Optics

Optometrics
A Dynasil Company

LASER COMPONENTS

Interference Filters

- 10NM Bandpass Filters
- Broadband Filters
- Laser Line Filters
- Long Pass Cut-On Filters
- Astronomy Filters

For Applications In:
Analytical Chemistry
Physics
Life Sciences
Engineering
Communications

11/21 / V03 / KC-IF / optometrics/interference-filters

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Optometrics Corporation has, for more than twenty five years, designed and manufactured a broad selection of interference filters for a variety of applications in the industrial, educational and research markets.

Designing and producing interference filters is a complex procedure requiring thin-film expertise and sophisticated instrumentation.

Optometrics Corporation produces its filters in-house on customized vacuum systems, operated by a staff of experienced technicians.

We manufacture interference filters with central wavelengths from 337 nm to 1.064µ in various sizes ranging from 12.7 mm diameter up to 50 mm square and two levels of blocking.

This allows you to select the most economical filter that meets your optical performance criteria.

Facilities

Optometrics' facility in Ayer, Massachusetts contains space for offices, engineering, R&D and production. Equipment that support our broad range of capabilities includes:

- Four metal vacuum coating systems;
- Three thin-film soft coated filter vacuum coating systems;
- Two Ion-Assisted Deposition hard coat vacuum coating systems;
- Three grating ruling engines;
- Production holographic laboratory;
- R&D holographic laboratory;
- Full replication and lamination facilities;
- Full assembly, alignment and test facilities;
- Full complement of test equipment for spectral testing from the UV to the Far Infrared, for mechanical and flatness testing, for humidity and environmental testing;
- Extensive marking, packaging and bar coding equipment and capabilities

Products

- **Gratings**
  Originals and Replicated, Ruled and Holographic; Grazing Incidence, Echelles, Telecom and Transmission Gratings
- **Beamsplitters**
  Reflecting/Transmitting Beamsplitters, Transmission Grating Beamsplitters, Beam Dividers/Combiners

- **Optical Components**
  Mirrors, Lenses, Windows, Flats, Beamsplitters, Prisms
- **Filters**
  Hard and Soft Coated, Near Ultraviolet, Visible, Near Infrared, Laser Line Filters
- **Infrared & Laser Products**
  Laser Gratings, Holographic and Ruled Wire Grid Polarizers

- **Monochromators**
  Mini-Chrom Monochromators

- **Systems & Accessories**
  Monochromatic Light Modules, Sample Compartments, Detectors, Light Sources, Modular Recording Spectrophotometers
- **SPF-290S**
  Spectrophotometer for determining Sunscreen Protection Factors

Plus specialized packaging, bar coding and Kanban stocking arrangements for all OEM customers.

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Goals

Optometrics goal is to provide advanced optical components and systems for use in wavelength selection applications found in:

- Analytical Chemistry
- Life Sciences
- Telecom Applications
- Physics
- Education
- Space Sciences

and other applications where high quality optics are key.

In order to accomplish this, the Company has assembled state-of-the-art facilities and people to produce:

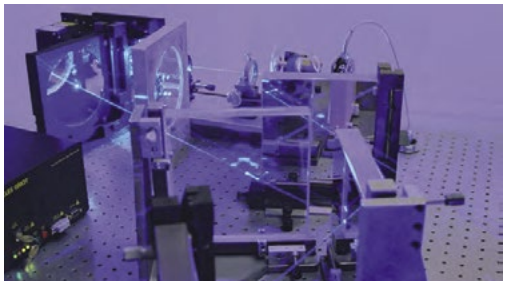
- interference filters
- diffraction gratings: ruled & holographic, original & replicated, reflection and transmission
- optical components
- Infrared gratings & products
- monochromators & accessories
- spectrophotometers
- wire grid polarizers: ruled & holographic
- Telecom components

OEM Services

Optometrics offers its OEM customers additional services:

- Kanban stocking arrangements
- Bar coding capabilities
- Specialized packaging services
- Customer names coded for confidentiality
- Higher level pre-aligned optical assemblies

The company is also proud of its ability to support customers in all phases of the product development cycle.



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Interference Filters | Background & Technology

Interference bandpass filters are relatively inexpensive wavelength selectors that allow transmission of a predetermined wavelength while rejecting or blocking other wavelengths. Interference filters are widely used in instrumentation for clinical chemistry, environmental testing, colorimetry, elemental and laser line separation, flame photometry, fluorescence, immunoassays, etc.

Optometrics Corporation produces thousands of filters specified by and designed for other instrument manufacturers. If our standard filters do not conform to your requirements, Optometrics can design and manufacture filters to your performance and dimensional specifications.

FILTERS AS WAVELENGTH SELECTORS

Interference filters should be considered when the application requires a limited number of known wavelengths, when energy throughput is more critical than wavelength resolution or when cost is more important than flexibility.

The relative low cost and simple installation of interference filters makes them the preferred wavelength selector for applications such as clinical chemistry, environmental testing, laser line separation and flame photometry, where the required wavelengths are well known.

