are trade-offs between them: holographic gratings provide less stray light while ruled gratings are more reflective, resulting in higher sensitivity.

Grating Efficiency Curves for "HR" gratings (see page 45) are identical to those in the "S" Optical Bench. Because the HC-1 Composite Grating is not available for the "S" Bench, its Grating Efficiency Curve is shown above right.





Grating Selection Chart

The **Groove Density** (mm^{-1}) of a grating determines its dispersion. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range. The **Spectral Range** is the dispersion of the grating across the linear array. The spectral range is set by the groove density and does not change. For ruled gratings, the **Blaze Wavelength** is the peak wavelength in an efficiency curve; for holographic gratings, it's the most efficient wavelength region. The **Best Efficiency** region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1*	UV-NIR	300	200-1100 nm	variable	200-1100 nm
H1	UV	600	425-445 nm	300 nm	200-575 nm
H2	UV-VIS	600	415-445 nm	400 nm	250-800 nm
H3	VIS-Color	600	410-440 nm	500 nm	350-850 nm
H4	NIR	600	410-430 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	205-220 nm	holographic: UV	200-400 nm
H6	NIR	1200	140-195 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	72-102 nm	holographic: UV	200-500 nm
H9	VIS-NIR	1200	165-205 nm	holographic: VIS	400-800 nm
H10	UV-VIS	1800	95-140 nm	holographic: UV	200-635 nm
H11	UV-VIS	1800	75-135 nm	holographic: VIS	320-800 nm
H12	UV-VIS	2400	60-100 nm	holographic: VIS	250-575 nm
H13	UV-VIS-NIR	300	900 nm	500 nm	300-1100 nm
H14	NIR	600	410-420 nm	1000 nm	650-1100 nm

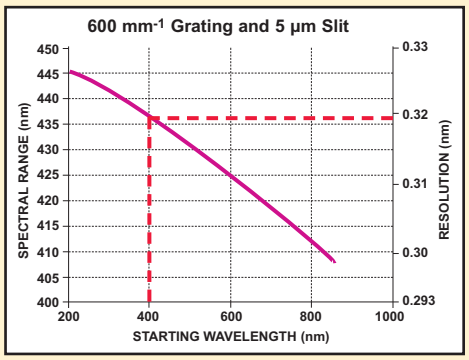
** We provide gratings free with the purchase of a spectrometer except for the HC-1, which is $600.*

Options for the "HR" Optical Bench

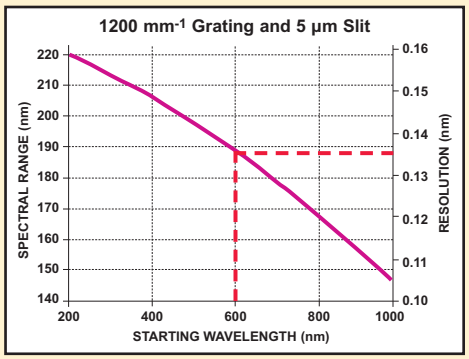
Predicted Ranges & Resolution

These graphs demonstrate the range and resolution of your "HR" Bench Spectrometer with a 5 µm slit. See our website for additional graphs of ranges and resolutions for every slit size.

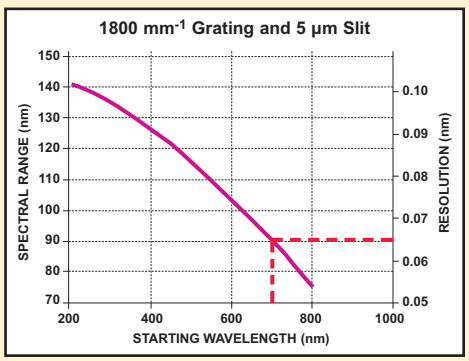
"HR" Bench with Sony Detector: HR2000 & HR2000+



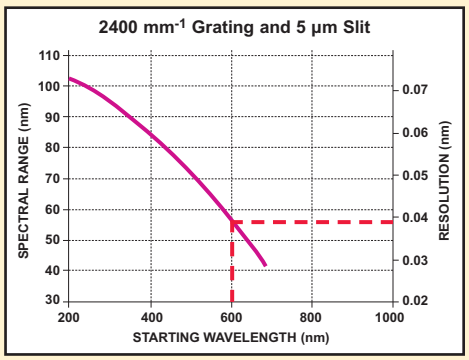
Example: *If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.32 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~188 nm, providing a 600-788 nm wavelength range and 0.137 nm resolution.*

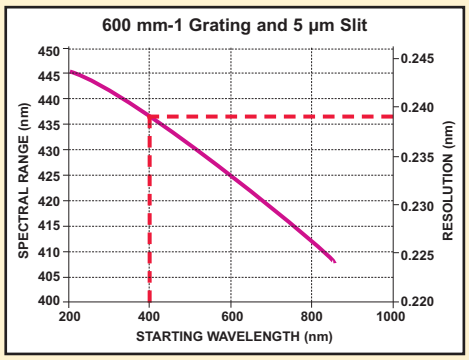


Example: *If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.065 nm resolution.*

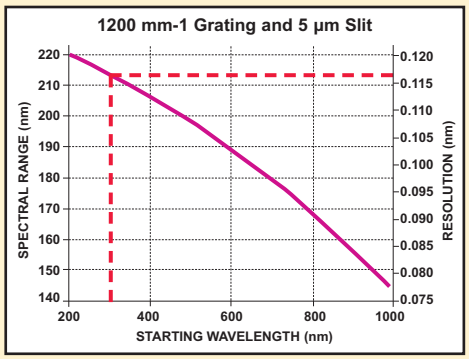


Example: *If the starting wavelength is 600 nm, then the range is ~56 nm, providing a 600-656 nm wavelength range and 0.039 nm resolution.*

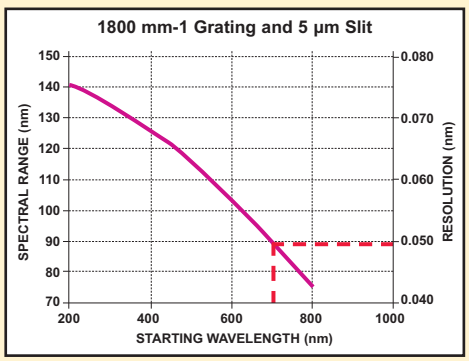
"HR" Bench with Toshiba Detector: HR4000



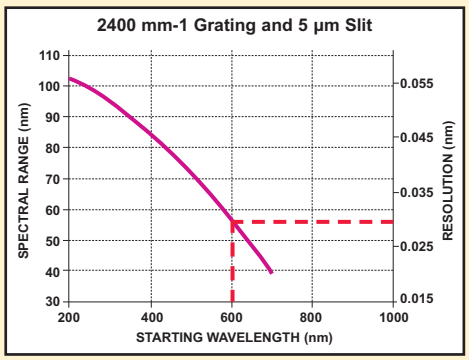
Example: *If the starting wavelength is 400 nm, then the range is ~437 nm, providing a 400-837 nm wavelength range and 0.239 nm resolution.*



Example: *If the starting wavelength is 300 nm, then the range is ~215 nm, providing a 300-515 nm wavelength range and 0.117 nm resolution.*



Example: *If the starting wavelength is 700 nm, then the range is ~90 nm, providing a 700-790 nm wavelength range and 0.05 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~56 nm, providing a 600-656 nm wavelength range and 0.029 nm resolution.*

QE65000 Scientific-grade Spectrometer

An example of a fluorescence setup with a QE65000.

Specifications	
PHYSICAL	
Dimensions (in mm):	182 x 110 x 47
Weight:	1050 grams
DETECTOR	
Detector:	Hamamatsu S7031-1006 back-thinned CCD (page 55)
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total)
Pixel size:	24.6 µm square size
Signal-to-noise ratio:	1000:1 (at full signal)
Dark noise:	3 RMS counts
Sensitivity:	400 nm: 22 electrons/count, 250 nm: 26 photons/count
OPTICAL BENCH	
Design:	f/4, Symmetrical crossed Czerny-Turner
Focal length:	101.6 mm input, 101.6 mm output
Entrance aperture:	5, 10, 25, 50, 100, or 200 µm wide slits (page 56)
Gratings:	14 gratings, UV through Shortwave NIR (page 56)
Filters:	OFLV-QE and OF-1 order sorting filters (page 56)
SPECTROSCOPIC	
Wavelength range:	Grating dependent
Optical resolution:	~0.14-7.7 nm FWHM
Integration time:	7 milliseconds to 15 minutes
Dynamic range:	25000:1 a single acquisition; 7.5 x 10^9 (system)
Stray light:	<0.05% at 600 nm, <0.10% at 435 nm
Fiber optic connector:	SMA 905 to 0.22 numerical aperture single-strand fiber
ELECTRONICS	
Power consumption:	500 mA @ 5 VDC no TE cool; 3 A @ 5 VDC with TE cool
Data transfer speed:	Full scans to memory every 4 ms with USB 2.0 port, 18 ms with USB 1.1 port, 300 ms with serial port
Inputs/Outputs:	10 onboard digital user-programmable GPIOs
TEMPERATURE & THERMOELECTRIC (TE) COOLING	
Temperature limits:	0 °C to 50 °C for spectrometer, no condensation
Temperature range:	13 °C maximum range between the high and low
Set point:	Software controlled
Lowest set point:	40 °C below ambient, to -15 °C
Stability:	±0.1 °C of set temperature in <2 minutes
COMPUTER	
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port; 32-bit Windows OS when using the serial port
Computer interfaces:	USB 2.0 @ 480 Mbps; RS-232 (2-wire) @ 115K baud
Peripheral interfaces:	SPI (3-wire); I^2C inter-integrated circuit

New Scientific-grade Spectrometer

The QE65000 Spectrometer is a unique combination of detector and optical bench technologies that provides users with high spectral response and high optical resolution in one package.

Quantum Efficiency to 90%

The Hamamatsu S7031-1006 FFT-CCD area detector used in the QE65000 provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photo-electron). Most of our other detectors are linear CCDs but with this "2D" area detector, we can bin a vertical row of pixels, which offers significant improvement in the signal-to-noise ratio and signal processing speed of the detector compared with a linear CCD where signals are digitally added by an external circuit.

Increased System Sensitivity

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the slit and the additional light, greatly improving system sensitivity.

Back-thinned: Great for the UV

Because the detector in the QE65000 is back-thinned (or back-illuminated), it has great native response in the UV and does not require the additional coatings that we typically apply to other detectors for UV applications.

Demanding Low Light-level Applications

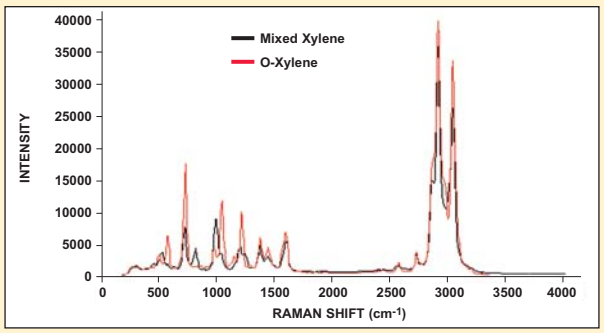
The QE65000 Spectrometer is a great option for low-light level applications such as fluorescence, Raman spectroscopy, DNA sequencing, astronomy and thin-film reflectivity. The TE-cooled detector (down to -15 °C) features low noise and low dark signal, which enables low-light-level detection and long integration times from 7 milliseconds to 15 minutes.

Onboard Programming

The QE65000 also has an onboard programmable micro-controller for controlling the spectrometer and accessories. You have access to 10 user-programmable digital Inputs/ Outputs and a pulse generator for triggering other devices.

QE65000: $9,999

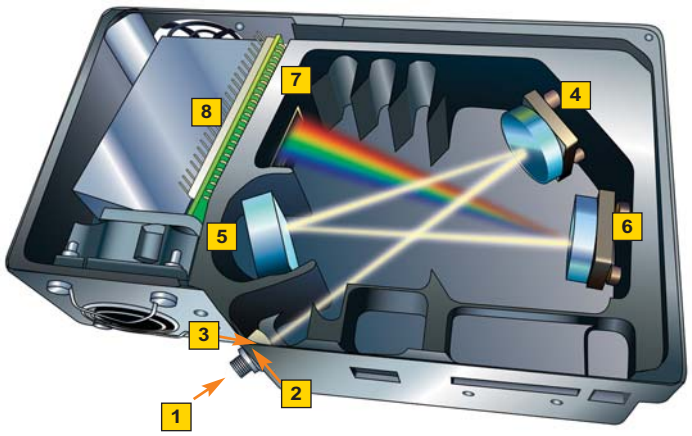
Comparing Xylenes



We used a QE65000 with a 10 µm slit and Grating H14, plus a 532 nm laser and probe, to acquire Raman spectra for xylene.

Options for the "QE" Optical Bench

Components of the "QE" Optical Bench



1 SMA 905 Connector
Light from a fiber enters the optical bench through the SMA 905 Connector. The SMA 905 bulkhead provides a precise locus for the end of the optical fiber, fixed slit, absorbance filter and fiber clad mode aperture.

2 Fixed Entrance Slit: specify slit size
Light passes through the installed slit, which acts as the entrance aperture. Slits are available in widths from 5 µm to 200 µm. Each is permanently fixed to the SMA 905 bulkhead. (Without a slit, a fiber acts as the entrance aperture.)

3 Absorbance Filter: optional
If selected, an OF-1 absorbance filter is installed between the slit and the clad mode aperture in the SMA 905 bulkhead. The filter is used to block second- and third-order effects.

4 Collimating Mirror: specify standard or SAG+
The collimating mirror is matched to the 0.22 numerical aperture of our optical fiber. Light reflects from this mirror, as a collimated beam, toward the grating. Opt to install a standard mirror or a SAG+UPG-HR mirror.

5 Grating: specify grating
We install the grating on a platform that we then rotate to select the starting wavelength you've specified. Then we permanently fix the grating in place to eliminate mechanical shifts or drift.

6 Focusing Mirror: specify standard or SAG+
This mirror focuses first-order spectra on the detector plane and sends higher orders to light traps built into the optical bench. Both the collimating and focusing mirrors are made in-house to guarantee the highest reflectance and the lowest stray light possible. Opt for a standard mirror or a UV-absorbing SAG+UPG-HR mirror.

7 OFLV Filters: optional
Our proprietary filters precisely block second- and third-order light from reaching specific detector elements.

8 Detector with TE cooling
The TE-cooled, back-thinned, "2D" detector provides great signal processing speed, improved signal-to-noise ratio and great native response in the UV. It generates virtually no dark noise, allowing for long integration times.

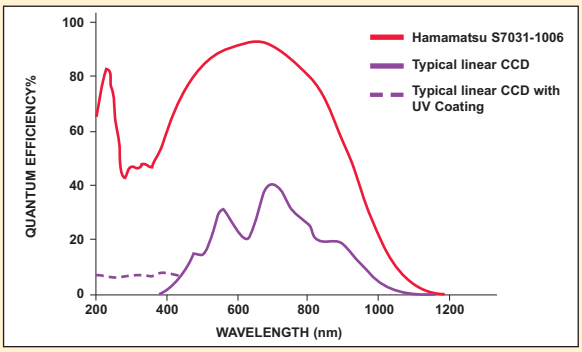
Back-thinned Area Detector

The Hamamatsu S7031-1006 FFT-CCD area detector in the QE65000 provides 90% quantum efficiency (defined as how efficiently a photon is converted to a photoelectron). The TE-cooled detector features low noise and low dark signal, which enables low-light-level detection and long integration times, thus achieving a wide dynamic range.

The S7031 is a 2D array, which allows us to bin pixels in a vertical column to acquire light from the entire height of the spectrometer's slit image. This improves light collection and signal-to-noise significantly. Because the detector is back-thinned (or back-illuminated), it has great native response in the UV and does not require the detector upgrade that we apply to other detectors for UV applications.

In our spectrometers with linear CCDs, the slit's width, not its height, regulates the amount of light entering the bench because linear CCDs cannot efficiently collect the light from the entire height of the slit. But in the QE65000, the 2D area detector can better take advantage of the height of the entrance slit and the additional light, greatly improving system sensitivity.

Detector Quantum Efficiency



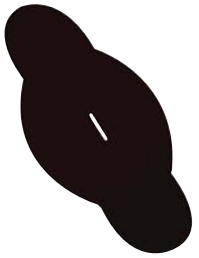
Detector Specifications	
Detector:	Hamamatsu S7031-1006 back-thinned area CCD
Detector range:	200-1100 nm
Pixels:	1024 x 58 (1044 x 64 total)
Pixel size:	24.6 µm square size
Active pixel area:	24.576 mm x 1.392 mm
Pixel well depth:	300,000 electrons/well; ~1.5 million electrons/column sum well
Signal-to-noise ratio:	1000:1 (at full signal)
A/D resolution:	16 bit
Dark noise:	3 RMS counts
Corrected linearity:	>99.8%
Sensitivity:	400 nm: 22 electrons/count, 250 nm: 26 photons/count
Dark current:	4000 e^-/pixel/sec @ 25 °C; 200 e^-/pixel/sec @ 0 °C
Quantum efficiency:	90% peak (see graph above)

Options for the "QE" Optical Bench

Fixed Entrance Slits

One option available with the user-configured QE65000 Spectrometer is selecting the size of the entrance aperture with the width determining the amount of light entering the bench. A slit is fixed in place; it only can be changed by our technicians.

Slit	Description	Pixel Resolution	Price
SLIT-5	5-µm wide x 1-mm high	~2.0 pixels	$150
SLIT-10	10-µm wide x 1-mm high	~2.2 pixels	$150
SLIT-25	25-µm wide x 1-mm high	~2.6 pixels	$150
SLIT-50	50-µm wide x 1-mm high	~3.3 pixels	$150
SLIT-100	100-µm wide x 1-mm high	~4.7 pixels	$150
SLIT-200	200-µm wide x 1-mm high	~8.9 pixels	$150



A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

Order-sorting & Blocking Filters

The OFLV-QE is a variable longpass filter that eliminates second- and third-order effects and is used with an HC-1 Grating in a 200-950 nm wavelength range system. Longpass blocking filters can also be used to restrict radiation to certain wavelength regions for eliminating second- and third-order effects. These 2-mm thick filters are installed permanently between the slit and the clad mode aperture in the bulkhead of the SMA 905 Connector.

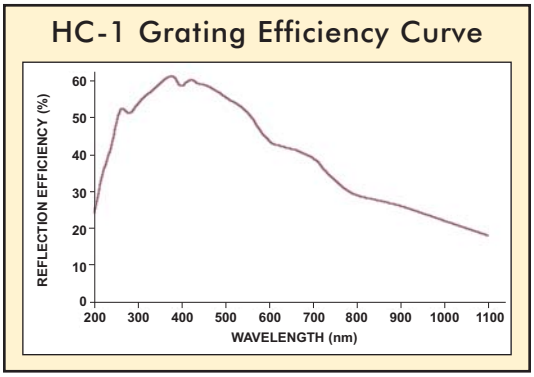
Item	Description	Price
OFLV-QE	Variable longpass filter is applied to the detector's window to eliminate second- and third-order effects for systems from 200-950 nm (use with Grating HC-1)	$250
OF1-WG305	Longpass filter; transmits light >305 nm	$50
OF1-GG375	Longpass filter; transmits light >375 nm	$50
OF1-GG475	Longpass filter; transmits light >475 nm	$50
OF1-OG515	Longpass filter; transmits light >515 nm	$50
OF1-OG550	Longpass filter; transmits light >550 nm	$50
OF1-OG590	Longpass filter; transmits light >590 nm	$50

Choosing a Grating

You choose from 14 gratings for each spectrometer, giving you flexibility in configuring your system. With each grating, you know its groove density (which helps determine the resolution), its spectral range (which helps determine the wavelength range), and its blaze wavelength (which helps determine the range with the most efficiency).

The **Groove Density** (mm^{-1}) of a grating determines its dispersion. The greater the groove density, the better the optical resolution possible, but the more truncated the spectral range. The **Spectral Range** is the dispersion of the grating across the linear array. The spectral range is set by the groove density and does not change. For ruled gratings, the **Blaze Wavelength** is the peak wavelength in an efficiency curve; for holographic gratings, it's the most efficient wavelength region. The **Best Efficiency** region is the range where efficiency is >30%. In some cases, gratings have a greater spectral range than is efficiently diffracted.

Grating Efficiency Curves are found on the following page, except for the HC-1 Composite Grating; its curve is shown here. We provide all gratings free with the purchase of a spectrometer, except for the HC-1, which is $600. When using the HC-1 in the QE65000, the wavelength range of the spectrometer is 200-950 nm.

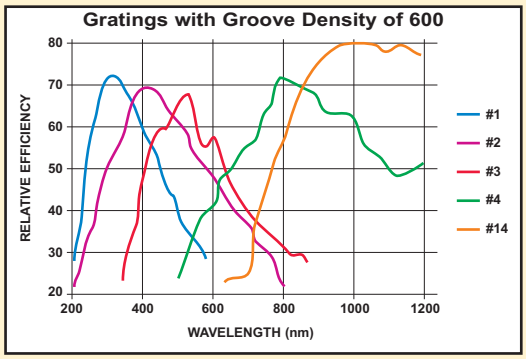


Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency (>30%)
HC-1	UV-NIR	300	200-950 nm	variable	200-1100 nm
H1	UV	600	373-390 nm	300 nm	200-575 nm
H2	UV-VIS	600	365-390 nm	400 nm	250-800 nm
H3	VIS-Color	600	360-386 nm	500 nm	350-850 nm
H4	NIR	600	360-377 nm	750 nm	530-1100 nm
H5	UV-VIS	1200	180-193 nm	holographic: UV	200-400 nm
H6	NIR	1200	123-170 nm	750 nm	500-1100 nm
H7	UV-VIS	2400	63-90 nm	holographic: UV	200-500 nm
H9	VIS-NIR	1200	145-180 nm	holographic: VIS	400-800 nm
H10	UV-VIS	1800	83-123 nm	holographic: UV	200-635 nm
H11	UV-VIS	1800	66-120 nm	holographic: VIS	320-800 nm
H12	UV-VIS	2400	52-88 nm	holographic: VIS	250-575 nm
H13	UV-VIS-NIR	300	790 nm	500 nm	300-1100 nm
H14	NIR	600	360-370 nm	1000 nm	650-1100 nm

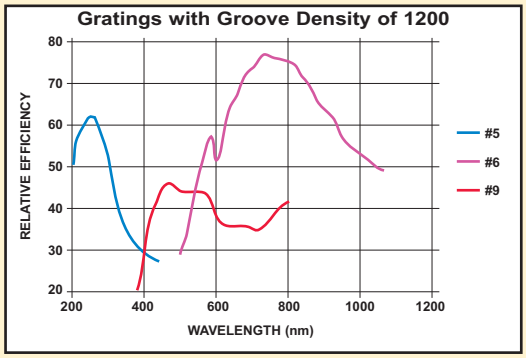
Options for the "QE" Optical Bench

Grating Efficiency Curves

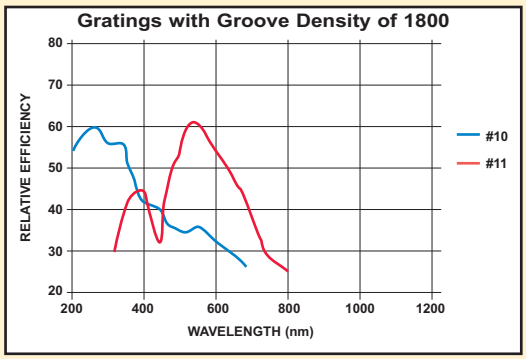
Below are the Grating Efficiency Curves for gratings with groove densities of 600, 1200, 1800 and 2400 mm^{-1}. See curves for all of our gratings at our website.



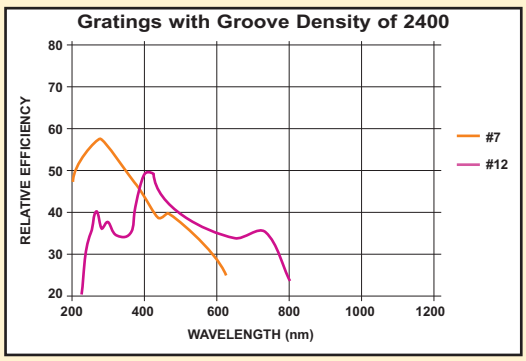
Efficiency Curves for Gratings 1, 2, 3, 4 and 14.



Efficiency Curves for Gratings 5, 6 and 9.



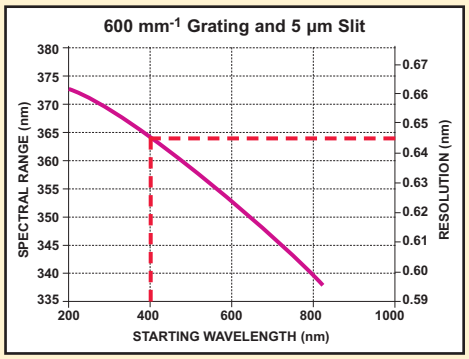
Efficiency Curves for Gratings 10 and 11.



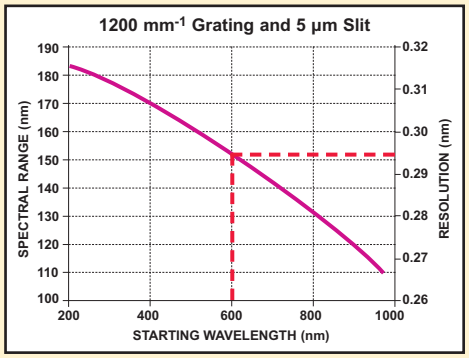
Efficiency Curves for Gratings 7 and 12.

Predicted Ranges & Resolution

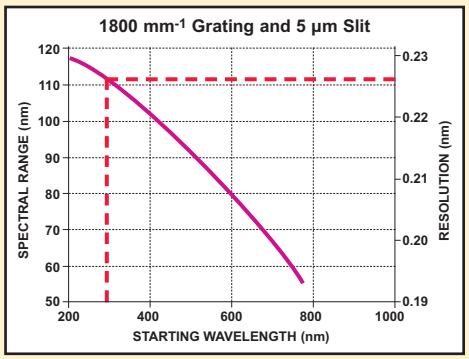
These graphs demonstrate the range and resolution of your "QE" Bench Spectrometer with a 5 µm slit. See our website for more graphs of ranges and resolutions for every slit size.



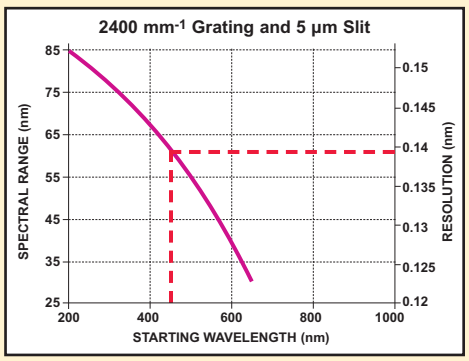
Example: *If the starting wavelength is 400 nm, then the range is ~364 nm, providing a 400-764 nm wavelength range and 0.645 nm resolution.*



Example: *If the starting wavelength is 600 nm, then the range is ~152 nm, providing a 600-752 nm wavelength range and 0.295 nm resolution.*



Example: *If the starting wavelength is 300 nm, then the range is ~112 nm, providing a 300-412 nm wavelength range and 0.226 nm resolution.*



Example: *If the starting wavelength is 450 nm, then the range is ~62 nm, providing a 450-512 nm wavelength range and 0.139 nm resolution.*

NIR-512 Near-IR Spectrometer

InGaAs Array Detector with TE Cooling

The NIR-512 Near-infrared Spectrometer features a 512-element InGaAs linear-array detector with onboard thermoelectric cooling. A thermistor monitors the array's temperature and a thermoelectric device can cool the array to 30 °C below ambient, keeping the array stable to within ±0.1 °C. You can set and monitor the detector's temperature via software.

900-1700 nm Wavelength Range

There is only one diffractive grating available with the NIR-512, Grating N1, and it provides a 900-1700 nm wavelength range.

Plug-and-Play USB Operation

The NIR-512 interfaces to a PC via USB 2.0. Data unique to each spectrometer are programmed into a memory chip on the NIR-512; when operating via the USB port, our spectrometer operating software reads these values for easy setup and hot swapping among PCs. The NIR-512 also has a serial port for interfacing to PCs, PLCs and other devices that support the RS-232 protocol. A 5 VDC wall transformer (included) is required for operation, whether interfacing to a PC via USB or RS-232.

Slit Size vs. Resolution vs. Intensity

Use the chart below left to help determine the best entrance aperture slit size for your application. Note that the smaller-sized slits provide excellent resolution, but low levels of throughput to the detector.

Applications

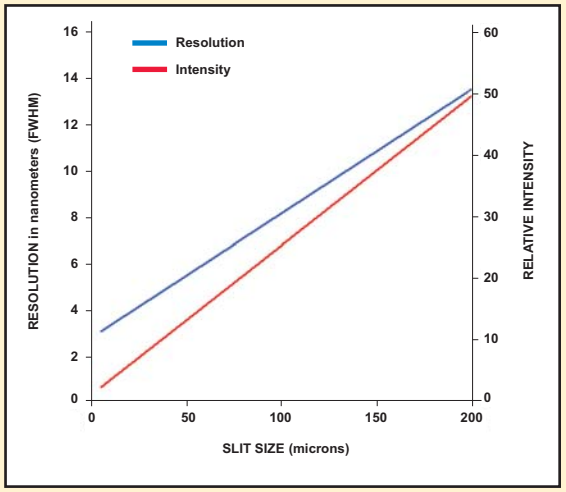
The NIR-512 and NIR256 Spectrometers may be used in a variety of applications:

- Sugar analysis
- Moisture analysis
- Pulpwood QC
- Laser characterization
- Alcohol analysis in brewing
- Nitrogen detection in soils
- Analysis of lubricants
- Fat, oil and lipid determination

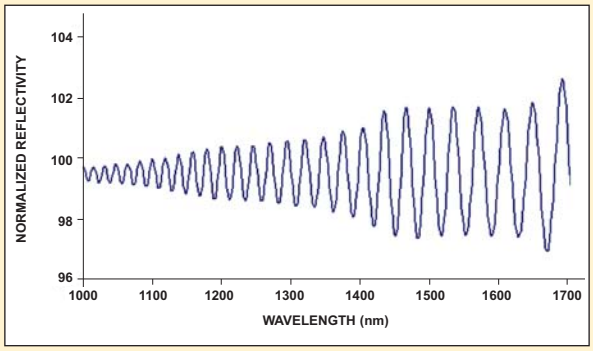
NIR-512: $14,995

See page 61 for a Spectrometer Comparison Chart of specifications for the NIR-512, NIR256-2.1 and NIR256-2.5.

NIR-512 Resolution and Intensity vs. Slit Size



NIR-512: Silicon Wafer Reflectivity



NIR256 Near-IR Spectrometers

High Performance

The NIR256-2.1 and NIR256-2.5 Near-infrared Spectrometers are designed for applications that require sensitivity in the near-infrared region. They feature cooled InGaAs array detectors and acquire data as fast as 10 milliseconds.

NIR256-2.1 Spectrometer: to 2100 nm

The NIR256 uses a 256-element InGaAs linear-array detector. With the NIR256 you have two grating options. With Grating N1, you have a 1200-2100 nm wavelength range. Grating N2 provides a 900-2100 nm wavelength range.

NEW NIR256-2.5 Spectrometer: to 2500 nm

The NIR256-2.5 Extended-range Spectrometer extends farther into the NIR, acquiring spectra up to 2.5 μm. Like its predecessors the NIR-512 and NIR256-2.1, the new NIR256-2.5 is centered around an InGaAs detector array, which is internally cooled for optimum signal-to-noise and sensitivity.

"Cool" Design

Each InGaAs detector has onboard thermoelectric cooling. A thermistor monitors the array's temperature and a thermoelectric device can cool the array to 30 °C below ambient, keeping the array stable to within ±0.1 °C. You can set and monitor the detector's temperature via software.

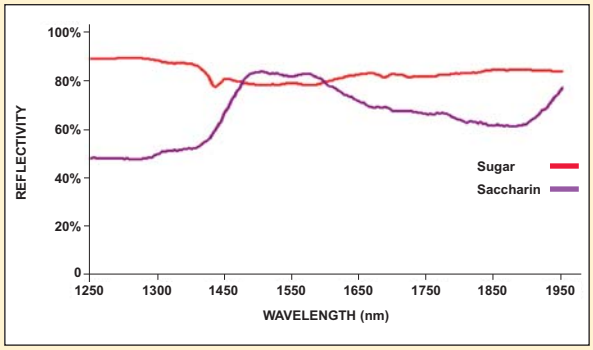
Integrated Design Provides Streamlined Start-up

A 16-bit A/D converter is mounted with the spectrometer in the same housing. A 5 VDC wall transformer (included) is required. When an NIR256 Spectrometer interfaces to a PC via the USB port, you have access to the spectrometer's EEPROM, where wavelength calibration coefficients and other information unique to your spectrometer are stored. Interface via an RS-232 serial port interface is also possible.

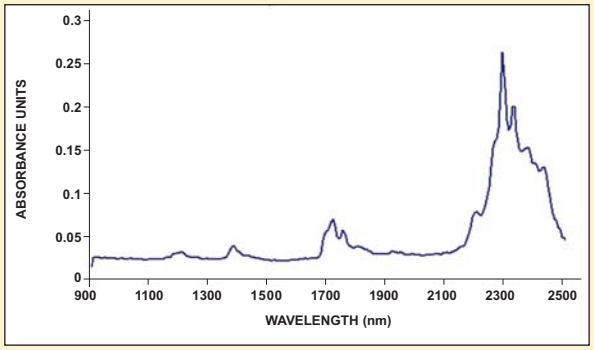
NIR256-2.1: $19,999
NIR256-2.5: $21,995

See page 61 for a Spectrometer Comparison Chart of specifications for the NIR-512, NIR256-2.1 and NIR256-2.5.

NIR256-2.1 Reflectance of Sugar



NIR256-2.5 Heptane Absorbance



Options for the "NIR" Optical Bench

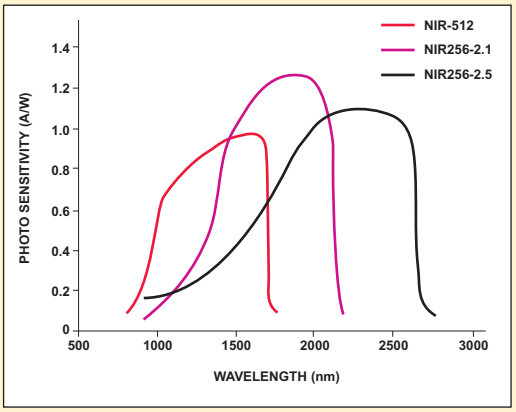
Detectors

In the "NIR" Spectrometers, we offer three different InGaAs linear array detectors, one 512-element array and two 256-element arrays.

The Hamamatsu detectors used in the "NIR" Optical Bench are InGaAs photodiode linear arrays with each pixel connected to a charge amplifier array comprised of CMOS transistors. These detectors deliver high sensitivity and stable operation in the near infrared.

The detectors all include onboard thermoelectric cooling. A thermistor monitors the array's temperature and a thermoelectric device can cool the arrays to 30 °C below ambient, keeping the array stable to within ±0.1 °C. In addition, you can set and monitor the detector's temperature via software.

Spectral Response Curves



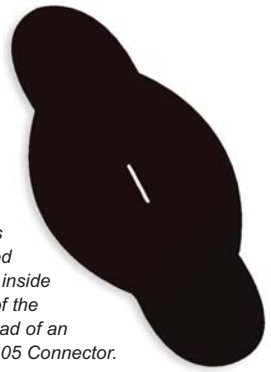
This graph compares the spectral response of the three NIR detectors at an operating temperature of 25 °C.

Detector Specifications

	NIR-512	NIR256-2.1	NIR256-2.5
Detector:	Hamamatsu G9204-512 InGaAs linear array	Hamamatsu G9206-256 InGaAs linear array	Hamamatsu G9208-256 InGaAs linear array
Detector range:	850-1700 nm	900-2100 nm	900-2550 nm
Pixels:	512	256	256
Pixel size:	25 µm x 500 µm	50 µm x 250 µm	50 µm x 250 µm
Defective pixels:	None	2%	5%
Signal-to-noise ratio:	4000:1	4000:1	4000:1
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	12 RMS counts	12 RMS counts	12 RMS counts
Maximum dark current:	60 pA @ 20° C	120 pA @ -15° C	2000 pA @ 15° C
Responsivity peak:	1.6 µm	1.95 µm	2.3 µm
Dynamic range:	5000:1	5000:1	4000:1
Operating temperature:	-5° C	-15° C	-15° C
Above zero integration time:	1000 ms	N/A	N/A

Fixed Entrance Slits

Another option available with user-configured "NIR" spectrometers is selecting the size of the entrance aperture. Entrance slits are rectangular apertures, 1-mm tall and various widths from 10 µm to 200 µm, with the width determining the amount of light entering the optical bench. A slit is fixed in place; it only can be changed by our technicians. You can opt against having a slit, in which case the diameter of the fiber connected to the spectrometer determines the size of the entrance aperture.



A slit is installed on the inside edge of the bulkhead of an SMA 905 Connector.

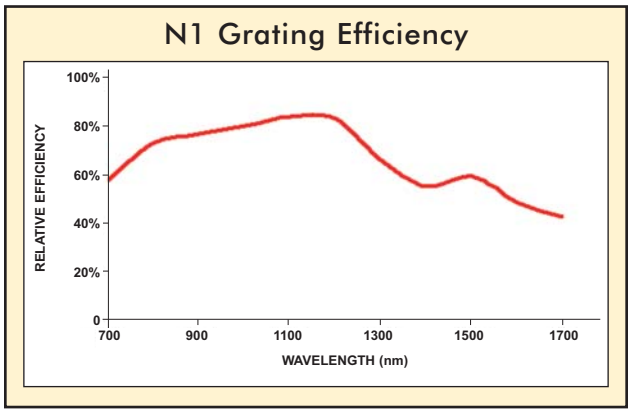
Slit	Description	NIR-512 Pixel Resolution	NIR256-2.1 Pixel Resolution	NIR256-2.5 Pixel Resolution	Price
SLIT-10	10-µm wide x 1-mm high	~2.4 pixels	~1.2	~1.2	$150
SLIT-25	25-µm wide x 1-mm high	~2.4 pixels	~1.2	~1.2	$150
SLIT-50	50-µm wide x 1-mm high	~2.9 pixels	~1.5	~1.5	$150
SLIT-100	100-µm wide x 1-mm high	~4.4 pixels	~2.2	~2.2	$150
SLIT-200	200-µm wide x 1-mm high	~7.9 pixels	~4.0	~4.0	$150

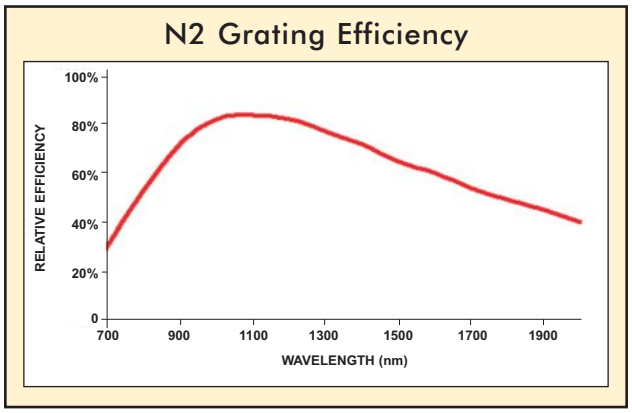
Options for the "NIR" Optical Bench

Grating Selection Chart & Grating Efficiency Graphs

Here are the Grating Selection Chart and the Grating Efficiency Curves for the two gratings available with the "NIR" optical bench.

Grating Number	Intended Use	Groove Density	Spectral Range	Blaze Wavelength	Best Efficiency
N1	NIR256 or NIR-512	300	900 nm	1000 nm	700-2100 nm
N2	NIR256 only	150	1600 nm	1600 nm	700-2500 nm





NIR-512, NIR256-2.1 & NIR256-2.5 Spectrometer Comparison Chart

Specification	NIR-512	NIR256-2.1	NIR256-2.5
Dimensions:	153.4 mm x 105.2 mm x 76.2 mm	153.4 mm x 105.2 mm x 76.2 mm	153.4 mm x 105.2 mm x 76.2 mm
Weight:	190 grams	190 grams	190 grams
Wavelength range:	900-1700 nm with Grating N1	900-2100 nm with Grating N2 1200-2100 nm with Grating N1	900-2500 with Grating N2
Responsivity peak:	1.6 µm	1.95 µm	2.3 µm
Detector:	Hamamatsu G9204-512 InGaAs linear array	Hamamatsu G9206-256 InGaAs linear array	Hamamatsu G9208-256 InGaAs linear array
Detector range:	850-1700 nm	900-2100 nm	900-2550 nm
Pixels:	512	256	256
Pixel size:	25 µm x 500 µm	50 µm x 250 µm	50 µm x 250 µm
Defective pixels:	None	2%	5%
Signal-to-noise ratio:	4000:1	4000:1	4000:1
A/D resolution:	16 bit	16 bit	16 bit
Dark noise:	12 RMS counts	12 RMS counts	12 RMS counts
Max dark current:	60 pA @ 20° C	120 pA @ -15° C	2000 pA @ 15° C
Operating temperature:	-5° C	-15° C	-15° C
Above zero integration time:	1000 ms	N/A	N/A
Focal length:	f/4, 40 mm	f/4, 40 mm	f/4, 40 mm
Entrance aperture:	10, 25, 50, 100 or 200 µm wide slits	10, 25, 50, 100 or 200 µm wide slits	10, 25, 50, 100 or 200 µm wide slits
Optical resolution:	typical resolution is ~3.0 nm FWHM	typical resolution is ~12.0 nm FWHM	typical resolution is ~3.0 nm FWHM
Integration time:	1 millisecond to 3 seconds	1 millisecond to 1 second*	1 millisecond to ~30 milliseconds*
Dynamic range:	5 x 10^6 (system); 5000:1 for a single acquisition	5 x 10^6 (system); 5000:1 for a single acquisition	5 x 10^6 (system); 4000:1 for a single acquisition
Fiber optic connector:	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber	SMA 905 to 0.22 numerical aperture fiber
Power consumption:	2 A @ 5 VDC	3 A @ 5 VDC	2 A @ 5 VDC
Data transfer speed:	Full scans into memory every 10 ms with USB port	Full scans into memory every 10 ms with USB port	Full scans into memory every 10 ms with USB port
Operating systems:	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port Any 32-bit Windows OS using serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port Any 32-bit Windows OS using serial port	Windows 98/Me/2000/XP, Mac OS X and Linux when using the USB port Any 32-bit Windows OS using serial port

** Hardware can go to 32 seconds, but the detectors' dark characteristics do not support it.*

Rack-mount Options for Stacking

Our fiber optic spectrometers and accessories are both flexible and modular, so that you can easily stack them in a variety of combinations, and install them into either a desktop-sized housing or a standard 19" industrial rack mount. This flexibility makes it possible to combine all components into a single, fully integrated package.

BOX-RACK has 14 slots.

Spectrometers

Several of our spectrometers will support up to eight channels -- one master channel and seven additional channels. S2000 or S1024DW Spectrometer systems of three or more spectrometer channels or three or more devices of any kind are installed into a Desktop Box (BOX-DESKTOP) or Rack Box (BOX-RACK). We use the item code prefix "MC" to designate systems that include a Desktop Box or Rack Box; for example, "MC-2000-5" describes an S2000 Spectrometer system with five channels.

BOX-DESKTOP has 7 slots.

Multiple USB2000 and HR4000 Spectrometers are configured using expansion hubs, in a series of master channels only. Also, USB2000 Spectrometers are available with accessories that attach directly to the spectrometer to create a self-contained system.

BOX-DUAL has 2 slots . . .

Spectrometer	Page	Stackable	Maximum Channels	Price/Master	Price/Additional
S2000	40	Yes	Master + 7 Additionals	$1,800	$799
S2000 with TR-2 Temperature Regulator	33	Yes	Master + 5 Additionals	$2,799 ($1,800 + $999 for TR-2)	$1,798 ($799 + $999 for TR-2)
PC2000	40	No	Master + 7 Additionals	$1,999	$799
S1024DW	41	Yes	Master + 7 Additionals	$2,599	$1,399
S1024DWX	41	Yes	Master + 7 Additionals	$3,999	$2,899
USB2000	38	No	1 Master only	$2,199	not applicable
HR4000	46	No	1 Master only	$3,999	not applicable

. . . for a spectrometer and another accessory.

Housing Options

Multiple spectrometers and components can be installed into available slots in our Rack Box or Desktop Box. Single- and dual-channel spectrometers are available in standard, compact housings, which are included in the spectrometer price. The Rack Box and Desktop Box are priced separately.

This configuration requires a BOX-RACK.

Item	Dimensions	Weight	Slots	Price
BOX-RACK	3U x 84 HP: 133 mm x 450 mm x 267 mm	3.6 kg	14	$900
BOX-DESKTOP	3U x 42 HP: 133 mm x 213 mm x 267 mm	2.5 kg	7	$825
BOX-DUAL	153 mm x 105 mm x 66 mm	0.7 kg	2	comes with spectrometer
BOX-SINGLE	143 mm x 105 mm x 40 mm	0.5 kg	1	comes with spectrometer

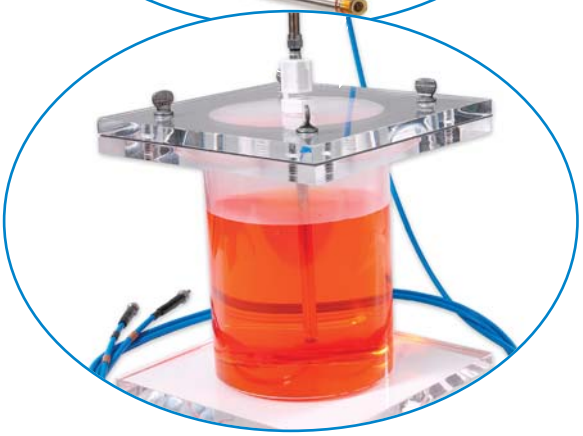
Stackable Components

Components that can be installed into Rack or Desktop housings include spectrometers, temperature regulators, analog-to-digital converters and light sources. In addition, accessories such as optical fibers, probes and sample holders couple to multiple-spectrometer systems via SMA 905 Connectors.

R-LS-450 Pulsed LED with an S2000 Spectrometer.

Item	Page	Description	Price
ADC1000-USB	84	Of the A/D options, only the ADC1000-USB can be installed into one of the housings	$599
TR-2 Temperature Regulator	33	The TR-2 is a thermoelectric device that stabilizes a bench to ± 0.1 °C, and provides spectral stability to ± 0.001 absorbance units (each channel requires its own TR-2)	$999
R-LS-1 Tungsten Halogen Light Source	126	The R-LS-1 and R-LS-1-LL Tungsten Halogen Light Sources are versatile white-light sources optimized for 360-2000 nm	$499
R-DT-MINI Deuterium Tungsten Halogen Light Source	122	The R-DT-MINI Deuterium Tungsten Halogen Light Source includes deuterium and tungsten halogen bulbs covering a ~200-2000 nm range	$1,199
R-LS-450 Pulsed LED Light Source	128	The R-LS-450 Pulsed LED Light Source produces pulsed and continuous output for fluorescence measurements; dual versions and other LED bulbs available	$499

Optical Sensors



Overview: Optical Sensors

Sensors for Real-Time, In Situ Analyte Monitoring

Ocean Optics has combined its expertise in miniature fiber optic spectroscopy with advances in materials science to develop an innovative line of modular fiber optic chemical-sensing systems.

Sensors are constructed by placing a transducer material at the tip of an optical fiber. These materials change optical properties in response to specific analytes in their immediate environment.

Our transducer materials include both fluorescence-based and absorbance-based indicators. These indicators are immobilized or trapped in a variety of proprietary materials, including sol-gels, hydrophobic and hydrophilic polymers, and cellulose acetate. Materials can be coated on flat substrates such as optical fibers, optical flats, cuvettes and other containers.

We produce components that can be used to monitor oxygen or pH in biological samples, headspace gases, slurries, cosmetics, foods, gases and liquids in natural environments.

Optical sensors can be used for a variety of applications. Here, our FOXY Fiber Optic Oxygen Sensor monitors headspace gases in food packaging.

FOXY O_2 Sensors Stack Up Against Electrodes

Commercial Electrodes		FOXY Oxygen Sensors
Most electrodes are designed for use in gas or liquids, but not both media	✔	FOXY measures both oxygen gas and dissolved oxygen in gases and liquids
Polarographic electrodes can be affected by changes in pH, salinity and ionic strength of the environment	✔	FOXY is immune to environmental changes in pH, salinity and ionic strength
Electrochemical electrodes are subject to interference from a number of substances and sampling conditions	✔	FOXY is immune to interference from moisture, carbon dioxide, methane and other substances
Electrodes can have a response time of 1.5 minutes, depending on temperature	✔	FOXY has fast response time, <1 second for dissolved O_2 and O_2 gas
Electrodes have a typical lifetime of 3 months	✔	FOXY has a long life – more than 1 year
Electrodes can consume oxygen of ~0.1 micrograms/hour	✔	FOXY does not consume oxygen, allowing for continuous contact with sample
Calibration may be needed hourly	✔	Frequent calibration is unnecessary
The temperature range for some electrodes is 0-45 °C	✔	FOXY probe temperature range is -60 °C to +80 °C
Electrodes often introduce electrical currents into a sampling setup	✔	FOXY allows remote sampling without introducing electrical fields to sample

Ocean Optics Offers Optical Sensor Coating Services

We've expanded our optical-sensor coating services, providing OEMs and product developers with multiple solutions in creating proprietary accessories for chemical sensing applications. You can take advantage of these services to develop and manufacture a variety of custom optical oxygen and pH sensor accessories including fiber optic probes, cuvettes, Petri dishes, microscope slides and more. The added services include the licensing of Ocean Optics proprietary oxygen and pH coating technologies, custom sensor coating development, and contract manufacturing services.

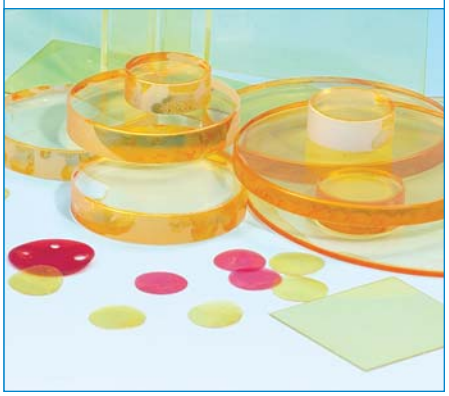
We can supply our proprietary optical sensor coating technologies to you through a license agreement. We manufacture the coatings and apply them to any media specified.

You can supply a proprietary indicator to be included in an Ocean Optics coating. We then produce the coating and apply it to the media specified.

You can supply a proprietary coating and indicator to us and we will apply the coating to the media specified. This option requires a contract agreement.

We can research and develop a proprietary coating for you. This option is available through NRE and/or research fees.

Services may also include costs associated with the type of sensor material; the surface area; and the time required to apply the sensor material to a substrate.



FOXY Oxygen Sensor Operation

Novel Technology

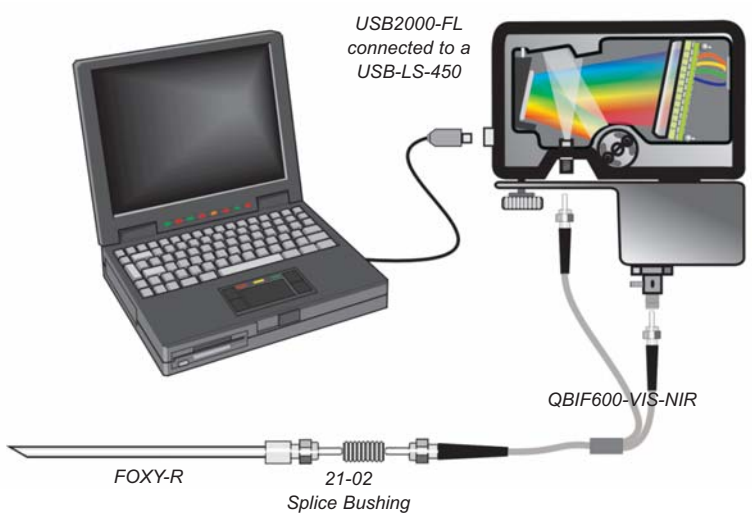
FOXY Fiber Optic Oxygen Sensors are sol-gel coated probes that use fluorescence quenching of a ruthenium complex trapped in a sol-gel matrix to measure the partial pressure of dissolved or gaseous oxygen. You specify one of our FOXY probes -- along with a spectrometer, A/D converter, light source and software -- to build a complete oxygen-sensing system.

Optical O_2 Sensors vs. Electrodes

Unlike electrodes, FOXY Sensors consume no oxygen and can be used in continuous contact with viscous samples such as foods, pharmaceuticals and biological samples. There are no membranes to change, solutions to fill, or samples to stir. FOXY Sensors are immune to EMI, to interference from various chemicals and gases, and to changes in pH, salinity and ionic strength.

Theory of Operation

1. A blue LED sends light, at ~475 nm, to one leg of a bifurcated optical fiber.
2. The fiber carries the light to the FOXY probe, which is polished to a 30° angle. The distal end of the probe tip consists of a thin layer of hydrophobic sol-gel material. A ruthenium complex is trapped in the sol-gel matrix, immobilized and protected from the sample.
3. The light from the LED excites the ruthenium complex at the probe tip. The excited ruthenium complex fluoresces, emitting energy at ~600 nm.
4. If the excited ruthenium complex at the probe tip encounters an oxygen molecule, the excess energy is transferred to the oxygen molecule in a non-radiative transfer, decreasing or quenching the fluorescence signal. The degree of quenching correlates to the partial pressure of oxygen in the sol-gel, which is in dynamic equilibrium with oxygen in the sample.
5. The fluorescence is collected by the probe and carried to the spectrometer via the other leg of the bifurcated optical fiber. The fluorescence intensity is measured and related to the partial pressure of oxygen through the Stern-Volmer equation.



Overview

Oxygen is sensed by measuring the decrease in fluorescence intensity of a fluorophore bound to the tip of an optical fiber. The sensor responds to the partial pressure of oxygen. It works equally well in gases, solutions and even viscous samples. Below is a list of components typically specified in an oxygen sensing application.

Spectrometer

We recommend the USB2000-FL Fluorescence Spectrometer, which is preconfigured with a 200 µm Slit, Grating #3 and a 360-1000 nm wavelength range. Grating #3 is blazed at 500 nm to optimize the fluorescence signal at 600 nm. Also included in the optical bench is an L2 Detector Collection Lens to increase light-collection efficiency.

Sampling Optics

The USB-LS-450 Pulsed Blue LED Excitation Source transmits light (at ~475 nm) to one leg of a QBIF600-VIS-NIR Bifurcated Optical Fiber Assembly, which is connected to one of our oxygen sensor probes via a 21-02 Splice Bushing. If the excited ruthenium at the probe tip encounters an oxygen molecule, the fluorescence signal decreases. OOISensors Application Software calculates partial pressure of the oxygen from this signal.

Measurements

OOISensors Software relates the fluorescence intensity to the level of oxygen using the Stern-Volmer equation. The software compares levels recorded by the user with the probe in known conditions.

Components	Page	Price
1. USB2000-FL Fluorescence Spectrometer	33	$2,499
Grating #3, 360-1000 nm range	44	included
200 µm Slit as entrance aperture	42	included
L2 Detector Collection Lens	43	included
2. USB-LS-450 Pulsed Blue LED Excitation Source	129	$549
3. QBIF600-VIS-NIR Premium-grade Bifurcated Fiber Assembly	140	$369
4. 21-02 Splice Bushing	156	$13
5. FOXY-R Fiber Optic Oxygen Sensor Probe	66	$499
6. OOISensors Application Software	70	$199
7. ASP Annual Service Package	193	$250
	Total:	$4,428

FOXY Oxygen Sensor Probes

Item	Probe Assembly	Dimensions	Pressure	Fiber	Typical Usage	Price
1 FOXY-R	1000 µm fiber in stainless steel ferrule	1.587 mm OD x 152.4 mm length	300 psi	BIF600-VIS-NIR	general purpose	$499
2 FOXY-AL300	300 µm fiber with aluminum jacketing	~500 µm OD x 1 meter length	300 psi	BIF200-VIS-NIR	fine spatial resolution applications	$499
2 FOXY-AL300-TM	300 µm fiber with aluminum jacketing	~500 µm OD x 1 meter length	300 psi	BIF200-VIS-NIR	tissue monitoring	$549
3 FOXY-18G	300 µm fiber with stainless steel 18-gauge tip	1.37 mm diameter 90 mm length tip	300 psi	BIF200-VIS-NIR	penetration of vial septa and rigid sample packaging	$599
3 FOXY-21G	300 µm fiber with stainless steel 21-gauge tip	790 µm diameter 90 mm length tip	300 psi	BIF200-VIS-NIR	penetration of soft sample packaging	$599
4 FOXY-OR125	1000 µm fiber in stainless steel ferrule	3.175 mm OD x 63.5 mm length	300 psi	BIF600-VIS-NIR	direct replacement for 1/8" OD O_2 electrodes	$599
5 FOXY-OR125-G	1000 µm fiber in stainless steel ferrule	3.175 mm OD x 63.5 mm length	300 psi	BIF600-VIS-NIR	direct replacement for O-ring grooved electrodes	$599
5 FOXY-OR125-GT	1000 µm fiber in titanium ferrule	3.175 mm OD x 63.5 mm length	300 psi	BIF600-VIS-NIR	direct replacement for O-ring grooved electrodes	$649
6 FOXY-T1000	1000 µm fiber in stainless steel ferrule	6.35 mm OD x 177.8 mm length	3000 psi	BIF600-VIS-NIR	process environments, high-pressure applications	$999
7 FOXY-T1000-RTD	1000 µm fiber in stainless steel ferrule	6.35 mm OD x 177.8 mm length	300 psi	BIF600-VIS-NIR	process environments (includes embedded RTD)	$1,499
8 FOXY-PI600	600 µm fiber with polyimide jacketing	710 µm OD x 2 meter length	300 psi	BIF400-VIS-NIR	environments where non-metallic probe is indicated	$499
9 FOXY-RESP	200 µm fiber in a plastic ferrule	6.35 mm OD x 107.9 mm length	300 psi	not applicable	measurement of oxygen tension in respiratory gases	$549

FOXY Oxygen Sensor Probes

FOXY Sensor Specifications

Here are the specifications for using the standard FOXY sensing material with one of the probes on page 66, coupled to an S2000 or USB2000 Spectrometer.

Specifications			
	Oxygen Gas (at 1 atmosphere of total pressure)		**Dissolved Oxygen in Water (at 25 °C)**
Dynamic range:	0-100 mole%, 0-760 mm Hg partial pressure	Dynamic range:	0-40.7 ppm, 0-760 mm Hg partial pressure
Response time:	Standard probe <1 second, 20-30 seconds with silicone overcoat	Response time:	Standard probe <1 second; 30-50 seconds with silicone overcoat
Resolution:	0.01% at 0% Oxygen, 0.04% at 20.9% Oxygen, 0.40% at 100% Oxygen	Resolution:	0.003 ppm at 0 ppm Oxygen, 0.02 ppm at 8.5 ppm Oxygen, 0.2 ppm at 40 ppm Oxygen
Stability:	0.03% per hour in temperature-controlled environment	Stability:	0.02 ppm per hour in temperature-controlled environment
Calibration:	Standard 2-point calibration (linear fit) is acceptable but multipoint calibration (second-order polynomial fit) is recommended for improved accuracy and extended dynamic range; single-temperature, single-point calibration using factory-calibrated FOXY Sensor probes		
Operating temperature:	For coated probes -60 °C to 80 °C		

Care of FOXY Probe

Your FOXY probe is very easy to maintain. It can be left in air indefinitely, but don't leave it exposed to your excitation source when it is not in use. Dropping the probe could cause the optical fiber to break. Be sure not to over-tighten the SMA connections. For cleaning options, see below.

Sterilization Method	Results
Sodium hypochlorite (bleach)	Safe -- seems to have no effect on probes
Gamma radiation	Safe -- seems to have no effect on probes
Hydrogen peroxide plasma gas, low temperature, Plazlyte	Degrades probe signal by about 15% with each cycle
Autoclaving (steam sterilization) >30 minutes at 121 °C	Each cycle decreases signal by 50%; probe lifetime is 6 to 8 cycles
Methanol and ethanol wash	Destroys probe signal with extended exposure, even with overcoat
Hydrogen peroxide	Destroys probe signal with extended exposure, even with overcoat
Ozone	Preliminary results indicate that it is harmful to probes
EtO (100% ethylene oxide gas) at room temperature	Unknown
EtO at temperatures above 100 °C	Unknown
UV radiation	Unknown

Chemical Compatibility

Though FOXY Probes work well in most solutions, some chemicals interfere with performance by deteriorating the fluorescence irreversibly or by chemically attacking the coating. Overcoats may reduce such interference. For chemical compatibility testing of samples, we suggest our FOXY-SGS products (page 68), where we coat various substrates such as microscope glass cover slips.

Chemical	Reaction
Acetone	Problematic
Acetonitrile	Problematic
Acids	Safe
Acrylonitrile	Problematic
Alcohols >50% concentration	Problematic
Alcohols <50% concentration	Safe (overcoat required)
Ammonia	Safe
Benzene (removes overcoat)	Problematic
Benzene (if analysis is short-term)	Safe
Diesel Fuel	Problematic
Dimethyl Sulfoxide (>60 hours)	Problematic
Ethanol	Problematic
Gasoline	Problematic
Heptane (removes overcoat)	Problematic
Hexane (removes overcoat)	Problematic
Hydrofluoric acid (HF)	Problematic
Isopropyl Acetate >60% concentration	Problematic
Isopropyl Alcohol <60% concentration	Safe (overcoat required)
Hydrogen Peroxide	Problematic
Ketones (such as acetone)	Problematic
Methanol <50% concentration	Safe (overcoat required)

Chemical	Reaction
Methyl Methacrylate	Problematic
Nitrogen Trifluoride (NF3)	Safe
Non-polar solvents	Problematic
N-Vinyl-2-Pyrrolidinone	Problematic
Organic solvents	Problematic
Perfluorodecalin (C10F18)	Safe
Perfluorohexane	Safe
Skydrol (Aviation Hydraulic Fluid)	Problematic
Sodium Hypochlorite	Safe
Sodium Sulfide	Safe
Sodium Hydroxide 1 Molar (NaOH)	Safe
Solutions with pH >10	Problematic
Styrene	Problematic
Sulfur Dioxide (SO_2)	Problematic
Sulfur Hexafluoride (SF6)	Safe
Tetrahydrofuran	Problematic
Toluene	Problematic
Toluene/Ethyl Acetate	Problematic
Trichloroethyelene	Problematic
Xylene	Problematic

FOXY Oxygen Sensor Accessories

Silicone Overcoats

We can apply silicone overcoats to FOXY Probes to improve chemical resistance, exclude ambient light and eliminate refractive index effects of the sample. We recommend an overcoat if you are using solutions or if you are switching between gases and solutions. Overcoats are free.

Item	Description	Response in Gases	Response in Solutions
FOXY-AF	RTV silicone adhesive overcoat (overcoat increases response time)	10-30 seconds	15-45 seconds
FOXY-AF-MG	High-strength RTV silicone adhesive overcoat is a medical implant-grade silicone -- a much thicker and more robust coating than the FOXY-AF (overcoat increases response time)	15-45 seconds	45-60 seconds (depending on viscosity)

FOXY Reconditioning/Recoating Service

The active material on all of our FOXY Probes is a fluorescent ruthenium complex immobilized in a submicron-thin sol-gel matrix. Cleaning and protection from harsh environments will extend the life of the sensor. Severe biofouling, physical abrasion, and chemical etching of the glass may erode the sensing surface. Should this erosion happen, we offer a probe recovery service. For FOXY-18G and FOXY-21G Needle Probes we re-polish the probe and add a new needle tip for $125. For all other FOXY probes, we re-polish and re-coat the probe for $100. Probe recovery takes about 2 weeks after receiving the probe.

