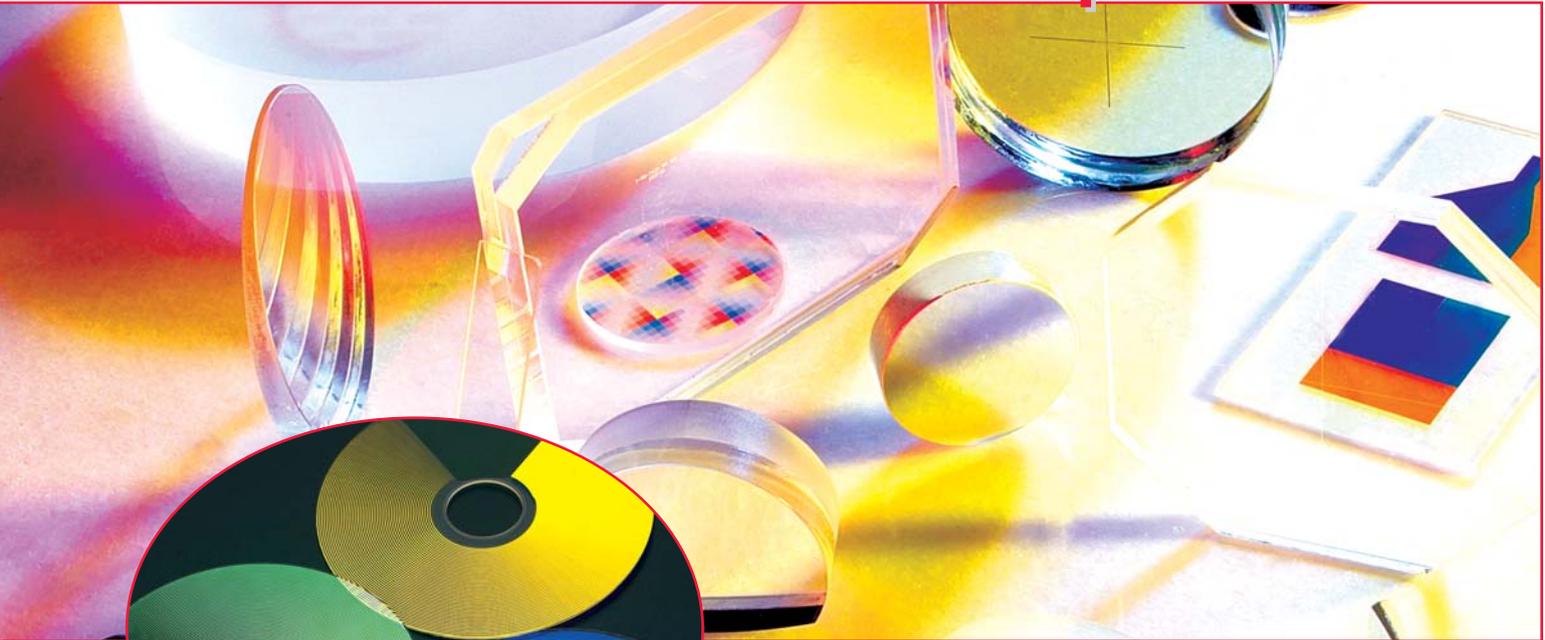


Thin Films & Optics



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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:
 - $\lambda/10$ 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.

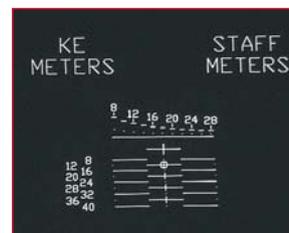
- | | | |
|--|--------------------------------------|---------------------------------------|
| <input type="radio"/> Dichroic, Dielectric, and Interference (UV to NIR) | <input type="radio"/> Oxides | <input type="radio"/> Fluorides |
| | <input type="radio"/> Beamsplitter | <input type="radio"/> High-reflective |
| | <input type="radio"/> Antireflective | <input type="radio"/> 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.





Thin Films & Optics Applications

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 $1/20\lambda$ 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 those listed below.