The energy throughput of an interference filter is usually much greater than can be achieved with a monochromator, where throughput is dependent on slit size, grating efficiency, input optics, etc. The entire clear aperture of an interference filter can be illuminated, resulting in high throughput and an excellent signal-to-noise ratio.

An application that requires numerous analytical wavelengths, variable resolution, far ultraviolet analysis, spectral analysis, etc., will require a prism or grating monochromator rather than interference filters. (See our Monochromators and Modules Brochure)

PRODUCTION

An interference filter is fabricated in 3 sections, one of which determines the central wavelength (CWL), halfbandwidth (HBW), and shape of the transmittance curve while the other two control the degree and range of blocking outside the passband. After thin film deposition is complete, the three sections are scribed, laminated, cut and mounted.

The bandpass section of an interference filter is made by repetitive vacuum deposition of thin layers of partially reflecting dielectric compounds on a glass substrate. A typical interference filter can have over fifty such layers, each one precisely controlled and evenly deposited over the preceding layer. The thickness of each layer is equal to a quarter wave ($\lambda/4$) of the filter central wavelength (λ). Alternating layers of dielectric materials with high and low refractive indices make up a stack. A half wave ($\lambda/2$) layer, or a multiple thereof, deposited between symmetric stacks, forms a spacer layer. The halfbandwidth of an interference filter is determined by the ratio of the indices of the high and low dielectric materials, the number of layers in a stack and the number of half waves in a spacer. A spacer layer and adjacent stacks form a “cavity”, the basic element of an interference filter. The number of cavities in the bandpass section determines the overall shape of the transmittance curve. Most Optometrics filters are made with three cavities, resulting in filters with steep slopes, improved blocking close to the passband and relatively flat tops.

Rejection of wavelengths resulting from destructive interference is limited to within 15% of the central wavelength. Therefore, additional glass or metallic blockers must be added to reduce out-of-bandpass transmittance. Metallic blockers, which consist of layers of silver deposited on the dielectric spacer layer, reflect and absorb radiation outside the filter passband and negates highter order passbands from X-ray to the far IR. The blocking capabilities of metallic

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ers are augmented in high performance filters by the addition of color transmitting glass and custom dyes that absorb UV or long wavelength radiation.

TEMPERATURE EFFECTS

The central wavelength of an interference filter can shift with increasing or decreasing temperatures. This effect, which is due primarily to the expansion or contraction of the spacer layers and the concomitant change in their refractive indices, is extremely small over normal operating ranges (≈ 0.01 nm/°C). Prolonged operation at high temperatures (>75° C) will irreversibly set the central wavelength lower. Temperatures above 125° C should be avoided.

Though interference filters will function at -50° C or lower, the cooling rate should not be allowed to exceed 5° C per minute. An excessive cooling rate can cause the glass substrate to crack or the filter to delaminate due to differential thermal contraction.

SOURCE ORIENTATION

An interference filter will function with either side facing the source. It is recommended, however, that the side with the "mirror–like" reflective coating be oriented toward the source. This will minimize any thermal effect that could result from the absorption of heat by the color glass or blockers on the other side.

ANGLE OF INCIDENCE

An interference filter should be illuminated with collimated radiation normal (perpendicular) to the surface of the filter. The central wavelength will shift slightly to a lower wavelength if the illuminating radiation is not normal to the filter. A deviation of less than 3 degrees results in a negligible wavelength shift. At large deviations, the wavelength shift is significant, transmittance decreases and the shape of the passband changes.

When noncollimated radiation impinges on the filter, the result is similar to that stated above. In this case, the effect is dependent on the cone angle of the illuminating radiation. Varying the angle of incidence from normal can be used to "tune" an interference filter within a limited wavelength range.

LIFE TIME

Interference filters in the UV-VIS-NIR range are subject to environmental deterioration due to moisture penetration of the hygroscopic dielectric layers. Though the bandpass and blocking sections of interference filters are laminated with epoxy, a high humidity environment can cause delamination.

A process known as scribing results in excellent moisture protection. Scribing removes all dielectric material from the periphery of a filter, allowing a glass-to-glass epoxy seal that minimizes moisture penetration. Optometrics filters are also sealed in a metal ring, but the primary purpose of the ring is to protect the filter from physical damage, particularly the relatively soft color glass. Optometrics randomly tests its filters in a humidity chamber and Optometrics' filters routinely pass MIL Std 810E aggravated test protocols.

INTEGRATED BLOCKING

Blocking refers to the degree to which transmitted radiation outside the filter passband is restricted. A blocking specification should state the wavelength range over which it is measured. Both the degree and range of blocking required are application dependent. Too little blocking will result in unacceptable stray light (high noise); too much will decrease throughput (low signal) and increase costs. Blocking is one of the most important specifications to be considered when selecting an interference filter.