FOXY-RECOV: $100
FOXY-RECOV-N: $125

Planar FOXY Sensors

Though FOXY Probes work well in most solutions, some chemicals interfere with sensor performance by deteriorating the fluorescence irreversibly or by chemically attacking the coating. We offer a variety of coated substrates for testing chemical reactions or for other applications where a probe is undesirable.

Item	Description	Typical Usage	Price
FOXY-SGS	Custom coating service for coating various substrates (supplied by user or Ocean Optics) with different transducer materials	qualitative, quantitative feasibility testing	Custom Pricing
FOXY-SGS-M	One 1" x 3" sol-gel spin-coated microscope slide	qualitative, quantitative testing	$80
FOXY-GF	Pack of 5 sol-gel coated fiberglass filters	qualitative, quantitative testing	$50
FOXY-RESP-FILM	Pack of 25 sol-gel coated glass fiber membranes for FOXY-RESP Respiration Monitor (see page 66)	qualitative, quantitative testing	$50

Example of FOXY-SGS

FOXY-SGS-M

FOXY-GF

Phenol Red pH Test Kit

The CHEMTEST-PH is a Phenol Red pH Test Kit that includes 100 tests in cuvettes with covers. The CHEMTEST-PH can be used to determine the pH level in solution. Simply add 3 mL solution to a cuvette, cap it, shake the cuvette to disperse the dye, and then measure the absorbance value of the reactive color to determine the pH level.

CHEMTEST-PH works with any Ocean Optics system that is configured for absorbance, including the CHEM2-series Spectrometers on pages 12-13 and the Maxwell Spectrophotometer on page 10. Software included.

CHEMTEST-PH: $99

FOXY Oxygen Sensor Accessories

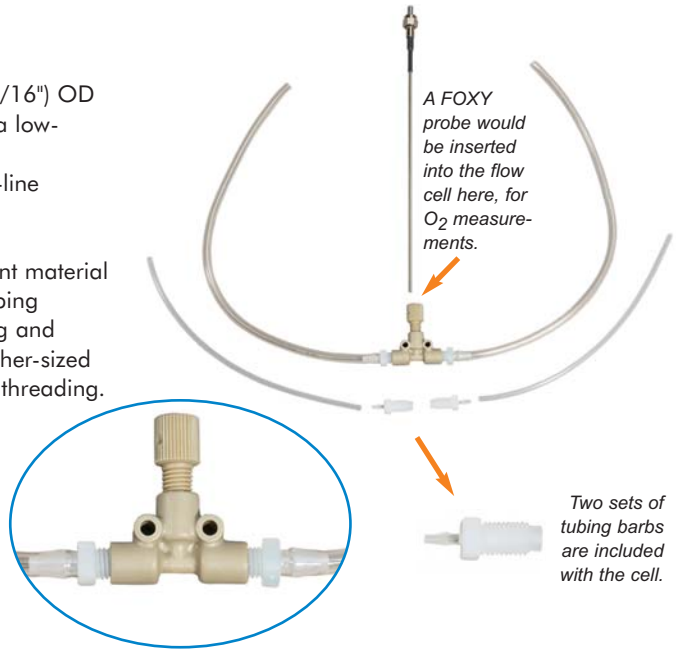
FOXY Flow Cell

The FOXY-FLOW-CELL is an in-line flow cell for 1.587 mm (1/16") OD FOXY probes, such as the FOXY-R. It was designed to use in a low-pressure flowing stream of liquid with a peristaltic or positive displacement pump. The flow cell also can be used as an on-line sampling accessory for 1/16" OD reflectance probes.

The tee flow cell is made of PEEK polymer, a radiation-resistant material that has excellent chemical resistance. Also included are 4 tubing barbs: 2 for 1/16" ID tubing and 2 for 1/8" ID tubing. (Tubing and pump are not included.) You can replace these fittings with other-sized fittings from Upchurch Scientific as long as they have 1/4-28 threading.

FOXY-FLOW-CELL: $100

Specifications	
Tee:	Upchurch Scientific PEEK tee
Tubing barbs:	(2) 1/8" Tefzel tubing barbs (2) 1/16" Tefzel tubings barbs
Ferrule:	1/16" ETFE ferrule
Nut:	1/16" PEEK nut
Threading size:	1/4-28
Pressure limits:	1000 PSI



Puncturing Needle

The FOXY-R-PNA Puncturing Needle is a FOXY Sensor accessory that allows 1.587 mm (1/16") outer diameter sensors -- such as the FOXY-R (page 66) -- to puncture through a septum and seal without damaging the sensor coating. The FOXY-R-PNA includes a 1/16" needle and a 1/16" Swagelok adapter to seal the sensor in place.

FOXY-R-PNA: $150

O_2 Acrylic Sampling Chambers

Our Acrylic Sampling Chambers are great accessories for O_2 sensing applications. The chambers can be used by biologists and zoologists in dissolved oxygen sensing applications such as respiration rate and metabolism rate monitoring of fish and crustaceans. The sampling chambers provide users with a fixed-volume environment.

Each chamber cover, depending on the model, is equipped with up to three high-pressure (220 psi) polypropylene collars and a Swagelok fitting for a FOXY Oxygen Sensor Probe. You can combine a sample chamber, probe, spectrometer and light source to configure a complete respirometer. The acrylic chambers have a temperature range of -30 °C to 82 °C and are FDA-approved for food-contact applications. The polypropylene fittings are temperature rated from 0 °C to 100 °C. Each chamber has a watertight seal seated between the body and its cover. Four thumbscrews are included to tighten the cover.

Item	Description	Dimensions	Fittings	Price
RESP-CL2IN	Clear Acrylic Round Chamber	44.4 mm ID x 139.7 mm length	1 bored 1/4" OD tubing fitting	$160
RESP-BL2IN	Black/Opaque Rectangle Acrylic Chamber	139.7 mm x 50.8 mm x 50.8 mm	1 bored 1/4" OD tubing fitting	$180
RESP-CL4IN	Clear Acrylic Round Chamber	95.2 mm ID x 139.7 mm length	2 bored 1/4" OD tubing fittings	$175
RESP-BL4IN	Black/Opaque Rectangle Acrylic Chamber	140 mm x 101.6 mm x 101.6 mm	2 bored 1/4" OD tubing fittings	$195
RESP-CL6IN	Clear Acrylic Round Chamber	146 mm ID x 139.7 mm length	3 bored 1/4" OD tubing fittings	$190
RESP-BL6IN	Black/Opaque Rectangle Acrylic Chamber	139.7 mm x 127 mm x 127 mm	3 bored 1/4" OD tubing fittings	$210

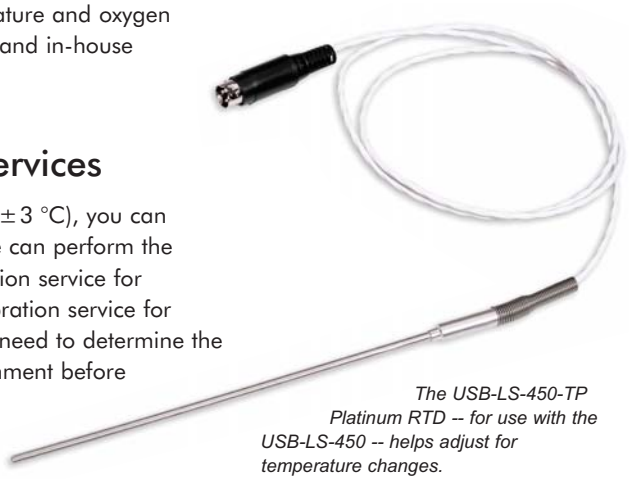
FOXY Temperature Compensation

FOXY Sensors are affected by temperature. Temperature affects the fluorescence decay time, fluorescence intensity, collisional frequency of the oxygen molecules with the fluorophore, and the diffusion coefficient of oxygen. The net effect: a change in the calibration slope. Because of this, the sample must be maintained at a constant temperature (±3 °C) for best results. If this is impractical, the sensor can be calibrated by measuring temperature and oxygen concurrently using one of our temperature-compensation accessories and in-house calibration services.

In-house FOXY Temperature Calibration Services

If your sample cannot be maintained at a constant temperature (±3 °C), you can perform a temperature calibration in OOISensors Software or we can perform the calibration for you. The FOXY-CAL is an in-house factory-calibration service for environments from 0-80 °C. The FOXY-CAL-EXT is a factory-calibration service for extended temperature ranges below 0 °C or above 80 °C. You'll need to determine the temperature and O_2 concentration range of your sample environment before ordering an in-house calibration service.

FOXY-CAL: $199
FOXY-CAL-EXT: $299



The USB-LS-450-TP Platinum RTD -- for use with the USB-LS-450 -- helps adjust for temperature changes.

FOXY Thermistor & Thermocouples

Item	Description	Price
FOXY-TS1	Thermistor is 1/8" outer diameter stainless steel tubular electrode probe that monitors temperatures from 0 °C to 100 °C; it most often is used for liquid immersion	$105
FOXY-T-MOD-1	An RS-232 module interfaces up to 4 of the FOXY-TS1 Thermistors to your PC	$500
FOXY-TK1	Thermocouple is a 1/8" outer diameter K-type electrode that monitors temperatures from -150 °C to 220 °C	$105
FOXY-TK1-W	Wire-type thermocouple that monitors temperatures from -150 °C to 220 °C	$105
FOXY-T-MOD-K	An RS-232 module interfaces up to 4 of the FOXY-TK1 Thermocouples to your PC	$500

FOXY RTDs

We offer three RTDs to adjust for temperature changes. The USB-LS-450-TP is a 1/8" outer diameter, 100 ohm platinum RTD that connects to the USB-LS-450 Excitation Source. The USB-LS-450's onboard memory can be programmed to store temperature and oxygen calibration coefficients. (For more on the USB-LS-450, see page 129.) The USB-LS-450-TP16 is a 16-gauge needle RTD, also for use with the USB-LS-450. The FOXY-T1000-RTD (at right) is a FOXY-T1000 probe, but with an embedded RTD in the 1/4" outer diameter casing.

USB-LS-450-TP: $99
USB-LS-450-TP16: $249
FOXY-T1000-RTD: $1,499

FOXY Sensor Software

OOISensors Software is a 32-bit, advanced acquisition and display program that provides a real-time interface to display and processing functions for use with our O_2 and pH sensors. OOISensors can acquire data, convert the data into concentration values, and save the data in spectral files and logs. The software has the ability to perform timed experiments and to display and correct for temperature fluctuations and for atmospheric pressure changes in the sample. It can also display pH values when used with our pH probe.

OOISensors: $199

FOXY-LITE Handheld Oxygen Sensor

Handheld System

The FOXY-LITE Handheld Oxygen Sensor is a compact, portable sensor that combines the convenience of handheld operation with the advantages of optical sensing. The FOXY-LITE uses time-resolved fluorometry and sol-gel based optical sensing technology to enable a variety of oxygen sensing applications.

Time-resolved Fluorometry

The FOXY-LITE uses an onboard blue (470 nm) pulsed LED excitation source and a single-element detector that is filtered to sense fluorescence at 600 nm. The FOXY-LITE measures the decay of fluorescence over time to determine oxygen levels in a sample. This setup makes the FOXY-LITE immune to effects from ambient light, refractive index changes and photobleaching.

Digital Display

The FOXY-LITE features an easy-to-read LCD screen that displays oxygen concentration or a strip chart that plots oxygen values over time. Oxygen values can also be shown in ppm, in % oxygen or in user-defined units. TTL signals in the FOXY-LITE are accessible to set overlimit/underlimit alarms for oxygen values. For measurements that require temperature compensation, temperature is displayed when the FOXY-LITE is used with an RTD. If needed, the FOXY-LITE can interface to a PC via a USB or serial port. Optional software on your PC can be used to analyze and log data.

Optical Sensor with Standard FOXY Coating

The FOXY-LITE comes with an optical fiber and the FOXY-R Oxygen Probe (page 66) with the standard FOXY sol-gel coating.

New HIOXY Sensor Formulation!

We are developing a new sol-gel matrix sensor coating that measures oxygen in solvents. This new HIOXY formulation is applied to a probe for use with the FOXY-LITE, to use in a variety of applications including fuel tank head-space analysis and dissolved O_2 monitoring in non-polar solvents such as:

- Acetone
- Ethanol
- JET-A (Jet Fuel)
- Xylene
- Diesel Fuel
- Trichloroethyelene
- Methyl Methacrylate
- Skydrol (Aviation Hydraulic Fluid)

FOXY-LITE: $1,999

Specifications

	Oxygen Gas (at 1 atmosphere of total pressure)	Dissolved Oxygen in Water (at 25 °C)
Dynamic range:	0-100 mole%; 0-760 mm Hg partial pressure	0-40.7 ppm; 0-760 mm Hg partial pressure
Resolution:	0.06% at 0% Oxygen 0.3% at 20% Oxygen 5% at 100% Oxygen	0.02 ppm at 0 ppm Oxygen 0.12 ppm at 8.5 ppm Oxygen 2.04 ppm at 40.7 ppm Oxygen
Stability:	±0.03 mole%; ±0.23 mm Hg	±0.012 ppm; ±0.23 mm Hg
Minimum detection:	0.1% mole%; 0.76 mm Hg	0.04 ppm
Accuracy (0-25 Mole%):	Linear (2-point Minimum Calibration): 3% Polynomial (3-point Minimum Calibration): 2%	Linear (2-point Minimum Calibration): 3% Polynomial (3-point Minimum Calibration): 2%
Accuracy (0-100 Mole%):	Linear (2-point Minimum Calibration): 30% Polynomial (3-point Minimum Calibration): 6%	Linear (2-point Minimum Calibration): 30% Polynomial (3-point Minimum Calibration): 6%
Response time:	<1 second (no overcoat necessary)	<1 second (no overcoat necessary)
Operating temperature:	0 °C to 50 °C	0 °C to 50 °C
Sterilization:	Gamma radiation or sodium hypochlorite (bleach or Clorox)	Gamma radiation or sodium hypochlorite (bleach or Clorox)
Probe assembly:	1000 µm fiber in stainless steel ferrule	1000 µm fiber in stainless steel ferrule
Probe dimensions:	1.587 mm OD x 152.4 mm length	1.587 mm OD x 152.4 mm length

Fiber Optic pH Sensors

Sensor Holds Indicator Dyes

The Fiber Optic pH Sensor system consists of a fiber optic probe designed to hold immobilized colorimetric indicator dye materials, plus a light source, spectrometer and OOISensors Software. You can supply your own indicator material, or select from our line of transparent or reflective films. Calibration involves recording spectra in high and low pH samples, and in at least one pH standard such as a NIST-traceable buffer.

Transmissive & Reflective pH Films

Transmissive films are for clean, transparent samples. These films consist of a cellulose mechanical matrix surrounded by a hydrophilic polymer that entraps the indicator dye. Reflective films are used for turbid or absorbing media.

Film Performance

When immersed in water, the film dyes may leach very slowly over time and will have to be replaced. The film response rate is slow (on the order of minutes), being limited by diffusion of ions into the material. Increasing stirring speed, ionic strength and temperature all tend to increase the response rate and do not affect the pH measurement. Nearly any aqueous sample environment is suitable, as are some solvents. Contact our Applications Scientists for details.

TP300 Probe

The TP300-UV-VIS Probe (at right) is a chemically inert PEEK transmission probe that can be equipped with a tip (RT-PH) for mounting transmissive films in the optical path. Light is directed via one fiber through the mounted film to a mirror. Then light is redirected back through the film to a receive fiber that returns the light to the spectrometer. The sample is free to flow over the sides of the film. By using an RTP-2-10 (adjustable from 2-10 mm) or RTP-10-20 (adjustable from 10-20 mm) transmission tip, the TP300-UV-VIS can be used for routine transmission measurements. See page 149 for details.

TP300-UV-VIS: $750
RT-PH Tip: $240

RFP200 Probe

The RFP200-UV-VIS Reflective Film Probe consists of a 6-around-1 fiber bundle in a chemically inert 6.35-mm outer diameter Torlon body. The open tip of the probe screws onto the body to hold 3.17-mm to 4.76-mm discs of reflective indicator material. The 6-fiber leg attaches to the light source; the central fiber leg connects to the spectrometer. The sample has access to the sensing material from one side only.

RFP200-UV-VIS: $499

Use transmissive films with the TP300-UV-VIS Probe for transparent samples. Use reflective films with the RFP-200-UV-VIS Probe for turbid, dense samples.

Transmissive Indicator Dye Films for pH Sensing

Item	Film Type	pH Range	Color Change	Price
F-PR	Phenol Red	6.5-8.5	yellow-purple	$50
F-CR	Cresol Red	8.0-10.0	orange-purple	$50
F-MCP	m-Cresol Purple	8.5-10.5	yellow-purple	$50
F-TB	Thymol Blue	9.0-12.0	yellow-purple	$50
F-BY	Brilliant Yellow	7.0-9.0	yellow/red-purple	$50
F-xxx	Transparent Film	reference	not applicable	$50
FILM300	Sample pack of transmissive films			$50

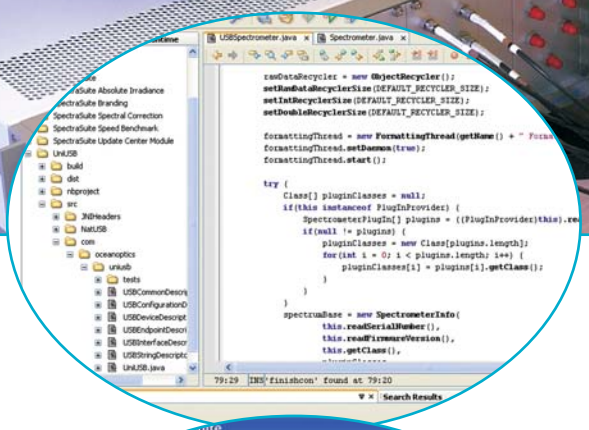
All pH films come in packages of 5 films.

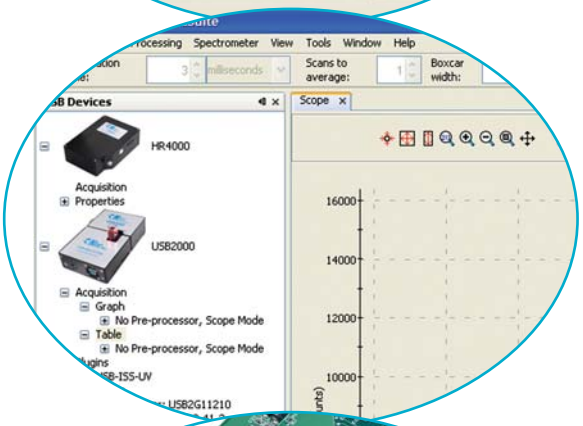
Reflective Indicator Dye Films for pH Sensing

Item	Film Type	pH Range	Color Change	Price
FR-PR	Phenol Red	6.5-8.5	yellow-purple	$50
FNY-PR	Phenol Red Nylon	6.5-8.5	yellow-purple	$50
FR-CR	Cresol Red	8.0-10.0	orange-purple	$50
FR-MCP	m-Cresol Purple	8.5-10.5	yellow-purple	$50
FR-TB	Thymol Blue	9.0-12.0	yellow-purple	$50
FR-BY	Brilliant Yellow	7.0-9.0	yellow/red-purple	$50
FILM	Sample pack of reflective films			$50

All pH films come in packages of 5 films.

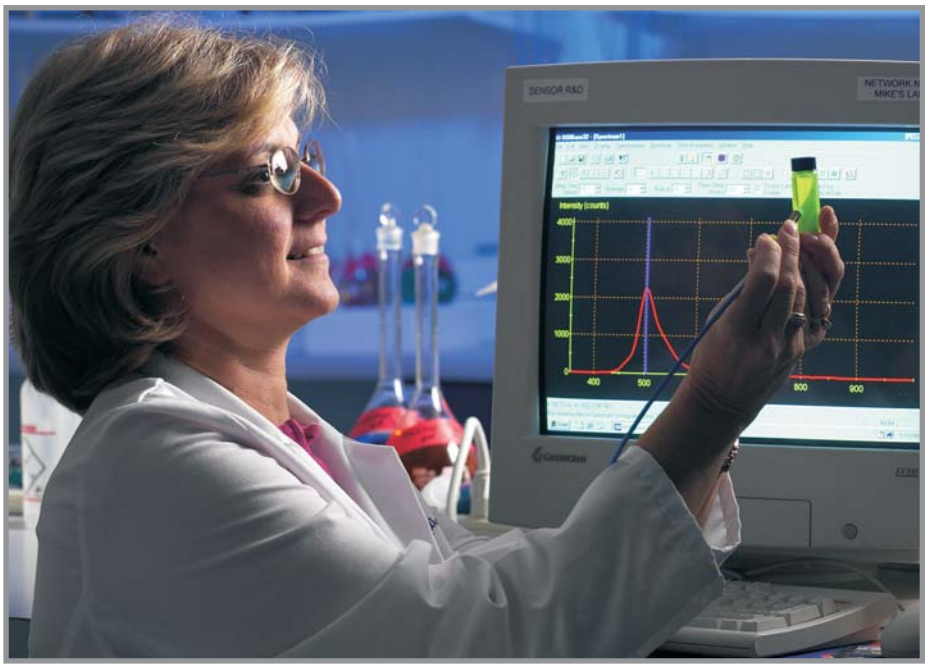
Software & Data Acquisition





Overview: Software & Data Acquisition

Real-time Interface to the PC of Your Choice

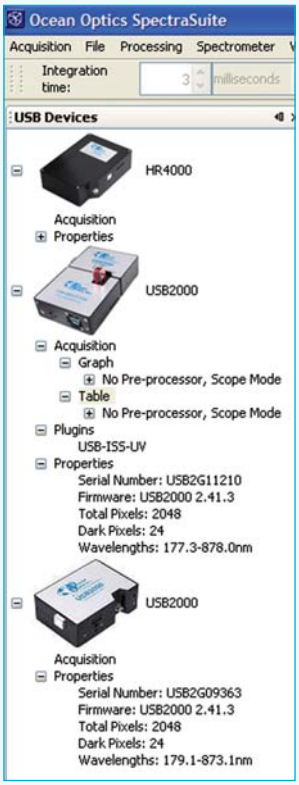


Ocean Optics data acquisition options allow you to interface your spectrometer to any desktop or notebook PC, whether it operates in Mac, Linux or Windows operating systems. Our plug-and-play spectrometers connect directly to the USB port of any desktop or notebook PC.

We also offer analog-to-digital converters, including USB, PCI-bus and ISA-bus cards. Real-time data acquisition for almost any type of application is made possible by our new operating, application and software development packages. We also offer custom software-development services.

The Joys of Java

Introducing SpectraSuite and OmniDriver: Multi-platform Marvels



You spoke, we listened. After nearly 15 years and thousands of spectroscopy applications, we've taken the best of your suggestions – and added a few clever wrinkles of our own -- to create the industry's first modular, operating system-independent spectroscopy software platform and driver. SpectraSuite, a Java-based spectroscopy software that operates on Windows, Macintosh and Linux operating systems, offers a host of robust features for remarkable power and flexibility.

Like SpectraSuite, OmniDriver is cross-platform, Java-based software. It combines the best of our earlier device driver packages – high-speed data acquisition, customization of acquisition and processing parameters, and so on – with additional features to make it the only spectroscopy driver you'll ever need.

There's much more on SpectraSuite and OmniDriver in the next few pages – so prepare to be dazzled.

More About Java

One of the most important decisions in developing SpectraSuite and OmniDriver was the selection of Java as the programming language. Java is an object-oriented programming language, developed in the mid-'90s by Sun Microsystems, Inc., that was designed as a robust, platform-independent programming environment that manages memory on its own. (When it comes to distributed applications, nothing beats Java. For additional information, visit java.sun.com.) We've taken Java a step further by making it platform- and spectrometer-independent – i.e., the same code works for all of our USB-based spectrometers.

A New Generation of Spectroscopy Software

SpectraSuite & OmniDriver

It's long been a goal of ours to create one hardware device driver program that would control all of our hardware as well as other manufacturers' devices, from any type of computer operating system environment and from which all software applications would run. The answer was to use Java as the programming language. Java was designed to be platform-neutral, making it the perfect programming language for our customers around the globe.

Ocean Optics is a member of Sun Microsystems' iForce Partner Program. Sun developed Java.

What SpectraSuite & OmniDriver Mean for You

Aside from the additional power and flexibility they provide, SpectraSuite and OmniDriver will affect customers in two significant ways. First, there is a $199 charge for SpectraSuite, a price that's comparable to what our competitors offer. Second, all existing Ocean Optics software will no longer be upgraded -- supported, yes; upgraded, no. Here's some additional important information about the transition to SpectraSuite and OmniDriver:

Q Does SpectraSuite replace OOIBase32? Is there a charge for SpectraSuite?

A Yes, SpectraSuite replaces OOIBase32, and yes, there is a charge for SpectraSuite -- $199. You'll still have access to free operating software -- OOIBase32 will be available for download from our website -- but it will no longer be upgraded and will not work with spectrometers developed and introduced after August 2005.

Q Can I upgrade from OOIBase32 to SpectraSuite?

A Absolutely. Anyone who provides us with the serial number of an Ocean Optics USB-interface spectrometer will be able to upgrade to SpectraSuite for just $99.

Q Which existing Ocean Optics software will SpectraSuite and OmniDriver replace?

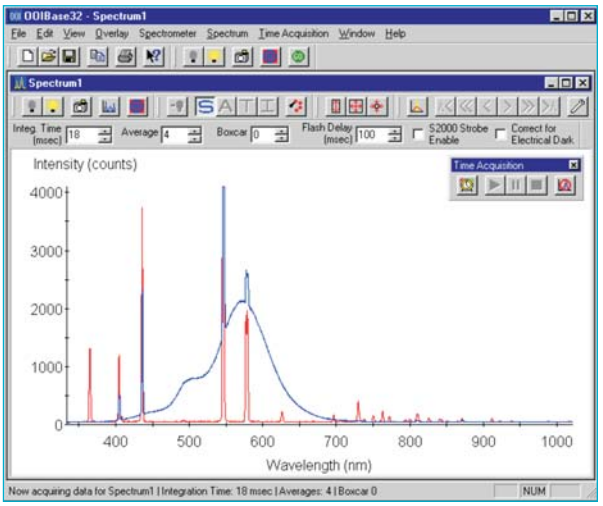
A OOIBase32 Spectrometer Operating Software and OOIBase32 Platinum Script-writing Software; plus the OOIWinIP Windows Interface Package, OOILVD LabVIEW Software Device Driver Package, OOIHSD High-speed Driver Library and OOISPM Spectral Processing Module. Windows CE tools such as OOIPS2000-S Operating Software and OOIHIP Handheld Interface Package will become obsolete.

Q What about existing applications software?

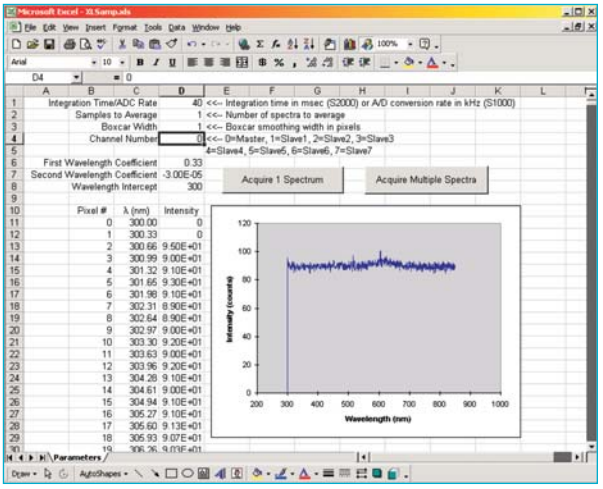
A SpectraSuite is the platform for all future Ocean Optics application software development. At press time, software applications including OOIChem, OOISensors, OOIColor and OOIIrrad-C were being migrated to the SpectraSuite platform. The applications software on pages 80-81 is actually the pre-SpectraSuite applications software.

Q Will Ocean Optics continue to support earlier versions of its software?

A Yes, we will continue to technically support old versions of all of our software products and, if necessary, post software fixes on our website. In fact, we still occasionally get support questions about SpectraScope – our original spectrometer operating software, which is older than dirt in software years. What we won't do is upgrade any older software with new features, nor will we upgrade older software to work with Ocean Optics hardware developed after August 2005.



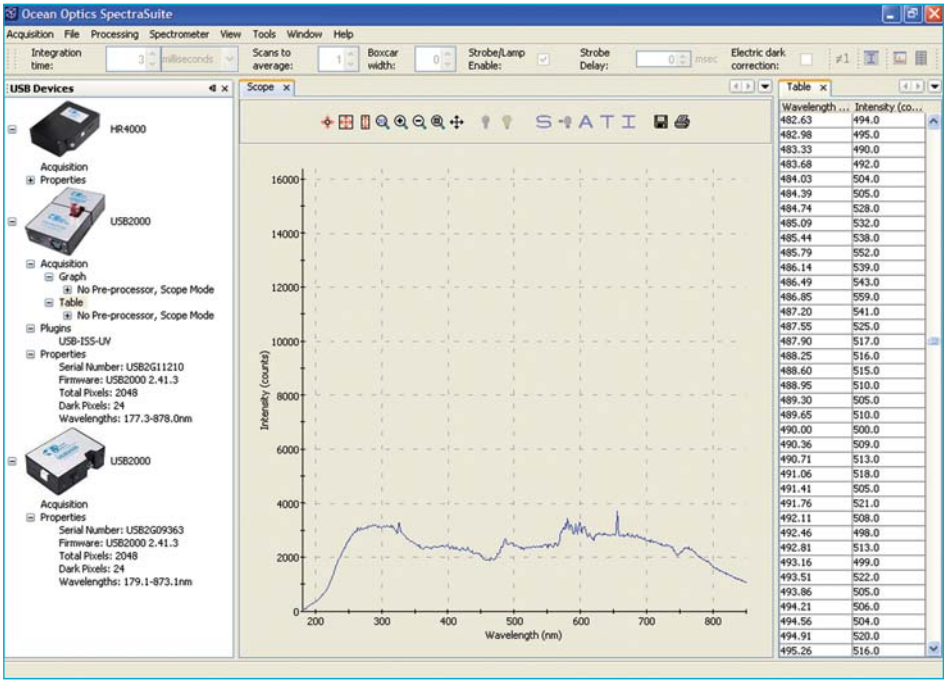
OOIBase32 (above), our free spectrometer operating software for over 6 years, will still be available for free download from our website – but it will no longer be upgraded and will not work with hardware created after August 2005. Our software products, including OOIWinIP Windows Interface Package for software development (below), will continue to be supported.



SpectraSuite Spectroscopy Platform Software

The New Revolution

In 1992, we revolutionized the optical sensing industry when we introduced the first-ever modular, miniature spectrometer. Now, with more than 55,000 spectrometers sold and the experience of thousands of applications, we're kick-starting the market again with SpectraSuite, the first modular, OS-independent spectroscopy software platform.



SpectraSuite is a platform-independent application that provides graphical and numeric representation of spectra in one window.

Spectroscopy on any Operating System

SpectraSuite is a completely modular, Java-based spectroscopy software platform that operates on Windows, Macintosh and Linux operating systems. The software can control any Ocean Optics USB spectrometer and device, as well as any other manufacturer's USB instrumentation (using the appropriate drivers). The SpectraSuite interface looks and feels the same on all operating systems yet retains the familiar appearance of an application native to each OS. Ocean Optics is the first to offer such a flexible, feature-packed application with this level of cross-platform capability.

Our Platform for the Future

SpectraSuite is the platform for all future Ocean Optics application software development. Current software applications including OOIChem, OOISensors, OOIColor and OOIIrrad-C will be migrated to the SpectraSuite platform in the near future.

Ultimate USB Spectrometer & Device Control

SpectraSuite easily manages multiple USB spectrometers – each with different acquisition parameters – in multiple windows, and provides graphical and numeric representation of spectra from each spectrometer. Using SpectraSuite, you can combine data from multiple sources for applications that include upwelling/downwelling measurements, dual-beam referencing and process monitoring.

Modular Framework Lets SpectraSuite Work The Way You Work

The SpectraSuite framework is modular, so that every function in it can be altered or replaced. For instance, the data acquisition functions, the scheduling functions, the data processing functions and the rendering functions are all separate modules. You can add or delete modules to create a proprietary user interface or functionality; create modules to perform calculations; automate experiment routines and more. You or your Ocean Optics application developer can easily customize SpectraSuite through Java code.

SpectraSuite

Can be used with these Ocean Optics Spectrometers:

USB2000

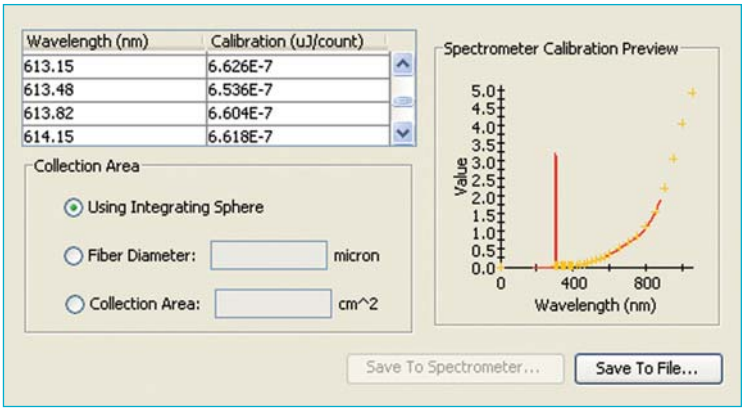
HR2000

HR4000

HR2000+

QE65000

when interfacing to a PC via USB port



SpectraSuite Spectroscopy Platform Software

Original Equipment Manufacturers

OEMs in particular will find SpectraSuite's modularity most beneficial, as all visual aspects of the program's user interface can be altered to create a fully branded application.

Advanced Data Capture Control

SpectraSuite provides the user with advanced control of episodic data capture attributes. For instance, a user can acquire data for a fixed number of scans or for a specific interval. Initiation of each scan can be externally triggered or event-driven. Captured data is quickly stored into system memory at speeds as fast as 1 scan per millisecond, with speeds limited by hardware performance.

21 CFR Part 11 Compliant

SpectraSuite is 21 CFR Part 11 compliant with an encoded binary file. This binary data format tracks the complete history of all processing steps that are performed on the data. SpectraSuite stores and provides data in a variety of other formats including tab-delimited ASCII (for Excel or other analysis packages), GRAMS SPC, and JCAMP. Additionally, SpectraSuite offers a database module where arbitrary data can be stored in any user-selectable format. Another benefit of the software's binary data tracking function is that it offers a user "process do-overs." A user can change the values of various parameters in a process and apply those changes to data without having to recreate an entire process.

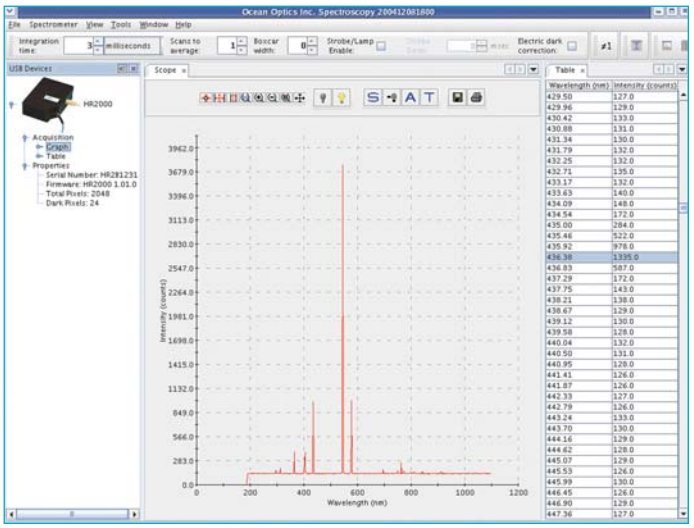
We Are The World

SpectraSuite is fully "internationalized." All of the software's menus, dialog boxes, prompts, messages and files can reflect a native language by simply changing a single file. Currently, modules that support English, German, Japanese and Russian are available. Support for Chinese, French and Spanish will be available in late 2005.

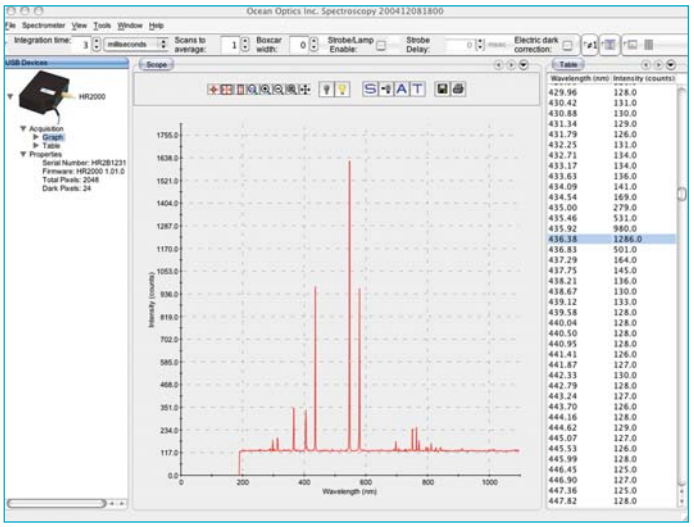
Limited-time Pricing

SpectraSuite is priced at $199. For all of our customers who can provide a serial number for an Ocean Optics spectrometer with a USB interface that was purchased before September 1, 2005, SpectraSuite is available for $99 for a limited time (specify SpectraSuite-I). To download upgrades to SpectraSuite, sign up for a yearly subscription (SpectraSuite-U). We also offer volume discounts, so please call for pricing of multiple copies. If you need unlimited copies of SpectraSuite, a site license can be purchased for $4,999, which allows one location, such as a university, to download as many copies of the software as necessary.

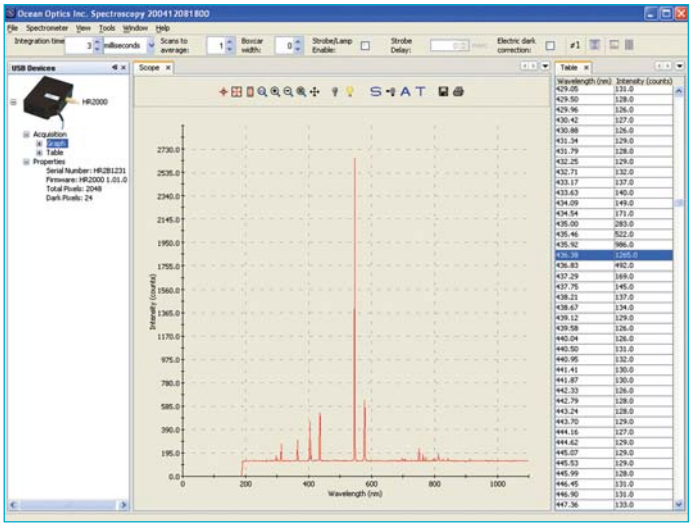
SPECTRASUITE:	$199
SPECTRASUITE-I:	$99
SPECTRASUITE-U:	$99
SPECTRASUITE-S:	$4,999



In a Linux Operating System.



In a Macintosh Operating System.

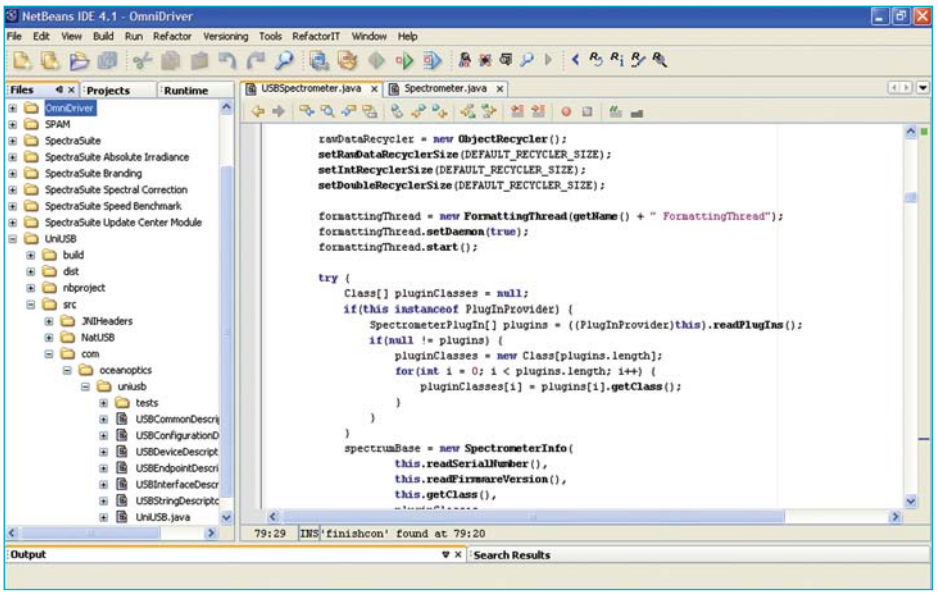


In a Windows Operating System.

OmniDriver Spectroscopy Development Platform

More Than a Device Driver

OmniDriver is more than just a device driver – it's a driving force – a multi-platform software marvel that eliminates OS-imposed boundaries and creates endless possibilities for those who demand absolute control of USB spectrometers, accessories and devices in their optical sensing systems.



A culmination of our best software driver packages, OmniDriver lets you harness the power of high-speed data acquisition, spectral processing, data analysis, visual data representation and data flow in a single cross-platform driver. Integrate OmniDriver into your own software application for complete control over USB spectrometers and devices in virtually any environment.

Developed in Java

OmniDriver was created in the Java environment and includes native libraries for select Windows, Macintosh and Linux operating systems. Using OmniDriver, you can develop robust applications to control multiple Ocean Optics USB spectrometers and direct-attach devices across these different operating systems. Ocean Optics is the first and only provider in the optical sensing industry to offer this level of cross-platform compatibility.

Why Java? Who Gives a Hill of Beans?

Java was designed as a platform-neutral development language, making it the perfect language for our customers who work in diverse industries, markets, environments and geographic areas. Applications written in Java are environment-independent; they can work across all operating systems. This is a very advantageous feature for product developers and OEMs wanting to expand their product offering with systems that work on multiple operating platforms.

Complete Platform & Device Independence

In developing OmniDriver, we took the Java philosophy a step further to create a device driver that is not only platform-independent, but also spectrometer-independent; the same Java code works with all Ocean Optics USB spectrometers and direct-attach devices. Plus, OmniDriver can control any manufacturer's USB spectrometer and supports any USB device with the appropriate drivers.

OmniDriver

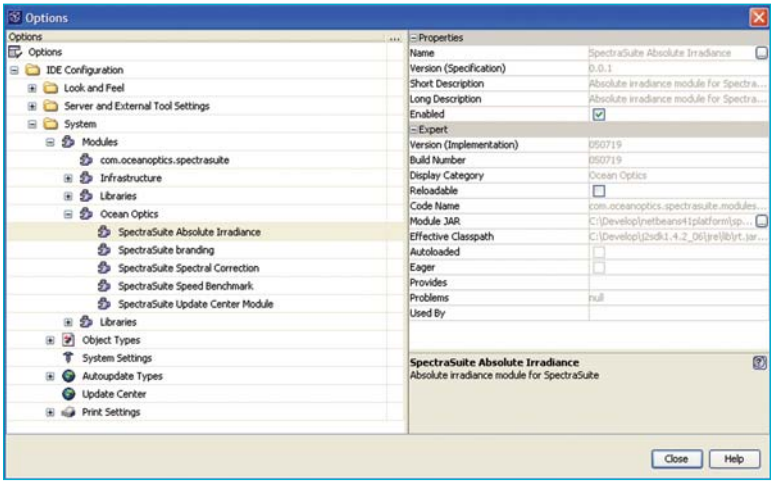
Can be used with these Operating Systems

Windows	**Windows 2000 or later**
Macintosh	**OSX 10.2 or later**
Linux*	**Red Hat 9 or later**
	Fedora Core, any version
	Debian 3.1 (Sarge)
	SUSE, 9.0 or later

** OmniDriver will work with any Linux OS with a kernel 2.4.27 or later and libstdc ++ version 5.*

Windows, Mac & Linux Driver: OmniDriver

"I don't know how to program in Java"
But chances are you know how to program in C, C++, Pascal, Visual Basic, Delphi, C++ Builder or one of many Microsoft Office Applications. The bottom line is that you don't need to know Java to use OmniDriver. Our wrapper libraries take care of the Java code; we provide Framework (Mac), Dynamic Link Library (Windows), Shared Object (Linux) and a .NET object (Windows). Did we mention that you don't have to know Java?



OmniDriver Components

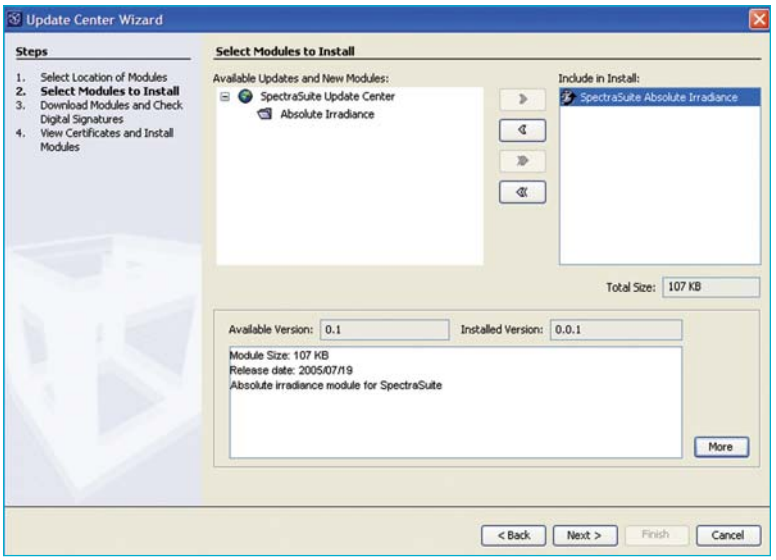
What does it take to make such a robust driver? OmniDriver offers these components:

UniUSB

The only fully functional cross-platform USB device driver library in existence! UniUSB lets software communicate with any USB device on any Windows, Macintosh or Linux operating system.

HighResTiming

Time stamping that is accurate to sub-microsecond performance; great for chemical kinetics and other applications that require complex time accountability.



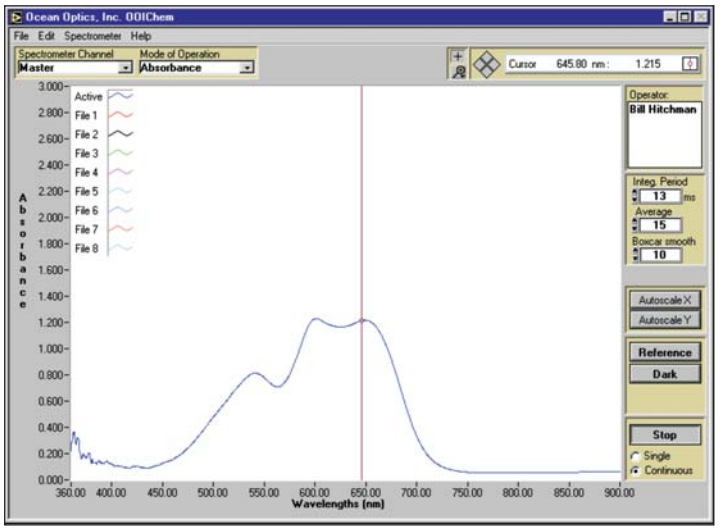
SPAM

Yes, you'll want this SPAM! Spectral Processing and Manipulation performs all spectral processing math from subtracting dark to radiometric color analysis. SPAM provides you with the ability to harness the power of Ocean Optics' spectral processing commands for your own applications and does not require you to use Ocean Optics spectrometers or hardware. SPAM is available as a stand-alone module or as part of the OmniDriver package (OMNI+SPAM).

OMNIDRIVER:	$399
SPAM:	$199
OMNI+SPAM:	$499

Application Software

Software for Chemistry Teaching Labs

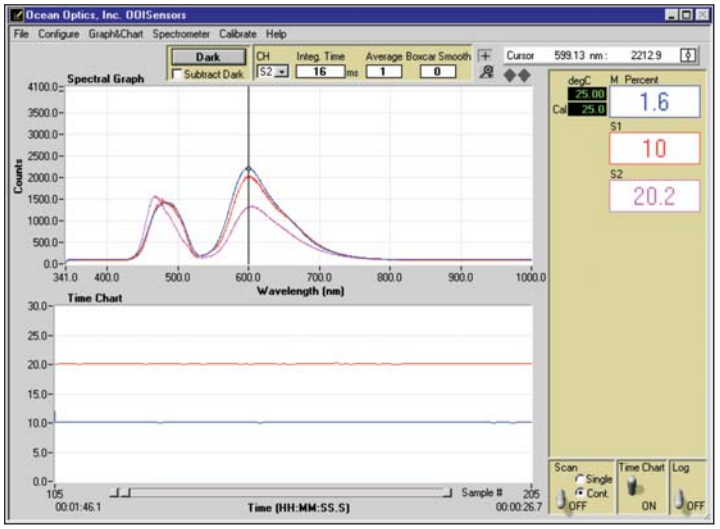


The user interface in OOIChem Software allows you to view a spectrum, such as the absorbance spectrum above, and make changes to acquisition parameters -- such as the integration period and boxcar smoothing -- in one window.

- Provides an easy-to-follow format ideal for undergraduate-level students and beginning spectroscopists
- Contains five modes of operation: Scope, Absorbance, Transmission, Relative Irradiance and Concentration
- Includes a Beer's Law spreadsheet for performing calibrations from standard solutions
- Adds into the spectral window as many as eight previously saved overlay spectra
- Performs kinetics experiments
- Saves data as ASCII files and stores and retrieves sample spectra
- Requirements: minimum 32 MB RAM and a Windows 32-bit operating system

OOIChem: $199

Software for Operating Sensors



OOISensors Software gives you the opportunity to view spectral data from multiple spectrometer channels (top part of the graph) as well as collect and view oxygen, sensor or pH data over time (bottom part of the graph).

Note: The applications described here are available as is, but soon will be migrated to our new SpectraSuite platform (pages 74-77). Consult an Applications Scientist for details.

- Operating software for our FOXY Fiber Optic Oxygen Sensing systems and Fiber Optic pH Sensors
- Obtains partial pressure, pH or concentration values from sensors
- Controls all system parameters
- Performs time acquisition experiments
- Collects data from up to eight spectrometer channels simultaneously and displays the results in a single spectral window
- Allows each spectrometer channel to have its own data acquisition parameters
- Monitors temperature and corrects the data for any fluctuations in temperature and pressure
- Oxygen calibration procedure supports first-and second-order polynomial algorithms
- Requirements: minimum 32 MB RAM and a Windows 32-bit operating system

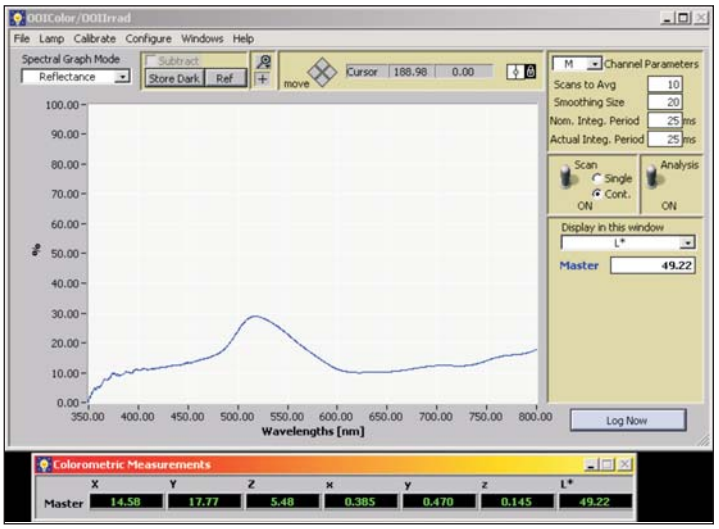
OOISensors: $199

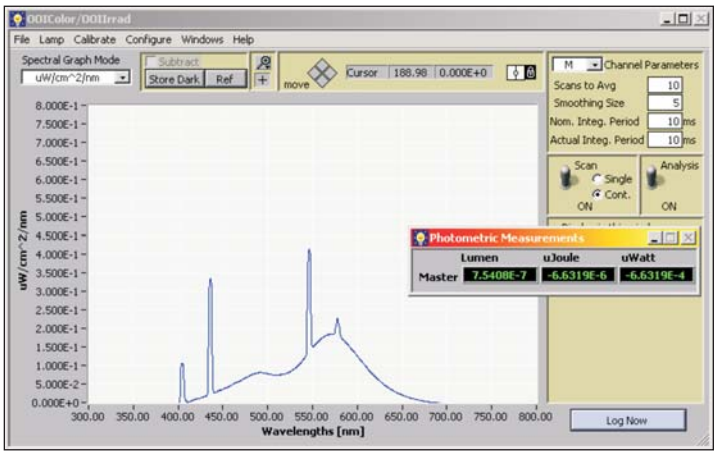
Application Software

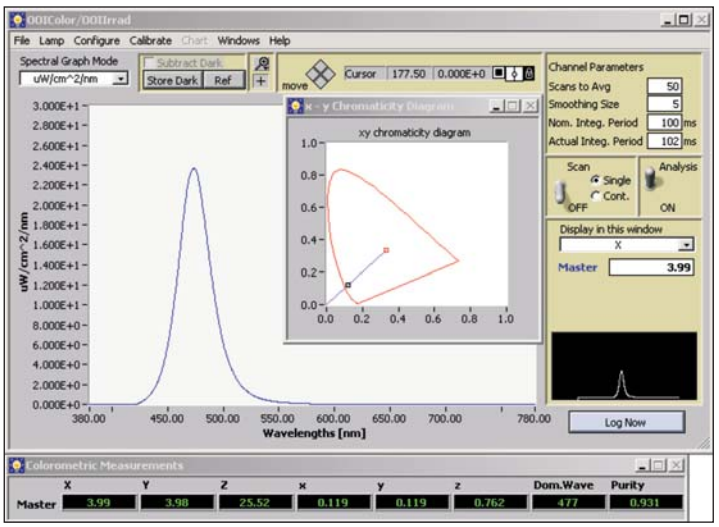
Software for Reflective & Emissive Color & Absolute Irradiance

- Provides radiometric and color analysis in one package
- Provides dominant wavelength and wavelength purity
- Analyzes peak wavelength, full width at half max, centroid and central wavelength
- Measures absolute spectral intensity of light and other emission sources
- Calculates integrated intensity between user-specified wavelengths
- Obtains photopic or scotopic data calculated in lumen, lux and candela based on CIE standards
- Provides microjoules, microwatts, number of photons and much more
- Calculates reflective or emissive color
- Provides color-space values XYZ and L*a*b* in graph form
- Offers CIE standard illuminants for reflective color (A, B, C, D50, D55, D65, D75, F1, etc.)
- Calculates L*a*b*, XYZ, xyz, u'v'w', hue, RGB, chroma, saturation, CCT (correlated color temperature) and more
- Supplies intensity values of 19 standard CIE illuminants and calibrates field tiles
- Requirements: minimum 32 MB RAM and a Windows 32-bit operating system

OOIIrrad-C: $399

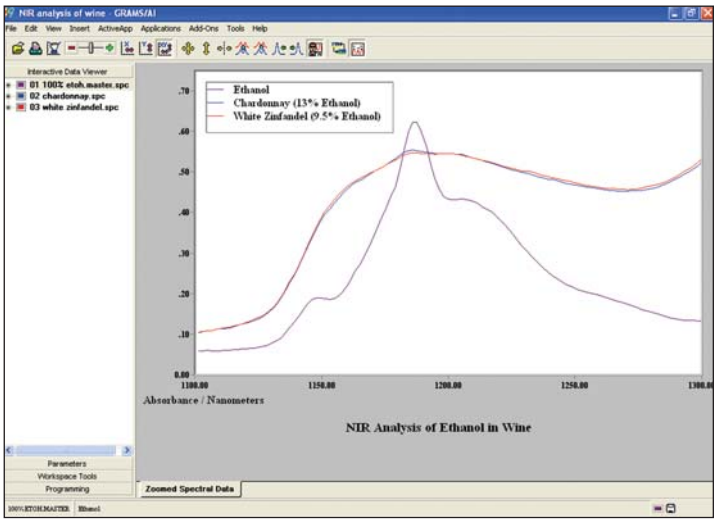






GRAMS Spectroscopy Software

GRAMS spectroscopy software provides great tools for visualizing, processing and managing spectroscopy data. The GRAMS software includes several productivity applications that can be used alone or work together. All Ocean Optics software allows you to save data in SPC and ASCII formats, both of which are supported by the GRAMS applications described here.



The GRAMS/AI window above shows wine analysis performed with our NIR-512 Spectrometer and then processed in GRAMS/AI.

GRAMS/AI

GRAMS/AI is a comprehensive processing, visualization and reporting package for data from many types of spectroscopic instruments. GRAMS/AI provides multiple methods for accessing data including directly loading data files created by Ocean Optics software and spectrometers. GRAMS/AI includes capabilities for interchanging data with Microsoft Excel, and can access data from other GRAMS applications such as Spectral ID spectral search libraries (see below).

Multi-page workbooks store specific data display preferences; workbook pages or even entire workbooks can be automated to perform specific functions or process data. The Design Science Equation Editor allows you to add mathematical formulas. From simple data smoothing to advanced peak fitting, GRAMS/AI tracks all file changes in the data set's Audit Trail section.

GRAMS/AI works with data from UV-VIS, fluorescence, Raman and NIR spectrometers and offers:

- Baseline correction (multi-point, polynomial fit), peak fitting (Gaussian, Lorentzian, Voigt), smoothing, derivatives, automatic spectral subtraction, spectral unit conversion, and more.
- Raman support such as ATR pathlength correction, interferogram compute, Kramers-Kronig transform, Raman shift correction, and a CCD spectrometer calibration routine.
- Colorimetric analyses such as L*a*b* using standard CIE illuminants.

GRAMSAI: $2,095

PLSplus/IQ

The PLSplus/IQ module allows you to create and deploy chemometric calibration models for the laboratory and the production line. Chemometric techniques such as PLS help to quickly analyze complex samples from their spectral signatures. PLSplus/IQ is designed to make this process as simple as possible:

- First, the spreadsheet-like Training Set Editor gathers all spectral data files together for a calibration.
- Next, the Experiment Manager creates combinations of modeling conditions to investigate as a series of separate "experiments." Each experiment consists of settings that define the model to be calculated. This includes model type (PLS, PCR, PCA), data preprocessing options and the spectral regions to use.
- Finally, you choose the type of model diagnostics to run and start the calculations.

GR-PLSPLUS/IQ $595

Spectral ID

Spectral ID is a comprehensive software package for spectral pattern matching or "library searching" for qualitative identification of compounds. It includes proven and powerful search algorithms for materials identification. You can easily add spectra to a custom collection using the QuickAdd feature, or by importing entire directories or lists of raw data files. Commercial spectral library collections can be combined with custom-built collections to give you broad coverage of compounds in a single search. You can combine Text, Peak and Full Spectrum searches, select specific spectral regions, or select whole spectra. You can even automatically remove the spectrum of a match from the spectrum of a mixture sample, then search the remainder spectrum again. Spectral ID can automatically link and share data with GRAMS/AI.

GR-SPECID: $749

SpecLine Software for Compound ID

Identifies Elements & Compounds

SpecLine Software is a powerful new tool designed for identifying atomic emission lines and molecular bands in spectral data. SpecLine's advanced evaluation, search, compare and identify functions -- and its extensive library of over 100 elements and over 400 compounds -- enable you to quickly identify unknown lines, peaks and bands. SpecLine was designed for scientists, engineers and researchers using emission spectroscopy in fields such as astrophysics, the plasma sciences, and plasma processing.

Searching and Comparing Data

In the Line Identification window, you can define all the parameters for your search in a Periodic Table screen (top right), and begin the process with just a single click. SpecLine can analyze even the most complex spectral data, including spectra with double lines, line shoulders and complex band structures. Up to 12 separate spectra, even if they are in different file formats, can be combined for comparative purposes.

Identification

SpecLine applies a variety of sophisticated filter functions such as Wiener-Fourier and polynomial noise removal to identify the elements and compounds in your spectra. After SpecLine applies comparative searches to its extensive atomic, ionic and molecular database of over 100 elements in several ionization states and over 400 elemental compounds, it provides detailed data on each identified peak and line, such as the name of the element, the peak's wavelength, the electron voltage and its transition state and quantum number.

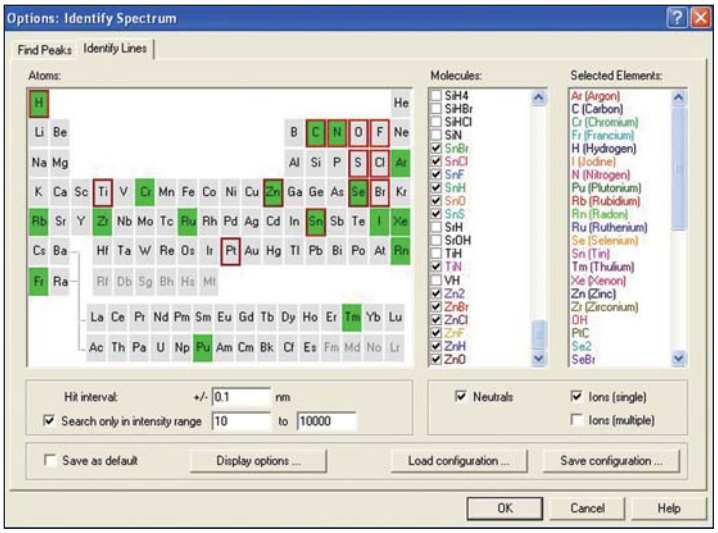
Opening Spectra & Saving Data

SpecLine can analyze spectral data from various spectroscopy software applications; it also can open all Ocean Optics software file formats as well as SPC and ASCII file formats. In addition, you can save all of SpecLine's identification data in its native file format or export it into various applications, such as Excel.

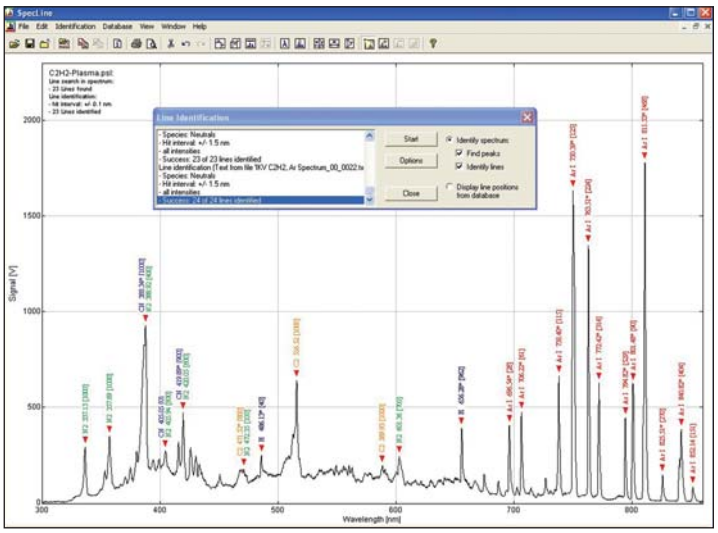
Hardware Keys

SpecLine Software comes with a USB or parallel-port (printer port) hardware key. The key is a security device to protect against unlicensed copies. It connects to an input/output port on your computer and must be used to run the software. SpecLine-U comes with a USB hardware key for use with Windows 98/2000/ME/XP operating systems (but not Windows 95 or NT). SpecLine-P comes with a feed-through parallel port hardware key.