Applications

Entertainment/ Lighting	Consumer Electronics	Reticles	Instrumentation	Metrology	Optical Networking
AR coatings for GOBOS Broadband antireflection coated filters for entertainment lighting Coatings for light envelopes Dichroic filters for stage lighting Filters for special effects lighting Hot and cold mirrors for lighting fixtures Large-format still images	Dielectric coatings for personal digital assistant screens RGB filters for LCD and projection displays Patterned GOBOS for projection systems Color technology for HDTV, high-def monitors, and rear-projection TVs UVA-B-C filters in cameras	Binoculars Bore-sighting devices Fire control Precision optics for E-O systems	Bandpass filters for medical fiber optic instruments Hyper-spectral imaging filters for CCD cameras RGB color filters for CCD detectors Second- and third-order blocking filters for spectroscopy Spectroscopic kits for optics inspection Optics for optical benches in spectrometers	Flats for inspecting optics Collimation Testers for examining and adjusting the collimation of laser beams Spectroscopic kits for optics inspection Reflectance standards, NIST-traceable Long Trace Profilometer for large flats and aspheres	AR coatings for network components Bandpass filters, gain flatteners and rejection filters for DWDM Coatings for MEMS, waveguide relays and switches Filters for wavelength add/drop couplers Tunable filters for transmitters and receivers

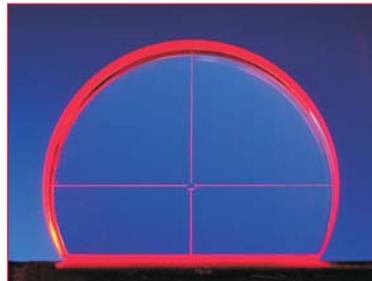
Examples of Custom Products

Variable Saturation Filters



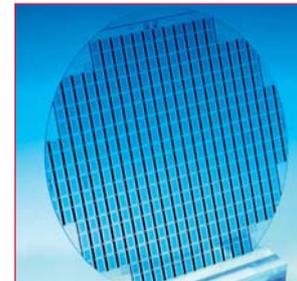
- Excellent optical transmission efficiency for superior brightness
- Temperature and humidity stability for consistent color
- Used in entertainment, display and lighting fixtures

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 wafer surfaces

Technologies for Entertainment and Consumer Applications

Our patterned dichroic filters can be patterned with such precision that it's possible to project even large-format still images with remarkable resolution and clarity. With that same technology, we've developed a line of "colored light" products for theatrical, worship and architectural lighting installations, anchored by the award-winning SeaChanger Color Engine (at right). SeaChanger is a four-filter color changer designed as an accessory for ETC Source Four Ellipsoidals, the world's most popular stage lights. SeaChanger fills a niche between inexpensive but maintenance-intensive color gel scrollers -- the traditional color-changer technology for stage lighting -- and higher priced moving lights, and has appeared everywhere from church productions to Broadway musicals. We've also produced filters for the next generation of micro-mirror-based digital display technologies, as well as precision mirror coatings and optics designed to improve the safety and performance of a wide range of consumer products.



www.SeaChangerOnline.com
SEACHANGER



Specular Reflectance Standards



With the STAN-SSH High-reflectivity Specular Reflectance Standard (above), you receive a certificate of calibration in paper and electronic formats.

We offer three specular reflectance standards for use as references when measuring the reflection of surfaces with high or low specular reflectivity. The superior coatings on the substrates are environmentally stable; they are able to withstand high temperatures and mechanical stresses. Reflectivity values for the standards are built into our software to provide a reference for any specular measurement.

We offer a STAN-SSH High-reflectivity Specular Reflectance Standard designed as a standard reference when measuring the optical substrates, optical coatings, machined metals and semiconductor materials. (A NIST version of the STAN-SSH is also available.) The STAN-SSL Low-reflectivity Specular Reflectance Standard can be used as a reference when measuring samples such as thin film coatings, anti-reflective coatings, blocking filters and substrates. For details on the specular reflectance standards, see page 108.

STAN-SSH:	\$499
STAN-SSH-NIST:	\$999
STAN-SSL:	\$499

Collimation Testers

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. Each tester is available in apertures ranging from 10 mm to 200 mm in diameter, and is useable from 350-2500 nm.

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. See page 111 for details on all of our collimation testers.



Optical Flats

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. 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 110.





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 square 25.4 x 25.4 x 3 mm	\$50
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-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
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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 16 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 113 for details.