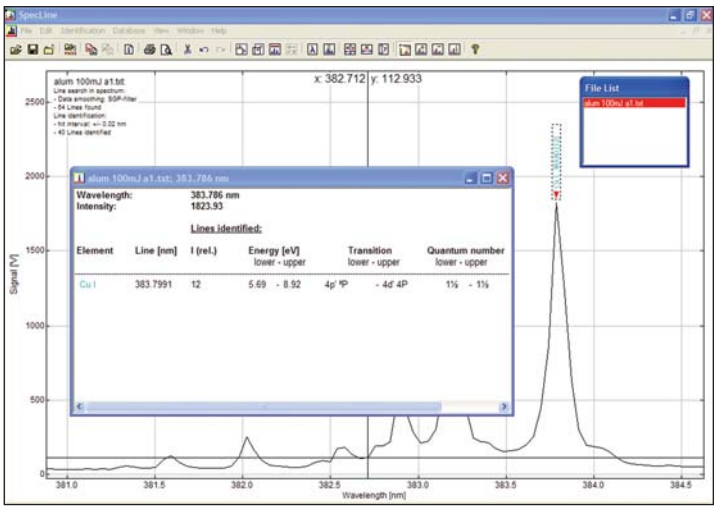
SPECLINE-P: $3,078
SPECLINE-U: $3,078



In the Identify Lines window, you can search atoms from a Periodic Table, molecules from an extensive list, and elements in single or multiple ionization states.



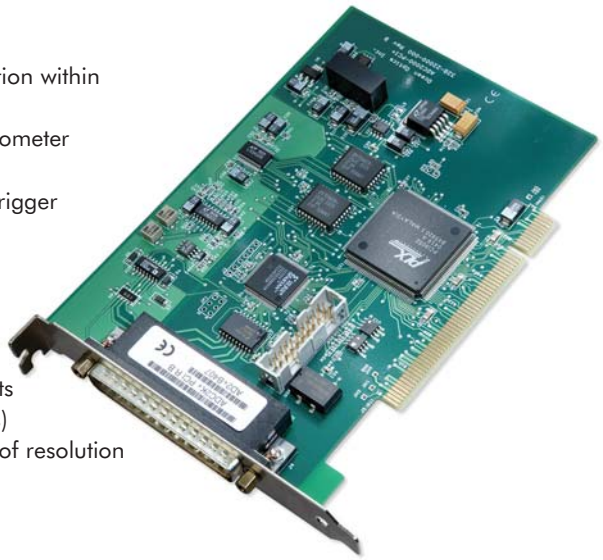
In this window, a search on the peaks and lines in a spectrum has been completed and identified successfully.



This window demonstrates SpecLine's ability to provide detailed data on just one emission line.

Analog-to-Digital Converters

ADC2000-PCI+ for PCI-bus



- This A/D card has 2 MHz sampling frequency for data acquisition within 2 milliseconds
- Channel rotator function acquires data from up to eight spectrometer channels simultaneously
- Has standard modes for free-running operation and external trigger modes for synchronizing external events
- Processes full scans into memory every 5 milliseconds
- Half-length, 12-bit A/D card fits easily into a PCI-bus slot in a PC and connects to the spectrometer via a 1-meter CBL-2 cable (included)
- Additional PC slot protector provides eight digital inputs/outputs and eight analog outputs (analog outputs incur additional fees)
- Provides advanced features such as pixel rotation with no loss of resolution

ADC2000-PCI+: $699
CBL-2 Cable: $50 (included)

ADC1000-USB for External USB

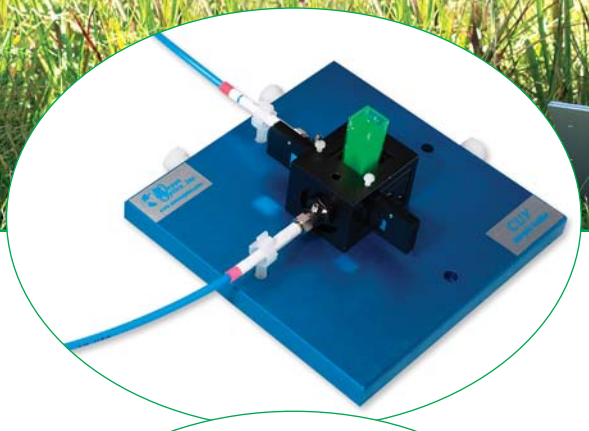
- Easily connects to PCs via USB port or serial port
- 1 MHz sampling frequency enables acquisition of data in 3 ms
- Plugs directly into back of your existing spectrometer (as in the main picture at right), or can be stacked or rack-mounted with the spectrometer in the same housing (see insets, one with housing and one without)
- Channel rotator function enables simultaneous acquisition of data from up to eight spectrometer channels
- Has standard modes for free-running operation and external trigger modes for synchronization of external events
- Provides D-Sub-15 pass-through for triggering the spectrometer and other accessories

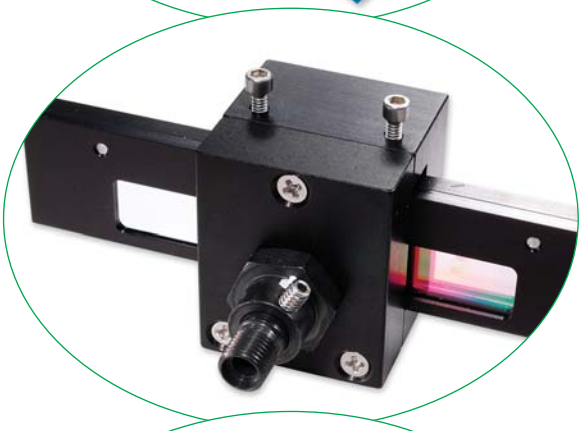
ADC1000-USB: $599
USB-CBL-1 USB Cable: $25 (included)
ADC-USB-SER Serial Cable: $49 (not included)

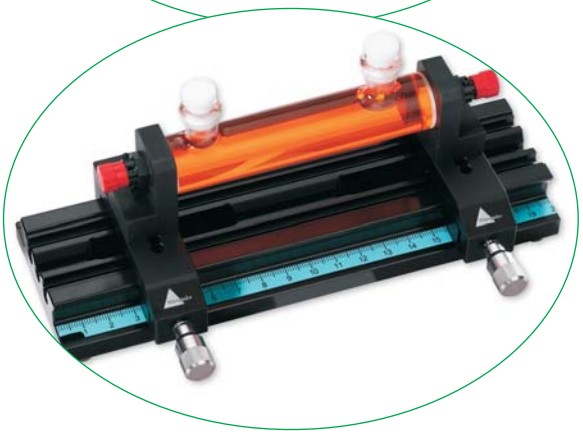
Specifications

	ADC2000-PCI+	ADC1000-USB
Dimensions:	168.8 mm x 127.9 mm x 18.3 mm	105.83 mm x 104.9 mm x 40.9 mm
Weight:	90 g	230 g
Power consumption:	250 mA @ 5 VDC	150 mA @ 5 VDC
Sampling frequency:	2 MHz (maximum)	1 MHz (maximum)
Integration time:	2 milliseconds to 60 seconds	3 milliseconds to 60 seconds
Data transfer rate:	Full scans into memory every 4 milliseconds; software time acquisition ~25 ms	Via USB port, full scans into memory every 14 milliseconds; via RS-232, full scans into memory every 300 milliseconds
Programmable flash delay:	0-65 seconds	0-255 milliseconds
Inputs/outputs:	8 digital I/Os	8 analog outputs, requires ADC-1000-DAC
Shutdown S2000 power:	yes	no
Spectrometer compatibility:	Supports S2000 Spectrometers	Supports S2000 and S1024DW Spectrometers
Board architecture/design:	32 bit/PCI bus	USB and RS-232 interface external A/D board
Operating systems:	Any 32-bit Windows operating system	Via USB port, Windows 98/Me/2000/XP, Mac OS X and Linux Via RS-232, any 32-bit Windows operating system
Interface cable:	Comes with a 25-pin, 1-meter cable for connecting the ADC2000-PCI+ to the spectrometer	Via USB port, comes with 1-meter cable (USB-CBL-1) to connect ADC1000-USB to PC Via RS-232, requires serial cable (not included, order ADC-USB-SER)
Software compatibility:	All 32-bit Ocean Optics software, except SpectraSuite and OmniDriver	
Multiple-channel capability:	Up to eight spectrometer channels	
A/D resolution/channels:	12 bit/up to 8 spectrometer channels	
Rotator capability:	yes	
Trigger modes:	3	

Sampling Accessories







Overview: Sampling Accessories

Sampling Accessories for Every Application

Ocean Optics provides modular components that can be configured easily for absorbance, transmission, reflectance, fluorescence, emission or scattering experiments. Often the sampling accessory is where light or excitation energy is collected from the light source, interacts with the sample, and sends the absorbed/transmitted, reflected or emitted light to the spectrometer. Sampling accessories also include the fixtures, such as collimating lenses, that provide specific sampling geometries. Accessories and fibers can be combined in an almost endless variety of configurations.

What's Your Field of View?

Four of our devices are used to control field of view (FOV) and aperture:

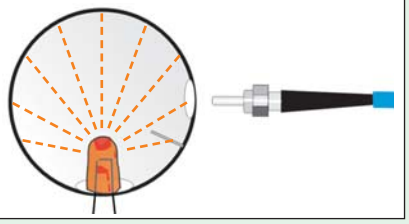
- Optical Fiber (25° FOV, aperture = fiber diameter)
- Collimating Lens (0° - 45° FOV, aperture = 3 mm)
- Cosine Corrector (180° FOV, aperture = 3.9 mm)
- Integrating Sphere (360° FOV, aperture = 25 mm)

Optical Fiber: 25°

Adjustable Collimating Lens: ~0-45°

Cosine Corrector: ~180°

Integrating Sphere: 360°



Partner Spotlight: Mikropack

We've known the folks at Mikropack GmbH ever since the German supplier of thin film and spectroscopy products became a distributor of our products nearly a decade ago. Today, Ocean Optics is the exclusive worldwide distributor of Mikropack spectroscopy products, and remains a supplier of OEM spectroscopy components used in Mikropack's thin film and ellipsometry measurement systems.

By adding nearly 200 of Mikropack's spectrometer sampling accessories, light sources and more to our product line, we're able to offer our customers the most comprehensive line of miniature fiber optic spectroscopy products in the industry. Mikropack benefits from another sales outlet for its products, the integration of our spectrometers into its thin film measurement products, and the resale of our products in Germany, Austria and Switzerland.

TECH NOTE

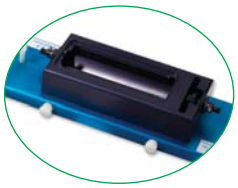
The divergence **(a)** of a beam focused using a single lens is: **tan(a) = d/f** where **f** is the focal length of the lens and **d** is the aperture or fiber diameter.

Sampling Accessories by Measurement Type

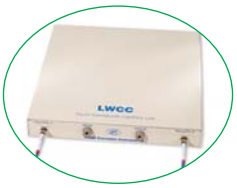
Our fiber optic sampling accessories create the optical interface part of our modular spectrometer systems. With so many sampling accessories from which to choose, you can meet the demands of a variety of experiments for absorbance, transmission, fluorescence, reflectance and emission.

Absorbance/Transmission

1-cm Cuvette Holder, p. 90



10-cm Cuvette Holder, p. 90



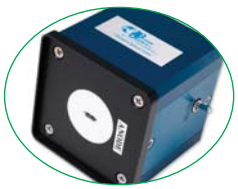
Longpass Flow Cells, p. 98

Cuvettes, p. 93

Integrated Sampling Systems, p. 92

Emission

Cosine Correctors, p. 107



LED Power Supply, p. 107

Integrating Spheres, p. 108

Collimating Lenses, p. 88

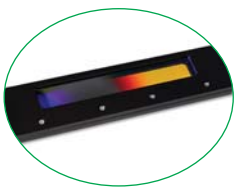
Direct-attach Integrating Sphere, p. 108

Fluorescence

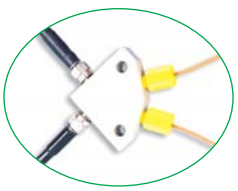
4-way Cuvette Holder, p. 90

Temperature-regulated Cuvette Holder, p. 91

EviDots and EviTags, p. 106



Linear Variable Filters, p. 94

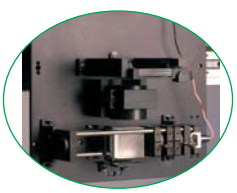


Flow Cells, p. 100

Reflectance

Diffuse Reflectance Standard, p. 110

Integrating Spheres, p. 109



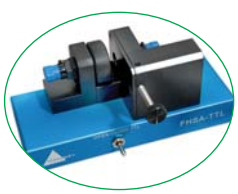
Long Trace Profilometer, p. 116

Reflection Stage, p. 115

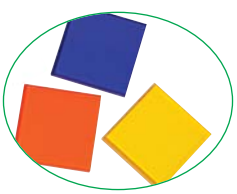
Reflection Sampling System, p. 114

Modifying Light

Variable Attenuator, p. 104



Filter Holders, p. 97



Filters, p. 96

Gershun Tube Kit, p. 105

Multiplexer, p. 104

Collimating Lenses

74-series Lens Fixtures

The 74-series Collimating Lenses are the common fiber optic-coupled lens fixture used throughout our extensive line of sampling accessories. The 74-series Lenses have an inner barrel threaded for SMA 905 Connectors. (FC barrels are available for $29; see page 156 for more.) The inner barrel slides relative to the lens fixture for adjusting the focus; a setscrew secures the barrel. Adjustment from a converging to diverging field of view (~45°) is possible.

74-UV Collimating Lens (200-2000 nm)
The 74-UV has an f/2 fused silica lens for 200-2000 nm. When focused for collimation, beam divergence is 2° or less, depending on fiber diameter. The 74-UV can be adjusted for UV-VIS or VIS-NIR setups.

74-VIS Collimating Lens (350-2000 nm)
The 74-VIS -- the basic lens fixture in an LS-1 Light Source -- has a BK-7 lens suitable for the VIS-NIR. These single-lens systems have the disadvantage of chromatic aberration, due to dispersion or variation in refractive index with wavelength.

74-ACR Collimating Lens (350-2000 nm)
The 74-ACR has two optical elements cemented together to form an achromatic doublet, optimized to correct for the spherical and chromatic aberrations inherent to single-lens systems.

74-DA Collimating Lens (200-2000 nm)
The 74-DA screw-in lens attaches directly to spectrometers for increased light throughput.

84-series Lens Fixture

The 84-series Collimating Lens is designed for coupling larger free-space beams to fibers. The fiber is coupled to the assembly with an inner 17.85-mm threaded barrel. The barrel positions the fiber ~100 mm from the lens surface and is adjusted to achieve a fine focus. The lens of the 84-UV-25 is especially suitable for collimating light at long distances in open air (it's been tested to distances of up to 40 feet). The 84-UV-25 has an 8-32 tapped hole for attaching to an optical post mount and then installing the mount in an optical breadboard or other fixture (far right).

Item	Diameter	Focal Length	Material	Wavelength	Operating Temp.	Connector	Price
74-UV	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$159
74-VIS	5 mm	10 mm	f/2 BK-7 glass	350-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$159
74-DA	5 mm	10 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 1/4-36 internal thread, 3/8-24 external thread	$159
74-ACR	5 mm	10 mm	BaF10 and FD10	350-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$199
74-UV-HT	5 mm	10 mm	High-temperature version of 74-UV	200-2000 nm	150 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$159
84-UV-25	25.4 mm	100 mm	f/2 fused silica Dynasil	200-2000 nm	70 °C	SMA 905, 6.35-mm ferrule, 3/8-24 external thread	$499

Collimating Lens Accessories

Right-angle Collimating Lens Holder

The 74-90-UV is an assembly for mounting lenses at right angles, and is especially useful for applications involving awkward optical fiber routing. It has a mirror located under its cap that reflects light from the collimating lens to 90°. Two ports accommodate 74-series Collimating Lenses (not included). An included nipple allows you to mount the 74-90-UV in male or female ports.

74-90-UV: $139

A Collimating Lens, above, is not included with the 74-90-UV.

Adjustable Collimating Lens Holders

The 74-ACH Adjustable Collimating Lens Holder (near right) consists of adjustable bars with several threaded holes for collimating lenses. The bars can be set far enough apart to accept samples up to ~100 mm thick, making the 74-ACH a convenient option for transmission measurements of large samples. (Collimating lenses and optical fibers not included.)

74-ACH Adjustable Collimating Lens Holder

The ACH-CUV-VAR Adjustable Collimating Lens and Cuvette Holder (see inset) is two products in one: a fixture for positioning collimating lenses at various heights or for holding extra-large or especially thick samples, and a holder for accepting cuvettes for transmission measurements. Its adjustable mount bars accept samples up to ~150 mm thick and its threaded holes hold collimating lenses (two 74-UV Collimating Lenses are included).

74-ACH: $299
ACH-CUV-VAR: $1,323

ACH-CUV-VAR Adjustable Collimating Lens and Cuvette Holder

Optical Post-mount Assembly

Also available is the OPM-M, which is a post-mount assembly for optical tables with metric M6 grids. The OPM-M has a lens holder (for a 74-UV Collimating Lens), an M4 metric optical post and an M6 metric post holder.

OPM-M: $180

OPM-M Optical Post Mount Assembly

OPM-1, OPM-2 and OPM-4 Optical Posts

OPM-SMA Optical Post Mount

Optical Post Mount & Optical Posts

The OPM-SMA is a fixture for mounting 74-series Collimating Lenses and SMA 905-terminated optical fibers. The OPM-SMA consists of a 1.5" OD disk with 3/8-24 threads to accommodate the lenses. You can use the OPM-SMA with SMA 905-terminated optical fibers. The OPM-SMA includes 8-32 (Imperial) and M6 (metric) threads for attaching to an optical post.

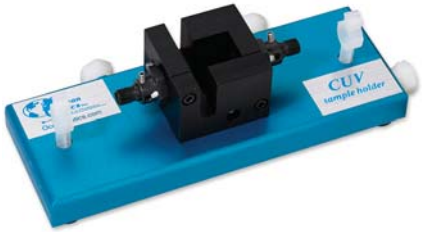
We offer four optical posts (in 25.4-mm, 50.8-mm, 76.2-mm and 101.6-mm heights) to attach to the OPM-SMA. These posts screw into optical bread-boards via a 1/4-20 tapped hole in the bottom of each post.

OPM-SMA: $149
OPM-1, -2, -3, -4: $15 each

Specifications

	74-90-UV	74-ACH	ACH-CUV-VAR	OPM-SMA	OPM-M
Dimensions (in mm):	16.5 x 16.5 x 19.9	152.4 x 76.2 x 152.4	200 x 67 x 157	38.1 OD x 10.2 width	30 mm OD x 6.5 width
Weight:	11.3 g	890.2 g	1,000 g	130 g (including post)	220 g (including post)
Threads:	3/8-24 (ports) 9.525 x 25.4 mm (nipple)	3/8-24 (mounting bars) 10-32 (setscrews for base)	3/8-24 (mounting bars) M6 (setscrews for base)	3/8-24 (lens holder) 8-32 (bore for mounting)	3/8-24 (lens holder) M4 (bore for mounting)
Material:	Black anodized Al	Blue anodized Al (base) Black anodized Al (bars)	Black anodized Al (base) Black anodized Al (bars)	Black anodized Al (mount) Stainless steel (post)	Black anodized Al (mount) Stainless steel (post)
Collimating lens included:	No	No	(2) 74-UV Lenses	No	No

Cuvette Holders



CUV-UV Cuvette Holder

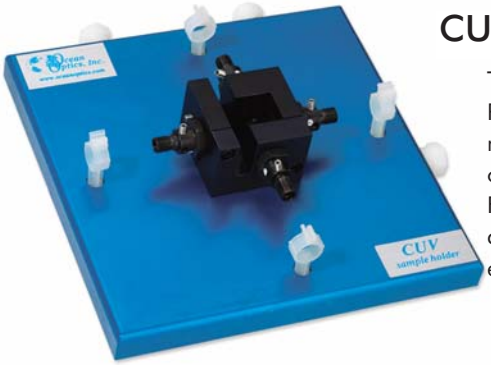
The CUV-UV (200-2000 nm) couples to lamps and spectrometers to create absorbance or transmission measurement systems. Two 74-UV lenses are mounted across a cell holder for square 1-cm cuvettes. The base includes channels for connection to a water bath for temperature regulation. The unit also accepts filters. An optional cover (CUV-COVER) excludes ambient light.

CUV-UV: $399

CUV-UV-10 Cuvette Holder

The CUV-UV-10 (200-2000 nm) accepts 10-cm cylindrical or flat-bottomed cuvettes. The CUV-UV-10 has two 74-UV Collimating Lenses that couple to light sources and spectrometers via optical fiber to make absolute absorbance systems for solutions and gases. Included is a shutter, a clamp for filters, water channels for temperature regulation, and a cover to exclude ambient light.

CUV-UV-10: $549



CUV-ALL-UV 4-way Cuvette Holder

The CUV-ALL-UV provides ports for 1-cm cuvettes from four directions. Position two collimators at 180° for absolute absorbance and transmission measurements, position two collimators at 90° for fluorescence or scattering, or use all four for simultaneous absorbance and fluorescence measurements. For fluorescence applications, increase the signal by replacing collimators with 74-MSP Mirror Plugs (see inset), which redirect energy back to the sample or back into a collimating lens.

CUV-ALL-UV: $809
74-MSP: $99

CUV-FL-DA Direct-attach Cuvette Holder

The CUV-FL-DA attaches to our light sources and couples via fibers to our spectrometers, creating systems for fluorescence and relative absorbance. The holder has a collimating lens and two mirrored screw plugs (74-MSP), which can be positioned per your application. A 6.35-mm slot is included for filters.

CUV-FL-DA: $399

CUV-VAR Variable Pathlength Cuvette Holder

The CUV-VAR has three functions: use its cuvette holder insert to create a 1-10 cm pathlength cuvette holder, create a 2-mm pathlength filter holder, or position its two 74-UV collimators to accept a flow cell. The included collimators are screwed into fixtures that slide along the base and can be set to create pathlengths up to 10 cm. Also available is a flow-cell adapter option (CUV-VAR-OPTION) for the CUV-VAR.

CUV-VAR: $1,186
CUV-VAR-OPTION: $363

Specifications

	CUV-UV	CUV-UV-10	CUV-ALL-UV	CUV-FL-DA	CUV-VAR
Dimensions:	58 mm x 140 mm x 38 mm	97 mm x 248 mm x 50 mm	147 mm x 147 mm x 40 mm	57 mm x 61 mm x 29 mm	200 mm x 67 mm x 70 mm
Weight:	230 g	1,040 g	540 g	80 g	726 g
Pathlength:	1 cm	10 cm	1 cm	1 cm	1 cm up to 10 cm
Filter slot:	Up to 6 mm, screw clamp	Up to 6 mm, wheel clamp	Up to 6 mm, screw clamp	Up to 6 mm, screw clamp	none
Water input fittings:	3.175-mm (1/8") NPT	3.175-mm (1/8") NPT	3.175-mm (1/8") NPT	none	none
Collimating lenses:	2 each 74-UV	2 each 74-UV	4 each 74-UV	2 each 74-UV	2 each 74-UV
Fiber termination:	SMA 905	SMA 905	SMA 905	SMA 905	SMA 905
"Z" dimension:	15 mm	15 mm	15 mm	15 mm	15 mm

Temperature-regulated Cuvette Holder

Precise Temperature Control

The CUV-TLC-50F Temperature-regulated Cuvette Holder is a high-quality, versatile sample chamber with a Peltier temperature controller calibrated against a NIST-traceable thermometer. The device controls the temperature of the holder from -55 °C to +105 °C and maintains a constant temperature to within ± 0.02 °C. The CUV-TLC-50F includes the cuvette holder and the external temperature controller box. To run the thermoelectric cooler efficiently, we offer a simple water pump and a water container.

Absorbance or Fluorescence

The CUV-TLC-50F (200-2000 nm) provides ports for viewing or illuminating 1-cm square cuvettes from four directions. Lenses are purchased separately to allow you to choose the best lenses for your application. For absorbance and transmission measurements, position two CUV-TLC-CL Collimating Lenses at 180°. For fluorescence applications, position two CUV-TLC-IL Imaging Lenses at 90° and position two CUV-TLC-MP Mirror Plugs in the remaining two collimator positions for increasing light throughput.

The CUV-TLC-IJ Insulation Jacket.

A Collimating Lens (far left) and Mirror Plug.

Additional Features

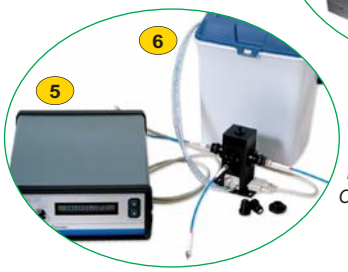
- A dry gas purge rids the chamber of condensation when operating at low temperatures or excludes O_2 (tubing for water and gas connections are included)
- Variable-speed magnetic stirring (a stir bar is included)
- Slit slots for each collimating lens port for modifying light entering and/or leaving the sample chamber (several removable optical slits included)

Another option is the CUV-TLC-FH Filter Holder.

PC Adapter Package

An optional CUV-TLC-ADP adapter package comes with Windows-compatible software that allows you to remotely start a test sequence, operate the controller box and monitor experiments. Without the CUV-TLC-ADP, you can control the holder's temperature mechanically from the controller box.

An absorbance setup might include the USB2000 Spectrometer, an LS-1 Light Source and two optical fibers.



The CUV-TLC-50F includes the controller box and the cuvette holder. Optical fibers and the CUV-TLC-BATH are separate.

Specifications	
Full (maximum) temperature range:	-55 °C to +105 °C
Normal temperature range:	0 °C to 85 °C
Precision:	±0.02 °C
Reproducibility:	±0.05 °C
Maximum illuminated area:	12 x 10 mm
"Z" dimension:	8.5 mm

	Item	Description	Price
1	CUV-TLC-50F	Fiber optic temperature-controlled cuvette holder and controller box with slits, magnetic stirrer and tubing	$3,820
2	CUV-TLC-FH	Filter holder for the CUV-TLC-50F	$470
3	CUV-TLC-CL	AR-coated fused-silica collimating lens with SMA 905 Connector (comes with steering plate)	$180
4	CUV-TLC-MP	Mirror plug for use with CUV-TLC-IL when conducting fluorescence measurements	$70
5	CUV-TLC-ADP	Optional PC adapter package for remotely operating the cuvette holder (serial cable included)	$95
6	CUV-TLC-BATH	Water pump and bucket for running the thermoelectric cooler efficiently	$99
7	CUV-TLC-IJ	Insulating jacket for the CUV-TLC-50F	$175
	CUV-TLC-IL	Imaging or focusing lens snaps onto CL collimating lens with SMA 905 Connector (comes with steering plate)	$290
	CUV-TLC-SP	Steering plate that mounts a lens or mirror plug onto the cuvette holder	$50
	CUV-TLC-ABSKIT	A kit for absorbance/transmission; contains CUV-TLC-50F, CUV-TLC-ADP, two CUV-TLC-CL, CUV-TLC-BATH	$4,374
	CUV-TLC-FLKIT	A kit for fluorescence; contains the CUV-TLC-50F, the CUV-TLC-ADP, two CUV-TLC-IL, two CUV-TLC-MP, two CUV-TLC-SP, CUV-TLC-BATH	$4,834
	CUV-TLC-MPKIT	A kit with all of the items necessary for absorbance/transmission and fluorescence	$4,964

Integrated Sampling Systems

An Integrated Sampling System is a spectroscopy accessory where the light source and sample compartments have been integrated into one package. These systems perform the same function as our cuvette holders, but have an advantage in that one or both fibers are eliminated from the setup.

USB-ISS-UV-VIS Integrated Sampling System

The USB-ISS-UV-VIS Integrated Sampling System is a direct-attach sample holder and deuterium tungsten halogen light source for 1-cm square cuvettes. The USB-ISS-UV-VIS allows you to adjust the intensity of the bulb via software. The sampling system has an electronic shutter for taking dark measurements and comes with a 5-volt power supply.

USB-ISS-UV-VIS: $1,499

USB-ISS-VIS Integrated Sampling Systems

The USB-ISS-VIS and USB-ISS-T both have a violet LED-boosted tungsten source and a sample holder that bolts to a 10-pin connector on the front of a USB2000 Spectrometer, which provides the power and control signals for the light source. The USB-ISS-VIS holds 1-cm cuvettes while the USB-ISS-T holds 12-mm OD test tubes. Both sampling systems cover the 390-900 nm range.

USB-ISS-VIS: $499
USB-ISS-T: $499

ISS-UV-VIS Integrated Sampling System

The ISS-UV-VIS combines a light source with a 1-cm cuvette holder for absorbance measurements. The ultraviolet light is provided by a deuterium bulb; visible light from a tungsten halogen bulb is focused through the deuterium lamp onto a diffuser. Solarization-resistant fiber (not included) is recommended. A 12 VDC wall transformer is included.

ISS-UV-VIS: $1,599

ISS-2 Integrated Sampling System

The ISS-2 combines a tungsten halogen light source with a diffuser on the illumination side and a collimating lens on the receiving side of a 1-cm cuvette holder, for absorbance measurements. A fiber (not included) connects the ISS-2 to any of our miniature spectrometers. A 12 VDC wall transformer is included.

ISS-2: $799

Specifications

	USB-ISS-UV-VIS	USB-ISS-VIS	USB-ISS-T	ISS-UV-VIS	ISS-2
Dimensions (mm):	198 x 105.1 x 40.6	40.7 x 88.8 x 34.1	40.7 x 88.8 x 34.1	198 x 104.9 x 40.9	155 x 50 x 53.3
Weight:	200 g	130 g	130 g	400 g	240 g
Power consumption:	1.8 A @ 5 VDC	160 mA @ 5 VDC	160 mA @ 5 VDC	420 mA @ 12 VDC	600 mA @ 12 VDC
Wavelength range (source)*:	200-2000 nm	390-2000 nm	390-2000 nm	200-2000 nm	400-2000 nm
Pathlength:	1 cm	1 cm	12 mm OD	1 cm	1 cm
Cuvette shape:	Square	Square	Round test tube	Square	Square
Light source:	Deuterium tungsten	Tungsten and violet LED	Tungsten and violet LED	Deuterium tungsten	Tungsten
Bulb life (hours):	800 (deut.); 2,000 (tung.)	45,000	45,000	800 (deut.); 2,000 (tung.)	900
Time to stabilized output:	~30 minutes	~5 minutes	~5 minutes	~30 minutes	~30 minutes
Filter slot:	None	None	None	None	6.35 mm
Recommended optical fibers:	None	None	None	QP400-025-SR	QP400-2-UV-VIS
Spectrometers:	USB2000	USB2000	USB2000	All	All
"Z" dimension:	15 mm	15 mm	15 mm	15 mm	15 mm

* *The wavelength range of the source may exceed the wavelength range of your spectrometer.*

Cuvettes & Sample Cells

Disposable UV & VIS Cuvettes

Our CVD-series Disposable Cuvettes are a low-cost, no-maintenance alternative to quartz cuvettes. All cuvettes have a 1-cm pathlength, 220-900 nm or 350-900 nm wavelength range coverage, and various filling volumes.

CVD-UV1S

CVD-UV1U

CVD-VIS1S

CVD-VIS1M

Item	Range	Material	Volume	Window in mm	Clear Sides*	Cover Needed	Price
CVD-UV1S (100 pk)	220-900 nm	Plastic	1.5-3.0 mL	4.5 x 23	4*	square	$55
CVD-UV1S-SAM (8 pk)							$10
CVD-UV1U (100 pk)	220-900 nm	Plastic	70 mL-1.8 mL	2 x 3.5	2	round	$55
CVD-UV1U-SAM (8 pk)							$10
CVD-VIS1S (100 pk)	350-900 nm	Polystyrene	1.5-3.0 mL	5 x 23	4*	square	$13
CVD-VIS1M (100 pk)	350-900 nm	Polystyrene	2.5-4.0 mL	10 x 35	2	square	$11

Cuvettes with 4 clear sides are suitable for fluorescence measurements. Cuvettes with 2 clear sides are for "straight-through" absorbance and transmission measurements.

Cuvette Covers

Disposable cuvette covers (top) come in packs of 100.

CVD-ROUND: $20

CVD-COVER (square): $20

To block ambient light, use one of our black anodized covers.

CUV-COVER: $25

CUV-COVER-TALL: $30

Quartz Cuvette Cells

We offer several popular Suprasil quartz cuvettes made by Starna, including macro, semi-micro, flow and cylindrical cells. If you need a cell not listed here, you can order it through Ocean Optics using the Starna catalog number (see Starna.com for details). The cells listed here are suitable for use from 200-2700 nm.

CV-Q-10

CVFL-Q-10

CVS-Q-10

CVF-Q-10

CV-Q-100

Item	Description	Windows	Path	Lid	Exterior (mm)	Volume	Price
CV-Q-10	Standard	2 clear	10 mm	Teflon cover	12.5 x 12.5 x 45	3.5 mL	$75
CVFL-Q-10	Fluorescence	4 clear	10 mm	Teflon stopper	12.5 x 12.5 x 45	3.5 mL	$149
CVS-Q-10	Self-masking	2 clear	10 mm	Teflon stopper	12.5 x 12.5 x 48	1.4 mL	$219
CVF-Q-10	Flow cell	2 clear	10 mm	M6 screws	12.5 x 12.5 x 35	0.42 mL	$369
CV-Q-100	Cylindrical	2 clear	100 mm	Teflon stoppers	22 OD x 102.5	28.2 mL	$165

Photometric Absorbance Standards

STAN-ABS Absorbance Standards are used to check the photometric accuracy of spectrophotometer systems. Data charts and NIST-traceable certificates of analysis come with each kit. Each kit consists of a background reference and low, medium and high absorbance solutions, each 125 mL in volume. These polymer-based standards utilize submicron, non-surface charged, solid spheres in ultrapure water. The STAN-ABS-UV is certified for wavelengths from 200-450 nm, while the STAN-ABS-VIS covers wavelengths from 400-900 nm.

STAN-ABS-UV: $335

STAN-ABS-VIS: $335

Linear Variable Filters

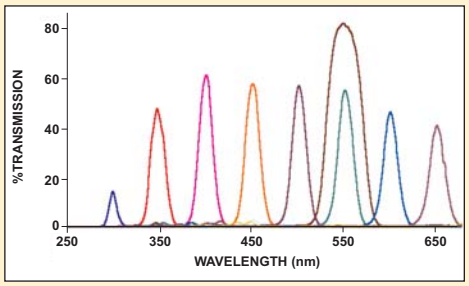
Novel Filtering Technology

We've combined our patented high-pass and low-pass Linear Variable Filters to create the world's first bandpass filter with an adjustable center wavelength and adjustable bandpass. Each filter features an excellent transmission band (~90%) and blocking band (99.8%). These filters -- with interference coatings applied to 57 mm x 10 mm quartz substrates -- are especially useful for spectrally shaping the excitation energy from broadband sources used for fluorescence.

Slide Carriers

These off-the-shelf filters are epoxied into slide carriers that allow you to move the transmission or blocking band throughout the filter's wavelength range.

LVF-HL Variable Bandwidth Filter



These spectra were taken with an LVF-HL to show how a transmission bandwidth can be set throughout the filter's range (300-750 nm).

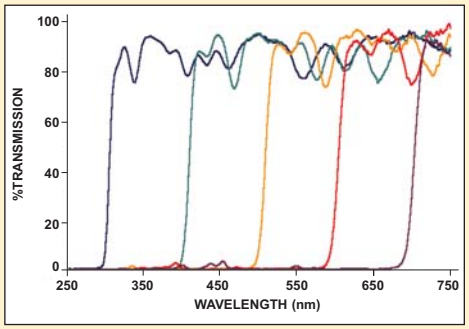
Single High-pass & Single Low-pass Filter

The LVF-H High-pass Filter is a single filter that blocks light at 98.8% up to a transition wavelength that varies along its length. At that point, the LVF-H passes light better than 90%. The LVF-L Low-pass Filter is a single filter that passes light at 88% up to a transition wavelength that varies along its length. At that point, the LVF-L blocks light better than 98.8%.

Double High-pass & Double Low-pass Filters

We take two identical LVF-H or LVF-L filters, align them so that the transition wavelengths of both filters are matched, and then epoxy them together in their slide carriers. The benefit of having double filters versus a single filter is that the optical density of the blocking band increases to 99.96%. However, the transmission band is reduced to 80%.

LVF-H High-pass Filter



The transition wavelength from blocking to transmission band varies according to the filter's position in front of the collimating lens.

High-pass & Low-pass Variable Bandpass Filters

By fastening together a high-pass filter and a low-pass filter, we created a variable bandpass filter that allows you to adjust the center wavelength and the bandwidth. We preset the transmission bandwidth at ~25 nm FWHM, but adjusting four screws allows you to slide the filters against one another to create a transmission bandwidth as wide as ~100 nm and as narrow as ~20 nm.

LVF Accessories

The LVF filters and slide carriers can be inserted easily into spectrometer setups with our LVF accessories. See the next page for details.

Item	Description	Price
LVF-H	A single high-pass filter for 300-750 nm	$249
LVF-L	A single low-pass filter for 300-750 nm	$249
LVF-HH	Two LVF-H high-pass filters epoxied together for 300-750 nm	$499
LVF-LL	Two LVF-L low-pass filters epoxied together for 300-750 nm	$499
LVF-HL	An LVF-H high-pass filter and LVF-L low-pass filter fastened together to create an adjustable bandpass linear variable filter	$499
LVF-UV-H	A single high-pass filter for 230-500 nm	$249
LVF-UV-L	A single low-pass filter for 230-500 nm	$249
LVF-UV-HH	Two LVF-UV-H high-pass filters epoxied together for 230-500 nm	$499
LVF-UV-LL	Two LVF-UV-L low-pass filters epoxied together for 230-500 nm	$499
LVF-UV-HL	An LVF-UV-H high-pass filter and LVF-UV-L low-pass filter fastened together to create an adjustable bandpass linear variable filter	$499

Accessories for Linear Variable Filters

LVF Accessories in Setups

We offer several LVF Linear Variable Filters as either high-pass, low-pass or, when we use them as pairs -- as we do for the LVF-HL -- variable bandwidth filters. These filters are installed into slide carriers, which can accommodate both the single-filter and double-filter configurations. The slide carriers fit into our slide carrier accessories, which make it possible to integrate LVFs with our spectrometers and accessories into fluorescence and absorbance setups.

The LVF is epoxied into a slide carrier, which fits into our LVF accessories, like the FH-LVF Filter Holder.

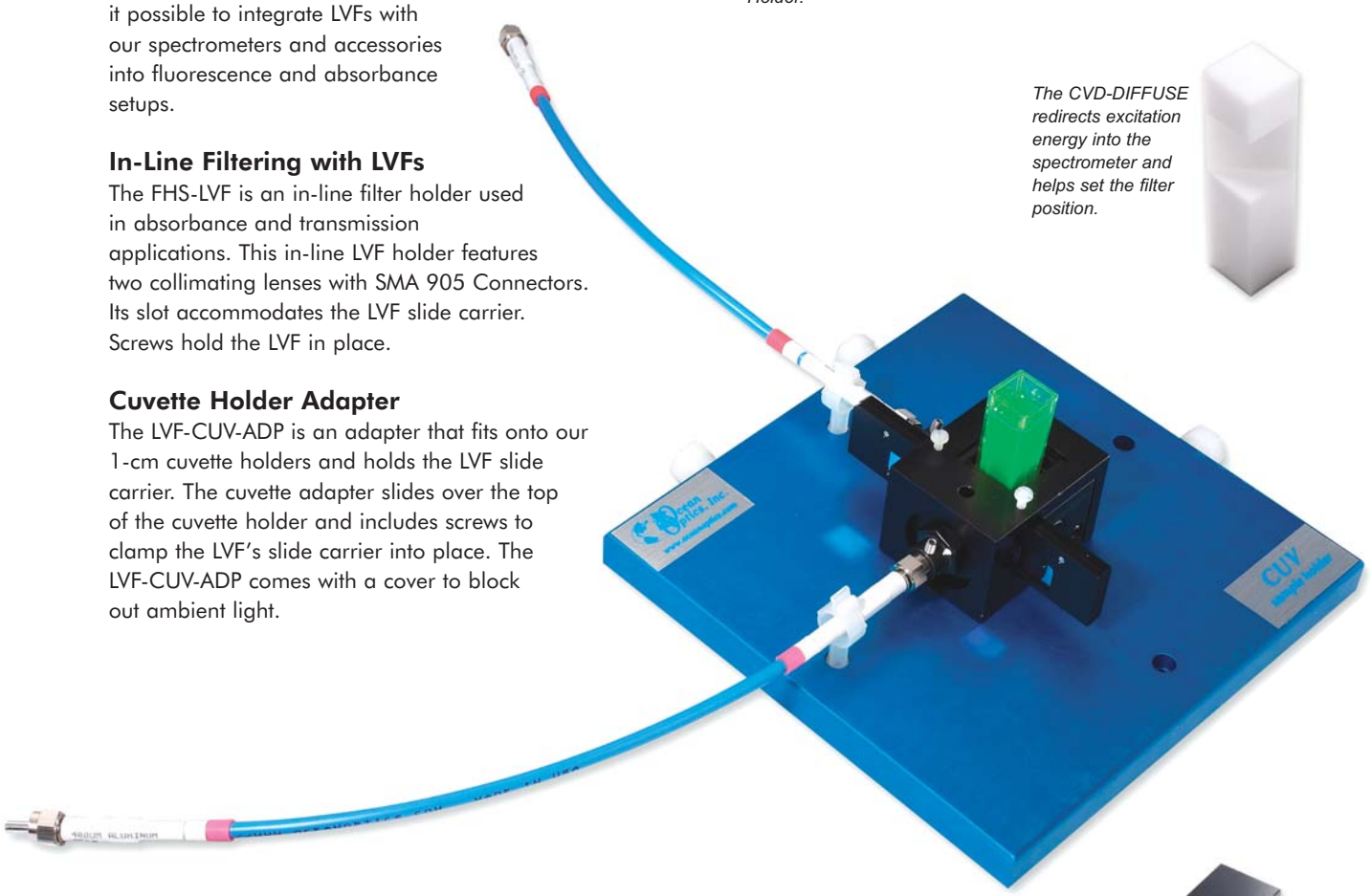
In-Line Filtering with LVFs

The FHS-LVF is an in-line filter holder used in absorbance and transmission applications. This in-line LVF holder features two collimating lenses with SMA 905 Connectors. Its slot accommodates the LVF slide carrier. Screws hold the LVF in place.

The CVD-DIFFUSE redirects excitation energy into the spectrometer and helps set the filter position.

Cuvette Holder Adapter

The LVF-CUV-ADP is an adapter that fits onto our 1-cm cuvette holders and holds the LVF slide carrier. The cuvette adapter slides over the top of the cuvette holder and includes screws to clamp the LVF's slide carrier into place. The LVF-CUV-ADP comes with a cover to block out ambient light.



Diffuser for Redirecting Excitation Light

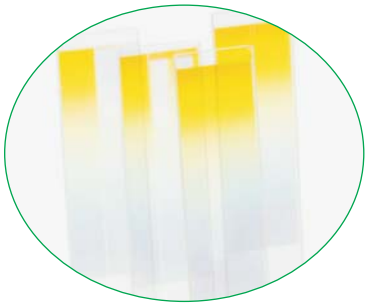
The CVD-DIFFUSE, a 1-cm cuvette-shaped piece of PTFE material, has a 45° surface at the measurement height and is used with an LVF in a fluorescence cuvette holder to redirect excitation energy 90° into the spectrometer. This facilitates setting the filter position -- i.e., while the CVD-DIFFUSE is inserted in the cuvette holder, you position the LVF to select the wavelength region passed by the filter.

When using an LVF with a cuvette holder like our CUV-ALL 4-way Cuvette Holder, you will need the LVF-CUV-ADP Cuvette Holder Adapter. The LVF (in a slide carrier) is inserted in front of the sample and held in place by the LVF-CUV-ADP (shown at right), with a cover to block ambient light.

Item	Description	Price
LVF-CUV-ADP	An adapter for a 1-cm pathlength cuvette holder that holds the slide carriers in place	$99
CVD-DIFFUSE	A 1-cm cuvette-shaped PTFE for redirecting excitation energy	$99
FHS-LVF	In-line filter holder for LVFs	$399
LVF-KIT	Consists of the LVF-HL, LVF-CUV-ADP, FHS-LVF and CVD-DIFFUSE	$999
LVF-UV-KIT	Consists of the LVF-UV-HL, LVF-CUV-ADP, FHS-LVF and CVD-DIFFUSE	$999

Filters & Filtering Technology

Schott off-the-shelf filters.



Custom interference filters.

LVF Linear Variable Filters.

Patented Filtering Technology

We offer a complete line of custom and off-the-shelf optical filters -- including filters produced using our novel dichroic filter array and linear variable filter technologies -- for a variety of optical-sensing applications.

Custom Filters

Our dichroic filters can be patterned in areas as small as 2 μm, with spatial registration to within 1 μm, to produce multiwavelength arrays, stochastic patterns and even images. We possess the design savvy and manufacturing capacity necessary to produce high-volume OEM orders of virtually any precision optical filter design. For details, see page 160.

Off-the-Shelf Filters

We inventory a variety of Schott filters, as well as our own LVF Linear Variable Filters, for installation into optical benches, light sources, cuvette holders and in-line filter holders. For a complete list of off-the-shelf filters, see page 164. Our optical filters can be categorized by function:

- Longpass (Order-Sorting) Filters eliminate second- and third-order effects in spectrometer setups, and are installed into the optical benches of spectrometers (page 43) or used as loose filters.
- Low-pass and High-pass Filters eliminate second-order effects, limit stray light, and block excitation energy in fluorescence experiments. Options include our LVF Filters (page 94) or Schott filters (page 164).
- Balancing Filters absorb energy in some regions while transmitting energy in others, such as the BG 34 filter that comes with our LS-1 Tungsten Halogen Source. We also offer Schott-brand balancing filters (page 164).
- Bandpass Filters pass energy in a certain region and block the energy above and below that region. We offer Schott filters and our LVF Filters, the latter in an adjustable-bandwidth design (page 94).

Filter Holders for Optical Fibers

The INLINE-FH In-line Filter Holder (top photo) holds INLINE-OF Filters or other filters 8 mm in diameter and 2-5 mm thick. The Filter Holder includes two collimating lenses and connects to two fibers for in-line filtering.

The FH-SMA (bottom photo) allows you to mount filters or diffusers at the end of SMA 905-terminated optical fibers. The FH-SMA accepts 8-mm diameter filters in thicknesses of 1-7 mm. We include an Allen wrench to adjust the barrel of the SMA 905 Connector to accommodate various filter thicknesses.

See page 164 for information on available Absorbing Glass Filters and Neutral Density Filters for the INLINE-FH or FH-SMA.

INLINE-FH:	**$402**
INLINE-OF:	**$102**
FH-SMA:	**$130**

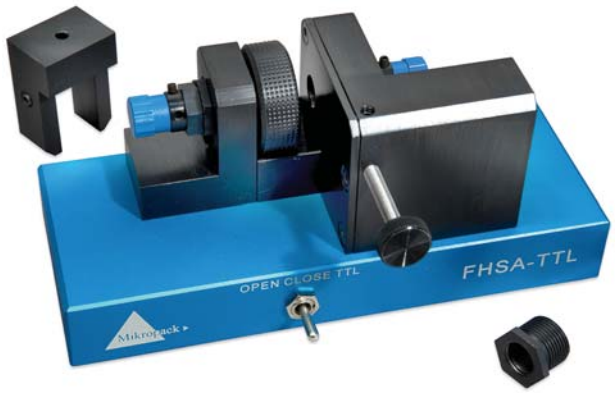
Specifications

	FH-SMA	INLINE-FH
Dimensions:	16 mm diameter	15 mm diameter
Weight:	10 g	20 g
Filter size:	8 mm diameter, 1-7 mm thick	8 mm diameter, 2-5 mm thick
Material:	Anodized aluminum	Stainless steel (collimating lenses have anodized housings)

Filter Sample Holders

We offer a variety of fixtures that couple via SMA 905 Connectors to our fiber optic spectrometers and light sources for transmission measurements of optical filters.

Filter & Cuvette Holders



What's unique about the FHSA Filter/Cuvette Holders is you can configure the holders to sample either cuvettes or filters. Use the FHSAs to measure transmission of 1-cm square cuvettes or filters up to 7 mm thick. In addition, FHSAs interface via RS-232 bus to PCs, allowing you to control some functions of the FHSAs via software, which is included. With the FHSA-TTL, you have manual control of attenuation (adjustable from 0-100%), and manual or software control of a shutter. With the FHSA-RS232, you have software control of both the attenuation and shutter functions. Both versions include a 12 VDC power supply.

FHSA-TTL: $1,223
FHSA-RS232: $2,156

In-line Filter Holder

The FHS-UV In-line Filter Holder is a dual-purpose fixture for projecting a collimated beam of light through a flat optical filter. The FHS-UV can measure the transmission of filters, or provide a location in an optical system for inserting filters. It has two 74-UV Collimating Lenses mounted across a filter holder, which holds round filters up to 25 mm in diameter and samples up to 6 mm thick. (For large filters and other samples, see the 74-ACH Adjustable Collimating Lens Holder.) A bushing keeps the filter against the reference surface. A shutter facilitates taking dark measurements.

FHS-UV: $399

Direct-attach Filter Holder for USB2000

The USB-FHS Filter Holder has a light source mounted onto a base plate designed to fixture the lamp to a USB2000 Spectrometer. The light source includes a tungsten source and violet LED, which provide extra signal in the blue region. The USB-FHS is used to measure the transmission of filters and other samples up to 18-mm thick.

USB-FHS: $499

Specifications

	FHSA-TTL	FHS-UV	USB-FHS
Dimensions:	140 mm x 50 mm x 50 mm	50.6 mm x 140 mm x 43.1 mm	153.3 mm x 89 mm x 40.8 mm (with base plate)
Weight:	490 g	240 g	320 g (with base plate)
Power consumption:	100 mA @ 12 VDC	None	160 mA @ 5 VDC
Filter size (maximum):	Any sample up to 7 mm thick	25-mm diameter round; any sample up to 6-mm thick	50-mm diameter round; any sample up to 18-mm thick
Light source:	None	None	Tungsten bulb and violet LEDs
Wavelength range:	200-2000 nm	200-2000 nm	390-950 nm
Optical fibers required:	Yes	Yes	No
Spectrometer:	All	All	USB2000
Cuvette dimensions:	10 mm x 10 mm	None	None
Shutter frequency:	5 Hz/60 dB (maximum)	None	None
Shutter response time:	7 µsec	None	None

SpectroPipetter Microcell

Easy to Use -- Just Pipette and Measure

The PIP-10-2 SpectroPipetter Microcell is a combination micropipetter and 10-mm pathlength microcell for low-volume sampling. Samples are loaded into a capillary tube with an optical fiber plunger, which is activated by depressing the thumbpad and releasing it to draw in the fluid. A mirror on the distal side of the capillary completes the optical path.

Requires 2 µL of Sample

The pipetter is equipped with a bifurcated fiber, which couples to our spectrometers and compact light sources to create low-volume absorbance systems. The SpectroPipetter requires only 2 µL of sample for a spectral measurement.

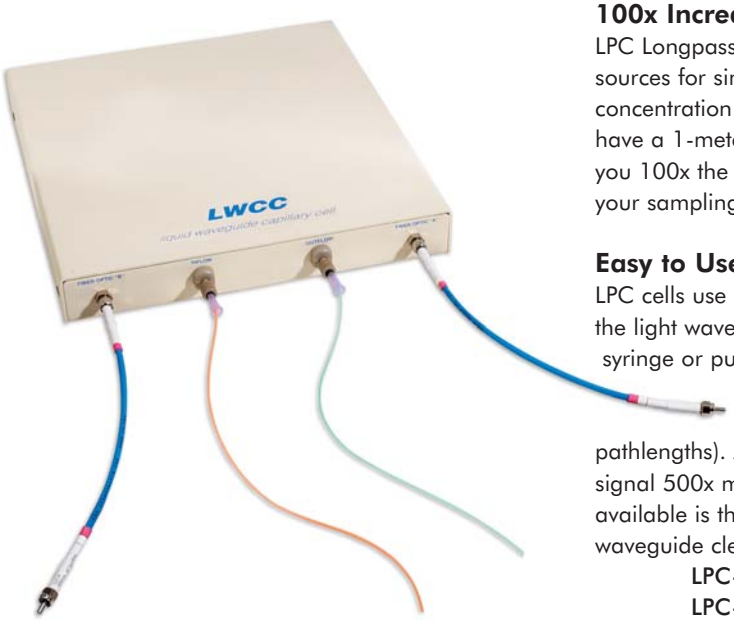
Cleaning Kit

To remove fluid or dye from the cell, use the PIP-UCK Cleaning Kit. It contains an ultrasonic cleaning bath (at right) and a bottle of cleaning solution. Additional PIP-UCK-CS Cleaning Solution (below right) is also available.

PIP-10-2: $1,995
PIP-UCK: $165
PIP-UCK-CS: $25

Specifications	
Wavelength range:	230-850 nm
Sample volume:	2 µL
Light pathlength of cell:	10 mm
Temperature range:	4 °C to 99 °C
Optical fiber length:	1.3 m
Core diameter of launch fibers:	Bundle of (3) 200 µm optical fibers
Core diameter of return fiber:	200 µm

Longpass Flow Cells



100x Increase in Sensitivity

LPC Longpass Flow Cells couple to our spectrometers and light sources for simple, efficient measurements of low-volume, low-concentration aqueous samples (230-800 nm). With the LPC-1, you have a 1-meter cell with an internal volume of only 240 µL, giving you 100x the sensitivity over a 1-cm pathlength cuvette holder as your sampling device.

Easy to Use

LPC cells use a capillary tube as both the sample compartment and the light waveguide. You inject the sample into the fluidic ports with a syringe or pump; optical fibers connect to SMA 905 Connectors to deliver and return light to the spectrometer. We offer these cells in 1- and 5-meter pathlengths (call for other pathlengths). A 5-meter cell (250 µL/meter) increases the absorbance signal 500x more than a 1-cm cuvette. Also available is the LPC-CLEANKIT (see inset), a waveguide cleaning kit for the LPCs.

LPC-1: $1,695
LPC-5: $3,350
LPC-CLEANKIT: $59

Specifications			
Dimensions:	254 mm x 279 mm	Maximum sample temperature:	160 °C
Weight:	140 g	Tubing inner diameter:	550 µm
Wavelength range:	230-800 nm (depending on sample solution)	Tubing:	Fused silica inner tubing coated with Teflon AF
Tubing volume:	250 µL/meter	Fluid fittings:	1/16", 1/32" compression fittings
Fiber connectors:	SMA 905	Maximum pressure:	2000 psi
Fiber core diameter:	400 µm	Chemical resistance:	Most organic and inorganic solvents

Cell for Capillary Electrophoresis

Solutions Absorbance

The CUV-CCE Electrophoresis Sample Cell is an optical fixture for measuring the absorbance of solutions in chromatography or capillary electrophoresis systems. The cell's design -- light projects through the sides of the silica tubing -- eliminates pressure limits commonly associated with tubing breakdown in electrophoresis systems.

Excellent Chemical Resistance

The CUV-CCE cell, fixtures and fittings are made of robust PEEK material. The cell, which can be purchased separately as CUV-CCE-CROSS, has a through-hole of 0.51 mm and comes with 10-32 coned female threads and four fittings. Two fibers (included) face each other across the sample tubing. To complete the system, we recommend a spectrometer and a DH2000-BAL Light Source (see 120).

Fibers & Tubing Sleeves Included

The CUV-CCE comes with two 300-µm solarization-resistant fibers and tubing sleeves to connect tubing to the threaded ports. You can also purchase the CUV-CCE-CROSS tubing sleeves separately. Other sleeve sizes are available.

CUV-CCE:	$599
CUV-CCE-CROSS:	$65
CUV-CCE-TUBING:	$15

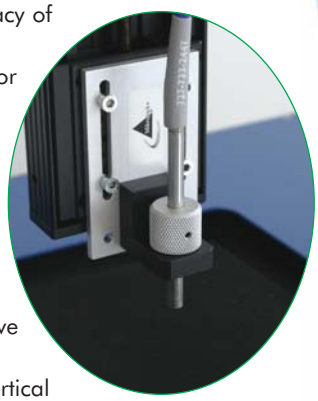
Specifications

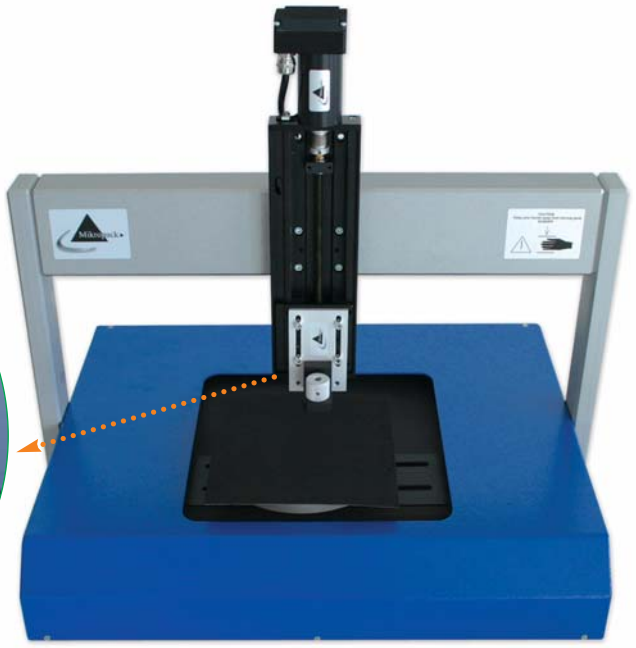
Dimensions:	28.6 mm x 28.6 mm (cross); 50.8 mm x 50.8 mm (cross with fittings)
Weight:	9.4 g
Cell material:	PEEK polymer
Fixtures & fittings material:	PEEK polymer
Threads:	10-32
Through-hole:	0.51 mm
Fittings:	(4) F-300 double-winged nuts with F-142 ferrule
Swept volume:	0.721 µL
Tubing sleeve diameter:	0.41 mm inner diameter, 1.57 mm outer diameter
Tubing sleeve length:	31.8 mm
Tubing size accommodated:	350-390 µm outer diameter
Pressure rating (tubing):	6,000 psi (414 bar)

XYZ Mapping Tables

Versatile Design

We offer four high-precision linear XYZ Mapping Tables. The mapping table -- with a linear axis resolution of 1 µm and an accuracy of ±5 µm -- is ideal for spatial mapping of spectral features or for multisampling in microwell plates. See the table below for a list of mapping table options and prices.





Additional Functions

The XYZ Table comes with an electric motor and encoder to drive each axis, along with a CNC Controller and a portal for the vertical (Z-axis) stage. The table makes it possible to measure every sample within an X-Y range of 150 mm x 150 mm or 200 mm x 150 mm. With the 100-mm vertical stage, you can attach holders for probes and other kinds of sampling devices, which are purchased separately.

PC Control

The system requires 110-240 VAC to operate (included) and interfaces via RS-232 bus to PCs. Computer-controlled operation of the motors is available. Speak to one of our Applications Scientists for details.

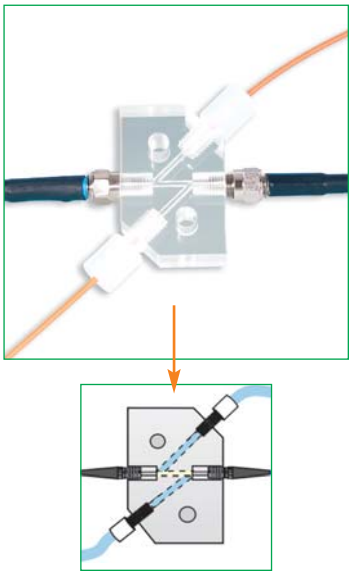
Item	X-axis	Y-axis	Z-axis	Price
XY(Z)-150 X150+	150 mm	150 mm	Optional	$11,643
XY(Z)-200X150+	200 mm	150 mm	Optional	$12,074
XYZ-150 X150X100	150 mm	150 mm	100 mm	$14,165
XYZ-200X150X100	200 mm	150 mm	100 mm	$14,595
Z-AXIS-100+	None	None	100 mm	$2,660

Specifications

Dimensions base: Dimensions rail:	476 x 375 x 89 mm 508 x 38 x 165 mm	Travel range:	150 mm x 150 mm (minimum)
Weight:	14.7 kg	Controller:	CNC Controller (2-3 axes)
Power input:	110-240 VAC	Interface:	RS-232

Flow Cells for Flow Injection Analysis

We offer two optical flow cells with a "Z" configuration, to measure the optical absorbance of fluids moving through flow injection systems. Each flow cell has a 1.5-mm inner diameter; sample and waste tubing are connected with 1/4-28 fittings (included). Couple flow cells to our spectrometers to monitor chemical or biological processes, and immunoassays. These automated fluid sampling systems eliminate measurement errors that can occur with manual processes.



Specifications			
Cell materials:	PEEK, Plexiglas, Teflon or SS	FIA connectors:	1/4-28
Inner diameter:	1.5 mm	Tubing:	1/16" Teflon, ~3 m
Window material:	UV-grade fused silica	Fiber connectors:	SMA 905 for FIA-Z-SMA cells; 1.58-mm stainless steel ferrules for FIA-Z-CELL cells
Window thickness:	1 mm		
Wavelength range:	260-2000 nm		

FIA-Z-SMA: For Use with Standard Fibers

In the FIA-Z-SMA Flow Cell, optical fibers (available separately) connect to SMA 905 fittings to transmit and receive light through the central axis of the Z. The FIA-Z-SMA Cell uses silica windows as wetting surfaces at each fiber optic junction, and is available in PEEK polymer, Plexiglas (pictured top right), stainless steel or Teflon.

Item	Description	Pathlength	Cell Material	Price
FIA-Z-SMA-PEEK	Z Flow Cell with SMA 905 Connectors	10 mm	PEEK	$529
FIA-Z-SMA-PLEX	Z Flow Cell with SMA 905 Connectors	10 mm	Plexiglas	$529
FIA-Z-SMA-SS	Z Flow Cell with SMA 905 Connectors	10 mm	Stainless steel	$529
FIA-Z-SMA-TEF	Z Flow Cell with SMA 905 Connectors	10 mm	Teflon	$529
FIA-ZSMA-20-PE	Z Flow Cell with SMA 905 Connectors	20 mm	PEEK	$529
FIA-ZSMA-20-PLE	Z Flow Cell with SMA 905 Connectors	20 mm	Plexiglas	$529
FIA-ZSMA-20-SS	Z Flow Cell with SMA 905 Connectors	20 mm	Stainless steel	$529
FIA-ZSMA-20-TEF	Z Flow Cell with SMA 905 Connectors	20 mm	Teflon	$529
FIA-ZSMA-50-PE	Z Flow Cell with SMA 905 Connectors	50 mm	PEEK	$629
FIA-ZSMA-50-PLE	Z Flow Cell with SMA 905 Connectors	50 mm	Plexiglas	$629
FIA-ZSMA-50-SS	Z Flow Cell with SMA 905 Connectors	50 mm	Stainless steel	$629
FIA-ZSMA-50-TEF	Z Flow Cell with SMA 905 Connectors	50 mm	Teflon	$629

1/4-28 fittings come with the cells.

FIA-Z-CELL: For Use with Ferruled Fibers

The FIA-Z-CELL Flow Cell is a variation on the FIA-Z-SMA that instead of windows uses optical fibers in 1.58-mm ferrules, a design that allows you to slide the ferrules in and out of the cell to adjust the optical pathlength from 0-10 mm. Standard cell materials are PEEK polymer, Plexiglas, stainless steel and Teflon.

Item	Description	Pathlength	Cell Material	Price
FIA-ZCELL-PEEK	Z Flow Cell with ferrules	10 mm	PEEK	$365
FIA-ZCELL-PLEX	Z Flow Cell with ferrules	10 mm	Plexiglas	$365
FIA-ZCELL-SS	Z Flow Cell with ferrules	10 mm	Stainless steel	$365
FIA-ZCELL-TEF	Z Flow Cell with ferrules	10 mm	Teflon	$365

This fiber is designed for the FIA-Z-SMA.

Fibers for Use with FIA Cells

An FIA-Z-SMA requires two 200 µm or 400 µm diameter optical fiber assemblies like the ones listed below, or see page 138 for more choices. The FIA-ZCELL requires two optical fiber assemblies with ferrule terminations. Each price below is for one assembly, but two are required.

Item	Description	For Cell	Price
P400-2-UV-VIS	(1) 400 µm fiber assembly with SMA 905 Connectors	FIA-Z-SMA	$119
P200-2-UV-VIS	(1) 200 µm fiber assembly with SMA 905 Connectors	FIA-Z-SMA	$99
FIA-P400-SR	(1) 400 µm fiber assembly with ferrule terminations	FIA-ZCELL	$215
FIA-P200-SR	(1) 200 µm fiber assembly with ferrule terminations	FIA-ZCELL	$210

These fibers have ferrules for use with the FIA-Z-CELL.

Fluorescence Flow Injection Analysis System

Parts-per-trillion Sensitivity

The FIA-PMT-FL Photomultiplier Flow-through Detection System provides parts-per-trillion sensitivity for ultra-low fluorescence, chemiluminescence and bioluminescence measurements. Because of its heavy-duty, chemically resistant housing, the system can withstand harsh industrial environments.

Modular Design

The FIA-PMT-FL is built to order with either an internal excitation lamp or with an optical fiber interfacing to an external lamp. Excitation lamp source options include tungsten, mercury vapor, LEDs and laser diodes. Emission and excitation filters are mounted in slots in the enclosure, allowing for easy removal or exchange. Though the system uses a 100 µL flow-through cuvette, you can use 1-cm pathlength cuvettes for manual measurements.

Easy PC Interface & Optimized Software

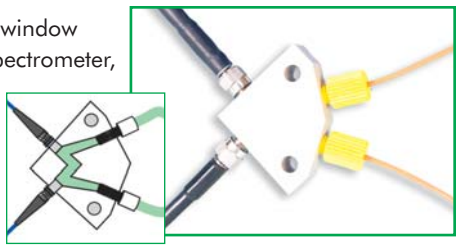
Included with the system is Windows-based software that allows you to set the integration time and voltage counts, and to obtain time histories of the measurements, both plotted and tabulated. The software can also automatically create calibration curves and control additional devices such as certain syringe and peristaltic pumps, injection valves, selection valves and autosamplers. ActiveX control is included for controlling the FIA-PMT-FL from your own software. The FIA-PMT-FL plugs into the RS-232 serial port of a PC.

FIA-PMT-FL: $6,495

Specifications	
Spectral range:	310-750 nm
Detector:	Photo-counting photomultiplier tube
PMT dynamic range:	2 x 10^6
Responsivity:	5 x 10^{17} cps/watt (@ 400 nm)
Detection limits:	2 parts per trillion w/fluorescein @ 250 ms integration time
Pulse-pair resolution:	10 ns
Flow cell pathlength:	10 mm
Flow cell volume:	100 µL with standard flow-through cuvette
Filters:	Excitation or emission; 11.8 mm diameter; call for details
Computer interface:	RS-232
Operating systems:	Windows 98/Me/2000/XP operating systems

Fluorescence Flow Cell for Flow Injection

With the FIA-SMA-FL Fluorescence Flow Cell, a fiber sends excitation energy via a window into a sample compartment. A second fiber, oriented at 90° and connected to a spectrometer, collects the emitted energy. Each cell has two optical windows and SMA 905 Connectors (which do not contact the fluids). Also included are Teflon tubing and chemically-resistant tubing connectors and seals. Two 600 µm fibers are required.

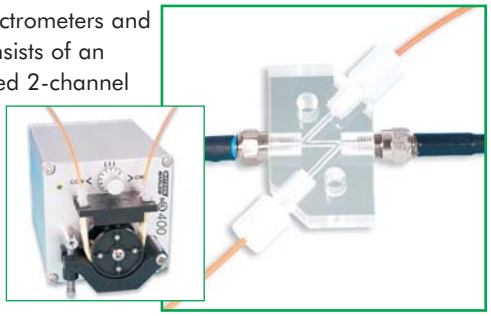


FIA-SMA-FL: $435

P600-2-UV-VIS: $159 (each; 2 required)

Flow Cell Kit for Flow Injection Analysis

The FIA-1000-Z Flow Cell Kit is a fluid sampling system that couples to our spectrometers and light sources for rapid, quantitative UV-VIS-NIR analysis of solutions. The kit consists of an FIA-Z-SMA "Z"-type flow cell (page 100), the FIA-PUMP-C (a computer-controlled 2-channel peristaltic pump), and operating software to control the pump via a PC's serial port. A pair of optical fibers (not included) is required. The FIA-Z-SMA has an optical pathlength of 10 mm and an inner diameter of 1.5 mm, and is available in PEEK polymer, Plexiglas, stainless steel or Teflon. (Tubing is not included.) You can also purchase the pump separately.

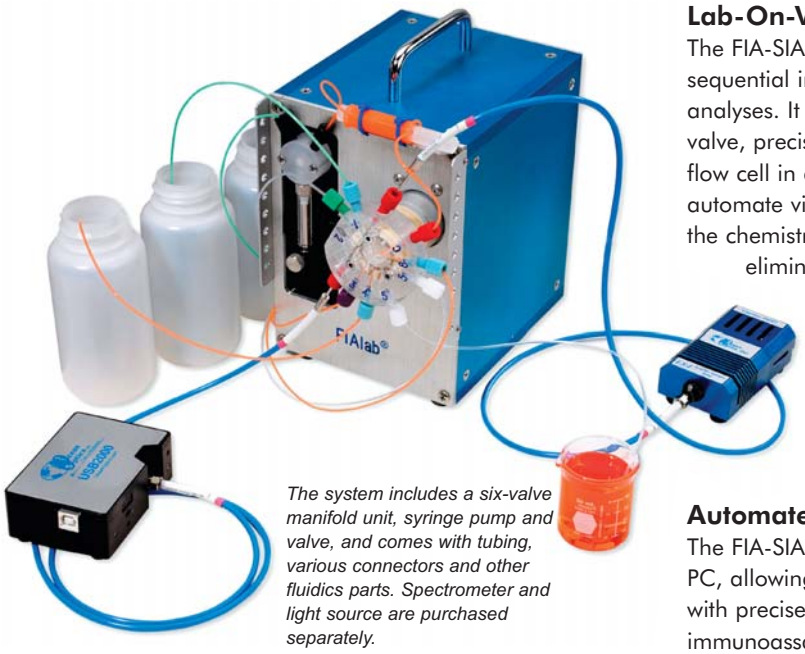


FIA-1000-Z: $1,300

FIA-PUMP-C: $804

Specifications			
Spectral range:	260-2000 nm	Pathlength:	10 mm
Cell materials:	PEEK, Plexiglas, stainless steel or Teflon	Tubing:	1/16" Teflon, ~3 m, with 1/4-28 connectors
Inner diameter:	1.5 mm	Pump:	105 mm x 105 mm x 185 mm; 2.1 kg
Window:	1 mm thick, UV-grade fused silica	Flow rate:	200 mL/minute/channel, depends on RPM and tubing diameter
Pathlength:	10 mm	Pressure rating:	25 psi

Sequential Injection System



The system includes a six-valve manifold unit, syringe pump and valve, and comes with tubing, various connectors and other fluidics parts. Spectrometer and light source are purchased separately.

Lab-On-Valve Technology

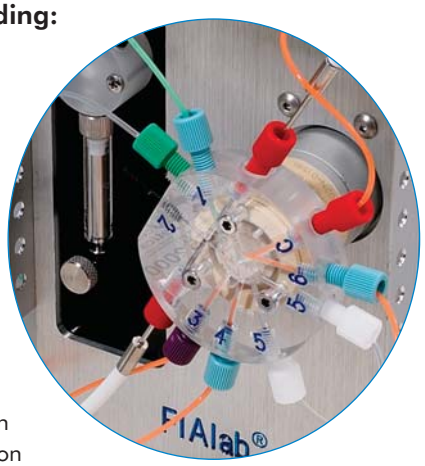
The FIA-SIA-LOV Lab-On-Valve System is a compact sequential injection analyzer for all-in-one chemical analyses. It combines a computer-controlled six-position valve, precision syringe pump, and spectrophotometric flow cell in a 12.7 cm x 15.3 cm package that can automate virtually any wet-chemistry lab procedure. All of the chemistry takes place within the valve manifold -- eliminating the need for additional tubing and connectors. All of the ports are interconnected by microchannels, and a built-in multi-purpose flow cell interfaces to optical fiber probes for spectral analyses in either absorbance or fluorescence mode.

Automate Virtually Any Wet Lab Procedure

The FIA-SIA-LOV comes with software and interfaces to a PC, allowing you to fully automate wet lab procedures with precise control of assay parameters including immunoassays, dilution monitoring and reagent/sample ratio for continuous or stopped-flow measurements. Via the software, you assign each of the Lab-On-Valve's ports a specific function. Software controls procedures with simple commands to set up and sequence through these processes. In fact, changing procedures is as easy as opening a stored script and switching reagent bottles.

Control numerous assay parameters including:

- Bead trapping
- Composite sample handling
- Flow injection
- Flow through
- Holding coil
- Mixing
- Optical monitoring
- Reagent aspiration
- Sample dilution
- Sample aspiration
- Sequential injection
- Waste elimination



Cost-effective Methodology

The FIA-SIA-LOV also offers a cost-effective, microliter-volume methodology -- it produces less waste, saves money and introduces fewer chemicals into the environment than other wet chemistry technologies. The unit weighs just 3.6 kg, making it both portable and easy to install in small incubators for temperature and humidity control. Also, the FIA-SIA-LOV easily can be positioned near ETAAS and MS systems so that micro-volumes of processed samples need not be transported through long conduits, which can cause sample degradation.

Modular Turnkey Chemical Analyzer

The FIA-SIA-LOV unit was developed by flow injection system specialist and Ocean Optics partner FIAlab Instruments, and is compatible with our spectrometers, light sources and optical fibers for dynamic spectral analyses of optical absorbance or fluorescence of fluids. Nearly any standard colorimetric flow injection analysis method can be adapted to, and performed on, the FIA-SIA-LOV, with few or no modifications to the manifold.

Replacement Parts

The FIA-SIA-LOV consists of the FIA-SIA Micro Sequential Injection Analyzer unit and the FIA-LOV Lab-on-a-Valve Manifold, each of which can be purchased separately.

FIA-SIA-LOV:	$13,450
FIA-SIA:	$10,950
FIA-LOV:	$1,275

Specifications	
Dimensions:	12.7 cm x 15.3 cm x 15.3 cm
Weight:	3.6 kg
Spectral range:	260-2000 nm
Cell materials:	PEEK, Plexiglas, Teflon or SS
Inner diameter:	1.5 mm
Window material:	UV-grade fused silica
Window thickness:	1 mm
Pathlength:	10 mm
Fiber connectors:	SMA 905
Tubing:	1/16" Teflon, ~3 m
Tubing connectors:	1/4-28
Pump dimensions:	105 mm x 105 mm x 185 mm
Pump weight:	2.1 kg
Flow rate:	200 mL/minute/channel (depending on RPM and tubing diameter)
Pressure rating:	25 psi

Positive Displacement Pump

Displaces Volumes from 1 µL

The PUMP-IT-1000 Positive Displacement Pump is a pulsed pump that displaces from 1 µL to 250 µL of fluid with each pump or cycle. The amount of fluid displaced with each cycle is set via software. The amount pumped is precise to 0.3% with repeatability of better than 0.5%.

Various Fittings

Applications

The PUMP-IT is particularly useful for those wanting to automate the delivery of reagents into accurate flow setups. Typical applications include blood chemistry, blood analysis, particle sizing, in vitro diagnostics and biopharmaceutical analysis.

PC/Software-controlled

The pump connects to a PC via an RS-232 port and a controller box and is controlled with software (included). The PUMP-IT is a low-cost alternative to expensive syringe, vacuum, peristaltic and other pumps. Not only can you select the displacement amount, you can regulate the speed of the displacement via software.

Long-life Design

For accurate mixing and/or dilution of fluids, the pump has upper and lower limits that can be set mechanically and via the software. The pump provides a ripple-free and bubble-free flow. The pump's piston and head are made out of PEEK, while the body is made from aluminum. The piston in the pump will last about 1-2 million cycles before it shows evidence of wear. The PUMP-IT has the flexibility to be positioned in any orientation.

What's Included

The PUMP-IT-1000 comes with the controller box and power supply; an RS-232 cord; software; 10 feet of tubing; various nylon fittings, plugs and caps; and a 250-µL sample bottle. You can also order the pump only (PUMP-IT-PUMP).

PUMP-IT-1000: $999
PUMP-IT-PUMP: $565

Specifications	
Full scale volume:	250 µL
Volume per full step:	0.028 µL
Throughput:	>60% (based on 400 µm optical fiber)
Actuator:	5 VDC, 0.49 amp/phase, 10.2 ohm/phase, 9.6 mHz/phase
Repeatability:	<0.5%
Precision:	<0.3%
Pump head:	Acrylic (custom options include polycarbonate and PEEK)
Pump piston:	PEEK (custom options include stainless steel, ceramic and glass)
Pump body:	Aluminum (custom options include stainless steel and acrylic)
Dimensions:	Pump -- 3.50 cm x 3.50 cm x 16.94 cm Controller -- 11.93 cm x 11.93 cm x 6.35 cm
Controller:	Unipolar/Bipolar dual stepper motor control PCB, 7.5 VAC, 1 A
Baud rate:	2400 or 9600 baud serial connection
AC adapter:	7.5 VAC, 1 A
Tubing:	10 feet of Tygon tubing
Standard nylon fittings:	10 female Luer fittings, 1/4 hex to 10-32 thread 10 male Luer fittings, 1/4 hex to 10-32 thread 10 Luer plugs and 10 caps 10 1/16" ID barbed fittings with10-32 thread 10 1/16" ID barbed tee fittings 10 1/16" ID elbow fittings

Optical Multiplexer

An MPM-2000-2x8 has two input ports and 16 outputs. Here, we used a USB2000 Spectrometer and an LS-1 Light Source as the input ports.

Flexibility for Multipoint Sampling

Our MPM-2000 Fiber Optic Multiplexers take light to a spectrometer or from a light source connected to one of the input ports and distribute it to either 8 or 16 outputs. The light is distributed through the output ports in sequential order, with switching times between channels of less than 150 milliseconds. Multiplexers often are found in process industries, where multiple locations need to be measured with one spectrometer channel and/or light source.

High-precision Instrument

All versions of the MPM-2000 include a DC motor, which has excellent speed control without sacrificing power. The motor is on a rotator block and includes an encoder, which converts movement into a digital pulsed output. Each channel in the multiplexer has a collimating lens connecting to an internal optical fiber system. The MPM-2000 provides accurate measurements with a repeatability of 99% and offers optical throughput better than 60%.

Multiple Versions

The MPM-2000 comes with either 2 input channels -- with each input channel corresponding to 8 output channels -- or with 1 input channel and 16 output channels. You must choose either a UV-VIS (250-800 nm) or VIS-NIR (350-2000 nm) multiplexer.

Software-controlled

The multiplexers interface to a PC via an RS-232 port and come with software and a driver for complete PC control. The software allows you full control of the switching order, switching delay time and system calibration.

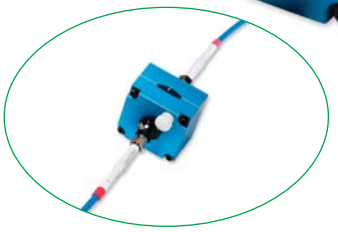
MPM-2000-1X16-UV:	$7,714
MPM-2000-1X16-VIS:	$7,714
MPM-2000-2X8-UV:	$8,021
MPM-2000-2X8-VIS:	$8,021

Specifications	
Dimensions:	230 mm x 200 mm x 150 mm (fits into 19" system: 33TE, 3HE, etc.)
Wavelength range:	250-800 nm (UV/VIS) or 350-2000 nm (VIS/NIR)
Optical throughput:	> 60% (when using standard 400 µm fibers)
Motor:	Direct-current motor
Optical fibers:	400 µm diameter optical fibers
Repeatability:	> 99%
Switching time:	150 milliseconds between adjacent positions
Interface:	RS-232 (optional USB)
Power requirement:	24 VDC, 1.2 A (includes WT-24V-E power supply)
Connectors:	SMA 905

Fiber Optic Variable Attenuator

The FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps control the amount of light transmitted between two fibers. Two fibers screw into either side of the FVA-UV via SMA 905 Connectors with collimating lenses, which project light across a metal disc in which a slit has been cut. The width of the slit varies as a function of radial position, which is adjusted manually. Rotating the disc varies the attenuation from 0-100% uniformly across a 200-2000 nm wavelength range. An FVA-ADP attaches the FVA-UV directly to a light source.

FVA-UV:	$499
FVA-ADP:	$99

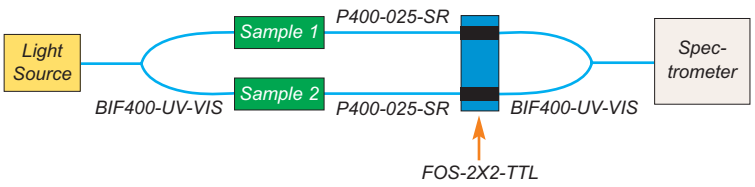


Specifications	
Dimensions:	38.1 mm x 59.4 mm x 40 mm
Weight:	90 g
Assembly ports:	3/8-24 threads for collimating lenses
Wheel lock:	6-32 nylon thumbscrew
ADP adapter:	Directly attaches to a light source with a collimating lens
Connector:	SMA 905

Fiber Optic Dual Switch with TTL Line

The FOS-2X2-TTL Fiber Optic Dual Switch was designed to provide you with flexibility in routing, splitting and controlling light. The FOS has two light channels; each has its own TTL-controlled shutter. You can opt to have one light channel open at a time, have both open, or have both closed. The FOS is useful for monitoring the drift of the light source or for measuring two samples with one spectrometer channel and one light source. The diagram below is an example of how the FOS can be utilized. In this setup, the FOS eliminates the need for a second spectrometer channel.

FOS-2X2-TTL: $1,664



In this setup, light enters a Bifurcated Optical Fiber Assembly and then splits into two arms, one for each sample. Light interacts with each sample and travels through another fiber assembly, each into its own port in the FOS. Another Bifurcated Assembly collects the light from the FOS and sends it to the spectrometer. In this setup, you would switch the shutter on the FOS from one light channel to another in order to get clean data from each sample. Without the FOS, you would need another spectrometer channel to monitor the two samples.

Specifications	
Dimensions:	100 mm x 70 mm x 70 mm
Weight:	455 g
Material:	Anodized aluminum
Switch frequency:	Maximum of 5 Hz
Power:	12 VDC
Operation:	Manual switch or TTL input signal

Electronic TTL Shutter

In spectrometer setups, the INLINE-TTL TTL-driven shutter allows you to block the light path without disturbing the experiment setup -- for example, by turning the light source on and off. The laser-cut shutter is installed between two collimating lenses, which attach to two optical fibers. The INLINE-TTL is driven by a small board with a TTL input. Included is a cable for interfacing to a spectrometer.

INLINE-TTL-S: $988

Specifications	
Dimensions:	140 mm x 50 mm x 50 mm
Weight:	~600 g
Shutter-Input:	TTL maximum 5 Hz
Power requirements:	12 VDC (power supply included)
Power consumption:	100 mA maximum
Maximum frequency:	5 Hz

Field of View Control

The Gershun Tube Kit (GER-KIT) controls the field of view of our SMA 905-terminated optical fiber. It also directly attaches to a spectrometer with an SMA 905 Connector. User-interchangeable apertures provide many different fields of view from 1° to 28°. (When the GER-KIT is used with our optical fiber, the field of view cannot exceed the optical fiber's 25° field of view if you are measuring radiance.)

GER-KIT: $499

Specifications	
Material:	Black anodized aluminum
Interior:	Bead-blasted surface to reduce off-axis reflections
Connection:	Directly attaches to one of our spectrometers or couples to an SMA 905-terminated optical fiber with included adapter barrel
Apertures:	1°, 3°, 8°, 10° and 14° apertures included, providing 1°, 2°, 3°, 6°, 8°, 10°, 14°, 16°, 20° and 28° fields of view

Semiconductor Nanocrystals

Evident Technologies, an Ocean Optics partner, develops extremely high-quality, low-cost semiconductor nanocrystals. These quantum dots are nanometer-scale materials that have properties between that of molecules and bulk materials. This enables Evident to produce "designer atoms" through atomic-level manipulation. When combined with our spectrometers and excitation sources, these nanocrystals have been used in biology applications as fluorescent tags to measure and quantify biological phenomena, and in photonics as tunable colors for light-emitting diodes. EviTags are an ideal tagging tool for high-throughput screening in micro-fluidic systems, as well as cell imaging and pathogen detection. For most applications, we recommend our USB2000-FLG Spectrometer and some combination of our light sources and filters to excite EviDots and EviTags. Contact one of our Applications Scientists for details.

EviDot Core & Core-shell Nanocrystals

EviDot Core Nanocrystals are manufactured quantum dots ranging in size from 2-10 nm with fewer than 1,000 atoms. Each Core type is made of the same material but exhibits different emission properties based on size. Cores produce high quantum yields with intense fluorescence at targeted peak wavelengths. EviDot Core-shell Nanocrystals are Core Nanocrystals with a zinc sulfide coating that stabilizes the Core, improves quantum yield and reduces photodegradation.

Item Code	Description	Semiconductor Nanocrystals	Vials	Volume per Vial	Price
QD-CS-VIS	Core Shell EviDot Test Kit with 1 vial each of the following: • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	Cadmium selenide nanocrystals with zinc sulfide shell (CdSe/ZnS)	6	30 mg dots in 4 mL of toluene solvent	$649
QD-CS-1V	Core Shell EviDots. Specify 1 vial only from the following: • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	Cadmium selenide nanocrystals with zinc sulfide shell (CdSe/ZnS)	1	50 mg dots in 5 mL of toluene solvent	$449
QD-C-VIS	Core EviDot Test Kit with 1 vial each of the following: • 500 nm • 520 nm • 545 nm • 570 nm • 595 nm • 618 nm	Cadmium selenide (CdSe)	6	35 mg dots in 4 mL of toluene solvent	$649
QD-C-1V	Core EviDots. Specify 1 vial only from the following: • 500 nm • 520 nm • 545 nm • 570 nm • 595 nm • 618 nm	Cadmium selenide (CdSe)	1	50 mg dots in 5 mL of toluene solvent	$349
QD-NIR	Core EviDot Test Kit with 1 vial of 850 nm and 950 nm	Lead sulfide (PbS)	2	10 mg dots in 4 mL toluene	$249
QD-NIR-1V	Core EviDots. Specify 1 vial only of 850 nm or 950 nm	Lead sulfide (PbS)	1	10 mg dots in 4 mL toluene	$199
QD-IR	Core EviDot Test Kit with 1 vial of 1310 nm and 1550 nm	Lead selenide (PbSe)	2	10 mg dots in 4 mL hexane	$699
QD-IR-1V	Core EviDots. Specify 1 vial only from the following: • 1100 nm • 1310 nm • 1550 nm • 1900 nm	Lead selenide (PbSe)	1	10 mg dots in 4 mL hexane	$524

For more details on EviDots, please visit our website at OceanOptics.com/Products/Evidots.asp.

EviTag Core-shell Nanocrystals

EviTag Nanocrystals are Core-shell Nanocrystals with an additional proprietary coating that makes the Core shells water-stable. EviTags now open the EviDot technology to life science applications. In fact, ligands (carboxyl or amine) are attached to the proprietary coating so that they can easily be bound to nucleic acids, antibodies and proteins.

Item Code	Description	Vials	Terminal Group	Volume per Vial	Price
QD-TAG-KIT	Core-shell EviTag Test Kit with 1 vial each of the following: • 490 nm • 520 nm • 540 nm • 560 nm • 600 nm	5	Carboxyl	0.125 mg tags in 0.5 mL of deionized water	$1499
QD-TAG-1V	Core-shell EviTags. Specify 1 vial only from the following: • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	1	Carboxyl	0.125 mg tags in 0.5 mL of deionized water	$399
QD-TAG-A-KIT	Core-shell EviTag Test Kit with 1 vial each of the following: • 490 nm • 520 nm • 540 nm • 560 nm • 600 nm	5	Amine	0.125 mg tags in 0.5 mL of deionized water	$1499
QD-TAG-A-1V	Core-shell EviTags. Specify 1 vial only from the following: • 490 nm • 520 nm • 540 nm • 560 nm • 580 nm • 600 nm • 620 nm	1	Amine	0.125 mg tags in 0.5 mL of deionized water	$399

For more details on EviTags, please visit our website at OceanOptics.com/Products/Evitags.asp.

Cosine Correctors for Emission Collection

Collect Radiation from 180°

Our Cosine Correctors couple to optical fibers and spectrometers for relative and absolute spectral intensity measurements, for emissive color applications, and for evaluation of light sources such as LEDs and lasers.

Probe Option

When the CC-3 and CC-3-UV are screwed onto the end of an optical fiber, the cosine corrector and optical fiber become an irradiance probe. The probe couples to one of our spectrometers to measure the intensity of light normal to the probe surface.

Direct-attach Option

The CC-3-DA screws directly onto the SMA 905 Connector of a USB2000, HR4000 or S2000 Spectrometer, creating a complete spectroradiometric system and eliminating the need for an optical fiber.

Diffusing Material: UV-VIS or VIS-NIR

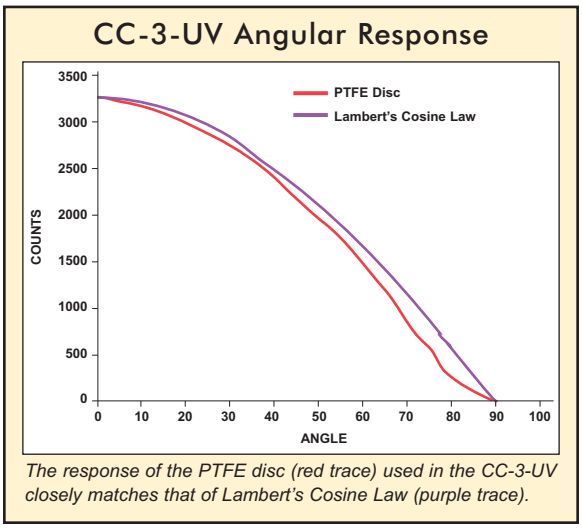
The diffusing material used in the cosine corrector is a thin disk of opaline glass (350-1100 nm) or PTFE (200-1100 nm) that sits at the end of a stainless steel barrel. Call for details about our new HY-IRRAD irradiance collectors; one for air and one for water.

CC-3:	$99
CC-3-UV:	$129
CC-3-DA:	$299
HY-IRRAD-A:	$295
HY-IRRAD-W:	$295

Specifications

	CC-3	CC-3-UV	CC-3-DA
Diffusing material:	Opaline glass	PTFE	PTFE
Wavelength range:	350-1000 nm	200-1100 nm	200-1100 nm
Dimensions:	6.35 mm OD	6.35 mm OD	12.7 mm OD
Field of view:	180°	180°	180°

The CC-3-DA (above center) attaches directly to an SMA 905 Connector on a spectrometer (left), creating a spectroradiometer. The CC-3 and CC-3-UV (above left and right) attach to optical fibers, creating Irradiance Probes.



The response of the PTFE disc (red trace) used in the CC-3-UV closely matches that of Lambert's Cosine Law (purple trace).

Power Supply & Controller for LEDs

Measuring LEDs

The LED-PS Power Supply works with our spectrometers and the FOIS-1 Fiber Optic Integrating Sphere (see page 108) for spectroradiometric and color measurements of LEDs. The LED-PS unit has easy-to-reach electrical connectors for mounting LEDs that are 9.52-mm diameter or smaller with 2.77-mm lead spacing.

Adjustable Drive Current

The LED-PS holds the LED in place, powers the LED, and displays the LED's drive current. The drive current is adjustable, with a digital display to indicate the current level. With the LED-PS-NIST, the current meter is calibrated against a NIST-traceable standard. For more on LED measurements, see page 16.

LED-PS:	$499
LED-PS-NIST:	$749
LED-PS-RECAL:	$199

Specifications

Dimensions:	56.8 mm x 56.8 mm x 56 mm
Weight:	170 g
Power consumption:	Up to 100 mA @ 12 VDC; depends on setting
LED drive current:	12-50 mA with 0.1 mA resolution
Drive current accuracy:	±1.0%
LED mount:	2.77 mm lead spacing, PTFE base

Integrating Spheres for Irradiance/Emission

ISP-I Integrating Spheres

Specifications	
Weight:	330 g (ISP-30); 730 g (ISP-50); 1,650 g (ISP-80)
Spectral range:	200-2500 nm
Sphere coating:	Proprietary PTFE-based diffusing material
Reflectivity:	>98% (400-1500 nm); >95% (250-2000 nm)

Emission Collection

ISP-I Integrating Spheres are convenient sampling optics that couple to our spectrometers via optical fibers to measure the spectral output from 200-2500 nm of LEDs, lasers and other light sources. Each integrating sphere consists of a proprietary PTFE-based, sintered diffusing material -- in diameters of 30 mm, 50 mm or 80 mm -- that provides a Lambertian surface for irradiance measurements.

LED Measurement & Direct-attach Option

An ISP-LED-ADP adapter holds in place 3 mm, 5 mm or 8 mm LEDs and screws into the sample port of the ISP-50-8-I Integrating Sphere for measuring LEDs. The adapter ensures reproducibility. Another option is the USB-ISP-50 or USB-ISP-80, which directly attach to a USB2000 Spectrometer, eliminating the need for a read fiber. If the sample ports are too small, we offer custom sample port sizes for all ISPs. Custom machining for ports in diameters of 8, 10, 12, 14, 16 or 20 mm is available (see below).

Item	Description	Sample Port	Max. Fiber	Price
ISP-30-6-I:	Integrating sphere, 59 mm diameter, 58 mm high	6 mm	800 µm	$1,228
ISP-50-8-I:	Integrating sphere, 80 mm diameter, 78 mm high	8 mm	600 µm	$1,598
ISP-80-8-I:	Integrating sphere, 107 mm diameter, 117 mm high	8 mm	400 µm	$1,981
ISP-LED-ADP:	Holds in place 3, 5 or 8 mm LED for reproducibility; for use with ISP-50-8-1	N/A	N/A	$185
USB-ISP-50:	ISP-50-8-I with connector for directly attaching to a USB2000 Spectrometer	8 mm	600 µm	$2,048
USB-ISP-80:	ISP-80-8-I with connector for directly attaching to a USB2000 Spectrometer	8 mm	400 µm	$2,417
ISP-PORT-1:	Custom sample port machining of 8, 10, or 12 mm diameter	8, 10 or 12 mm	400 µm	$172
ISP-PORT-2:	Custom sample port machining of 14,16 or 20 mm diameter	14, 16 or 20 mm	400 µm	$323
HL-2000-CAL-ISP	NIST-traceable radiometric standard for use with ISP-50-8-I; see page 131	N/A	N/A	$825

FOIS-1 Fiber Optic Integrating Spheres

In the picture top right, the FOIS-1 is being used to measure LEDs. In the picture bottom right, the FOIS-1 is attached to a 74-ACH, a setup often used when making transmission measurements of curved optics. An optic is set between the FOIS-1 and the right arm of the 74-ACH.

Specifications			
Dimensions:	56.8 mm x 62.4 mm (housing) 38.1 mm diameter (sphere)	Weight:	240 g
		Spectral range:	200-2500 nm
Top mounts:	(2) 6-32; (2) 8-32; (1) 1/4-20	Sample port:	9.5 mm aperture
Side mounts:	SMA 905 Connector; (1) 8-32	Sphere coating:	Spectralon

360° Emission Collection

The FOIS-1 is a compact sampling optic that collects light from emission sources such as LEDs and lasers, or that measures light fields with a 360° field of view.

Principle of Operation

At the heart of the FOIS-1 is Spectralon, a white diffusing material with a highly Lambertian surface. Light enters the sphere via a 9.5-mm diameter port while a fiber -- oriented at 90° to the sample port -- collects the light. The size of the FOIS-1 and its three mounting holes make it easy to connect the sphere to other items, such as the 74-ACH Adjustable Collimating Lens Holder (at left).

Use with Calibrated Light Source

Before measuring the absolute spectral intensity of emission sources, use the LS-1-CAL-INT Calibrated Light Source to calibrate the absolute spectral response of your spectroradiometric system. For more on the LS-1-CAL-INT, see page 131.

FOIS-1: $499

Integrating Spheres for Reflectance

ISP-REF Illuminated Integrating Sphere

The ISP-REF Illuminated Integrating Sphere couples to our spectrometers to measure the total integrated reflectance of surfaces placed against the sphere's sample port. The ISP-REF can measure variegated and opaque samples.

The ISP-REF measures the reflectance from flat surfaces pressed against its 10.3-mm diameter sample port. Illumination is provided by an internal tungsten halogen lamp powered with a 12 VDC wall transformer. The lamp is baffled so that all light that strikes the sample has been reflected from the sphere walls. The sphere's highly Lambertian interior provides a uniform 180° illumination field. The sample is viewed from 8° from normal by a lens system that couples to the fiber optic sample port. The field of view is restricted to the sample area, and has a divergence of ~2°. A simple switch allows you to open or close a gloss trap opposite the lens for the inclusion or exclusion of specular reflectance. A reference fiber port is provided to connect to a second spectrometer channel to monitor the output of the light source during long experiments, or for bringing external light into the sphere.

ISP-REF: $1,599
ISP-REF-B Bulb: $40

ISP-R Integrating Spheres

The ISP-Rs are distinguished by their compact size and sturdy design. Each has SMA 905 fiber ports at 90° (to connect to a spectrometer) and 8° (to connect to a light source for direct illumination).

Each sphere is made of a sintered PTFE, which is >98% reflective in the visible. The spheres are available in diameters of 30 mm, 50 mm and 80 mm. Sample port diameters are 6 mm for the 30-mm sphere and 8 mm for the 50-mm and 80-mm spheres. If the 6-mm or 8-mm diameter sample ports are too small, custom sample port sizes for all ISP-Rs are available. For sample ports in diameters of 8, 10, or 12 mm, select ISP-PORT-1. To custom machine a 14,16 or 20 mm sample port, order an ISP-PORT-2.

The gloss-trap version (see inset, far right) comes with two cylindrical pieces -- one is made of black absorbing material and the other of white reflecting material -- that fit into a hole at the top of the sphere. When using the white gloss trap, you can make specular and diffuse measurements. When using the black gloss trap, you can use the ISP-Rs for diffuse measurements.

ISP-30-6-R: $1,597
ISP-50-8-R: $1,844
ISP-80-8-R: $2,227
ISP-50-8-R-GT: $1,986
ISP-PORT-1: $172
ISP-PORT-2: $323

Specifications

	ISP-REF	ISP-30-6-R	ISP-50-8-R	ISP-80-8-R	ISP-50-8-R-GT
Dimensions:	54 mm x 57 mm x 83 mm	59 mm dia., 58 mm high	80 mm dia., 78 mm high	107 mm dia., 117 mm high	80 mm dia., 78 mm high
Weight:	864.7 g	330 g	730 g	1,650 g	743.3 g
Power consumption:	600 mA @ 12 VDC (lamp)	None	None	None	None
Spectral range:	360-2000 nm	200-2500 nm	200-2500 nm	200-2500 nm	200-2500 nm
Sphere diameter:	38.1 mm	30 mm	50 mm	80 mm	50 mm
Sample port diameter:	10.32 mm	6 mm	8 mm	8 mm	8 mm
Sphere coating:	Spectralon	PTFE material	PTFE material	PTFE material	PTFE material
Reflectance:	Diffuse or specular and diffuse	Specular and diffuse	Specular and diffuse	Specular and diffuse	Diffuse
Reflectivity:	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)	>98% (400-1500 nm) >95% (250-2000 nm)
Bulb:	10,000-hour bulb; 2800 K	None	None	None	None

Diffuse Reflectance Standards

WS-1

WS-1 Diffuse Reflectance Standard

The WS-1 Diffuse Reflectance Standard (at left) is made of PTFE, a diffuse white plastic that provides a Lambertian reference surface for reflectance experiments. The WS-1 comes in an anodized aluminum housing, and is hydrophobic, chemically inert and very stable, even in deep-ultraviolet applications. It is >98% reflective from 250-1500 nm and >95% reflective from 250-2200 nm.

WS-1: $299

WS-1-SL

WS-1-SL White Reflectance Standard with Spectralon

The WS-1-SL is a diffuse reflectance standard from Labsphere and is made from their patented diffuse reflectance material, Spectralon. Spectralon is hydrophobic and is thermally stable to 350 °C. The durable material provides highly accurate, reproducible data. Unlike all the other PTFE-based standards on this page, the WS-1-SL often can be smoothed, flattened and cleaned if nicked or soiled.

WS-1-SL: $329


WS-1-SS

WS-1-SS Includes Stainless-steel Housing

The WS-1-SS comes in a stainless steel housing and has the same properties as the WS-1. In addition, the surface of the WS-1-SS is slightly recessed to allow the RPH-1 Reflection Probe Holder to sit on the standard without coming in direct contact with the standard's surface.

WS-1-SS: $364

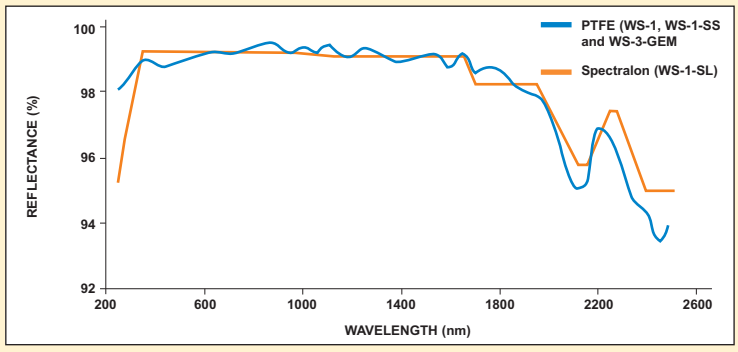
WS-3-GEM White Reference Tile

Conceived for use in colorimetric applications involving diamonds and other gems, the WS-3-GEM White Reference Tile consists of a diffuse PTFE material, shaped to form a holder within its stainless steel receptacle. Because of its concave shape, the WS-3-GEM becomes an integrating sphere when illuminated. The WS-3-GEM has >98% reflectivity from 250-1500 nm and >95% reflectivity from 250-2200 nm. Like the WS-1, the WS-3-GEM's reflectance material is hydrophobic, chemically inert and very stable, even in deep-UV applications.

WS-3-GEM: $487


WS-3-GEM

Reflectivity of the White Standards



Specifications

	WS-1	WS-1-SL	WS-1-SS	WS-3-GEM
Dimensions:	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 32 mm OD, 10 mm thick (tile)	38 mm diameter (housing) 31 mm OD, 10 mm thick (tile)
Weight:	30 g	30 g	30 g	70 g
Spectral range:	250-2000 nm	250-2500 nm	250-2000 nm	250-2000 nm
Housing:	Aluminum	Delrin holder, protective cover	Stainless steel	Stainless steel
Reflectivity:	>98% (250-1500 nm) >95% (250-2200 nm)	99% (400-1500 nm) >96% (250-2000 nm)	>98% (250-1500 nm) >95% (250-2200 nm)	>98% (250-1500 nm) >95% (250-2200 nm)

Specular Reflectance Standards

Versatile & Durable Standards

We offer three specular reflectance standards for use as references when measuring the reflection of surfaces with high or low specular reflectivity. Each standard consists of a 31.7-mm outer diameter optical reflectance material in a protective aluminum receptacle with screw-on top. The superior coatings on the substrates are environmentally stable; they are able to withstand high temperatures and mechanical stresses.

Software Referencing & Calibration

Reflectivity values for the standards are built into our Spectroscopy Operating Software to provide a reference for any specular measurement. You simply choose the standard from a software menu and the software reads data from the electronic file shipped with the standard.

For High Reflectivity

The STAN-SSH High-reflectivity Specular Reflectance Standard is a fused-silica substrate coated with aluminum and protected by a thin layer of magnesium fluoride. This standard is typically used for measuring high-reflectance surfaces of optical substrates and coatings, machined metals and semiconductor materials. Values for the STAN-SSH are calculated for any angle from 0-45°.

For Calibrated High Reflectivity

Also available is a calibrated version of the STAN-SSH. The STAN-SSH-NIST is calibrated at a 6° angle traceable to NIST and is accurate to ±0.1% from 250-2500 nm. The STAN-SSH-NIST comes with calibrated reflectivity values (from a 6° angle) in both paper and electronic formats. We recommend a periodic recalibration of the STAN-SSH-NIST, which costs $149. Should the calibrated surface become corrupted, a recoat and calibration service is available for $299.

For Low Reflectivity

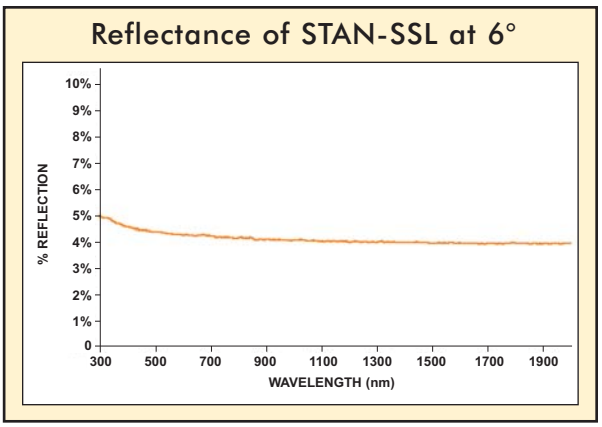
The STAN-SSL Low-reflectivity Specular Reflectance Standard is a black glass standard that can be used as a reference when measuring the low-reflectance surfaces of samples such as thin film coatings, anti-reflective coatings, blocking filters and substrates.

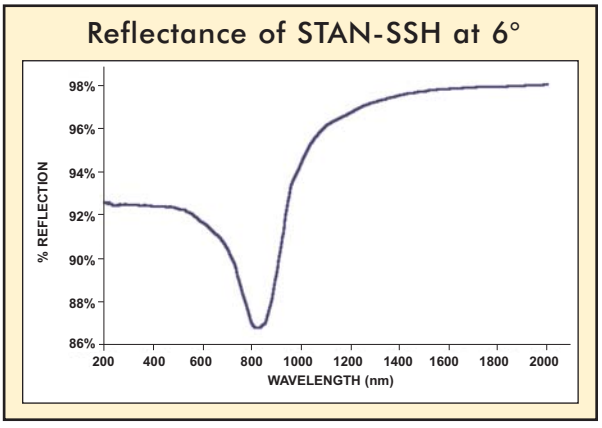
Holder Protects Standards

We also offer a holder for use with our reflectance standards. The STAN-HOLDER supports a standard during measurements, which helps to preserve its coating.

STAN-SSH:	$499
STAN-SSH-NIST:	$999
STAN-SSL:	$499
STAN-HOLDER:	$75

With the STAN-SSH High-reflectivity Specular Reflectance Standard (above), you receive a certificate of calibration in paper and electronic formats.





Specifications

	STAN-SSH	STAN-SSH-NIST	STAN-SSL
Substrate dimensions:	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height	31.75 mm outer diameter x 6.35 mm height
Housing dimensions:	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height	38 mm outer diameter x 19 mm height
Weight:	40 g	40 g	40 g
Reflectance material:	Front-surface protected aluminum mirror on fused silica substrate	Front-surface protected aluminum mirror on fused silica substrate	Schott ND9 glass
Reflectivity:	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~5% (200-950 nm) ~4% (950-2500 nm)

Optical Flats

Visual Reference

Each Optical Flat is a finely polished optical reference surface that can be used to visually inspect the flatness of optical components such as mirrors, filters, prisms and windows. Flats can also be used as windows for interferometry applications.

What to Select

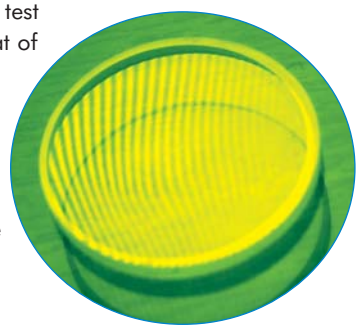
We offer single-sided flats made from either fused silica or Zerodur, each of which can be enhanced with an aluminum coating to increase contrast and improve the visual reference. We manufacture flats ranging from 1" to 6" in diameter and with flatness accuracies as precise as 1/20 wave.

Fused Silica or Zerodur

Your selection of fused silica or Zerodur flats depends on the application. Fused silica has a low thermal expansion and is highly resistant to abrasion. Zerodur is a glass ceramic that exhibits an even lower thermal expansion, making it useful for applications with significant temperature fluctuations.

How Flats Work

The choice of flatness accuracy depends on the application. For example, if the test surface is flatter than 1/4 wave, a more precise 1/10 wave flat is required to display the interference pattern change. When an Optical Flat is placed in contact with a test surface and illuminated with monochromatic light, an interference pattern of light and dark bands forms. A curved interference pattern like the one shown here indicates that the flatness of the test surface is less than that of the reference. Evenly spaced patterns indicate that the flatness of the test surface is equal to or higher than that of the reference.



Fused Silica Optical Flats

Item	Diameter	Center Thickness	Aluminum Coating	Flatness	Price
FLS-10-SS	1.0"	0.5"	No	1/10λ	$200
FLS-10-SSM	1.0"	0.5"	Yes	1/10λ	$250
FLS-12-SS	1.0"	0.5"	No	1/20λ	$225
FLS-12-SSM	1.0"	0.5"	Yes	1/20λ	$270
FLS-14-SS	1.0"	0.5"	No	1/4λ	$170
FLS-14-SSM	1.0"	0.5"	Yes	1/4λ	$210
FLS-20-SS	2.0"	0.5"	No	1/10λ	$290
FLS-20-SSM	2.0"	0.5"	Yes	1/10λ	$330
FLS-22-SS	2.0"	0.5"	No	1/20λ	$350
FLS-22-SSM	2.0"	0.5	Yes	1/20λ	$400
FLS-24-SS	2.0"	0.5"	No	1/4λ	$230
FLS-24-SSM	2.0"	0.5"	Yes	1/4λ	$255
FLS-40-SS	4.0"	0.75"	No	1/10λ	$650
FLS-40-SSM	4.0"	0.75"	Yes	1/10λ	$765
FLS-42-SS	4.0"	0.75"	No	1/20λ	$765
FLS-42-SSM	4.0"	0.75"	Yes	1/20λ	$875
FLS-60-SS	6.0"	1.0"	No	1/10λ	$1,200
FLS-60-SSM	6.0"	1.0"	Yes	1/10λ	$1,325
FLS-62-SS	6.0"	1.0"	No	1/20λ	$1,395
FLS-62-SSM	6.0"	1.0"	Yes	1/20λ	$1,665

Zerodur Optical Flats

Item	Diameter	Center Thickness	Aluminum Coating	Flatness	Price
FLZ-10-SS	1.0"	0.5"	No	1/10λ	$200
FLZ-10-SSM	1.0"	0.5"	Yes	1/10λ	$250
FLZ-12-SS	1.0"	0.5"	No	1/20λ	$225
FLZ-12-SSM	1.0"	0.5"	Yes	1/20λ	$270
FLZ-14-SS	1.0"	0.5"	No	1/4λ	$170
FLZ-14-SSM	1.0"	0.5"	Yes	1/4λ	$210
FLZ-20-SS	2.0"	0.5"	No	1/10λ	$290
FLZ-20-SSM	2.0"	0.5"	Yes	1/10λ	$330
FLZ-22-SS	2.0"	0.5"	No	1/20λ	$350
FLZ-22-SSM	2.0"	0.5"	Yes	1/20λ	$400
FLZ-24-SS	2.0"	0.5"	No	1/4λ	$230
FLZ-24-SSM	2.0"	0.5"	Yes	1/4λ	$255
FLZ-40-SS	4.0"	0.75"	No	1/10λ	$650
FLZ-40-SSM	4.0"	0.75"	Yes	1/10λ	$765
FLZ-42-SS	4.0"	0.75"	No	1/20λ	$765
FLZ-42-SSM	4.0"	0.75"	Yes	1/20λ	$875
FLZ-60-SS	6.0"	1.0"	No	1/10λ	$1,200
FLZ-60-SSM	6.0"	1.0"	Yes	1/10λ	$1,325
FLZ-62-SS	6.0"	1.0"	No	1/20λ	$1,395
FLZ-62-SSM	6.0"	1.0"	Yes	1/20λ	$1,665

Specifications

	FLS (Fused Silica)	FLZ (Zerodur)
Surface quality:	60-40	60-40
Wedge:	< 5 minutes	< 5 minutes
Tolerance:	± 1 mm on CT ± 0.25 mm on diameter	± 1 mm on CT ± 0.25 mm on diameter
Refractive index:	1.458 n_d	1.542 n_d
Abbe #:	67.7 v_d	56.2 v_d
Thermal expansion:	0.55 x 10^{-6} °C^{-1}	0.10 x 10^{-6} °C^{-1}

Shear-plate Collimation Testers

Applications Versatility

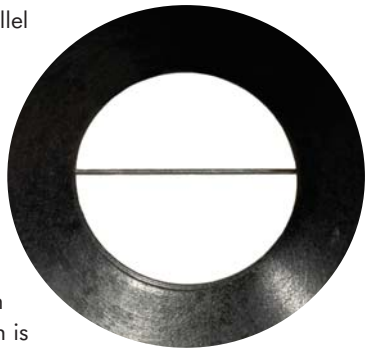
Use Shear-plate Collimation Testers to examine and adjust the collimation of laser light, or to measure the wavefront curvature and divergence/convergence magnitude of large-radius optical components.

Various Aperture Sizes from 350-2500 nm

Each tester is useable from 350-2500 nm, and is available in apertures ranging from 10-200 mm. Each tester consists of a wedged, high-quality optical flat housed in a heavy-duty anodized aluminum frame.

Basic Operation with Interferometric Design

The testers are remarkably easy to use: When a planar wavefront is incident at an angle of 45°, two reflected wavefronts result. The lateral separation of these wavefronts is referred to as shear. Fringes -- parallel patterns of light and dark areas -- will be seen in the overlapping region of the two images. Collimating the laser beam is a matter of adjusting the collimating system until the fringe pattern is parallel to the shadow of the collimation tester's reference wire.



Collimation Testers

Item Code	Aperture Size	Price
CT-10	10 mm	$600
CT-20	20 mm	$700
CT-50	50 mm	$800
CT-75	75 mm	$950
CT-100	100 mm	$1,200
CT-125	125 mm	$1,700
CT-150	150 mm	$2,800
CT-200	200 mm	$4,800

Thin Film Reference Wafer

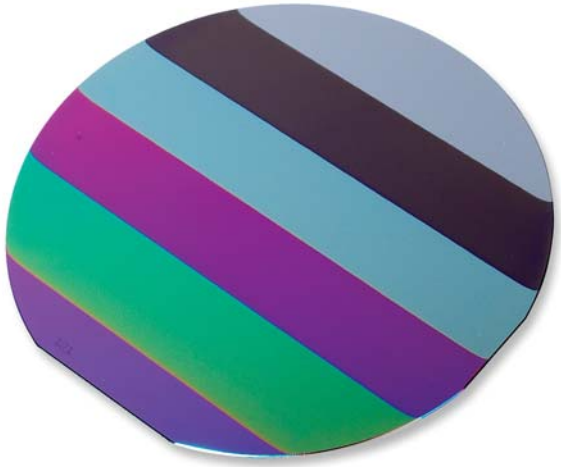
5-step Wafer

When measuring the thickness of substrates such as silicon wafers or optical layers, consider our Silicon-Silicon Dioxide (Si-SiO_2) Reference Wafer. This 9.8-cm (4") diameter, 5-step wafer has a calibrated thickness range of 0-500 nm, and is ideal for use as a reference standard when measuring the thickness of thin, transparent layers on various substrates.

Calibrated

The Reference Wafer consists of a thin wafer of silicon dioxide on silicon, with each transparent step numbered and etched on the wafer surface. A calibration data sheet -- the wafer is calibrated using an ellipsometer -- includes information for each step such as the X and Y positions, δ (Psi), ψ (Delta), period (in nm) and thickness (in nm).

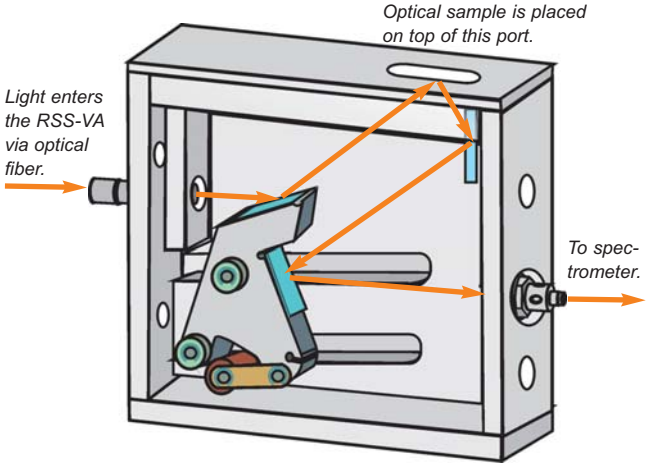
REFERENCE: $585



Step Sizes
0-500 nm with 100 nm steps:

0 nm (uncoated)
100 nm (±20 nm)
200 nm (±20 nm)
300 nm (±20 nm)
400 nm (±20 nm)
500 nm (±20 nm)

Variable-angle Reflection Sampling System



Specifications	
Dimensions:	114.3 mm x 41.3 mm x 101.6 mm
Weight:	980 g
Sample port:	19.0 mm x 6.4 mm
Connectors:	(2) SMA 905 Connectors (for illumination fiber & read fiber)
Surface mount:	3-point
Angles of incidence:	~10° to ~50° (user-adjusted)
Recommended fibers:	100 µm (illumination and read)
Material:	Black anodized aluminum

Measure Optical Substrates at Different Angles of Incidence

The RSS-VA Variable-angle Reflection Sampling System is a cleverly designed opto-mechanical device for measuring specular reflection of optical substrates at varying angles of incidence. When coupled to our spectrometers and light sources, the RSS-VA becomes a compact, low-cost alternative to the unwieldy, high-priced systems typically used to characterize optical substrates such as metallic and dielectric coatings.

Opto-Mechanical Design

The RSS-VA has two ports for SMA 905-terminated optical fibers: one to illuminate the optical substrate, the other to collect the reflectance and send it to the spectrometer (see drawing). This fiber-in/fiber-out design takes advantage of a sophisticated optical train that allows users to change the angle of incidence (AOI) from 10° to 50° simply by manipulating the carriage inside the black anodized stainless steel device housing. A thumbscrew locks the optical assembly at a fixed angle. Also included is a three-point surface mount for holding the sample in a fixed position.

Reflectance Standards

To normalize measurements taken with the RSS-VA, you will need a reflectance standard such as the STAN-SSH High-reflectivity Specular Reflectance Standard or STAN-SSL Low-reflectivity Specular Reflectance Standard (page 111). The STAN-SSH is also available in a NIST-traceable version, with values available in hard-copy and electronic formats.

Adapter Plate for Small Optics

The RSS-VA is available with an adapter (RSS-VA-ADP) to accommodate smaller optics. The adapter fits over the standard sample port aperture, which is 19.0 mm x 6.4 mm.

When AOI is A-OK

In many applications involving optical components it is necessary to understand how individual components function at varying AOI. In fact, most optical designs place components at AOI other than "normal" -- i.e., at 0°, with the beampath 90° to the substrate. For devices with multiple components -- our spectrometer optical benches, for example -- system efficiency can only be fully characterized by measuring the reflectivity of each component as a function of its AOI. To accomplish this, all that's needed is a USB2000-VIS-NIR Spectrometer, an LS-1 Tungsten Halogen Light Source, the RSS-VA, two optical fibers and a reflectance standard.

RSS-VA: $1,400
RSS-VA-ADP: $99

Reflection Stage

The Single-Point Reflection Stage is a probe holder for reflection measurements of optical layers and other substrates up to 150 mm in diameter. The probe holder accommodates fiber optic probes and other sampling devices up to 6.35 mm in diameter, and slides up and down a stainless steel post for adjustment to heights as great as ~63.5 mm. The reflection stage has an anodized base plate that is scored in concentric circles of varying diameters, to act as a guide when positioning round samples. For a list of all of our probe holders, see page 155.

STAGE: $547

Specifications	
Dimensions (base):	152.4 mm diameter
Dimensions (sample area):	101.6 mm diameter*
Weight:	620 g
Height:	Rail height adjustable to 63.5 mm
Materials:	Anodized aluminum plate, stainless steel post and post holder

** Represents the area of scored concentric circles. You could use the entire base plate area, which is larger, for your sample.*

Reflection & Transmission Stage

The Stage-RTL-T is a novel sampling system for analysis of substrate materials such as silicon, metals, glass and plastics. The RTL-T couples to our spectrometers and light sources, and can be configured in a variety of setups for reflection and transmission measurements.

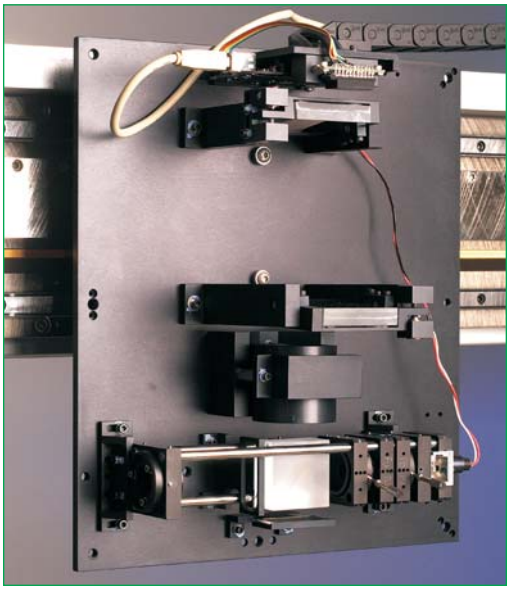
The Stage-RTL-T consists of a variable rail attached to a base plate, with three devices that attach to the rail with a thumbscrew. From bottom to top, these devices are a fiber holder with collimating lens; a sample holder for reflection or transmission; and a light trap to mitigate the effects of back reflection and ambient light. (Remove the light trap to access a second collimating lens.)

The STAGE-RTL-T is remarkably versatile: perform reflection measurements with the probe positioned above or below the sample (measuring from below maintains a constant distance between probe and sample); make reflection measurements with the light trap in place; or measure transmission of samples using two fibers. For a list of all probe holders, see page 155.

STAGE-RTL-T: $1,995

Specifications	
Dimensions (base):	206.3 mm diameter
Dimensions (sample area):	152.4 mm diameter (sample holder)
Weight:	4.5 kg
Height:	Rail height adjustable to 400 mm
Materials:	Anodized aluminum

Long Trace Profilometer



The LTP-V has a linear servomotor that's so accurate it can position itself within 0.5 mm. The streamlined optical head design (shown above) is temperature-insensitive and has only two optical controls -- beam amplitude and sample-versus-reference balance. A polarizing beamsplitter is accurate to 1/20 wave. Included is a miniature CCD-array system that interfaces to PCs via a USB cable.

Specifications	
Scan length:	1500 mm
Scan velocity:	3 mm/second (assuming 1-mm steps, 1 sample)
Position accuracy:	± 0.5 µm
Slope accuracy:	<1 microradian
Height accuracy:	<50 nm; 10-nm variations have been measured
Slope measurement range:	±5.0 milliradian

Unique Optical Profiling Tool

The LTP-V Long Trace Profilometer is an interferometric optical profiling instrument for absolute figure measurement of flats, spheres and aspheres up to 1500 mm in diameter. The LTP-V characterizes the figure and mid-frequency errors on cylindrical aspheres over 1 meter in length, and excels at measuring the shape of exotic aspheric optics, adaptive optics and mirror-bending mechanisms. With the LTP-V, optical surfaces can be measured quickly, easily and with nanometer precision and accuracy -- without the need for null corrector lenses or external reference surfaces. It is the only instrument now available for absolute figure measurement of optics as large as 150 cm in diameter.

About the Instrument

Conceived at Brookhaven National Laboratory and commercialized by Continental Optical in the early 1990s, the Long Trace Profilometer has been completely redesigned since our acquisition of Continental Optical in 2000. The LTP-V is a slope-measuring interferometer that measures the phase difference between two co-linear probe beams as they move across the sample surface. It is extremely insensitive to vibrations, which makes it suitable for use in laboratory environments.

Absolute Accuracy

What sets the LTP-V apart from other profile-measuring instruments is its ability to correct for real-time probe beam angular errors during the traverse of the linear beam, without the need for a calibrated external reference standard. Variations in the probe beam pointing direction are measured and subtracted from the test surface slope, resulting in the absolute slope profile and measurement of the absolute radius of curvature of the test surface.

Pricing

A great deal of care and consultation is required before the purchase of an LTP-V. The cost for the LTP-V includes these consultations, shipping of the instrument, installation of the instrument, and training in its operation. The LTP-VMIR is an additional attachment for taking vertical and inverted mirror scans. The LTP-CALSTD is a calibrated standard mirror for use as a reference source.

LTP-V:	$120,000
LTP-VMIR:	$1,500
LTP-CALSTD:	$1,000

Light Sources

Overview: Light Sources

Sources for Illumination, Excitation, Calibration

The development of Ocean Optics miniature fiber optic spectrometers created the need for comparably sized and priced accessories, including light sources. Since no such sources existed, we developed our own -- compact, modular sources complemented by the best light sources for spectroscopy that our vendor partners can provide.

Sources for illumination cover various wavelength ranges to enable absorbance, reflectance and fluorescence measurements from the deep UV to the NIR. Compact light-emitting diodes produce output for fluorescence measurements. For fast, reliable spectrometer wavelength calibrations, we offer Mercury and Argon sources. Design features such as built-in filter slots, combined with optional accessories such as direct-attach cuvette holders, make sampling simple.

Ocean Optics Modular Light Source Options

Deuterium Light Sources: Used most often for UV absorbance and reflectance measurements.

Combination Deuterium and Tungsten Light Sources: Used as single illumination sources for measurements across broad wavelength ranges.

Pulsed Xenon Lamps: Used as long-life sources for absorbance, reflectance and fluorescence measurements, and for measuring optically or thermally labile samples.

Calibrated Light Sources: Used to calibrate the absolute spectral intensity of a system in irradiance applications.

Tungsten Halogen Light Sources: Used most often as standard VIS-NIR light sources for absorbance, reflectance of solid objects, and color measurement.

Light-emitting Diodes: Used as excitation sources for fluorescence. Feature minimal warm-up and high stability. Power is lower and spectral width is wider than with lasers.

Wavelength Calibration Sources: Used to calibrate the wavelength of spectrophotometric systems. Mercury argon source is for UV-NIR and the argon source is for NIR.

Type	Product	Wavelength Range	Output	Measurement Type	Page
Deuterium Tungsten Halogen	DH2000-BAL DH2000	~230-2000 nm	Continuous	Absorbance, Reflectance, Fluorescence, Transmission	120 121
Miniature Deuterium Tungsten Halogen	DT-MINI-2 DT-MINI DT-MINI-2-GS USB-DT	~200-2000 nm	Continuous	Absorbance, Transmission, Reflectance	122 122 122 123
Deuterium	D2000	~215-400 nm	Continuous	Absorbance, Reflectance, Fluorescence, Transmission	124
Xenon	PX-2 HPX-2000	220-750 nm 185-2000 nm	Pulsed Continuous	Absorbance, Reflectance, Fluorescence, Transmission	125
LEDs	LEDs (several wavelengths)	380, 395, 470, 475, 518, 590, 640 and 450-630 nm	Pulsed or Continuous	Fluorescence	128-129
Tungsten Halogen	LS-1 HL-2000	360-2000 nm 360-2000 nm	Continuous	Absorbance, Reflectance, Transmission	126 127
Calibrated Deuterium Tungsten Halogen	DH2000-CAL	~215-1050 nm	Continuous	Calibration (Radiometric)	130
Calibrated Tungsten Halogen	LS-1-CAL HL-2000-CAL	300-1050 nm 300-1050 nm	Continuous	Calibration (Radiometric)	131
Mercury Argon	HG-1 CAL-2000	253-1700 nm 253-1700 nm	Continuous	Calibration (Wavelength)	132
Argon	AR-1	253-1700 nm	Continuous	Calibration (Wavelength)	133

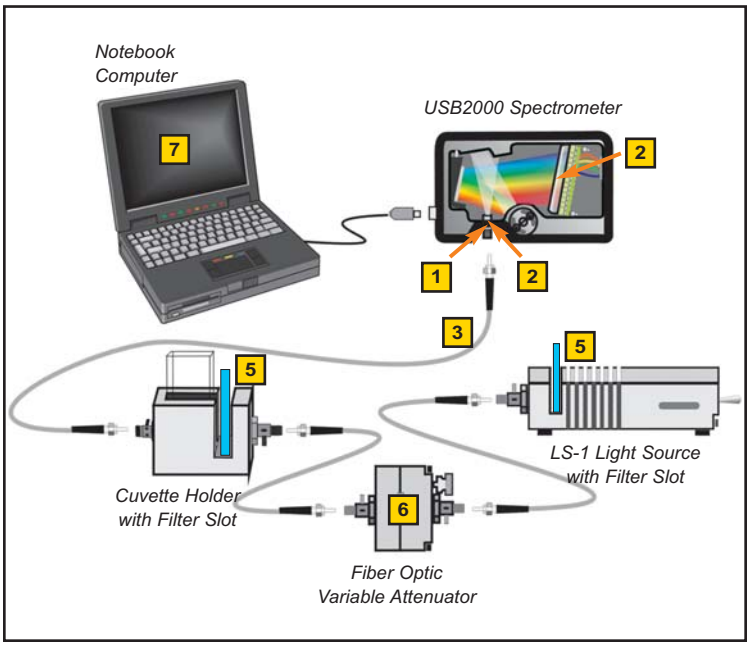
Overview: Light Sources

Ways to Modify Light

Our products provide you with many options for modifying the light transmitted to the spectrometer's detector. The illustration here is a fabricated configuration -- as few would have a setup exactly like it -- to demonstrate several ways in which you can modify light.

For high-intensity light-level applications such as laser characterization, more light will reach the spectrometer than likely can be detected successfully by the high-sensitivity CCD-array detector used in most of our spectrometers. Also, some absorbance experiments may require signal attenuation; too much light can saturate the reference measurement.

In some instances, saturation is avoided by using a different grating, changing the optical bench entrance aperture or adding neutral-density filters to the optical path. Another option is to adjust (via software) the spectrometer integration time to limit the interval during which the detector collects light.



1 Entrance Aperture: Slit

An installed slit acts as the entrance aperture to the optical bench and regulates the amount of light entering the optical bench. The slit size is specified by the user. Slits are optional, and range in size from 5 µm to 200 µm.

2 Installed Filters

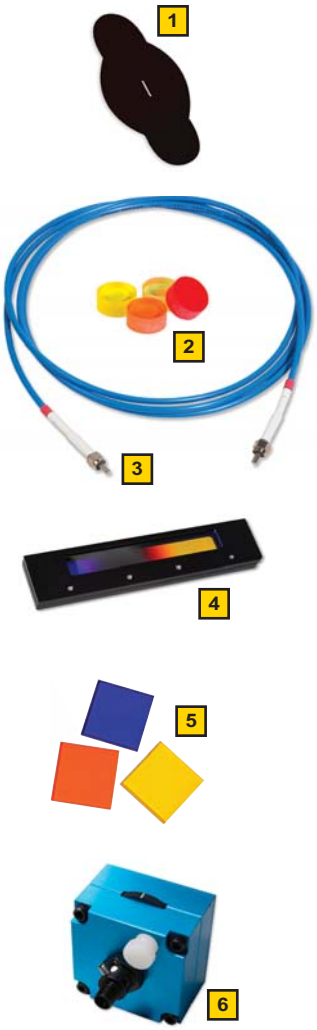
In addition to the variable longpass OFLV Filter -- an order-sorting filter applied to the detector's window -- we offer optional bandpass and longpass blocking filters to restrict radiation in certain wavelength regions.

3 Optical Fiber

Our optical fibers are available from 8 µm to 1000 µm in diameter. If you need a great deal of light for your application, you should select a large-diameter fiber. Also, in the absence of a slit, the fiber connected to the spectrometer acts as the optical bench entrance aperture.

4 Linear Variable Filters

Our high-pass, low-pass and adjustable-bandpass filters have excellent blocking characteristics and resistance to heat, making these filters ideal for spectrally shaping the light emitted from broadband sources.



5 Loose Filters

Our loose filters fit into our light sources, cuvette holders and in-line filter holders. High-pass Filters eliminate second- and third-order effects, test for stray light, and block excitation energy. Balancing Filters absorb energy in some regions while transmitting in others. Bandpass Filters pass energy in one region and block light above and below that region.

6 Fiber Optic Variable Attenuator

The FVA-UV Fiber Optic Variable Attenuator is an opto-mechanical device that helps control the amount of light transmitted between two fibers. The FVA-UV attenuates light uniformly at all wavelengths from the ultraviolet through the near-infrared.

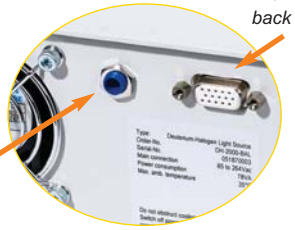
7 Integration Time

Integration Time is a setting in our software and is specified by the user. The integration time of the spectrometer is analogous to the shutter speed of a camera. The higher the value specified for the integration time, the longer the detector "looks" at the incoming photons. For more information about integration time, see any of our software manuals.

Balanced Deuterium Tungsten Halogen Source

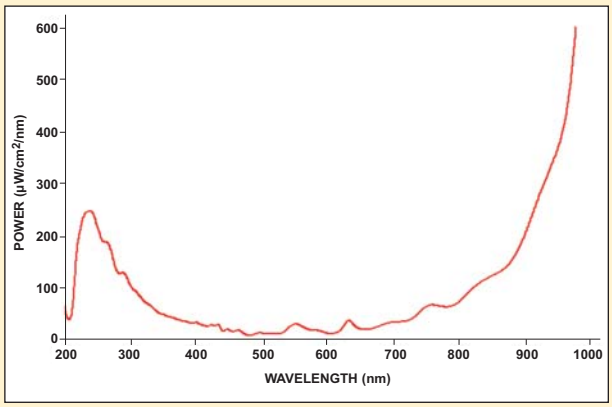
You can operate the shutter via a switch on the front of the light source . . .

. . . or via a TTL line from the back of the lamp.



Here, you can adjust the power for the tungsten bulb.

DH2000-BAL Spectral Output



Specifications	
Dimensions:	150 mm x 135 mm x 319 mm
Weight:	3.8 kg
Power consumption:	25 W (deuterium); 20 W (tungsten halogen)
Wavelength range:	230-400 nm (deuterium); 360-2000 nm (tungsten halogen)
Humidity:	5-95% non-condensing at 40 °C
Lamp voltage:	Ignition 350 V/20°
Tungsten bulb voltage:	Adjustable from 4.5 to 11.5 volts
Lamp current:	Operating 85 V/0.3A
Lamp lifetime:	1,000 hours
Current voltage drift:	<0.01% per hour
Voltage stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Operating temperature:	5 °C - 35 °C
Power requirements:	85-264 V 50/60 Hz
Power consumption:	190 W maximum
Warm-up time:	40 min. (deuterium); 20 min. (tungsten halogen)
Electronic certifications:	CE; VDI/VDE 0160; EN 61010

UV-NIR Spectral Range with Balanced Output

We've applied our expertise in patterned dichroic filters to an innovation in light source technology to create the only combined-spectrum illumination source available that eliminates saturation and signal-to-noise problems associated with the D-alpha line in the deuterium source. The DH2000-BAL Deuterium Tungsten Halogen Light Source combines deuterium and tungsten halogen light sources in a single optical path, producing a powerful, stable output from 230-2000 nm.

About the D-alpha Line

All deuterium sources have a D-alpha line, revealed as a sharp peak in the visible portion of the spectrum, that produces "unbalanced" output in the deuterium and tungsten halogen sources. Correcting for this peak -- a sharp spectral feature near 655 nm -- is difficult. For example, if you adjust spectrometer integration time to reduce the intensity of this saturated peak, the efficiency of the system at ultraviolet wave-lengths drops significantly, compromising the signal-to-noise of the spectrum. Also, spectrometer efficiency is typically greatest in the same general spectral range as the 655 nm line, exaggerating its effects.

Proprietary Filtering Technology

Using the same high-precision patterned dichroic filter technology that distinguishes our Linear Variable Filters (page 94), the DH2000-BAL:

- balances the intensity of the deuterium and tungsten halogen sources
- eliminates the D-alpha, D-beta and Fulcher lines
- eliminates problems associated with saturation
- produces a "smoother" spectrum across the entire wavelength range.

Upgrading Existing DH2000s with Kits

If you own a DH2000 and would like to upgrade the light source with the filtering technology used in the DH2000-BAL, but don't wish to purchase a new light source, you can order a DH-BAL-KIT (at left) and install the upgrade yourself.

For those owning a DH2000-S shuttered version of the lamp, specify the DH-BAL-KIT-S.

Optical Fibers

We recommend using our solarization-resistant optical fibers with the DH2000-BAL. See pages 139 and 140 for details.

DH2000-BAL:	$3,303
DH-BAL-KIT:	$1,614
DH-BAL-KIT-S:	$1,665

Deuterium Tungsten Halogen Sources

UV-NIR Spectral Range

The DH2000 Deuterium Tungsten Halogen Light Source combines the continuous spectrum of deuterium and tungsten halogen light sources in a single optical path. The combined-spectrum light source produces a powerful, stable output from 215-2000 nm. In addition, deep-UV versions of the DH2000 are available, with a 190-2000 nm range.

Options & Accessories: Shutter & Filter Holder

Integrated shutters are available and can be driven either by a switch or by a TTL signal. Another option is to include a filter holder with the source (see inset), which accepts filters up to 4 mm in thickness and as large as 25-mm square or 20-mm round in diameter. All versions of the DH2000 have an SMA 905 Connector for easy coupling to our spectrometers and accessories via optical fiber.

Adjustable Power

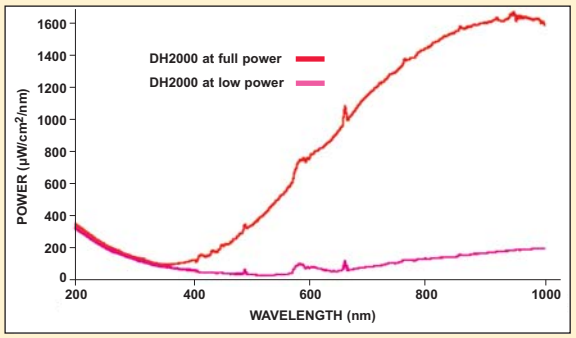
All versions of the DH2000 have a potentiometer on the back of the light source to adjust the intensity of the tungsten halogen output. This potentiometer allows you to adjust the optical power of the tungsten halogen light from 10-100%.

Optical Fibers

We recommend using our solarization-resistant optical fibers with all versions of the DH2000. See pages 139 and 140 for details.

DH2000: $2,421

DH2000 Spectral Output



The spectral output of the DH2000 at full power is in red and the tungsten halogen bulb at low power is in pink.

Additional DH2000 Light Sources and Accessories

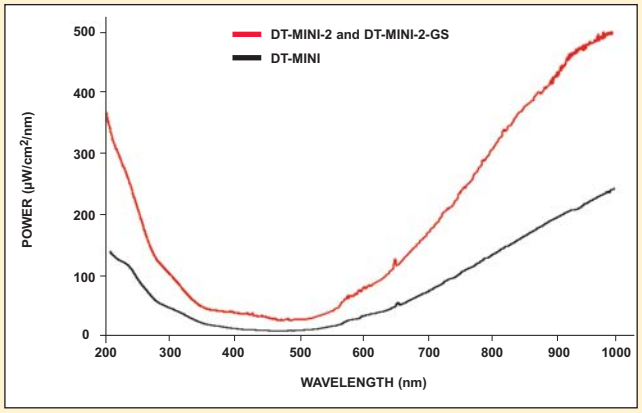
Item	Description	Price
DH2000-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range	$2,678
DH2000-S	Comes with a shutter controlled via a TTL signal or a manual switch up to 5 Hz	$2,808
DH2000-S-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range and comes with a shutter (controlled via a TTL signal or a manual switch up to 5 Hz)	$3,066
DH2000-FHS	Comes with a filter holder for filters up to 25-mm square or 20-mm round and 4-mm thick	$3,064
DH2000-FHS-DUV	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range; comes with a filter holder for filters up to 25-mm square or 20-mm round and 4-mm thick; and has a shutter controlled via TTL	$3,454
DH2000-S-DUV-TT	Uses a deep-UV deuterium bulb, which provides a 190-2000 nm wavelength range and comes with a shutter (controlled via an included external TTL line)	$3,456
DH2000-BH	Replacement tungsten halogen bulb for all versions of the DH2000	$142
DH2000-BD	Replacement deuterium bulb for DH2000, DH2000-S, DH2000-FHS	$594
DH2000-DUV-B	Deep-UV replacement deuterium bulb for DH2000-DUV, DH2000-S-DUV, DH2000-FHS-DUV	$710

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Current voltage drift:	<0.01% per hour
Weight:	3.8 kg	Current voltage stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Power consumption:	25 W (deuterium); 20 W (tungsten halogen)	Lamp current:	Operating 85 V/0.3A
Wavelength range:	190-2000 nm (deep-UV deuterium bulb & tungsten halogen bulb) or 215-2000 nm (standard deuterium bulb and tungsten halogen bulb)	Lamp lifetime:	1,000 hours
		Lamp voltage:	Ignition 350 V/20°
		Tungsten bulb voltage:	Adjustable from 4.5 to 11.5 volts
Aperture:	0.5 mm	Power requirements:	85-264 V 50/60 Hz
Operating temperature:	5 °C - 35 °C	Total power:	100 W
Humidity:	5-95% without condensation at 40 °C	Power consumption:	190 W maximum
Electronic certifications:	CE; VDI/VDE 0160; EN 61010	Warm-up time:	40 minutes deuterium; 20 minutes tungsten halogen

Mini Deuterium Tungsten Halogen Sources

Spectral Output: DT-MINI-2 vs. DT-MINI



~200-1100 nm Spectral Range

Our DT-MINI-series Deuterium Tungsten Halogen Light Sources combine the continuous spectrum of a high-powered, RF-excited deuterium light source and a tungsten halogen light source in a single optical path. The combined-spectrum sources produce stable spectral output from ~200-1100 nm in a compact package.

0.5 mm Aperture: More Powerful Output

The original DT-MINI was our first foray into a compact and versatile UV-NIR light source, and is still a great choice for a range of applications and measurements. The advantage of the newer DT-MINI-2 is that it uses a bulb with a 0.5 mm diameter aperture, which results in more focused, uniform beam coupling to our optical fibers. Also, the DT-MINI-2 is only $100 more than the DT-MINI, which we will continue to offer.

Shutter Version

The DT-MINI-2-GS Deuterium Tungsten Halogen Light Source (lower left), also utilizes the bulb with the 0.5-mm diameter aperture. Its added feature is a shutter for blocking the light path, which can be controlled via a manual switch or TTL. There is also a switch for turning the deuterium source on and off, and one for turning the tungsten halogen source on and off; each switch can be used independently of the other.

Rack-mount Version

Rack-mount versions of DT-MINI-series lamps are available. These sources can be hard-wired to a spectrometer channel and racked into a Dual Box, Rack Box or Desktop Box with other accessories. For more on rack-mount systems and enclosures, see page 62.

DT-MINI-2:	$1,499
DT-MINI-2-GS:	$1,611
DT-MINI:	$1,399
DT-MINI-2-B Bulb*:	$457
DT-MINI-B Bulb*:	$427

** The DT-MINI-2-B Bulb can only be used in the DT-MINI-2 and DT-MINI-2-GS sources. Likewise, the DT-MINI-B Bulb can only be used in the DT-MINI and DT-MINI-GS.*

Specifications

	DT-MINI-2	DT-MINI-2-GS
Dimensions:	153.4 mm x 104.9 mm x 40.9 mm	140 mm x 50 mm x 125 mm
Weight:	330 g	475 g
Power consumption:	350 mA @ 12 VDC	350 mA @ 12 VDC
Spectral range:	200-410 nm (deuterium); 360-2000 nm (tungsten halogen)	200-410 nm (deuterium); 360-2000 nm (tungsten halogen)
Ignition delay:	<2.0 seconds (delay for cold start-up may be longer)	<2.0 seconds (delay for cold start-up may be longer)
Warm-up time:	10 minutes (deuterium); 1 minute (tungsten halogen)	10 minutes (deuterium); 1 minute (tungsten halogen)
Lamp power:	3.8 watts (deuterium); 1.2 watts (tungsten halogen)	3.8 watts (deuterium); 1.2 watts (tungsten halogen)
Bulb lifetime:	~800 hours (deuterium); 2,000 hours (tungsten halogen)	~800 hours (deuterium); 2,000 hours (tungsten halogen)
Stability:	0.3% peak-to-peak (over 4 hours) after 30-minute warm-up	0.3% peak-to-peak (over 4 hours) after 30-minute warm-up
Connector:	SMA 905	SMA 905

USB-DT Deuterium Tungsten Halogen Source

Most Versatile Lamp We Offer

The USB-DT Deuterium Tungsten Light Source is our most versatile combination UV-VIS light source. There are several ways to use the USB-DT: as a stand-alone source, stacked atop the USB2000 via the USB-ADP-DT2 adapter, or connected to a spectrometer via a Breakout Box. Though the USB-DT can be stacked on top of the USB2000, it is not the kind of direct-attach source that eliminates fibers; the USB-DT requires fibers. This compact source is about the size of a deck of cards, provides stable, broadband output from 200-2000 nm, and requires a simple 5-volt wall transformer for power.

Software Control

When the USB-DT is stacked with the USB2000 or used with an HR4000, HR2000+ or QE65000 and the Breakout Box (see page 47), you can control the following lamp functions through software:

- adjusting the intensity of the tungsten source
- activating the internal shutter to block the light path
- controlling on/off switch of each source independently
- utilizing a low-power shutdown mode
- saving settings in memory

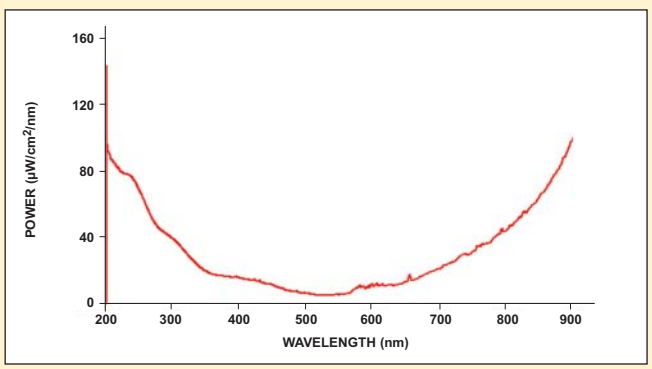
Novel Deuterium Tungsten Halogen Sources

Our deuterium tungsten halogen sources combine the continuous spectrum of deuterium and tungsten halogen lamps in a single optical path. These combined-spectrum sources produce stable, continuous UV-VIS output that make them ideal for applications such as absorbance spectroscopy.

USB-DT:	$1,499
USB-DT-B Bulb:	$205
USB-ADP-DT2:	$75
HR4-BREAKOUT:	$199

Spectrometer With USB-DT	Directly Stackable	Software Control of all USB-DT Functions
USB2000	Yes, with USB-ADP-DT2	Yes, when stacked atop the USB2000 with a USB-ADP-DT2
HR2000	No	No
HR2000+	No	Yes, when used with HR4-BREAKOUT
HR4000	No	Yes, when used with HR4-BREAKOUT
QE65000	No	Yes, when used with HR4-BREAKOUT

USB-DT Spectral Output



The USB-DT has a 15-pin connector for interfacing to the spectrometer.

USB-ADP-DT2 Connector.

The USB-DT can be set up in a variety of ways. It can be stacked atop a USB2000 with the USB-ADP-DT2 connector (above), or used as a stand-alone component with an Ocean Optics spectrometer.

Specifications

Dimensions:	81 mm x 90 mm x 37 mm
Weight:	260 g
Power consumption:	1.5 A @ 5 VDC
Spectral range:	200-2000 nm
Time to stabilized output:	15 minutes
Bulb life:	800 hours for deuterium; 2,000 hours for tungsten
Connector:	SMA 905
Power output:	see Spectral Output graph at left
Stability:	0.5% peak-to-peak (after warm-up)

D2000 Deuterium Light Sources

UV Range + Great Performance

The D2000 Deuterium Light Source produces a powerful, stable output from 215-400 nm. A deep-UV version is available for wavelength coverage of 190-400 nm. The D2000 is an extremely stable source, with peak-to-peak stability of <0.005% and drift of only ±0.5% per hour.

Options & Accessories

All versions of the D2000 have an SMA 905 Connector for easy coupling to our spectrometers and fiber optic accessories, as well as safety goggles and a cover for blocking the light when the fiber is not attached. The 1,000-hour deuterium bulb used in the D2000 can be replaced easily.

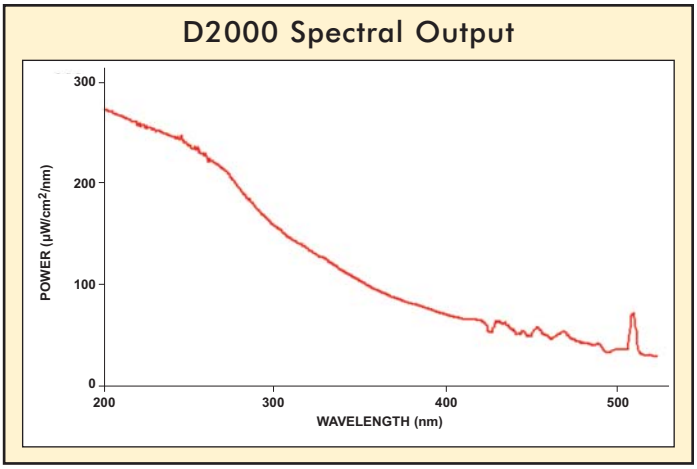
Shutter Option

The D2000 is available with an optional integrated shutter. You can operate the shutter via a manual switch on the front of the lamp. In addition, you can control the shutter electronically via software or a TTL signal from an output port on the back of the lamp.

Optical Fibers

We recommend using our solarization-resistant optical fibers with all versions of the D2000. See pages 139-140 for details.

D2000: $2,003



Additional D2000 Light Sources and Accessories

Item	Description	Price
D2000-DUV	Uses a deep-UV deuterium bulb, which provides a 190-400 nm wavelength range	$2,282
D2000-S	Comes with a shutter (controlled via a TTL signal or switch)	$2,378
D2000-S-DUV	Uses a deep-UV deuterium bulb, which provides a 190-400 nm wavelength range, and comes with a shutter (controlled via a TTL signal or switch)	$2,647
DH2000-BD	Replacement deuterium bulb for the D2000 and the D2000-S	$594
DH2000-DUV-B	Replacement deuterium bulb for the D2000-DUV and the D2000-S-DUV	$710

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Bulb lifetime:	1,000 hours for standard or deep-UV bulb
Weight:	3.8 kg	Operating temperature:	5 °C - 35 °C
Power consumption:	830 mA @ 230 VDC or 1660 mA @ 115 VDC	Humidity:	5-95% without condensation at 40 °C
Wavelength range:	215-400 nm (standard bulb); 190-400 nm (deep-UV bulb)	Radiation characteristic:	Aperture 0.5 mm, numerical aperture 26° (13°)
Peak-to-peak stability:	<0.005% at 250 nm	Power requirements:	85-264 V 50/60 Hz
Drift:	±0.5% per hour at 250 nm	Electronic certifications:	CE; VDI/VDE 0160; EN 61010
Warm-up time:	40 minutes	TTL-shutter input:	Up to 5 Hz maximum (shutter versions only)
Voltage and current:	Ignition 350V/20°; operating 85 V/0.3A	Shutter speed:	10 msec minimum

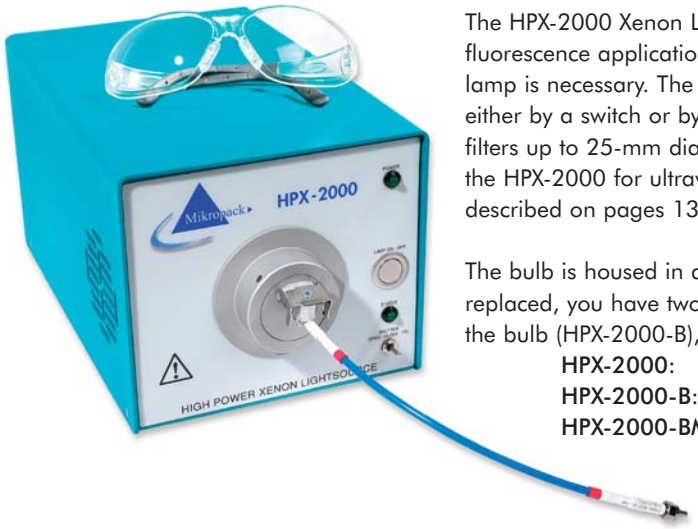
Xenon Sources

Pulsed & Continuous Xenon Light Source

The PX-2 Pulsed Xenon Lamp is a high flash rate, short-arc xenon lamp from 220-750 nm. The PX-2 is a great source for applications requiring absorbance, reflectance or fluorescence measurements, and is especially useful for measuring optically or thermally labile samples. The PX-2 is a low-power lamp with excellent pulse-to-pulse stability. It provides two trigger modes for software control of the flash rate. It comes with a regulated power supply and an interface cable to connect to the spectrometer.

PX-2: $769
PX-2-B Bulb: $379
USB-ADP-PX2: $50

High-powered Continuous-wave Xenon Source

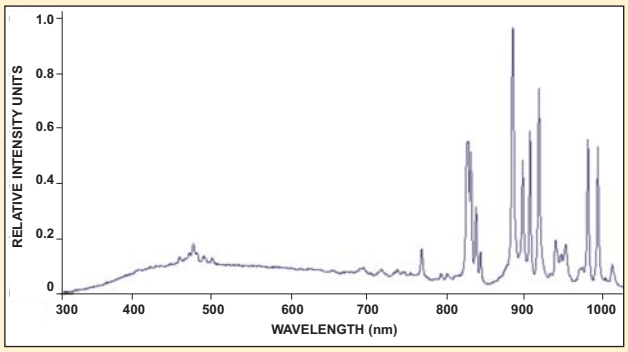


The HPX-2000 Xenon Light Source (185-2000 nm) is especially useful for fluorescence applications, and for other applications where a high-intensity lamp is necessary. The HPX-2000 has an integrated shutter, which can be driven either by a switch or by a TTL signal. It also comes equipped with a slot for filters up to 25-mm diameter or square, and up to 14-mm thick. (If operating the HPX-2000 for ultraviolet applications, use the solarization-resistant fiber described on pages 139-140.)

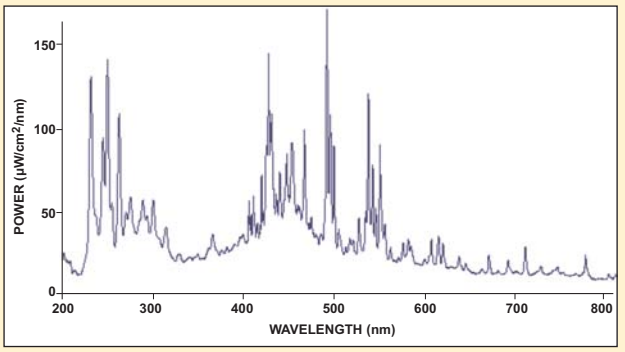
The bulb is housed in an easy-to-remove bulb module. If your bulb needs to be replaced, you have two options. You can send the module back to us to replace the bulb (HPX-2000-B), or you can order another bulb module (HPX-2000-BM).

HPX-2000: $5,517
HPX-2000-B: $1,064
HPX-2000-BM: $2,473

HPX-2000 Spectral Output



PX-2 Spectral Output



Specifications

	HPX-2000	PX-2
Dimensions:	145 mm x 165 mm x 260 mm	153.4 mm x 104.9 mm x 40.9 mm
Weight:	4.3 kg	370 g
Power consumption:	60 W AC	1 A @ 12 VDC
Spectral range:	185-2000 nm	220-750 nm
Power output:	35 watts	45 microjoules per pulse maximum; 9.9 watts average power; 220 Hz pulse rate maximum
Trigger input:	External TTL positive pulse via 15-pin connector (shutter)	External TTL positive pulse via 15-pin connector
Pulse duration:	Not applicable	5 microseconds (at 1/3 height of pulse)
Lifetime:	1,000 hours minimum; 2,000 hours typical	10^9 pulses (estimated 230 days continuous operation at 50 Hz pulse rate)
Connector:	SMA 905	SMA 905
Timing signals:	Not applicable	Multiple mode available from S2000 -- up to 220 Hz; single mode available from S2000 -- varies with scan rate

LS-1 Tungsten Halogen Light Sources

360-2000 nm Spectral Range

The LS-1 Tungsten Halogen Light Source is a versatile white-light source useful for absorbance, reflectance and color measurements for the VIS-NIR (360-2000 nm). The lamp offers high color temperature and an efficient output.

Rack-mountable

Install sources with spectrometers and other devices into a Rack Box or Desktop Box. For details, see page 62.

Long Life

The LS-1 comes with a 900-hour bulb. Also available is the LS-1-LL, which comes with a 10,000-hour bulb for extra-long life bulb performance. LS-1 Light Sources come with a 12 VDC power supply (WT-12V).

Color-correcting & Signal-attenuating Accessories

The LS-1 is one of the most popular miniature spectroscopy light sources ever. That experience has provided us with lots of customer feedback, including the idea to add components to allow users to modify the light output -- something we now include in the price of the light source:

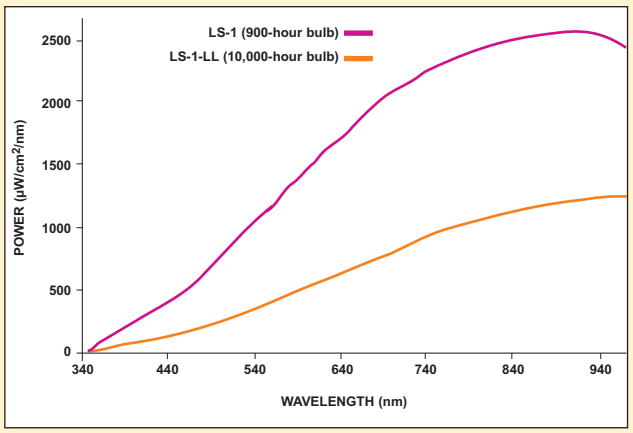
- a 12.7-mm diameter color-correcting filter that can be installed into the light source to enhance the signal in the blue and NIR regions
- three PTFE discs of various thickness to create a diffuse source -- by attenuating the light 50%, 75% or 99% -- when spectrometer saturation is an issue

Maximum Flexibility

The LS-1 has an SMA 905 Connector for easy coupling to our spectrometers and accessories, including optical fibers, cuvette holders and probes. A built-in slot accepts optical filters up to 3 mm in thickness.

LS-1: $499
LS-1-LL: $549

LS-1 and LS-1-LL Spectral Output



Additional LS-1-series Light Sources and Accessories

Item	Description	Price
R-LS-1	Rack-mounted LS-1 with color-correcting filter and diffusers	$499
R-LS-1-LL	Rack-mounted LS-1-LL with color-correcting filter and diffusers	$549
LS-1-B	900-hour replacement bulb for LS-1	$45
LS-1-LL-B	10,000-hour replacement bulb for LS-1-LL	$55
OF2-LS	Additional filter set for use with LS-1 source includes: BG 34, GG 395 and OG 550 filters, as well as PTFE diffusing discs	$100

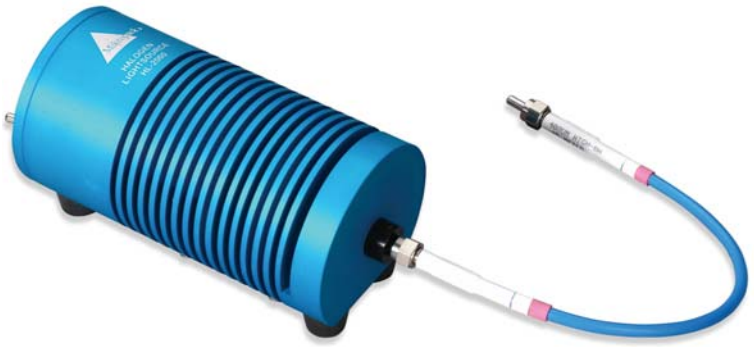
Specifications

Dimensions:	113.5 mm x 50.8 mm x 31.6 mm	Bulb life:	900 hours (LS-1); 10,000 hours (LS-1-LL)
Weight:	140 g	Output to bulb:	5 volts/1.3 amps
Power consumption:	600 mA @ 12 VDC	Output regulation:	0.2% voltage
Spectral range:	360-2000 nm	Internal filter accessory:	BG 34 balancing filter
Time to stabilized output:	~30 minutes	External filter slot:	Accepts filters up to 3-mm thickness
Bulb color temperature:	3100 K (900-hour bulb); 2800 K (10,000-hour bulb)	Spectral attenuation:	50%, 75% and 99% with PTFE disc accessories
Power output:	6.5 watts (without a fiber)	Connector:	SMA 905

HL-2000 Tungsten Halogen Light Sources

Great Versatility

The HL-2000 Tungsten Halogen Light Sources are versatile sources optimized from 360-2000 nm. The lamps feature adjustable focusing of the SMA 905 Connector to maximize light coupling into a fiber. A fan keeps the light sources cool and stable.



Long-lifetime Option

The HL-2000 comes with a 1,500-hour bulb. A 10,000-hour long-life version is also available.

Filter Slot

A built-in filter slot on all standard HL-2000s accepts optical filters up to 25.4-mm round or up to 50.8-mm square and 3 mm thick. The HL-2000-LVF-HP also accepts our LVF Linear Variable Filters (see page 94.)

High-power Version

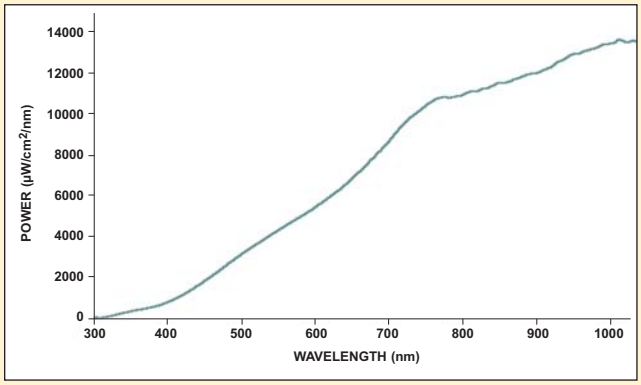
For applications requiring large-diameter optical fibers or fiber and probe bundles, a special high-power version of the HL-2000 is available. The bulb used in the HL-2000-HP is a 20-watt bulb. We recommend 1000 μm diameter optical fiber for use with the high-power versions of the HL-2000.

Attenuator & Shutter Option

The HL-2000-FHSA version of the HL-2000 includes a shutter and an attenuator that allows you to control the intensity of the light source from 0-100%. A locking screw allows you to manually fix the intensity position for the long term. In addition, you can opt to control the attenuator and the TTL shutter via RS-232 with the HL-2000-HP-232.

HL-2000: $583

HL-2000 Spectral Output



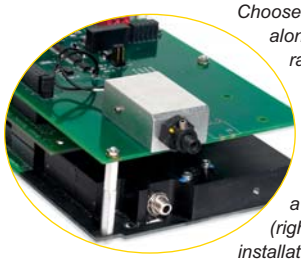
Additional HL-2000 Light Sources & Bulbs

Item	Description	Price
HL-2000-LL	Long-life version (10,000-hour)	$632
HL-2000-FHSA	Includes filter holder, attenuator and shutter	$1,232
HL-2000-FHSA-LL	Includes filter holder, attenuator, shutter and long-life 10,000-hour bulb	$1,276
HL-2000-HP	High-powered, 20 W version	$1,000
HL-2000-HP-FHSA	High-powered, 20 W version with filter holder, attenuator and shutter	$1,519
HL-2000-HP-232	High-powered, 20 W version with RS-232 control in rack mount housing; comes with script for software control	$2,156
HL-2000-LVF-HP	High-powered, 20 W version with filter slot for Linear Variable Filters; comes with shutter and attenuator	$1,590
HL-2000-B	Standard 1,500-hour spare bulb	$72
HL-2000-B-LL	Long-life 10,000-hour spare bulb	$84
HL-2000-HP-B	High-power 2,000-hour spare bulb	$121

Specifications

	HL-2000	HL-2000-LL	HL-2000-HP	HL-2000-HP-232
Dimensions:	62 mm x 60 mm x 150 mm	62 mm x 60 mm x 150 mm	62 mm x 60 mm x 150 mm	70 mm x 100 mm x 160 mm
Weight:	500 g	500 g	500 g	600 g
Output:	7 watts	7 watts	20 watts	20 watts
Output to bulb:	1.4 A @ 5 VDC	0.970 A @ 5 VDC	1.6 A @ 24 VDC	1.6 A @ 24 VDC
Wavelength range:	360-2000 nm	360-2000 nm	360-2000 nm	360-2000 nm
Stability:	0.5%	0.5%	0.5%	0.5%
Drift:	<0.3% per hour	<0.3% per hour	<0.3% per hour	<0.3% per hour
Time to stabilize:	~5 minutes	~5 minutes	~5 minutes	~5 minutes
Bulb lifetime:	1,500 hours	10,000 hours	2,000 hours	2,000 hours
Bulb color temperature:	2,960 K	2,800 K	3,000 K	3,000 K
Temperature:	5 °C - 35 °C	5 °C - 35 °C	5 °C - 35 °C	5 °C - 35 °C
Humidity:	5-95% at 40 °C	5-95% at 40 °C	5-95% at 40 °C	5-95% at 40 °C

LED Light Sources



Choose your LED in a stand-alone housing (above) or rack-mounted with a spectrometer and other accessories (left). We also sell the LEDs listed below individually in a 12.7-mm barrel (right) for easy installation and alignment.

Excellent Excitation Sources for Fluorescence

Our LED Light Sources produce either pulsed or continuous output for high-sensitivity fluorescence measurements. They were designed for use with our fluorescence spectrometers (pages 32-33), sensors and other accessories.

Software Operation & Synching with Detector

The LED Sources can be turned on/off through manual or software operation. Or, configure lamp pulse rates via jumper blocks on the lamp or on the circuit board of the S2000 Spectrometer.

Stand-alone and Rack-mount Versions

Each LED Source connects to a spectrometer via an interface cable. First, decide if you want an LED in its own stand-alone housing (see top left) or if you want the LED racked with a spectrometer (see inset). Then, choose the LED distinguished by wavelength to install in the housing. For those with limited space, we can install two LEDs on one rack-mount card. You can also purchase just the LED; they come in easy-to-install barrels.

LED with Housing:	$499
LED Rack-mounted:	$499
LED Bulb alone:	$100

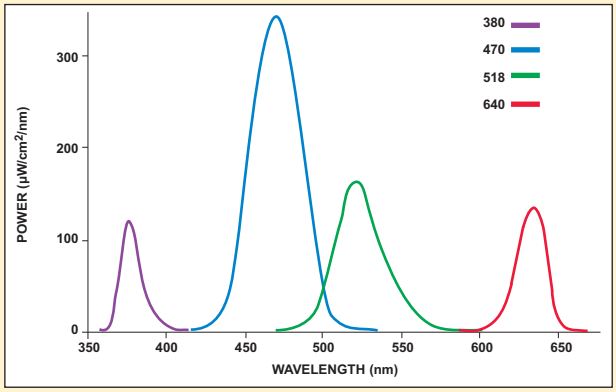
Additional LED Light Sources

You can order one of the LEDs listed below, either alone or installed in a housing/rack mount. We offer seven LEDs that can be used in the same housing. All LEDs can be used in pulsed or continuous mode through manual or software operation.

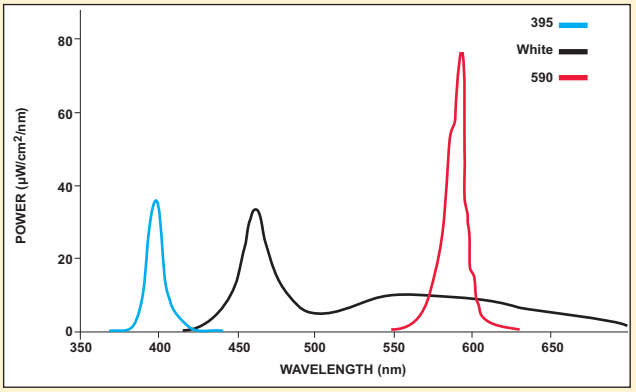
Item	Description	Color	Power*	Price of LED Alone	Price of LED with Housing
LED-380	380 nm wavelength UV LED	UV	45 µW	$100	$499
LED-395	395 nm wavelength VIS LED	Light Blue	25 µW	$100	$499
LED-470	470 nm wavelength VIS LED	Blue	35 µW	$100	$499
LED-518	518 nm wavelength VIS LED	Green	35 µW	$100	$499
LED-590	590 nm wavelength VIS LED	Yellow	40 µW	$100	$499
LED-640	640 nm wavelength VIS LED	Red	50 µW	$100	$499
LED-WHITE	450-630 nm wavelength VIS LED	White	50 µW	$100	$499
LED-KIT	Set of 6 LEDs: LED-380, LED-395, LED-518, LED-590, LED-640, LED-WHITE	Mixed	Mixed	$499	$998

** Power into a 600 µm Patch Cord Optical Fiber Assembly*

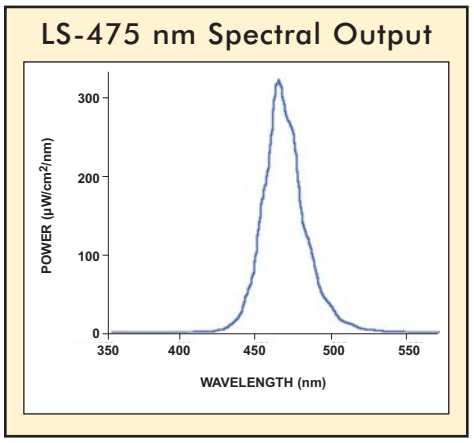
Spectral Output for LED Bulbs: 380 nm, 470 nm, 518 nm and 640 nm



Spectral Output for LED Bulbs: 395 nm, White, 590 nm



Pulsed Blue LED Light Source



Lamp Available for All Spectrometers

The LS-475 Blue LED Light Source produces pulsed or continuous spectral output centered at 475 nm. The LS-475 is designed as an excitation source for fluorescence measurements. The LS-475 often is paired with one of our preconfigured fluorescence spectrometers (page 33).

Specifications	
Dimensions:	62 mm x 60 mm x 150 mm
Wavelength range:	460-490 nm
Power consumption:	25 mA @ 12 VDC
LED output:	50 µW with a 600 µm optical fiber
Stability:	±1.0% drift after 2-minute warm-up
Connector:	SMA 905

High-stability & Fan-cooled

The LS-475 has a very stable output and keeps cool with a built-in fan. The lamp provides better than ±1.0% drift after a 2-minute warm-up time. It has an SMA 905 Connector for coupling to optical fiber assemblies and a filter slot that accepts 25.4-mm round or 50.8-mm square filters up to 3-mm thick. An 800 mA, 12 VDC power supply comes with the unit.

LS-475: $711

Direct-attach LED Light Source

Direct-attach Lamp for USB2000 Spectrometer

The USB-LS-450 Pulsed Blue LED Light Source is designed as a direct-attach excitation source for the USB2000 Spectrometer. The USB-LS-450 is an LED that produces either pulsed or continuous output centered at 470 nm -- the blue region -- for fluorescence measurements. It connects to the spectrometer via a 10-pin connector. The USB2000 provides power to the LED and also enables synchronization functions.

Benefit for O_2 Sensor Users

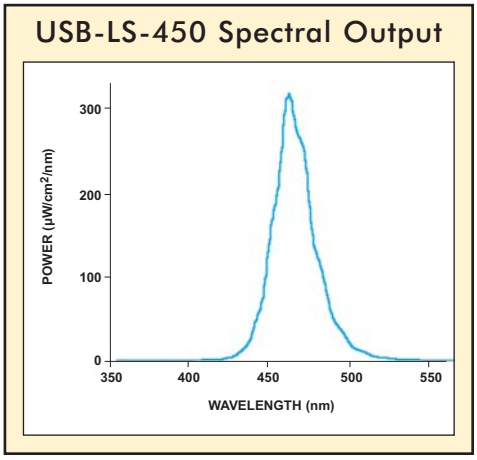
The USB-LS-450 features a built-in, 24-bit analog-to-digital converter that is configured for a 100 ohm platinum temperature probe (USB-LS-450-TP). The USB-LS-450's onboard memory can be programmed to store temperature and oxygen calibration coefficients.

Other LED Options

You can purchase the USB-LS-450, which comes with the 470 nm LED, or you can purchase the USB-LS-LED, which includes everything but the LED. You can then specify one of the other LEDs we offer on page 128.

USB-LS-450: $549
USB-LS-LED: $549
USB-LS-450-TP: $99

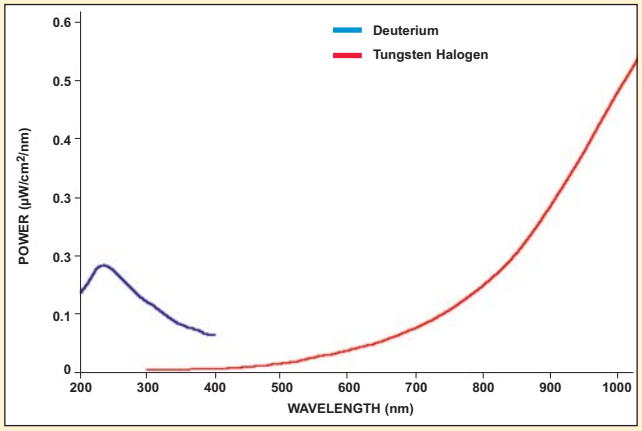
Specifications			
Dimensions:	89 mm x 57 mm x 34.5 mm	Wavelength range:	460-490 nm
Weight:	120 g	Power consumption:	60 mA @ 5 VDC
Stability:	±1.0% drift after 2-minute warm-up period	Power output:	60 µW (minimum) into a 600 µm optical fiber



Radiometric Calibration Standards: UV-NIR

The DH2000-CAL is calibrated for use with either a CC-3 Cosine Corrector or with an optical fiber. The lamp comes with a CC-3.

DH2000-CAL Spectral Output



These spectral output graphs were taken separately for the deuterium (200-400 nm) and the tungsten halogen bulbs (400-1100 nm).

Calibrated from 210-1050 nm

The DH2000-CAL Deuterium Tungsten Halogen Calibration Standard is a UV-NIR light source used to calibrate the absolute spectral response of a radiometric system. With the DH2000-CAL and our OOIIrrad-C Irradiance Software, you can determine known absolute intensity values at wavelengths from 210-1050 nm.

Calibrated for Bare Fiber & Cosine Corrector

The DH2000-CAL is calibrated for use with optical fibers or a cosine corrector; the calibration data includes absolute intensities for wavelengths between 210-1050 nm at the fiber entrance port for both a bare fiber and an included CC-3-UV Cosine Corrector (page 107).

NIST-traceable Calibration Certificate

The DH2000-CAL is calibrated with a NIST-traceable standard. The DH2000-CAL comes with a calibration certificate and a diskette with a data file compatible with our software. The calibration data -- absolute spectral intensity values in $\mu W/cm^2/nm$ measured at the fiber port -- is provided for use with our Irradiance Software (not included, see page 81).

Recalibration of Your DH2000-CAL

The DH2000-CAL typically provides 50 hours of operation before recalibration is necessary. We recalibrate these lamps in-house. (For more information on the DH2000-RECAL service, contact an Applications Scientist.)

DH2000-CAL: $3,148
DH2000-RECAL: $399

In-house Calibration Service

Also, you don't need a DH2000-CAL to take advantage of our in-house SPEC-CAL-UV radiometric calibration service for UV spectrometers. The calibration is good for about one year, provided the optical fiber is not removed from the setup, as the system is calibrated for use with a specific fiber.

SPEC-CAL-UV: $499

Radiometric Calibration Sources are not illumination sources for spectroscopic measurements. Use the DH2000-BAL (page 120) for illumination.

Specifications

Dimensions:	150 mm x 135 mm x 319 mm	Current voltage drift:	<0.01% per hour
Weight:	3.8 kg	Current voltage stability:	<5 x 10^{-6} peak-to-peak (0.1-10.0 Hz)
Power consumption:	25 W (deuterium); 20 W (tungsten halogen)	Operating temperature:	5 °C - 35 °C
Calibrated range:	210-1050 nm	Humidity:	5-95% without condensation at 40 °C
Calibration accuracy:	±5%	Total power:	100 watts
Calibration valid for:	50 hours	Max. power consumption:	190 watts
Lamp current:	Operating 85 V/0.3A	Warm-up time:	40 minutes (deuterium)
Lamp voltage:	350 V		20 minutes (tungsten halogen)
Power requirements:	85-264 V 50/60 Hz	Electronic certifications:	CE; VDI/VDE 0160; EN 61010

Radiometric Calibration Standards: VIS-NIR

Calibrated with Fiber & Cosine Corrector

The LS-1-CAL is designed for calibrating the absolute spectral response of a complete system consisting of a spectrometer and an optical fiber and/or a CC-3-UV Cosine Corrector (page 107). The HL-2000-CAL is designed for calibrating a system consisting of a spectrometer and a cosine corrector. The calibration data for both the LS-1-CAL and the HL-2000-CAL includes absolute intensities for wavelengths between 300-1050 nm.

The LS-1-CAL is calibrated for use with a fiber and/or a CC-3 Cosine Corrector (not included).

Calibrated for Use with Integrating Sphere

The LS-1-CAL-INT is designed for calibrating the absolute spectral response of a system that uses the FOIS-1 Fiber Optic Integrating Sphere (page 108) as the sampling optic. The LS-1-CAL-INT comes with a diffuser plug that fits into the sample port of the FOIS-1 to measure absolute spectral intensities of LEDs and other emission sources. The HL-2000-CAL-ISP is designed for calibrating the absolute spectral response of your system when using the ISP-50-8-I Integrating Sphere (page 108) as your sampling optic.

The LS-1-CAL-INT is calibrated specifically for use with the FOIS-1 Integrating Sphere. Notice the PTFE diffuser plug that's seated where an SMA 905 Connector is usually installed. This plug fits snugly into the sample port of the FOIS-1.

What's Included

Each of these radiometric sources comes with a regulated 12 VDC power supply. Also included is a calibration certificate and a diskette with data files for use with our Irradiance Software. Neither the LS-1-CAL nor the HL-2000-CAL lamps comes with a CC-3 Cosine Corrector.

Recalibrating Your Source

These calibrated sources provide 50 hours of operation before an in-house recalibration (called the LS-1-RECAL and the HL-2000-RECAL) is necessary.

LS-1-CAL:	$749
LS-1-CAL-INT:	$749
LS-1-RECAL:	$199
HL-2000-CAL:	$815
HL-2000-CAL-ISP:	$825
HL-2000-RECAL:	$199

The HL-2000-CAL is used for calibrating most radiometric systems, while the HL-2000-CAL-ISP is used with ISP Integrating Spheres.

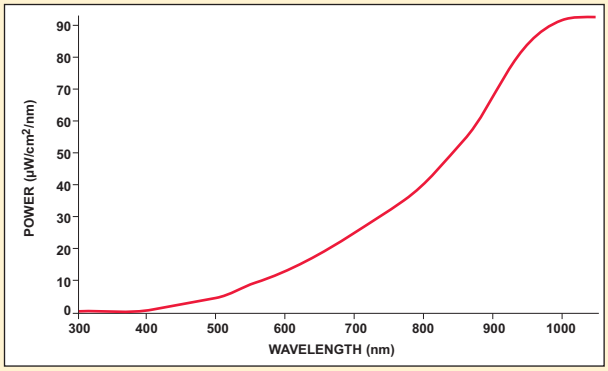
In-house Calibration

If you do not want to purchase one of these calibration sources, we offer the SPEC-CAL in-house radiometric calibration service for 300-1050 nm.

SPEC-CAL:	$499

Specifications	
Power consumption:	600 mA @ 12 VDC
Spectral range:	300-1050 nm (calibrated)
Power output:	6.5 watts
Recalibration:	Required after 50 hours of operation
Bulb color temperature:	3100 K
Output regulation:	0.2% voltage
Time to stabilized output:	~30 minutes
Connector:	SMA 905 for fiber; 6.35-mm barrel for cosine corrector; PTFE plug for integrating sphere

LS-1-CAL Spectral Output



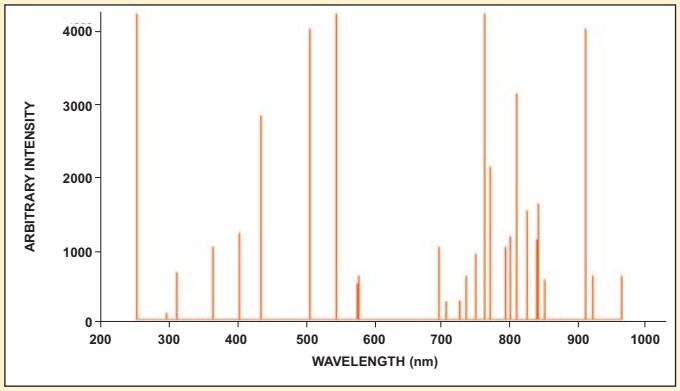
Above is the typical calibration output when using the LS-1-CAL or HL-2000-CAL with a CC-3 Cosine Corrector.

Wavelength Calibration Standard for UV-VIS

The HG-1.

The CAL-2000.

HG-1 & CAL-2000 Spectral Output



Mercury emission lines are <600 nm. Argon emission lines are >600 nm, and are shown on an exaggerated amplitude scale.

Wavelength Calibration Sources

The HG-1 and CAL-2000 Mercury Argon Calibration Sources are spectral wavelength calibration sources for spectrometer systems. The HG-1 and the CAL-2000 produce low-pressure mercury and argon atomic emission lines from 253-1700 nm for use in performing fast, reliable spectrometer wavelength calibrations. A list of mercury and argon spectral emission lines is printed on each lamp's housing.

Drift Occurs in all Spectrometers

Our spectrometers are carefully calibrated as part of our standard quality assurance process. However, as is the case with all optical benches, slight drifts in wavelength occur due to time and environmental conditions. If wavelength accuracy is an important part of your application, consider including calibration spectra with every experiment.

Convenient Operation

Wavelength calibration with the HG-1 or the CAL-2000 requires a power supply (included) and an optical fiber to connect from the source to your spectrometer. You will need a spreadsheet program such as Microsoft Excel or a calculator that performs third-order polynomial regressions.

Convenient Portability

Both calibration sources operate with a 12 VDC power supply (included) or a 9V battery (not included) for field use. Both sources feature an SMA 905 Connector for interfacing to optical fiber assemblies and have bulbs with a 3,500-hour lifetime. You can replace the bulb in the CAL-2000, but not in the HG-1.

HG-1:	**$399**
CAL-2000:	**$437**
CAL-2000-B Bulb:	**$175**

For only $250 per spectrometer channel, you can purchase the ASP Annual Service Package, which entitles you to a yearly spectrometer inspection, wavelength calibration, optical alignment, linearity calibration, signal-to-noise analysis and much more. *See page 193 for more.*

Specifications

	HG-1	CAL-2000
Dimensions:	125.7 mm x 70 mm x 25.8 mm	130 mm x 125 mm x 50 mm
Weight:	40 g	410 g
Power consumption:	250 mA @ 12 VDC	250 mA @ 12 VDC
Spectral range:	253-1700 nm	253-1700 nm
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (not included)	12 VDC wall transformer (included) or 9 VDC battery (not included)
Internal voltage:	600 volts at 30 kHz	600 volts at 30 kHz
Bulb lifetime:	~3,500 hours (at 20 mA)	~3,500 hours (at 20 mA)
Stabilization:	1 minute	1 minute
Connector:	SMA 905	SMA 905

Wavelength Calibration Standard for NIR

Calibration Source for NIR Spectrometers

The AR-1 Argon Calibration Source is a spectral wavelength calibration source specifically designed for NIR spectrometers like our NIR256 and NIR-512 (see pages 58-59). The AR-1 produces low-pressure argon atomic emission lines from 696-1704 nm for use in performing fast, reliable spectrometer wavelength calibrations. The spectral emission lines are printed on the lamp's housing.

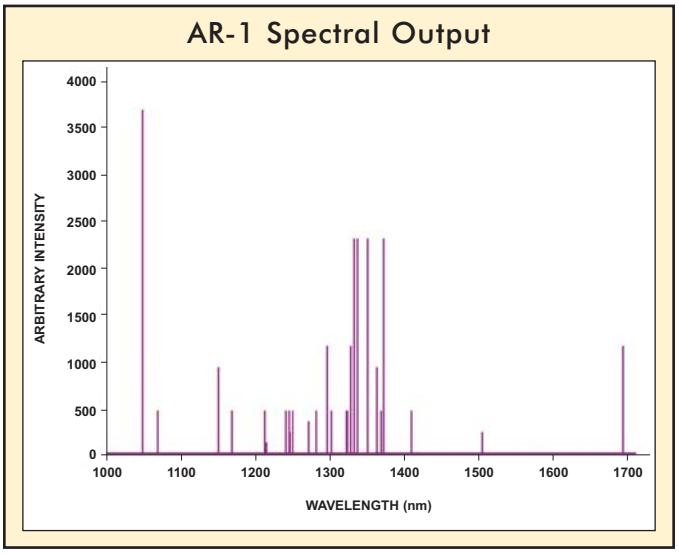
Convenient Operation

Our spectrometers are carefully calibrated as part of our standard quality assurance process. However, as is the case with all optical benches, slight drifts in wavelength occur due to time and environmental conditions. With the AR-1, you can recalibrate your spectrometer using a spreadsheet program such as Microsoft Excel or a calculator that performs third-order polynomial regressions.

Conveniently Portable

The AR-1 operates with a 12 VDC power supply (included) or a 9V battery (not included) for field use. The AR-1 features an SMA 905 Connector for interfacing to optical fiber assemblies.

AR-1: $399



Specifications	
Dimensions:	125.7 mm x 70 mm x 25.8 mm
Weight:	40 g
Power consumption:	250 mA @ 12 VDC
Spectral range:	696-1704 nm
Power requirements:	12 VDC wall transformer (included) or 9 VDC battery (not included)
Internal voltage:	600 volts at 30 kHz
Bulb lifetime:	~3,500 hours (at 20 mA)
Amplitude stabilization:	~1 minute
Connector:	SMA 905

Cuvette Wavelength Calibration Adapter

The PS-HG1-ADP Wavelength Calibration Adapter is a 1-cm square fixture that fits into a 1-cm pathlength sample chamber and then connects to the HG-1 Mercury Argon Calibration Standard or the AR-1 Argon Wavelength Calibration Standard via optical fiber. (Neither Wavelength Calibration Standard nor optical fiber is included.) The adapter is designed for performing a wavelength calibration for a USB2000 Spectrometer and a direct-attach sampling system. However, the adapter can be used with any post-dispersive spectrometer and 1-cm cuvette holder, whether it's designed by Ocean Optics or another manufacturer.

PS-HG1-ADP: $259

Bulbs, Power Supplies & Accessories

Spare Power Supplies

Item	Description	Plug Style	Current	Regulated	Price
WT-12V	12-volt power supply, 110/220	US	800 milliamps	Yes	$25
WT-12V-R	12-volt power supply, 110/220	US	2.5 Amps	Yes	$100
WT-12V-E	12-volt power supply, 110/220	European	800 milliamps	Yes	$20
WT-12V-R-E	12-volt power supply, 110/220	European	2.5 Amps	Yes	$100
WT-24V	24-volt power supply, 110/220	US	2.5 Amps	Yes	$50

WT-12V-E European Power Supply.

Bulbs for Ocean Optics Light Sources

Item	Description	Price
DH2000-BD	Spare or replacement deuterium bulb for D2000, DH2000 and DH2000-BAL sources	$594
DH2000-DUV-B	Spare or replacement deep-UV deuterium bulb for D2000-DUV and DH2000-DUV sources	$710
DH2000-BH	Spare or replacement tungsten halogen bulb for DH2000 and DH2000-BAL sources	$142
DT-MINI-B	Spare bulb for DT-MINI and DT-MINI-GS (white or blue bulb housing)	$427
DT-MINI-2-B	Spare bulb for DT-MINI-2 and DT-MINI-2-GS (yellow bulb housing)	$457
HL-2000-B	Spare or replacement tungsten halogen bulb for the HL-2000 (1,500-hour, 2,960 K)	$72
HL-2000-B-LL	Spare or replacement long-life tungsten halogen bulb for the HL-2000-LL (10,000-hour, 2,800 K)	$84
HL-2000-HP-B	Spare or replacement tungsten halogen bulb for all HL-2000-HPs	$121
HPX-2000-BM	Spare or replacement xenon bulb module for the HPX-2000	$2,473
HPX-2000-B	Spare or replacement xenon bulb for the HPX-2000	$1,064
LED-380	Interchangeable, 380-nm LED for LS-450	$100
LED-395	Interchangeable, 395-nm LED for LS-450	$100
LED-518	Interchangeable, 518-nm LED for LS-450	$100
LED-590	Interchangeable, 590-nm LED for LS-450	$100
LED-640	Interchangeable, 640-nm LED for LS-450	$100
LED-WHITE	Interchangeable, white LED for LS-450	$100
LED-KIT	LED kit with 380-nm, 395-nm, 518-nm, 590-nm, 640-nm and white LEDs, for LS-450	$499
LS-1-B	Spare or replacement tungsten halogen bulb for LS-1 (900-hour, 3100 K bulb)	$45
LS-1-LL-B	Spare or replacement long-life tungsten halogen bulb for LS-1 or LS-1-LL (10,000-hour, 2800 K bulb)	$55
PX-2-B	Spare or replacement xenon bulb for the PX-2	$379
USB-ISS-UV-B	Spare or replacement deuterium and tungsten bulb for USB-ISS-UV-VIS	$399
USB-ISS-VIS-B	Spare or replacement tungsten bulb for the USB-ISS-VIS source	$199
D-1000-B	Spare or replacement deuterium bulb for the D-1000	$425
D-1000-REM-B	Spare or replacement bulb for D-1000-REM systems	$425
DT-1000-B	Spare or replacement deuterium bulb for the DT-1000	$485
DT-1000-BT	Spare or replacement tungsten halogen bulb for the DT-1000	$125
DT-1000-REM-B	Spare or replacement bulb for DT-1000-REM systems	$485
DT-1000-BT-CE	CE-certified tungsten halogen bulb for the DT-1000	$125

The DH2000-BD deuterium bulb used in all D2000s and DH2000s.

The CAL-2000-B.

The DH2000-BH tungsten halogen bulb used in all DH2000s.

Bulb for the HL-2000.

The DT-MINI bulb unit.

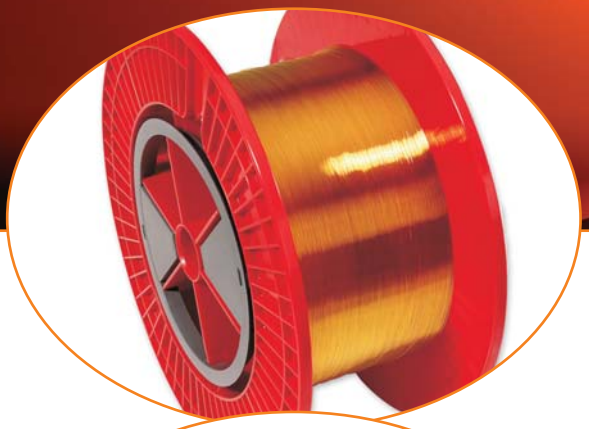
The LS-1-B replacement bulb for the LS-1.

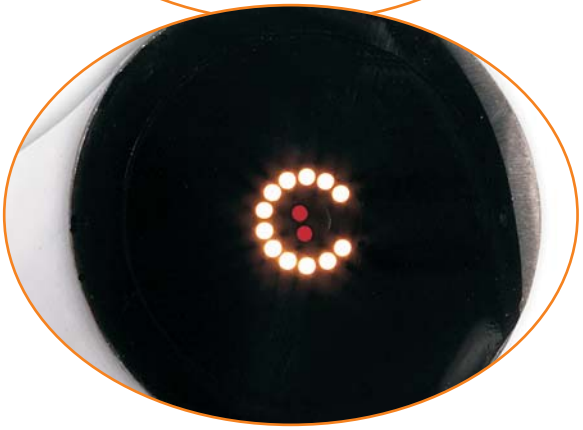
Other Light Source Accessories

Item	Description	Price
CBL-PX-2	Cable for connecting PX-2 to S2000 Spectrometer	$25
FCBARREL	6.35-mm outer diameter stainless steel barrel threaded for FC connectors that inserts into our 74-series Collimating Lenses	$29
FOT-SMA WRENCH	SMA wrench for easily attaching Laboratory-grade optical fibers to SMA 905 Connectors on Ocean Optics products	$10

Bulb module for the HPX-2000.

Fibers & Probes





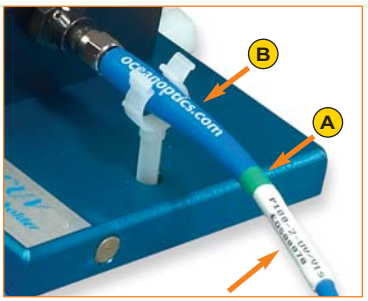
Overview: Fibers & Probes

New Production Flow Provides More Choices

Ocean Optics is the most versatile supplier of optical fibers and accessories for spectroscopy in the industry. We offer everything from one-off patch cords and custom assemblies, to process-ready fiber and OEM builds for all sorts of applications. An array of assembly types, jacketing options, and connectors and terminations can be mixed and matched in hundreds of configurations. Our fiber accessories and fixtures allow you to easily connect or manipulate fibers, and integrate them into tricky experiment set-ups. Bulk fibers and fiber assembly-making kits and components are also available. Ultimately, it's the flexibility of our custom fiber-assembly capabilities that sets us apart. We've even developed an Internet-based custom fiber quoting system that delivers to you a quotation and CAD drawing quickly and efficiently.

Anatomy of an Assembly

Our optical fiber assemblies and probes are clearly and cleanly labeled in multiple ways so that you always know what kind of optical fiber you are working with. There are 2 main color indicators. A color band (A) tells you what diameter fiber with which you are working. The assembly's boot color (B) lets you know the fiber type and the most efficient wavelength range in which your fiber will work. Throughout this section, you will see colored circles (● ● ● ●) next to products to indicate the fiber type and wavelength range of the assembly. All of this information is printed on a white label wrapped around the fiber. It also includes the serial number of your assembly.



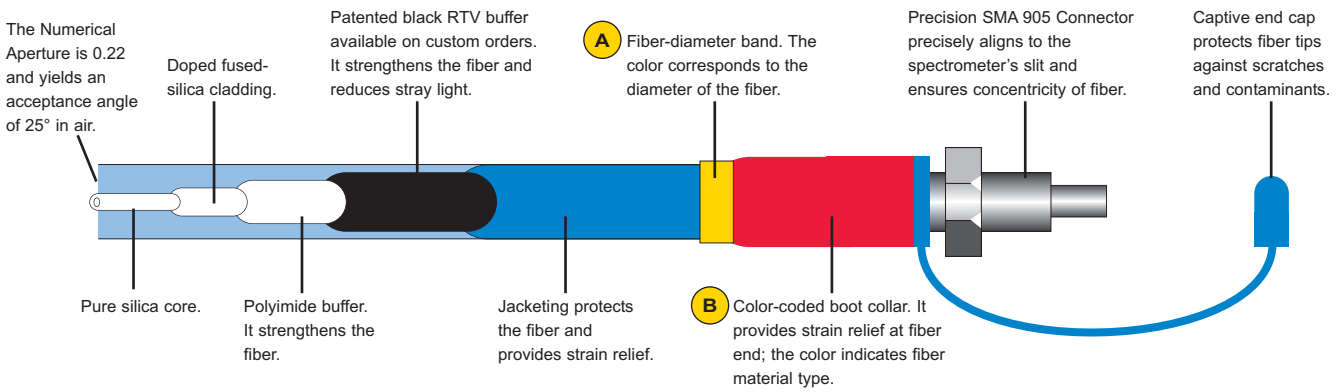
A white label on an assembly includes the product name and serial number.

(A) Color Bands

Purple:	8 µm
Blue:	50 µm
Green:	100 µm
Yellow:	200 µm
Gray:	300 µm
Red:	400 µm
Orange:	500 µm
Brown:	600 µm
Clear:	1000 µm

(B) Boot Collar Colors

Gray	Solarization-resistant	UV/SR-VIS	190-800 nm (most efficient)
Blue	High OH content	UV-VIS	300-800 nm (most efficient)
Red	Low OH content	VIS-NIR	400-2100 nm (most efficient)
Green	Ultra Low OH content	VIS-NIR	400-2500 nm (most efficient)



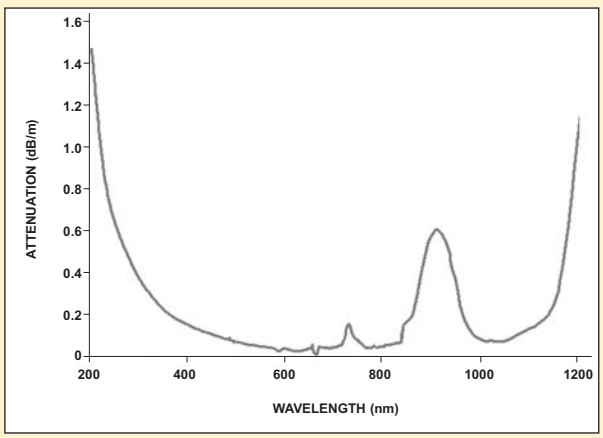
Overview: Fibers & Probes

Optical Fiber Specifications

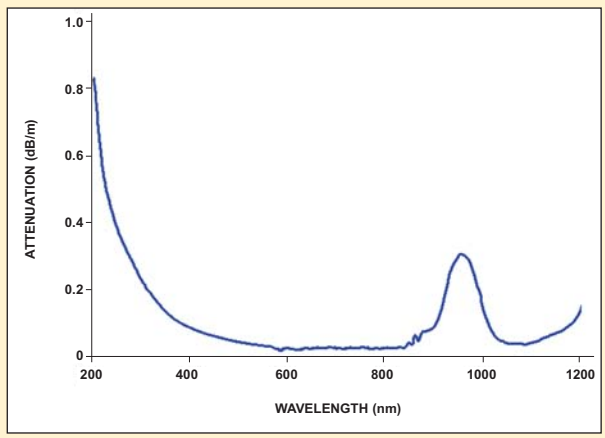
Fiber & Probe Assemblies	Fiber Type	Core Size Diameter	Cladding Thickness	Buffer Thickness	Buffer Material	Maximum OD Total	Operating Temperature	Long Bend Radius	Short Bend Radius
8 µm assemblies	● ● ●	9 µm +/-0.5 µm	58 µm +/-3 µm	60 µm +/-5 µm	Acrylate	250 µm	-50 to 85 °C	4 cm	2 cm
50 µm assemblies	● ● ●	50 µm +/-5 µm	35 µm +/-5 µm	17 µm +/-3 µm	Polyimide	155 µm	-65 to 300 °C	4 cm	2 cm
100 µm assemblies	● ● ●	100 µm +/-3 µm	12 µm +/-5 µm	17 µm +/-3 µm	Polyimide	155 µm	-65 to 300 °C	4 cm	2 cm
200 µm Assemblies	●	200 µm +/-4 µm	10 µm +/-3 µm	45 µm +/-21 µm	Aluminum	331 µm	-269 to 400 °C	4 cm	2 cm
200 µm assemblies	● ● ●	200 µm +/-4 µm	10 µm +/-4 µm	10 µm +/-5 µm	Polyimide	243 µm	-65 to 300 °C	8 cm	4 cm
300 µm assemblies	●	300 µm +/-6 µm	15 µm +/-7 µm	20 µm +/-10 µm	Polyimide	380 µm	-65 to 300 °C	12 cm	6 cm
300 µm Assemblies	●	300 µm +/-6 µm	15 µm +/-3 µm	45 µm +/-21 µm	Aluminum	441 µm	-269 to 400 °C	6 cm	3 cm
400 µm Assemblies	●	400 µm +/-8 µm	20 µm +/-3 µm	45 µm +/-21 µm	Aluminum	551 µm	-269 to 400 °C	8 cm	4 cm
400 µm Assemblies	● ● ●	400 µm +/-8 µm	20 µm +/-3 µm	20 µm +/-7 µm	Polyimide	487 µm	-65 to 300 °C	16 cm	8 cm
500 µm assemblies	● ● ●	500 µm +/-10 µm	25 µm +/-3 µm	20 µm +/-10 µm	Polyimide	600 µm	-65 to 300 °C	20 cm	10 cm
600 µm assemblies	● ● ●	600 µm +/-10 µm	30 µm +/-3 µm	25 µm +/-10 µm	Polyimide	720 µm	-65 to 300 °C	24 cm	12 cm
1000 µm assemblies	●	1000 µm +/-20 µm	25 µm +/-3 µm	50 µm +/-40 µm	Acrylate	1065 µm	-50 to 85 °C	30 cm	15 cm
1000 µm assemblies	●	1000 µm +/-20 µm	50 µm +/-3 µm	50 µm +/-40 µm	Acrylate	1120 µm	-50 to 85 °C	30 cm	15 cm

Attenuation Spectra for Each Fiber Type

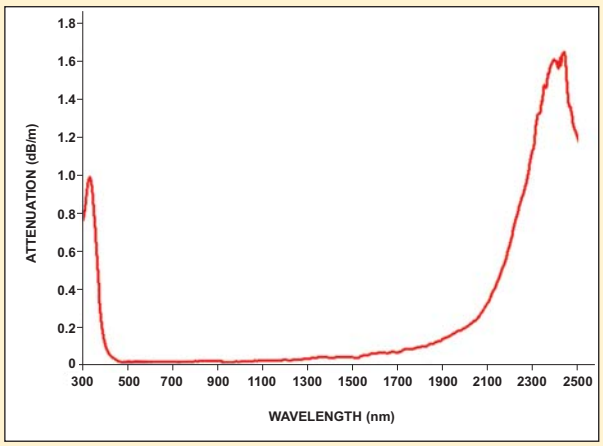
UV/SR-VIS Fibers -- Gray ●



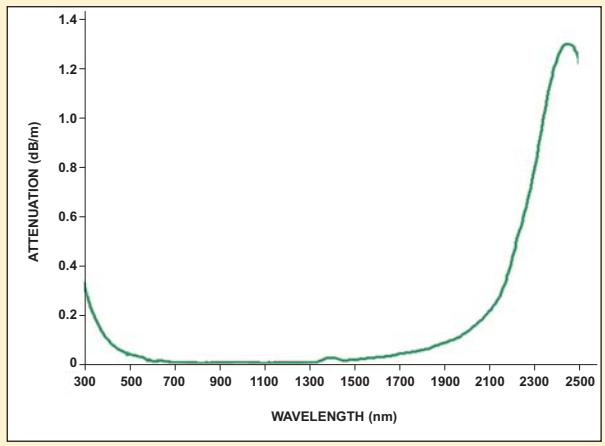
UV-VIS High OH Fibers -- Blue ●



VIS-NIR Low OH Fibers -- Red ●



VIS-NIR Ultra-low OH Fibers -- Green ●



Laboratory-grade Assemblies

Our Laboratory-grade Optical Fiber Assemblies offer high quality at an affordable price. These off-the-shelf assemblies include assemblies at various lengths, solarization-resistant assemblies, and bifurcated and splitter assemblies. We terminate Laboratory-grade Assemblies with standard SMA 905 Connectors. Our standard Laboratory-grade Assemblies act as both illumination and read fibers and connect easily to Ocean Optics spectrometers, light sources and sampling accessories.

Laboratory-grade Patch Cord Assemblies: 2-meter Lengths

Item	Description	Price
P8-2-SMA	8 µm diameter optical fiber; single mode; VIS-NIR	$100
P50-2-UV-VIS	50 µm diameter optical fiber; UV-VIS	$100
P50-2-VIS-NIR	50 µm diameter optical fiber; VIS-NIR	$100
P100-2-UV-VIS	100 µm diameter optical fiber; UV-VIS	$100
P100-2-VIS-NIR	100 µm diameter optical fiber; VIS-NIR	$100
P200-2-UV-VIS	200 µm diameter optical fiber; UV-VIS	$100
P200-2-VIS-NIR	200 µm diameter optical fiber; VIS-NIR	$100
P400-2-UV-VIS	400 µm diameter optical fiber; UV-VIS	$120
P400-2-VIS-NIR	400 µm diameter optical fiber; VIS-NIR	$120
P600-2-UV-VIS	600 µm diameter optical fiber; UV-VIS	$160
P600-2-VIS-NIR	600 µm diameter optical fiber; VIS-NIR	$160
P1000-2-UV-VIS	1000 µm diameter optical fiber;UV-VIS	$300
P1000-2-VIS-NIR	1000 µm diameter optical fiber; VIS-NIR	$300

Laboratory-grade Patch Cord Assemblies: 5-meter Lengths

Item	Description	Price
P50-5-UV-VIS	50 µm diameter optical fiber; UV-VIS	$150
P50-5-VIS-NIR	50 µm diameter optical fiber; VIS-NIR	$150
P100-5-UV-VIS	100 µm diameter optical fiber; UV-VIS	$150
P100-5-VIS-NIR	100 µm diameter optical fiber; VIS-NIR	$150
P200-5-UV-VIS	200 µm diameter optical fiber; UV-VIS	$150
P200-5-VIS-NIR	200 µm diameter optical fiber; VIS-NIR	$150
P400-5-UV-VIS	400 µm diameter optical fiber; UV-VIS	$180
P400-5-VIS-NIR	400 µm diameter optical fiber; VIS-NIR	$180
P600-5-UV-VIS	600 µm diameter optical fiber; UV-VIS	$250
P600-5-VIS-NIR	600 µm diameter optical fiber; VIS-NIR	$250

Laboratory-grade Patch Cord Assemblies: 10-meter Lengths

Item	Description	Price
P50-10-UV-VIS	50 µm diameter optical fiber; UV-VIS	$200
P50-10-VIS-NIR	50 µm diameter optical fiber; VIS-NIR	$200
P100-10-UV-VIS	100 µm diameter optical fiber; UV-VIS	$200
P100-10-VIS-NIR	100 µm diameter optical fiber; VIS-NIR	$200
P200-10-UV-VIS	200 µm diameter optical fiber; UV-VIS	$200
P200-10-VIS-NIR	200 µm diameter optical fiber; VIS-NIR	$200
P400-10-UV-VIS	400 µm diameter optical fiber; UV-VIS	$280
P400-10-VIS-NIR	400 µm diameter optical fiber; VIS-NIR	$280
P600-10-UV-VIS	600 µm diameter optical fiber; UV-VIS	$350
P600-10-VIS-NIR	600 µm diameter optical fiber; VIS-NIR	$350

Laboratory-grade Assemblies

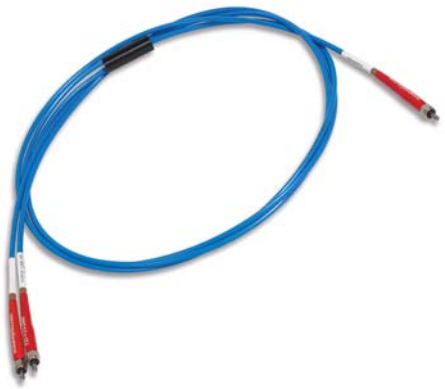
Laboratory-grade Solarization-resistant Assemblies

Ultraviolet radiation <300 nm degrades transmission in standard silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications below 300 nm, we recommend Solarization-resistant Assemblies. Shorter lengths for Solarization-resistant Assemblies maximize UV throughput. However, lengths over 2 meters are available.

Item	Description	Price
P300-1-AL/SR	300 µm diameter optical fiber; aluminum-coated; 1 meter length	$160
P300-1-SR	300 µm diameter optical fiber; 1-meter length	$100
P400-025-AL/SR	400 µm diameter optical fiber; aluminum-coated; 25-centimeter length	$130
P400-025-SR	400 µm diameter optical fiber; 25-centimeter length	$100
P400-2-AL/SR	400 µm diameter optical fiber; aluminum-coated; 2-meter length	$180
P400-2-SR	400 µm diameter optical fiber; 2-meter length	$130
P600-025-SR	600 µm diameter optical fiber; 25-centimeter length	$110
P600-1-SR	600 µm diameter optical fiber; 1-meter length	$120
P600-2-SR	600 µm diameter optical fiber; 2-meter length	$170

Laboratory-grade Bifurcated Optical Fiber Assemblies

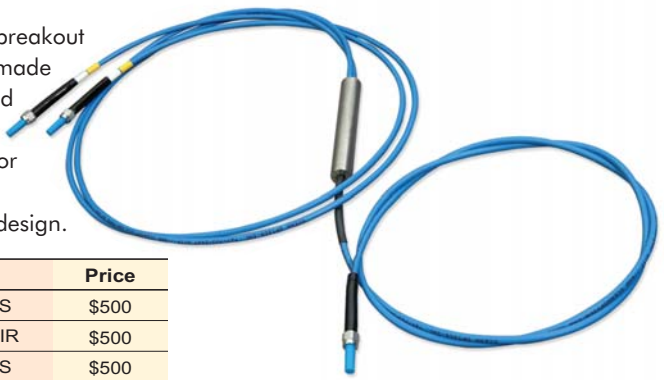
These 2-meter Bifurcated Optical Fiber Assemblies are Y-shaped assemblies that have two fibers of the same diameter side-by-side in the common end, or the tail of the assembly. From the nexus or breakout of the assembly, the two fibers diverge into two separate legs. You may specify that both fibers in the assembly are UV-VIS, VIS-NIR or one of each -- a "mixed" bifurcated assembly.



Item	Description	Price
BIF50-UV-VIS	50 µm diameter bifurcated assembly; UV-VIS	$250
BIF50-VIS-NIR	50 µm diameter bifurcated assembly; VIS-NIR	$250
BIF50-MIXED	50 µm diameter bifurcated assembly; MIXED	$250
BIF200-UV-VIS	200 µm diameter bifurcated assembly; UV-VIS	$250
BIF200-VIS-NIR	200 µm diameter bifurcated assembly; VIS-NIR	$250
BIF200-MIXED	200 µm diameter bifurcated assembly; MIXED	$250
BIF400-UV-VIS	400 µm diameter bifurcated assembly; UV-VIS	$280
BIF400-VIS-NIR	400 µm diameter bifurcated assembly; VIS-NIR	$280
BIF400-MIXED	400 µm diameter bifurcated assembly; MIXED	$280
BIF600-UV-VIS	600 µm diameter bifurcated assembly; UV-VIS	$330
BIF600-VIS-NIR	600 µm diameter bifurcated assembly; VIS-NIR	$330
BIF600-MIXED	600 µm diameter bifurcated assembly; MIXED	$330

Laboratory-grade Splitter Optical Fiber Assemblies

A splitter is a 2-meter Y-shaped assembly with a stainless steel breakout located midway from the ends of the assembly. Each splitter is made up of three separate optical fibers, all of the same diameter, and epoxied at the nexus of the Y-shaped assembly. A splitter can route light from two different sources to illuminate one sample or from one source to illuminate two samples. Splitters have lower transmission efficiency than other fiber assemblies due to their design.



Item	Description	Price
SPLIT200-UV-VIS	(1) 200 µm diameter fiber splitting into 2; UV-VIS	$500
SPLIT200-VIS-NIR	(1) 200 µm diameter fiber splitting into 2; VIS-NIR	$500
SPLIT400-UV-VIS	(1) 400 µm diameter fiber splitting into 2; UV-VIS	$500
SPLIT400-VIS-NIR	(1) 400 µm diameter fiber splitting into 2; VIS-NIR	$500

Premium-grade Assemblies

Our Premium-grade Optical Fiber Assemblies are durable, high-quality assemblies that consistently deliver uniform results with minimal signal variance. These assemblies are available in a wide variety of off-the-shelf configurations or can be customized per your specifications. With every order, you receive a Quality Control Report that includes both the serial number and transmission curve of the assembly.

Premium-grade Patch Cord Assemblies

Our 2-meter Premium-grade Patch Cord Assemblies are terminated with precision SMA 905 Connectors. They connect easily to spectrometers, light sources and sampling accessories and are available in standard lengths or can be ordered in custom lengths.

Item	Description	Price
QP8-2-SMA	8 µm diameter optical fiber; single mode; VIS-NIR	$160
QP50-2-UV-VIS	50 µm diameter optical fiber; UV-VIS	$150
QP50-2-VIS-NIR	50 µm diameter optical fiber; VIS-NIR	$150
QP100-2-UV-VIS	100 µm diameter optical fiber; UV-VIS	$150
QP100-2-VIS-NIR	100 µm diameter optical fiber; VIS-NIR	$150
QP200-2-UV-VIS	200 µm diameter optical fiber; UV-VIS	$150
QP200-2-VIS-NIR	200 µm diameter optical fiber; VIS-NIR	$150
QP400-2-UV-VIS	400 µm diameter optical fiber; UV-VIS	$170
QP400-2-VIS-NIR	400 µm diameter optical fiber; VIS-NIR	$170
QP600-2-UV-VIS	600 µm diameter optical fiber; UV-VIS	$210
QP600-2-VIS-NIR	600 µm diameter optical fiber; VIS-NIR	$210
QP1000-2-UV-VIS	1000 µm diameter optical fiber; UV-VIS	$360
QP1000-2-VIS-NIR	1000 µm diameter optical fiber; VIS-NIR	$360

The Premium-grade Assemblies have a silicone-coated steel monocoil jacketing with a Nomex braid for superior strain relief and protection.

Premium-grade Solarization-resistant Assemblies

Ultraviolet radiation below 300 nm degrades transmission in silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications <300 nm, we recommend solarization-resistant assemblies.

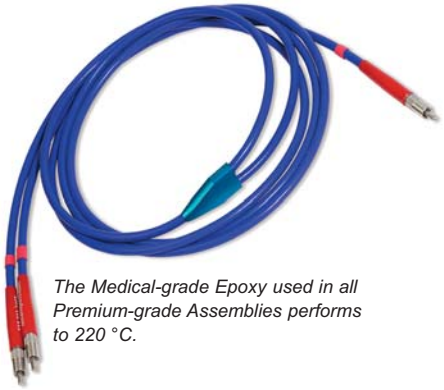
Item	Description	Price
QP300-1-SR	300 µm diameter optical fiber; 1-meter length	$150
QP400-025-SR	400 µm diameter optical fiber; 25-centimeter length	$120
QP400-2-SR	400 µm diameter optical fiber; 2-meter length	$180
QP600-025-SR	600 µm diameter optical fiber; 25 centimeter length	$130
QP600-1-SR	600 µm diameter optical fiber; 1-meter length	$180
QP600-2-SR	600 µm diameter optical fiber; 2-meter length	$220

Premium-grade Assemblies come with high-quality SMA 905 Connectors with extra-long ferrules for easy manipulation.

Premium-grade Bifurcated Optical Fiber Assemblies

Our 2-meter Premium-grade Bifurcated Optical Fiber Assemblies are Y-shaped assemblies with two fibers of the same diameter side-by-side in the common end of the assembly. From the breakout of the assembly, the two fibers diverge into two legs, which can be UV-VIS, VIS-NIR or one of each -- a "mixed" assembly.

Item	Description	Price
QBIF50-UV-VIS	50 µm diameter bifurcated assembly; UV-VIS	$300
QBIF50-VIS-NIR	50 µm diameter bifurcated assembly; VIS-NIR	$300
QBIF50-MIXED	50 µm diameter bifurcated assembly; MIXED	$300
QBIF200-UV-VIS	200 µm diameter bifurcated assembly; UV-VIS	$300
QBIF200-VIS-NIR	200 µm diameter bifurcated assembly; VIS-NIR	$300
QBIF200-MIXED	200 µm diameter bifurcated assembly; MIXED	$300
QBIF400-UV-VIS	400 µm diameter bifurcated assembly; UV-VIS	$330
QBIF400-VIS-NIR	400 µm diameter bifurcated assembly; VIS-NIR	$330
QBIF400-MIXED	400 µm diameter bifurcated assembly; MIXED	$330
QBIF600-UV-VIS	600 µm diameter bifurcated assembly; UV-VIS	$370
QBIF600-VIS-NIR	600 µm diameter bifurcated assembly; VIS-NIR	$370



The Medical-grade Epoxy used in all Premium-grade Assemblies performs to 220 °C.

Unjacketed Bulk Optical Fiber

We offer spooled, unjacketed optical fiber primarily for those interested in making their own assemblies. We offer various core diameters from 50 µm to 600 µm. To improve the fiber's strength and flexibility, we triple-coat it with a polyimide buffer before spooling. We offer all types of unjacketed optical fiber: High OH (high hydroxyl content for UV-VIS), Low OH (very low hydroxyl content for VIS-NIR) and Solarization-resistant (for UV-VIS). Each fiber type is optimized for use in a particular wavelength range. Unjacketed bulk optical fiber doesn't include a colored boot collar that indicates the fiber type, but they do fall into the same fiber types as our standard assemblies. See more on each fiber type on page 137.

Fiber Types

Gray	Solarization-resistant	UV/SR-VIS	190-800 nm (most efficient)
Blue	High OH content	UV-VIS	300-800 nm (most efficient)
Red	Low OH content	VIS-NIR	400-2100 nm (most efficient)

Unjacketed Bulk Optical Fiber

Item	1 meter	10 meter	50 meter	100 meter	500 meter	1000 meter	1500 meter	2000 meter
FIBER-50-UV	$15.78/meter	$6.78/meter	$5.98/meter	$5.59/meter	$4.93/meter	$4.34/meter	$4.05/meter	$3.76/meter
FIBER-50-VIS	$15.78/meter	$6.78/meter	$5.98/meter	$5.59/meter	$4.93/meter	$4.34/meter	$4.05/meter	$3.76/meter
FIBER-100-UV	$15.78/meter	$6.78/meter	$5.98/meter	$5.59/meter	$4.93/meter	$4.34/meter	$4.05/meter	$3.76/meter
FIBER-100-VIS	$15.78/meter	$6.78/meter	$5.98/meter	$5.59/meter	$4.93/meter	$4.34/meter	$4.05/meter	$3.76/meter
FIBER-200-UV	$14.38/meter	$5.38/meter	$4.58/meter	$4.26/meter	$3.74/meter	$3.29 meter	$3.07/meter	$2.85/meter
FIBER-200-VIS	$14.38/meter	$5.38/meter	$4.58/meter	$4.26/meter	$3.74/meter	$3.29/meter	$3.07/meter	$2.85/meter
FIBER-300-UV	$18.75/meter	$9.75/meter	$8.95/meter	$8.41/meter	$7.46/meter	$6.57/meter	$6.13/meter	$5.69/meter
FIBER-300-VIS	$18.75/meter	$9.75/meter	$8.95/meter	$8.41/meter	$7.46/meter	$6.57/meter	$6.13/meter	$5.69/meter
FIBER-400-UV	$23.38/meter	$14.38/meter	$13.58/meter	$12.81/meter	$11.39/meter	$10.04/meter	$9.37/meter	$8.70/meter
FIBER-400-VIS	$23.38/meter	$14.38/meter	$13.58/meter	$12.81/meter	$11.39/meter	$10.04/meter	$9.37/meter	$8.70/meter
FIBER-500-UV	$31.25/meter	$22.25/meter	$21.45/meter	$20.29/meter	$18.08/meter	$15.95/meter	$14.88/meter	$13.82/meter
FIBER-500-VIS	$31.25/meter	$22.25/meter	$21.45/meter	$20.29/meter	$18.08/meter	$15.95/meter	$14.88/meter	$13.82/meter
FIBER-600-UV	$36.88/meter	$27.88/meter	$27.08/meter	$25.63/meter	$22.86/meter	$20.17/meter	$18.82/meter	$17.47/meter
FIBER-600-VIS	$36.88/meter	$27.88/meter	$27.08/meter	$25.63/meter	$22.86/meter	$20.17/meter	$18.82/meter	$17.47/meter

Solarization-resistant Unjacketed Bulk Optical Fiber

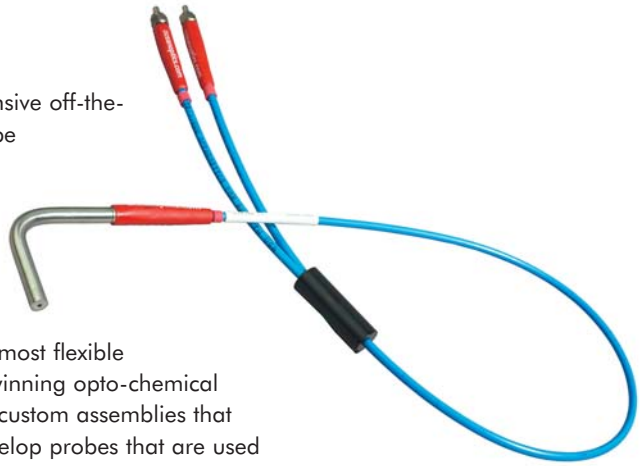
Ultraviolet radiation <300 nm degrades transmission in standard silica fibers, resulting in solarization (increased light absorption in the UV fiber that can invalidate data). For applications <300 nm, we recommend Solarization-resistant fiber. Shorter lengths for Solarization-resistant fiber maximize UV throughput.

Item	1 meter	10 meter	50 meter	100 meter	500 meter	1000 meter	1500 meter	2000 meter
FIBER-200-SR	$15.00/meter	$6.00/meter	$5.20/meter	$4.85/meter	$4.27/meter	$3.76/meter	$3.51/meter	$3.26/meter
FIBER-300-SR	$19.38/meter	$10.38/meter	$9.58/meter	$9.01/meter	$7.99/meter	$7.04/meter	$6.57/meter	$6.10/meter
FIBER-400-SR	$28.75/meter	$19.75/meter	$18.95/meter	$17.91/meter	$15.96/meter	$14.07/meter	$13.13/meter	$12.19/meter
FIBER-500-SR	$40.00/meter	$31.00/meter	$30.20/meter	$28.60/meter	$25.52/meter	$22.51/meter	$21.01/meter	$19.51/meter
FIBER-600-SR	$45.75/meter	$36.75/meter	$35.95/meter	$34.06/meter	$30.41/meter	$26.82/meter	$25.03/meter	$23.24/meter

Custom Assembly Options

Custom is Our Standard!

If you haven't yet found the exact assembly you need in our extensive off-the-shelf collection, then ask about our custom optical fiber and probe development services. We stock a wide variety of jacketing materials, connectors, ferrules and fiber core sizes that allow us to design and deliver a custom solution.

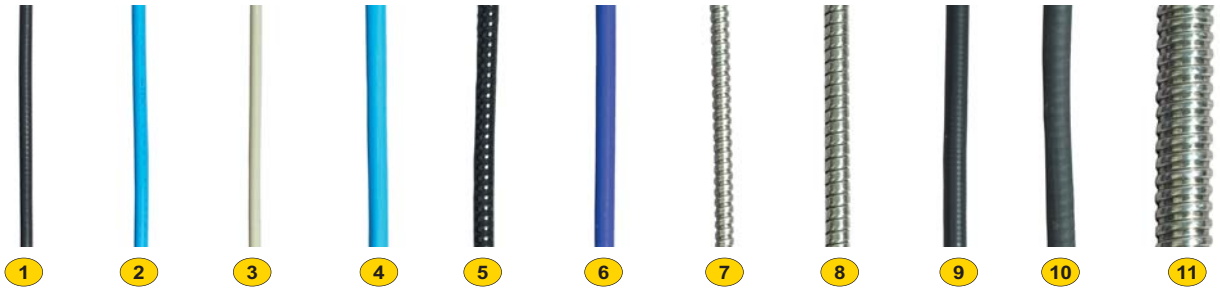


We were commissioned to design this 90º Probe to solve a difficult fiber routing problem.

Optical fiber technology has been paramount to our success and makes possible our "take the instrument to the sample" maxim. We've used optical fiber technology to create the world's most flexible miniature fiber optic spectrometer, as well as to develop award-winning opto-chemical sensors, innovative probes and sampling accessories. We create custom assemblies that work underwater and in high-temperature environments. We develop probes that are used in harsh environments like smokestacks, as well as probes that are used in delicate in vivo applications.

- Our Custom Fiber Ordering System enhances communication and expedites your order.
- Tell us about the environment and application in which the assembly will be used. We'll create the mechanical drawing and work with you to determine the final design.
- We'll provide you with specifications on jacketing material, connectors, core optical fiber type, epoxy, temperature ratings and more.

Jacketing Options



Item		Description	Temp. Limits	Chemical Resistance	Steam Sterilizable	Mechanical Tolerance	Length Limits
1	PVC Monocoil	OEM applications only	70 °C	Poor	No	Good	6 m
2	Zip Tube Blue PVC*	Best for budget-conscious applications; standard in Laboratory-grade Assemblies	100 °C	Poor	No	Good	50 m
3	PEEK	Good for hydrogen peroxide applications	260 °C	Excellent	Yes	Good	10 m
4	Zip Tube Blue PVC*	Best for budget-conscious applications; larger diameter than #2	100 °C	Poor	No	Good	50 m
5	PVC over Brass BX Tube	Glossy PVC covered over brass BX tube	100 °C	Good	No	Good	20 m
6	Silicone Monocoil	High-end jacketing; standard in Premium-grade Assemblies	250 °C	Good	Yes	Good	20 m
7	Stainless-steel BX	OEM applications only; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Poor	4 m
8	Stainless-steel fully interlocked BX	Excellent stainless steel jacketing supports longer lengths of fiber; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Excellent	40 m
9	Brake cable	OEM applications only	120 °C	Good	No	Good	20 m
10	Stainless-steel BX with heat shrink	Neoprene synthetic rubber over stainless steel; resists heat	120 °C	Good	No	Excellent	10 m
11	Large-diameter stainless-steel BX	OEM applications only; optional polyolefin heatshrink overcoat	250 °C	Good	Yes	Poor	4 m

** Custom printing available for OEMs.*

Custom Assembly Options

Connector & Connector Adapter Options

Our fiber assemblies are available with several connector options. For an upgrade fee that includes the cost of the custom connector and labor, we will replace the standard SMA 905 Connector (included in the assembly price) with any custom connector from the list below (priced separately). When ordering custom connectors, please specify the diameter size of the optical fiber to which it will be attached. You also can order connectors separately.

Item	Description	Connector Price
CONN-ST	Stainless-steel ST Connector	$20
CONN-FC	Stainless-steel FC Connector	$18
CONN-QSMA	Premium-grade SMA 905 Connector (standard in Premium-grade assemblies)	$16
CONN-SMA	Laboratory-grade SMA 905 Connector (standard in Laboratory-grade assemblies)	$13
CONN-PSMA	Process-grade SMA 905 Connector used with an assembly with Tefzel Jacketing	$23
CONN-QSMA-O	Premium-grade SMA 905 Connector with O-ring	$26
CONN-SMA-O	Laboratory-grade SMA 905 Connector with O-ring	$23
CONN-PSMA-O	Process-grade SMA 905 Connector with O-ring	$33
CONN-LSMA	Laser SMA 905 Connector for use during laser or other high-intensity applications	$30

Connector Adapters

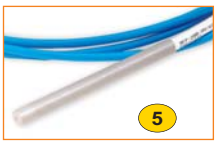
Connector adapters allow you to mate an item with an SMA 905 Connector to an item with either an ST or FC Connector.


SMA-ST-ADP


SMA-FC-ADP

Item	Description	Price
SMA-ST-ADP	SMA-to-ST Adapter for interfacing an item with an SMA 905 Connector to an item that has an ST Connector	$50
SMA-FC-ADP	SMA-to-FC Adapter for interfacing an item with an SMA 905 Connector to an item that has an FC Connector	$50

Ferrule Options



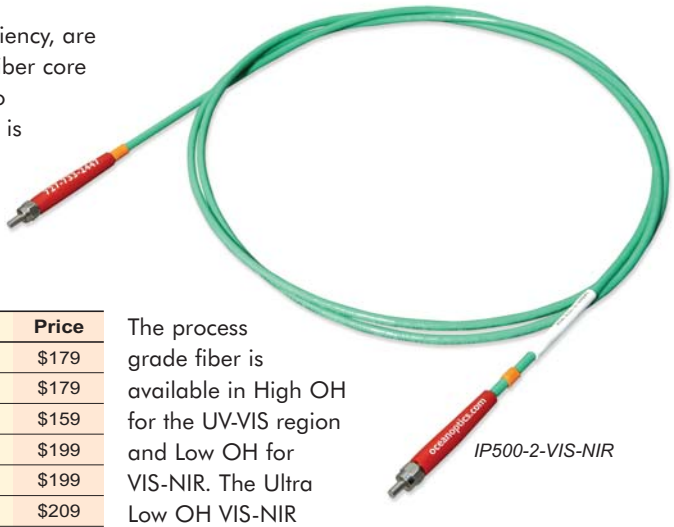
	Description
1	1/4" diameter stainless-steel ferrule often used in solution transmission measurements
2	1/4" diameter PEEK ferrule used in harsh environments for solution transmission measurements
3	1/4" diameter stainless-steel ferrule used in reflection measurements
4	1/4" diameter Torlon ferrule with cap
5	1/4" diameter PEEK ferrule used in harsh environments
6	1/8" diameter stainless-steel ferrule
	1/16" diameter stainless-steel ferrule
	1/4" diameter stainless-steel ferrule with the tip angled to 30°
	Fiber-to-lens ferrule that comes with a collimating lens

Epoxy Options

Item	Description	Operating Temp. Continuous	Operating Temp. Intermittent	Chemical Compatibility
EPO-TEK 353ND	Standard epoxy in all fiber assemblies	220 °C	350 °C	Good
EPO-TEK 354ND	Slightly lower curing stress on the fiber than 353ND	200 °C	300 °C	Good
EPO-TEK OM125	Lowest curing stress on the fiber of the three epoxies	150 °C	250 °C	Fair
EPOXY-TEST	Free sample slide of all epoxies for compatibility testing	NA	NA	NA

Process-grade Standard Assemblies

Our Process-grade Assemblies have excellent transmission efficiency, are very robust, and can be used in conditions up to 220 °C. The fiber core and cladding are covered with our patented Black RTV buffer to eliminate any stray light, and then coated with Teflon. The fiber is encased in an extruded Tefzel jacket with Kevlar strands to provide superior pull strength for putting the fiber into conduit in applications requiring long cable runs. Our stainless steel process-grade connectors are used to provide superior resistance to corrosion.



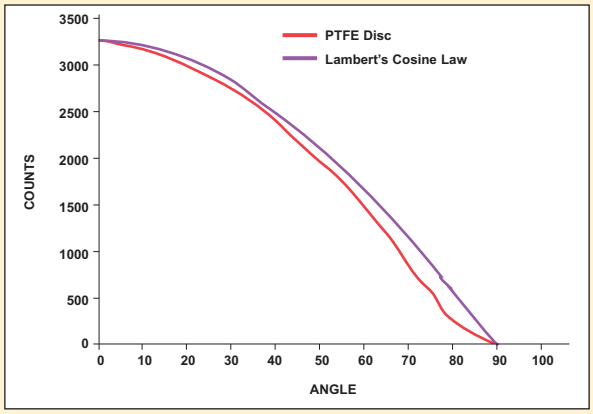
IP500-2-VIS-NIR

Item	Description	Length	Price
IP320-2-UV-VIS	320 µm diameter fiber; UV/VIS	2 meters	$179
IP320-2-VIS-NIR	320 µm diameter fiber; VIS/NIR	2 meters	$179
IP200-2-ULTRA	200 µm diameter fiber; Ultra Low OH	2 meters	$159
IP500-2-UV-VIS	500 µm diameter fiber; UV/VIS	2 meters	$199
IP500-2-VIS-NIR	500 µm diameter fiber; VIS/NIR	2 meters	$199
IP500-2-ULTRA	500 µm diameter fiber; Ultra Low OH	2 meters	$209
IP200-20-ULTRA	200 µm diameter fiber; Ultra Low OH	20 meters	$559
IP500-20-VIS-NIR	500 µm diameter fiber; VIS/NIR	20 meters	$629
IP500-20-ULTRA	500 µm diameter fiber; Ultra Low OH	20 meters	$629

The process grade fiber is available in High OH for the UV-VIS region and Low OH for VIS-NIR. The Ultra Low OH VIS-NIR fibers are designed for long cable lengths and for use with our NIR256 and NIR-512 InGaAs Spectrometers that extend to 2.5 µm.

Cosine-corrected Irradiance Probe

CC-3-UV Angular Response



The response of the PTFE disc (red trace) that's used in the CC-3-UV nearly matches that of Lambert's Cosine Law (purple trace).

CC-3 and CC-3-UV Cosine Correctors collect radiation from a 180° solid angle. When screwed onto the end of an optical fiber, the cosine corrector and optical fiber become an irradiance probe, measuring the intensity of light normal to the probe surface defined by the diffusing material. The probe then couples to one of our spectrometers to make a complete spectroradiometer for relative and absolute spectral intensity measurements, such as measuring UV-A and UV-B in natural solar environments, evaluating emissive color sources and analyzing light sources such as LEDs and lasers.

The CC-3 has an opaline glass diffuser for VIS-NIR; the CC-3-UV has a PTFE diffuser for UV-NIR. Each disc sits flush at the end of 6.35-mm outer diameter barrel, which is threaded on one side for SMA 905 Connectors. Call for details about our new HY-IRRAD irradiance collectors; one for air and one for water. See pages 138-140 for selecting a fiber to couple to a cosine corrector to create an irradiance probe.

CC-3:	$99
CC-3-UV:	$129
HY-IRRAD-A:	$295
HY-IRRAD-W:	$295

Specifications

	CC-3	CC-3-UV
Diffusing material:	Opaline glass	PTFE
Wavelength range:	350-1000 nm	200-1100 nm
Disc thickness:	7.9 mm	7.9 mm
Dimensions:	6.35 mm OD	6.35 mm OD
Field of view:	180°	180°
Connector:	SMA 905	SMA 905

Flame Loop Fiber Optic Probe

Heat-resistant Fiber Optic Probe

The FL-400 Flame Loop Fiber Optic Probe couples to our spectrometers to measure in situ emission spectra of samples such as dissolved metals and high-temperature plasmas. The FL-400 consists of a high-temperature 400 µm gold-jacketed UV-VIS optical fiber in an 8-inch-long nickel sleeve. The assembly operates in temperatures up to 700 °C. The probe connects to the 21-02 Splice Bushing and a P400-2-UV-VIS Optical Fiber, which couples to a spectrometer to measure emission spectra.

Use as a Traditional Flame Loop Probe

The FL-400 is especially beneficial as an emission spectroscopy teaching tool to observe atomic emission lines of dissolved metals. You simply dip the loop in your sample material and pass the loop over an open flame to take emission measurements.

Use as a Heat-resistant Fiber Probe

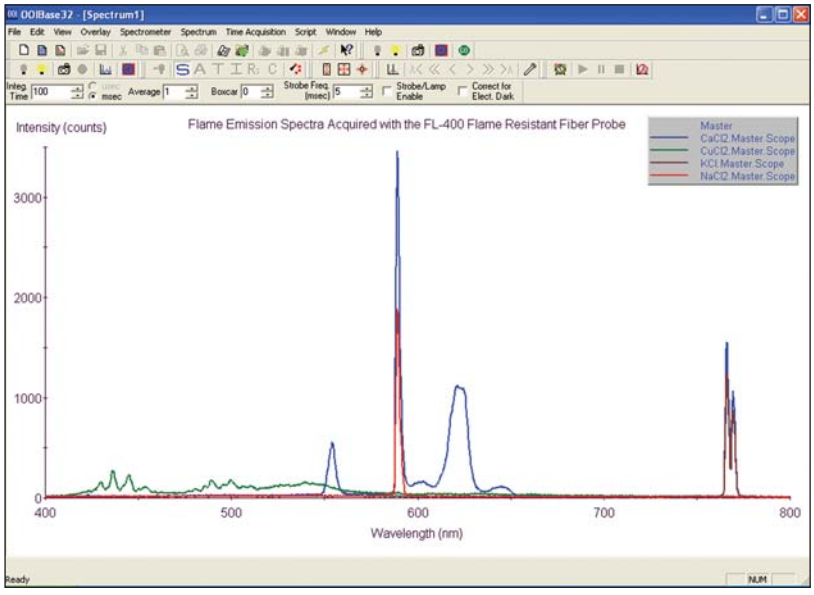
To use the FL-400 as a heat-resistant emission probe, simply remove the flame loop. You can then insert the FL-400 into a high-temperature environment to monitor emission from a heat source.

Ordering Info

Components are sold separately; the probe, a P400-2-UV-VIS Optical Fiber and a 21-02 Splice Bushing are required for a complete assembly.

FL-400:	$499
P400-2-UV-VIS:	$119
21-02:	$13

Probe Assembly Specifications	
Fiber diameter:	400 µm core diameter
Fiber core/cladding:	Fused silica core and doped, fused silica cladding
Fiber jacketing:	Gold
Fiber type:	1 single-strand, multimode fiber
Wavelengths covered:	300-800 nm
Probe sleeve (ferrule):	Nickel
Probe dimensions:	17.78 cm length, 20-gauge probes with 0.902 mm OD
Temperature range:	-269 °C to 700 °C
Numerical aperture:	0.22
Connector:	SMA 905



These spectra were taken using the FL-400 Flame Loop Fiber Optic Probe.

Reflection/Backscattering Probes

Multiple Probe Options = Application Versatility
Our R-series Fiber Optic Reflection Probes are used for measuring specular or diffuse reflectance from a surface, fluorescence from solid surfaces, or backscattering and fluorescence in solutions and powders. These probes can be optimized for the UV-VIS (300-800 nm) or VIS-NIR (400-2100 nm), or a combination of both ranges.

Our standard reflection probes use a 6-around-1 close-packing design to ensure parallel orientation of the fibers.

R200-7 & R400-7 Probes

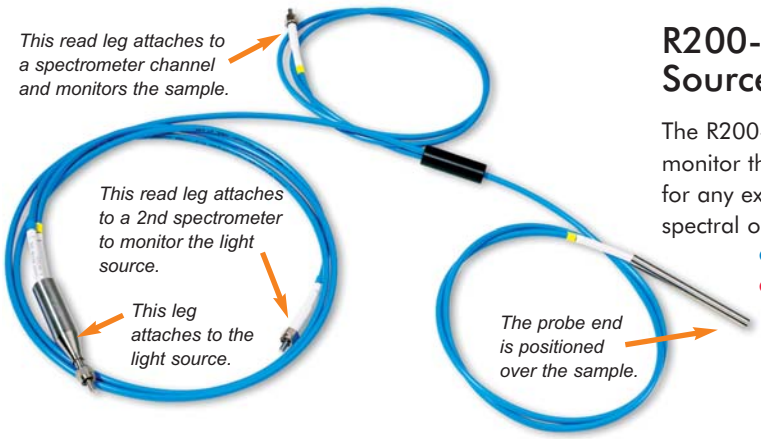
Our R200-7 and R400-7 Probes are based on a natural close-packing arrangement of optical fibers. Typically, the arrangement is a tight bundle of seven optical fibers -- six illumination fibers around one read fiber. This arrangement ensures parallel orientation of the fibers. The center or read fiber splits from the other six fibers and couples to a spectrometer. The outer six illumination fibers connect to the light source. The R200-7 uses 200 µm diameter fibers and the R400-7 uses 400 µm diameter fibers. Each comes in a stainless steel ferrule. Choose either UV-VIS (300-800 nm) or VIS-NIR (400-2100 nm) as standard options or use a combination of both ranges as a custom option.

- **R200-7-UV-VIS: $399**
- **R400-7-UV-VIS: $499**
- **R200-7-VIS-NIR: $399**
- **R400-7-VIS-NIR: $499**

RP200-7 PEEK Ferrule Option

The RP200-7-UV-VIS consists of a bundle of 200-µm fibers in a six-around-one design, but has a PEEK ferrule for applications where samples may be corrosive to the standard stainless-steel ferrule.

- **RP200-7-UV-VIS: $499**



R200-REF Reference Probe for Light Source Monitoring

The R200-REF consists of an R200-7 and an additional fiber to monitor the illumination (or reference) source, which is useful for any experiment in which variation or instability in the spectral output of the light source needs to be monitored.

- **R200-REF-UV-VIS: $549**
- **R200-REF-VIS-NIR: $549**

Reflection/Backscattering Probes

Probe for Expanded Wavelength Coverage

The R200-MIXED has 14 fibers -- six UV-VIS and six VIS-NIR illumination fibers, plus one UV-VIS and one VIS-NIR read fiber (see bundle photo at right). It couples easily to a dual-channel spectrometer in which each channel is set for a different wavelength range.

R200-12-MIXED: $749

Angled Probe for Solutions & Powders

Our angled reflection probes also have a six-around-one design, but employ a 30° window to remove specular reflection effects when the probe is immersed in dense solutions and powders. We offer the angled probe with two different diameter fibers, 200 µm and 400 µm. This probe is especially useful for fluorescence measurements.

- **R200-ANGLE-UV: $499**
- **R400-ANGLE-UV: $599**
- **R200-ANGLE-VIS: $499**
- **R400-ANGLE-VIS: $599**

Reflection/Backscattering Probe Comparison

Item	Description	Fiber Diameter	Wavelength Range	Ferrule	Price
R200-7-UV-VIS	6 illumination fibers around 1 read	200 µm	300-800 nm	1/4" stainless steel	$399
R200-7-VIS-NIR	6 illumination fibers around 1 read	200 µm	400-2100 nm	1/4" stainless steel	$399
R200-ANGLE-UV	6 illumination fibers around 1 read (with a 30° window)	200 µm	300-800 nm	1/4" stainless steel	$499
R200-ANGLE-VIS	6 illumination fibers around 1 read (with a 30° window)	200 µm	400-2100 nm	1/4" stainless steel	$499
R200-REF-UV-VIS	R200-7 with 8th fiber to monitor illumination source	200 µm	300-800 nm	1/4" stainless steel	$549
R200-REF-VIS-NIR	R200-7 with 8th fiber to monitor illumination source	200 µm	400-2100 nm	1/4" stainless steel	$549
R200-12-MIXED	14 fibers -- 6 UV-VIS and 6 VIS-NIR illumination fibers, 1 UV-VIS read fiber and 1 VIS-NIR read fiber	200 µm	mixed	1/4" stainless steel	$749
R400-7-UV-VIS	6 illumination fibers around 1 read	400 µm	300-800 nm	1/4" stainless steel	$499
R400-7-VIS-NIR	6 illumination fibers around 1 read	400 µm	400-2100 nm	1/4" stainless steel	$499
R400-ANGLE-UV	6 illumination fibers around 1 read (with a 30° window)	400 µm	300-800 nm	1/4" stainless steel	$599
R400-ANGLE-VIS	6 illumination fibers around 1 read (with a 30° window)	400 µm	400-2100 nm	1/4" stainless steel	$599
R600-7-SR-125F	6 illumination fibers around 1 read	600 µm	190-800 nm	1/8" stainless steel	$899
R600-7-UV-125F	6 illumination fibers around 1 read	600 µm	300-800 nm	1/8" stainless steel	$849
R600-7-VIS-125F	6 illumination fibers around 1 read	600 µm	400-2100 nm	1/8" stainless steel	$849
RP200-7-UV-VIS	6 illumination fibers around 1 read; PEEK ferrule	200 µm	300-800 nm	1/4" PEEK ferrule	$499

Specifications

Fiber core diameter:	200 µm, 400 µm and 600 µm	Terminations:	SMA 905
Fiber bundle:	6 illumination fibers around 1 read fiber	Sheathing:	Blue PVC with Kevlar reinforcement
Ferrule:	Stainless steel or PEEK	Temperature range:	-20 °C to 80 °C
Ferrule dimensions:	76.2 mm x 6.35 mm	Fiber length:	2 meters (breakout: 1 meter); custom lengths available
Numerical aperture:	0.22		

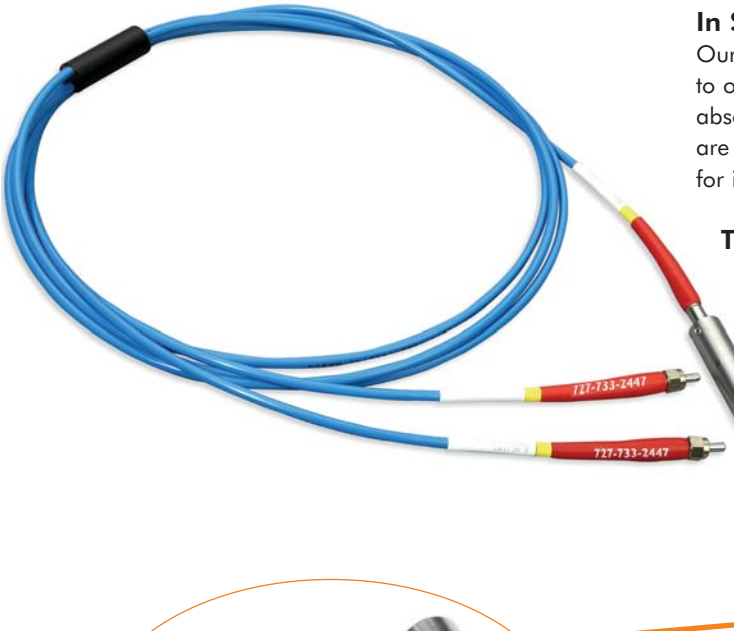
Reflection Probe Holders

The RPH-1 and RPH-2 are anodized aluminum platforms with holes at 45° and 90°. The RPH-1 holds 6.35-mm (1/4") diameter probes but with the RPH-ADP -- an adapter that fits on the RPH-1 -- you can secure 3.17 mm (1/8") diameter probes as well. The RPH-2 is for use with SMA 905-terminated optical fibers only.

RPH-1: $75
RPH-ADP: $69
RPH-2: $96

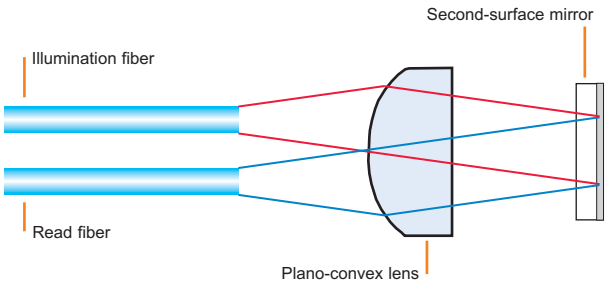
RPH-1 *RPH-2*

Transmission Dip Probes



The stainless steel RT-series tips screw onto the end of the T300-RT or T200-RT.

Transmission Dip Probe Operation



Specifications	
Fiber type:	T300: 300 µm Solarization-resistant, 190-800 nm T200: 200 µm VIS-NIR, 400-2100 nm
Pressure limit:	100 psi
Temperature limit:	100 °C without sleeve
Outer diameter:	6.35 mm
Probe length:	127 mm
Fiber length:	2 meters
Breakout:	1.5 meters from the end of the probe
Optics:	Fused silica
Probe wetted materials:	Stainless steel, fused silica, EPO-TEK 353ND
Pathlength:	2, 4, 5 or 10 mm
Fiber jacketing:	PVC Monocoil
Connector:	SMA 905
Probe sleeve:	Stainless steel

In Situ Monitoring

Our T300-RT and T200-RT Transmission Dip Probes couple to our spectrometers and light sources to measure absorbance and transmission in solutions. These probes are especially useful for embedding into process streams for in situ, real-time sample monitoring.

Theory of Operation

In transmission dip probes, light is transmitted from the illumination fiber through a plano-convex lens and through the sample compartment to a flat, second-surface mirror. The light reflects from this mirror and is focused by the lens onto the read fiber. The advantage of the transmission probe is its compact optical design, which fits into a 6.35-mm (1/4") outer diameter stainless steel body, or ferrule. The trade-offs with these probes are that they measure both transmitted light and backscattered light from the sample and have internal reflections that limit the dynamic range of the measurement. Still, at less than $1,000, transmission probes are a cost-effective option for many on-line and lab applications.

T300-RT Design

The T300-RT-UV-VIS Transmission Dip Probe consists of two 300-µm solarization-resistant optical fibers -- one illumination optical fiber and one read optical fiber -- in a 3.175-mm (1/8") outer diameter stainless steel assembly that slides into a 127-mm long, 6.35-mm (1/4") outer diameter stainless steel ferrule. Each leg of the assembly has an SMA 905 termination so that one leg can be attached to a light source and the other to a spectrometer.

T200-RT Design

The T200-RT-VIS-NIR Transmission Dip Probe has the same optical design as the T300-RT-UV-VIS, but is made with two 200-µm VIS-NIR optical fibers in its assembly.

Process Applications

Both probes fit into a standard 1/4" Swagelok fitting for installation into a pipe or reactor. Probe optics are mounted with an epoxy that offers superior chemical resistance to most solvents and can tolerate high temperatures.

Screw-on Tips: Choose Your Pathlength

Available separately are the screw-on, interchangeable probe tips necessary to use either probe. The RT-series tips come in pathlengths of 2 mm, 4, mm, 5 mm or 10 mm so that sampling setups can be configured for optically dense or dilute solutions.

- T300-RT-UV-VIS: $750
- T200-RT-VIS-NIR: $750

RT-2MM: $240
RT-4MM: $240
RT-5MM: $240
RT-10MM: $240

Transmission Dip Probes

Dip Probe for Hostile Environments

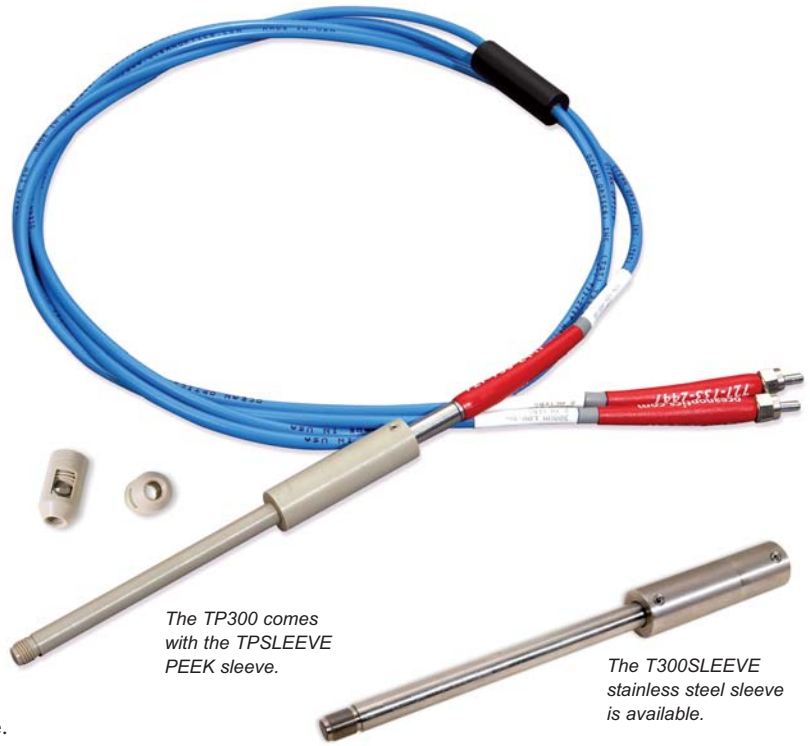
The TP300-UV-VIS Transmission Dip Probe couples to our spectrometers and light sources to measure the absorbance and transmission of solutions in harsh environments.

Probe Assembly

The TP300-UV-VIS consists of two 300-µm optical fibers -- one illumination optical fiber and one read optical fiber -- in a 3.175-mm (1/8") outer diameter stainless steel assembly sealed into a PEEK polymer sleeve. You have the option of choosing solarization-resistant fibers or VIS-NIR fibers for your assembly.

PEEK Polymer Sleeve

The sleeve is designed for environments with temperatures up to 200 °C. The PEEK material is also radiation-resistant and has low flammability and excellent chemical resistance. The PEEK sleeve (TPSLEEVE) comes with the TP300-UV-VIS. An additional stainless steel sleeve (T300SLEEVE) is available.



The TP300 comes with the TPSLEEVE PEEK sleeve.

The T300SLEEVE stainless steel sleeve is available.

Theory of Operation

The TP300 works the same way as the T300-RT and T200-RT probes. Light travels from the light source into the illumination leg of the probe and through a lens near the end of the probe. The light then transmits through the sample compartment to a second-surface mirror. The light reflects and travels back through the sample compartment a second time and is then focused by the lens onto the read fiber and through the read leg of the probe to the spectrometer.

Adjustable-pathlength Tips

There are two adjustable-pathlength tips (2 mm to 10 mm pathlengths or 10 mm to 20 mm pathlengths) available for the TP300-UV-VIS. Additionally, an RT-PH tip for mounting pH films in the optical path can be used for pH-sensing applications.

- **TP300-UV-VIS: $750**
- **TP300-VIS-NIR: $750**

T300SLEEVE: $250
TPSLEEVE: $250
RTP-2-10 Tip: $240
RTP-10-20 Tip: $240
RT-PH Tip: $240

The RTP-series Tips (above) are for transmission and absorbance measurements. The RT-PH Tip (left) turns the TP300 Probe into a pH Sensor (see page 72).

Specifications			
Fiber type:	TP300-UV-VIS -- 300 µm Solarization-resistant, 190-800 nm TP300-VIS-NIR -- VIS-NIR Low OH content, 400-2100 nm	Pathlength:	Adjustable from 2-10 mm or from 10-20 mm RT-PH - fixed 16-mm pathlength
Outer diameter:	3.175 mm	Outer materials:	PVC for jacketing, PEEK polymer for sleeve
Length:	107.9 mm for probe, 2 meters for fiber	Temperature limit:	200 °C with PEEK sleeve
Optics:	Fused silica	Pressure limit:	100 psi

Industrial Process Probe

Industrial Environments up to 250 psi, 300 °C

Our TI300-series Transmission Industrial Dip Probes can be used in environments with pressure limits up to 250 psi and at temperatures up to 300 °C. The TI300-UV-VIS uses 300 µm diameter solarization-resistant optical fiber (190-800 nm), while the TI300-VIS-NIR uses 300 µm diameter VIS-NIR optical fiber (400-2200 nm). The TI300 probes couple to our spectrometers and light sources to measure solutions absorbance and transmission in industrial applications.

Sampling Tips Use O-rings, Replacing Epoxy

With our other transmission probe offerings, we use high-grade epoxy to adhere the sampling optics to the sampling tips. However, most epoxies lose their adhesive properties in continuous heat over 220 °C. With the TI300s, we mounted the probe optics into the sampling tips using Parker perfluoroelastomer (Parofluor ULTRA) O-ring seals. The material in these special O-rings offers broad chemical resistance, excellent thermal stability and temperature resistance up to 300 °C. The other materials in the screw-on, interchangeable sampling tips are grade 303 stainless steel, a back-coated quartz mirror and a quartz lens. The tips come in pathlengths of 2, 5, 10, 25 and 50 mm so that sampling setups can be configured for optically dense or dilute solutions.

Probe Ferrule & Jacketing

The TI300s use a fully-interlocked stainless-steel jacketing over Teflon tubing and have an outer diameter of 0.68 cm. The immersible part of the probe, the ferrule, is also made from 303 stainless steel and measures 12.7 cm in length, with an outer diameter of 1.27 cm.

How it Works

In a TI300 probe, there are two 300-µm optical fibers -- one illumination optical fiber and one read optical fiber -- in a 12.7-mm diameter stainless-steel ferrule. Light transmits via the illumination fiber through a plano-convex lens and the sample compartment to a flat, second-surface mirror (see diagram on page 148). The light reflects from this mirror, travels back through the sample compartment and is focused by the lens onto the read fiber and through the read leg of the probe to the spectrometer. The trade-offs with these probes are that they measure both transmitted light and backscattered light from the sample and have internal reflections that limit the dynamic range of the measurement. But at less than $1,600 (for the TI300 probe and one sampling tip), a TI300 probe, with its high pressure and temperature limits, is a great option for many industrial applications.

- **TI300-UV-VIS: $1,299**
- **TI300-VIS-NIR: $1,299**

RT-TI-2MM: $299
RT-TI-5MM: $299
RT-TI-25MM: $299
RT-TI-50MM: $299

Specifications	
Fiber type:	TI300-UV-VIS -- 300 µm diameter Solarization-resistant fiber, 190-800 nm TI300-VIS-NIR -- 300 µm diameter VIS-NIR Low OH content fiber, 400-2100 nm
Wavelength range:	TI300-UV-VIS -- 190-800 nm TI300-VIS-NIR -- 400-2100 nm
Pressure limit:	250 psi
Temperature limit:	300 °C
Sampling tip body:	303 stainless steel
Sampling tip optics:	Quartz back-coated mirror and quartz lens
Sampling tip O-ring:	Parker perfluoroelastomer (Parofluor ULTRA) O-ring seal
Probe ferrule:	12.7 mm outer diameter 303 stainless steel
Probe jacketing:	Fully-interlocked stainless-steel jacketing over Teflon tubing; total 6.8 mm outer diameter
Length:	Fiber -- 2 meters Ferrule -- 12.7 cm without tip Tips -- 2.6 cm to 4.99 cm, depending on tip
Breakout distance:	1 meter from the end of the probe
Immersible length:	12.7 cm
Optical pathlengths:	2, 5, 10, 25 and 50 mm pathlengths available
Connectors:	SMA 905

Vacuum Feedthroughs

Feedthroughs with Industry-standard Flanges

These Vacuum Feedthroughs are welded into industry standard flanges, designed for monitoring high-vacuum applications from inside a vacuum system with external equipment, such as our spectrometers. The optical fiber inside of the VFT is hermetically sealed into a stainless steel shell. These VFTs come in two standard flange types: Conflat Flanges and ISO KF Flanges. The flanges use surgical-grade stainless steel with glass-ceramic seals. The flange-to-seal's metal-to-glass design allows the entire assembly to perform up to either 250 °C and 10^{-10} Torr for the Conflat Flanges or 150 °C and 10^{-8} Torr for the ISO KF Flanges.

VFT-1000-UV-133

VFT-1000-UV-275

VFT-1000-UV-16

VFT-1000-UV-40

Item	Fiber Type	Range	Flange Type	Price
● VFT-200-UV-133	200-µm diameter UV-VIS	300-800 nm	1.33" OD Conflat	$279
● VFT-200-VIS-133	200-µm diameter VIS-NIR	400-2100 nm	1.33" OD Conflat	$279
● VFT-400-UV-133	400-µm diameter UV-VIS	300-800 nm	1.33" OD Conflat	$440
● VFT-400-VIS-133	400-µm diameter VIS-NIR	400-2100 nm	1.33" OD Conflat	$440
● VFT-600-UV-133	600-µm diameter UV-VIS	300-800 nm	1.33" OD Conflat	$450
● VFT-600-VIS-133	600-µm diameter VIS-NIR	400-2100 nm	1.33" OD Conflat	$450
● VFT-1000-UV-133	1000-µm diameter UV-VIS	300-800 nm	1.33" OD Conflat	$485
● VFT-1000-VIS-133	1000-µm diameter VIS-NIR	400-2100 nm	1.33" OD Conflat	$485
● VFT-200-UV-275	200-µm diameter UV-VIS	300-800 nm	2.73" OD Conflat	$450
● VFT-200-VIS-275	200-µm diameter VIS-NIR	400-2100 nm	2.73" OD Conflat	$450
● VFT-400-UV-275	400-µm diameter UV-VIS	300-800 nm	2.73" OD Conflat	$455
● VFT-400-VIS-275	400-µm diameter VIS-NIR	400-2100 nm	2.73" OD Conflat	$455
● VFT-600-UV-275	600-µm diameter UV-VIS	300-800 nm	2.73" OD Conflat	$465
● VFT-600-VIS-275	600-µm diameter VIS-NIR	400-2100 nm	2.73" OD Conflat	$465
● VFT-1000-UV-275	1000-µm diameter UV-VIS	300-800 nm	2.73" OD Conflat	$499
● VFT-1000-VIS-275	1000-µm diameter VIS-NIR	400-2100 nm	2.73" OD Conflat	$499
● VFT-200-UV-16	200-µm diameter UV-VIS	300-800 nm	1.18" OD KF16 ISO	$430
● VFT-200-VIS-16	200-µm diameter VIS-NIR	400-2100 nm	1.18" OD KF16 ISO	$430
● VFT-400-UV-16	400-µm diameter UV-VIS	300-800 nm	1.18" OD KF16 ISO	$435
● VFT-400-VIS-16	400-µm diameter VIS-NIR	400-2100 nm	1.18" OD KF16 ISO	$435
● VFT-600-UV-16	600-µm diameter UV-VIS	300-800 nm	1.18" OD KF16 ISO	$445
● VFT-600-VIS-16	600-µm diameter VIS-NIR	400-2100 nm	1.18" OD KF16 ISO	$445
● VFT-1000-UV-16	1000-µm diameter UV-VIS	300-800 nm	1.18" OD KF16 ISO	$480
● VFT-1000-VIS-16	1000-µm diameter VIS-NIR	400-2100 nm	1.18" OD KF16 ISO	$480
● VFT-200-UV-40	200-µm diameter UV-VIS	300-800 nm	2.16" OD KF40 ISO	$445
● VFT-200-VIS-40	200-µm diameter VIS-NIR	400-2100 nm	2.16" OD KF40 ISO	$445
● VFT-400-UV-40	400-µm diameter UV-VIS	300-800 nm	2.16" OD KF40 ISO	$450
● VFT-400-VIS-40	400-µm diameter VIS-NIR	400-2100 nm	2.16" OD KF40 ISO	$450
● VFT-600-UV-40	600-µm diameter UV-VIS	300-800 nm	2.16" OD KF40 ISO	$460
● VFT-600-VIS-40	600-µm diameter VIS-NIR	400-2100 nm	2.16" OD KF40 ISO	$460
● VFT-1000-UV-40	1000-µm diameter UV-VIS	300-800 nm	2.16" OD KF40 ISO	$495
● VFT-1000-VIS-40	1000-µm diameter VIS-NIR	400-2100 nm	2.16" OD KF40 ISO	$495

Each end of a VFT is terminated with an SMA 905 Connector and couples easily to optical fibers via a 21-02 Splice Bushing (two are included with each VFT).

VFT-series Feedthroughs

Our general-purpose VFT-series Vacuum Feedthroughs are designed to penetrate NEMA enclosures. The VFT screws into a 3/8-24 external threaded hole in the vacuum chamber, or bolts into a smooth hole with the provided nut and washer.

Item	Fiber Type	Range	Price
● VFT-200-SR	200-µm diameter SR fiber	190-800 nm	$299
● VFT-200-VIS	200-µm diameter VIS-NIR fiber	400-2100 nm	$299
● VFT-400-SR	400-µm diameter SR fiber	190-800 nm	$299
● VFT-400-VIS	400-µm diameter VIS-NIR fiber	400-2100 nm	$299
● VFT-600-SR	600-µm diameter SR fiber	190-800 nm	$299
● VFT-600-VIS	600-µm diameter VIS-NIR fiber	400-2100 nm	$299
● VFT-1000-UV	1000-µm diameter UV-VIS fiber	300-800 nm	$299
● VFT-1000-VIS	1000-µm diameter VIS-NIR fiber	400-2100 nm	$299

Specifications

	VFTs with Conflat Flanges	VFTs with KF ISO Flanges	VFT-Series
Temperature limit:	250 °C	150 °C	140 °C
Vacuum range:	1 x 10^{-10} Torr	1 x 10^{-8} Torr	1 x 10^{-9} Torr
Numerical aperture:	0.22, and acceptance angle of 24.8°	0.22, and acceptance angle of 24.8°	0.22, and acceptance angle of 24.8°

Bare Fiber Adapter Kit

The SMA-PUCK, sold separately from the BFA-KIT.

The BFA-KIT Bare Fiber Adapter Kit is for the fiber tinkerer who wants to polish bare (unjacketed) optical fiber. The kit comes with fiber polishing holders for various sizes of optical fibers.

The Bare Fiber Adapter Kit includes the following:

- 6 fiber polishing holders for various sizes of optical fiber: (1 each for 100 µm, 200 µm, 300 µm, 400 µm, 600 µm and 1000 µm optical fibers)
- a BFA-KIT-CHUCK connect-and-release adapter (which can be purchased separately as well) to fasten the SMAs onto bare optical fiber.
- several pieces of wire for cleaning out the polishing holders and connect-and-release adapter.

An SMA-PUCK polishing puck is not included with the BFA-KIT, but is available separately. The puck is used to polish the surface of an optical fiber.

Need a special SMA 905 Connector? We can drill out an SMA 905 Connector from 149 µm to 2705 µm. Custom-drilled connectors are available for $50 each.

BFA-KIT:	$249
BFA-KIT-CHUCK:	$169
SMA-PUCK:	$129

How to Use the BFA-KIT

Select the fiber polishing holder that corresponds to the diameter of your bare optical fiber.

Attach the fiber polishing holder to the front of the BFA-KIT-CHUCK connect-and-release adapter.

Thread your bare optical fiber through the back of the chuck and into the holder and fasten. The holder allows you to easily work with the fiber for various purposes, such as polishing.

Fiber Tinkerer's Kit

The FT-KIT Fiber Tinkerer Kit (left) includes an assortment of randomly selected, unterminated UV-VIS and VIS-NIR optical fibers. Each fiber included in the kit will be at least 1 meter in length. The Fiber Termination Kit (TERM-KIT) on the following page includes all the tools needed to terminate and polish fiber.

FT-KIT: $99

Fiber Termination Kit

Inspect & Repair Fibers

The TERM-KIT Termination Kit provides you with all the tools you need to properly polish and terminate an optical fiber. The TERM-KIT is great for inspecting, repairing and polishing optical fiber assemblies. If you would like unterminated fibers for use with the TERM-KIT, the FT-KIT Fiber Tinkerer Kit includes an assortment of optical fibers in lengths of at least 1 meter (see page 152 for details).

Included in Each TERM-KIT

- 4 SMA 905 Connectors for 50 µm or 100 µm fibers
- 4 SMA 905 Connectors for 200 µm optical fibers
- 4 SMA 905 Connectors for 400 µm optical fibers
- 4 SMA 905 Connectors for 600 µm optical fibers
- 4 SMA 905 Connectors for 1000 µm optical fibers
- polishing puck
- glass polishing plate (15 cm x 15 cm)
- dozens of polishing papers
- 5-cavity crimp tool (for 2.6, 3.4, 3.8, 4.5 and 6.4 mm cavities)
- scoring tool
- inspection scope
- 2-hour cure epoxy
- optical wipes

TERM-KIT: $599

Terminators

Our SMA 905 Connector Kits are an excellent complement to the standard Termination Kit (above). We offer six different sizes, each with 10 SMA 905 Connectors of the same size, drilled for precise alignment with our optical fiber. The difference between each kit is the diameter size of the SMA 905 Connector. We offer 150 µm, 270 µm, 380 µm, 490 µm, 710 µm and 1300 µm diameter connectors.

TERMKIT-SMA-710

TERMKIT-SMA-270

TERMKIT-Q SMA-710

TERMKIT-QSMA-270

Item	Fiber Type	For Use with Fiber Diameters of	Price
TERMKITSMA-150	10 SMA Connectors for 100-micron and 50-micron fibers	100 µm	$75
TERMKITSMA-270	10 SMA Connectors for 200-micron fibers	200 µm	$75
TERMKITSMA-380	10 SMA Connectors for 300-micron fibers	300 µm	$75
TERMKITSMA-490	10 SMA Connectors for 400-micron fibers	400 µm	$75
TERMKITSMA-710	10 SMA Connectors for 600-micron fibers	600 µm	$75
TERMKITSMA-130	10 SMA Connectors for 1000-micron fibers	1000 µm	$75
TERMKITQSMA-150	10 Premium SMA Connectors for 100-micron and 50-micron fibers	100 µm	$170
TERMKITQSMA-270	10 Premium SMA Connectors for 200-micron fibers	200 µm	$170
TERMKITQSMA-380	10 Premium SMA Connectors for 300-micron fibers	300 µm	$170
TERMKITQSMA-490	10 Premium SMA Connectors for 400-micron fibers	400 µm	$170
TERMKITQSMA-710	10 Premium SMA Connectors for 600-micron fibers	600 µm	$170
TERMKITQSMA-130	10 Premium SMA Connectors for 1000-micron fibers	1000 µm	$170

Optical Fiber Kits

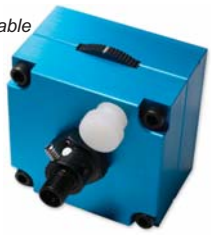
Fiber Optic Kit -- UV-VIS

We've taken our most popular laboratory-grade optical fiber assemblies and accessories and combined them into cost-saving Optical Fiber Kits -- perfect for testing, teaching or just plain tinkering. The FOP-UV Optical Fiber Kit consists of five patch cord optical fiber assemblies, the Fiber Optic Variable Attenuator, a CC-3-UV Cosine Corrector, a fiber wrench and more. By buying a kit instead of each product separately, you save over $400. The table below lists the items in the kit.

FOP-UV KIT: $999

FOP-UV Items	Description	Price
P50-2-UV-VIS	(1) 50 µm diameter optical fiber; UV-VIS	$99
P200-2-UV-VIS	(1) 200 µm diameter optical fiber; UV-VIS	$99
P400-025-SR	(2) 400 µm diameter optical fibers; UV, SR	$198
P600-2-UV-VIS	(1) 600 µm diameter optical fiber; UV-VIS	$159
21-02	(2) Splice bushings	$26
21-01	(2) Bulkhead bushings	$18
FVA-UV	(1) Fiber Optic Variable Attenuator	$499
FOT-SMAWRENCH	(1) Fiber Wrench	$10
CC-3-UV	(1) Cosine Corrector	$129
FCBARREL	(2) 6.35-mm OD barrel for FC connectors	$58
FIBER-WRAP	(3) 2-foot-long pieces of fiber wrap	$10
74-UV	(1) Collimating Lens	$159
	Total, if purchased separately:	**$1,464**

The FVA-UV Fiber Optic Variable Attenuator helps control the amount of light transmitted between two fibers.



The 74-UV Collimating Lens can be screwed onto the end of a fiber to collimate light.

The FC-BARREL accepts FC-terminated fibers for use with our lenses, lamps and other fixtures.

The FIBER-WRAP is used to bundle and protect optical fibers.

The CC-3 Cosine Corrector attaches to optical fiber to create an irradiance probe.

The 21-01 SMA Bulkhead Bushing allows you to position an optical fiber on a through-panel such as a chamber wall.

The 21-02 Splice Bushing is an in-line adapter that mates two SMA 905 Connectors, such as those on optical fibers.

The FOT-SMAWRENCH slips over SMA 905 Connectors to secure fibers to spectrometers, collimating lenses and accessories.

Fiber Optic Kit -- VIS-NIR

The FOP-VIS Optical Fiber Kit consists of five patch cord optical fiber assemblies, the Fiber Optic Variable Attenuator, CC-3 Cosine Corrector, fiber wrap, a fiber wrench and more. By buying a kit instead of each product separately, you save nearly $500. The table below lists the items included in the kit.

FOP-VIS KIT: $999

FOP-VIS Items	Description	Price
P50-2-VIS-NIR	(1) 50 µm diameter optical fiber; VIS-NIR	$99
P200-2-VIS-NIR	(1) 200 µm diameter optical fiber; VIS-NIR	$99
P400-2-VIS-NIR	(2) 400 µm diameter optical fibers; VIS-NIR	$238
P600-2-VIS-NIR	(1) 600 µm diameter optical fiber; VIS-NIR	$159
21-02	(2) Splice bushings	$26
21-01	(2) Bulkhead bushings	$18
FVA-UV	(1) Fiber Optic Variable Attenuator	$499
FOT-SMAWRENCH	(1) Fiber Wrench	$10
CC-3	(1) Cosine Corrector	$99
FCBARREL	(2) 6.35-mm OD barrel for FC connectors	$58
FIBER-WRAP	(3) 2-foot-long pieces of fiber wrap	$10
74-UV	(1) Collimating Lens	$159
	Total, if purchased separately:	**$1,474**

The P400-2-VIS-NIR Laboratory-grade Optical Fiber in the FOP-VIS Kit.

Fiber & Probe Fixtures & Holders

C-Mounts

Our C-MOUNT-MIC Adapter Assembly with adjustable focusing barrel has an SMA 905 Connector in its center for attaching to optical fibers. The internal C-mount threads of this assembly allow you to adapt fiber optic spectrometers to other optical devices such as microscopes and telescopes.

The MFA-C-MOUNT also connects to optical devices such as microscopes and telescopes, but its center connector is designed to accept probes with 6.35-mm (1/4") outer diameter ferrules.

C-MOUNT-MIC: $125
MFA-C-MOUNT: $400

The MFA-C-Mount.


The C-MOUNT-MIC Adapter Assembly.

Phototubus Microscope Adapter

The MFA-PT Phototubus Microscope Adapter adapts to a Phototubus outlet on microscopes and accepts SMA 905-terminated optical fibers.

MFA-PT: $370


The MFA-PT Phototubus Microscope Adapter.

Right-angle Collimating Lens Holder

The 74-90-UV is an assembly for mounting lenses at right angles, and is especially useful for applications involving awkward optical fiber routing. It has a mirror located under its cap that reflects light from the collimating lens to 90°. Two ports accommodate 74-series Collimating Lenses (not included).

74-90-UV: $139


The 74-90-UV Right-angle Collimating Lens Holder with optical fiber.

Reflection Probe Holders

The RPH-1 (far right) and RPH-2 (near right) are anodized aluminum platforms with holes drilled at 45° and 90° angles to the surface. The RPH-1 holds 6.35-mm (1/4") diameter Reflection Probes. The RPH-2 is for use only with reflection probes with SMA 905 Connectors. The Curved Surface Probe Holders accommodate 6.35-mm (1/4") outer diameter probes for measuring reflection of curved surfaces. The CSH (right) has a hole drilled at a 90° angle to the surface. The CSH-45 has a hole drilled at a 45° angle to the surface.

RPH-1: $75
RPH-2: $96
CSH: $93
CSH-45: $126


RPH-2

RPH-1

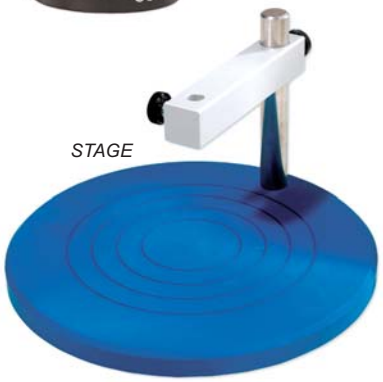
CSH

Optical Stages

The Single-Point Reflection Stage (at right) is a probe holder for reflection measurements of optical layers and other substrates up to 150 mm in diameter. The probe holder accommodates fiber optic probes and other sampling devices up to 6.35 mm in diameter.

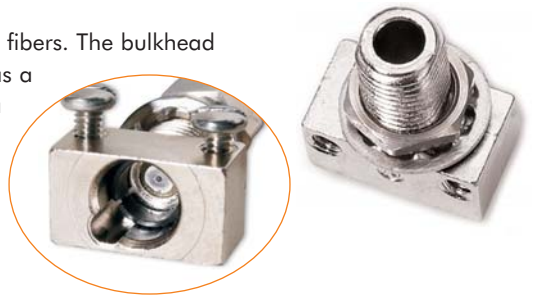
The Stage-RTL-T is also a sampling system for analysis of substrate materials. The STAGE-RTL-T can be configured for reflection and transmission measurements. For details on both stages, see page 115.

STAGE: $547
STAGE-RTL-T: $1,995


STAGE

Fiber & Probe Accessories

Bulkhead Bushing



The 21-01 SMA Bulkhead Bushing assembly is a device mount for optical fibers. The bulkhead bushing allows you to position an optical fiber on a through-panel such as a chamber wall. For example, to monitor a chamber, you could configure a sampling optic that consists of an SMA 905-terminated optical fiber screwed into the bulkhead bushing and mounted to a chamber window.

21-01: $9

Splice Bushing

The 21-02 SMA Splice Bushings are in-line adapters that connect SMA 905-terminated optical fibers (or any two objects with SMA 905 terminations). A splice bushing consists of a 0.75" screw with female ends. The standard 21-02 is made of nickel-plated brass while the 21-02-SS is made of stainless steel. They are useful for coupling patch cords to fiber optic probes and other devices, or for any multiple-fiber application where coupling our standard optical fibers and accessories is preferable to creating costly and complex fiber optic assemblies.

21-02: $13
21-02-SS: $49

Bulkhead & Splice Bushing Combo

The 21-02-BH SMA Bulkhead Splice Bushing is an in-line adapter that connects SMA 905-terminated optical fibers through a chamber wall or panel. The 21-02-BH features an O-ring for sealing against the inside of the panel wall and a nut and lockwasher for mounting to the outside of the panel wall.

21-02-BH: $23

FC Barrel

Our collimating lenses come standard with SMA 905 Connectors and interface to our SMA-terminated fibers. If you have FC-terminated fiber, your could remove the inner 6.35-mm OD SMA barrel and replace it with this FC Barrel to connect to our products.

FCBARREL: $29

Finger Fiber Wrench

The FOT-SMAWRENCH is a wrench that slips over the hex nut of the SMA 905 Connector used in Laboratory-grade Optical Fibers and helps to easily attach the fiber to connectors on spectrometers, light sources, collimating lenses and many other accessories.

FOT-SMAWRENCH: $10

Modemixer/Modestripper

The Modemixer/Modestripper is an in-line, 3-mm Suprasil rod that connects two SMA 905-terminated optical fibers to mix core modes and eliminate clad modes throughout 180-2100 nm.

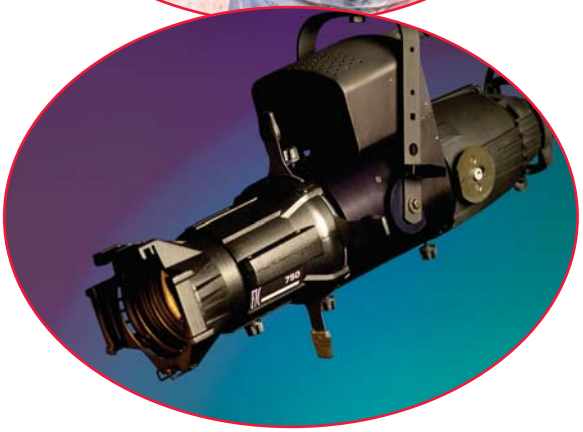
ADP-SMA-SMA: $245

Fiber Wrap

Fiber Safety Wrap is a protective spiral wrap used to bundle and protect optical fibers. The durable wrap comes in 2-foot sections of red, yellow and green.

FIBER-WRAP: $10

Thin Films & Optics



Overview: Thin Films & Optics

Precision, Experience & New Technology

The thin films and optics division that we established nearly five years ago provides the most versatile of in-house manufacturing arts: the innovation to create patented patterned dichroic filters for display and scientific applications, and the expertise to produce optics and coatings in OEM volumes. We are often our own best customer, applying the kind of spectroscopy-savvy insight that few optics suppliers can provide to the development of filters and optics that enhance our spectrometers and accessories. Our "colored light" products are among the most robust in the world, making them ideal for theatrical and architectural applications. One such product is the SeaChanger Color Engine, a color-changing device for stage lighting.

It all starts with a patented dichroic filter array process (see sidebar below), which creates patterns precise enough to project still images. There's much more, including both custom and off-the-shelf filters and precision optics for markets ranging from the entertainment industry to the military; optical metrology products such as laser-collimation testers and optical flats; and optical services from machining and microlithography to etching and QC testing.

Thin Films

Specifications

Substrates:
up to 455 mm diameter

Image size:
up to 250 mm square

Pattern resolution:
to 2 μm features

Spatial resolution:
to 1 μm

Temperature tolerance:
-80 °F to 700 °F

Coating wavelength range:
200-2500 nm

Coatings used in patterning:
see coating types below

Coating Types

- Antireflective
- Beamsplitter
- Dichroic, Dielectric, and Interference (UV to NIR)
- Fluorides
- High-reflective
- Metals
- Oxides
- Custom

Optics

Specifications

Curvature:
plano, concave, convex

Deviation/wedge:
<0.002 mm

Wavefront:
<1/20 wave

Flatness:
λ/10 at 633 nm

Irregularity:
<1/20 wave

Mechanical tolerance:
<0.010 mm

Parallelism:
<30 arc seconds

Surface quality:
better than $<10^{-5}$

Surface roughness:
<10 angstrom RMS

Size of finished optic:
1 mm to 200 mm

High-precision Optics

- Beamsplitters
- Collimation Testers
- Filters
- Flats
- Laser Mirrors and Optics
- Lenses and Windows
- Mirrors
- Prisms & Spheres
- Reticles

Patented Coating Technology

We have pioneered an optical coatings production method that combines optical thin film deposition techniques with microlithographic procedures. This patented process enables micron-scale precision patterning of optical thin film dichroic coatings -- which selectively transmit or reflect light according to its wavelength -- on a single substrate.

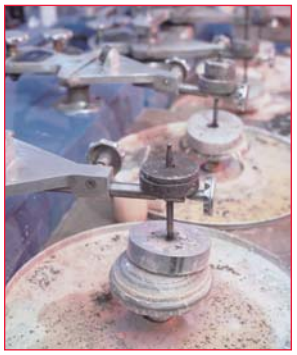
With this process, we create multipatterned arrays of optical filters for use in various products, including micromechanical and optical waveguide-based devices and dense wavelength division multiplexers. The process also can be applied to multipart bonded filter applications common to the manufacture of digital data projectors, LCD display panels and CCD camera detectors. In fact, many optical coatings can be patterned, including dielectric multiple-layer reflectors, bandpass filters, dichroic edge filters and broadband anti-reflection coatings. Our technique also is used to deposit enhanced metal reflectors, low-reflectivity opaque metals and electrically conductive transparent patterns.

Thin Films & Optics Capabilities

Our expertise in electro-optics, spectroscopy, optical fibers and precision optics offers great value to researchers and OEMs seeking a flexible, full-service supplier. We offer a range of skills, techniques and services to provide you with state-of-the-art, one-stop-shopping optical manufacturing. Since all grinding, polishing, coating and assembly operations are performed in-house, we have absolute control over the entire process, whether for prototype or production optics.

Raw Materials

We select only top-grade materials for machining into the optical component you need for your application. Glasses and ceramics include Borosilicate glass, fused quartz, Zerodur and ULE.



Machining & Finishing

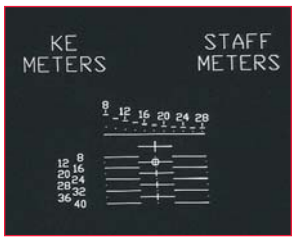
Our full-size machine shop creates metal components and assemblies with equipment such as CNC mills and lathes and other machine shop tools. Our shaping and finishing capabilities -- double-side grinding, cutting and polishing equipment for plano, concave and convex optics -- apply to materials up to 200 mm in diameter or 220 mm in length.

Reticles

Our etch-and-fill reticles can be fabricated with line widths from 0.005 mm to 0.5 mm. Etchings are available with black, white or red fill. The middle photo in the column at right is a close-up of a 0.015 mm line-width etching. In addition to etch & fill, reticles can be constructed of dielectric and metal vacuum deposited materials.

Assembly

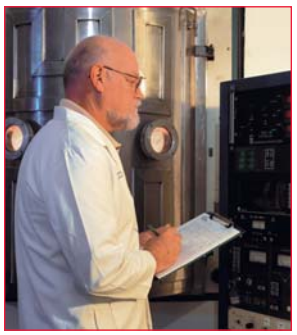
Our in-house machining capabilities allow us to provide a wide range of assembly services, including optical cementing, thin film and surface mounting, thin film bonding, soldering and wiring.



Coating & Microlithography

Our patented optical coating technology combines optical thin film deposition techniques with microlithographic procedures to provide a variety of precise, cost-effective, optical thin film coatings. This high-precision patterning can be applied to whatever filtering configuration the customer requests, and provides color filtering, spatial resolution, transmission efficiency and durability that's superior to dye-colored gels and other commonly used filtering technologies. All of the coatings listed below can be deposited onto optical substrates using this patented process.

- Dichroic, Dielectric, and Interference (UV to NIR)
- Oxides
- Beamsplitter
- Antireflective
- Fluorides
- High-reflective
- Metals

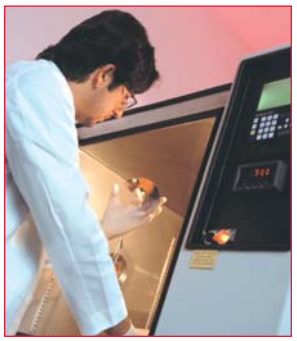


QC Standards

Our standards program adheres to ISO 9001 guidelines and strict quality control procedures. We meet military compliance requirements (MIL-PRF-13830), and adhere to SPC and Total Quality Management document control and manufacturing practices.

QC Testing

We perform optical-surface, spectral, environmental and mechanical testing on all products to ensure the highest quality. Our full-service metrology department has at its disposal equipment such as interferometers, a radius bench, alignment telescopes and spectrophotometers.



Custom Filters & Optics

Our expertise in a wide range of optical applications offers great value to researchers and OEMs seeking a flexible, full-service supplier. We offer applications know-how that few manufacturers can match. Because of our applications knowledge and our high manufacturing standards -- a surface accuracy to 1/20λ and a scratch-to-dig rating of 10:5 -- we can meet most any optical specification. Our custom products can be integrated into many applications, including coated envelopes for the architectural lighting industry, data projection color wheels for consumer electronics markets, CCD camera and spectral imaging filters for scientific instrumentation, and optical components for the telecom industry.

Applications

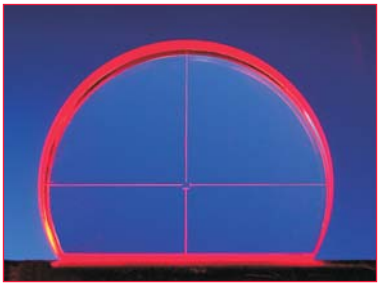
Entertainment/ Lighting	Consumer Electronics	Reticles	Instrumentation	Metrology	Optical Networking
AR coatings for GOBOs	Dielectric coatings for personal digital assistant screens	Binoculars	Bandpass filters for medical fiber optic instruments	Flats for inspecting optics	AR coatings for network components
Broadband antireflection coated filters for entertainment lighting	RGB filters for LCD and projection displays	Bore-sighting devices	Hyper-spectral imaging filters for CCD cameras	Collimation Testers for examining and adjusting the collimation of laser beams	Bandpass filters, gain flatteners and rejection filters for DWDM
Coatings for light envelopes	Patterned GOBOs for projection systems	Fire control	RGB color filters for CCD detectors	Spectroscopic kits for optics inspection	Coatings for MEMS, waveguide relays and switches
Dichroic filters for stage lighting	Color wheels for HDTV, high-def monitors, and rear-projection TVs	Precision optics for E-O systems	Second- and third-order blocking filters for spectroscopy	Reflectance standards, NIST-traceable	Filters for wavelength add/drop couplers
Filters for special effects lighting	UVA-B-C filters in cameras		Spectroscopic kits for optics inspection	Long Trace Profilometer for large flats and aspheres	Tunable filters for transmitters and receivers
Hot and cold mirrors for lighting fixtures			Optics for optical benches in spectrometers		
Large-format still images					

Examples of Custom Products

Variable Saturation Filters

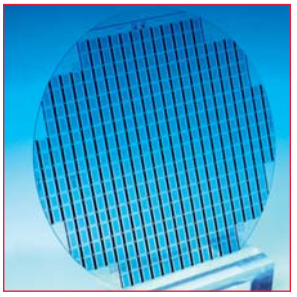
- Available in standard sizes and custom designs
- Excellent optical transmission efficiency for superior brightness
- Temperature and humidity stability for consistent color
- Used in entertainment, display and lighting fixtures

Reticles



- Used for targeting systems, firearm scopes and binoculars
- Etch-and-fill or dielectric-and-metallic patterns
- Superior line and image quality

Patterned MEMs Windows

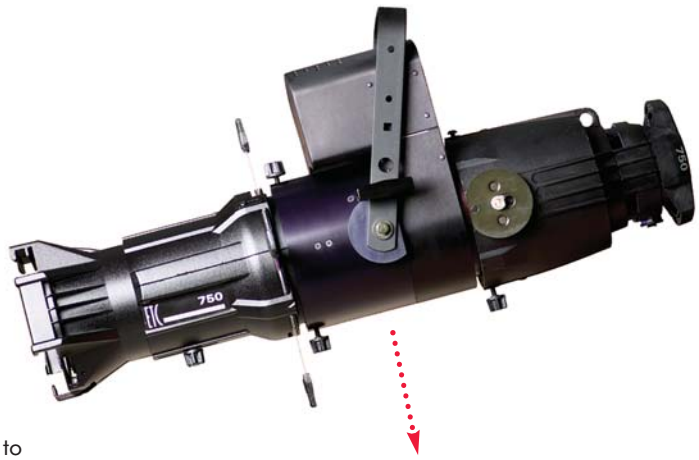


- Patterned MEMs Windows on a variety of custom-sized wafers
- Antireflective coatings available in ranges from 200-2500 nm
- Patterns aligned with great precision on both surfaces of the wafer

SeaChanger Color Engine

Dichroic Color Changer with Unmatched Color, Brightness and Versatility

The SeaChanger Color Engine is a dynamic new CYM color changer for ETC Source Four Ellipsoidals. SeaChanger uses Ocean Optics' patented dichroic filter technology to create a virtually endless palette of stable, reproducible colors that do not shift or fade with time or temperature. SeaChanger is a self-contained unit with an internal power supply and 6-channel DMX control. The unit installs within seconds -- without tools.

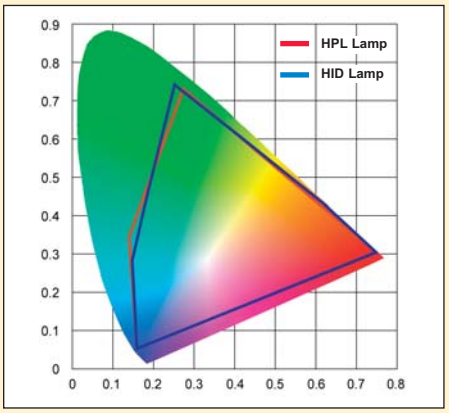


The SeaChanger (left) fits between the lamp and the lens module of the ETC Source Four ERS (above). The SeaChanger's bayonet mount secures it to the Source Four.

Advantages of Dichroic Color Filters

Ocean Optics' patented optical coatings production method combines optical thin film deposition techniques with microlithographic procedures. This process allows us to create micron-scale precision patterning of dichroic coatings on a single substrate -- such as a monolithic colored filter for stage lighting -- with spatial resolution, transmission efficiency and filter durability that's superior to dye-colored gels and other technologies. Our patented processes yield the most robust and highest transmission dichroics available -- filters so hardened they are essentially ceramic in nature. These properties offer great resistance to heat and humidity, eliminating the need for noisy cooling fans in the SeaChanger. Our dichroic patterned filters allow you to control color, intensity and saturation to unprecedented levels of precision.

The SeaChanger Color Gamut



Millions of Color Combinations

SeaChanger employs four patterned filters -- cyan, yellow, magenta and a neutral density (dimmer) filter -- in a 7.0" x 11.5" module that weighs less than 12 lb. and is designed to fit the ETC Source Four ERS. Users can configure filters in up to 4 billion combinations to create a nearly infinite variety of colors -- from delicate pastels to deep, saturated primaries. Also available is an optional high-saturation magenta color wheel that, when used in place of the dimmer wheel, generates deeper reds and blues.

Color Matching & Other Capabilities

The SeaChanger is available with a DMX-to-USB converter and will interface to a PC loaded with add-on software that matches the color engine's CYMK combinations to more than 300 Rosco gel filters and other gel book values. For added convenience, SeaChanger also supports the Remote Device Management (RDM) protocol and can be programmed for stand-alone operation.

Pricing & Distribution Options

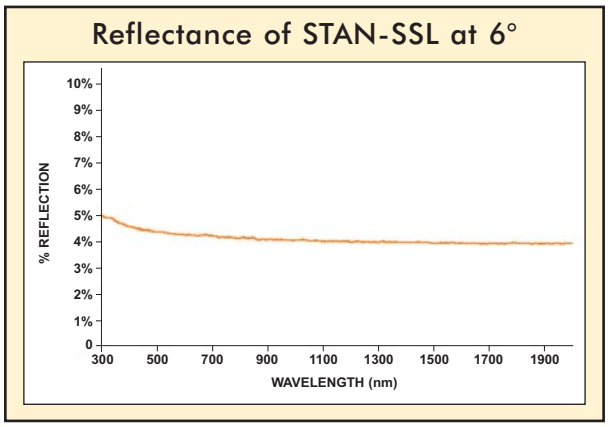
The SeaChanger Color Engine retails for $2,499, and can be ordered with the optional XM Extreme Magenta color wheel at no additional cost. (Spare color wheels are $299.) Distributor and volume pricing are available. For details, please contact us at 727.733.2447.

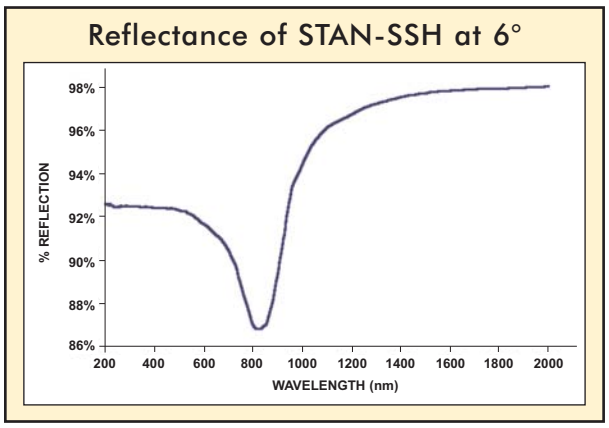
Specifications	
Size/weight:	7.0" x 11.5", 12 lb.
Power input:	Internal 110/220 VAC auto-sensing (auto-switching)
Control:	DMX512 5-pin male and female XLR; RDM also available
Channels:	8-bit DMX addressable via RDM or on-board display Channels 1,2,3: 0-90% saturation CYM color mixing Channel 4: 0-99% dimming Channel 5: 1-30 second wheel speeds Channel 6: Control
Ambient temperature:	40 °C (maximum); 0 °C (minimum)
White light efficiency:	>85%
Beam characteristics:	Preserves all ETC Source Four Ellipsoidal beam characteristics
Color mapping:	Nearly infinite color mapping within a gamut of the CIE triangulated color space
Mounting:	Suspension on Source Four Ellipsoidal yoke from mounting points. Bayonet mount to fixture -- no tools required. Adaptable to Source Four tungsten or HID fixtures.
Maintenance:	Easy-out color engine removal for cleaning; safety cable ring

Source Four is a registered trademark of Electronic Theatre Controls, Inc. (ETC). Neither Ocean Optics nor the SeaChanger Color Engine is affiliated with ETC.

Specular Reflectance Standards

With the STAN-SSH High-reflectivity Specular Reflectance Standard (above), you receive a certificate of calibration in paper and electronic formats.





Versatile & Long-life

We offer three specular reflectance standards for use as references when measuring the reflection of surfaces with high or low specular reflectivity. Each standard consists of a 31.7-mm outer diameter optical reflectance material in a protective aluminum housing with screw-on top. The superior coatings on the substrates are environmentally stable; they are able to withstand high temperatures and mechanical stresses.

Software Referencing & Calibration

Reflectivity values for the standards are built into our software to provide a reference for any specular measurement. You simply choose the standard from a software menu and the software reads data from the electronic file shipped with the standard.

For High Reflectivity

The STAN-SSH High-reflectivity Specular Reflectance Standard is a fused-silica substrate coated with aluminum and protected by a thin layer of magnesium fluoride. It is designed as a standard reference when measuring the high-reflectance surfaces of optical substrates, optical coatings, machined metals and semiconductor materials. Values for the STAN-SSH are calculated for any angle from 0-45°.

For Calibrated High Reflectivity

Also available is a calibrated version of the STAN-SSH. The STAN-SSH-NIST is calibrated at a 6° angle traceable to NIST and is accurate to ±0.1% from 250-2500 nm. The STAN-SSH-NIST comes with calibrated reflectivity values (from a 6° angle) in both paper and electronic formats.

For Low Reflectivity

The STAN-SSL Low-reflectivity Specular Reflectance Standard is a black glass standard that can be used as a reference when measuring the low-reflectance surfaces of samples such as thin film coatings, anti-reflective coatings, blocking filters and substrates.

Recalibration

We recommend a periodic recalibration of the STAN-SSH-NIST, which costs $149. Should the calibrated surface become corrupted, a recoat and calibration service is available ($299).

STAN-SSH:	$499
STAN-SSH-NIST:	$999
STAN-SSL:	$499

Specifications

	STAN-SSH	STAN-SSH-NIST	STAN-SSL
Substrate dimensions:	31.75 mm OD x 6.35 mm height	31.75 mm OD x 6.35 mm height	31.75 mm OD x 6.35 mm height
Housing dimensions:	38 mm OD x 19 mm height	38 mm OD x 19 mm height	38 mm OD x 19 mm height
Weight:	40 g	40 g	40 g
Reflectance material:	Front-surface protected aluminum mirror on fused silica substrate	Front-surface protected aluminum mirror on fused silica substrate	Schott ND9 glass
Reflectivity:	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~87-93% (200-1000 nm) ~93-98% (1000-2500 nm)	~5% (200-950 nm) ~4% (950-2500 nm)

Shear-plate Collimation Testers

Versatile
Use Shear-plate Collimation Testers to examine the collimation of laser light, and as tools for measuring the wavefront curvature and divergence/convergence magnitude of optical components such as large-radius optics. Each tester consists of a wedged, high-quality optical flat housed in a heavy-duty anodized aluminum frame.

Various Aperture Sizes
Each tester is available in apertures ranging from 10 mm to 200 mm in diameter, and is useable from 350-2500 nm.

Easy Operation
The testers are remarkably easy to use: When a planar wavefront is incident at an angle of 45°, two reflected wavefronts result. The lateral separation of these wavefronts is referred to as shear. Fringes -- parallel patterns of light and dark areas -- will be seen in the overlapping region of the two images. Collimating the laser beam is a matter of adjusting the collimating system until the fringe pattern is parallel to the shadow of the collimation tester's reference wire.

The photo above is a close up of the front of a collimation tester.

Collimation Testers

Item Code	Aperture Size	Price
CT-10	10 mm	$600
CT-20	20 mm	$700
CT-50	50 mm	$800
CT-75	75 mm	$950
CT-100	100 mm	$1,200
CT-125	125 mm	$1,700
CT-150	150 mm	$2,800
CT-200	200 mm	$4,800

Optical Flats

Applications Flexibility
Each Optical Flat is a finely polished optical reference surface that can be used to visually inspect the flatness of optical components such as mirrors, filters, prisms and windows.

Extensive Selection
We offer single-sided optical flats in either fused silica or Zerodur, each of which can be enhanced with an aluminum coating to increase contrast and improve the visual reference. There are nearly 50 different flats available, ranging from 1" to 6" in diameter and with flatness accuracies as precise as 1/20 wave. For a complete list of prices and specifications, see page 112.

How Flats Work
When a flat is placed in contact with a test surface and illuminated with monochromatic light, an interference pattern of light and dark bands is formed. The shape of this pattern is an accurate visual representation of the flatness of the test surface. A curved interference pattern indicates that the flatness of the test surface is less than that of the reference surface. Evenly spaced interference patterns indicate that the flatness of the test surface is equal to or higher than that of the reference surface.

Absorbing Glass Filters

Schott Standard Filters

Colored Glass					ND Filters
BG 3	BG 40	GG 420	OG 570	UG 11	D0.15
BG 4	BG 42	KG 1	OG 590	VG 3	D0.3
BG 7	FG 3	KG 2	RG 6	VG 4	D0.6
BG 12	FG 4	KG 3	RG 9	VG 6	D1.0
BG 13	FG 10	KG 4	RG 610	VG 9	D1.3
BG 14	FG 12	KG 5	RG 630	VG 9	D1.6
BG 18	FG 13	NG 1	RG 645	VG 10	D2.0
BG 20	FG 16	NG 3	RG 665	WG 225	D2.3
BG 23	FG 17	NG 4	RG 695	WG 280	D2.6
BG 24 A	GG 375	NG 5	RG 715	WG 295	D3.0
BG 25	GG 385	NG 9	RG 725	WG 305	D3.3
BG 26	GG 395	NG 10	RG 780	WG 320	D3.6
BG 28	GG 400	NG 11	RG 830	WG 335	D4.0
BG 34	GG 435	NG 12	RG 850	WG 345	D4.3
BG 36	GG 455	OG 515	RG 1000	WG 360	D4.6
BG 38	GG 475	OG 530	UG 1		D5.0
BG 39	GG 495	OG 550	UG 5		

Please check with us on filter availability.

High-pass Filters

OF2-WG305	pass >305 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG375	pass >375 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG395	pass >395 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-GG475	pass >475 nm	square 50.8 x 50.8 x 3 mm or	$50
		square 25.4 x 25.4 x 3 mm	
OF2-OG515	pass >515 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-OG550	pass >550 nm	square 25.4 x 25.4 x 3 mm	$50

Balancing Filters

OF2-FG3	enhance blue and red	square 25.4 x 25.4 x 3 mm	$50
OF2-BG34	enhance blue and red	square 25.4 x 25.4 x 3 mm	$50
OF2-BG34R	enhance blue and red	round 12.7 mm OD	$50

Bandpass Filters

OF2-KG3	>325 nm and <700 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-U360	>340 nm and <380 nm	square 25.4 x 25.4 x 3 mm	$50
OF2-RG780	>780 nm and 50% transmission <2.7 µm	square 25.4 x 25.4 x 3 mm	$50

Filter Kit for use with LS-1 Light Source

OF2-LS	BG34, GG395, OG550, Teflon diffusers	$100

Schott Glass Filters

Schott glass filters absorb light energy in certain regions of the spectrum. These filters fit easily into our light sources, cuvette holders and in-line filter holders. Please check for availability.

High-pass Filters

High-pass Filters are transmissive approximately 50% at the nominal cutoff wavelength, >99% at wavelengths 50 nm higher than the cutoff, and less than 0.1% at 50 nm lower than the cutoff. High-pass filters are used to eliminate second- and third-order effects, test for stray light, and block excitation energy in fluorescence experiments.

Balancing Filters

Balancing Filters absorb energy in some regions while transmitting in others. The BG 34 filter, for example, reduces the light's intensity at 600 nm from a tungsten bulb while transmitting all of the light at the blue and red regions, where detector sensitivity in our spectrometers is lower.

Bandpass Filters

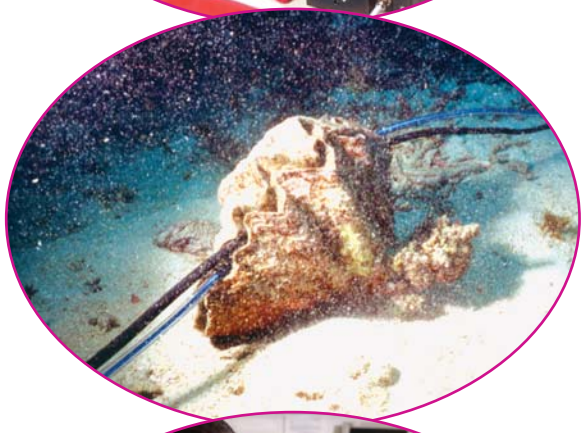
Bandpass Filters pass energy in a certain region and block energy above and below that region.

OF2, OF1 & Inline-OF Filters

We offer OF2 Filters (see top photo) for installing into the optical path of the spectrometer setup. We also offer OF1 Filters (see top photo in the column below) that are installed permanently in the SMA 905 Connector of the spectrometer. The OF1 filters are limited to the filters listed on page 43 and come in 4.75 mm diameter and 2 mm thickness.

In addition, our INLINE-FH Filter Holder (middle left) and FH-SMA Filter Holder (bottom left) also hold the filters listed in these tables, and are cut to 8 mm diameter and from 1 mm to 7 mm thick to fit these fixtures. Filters used in the INLINE-FH and FH-SMA Filter Holders are $100 each. See page 96 for details.

Resources



Overview: Resources

Our Know-how = More Resources for You

Find out more about our products, experience and support through the following:

Live Demonstrations
Each year we exhibit at nearly 50 trade shows around the world (OceanOptics.com/TradeShows.asp). At home, we conduct formal seminars and can customize training sessions to your requirements.

Science Curricula
Our *Educational Spectroscopy Grant Program* rewards educators and researchers for their use of spectroscopy in curricula or research. Information about grant-winning projects is posted at OceanOptics.com/Applications/GrantWinners.asp.

R&D Services
Our Applications Group will take ownership of your most challenging application needs. The Group provides optical and electronic design services, software engineering and spectral modeling, testing and validation, and rapid prototyping capabilities.

Reference Library
We have amassed nearly 300 technical papers featuring our spectrometers and accessories. Citations are on our website at OceanOptics.com/Applications.asp.

American Standard Robotics in St. Petersburg, Fla., prepares one of their VGTV-Xtreme Reconnaissance Vehicle robots equipped with an Ocean Optics spectrometer to identify the chemical involved in a simulated hazardous-material tanker trailer.

Technical Information on the Web

We believe in easy access to information. That's why we don't hide our prices and that's why we provide easily accessible technical documentation on our website, so that you can view manuals before you buy the instrument. We also include the manufacturer's name and the model number of components that go into our instruments. We want to provide you with all of the information you need not only to make the right purchasing decision, but also to get the best performance out of your Ocean Optics products.

- **OceanOptics.com/Technical.asp.** Choose the TECHNICAL button on our website to view and download information about our products and technology, including manuals and operating instructions, software downloads and system specifications.
- **Operating Instructions.** We provide hundreds of pages of easy-to-access operating instructions and specifications of our products so that you can read before you buy at OceanOptics.com/Technical/OperatingInstructions.asp.
- **Software Downloads.** Easily download the latest operating and application software, device drivers and code, utility programs and microcode at OceanOptics.com/Technical/SoftwareDownloads.asp.
- **Spectrometer System Specifications.** Spectrometer system performance depends on a host of factors, such as the detector, optical bench, grating, entrance aperture size and sampling optics, just to list a few. To help you understand how to configure spectrometer systems, visit OceanOptics.com/Technical/SystemSpecifications.asp.
- **Applications Database.** Choose the APPLICATIONS button from any Ocean Optics webpage to view an up-to-date bibliographic listing of journal and magazine articles that reference our products. Visit OceanOptics.com/Applications/References.asp.

55,000+ Spectrometers, 1,000s of Applications

We've sold over 55,000+ Ocean Optics optical-sensing systems since 1992, which has provided us with a body of applications knowledge that is unmatched in the industry. Our spectrometers are used in applications such as these:

- Air and soil in situ monitoring
- Astronomy
- Biological and chemical warfare agent detection
- Biotechnology
- Blood oximetry
- Cancer detection
- Chemistry
- Color measurement
- Crystal growth
- Display technologies
- Dissolved oxygen
- Elemental analysis
- Endpoint detection
- Exhaust emission analysis
- Flow injection analysis
- Fluorescence of corals
- Food processing
- Forensics
- Gemstone grading
- General R&D
- Headspace monitoring
- Laser characterization
- LED quality control
- Life sciences
- Manufacturing
- Medical research
- Non-destructive testing
- Optical filter transmission
- pH monitoring
- Pharmaceuticals
- Physics/Optics
- Physiological applications
- Plasma monitoring
- Process control
- Radiometry
- Raman spectroscopy
- Reaction kinetics
- Semiconductor processing
- Shelf life of food and beverages
- Stack emissions
- Thin film thickness
- Tissue composition

The ABCs of Absorbance

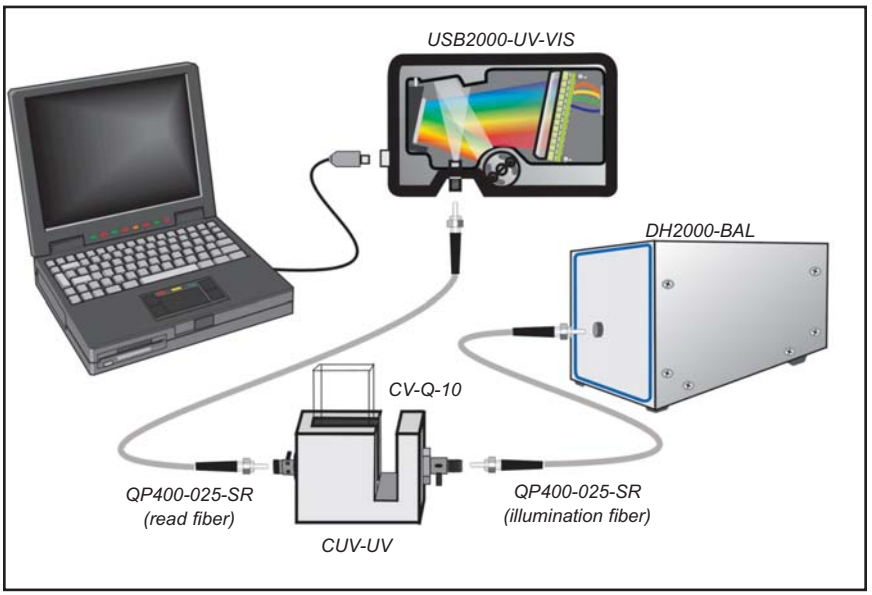
Like thousands of other educators, chemists at Miami (Ohio) University have equipped their labs with Ocean Optics spectrometers and accessories for basic spectroscopic measurements such as solutions absorbance.

Of particular interest is a PC-based setup for measuring the UV-VIS absorption spectrum of iodine crystals from 500-580 nm. This experiment is readily performed using an S2000 Spectrometer, LS-1 Tungsten Halogen Light Source, fiber optic patch cords and a 10-cm pathlength cuvette holder. Substitute a USB2000 Spectrometer (see drawing at right) to eliminate the external A/D card that completes the Miami University system.

Another option is the CHEMUSB2-UV-VIS Lab Spectrophotometer, which consists of a 200-850 nm USB-interface spectrometer, a combination deuterium tungsten halogen light source and 1-cm cuvette holder, high-speed electronics and software.

Solutions absorbance experiments are not limited to cuvette holder setups. Flow cells, on-line dip probes and other sampling optics are available, with the latter especially useful for in situ applications. For example, one Ocean Optics customer uses a UV-VIS spectrometer and dip probe to measure the absorbance of vanadium oxytrichloride (VOCl3), a potentially toxic liquid used in the production of rubber (the absorptivity of VOCl3 relates to its stability). Because the VOCl3 reacts with moisture in the air and forms vanadic and hydrochloric acids, it must be measured in a moisture-free environment. In situ measurements eliminate the need for potentially risky sample collection.

Setup: Solutions Absorbance



Overview

Absorbance measurements are used to quantify the concentration of gases and solutions (the latter is described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample (see Beer's Law, page 178).

Spectrometer

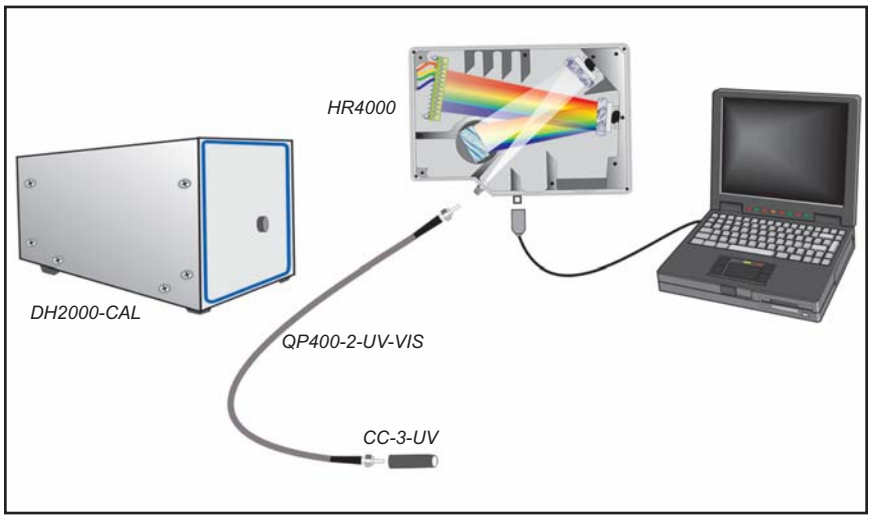
The USB2000-UV-VIS Spectrometer is ideal for absorbance measurements from 200-850 nm. The spectrometer is configured with Grating #1, which has peak efficiency at 300 nm. This configuration provides adequate resolution (~1.5 nm FWHM) for most solutions absorbance measurements. The built-in OFLV-200-850 Order-sorting Filter eliminates second-and third-order effects that otherwise yield false peaks in absorbance spectra. The preferred light source is the DH2000-BAL Deuterium Tungsten Halogen Light Source. The DH2000 is a less expensive source, but lacks the filtering technology that eliminates problems associated with the D-alpha line in the deuterium source.

Sampling Optics

For absolute absorbance measurements, use the 1-cm pathlength CUV-UV Cuvette Holder and the CV-Q-10 Quartz Cuvette. For relative absorbance, direct-attach USB accessories, dip probes and flow cells are available. We recommend QP400-025-SR Premium-grade Solarization-resistant Optical Fibers as illumination and read fibers. Use NIST-traceable STAN-ABS Photometric Absorbance Standards to provide certifiable results.

Components	Page	Price
1. USB2000-UV-VIS General Lab Spectrometer	34	$2,649
Grating #1, 200-850 nm range	44	included
25 µm Slit as entrance aperture	42	included
OFLV-200-850 Order-sorting Filter	43	included
UV2 Detector Upgrade	43	included
2. DH2000-BAL Deuterium Tungsten Halogen Light Source	120	$3,303
3. (2) QP400-025-SR Premium-grade SR Assemblies	140	$238
4. CUV-UV Cuvette Holder	90	$399
5. CV-Q-10 Quartz Cuvette	93	$75
6. STAN-ABS-UV Photometric Absorbance Standards	93	$335
7. SpectraSuite Spectroscopy Platform Software	76	$199
8. ASP Annual Service Package	193	$250
	Total:	**$7,448**

Setup: Upwelling/Downwelling



Overview

Upwelling radiation is radiation -- either reflected solar or emitted terrestrial -- that is directed upward from the earth's surface. Downwelling radiation is radiation that is directed toward the earth's surface from the sun or atmosphere. The relationship between the two (albedo) can be used to derive spectral information from vegetation, forest canopies, seabeds and more.

Spectrometer

An HR4000 Spectrometer with an HC-1 grating provides an elegant solution for upwelling and downwelling measurements. The HC-1 is a variable-blazed grating that covers the 200-1100 nm wavelength range; optical resolution is ~1.5 nm (FWHM) with a 50 µm slit as the entrance aperture. An OFLV-H4 Order-sorting Filter eliminates second- and third-order effects.

Sampling Optics

The spectrometer connects to a patch cord that screws into the CC-3-UV Cosine Corrector. The CC-3-UV can be used as part of a configuration for measuring absolute spectral irradiance. You'll need a DH2000-CAL (or LS-1-CAL for 300-1050 nm only) to calibrate the absolute spectral response of the system and OOIIrrad-C Software to calculate spectral intensity and photopic data in lumens, lux or candela. An alternative to the CC-3-UV is a Gershun tube, which has fixtures for adjusting the area of light from 1° to 28° and attaches directly to the spectrometer or to an optical fiber.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	46	$3,999
Grating HC-1, 200-1100 nm range	52	$600
50 µm Slit as entrance aperture	50	$150
OFLV-H4 Order-sorting Filter	51	$250
UV4 Detector Upgrade	51	$150
2. QP400-2-UV-VIS Premium-grade Patch Cord Assembly	140	$170
3. CC-3-UV Cosine Corrector	144	$129
4. DH2000-CAL Radiometric Calibration Standard	130	$3,148
5. OOIIrrad-C Software (for absolute irradiance measurements)	81	$399
6. SpectraSuite Spectroscopy Platform Software	76	$199
7. ASP Annual Service Package	193	$250
	Total:	**$9,444**

Measuring Mining Effects

In the small Pacific island of New Caledonia, a multinational team of researchers has used Ocean Optics spectrometers to measure the effects of strip mining on coastal erosion, sea grass growth and coral reef health.

The team focused on the relationship between above-water reflectance and turbidity profiles. The latter relates to fluxes in the presence of metals and various pollutants -- and thus, to sea grass growth and coral reef health.

A USB2000 Spectrometer set from 360-1100 nm measures reflectance and irradiance. The USB2000 connects to a patch cord that screws into a Gershun Tube, which has fixtures for adjusting the area of light entering the fiber -- in this case, to reduce the field of view to 3°. Upwelling irradiance and downwelling radiance measurements -- the spectral distribution of the underwater light field -- add valuable data.

The researchers also have measured the concentration of chlorophyll pigment in coastal waters and the reflectance of sand and mud collected at Caribbean, Mediterranean and Pacific beaches. The sand application used a dual-channel spectrometer for visible (410-900 nm) reflectance measurements of various natural sands. Reflectance spectra were deduced from successive measurements of upwelling irradiance using a Spectralon plate and downwelling radiance captured under natural light.

Ultimately, researchers will use satellite monitoring, spectroradiometric measurements and numerical models to better understand the nature of particulate transport in coral reef lagoons, especially as it relates to erosion rates in coastal areas.

O_2 Medical Diagnostics

Researchers at two Irish universities have monitored dissolved oxygen in cellular media in order to validate the optimum gassing technique to induce hypoxia in irradiated cells.

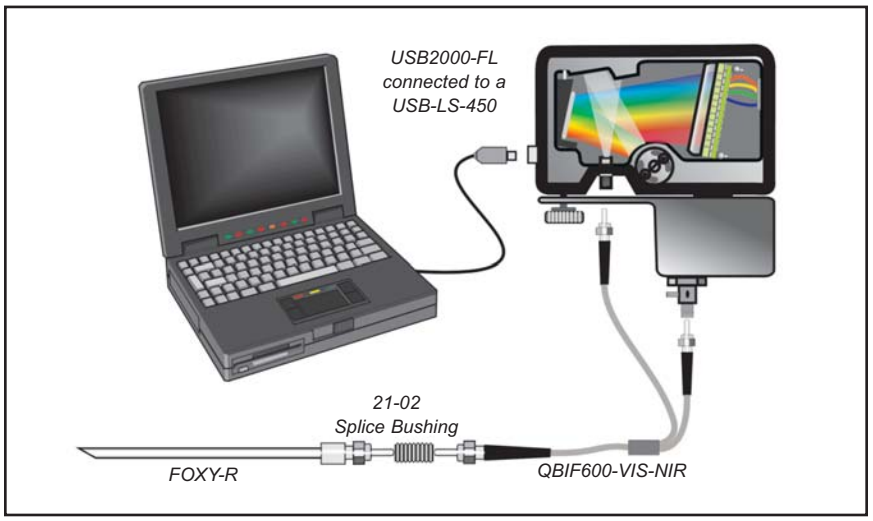
Scientists from University College Cork and Cork University Hospital measured irradiated HeLa cells -- a strain of human cells used for biological studies -- under both oxic (rich in oxygen) and hypoxic (lacking oxygen) conditions. With oxygen present, the irradiation injury to the cells was greater than when optimum levels of

hypoxia (~90%) were reached. To induce hypoxia, and thus mitigate any oxygen-enhancement injury, the cells were gassed with nitrogen. This hypoxia was confirmed with a FOXY Fiber Optic Oxygen Sensor and a USB2000 Spectrometer.

The FOXY Sensor has been used for other hypoxia experiments, including an application where clinicians determine how much of a diseased human limb targeted for amputation can be saved; the presence of oxygen correlates to tissue health. Monitoring dissolved oxygen in both human and animal tissue is a common application for the FOXY Sensor, which offers the advantages of being minimally invasive, not consuming the sample, and working well in viscous media.

Ultimately, the cellular hypoxia researchers determined that oxygen measurements of the cellular environment made with the FOXY Sensor matched the predicted hypoxic saturation values, depending on the amount and duration of nitrogen flushed through the sample chamber. The FOXY Sensor proved to be a valuable tool in confirming the desired level of hypoxia.

Setup: Oxygen Sensing



Overview

Oxygen is sensed by measuring the decrease in fluorescence intensity of a fluorophore bound to the tip of an optical fiber. The sensor responds to the partial pressure of oxygen in gases, liquids and even viscous samples.

Spectrometer

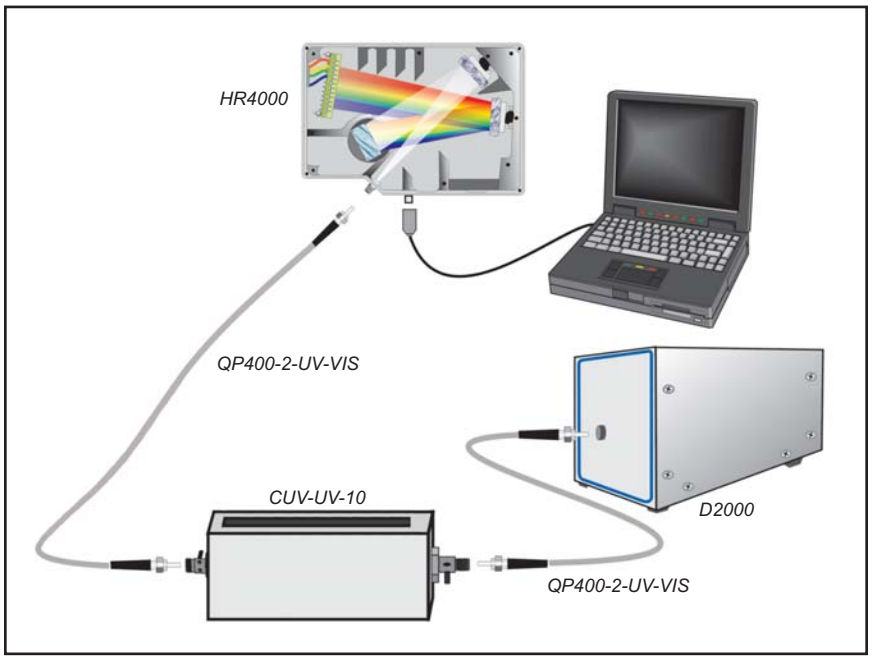
Our oxygen-sensing systems include ruthenium-coated probes that use fluorescence quenching to measure the partial pressure of dissolved or gaseous oxygen. For the "typical" oxygen-sensing system we recommend the USB2000-FL-450 Fluorescence Spectrometer, which has a 200 μm Slit and Grating #3 (360-1000 nm), which is blazed at 500 nm. Also included in the optical bench is an L2 Detector Collection Lens to increase light-collection efficiency and reduce stray light.

Sampling Optics

The USB-LS-450 Pulsed Blue LED Excitation Source transmits light at ~475 nm to one leg of a QBIF600-VIS-NIR Bifurcated Optical Fiber Assembly. The bifurcated assembly connects to the oxygen sensor probe -- there are over 12 probes from which to select -- via a 21-02 SMA Splice Bushing. If the excited ruthenium at the probe tip encounters an oxygen molecule, the fluorescence signal decreases. The fluorescence is collected by the probe and is transmitted to the spectrometer via the other leg of the bifurcated assembly. OOISensors Software calculates partial pressure of the oxygen from this signal. For more on sensor operation, see page 65.

Components	Page	Price
1. USB2000-FL-450 Fluorescence Spectrometer (and light source)	33	$3,049
Grating #3, 360-1000 nm range	45	included
200 μm Slit as entrance aperture	42	included
L2 Detector Collection Lens	43	included
2. USB-LS-450 Pulsed Blue LED Excitation Source	129	included
3. QBIF600-VIS-NIR Premium-grade Bifurcated Fiber Assembly	140	$370
4. 21-02 Splice Bushing	156	$13
5. FOXY-R Fiber Optic Oxygen Sensor Probe	66	$499
6. OOISensors Software	81	$199
7. ASP Annual Service Package	193	$250
	Total:	**$4,380**

Setup: Gas Absorbance



Overview

Absorbance measurements are used to quantify the concentration of solutions and gases (as described here) that absorb light in a media that transmits light. The signal in absorbance units is proportional to the molar absorptivity, pathlength and concentration of the sample. (See more on Beer's Law on page 178.)

Spectrometer

A setup for measuring benzene gas, for example, would call for an HR4000 High-resolution Spectrometer with an H7 grating and a 200-300 nm wavelength range. Optical bench accessories include an L4 Detector Collection Lens for increased light throughput, and a UV4 Detector Upgrade to transmit light in the UV. With a 5 μm slit, optical resolution of ~0.07 nm (FWHM) is possible. The preferred light source for work in the ultraviolet is the D2000 Deuterium Light Source.

Sampling Optics

The 10-cm pathlength CUV-UV-10 Cuvette Holder, the CV-Q-10 Cylindrical Cell and QP400-025-SR Premium-grade Solarization-resistant Optical Fibers (one fiber illuminates, the other reads signal) comprise the system's sampling optics. For applications requiring shorter pathlengths or open-air monitoring (see sidebar), use an optical fibers-and-collimating lenses configuration.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	46	$3,999
Grating H7, 2400 lines per mm, 200-300 nm range	52	included
5 μm Slit as entrance aperture	50	$150
L4 Detector Collection Lens	51	$150
UV4 Detector Upgrade	51	$150
2. D2000 Deuterium Light Source	124	$2,003
3. CUV-UV-10 Cuvette Holder	90	$549
4. CV-Q-100 Cylindrical Cell	93	$165
5. (2) QP400-2-UV-VIS Premium-grade Patch Cord Assemblies	140	$340
6. SpectraSuite Spectroscopy Platform Software	76	$199
7. ASP Annual Service Package	193	$250
	Total:	**$7,955**

Volcano Emissions

Active volcanoes emit various gases including sulphur dioxide (SO_2), a colorless, pungent gas that can irritate the skin and the mucous membranes of the eyes, nose and throat. Volcanologists regularly monitor SO_2, which absorbs in the UV.

For example, on the Caribbean island of Montserrat, researchers use three S2000 Spectrometers to collect UV absorbance (from 245-380 nm) of SO_2 in gas emissions. The spectrometers are set up at three plume sites, each of which is about 3.5 km from the volcano's dome. The spectrometers are small, making them simple to transport and deploy at the volcano site. The entire setup costs less than $10,000, within most budget limits and almost "disposable" (this is a volcano, after all).

The Montserrat researchers configured a system that makes efficient use of light-collection optics and provides good optical resolution (~3.5 nm FWHM). Each spectrometer is connected to a 1000 μm optical fiber, which screws into a telescope mount.

At the Montserrat Volcano Observatory (www.mvo.ms) sampling sites, spectra are collected every 4-6 seconds and transmitted to researchers at the observatory via modem; one complete scan of the plume takes 4-6 minutes. Depending on wind direction, data from two of the three spectrometers is used to calculate plume height, by comparing the angles at which peaks in the SO_2 plume are measured.

All That Glitters . . .

By some accounts, fluorescence of minerals has been observed for more than a century. For early miners, fluorescence of minerals such as calcite helped to target drilling operations to the richest bodies of ore. For amateur geologists, mineral fluorescence is a more esoteric pursuit: samples that fluoresce simply look really cool.

Consider genthelvite, an opaque mineral that fluoresces bright green under UV radiation and remains phosphorescent for a short period. In 2003, mineralogists Earl Verbeek and Herb Yeates measured fluorescence of both genthelvite and willemite (another fluorescent mineral) found in deposits at a site in New Jersey.

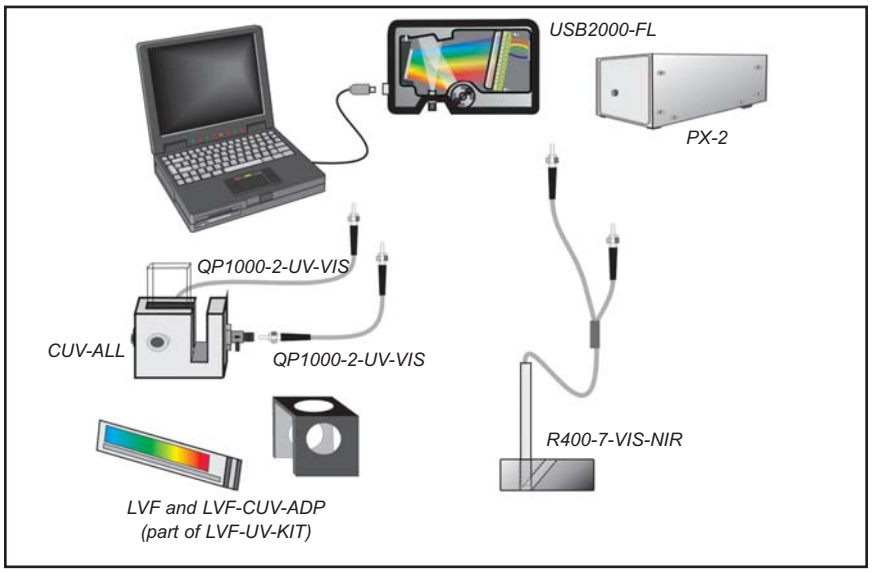
In a paper submitted to the Franklin-Ogdensburg Mineralogical Society, Verbeek and Yeates described using a USB2000-VIS-NIR Spectrometer (350-1000 nm), a high-power UV excitation source and a 600 μm probe to observe emission peaks of 511 nm for genthelvite and 528 nm for willemite.

Spectrometer integration times were set for 1000 ms to measure the dim (although visible to the naked eye) genthelvite fluorescence, compared with a 10 ms integration to measure the brighter willemite fluorescence.

To ensure that the light emitted from the samples came from the minerals themselves, Verbeek and Yeates measured the samples in a light-tight enclosure and filtered out excitation source wavelengths and ambient light.

Why does genthelvite fluoresce? Verbeek and Yeates identified the cause as divalent manganese -- a substitute for zinc in the genthelvite structure that is also responsible for the color in amethyst.

Setup: Fluorescence



Overview

Fluorescence measurements require a sensitive detector and an effective filter for discriminating between powerful excitation source wavelengths and weak spectral emissions from the sample.

Spectrometer

We offer several spectrometers useful for fluorescence, but recommend the high-sensitivity, preconfigured USB2000-FL Spectrometer for most general fluorescence applications. The USB2000-FL is set to 360-1000 nm and comes with a 200-μm slit and an L2 Detector Collection Lens for increased light throughput.

Sampling Optics

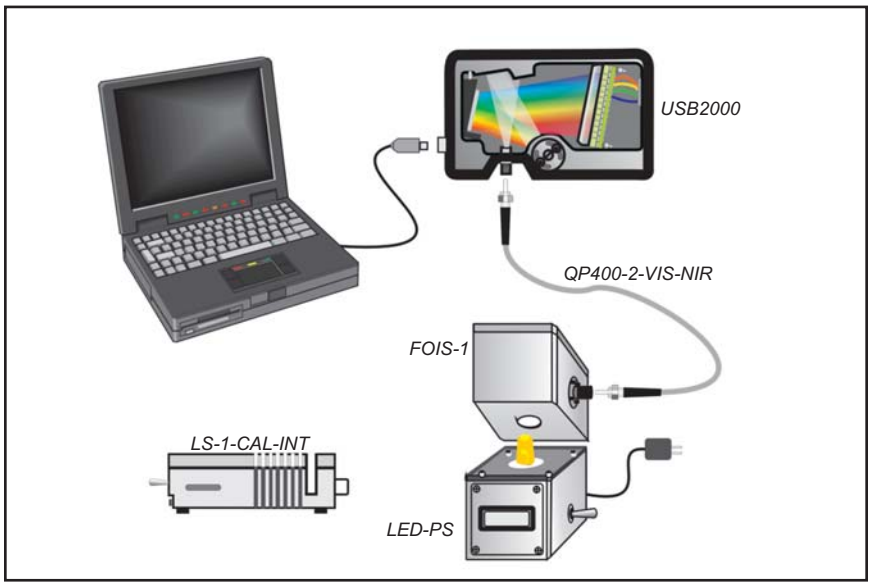
Your standard excitation source option is our PX-2 Pulsed Xenon Source. Our proprietary LVF Linear Variable Filters are excellent tools for spectrally shaping the excitation energy from broadband sources used for fluorescence. Various sampling optics are available for detecting picomolar-range concentrations of fluorophores from surfaces and in solutions and powders.

Spectrometer Components	Page	Price
1. USB2000-FL Spectrofluorometer	33	$2,499
Grating #3, 380-1000 nm range	44	included
200 μm Slit as entrance aperture	42	included
L2 Detector Collection Lens	43	included
SAG+UPG Mirrors	44	$250

Components for Use with Solutions	Page	Price
2. PX-2 Pulsed Xenon Source	125	$769
3. CUV-ALL-UV 4-way Cuvette Holder	90	$809
4. LVF-UV-KIT Linear Variable Filter Kit	94	$999
6. (2) QP1000-2-UV-VIS Premium-grade Patch Cord Assemblies	140	$720
7. (2) 74-MSP Mirrored Screw Plugs	90	$198
8. SpectraSuite Spectroscopy Platform Software	76	$199

Components for Use with Solids	Page	Price
2. PX-2 Pulsed Xenon Source	125	$769
3. R400-7-VIS-NIR Reflection/Backscattering Probe	146	$499
4. SpectraSuite Spectroscopy Platform Software	76	$199

Setup: LED Analysis



Overview

To measure the absolute spectral intensity and color of LEDs, specify the configuration described here or see page 16.

Spectrometer

We suggest a USB2000 Spectrometer with a 25 µm Slit and Grating #2 (350-1000 nm). An L2 Detector Collection Lens increases light-collection efficiency and reduces stray light. An OFLV-350-1000 Order-sorting Filter eliminates second- and third-order effects. This optical bench configuration maximizes system sensitivity, mitigating the light loss inherent with use of an integrating sphere -- the sampling optic of choice for most LED applications. (You also can collect LED signal with a CC-3-UV Cosine Corrector and fiber.)

Sampling Optics

The LED is mounted in the NIST-traceable LED-PS-NIST LED Power Supply, which provides a white background for the LED and a controlled drive current to characterize LED output. The FOIS-1 Integrating Sphere is placed over the LED-PS-NIST and collects the LED output. The attached optical fiber collects the light energy from the LED and transmits it to the spectrometer. The power and color of the LED is determined by comparing the LED to a radiant standard -- the LS-1-CAL-INT Calibrated Source, which fits into the sample port of the FOIS-1. OOIIrrad-C Irradiance and Color Software calculates absolute irradiance and spectral features such as dominant, central and centroid wavelength, and colorspace values such as X,Y,Z and L*, a*, b*.

Components	Page	Price
1. USB2000 Plug-and-Play Spectrometer	38	$2,199
Grating #2, 350-1000 nm range	44	included
25 µm Slit as entrance aperture	42	$150
L2 Detector Collection Lens	43	$150
OFLV-350-1000 Order-sorting Filter	43	$150
2. LS-1-CAL-INT Tungsten Halogen Calibrated Light Source	131	$749
3. LED-PS LED Power Supply	107	$499
4. FOIS-1 Integrating Sphere for Emission	108	$499
5. QP400-2-VIS-NIR Premium-grade Patch Cord Assembly	140	$170
6. OOIIrrad-C Irradiance and Color Software	81	$399
7. ASP Annual Service Package	193	$250
	Total:	**$5,215**

QC of LED Curing Lights

High-output LEDs may be a viable alternative to other light sources for curing ceramic materials used in dentistry, according to researchers from the University of Manchester in England.

As researchers Adrian Bennett and David Watts suggested in a 2003 article submitted to the journal *Dental Materials*, LEDs have longer lifetimes, are less prone to degradation and temperature effects, and require less power than tungsten halogen curing units.

To assess LED performance, Bennett and Watts used a radiometrically calibrated USB2000 Spectrometer to measure the absolute spectral output and irradiance of three LED curing units. The spectrometer was radiometrically calibrated using the LS-1-CAL Tungsten Halogen Light Source; a FOIS-1 Integrating Sphere collected the LED output and funneled it to an optical fiber coupled to the spectrometer. The spectral range of the LEDs also was measured.

By most criteria, Bennett and Watts concluded, the LED curing units compared favorably with the tungsten halogen curing units. However, longer curing times may be necessary with LEDs, which have lower irradiance than the tungsten halogen sources.

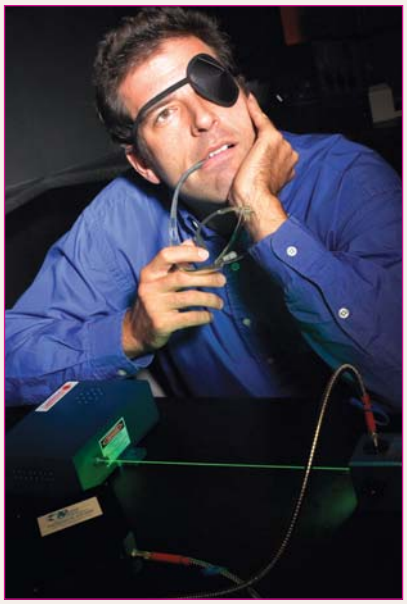
Similar studies also have been performed at the Indiana University School of Dentistry.

Whatever their ultimate application, LEDs can be analyzed for color and absolute spectral intensity very easily and inexpensively with Ocean Optics spectrometers and accessories.

Laser Plume Analysis

Ocean Optics spectrometers and accessories are useful tools for measuring the spectral output and power of lasers, with configurations as simple as the setup shown at right.

But we also provide components for applications involving what happens after the laser fires. Consider laser welding, which is now common to a number of industries. An Ocean Optics customer has used our PC Plug-in Spectrometer and an optical fiber to measure the plume created by a CO_2 laser used in welding metals such as copper and stainless steel alloys. Researchers were particularly interested in the processes related to welding of dissimilar materials.

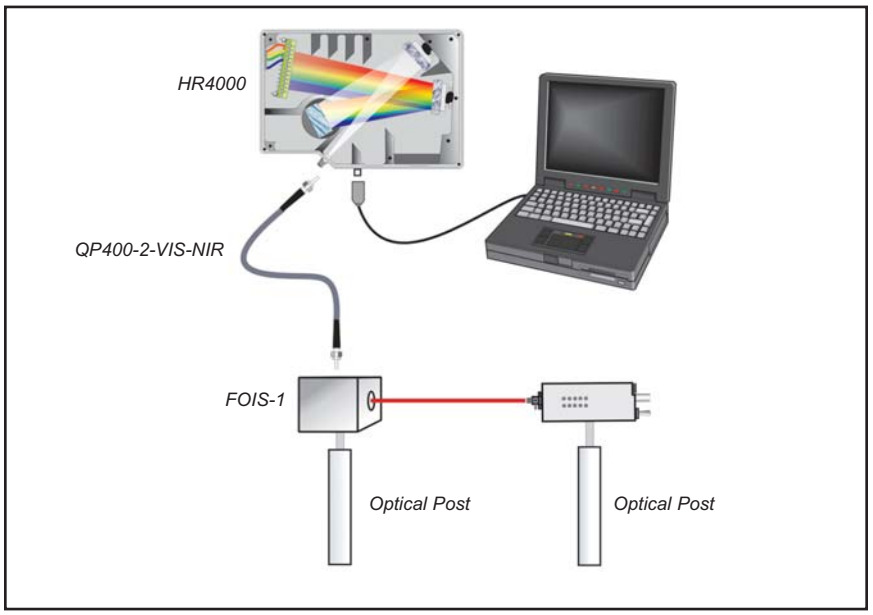


By measuring the concentration of elements within the laser weld plume, as well as the plume temperature, the researchers were able to determine the efficiency of the weld. Species identification is useful in controlling the welding of dissimilar alloys; plume temperature can be correlated to laser power and speed.

The UV-VIS spectrometer used in the study had a wavelength range of 263-523 nm. One leg of a bifurcated optical fiber carried light from a diode laser to the weld site; the other leg sampled the plume emission.

Ultimately, real-time monitoring of the laser weld plume makes it far simpler to correct process problems before large numbers of parts are affected. This increases manufacturing yields and speeds up inspection processes.

Setup: Laser Analysis



Overview

Our HR4000 High-resolution Spectrometer is ideal for measuring the spectral characteristics and intensity of continuous-wave and pulsed lasers. For high-power lasers, an integrating sphere or cosine corrector attenuates the light to avoid saturating the CCD array.

Spectrometer

The HR4000 Spectrometer uses the "HR" Optical Bench, which was designed to yield high optical resolution for resolving fine spectral features. For laser characterization, we recommend a grating with a high groove density, such as the H6 1200 mm-1 grating set to a 750-925 nm wavelength range and with a 5 μm Slit as the entrance aperture. This configuration provides ~0.12 nm resolution (FWHM). For better resolution consider an 1800 mm-1 or 2400 mm-1 grating.

Sampling Optics

There are several possible sampling setups: a CC-3-UV Cosine Corrector with an optical fiber; FOIS-1 Integrating Sphere with a fiber; or fiber assembly coupled to the laser. Optical posts are used to hold fixtures in place.

Measurements

Our operating software can detect the laser wavelength peak; OOIIrrad-C Irradiance and Color Software obtains peak, centroid and central wavelength values, and full-width half-maximum values.

Components	Page	Price
1. HR4000 High-resolution Spectrometer	46	$3,999
Grating #H6, 750-925 nm range	52	included
5 µm Slit as entrance aperture	50	$150
2. FOIS-1 Integrating Sphere for Emission	108	$499
3. OPM-3 Three-inch Optical Post (2)	89	$30
4. QP400-2-VIS-NIR Premium-grade Patch Cord Assembly	140	$170
5. OOIIrrad-C Application Software	81	$399
6. ASP Annual Service Package	193	$250
	Total:	**$5,497**

Setup: LIBS

Overview

The LIBS2000+ Broadband Spectrometer is a detection system for real-time elemental analysis in solids, solutions and gases. This high-resolution system provides full spectral analysis from 200-980 nm, with optical resolution of ~0.1 nm (FWHM), and is particularly useful for elemental identification.

Principle of Operation

An Nd:YAG pulsed laser beam is focused on the sample area. The energy of the laser generates a plasma, in which a trace amount of the sample has been ablated. As the plasma decays or cools, the plasma emits light of wavelengths that are distinct to each element. The emission is collected by a 7-fiber bundle and sent to the spectrometers for analysis.

Spectrometers

The LIBS2000+ uses seven HR2000 High-resolution Spectrometers, each with a 2048-element CCD array. This multiple-spectrometer system connects to a PC via one USB port. All seven spectrometers acquire data simultaneously; software displays the results.

Sampling Optics

The standard laser is a 50 mJ unit from Big Sky Laser, and comes with a power supply. Signal is collected by a fiber bundle comprising (7) 600 µm UV-VIS patch cords, each with a collimating focusing lens built into the fiber termination. The sample chamber has a remote laser safety lock.

Measurements

OOILIBS Software allows users to set operating parameters such as the laser Q-switch delay (the time between the firing of the laser and the beginning of spectral acquisition) and signal averaging of laser pulses.

Components	Page	Price
1. LIBS2000+ Laser-induced Breakdown Spectrometer	20	$30,000
2. LIBS-FIBER-BUN	20	included
3. LIBS-LASER Nd:YAG 50 mJ Laser (from Big Sky Laser)	21	$14,500
4. LIBS-SC Sample Chamber	21	$9,800
5. OOILIBS Software	20	$500
	Total:	**$54,800**

LIBS for Defense

In an earlier LIBS application, closely related spores of the genus *Bacillus* were deposited on silver membrane filters for analysis using broadband Laser-induced Breakdown Spectroscopy (LIBS). The observed spectral differences among the spores -- *Bacillus subtilis*, *Geobacillus stearothermophilus* and *Bacillus pumilus* -- provide evidence of the power of Ocean Optics' LIB2000+ Laser-induced Breakdown Spectrometer in resolving complex biological samples.

The presence of the spores' unique spectral lines, as well as different combinations of spectral lines, provide many opportunities for discrimination. While most of the unique peaks occurred in the *G. stearothermophilus* spectrum, spectral differences were observed in the spectra for all the spores. Spore characteristics such as surface profile and coat mineralization may account for these differences.

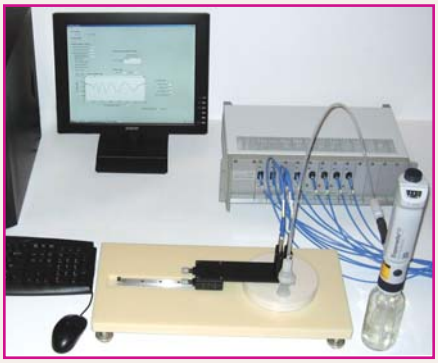
The results reported for the *Bacillus* spores, along with others obtained for biological molecules including nucleic acids and proteins, provide exciting evidence of the discriminating capability of our LIBS2000+. In fact, we are now working with the Army Research Laboratory to develop a man-portable LIBS system for field detection of chemical and biological warfare agents. The system will be able to make a complete analysis every one to two seconds, be small enough to carry in a backpack, and require very little power to operate.

Thin Film Thickness

Product developer Thickness Detection Systems (TDS) of Salt Point, N.Y., has integrated an Ocean Optics multichannel spectrometer into a broadband dissolution rate monitor (DRM) for analyzing very thin resist films used in the semiconductor and optics industries.

DRMs help to determine the thickness of thin film layers and the rate at which the film resist material dissolves -- important parameters in controlling thin film production processes. In its initial testing, Thickness Detection Solutions focused on applications involving films of <300 nm thickness, where existing monochromatic and polychromatic interferometric testing methods have had limited effectiveness.

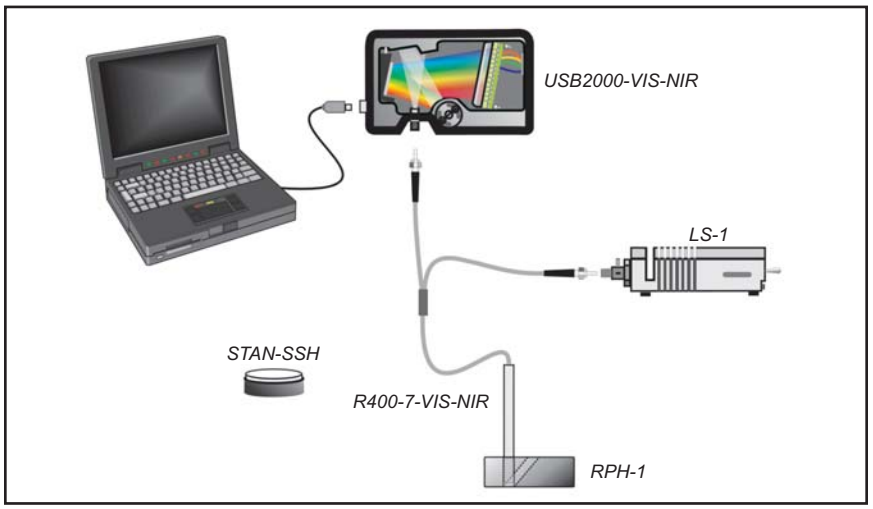
In testing, TDS used an SD2000 Dual-channel Spectrometer. Reflection measurements were performed with an R-series Reflection Probe. As TDS reports on its website, results indicated that multi-wavelength DRMs would be able to determine film thicknesses at discrete time intervals, to monitor photoresist phenomena that are difficult to separate with traditional DRMs, and to provide additional value to the researcher "by eliminating the need for discrete, static optical thickness measurement tools."



Today, TDS offers 1-, 2-, 4- and 8-channel configurations. TDS just recently announced the commercial release of its L-Series DRM product line for photoresist R&D, formulation studies, photoresist manufacturing QC, and polymer resin manufacturing QC.

The L-series line includes multiwavelength and multilayer analysis algorithms, which enable discrete thickness measurements to zero film thickness and provide accurate data of non-linear dissolution rate phenomena. For more details, visit www.thicknessdetection.com.

Setup: Metrology



Overview

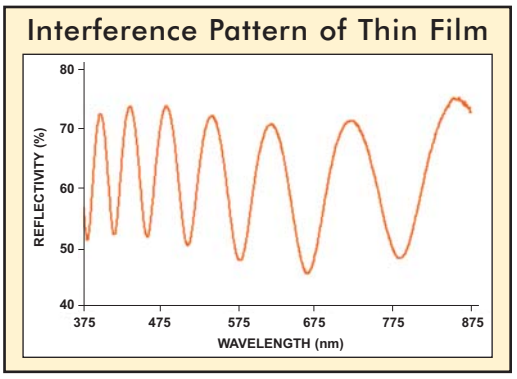
A thin film on a substrate can act as an etalon, creating an interference pattern superimposed on the surface reflectivity when viewed in reflection. The spacing of the pattern's sinusoidal peaks, when combined with the refraction index of the material, can be used to calculate the thickness of the material.

Spectrometer

The USB2000-VIS-NIR (350-1000 nm) is ideal for reflectometry of thin films. The spectrometer is preconfigured with Grating #3, which is blazed at 500 nm; an OFLV-350-1000 Filter to eliminate second- and third-order effects; and a 25 μm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics

The R400-7-VIS/NIR Reflection Probe positioned at 90° measures specular reflectance from surfaces such as thin films. An LS-1 Tungsten Halogen Lamp and a STAN-SSH High-reflectivity Specular Reflectance Standard complete the sampling setup.

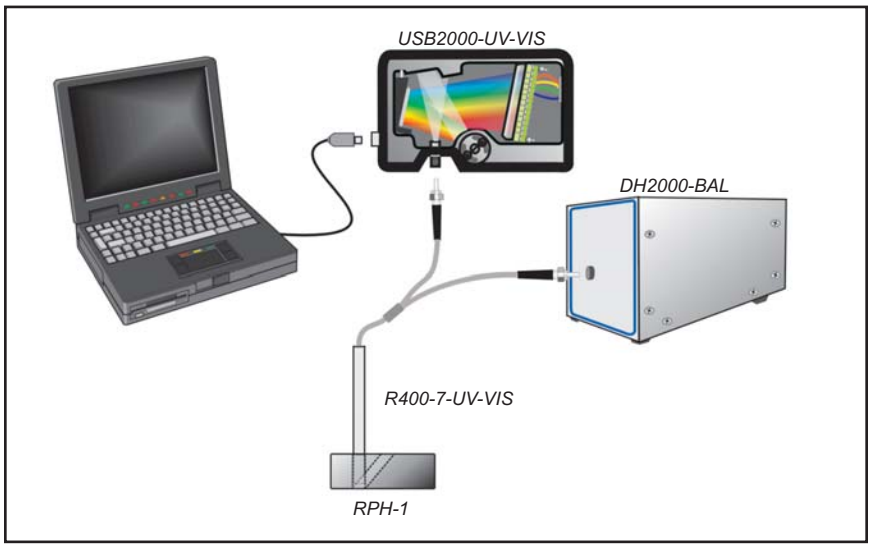


Measurements

Spectra observed in our operating software (see above) reveal oscillations caused by optical interference within the layers of the thin film substrate. Analysis of the wavelength position of the minima or maxima can determine either the thin film's thickness (with the known refractive index of the film) or its refractive index (with the known film thickness). Keep in mind that the thickness of samples may not be uniform; we recommend measuring several locations on the film.

Components	Page	Price
1. USB2000-VIS-NIR General-purpose Spectrometer	34	$2,499
Grating #3, 600 lines per mm, blazed at 500 nm	44	included
25 μm Slit as entrance aperture	42	included
OFLV-350-1000 Order-sorting Filter	43	included
2. LS-1 Tungsten Halogen Light Source	126	$499
3. R400-7-VIS-NIR Reflection/Backscattering Probe	146	$499
4. RPH-1 Reflection Probe Holder	167	$75
5. STAN-SSH High-reflectivity Specular Reflectance Standard	111	$499
	Total:	**$4,071**

Setup: UV-VIS Reflection



Overview

Diffuse reflection measurements can be used to determine information about the chemical content or color (see page 177) of a sample.

Spectrometer

The USB2000-UV-VIS (200-850 nm) is ideal for most UV-VIS reflectometry. The spectrometer is preconfigured with Grating #1, which is efficient in the deep UV; an OFLV-200-850 Order-sorting Filter to eliminate second- and third-order effects; and a 25 µm slit for optical resolution of ~1.5 nm (FWHM).

Sampling Optics

The R400-7-UV-VIS Reflection Probe measures diffuse or specular reflectance from surfaces, or backscattering from translucent materials and fluids. The RPH-1 Probe Holder positions the R400-7 at either 45° for diffuse reflection or 90° for specular reflection. (For reflection measurements with an integrating sphere, see page 109.) For illumination, we recommend the DH2000-BAL Deuterium Tungsten Halogen Light Source. If your application requires portability, use the smaller DT-MINI Deuterium Tungsten Halogen Light Source. (Because the DT-MINI is a low-power source, configure your spectrometer with a 50 µm Slit and an L2 Detector Collection Lens.)

Measurements

Reflectance standards include the WS-1 Diffuse Reflectance Standard (page 110) for diffuse measurements and the STAN-SSH Specular Reflectance Standard (page 111) for specular measurements. Use our software to correct data for deviations from 100% reflectivity of standards, field tiles or NIST-traceable materials.

Components	Page	Price
1. USB2000-UV-VIS General Lab Spectrometer	34	$2,649
Grating #1, 200-850 nm range	44	included
25 µm Slit as entrance aperture	42	included
OFLV-200-850 Order-sorting Filter	43	included
2. DH2000-BAL Deuterium Tungsten Halogen Light Source	120	$3,303
3. R400-7-UV-VIS Reflection Probe	146	$499
4. RPH-1 Reflection Probe Holder	147	$75
5. SpectraSuite Spectroscopy Platform Software	76	$199
6. ASP Annual Service Package	193	$250
	Total:	**$6,975**

Plants and Reflectance

Spectral reflectance measurements of fruits, vegetables and other plants have long been performed using Ocean Optics spectrometers, light sources and fiber optic probes, with applications in the lab and in the field.

For example, researchers at the University of Arkansas at Little Rock have measured spectral reflectance of rice seedlings (pictured) in relation to soil salinity and to the chlorophyll content of individual rice leaves -- two factors related to rice yield. The experiment setup included an S2000 Spectrometer, LS-1 Tungsten Halogen Light Source and R-series Fiber Optic Reflection Probe.

One of our favorite plant applications is a high school science fair-winning project covering similar territory. Then-student Naomi Levine used one of our old S1000 Spectrometers, a tungsten halogen source, and a fiber optic probe to measure the reflection at 90° of philodendron plant leaves. Naomi believed that correlating reflectance to fertilization levels could be useful in detecting over-fertilization in crops.

What Naomi discovered was that plant reflectance at wavelengths >700 nm was insensitive to the stress of over-fertilization (samples were fertilized at 4x the recommended amount), while the peak within the 530-630 nm range was noticeably sensitive to stress (manifest as increased leaf reflection). She concluded that the latter related to a decrease in chlorophyll and to the effects of osmosis. Osmosis caused water to collect between the cell membrane and cell wall and exposed more of the leaf surface, thus increasing reflectance.

As for Naomi, she graduated from Princeton University in 2003.

Nice Asp!

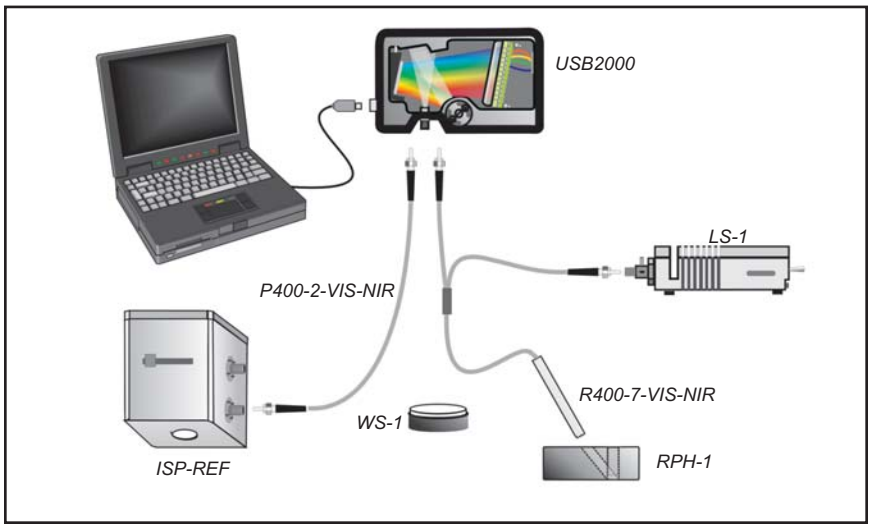
No, it's not an asp, but we couldn't resist. Dr. Ted Rohr -- a wildlife biologist and lecturer at RMIT University in Melbourne, Australia -- is actually holding an Australian Copperhead, which is one of the most venomous snakes in the world.

The Australian Copperhead is a front-fanged snake restricted to the cooler parts of Southeastern Australia. It preys on frogs, lizards, snakes and small mammals.

Rohr is studying the capacity of these snakes to undergo rapid color change -- from several shades of brown or green to black -- on the dorsal surface. Using a USB2000 Spectrometer and a fiber optic probe with a custom shield on its end (the shield helps to maintain a fixed distance to the sample point of interest), Rohr measured the reflectance of individual snake scales, both in the field and in the laboratory.

According to Rohr, the snake's ability to change body color makes sense in a cool-temperate environment, where thermal conditions can change many times during the season and even throughout the day. Changing colors is a perfect mechanism for adapting to fluctuations in temperature. However, body coloration is also important for camouflage. Being black may be great in order to absorb solar radiation, but it makes the snake more obvious to birds of prey -- and wary researchers!

Setup: Reflected Color



Overview

Color measurement involves determining the reflection spectrum of a sample and applying it to a standard illuminant. The amount of light energy the sample reflects is manipulated and reduced to tristimulus values X, Y and Z. These values correspond to the physiological response of the three types of color receptors in the human eye. X, Y and Z values are combined into uniform colorspace values such as L*, a* and b*.

Spectrometer

A USB2000 with a 25 µm Slit and Grating #2 (350-1000 nm) works well for color analysis. For those using an integrating sphere as the sampling optic, we recommend an L2 Detector Collection Lens to improve sensitivity.

Sampling Optics

When taking reflective-color measurements, your data depends on sampling geometry. The R400-7-VIS-NIR Reflection Probe provides illumination and detection from the same direction. If you use the probe at a 45°, it measures diffuse reflection. If you use the probe at a 90°, it measures specular reflection. The distance from the probe to the surface determines the sample size. An alternative is the ISP-REF Integrating Sphere, which provides 180° illumination and detection from flat surfaces for measuring specular and diffuse reflection.

Measurements

Reflectivity is measured against a reference standard such as the WS-1 Diffuse Reflectance Standard. OOIIrrad-C Irradiance and Color Software calculates a variety of colorspace values from the reflection spectra.

Components for Color Measurements	Page	Price
1. USB2000 Plug-and-Play Spectrometer	38	$2,199
Grating #2, 350-1000 nm range	44	included
25 µm Slit as entrance aperture	42	$150
L2 Detector Collection Lens	43	$150
OFLV-350-1000 Order-sorting Filter	43	$150
2. WS-1 Diffuse Reflectance Standard	110	$299
3. OOIIrrad-C Color Application Software	81	$399
4. LS-1 Tungsten Halogen Light Source	126	$499
5. R400-7-VIS-NIR Reflection Probe	146	$499
6. RPH-1 Reflection Probe Holder	147	$75
7. ASP Annual Service Package	193	$250
	Total:	**$4,670**

Spectral Identity

It's not uncommon for our customers to be unfamiliar with the absorbing or emitting wavelength or wavelength range of their analytes. In the next few pages, we've provided absorbance and emission data for many analytes. Our Applications Scientists are another good resource for this information -- after all, we've configured more than 55,000 spectrometers -- as are Internet searches and commercial ventures specializing in spectral data.

Absorption Wavelength Bands for Chromophores

Chromophore	System	Max. Absorption in nm	Absorb. Intensity
Acetylide	—C≡C—	175-180	6 000
Aldehyde	—CHO	210	strong
		280-300	11-18
Amine	—NH_2	195	2 800
Azido	>C=N—	190	5 000
Azo	—N=N—	285-400	3-25
Bromide	—Br	208	300
Carbonyl	>C=O	195	1 000
		270-285	18-30
Carboxyl	—COOH	200-210	50-70
Disulfide	—S—S—	194	5 500
		255	400
Ester	—COOR	205	50
Ether	—O—	185	1 000
Ethylene	—C=C—	190	8 000
Iodine	—I	260	400
Nitrate	—ONO_2	270 (shoulder)	12
Nitrile	—C≡N	160	—
Nitrite	—ONO	220-230	1 000-2 000
		300-400	10
Nitro	—NO_2	210	strong
Nitroso	—NO	302	100
Oxime	—NOH	190	5 000
Sulfone	—SO_2—	180	—
Sulfoxide	>S=O	210	1 500
Thiocarbonyl	>C=S	205	strong
Thioether	—S—	194	4 600
		215	1 600
Thiol	—SH	195	1 400
	—$(C=C)_2$— (acrylic)	210-230	21 000
	—$(C=C)_3$—	260	35 000
	—$(C=C)_4$—	300	52 000
	—$(C=C)_5$—	330	118 000
	—$(C=C)_2$— (alicyclic)	230-260	3 000-8 000
	C=C—C≡ C	219	6 500
	C=C—C=N	220	23 000
	C=C—C=O	210-250	10 000-20 000
		300-350	weak
	C=C—NO_2	229	9 500
Benzene		184	46 700
		204	6 900
		255	170
Diphenyl		246	20 000
Naphthalene		222	112 000
		275	5 600
		312	175
Anthracene		252	199 000
		375	7 900

Beer's Law

Beer-Lambert Law, more commonly known as Beer's Law, states that the optical absorbance of a chromophore in a transparent solvent varies linearly with both the sample cell pathlength and the chromophore concentration. Beer's Law is the simple solution to the more general description of Maxwell's far field equations describing the interaction of light with matter. In practice Beer's Law is accurate enough for a range of chromophores, solvents and concentrations, and is a widely used relationship in quantitative spectroscopy.

Absorbance is measured in a spectrophotometer by passing a collimated beam of light at wavelength λ through a plane parallel slab of material that is normal to the beam. For liquids, the sample is held in an optically flat, transparent container called a cuvette. Absorbance (A_λ) is calculated from the ratio of light energy incident passing through the sample (I_0) to the energy that is incident on the sample (I):

$$A_\lambda = -\log (I/I_0)$$

Beer's Law follows:

$$A_\lambda = \varepsilon_\lambda bc$$

- ε_λ = molar absorptivity or extinction coefficient of the chromophore at wavelength λ (the optical density of a 1-cm thick sample of a 1 M solution). ε_λ is a property of the material and the solvent.
- b = sample pathlength in centimeters
- c = concentration of the compound in the sample, in molarity (mol L^{-1})

In an absorbance experiment, light is attenuated not only by the chromophore, but also by reflections from the interface between air and the sample, the sample and the cuvette, and absorbance by the solvent. These factors can be quantified separately, but are often removed by defining I_0 as the light passing through a sample "blank" or "baseline" or reference sample (for example, a cuvette filled with solvent but zero concentration of the chromophore is used as the blank).

Many factors can affect the validity of Beer's Law. It is usual to check for the linearity of Beer's Law for a chromophore by measuring the absorbance of a series of standards. This "calibration" can also remove errors in the experiment, the equipment and the batch of reagents (such as cuvettes of unknown pathlength).

Spectral Identity

Determining Optical Resolution

The optical resolution, measured as Full Width Half Maximum (FWHM), of our spectrometers depends on the groove density of the grating and the width of the entrance aperture (slit width or fiber diameter).

In selecting these components, consider two trade-offs. First, the optical resolution improves as the groove density of the grating increases, but at the expense of spectral range and signal strength. Second, the resolution improves as the slit width or diameter of the fiber decreases, but at the expense of signal strength. The formula for calculating the optical resolution follows:

Step 1
Choose a Grating from the Grating Selection Chart. See the table below to locate the page for the grating choices for your spectrometer. Note the value in the Spectral Range column in the chart. Check the number of pixel elements in the spectrometer's detector. Divide the Grating's Spectral Range by the total number of Detector Elements in the detector. This is your Dispersion.

Step 2
Choose a Slit. See the table below to find the page on slit choices for your spectrometer. Note the value in the Pixel Resolution column in the slit chart. Multiply the Dispersion (nm/pixel value from Step 1) x Pixel Resolution of your entrance aperture. This is your Optical Resolution (in nm).

Example
Here is an example of how to calculate optical resolution of a USB000 Spectrometer using Grating #3 and a 10- μm slit. With this data, you can obtain the approximate optical resolution.

Step 1 650 nm ÷ 2048 = 0.32
Step 2 0.32 x 3.2 = 1.02 nm
FWHM = 1.02 nm

Finding Your Values

Spectrometer	Grating Spectral Range	Entrance Aperture Pixel Resolution
USB2000:	page 44	page 42
HR2000:	page 52	page 50
HR2000+:	page 52	page 50
HR4000:	page 52	page 50
QE65000:	page 56	page 55
NIR-512:	page 61	page 60
NIR256-2.1:	page 61	page 60
NIR256-2.5:	page 61	page 60

Absorption Wavelength Bands for Chromophores

Chromophore	Max. Absorption in nm	Absorb. Intensity
Phenanthrene	251	66 000
	292	14 000
Naphthacene	272	180 000
	473	12 500
Pentacene	310	300 000
	585	12 000
Pyridine	174	80 000
	195	6 000
	257	1 700
Quinoline	227	37 000
	270	3 600
	314	2 750
Isoquinoline	218	80 000
	266	4 000
	317	3 500

Absorption Wavelength Cutoffs for Solvents*

Solvent	Wavelength
Acetic Acid	260
Acetone	330
Acetonitrile	190
Benzene	280
1-Butanol	210
2-Butanol	260
Butyl acetate	254
Carbon disulfide	380
Carbon tetrachloride	265
1-Chlorobutane	220
Chloroform (stabilized with ethanol)	245
Cyclohexane	210
1,2-Dichloroethane	226
Diethyl ether	218
1,2-Dimethoxyethane	240
N,N-Dimethylacetamide	268
N,N-Dimethylformamide	270
Dimethylsulfoxide	265
1,4-Dioxane	215
Ethanol	210
2-Ethoxyethanol	210
Ethyl acetate	255
Ethylene chloride	228
Glycerol	207
Heptane	197

Solvent	Wavelength
Hexadecane	200
Hexane	210
Isobutyl alcohol	230
Methanol	210
2-Methoxyethanol	210
Methylcyclohexane	210
Methylene chloride	235
Methyl ethyl ketone	330
Methyl isobutyl ketone	335
2-Methyl-1-propanol	230
N-Methylpyrrolidone	285
Nitromethane	380
Pentane	210
Pentyl acetate	212
1-Propanol	210
2-Propanol	210
Pyridine	330
Tetrachloroethylene (stabilized with thymol)	290
Tetrahydrofuran	220
Toluene	286
1,1,2-Trichloro-1,2,2-trifluoroethane	231
2,2,4-Trimethylpentane	215
o-Xylene	290
Water	191

** Solvents are transparent at wavelengths greater than the stated cutoff.*

Absorption/Emission for Fluorophores

Fluorophore	Absorption in nm	Emission in nm
1,5 IAEDANS	336	490
4-Methylumbelliferone	385	502
5-Carboxynapthofluorescein (pH 10)	512/598	563/668
5-Carboxytetramethylrhodamine (5-TAMRA)	542	568
6-Carboxyrhodamine 6G	518	543
6-CR 6G	518	543
6-JOE	520	548
7-Amino-4-Methylcoumarin	351	430
7-Aminoactinomycin D (7-AAD)	546	647
7-Hydroxy-4-methylcoumarin	360	449,455
Acridine Orange +DNA	502	526
Alexa Fluor 350™	346 342	442 441
Alexa Fluor 430™	431	540
Alexa Fluor 488™	495,492	519,520
Alexa Fluor 532™	531,532	553,554
Alexa Fluor 546™	556,557	572,573
Alexa Fluor 568™	577,578	603
Alexa Fluor 594™	590,594	617,618
Alexa Fluor 633™	632	650
Alexa Fluor 647™	647	666
Alexa Fluor 660™	668	698
Alexa Fluor 680™	679	702
Allophycocyanin (APC)	630,645	655,660
AMCA (Aminomethylcoumarin)	345 347	425 444
AMCA-X	353	442
ATTO-TAG™ FQ	486	591
BCECF (high pH)	492,503	520,528
BCECF (low pH)	482	520
Bodipy 505/515	502	510
Bodipy 558/568	558	569
Bodipy 564/570	564	570
Bodipy 576/589	579	590
Bodipy 581/591	584	592
Bodipy 630/650-X	625	642
Bodipy 650/665-X	647	665
Bodipy 665/676	605	676
Bodipy FI	504,505	511,513
Bodipy TMR	542	574
Bodipy TR	589	617
Calcein	494	517
Calcein Blue	373	440
Calcium Crimson™	588,589	611,615
Calcium Green	501,506	531
Calcium Green-1 Ca2+ Dye	506	531
Calcium Orange	549	575
Calcofluor White	385,395,405	437,440,445
Cascade Blue™	377 398 399	420 423
CFP - Cyan Fluorescent Protein	430,433,436,(453)	474,475,476,(501)

Non-linearity & CCDs

All CCD detectors exhibit a non-linearity in their response to light; i.e., doubling the number of photons received during the sample interval results in slightly less than a doubling of the voltage output. The effects of non-linearity, if left uncorrected, will be slight but detectable errors in the calculation of normalized values (absorbance, transmission or irradiance).

The non-linearity is a consequence of the R-C circuit used to read out the electrons that are left on the CCD capacitor (the charge well). The effect is independent of light level, integration time and optics. It depends only on the charge in the charge well.

The pattern of non-linearity is different for the various detector models used in our spectrometers. The magnitude of the linearity varies from detector to detector, but fortunately it is the same for all pixels in the detector. This makes it possible to 1) measure the linearity, and 2) correct for the errors in software.

The ILX511 has a maximum response at 2000 counts (half well capacity). It drops to ~94% at 4000 counts and near zero counts. We can establish this curve precisely using an automated program that varies the integration time to precisely control the amount of light being sampled. This program (OOINLCorrect) is available for free download at our website at OceanOptics.com/Technical/Software Downloads.asp.

The linearity is captured from the experiments as a plot of normalized counts/sec versus counts for a constant light source observed at a series of integration times. The data is fit to a 7th order polynomial. The inverse of this function is stored in the software and/or on the EEPROM. When the linearity correction feature is turned on, all spectra are multiplied by the stored coefficients. Uncorrected spectra are linear to ~92%. Corrected spectra are linear to >99.8%.

Collimating Lenses

The 74-UV and 74-VIS Collimating Lenses screw onto the end of SMA 905-terminated fibers and other sampling optics to convert divergent beams of radiation (light) into a parallel beam. The optical fibers we sell have a field of view (FOV) of ~25° -- an acceptance angle that may not be appropriate for some experiments. Collimating lenses are adjustable, providing FOV angles from collimation (near 0°) to ~45°. Without the collimating lenses, the light would disperse more than is required for efficient transmission and collection of the signal.

Focus the Lamp's Collimating Lens

In order to obtain accurate data, the light entering and exiting a sample by means of a fiber/collimating lens assembly must be well collimated. Here are instructions for adjusting the focus of the collimators in a typical spectrometer setup.

1. Connect to the light source the fiber that you're going to use as the illumination fiber in your setup. The female SMA 905 Connector of the fiber must be screwed all the way into the male connector of the lamp.
2. Turn on the lamp and inspect the beam emitted from the other end of the fiber by pointing the fiber at a white piece of paper. The distance is not too critical but should be at least 3 inches from the surface.
3. Loosen the setscrew on the fiber barrel of the light source with an Allen wrench.
4. Slide the inner barrel of the collimating lens until you see an even intensity across the beam spot. The spot should be uniform in intensity and color.
5. Once the inner barrel is positioned so that a well-focused, uniform spot is obtained, tighten the setscrew. Don't put down the fiber and then tighten the setscrew as you may lose the focus.

Focus the Next Collimating Lens

6. The illumination fiber is still connected to the lamp and the lamp is on. Take the second collimating lens in your setup (removed from a cuvette holder, for example) and screw it securely onto the other end of the fiber. Point this end of the fiber at least 2 meters from a wall.
7. Repeat Steps 3, 4 and 5. Then remove the lens from the end of the fiber and install it back into your setup (back into a cuvette holder, for example).
8. Continue to adjust the focus of the other collimating lenses in your setup.

Absorption/Emission for Fluorophores (continued)

Fluorophore	Absorption in nm	Emission in nm
CL-NERF (Ratio Dye, pH)	504/514	540
Cy2™	489	506
Cy3.5™	581	598
Cy3™	514	566
Cy5.5™	675	695
Cy5™	649	666
Cy7™	710,743	767,805
Dabcyl	453	
Dansyl Cadaverine	335	518
DAPI	359	461
Di-4-ANEPPS	496	705
Di-8-ANEPPS (non-ratio)	488	605
	498	713
DiA (4-Di-16-ASP)	456	591
DIDS	341	415
DiI (DiIC18(3))	549,551	565
Dinitrolphenol	349	
DiO (DiOC18(3))	484,487	501,502
DM-NERF (Ratio Dye, high pH)	497/510	540
ELF 97	345	530
Eosin	524	545
Erythrosin	529,532	554,555
Ethidium Bromide	510,523	595,605
Ethidium homodimer -1 (EthD-1)	528	617
Europium (III) chloride	337	613
Fast Blue	360	440
Fluo-3	480-506,506	520,527
Fluo-4	494	516
Fluorescein (FITC)	490,494	520,525
Fluoro-Gold (Hydroxystilbamidine)	361	536
FluorX	494	520
FM 1-43™	479	598
Fura Red™ (high pH)	572	657
Fura-2, high calcium (Excitation ratio dye)	335	505
Fura-2, low calcium (Excitation ratio dye)	363	512
GFP (S65T)	498	516
Hoechst 33258	345	487
Hoechst 33342	347	483
JC-1	514	529
JO-JO-1	530	545
JO-PRO-1	532	544
Lucifer Yellow	425,428	528,536,540
Lyso Tracker Green	504,534	511,551
Mag-Fura-2 (Ratio Dye, Ca2+)	369/329	508
Mag-Fura-2 (Ratio Dye Mg2+)	369/330	511/491
Mag-Fura-5 (Ratio Dye, Ca2+)	369/330	505/500
Mag-Fura-5 (Ratio Dye, Mg2+)	369/332	505/482
Magnesium Green	506,507	531
Marina Blue	362	459
Mitotracker Green FM	490	516

Absorption/Emission for Fluorophores (continued)

Fluorophore	Absorption in nm	Emission in nm
Mitotracker Orange	551	576
NBD	466	539
Nile Red	515-555,559	590,640
Oregon Green™	503	522
Oregon Green™ 488	490,493	514,520
Oregon Green™ 500	497	517
Oregon Green™ 514	506	526
PKH26 (Sigma)	551	567
POPO-3	533	574
PO-PRO-3	539	567
Propidium Iodid (PI)	(305), 536,538	617
Pyrene	360	387
QSY 7	560	591
Rhod-2	552	576
Rhodamine 110	496,497	520
Rhodamine 123	507	529
Rhodamine 6G	525	555
Rhodamine B	540	625
Rhodamine Green	502	527
Rhodamine Phalloidine	542	565
Rhodamine Red	570	590
R-phycoerythrin (PE)	565	578
SITS (Ion Channels)	336	436
SNAFL-1 (Ratio Dye, pH)	508/540	543/623
SNARF1 Excitation and emission ratio dye	576/548	635/587
Sodium Green Na+, K+	506,507	532
SpectrumGreen (Vysis)	497/30, 509/31	538/44,524/56
SpectrumOrange (Vysis)	559/38,560	588/48
SPQ (6-methoxy-N-(3-sulfopropyl)	344	443
SYTO 11Dye for DNA, RNA	508,510	527,530
SYTO 13Dye for DNA, RNA	488,491	509,514
SYTOX Green (Nucleic Acid Stain	504	523
SYTOX Orange (Nucleic Acid Stain	547	570
Tetramethylrhodamine (TRITC)	555	576
Texas Red™	595	620
TO-PRO-1	515	531
TOTO-1	514	531,533
YFP (Yellow Fluorescent Protein)	513,520	527,532
YO-PRO-1	491	506
YOYO-1	491	508,509

Phosphorescence & Fluorescence

Phosphorescence and fluorescence are closely related subcategories of luminescence. The difference between the two is in the nature of a material's ground and excited states.

In a singlet excited state, the higher-energy orbital electron spins opposite the lower-energy orbital. The two electrons are considered "paired." In a triplet state, the electrons are "unpaired," and spin in the same direction. A return to the ground state from a singlet excited state does not require one of the electrons to change its spin orientation; a return from a triplet state to the ground state does require an electron's spin orientation to change.

Fluorescence is the photonic emission that occurs when the higher-energy electron in a singlet state returns to the lower-orbit electron. The laws of quantum mechanics permit this rapid transition at a rate near 10^{-8} second.

The fluorescence lifetime is the average period of time that a fluorophore remains in the excited singlet state. By comparison, phosphorescence emission occurs as the electronically excited condition of a material in the triplet state returns to the singlet ground state. Again, the laws of quantum mechanics prevail, and the probability of this transition is lower. The lifetime of an excited triplet state is much longer than that of an excited singlet state, producing phosphorescence lifetimes that range from milliseconds to seconds.

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Available Online: Engineering-level Documents
www.OceanOptics.com/Technical/EngineeringDocs.asp

- ADC1000-USB A/D Converter: Serial Port Interface Communications and Control Information
- ADC2000-PCI "Unrecognized By Windows" Solution
- Additional Troubleshooting Steps for the ADC2000-PCI
- CCD Detector and Linearity
- Correcting Device Driver Issues
- Hamamatsu S3902/S3903-series Photodiode-array
- HR2000 Spectrometer OEM Data Sheet
- HR4000 Spectrometer OEM Data Sheet
- Mini-D2T & CHEM2000 (ISS-UV-VIS) Lamp Replacement
- NIR512 Alternating Dark Pixel Levels
- PC2000/PC/104 OEM Data Sheet
- Pixel Rotation with S2000 Spectrometers
- PX2 Pulsed Xenon Lamp Stability
- QE65000 Spectrometer OEM Data Sheet
- Reprogramming a USB Device
- Sony ILX511 CCD-array Detector Specifications
- S2000 Spectrometer OEM Data Sheet
- Toshiba TCD1304AP CCD-array Detector Specifications
- USB Devices: Recovering a Corrupted EEPROM
- USB-ADP-H Serial Adapter Connecting to Spectrometer, Light Source, and Battery Pack
- USB-ADP-H Serial Adapter Used with USB-BP Battery Pack and/or USB LS-450 Light Source
- USB-ADP-PC Serial Adapter
- USB-ADP-PX2 Serial Adapter
- USB-LS-450 Temperature Recalibration
- USB2000 Spectrometer OEM Data Sheet

Available Online: System Specifications
www.OceanOptics.com/Technical/SystemSpecifications.asp

- Spectrometer Operating Principles
- Spectrometer Optical Resolution
- Spectrometer System Sensitivity

Available Online: Manuals
www.OceanOptics.com/Technical/OperatingInstructions.asp

Available Online: Software
www.OceanOptics.com/Technical/SoftwareDownloads.asp

Standard & Extended Warranty Coverage

Choose Annual Service Package for Additional Value

All products manufactured by Ocean Optics are warranted for one year. Ocean Optics also offers an Annual Service Package (ASP) that extends by one year the standard warranty on our spectrometers. The holder of the ASP is entitled to several benefits during the one-year period commencing with the spectrometer invoice date:

- Additional year of warranty protection and certification
- Factory calibration and certification of your spectrometer, including optical alignment, wavelength calibration, linearity calibration, stray light measurement and signal-to-noise analysis, optical resolution evaluation, baseline uniformity evaluation
- Waiver of $250 labor charge for upgrades to your spectrometer configuration, such as changing a slit or grating.
- A spiffy new Maxwell's Equations T-shirt – be the envy of all your friends

Also available is a *two-year* extended warranty renewal option for most of our spectrometers. Enjoy all the great ASP benefits with the additional year of coverage at a steep discount.

Item	Description	For These Spectrometers	Price
ASP	Extends the standard warranty from 1 year to 2 years. Price is per spectrometer channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000	$250
ASP-ES	A 1-year warranty package available to customers whose original warranty has expired. Price is per spectrometer channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000	$300
ASP-R	1-year renewal option for holders of expiring ASPs; price is per channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000	$250
ASP-R-E	2-year renewal option for holders of expiring ASPs; price is per channel.	USB2000, S2000, PC2000, HR2000, HR2000+, HR4000	$350
ASP-NIR	Extends the standard warranty on NIR Spectrometers from 1 year to 2 years.	NIR256-2.1, NIR256-2.5, NIR512	$1,000
ASP-QE	Extends the standard warranty on QE Spectrometers from 1 year to 2 years.	QE65000	$750

Ocean Optics Spectrometers Go for a Ride

This year's Photo Challenge winner has combined Ocean Optics near-infrared spectrometers and accessories into a remote-sensing system that measures the effects of saltgrass growth on a potentially harmful dust-producing dry lakebed in California.

David Groeneveld and his colleagues at HydroBio, a New Mexico-based provider of mapping and quantification services for bodies of water, marshes and irrigated land, are using an NIR512 Near-infrared Spectrometer, optical fiber and CC-3 Cosine Corrector for hyperspectral measurements of wet and dry saltcrusts and dust-emissive wind scars on Owens Lake, a dry lakebed about 180 miles north of Los Angeles.

The City of Los Angeles is cultivating 4 square miles of saltgrass -- a tough, wetland grass that can be used to stabilize soil and prevent erosion -- to help mitigate dust releases from the lakebed. Otherwise, windy conditions there could create the worst single source of PM10 particulates (aerosol particles smaller than 10 microns in aerodynamic diameter that can create a health hazard) in the Western Hemisphere.

Owens Lake is dry because its water was exported to Los Angeles in the 1920s. HydroBio has been hired to determine whether sufficient plant cover exists to prevent dust release.

Photo Challenge Grand Prize Winner of $1,000

HydroBio strapped their Ocean Optics gear to an all-terrain vehicle (ATV, above) and to a small airplane (at left) to collect spectral data. The sampling optics rigged to the ATV consisted of a pair of optical fibers pointed toward the ground and a single fiber with a cosine corrector pointed toward the sky. A similar sampling setup was used for the airplane measurements, with sampling optics positioned below the wing and aft of the canopy.

For more on HydroBio, visit their website at www.hydrobio.org.

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