Blocking is sometimes defined in "absolute" terms, which refers to the ratio of the largest peak outside the passband to the peak within the passband. Absolute blocking does not measure the total radiation (energy) outside the passband and has little meaning in spectroscopy, where all radiation outside the passband is considered stray light.

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Interference Filters | Background &

Integrated blocking is a more useful way to define blocking. It is the ratio of the total radiation (energy) outside the passband to the total radiation within the passband. For an integrated blocking value to be meaningful, the conditions under which the filter is to be used must be known. For example, the integrated blocking value of a 340 nm filter in an optical system with a UV source and photomultiplier will be considerably better than the same filter used with a tungsten lamp and silicon photodiode. The spectral response of a UV source and PMT detector system may overlap from about 200 nm to 400 nm, with considerable energy and detector sensitivity at 340 nm (high signal). Under these conditions, radiation detected through the filter outside the passband (stray light) is limited by both source and detector and can be easily controlled by standard blocking. If, however, the same 340 nm filter is used with another source and detector, stray light could be a problem and additional blocking may be required. The spectral response of a tungsten source and a silicon photodiode detector system may overlap from about 320 nm to 1100 nm, but with very little source energy or detector sensitivity at 340 nm (low signal). These conditions require that the filter have additional blocking to compensate for the source radiation and detector sensitivity from 400 nm to 1000 nm (ultra low noise).

Several equivalent notations are used by various manufacturers to specify blocking including absorbance, optical density, transmittance, scientific notation, rejection ratio and signal-to-noise ratio. To establish a blocking specification, Optometrics utilizes an optical system with a tungsten halogen lamp with a color temperature of 2800° K and a UV enhanced silicon photodiode. A transmittance notation is used since it is universally understood.

For spectroscopic applications, the degree of blocking should be consistent with the sample being used. Integrated blocking to 0.1%T (standard performance filter) will not cause an appreciable error with a low absorbing sample. For a highly absorbing sample (Abs ≥ 2.0), the 0.1% stray light would be 10% of the total transmitted signal, grossly affecting the accuracy of an assay. Therefore, a high performance filter is required, where integrated blocking is 0.01%T.

CHOOSING A FILTER

Select from our extensive range of standard filters or contact Optometrics with your requirements for an OEM quotation.

TYPES OF FILTERS

Bandpass Filters (10nm)
This type of interference filter finds wide application in spectral analysis, particularly those in clinical chemistry, spectral radiometry, environmental testing, laser line separation, flame photometry and color separation where the required wavelengths are well known.
(See Ordering Information on Pages 12-13)

Astronomy Filters
Four filters designed specifically for amateur astronomers who utilize CCD cameras for imaging planets, planetaries, diffuse nebula and other objects of the night sky. (See Ordering Information on Page 15)

Long-Pass Cut on filters
Long pass cut-on filters are widely used for additional blocking of UV radiation and for high transmission of a broad spectral region above a specified wave length (See Ordering Information on Page 16)

Neutral Density Filters
Neutral density filters control light intensity without selectively absorbing energies at specific wavelengths. They are, therefore, generally used to attenuate the intensity of a beam of light over a broad spectral region. (See Ordering Information on Page 17)

Laser Line Filters
Laser line filters are designed to isolate a particular laser line. (See Ordering Information on Page 18)

Application-Specific Filter Kits
Filter kits for a variety of spectroscopic kits are available for Laser Diodes, Flame Photometry Laser Lines and Immunochemistry.
(See Ordering Information on Page 19-20)

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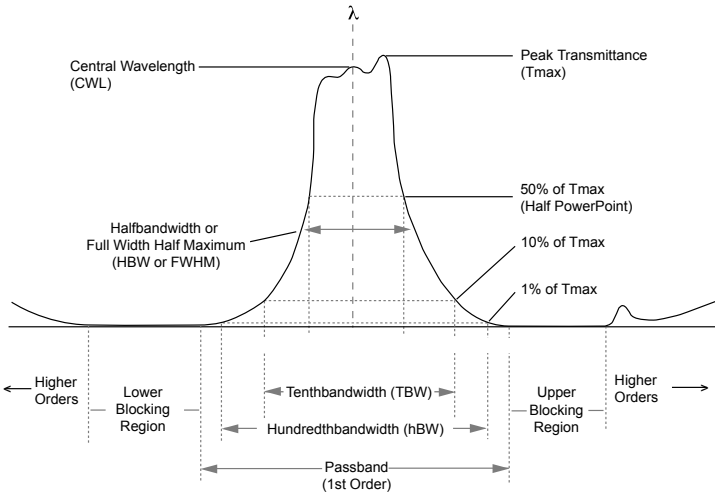
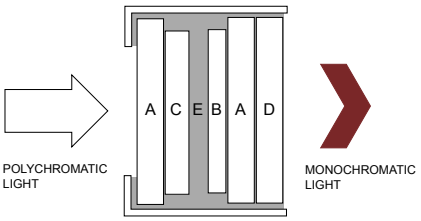
Interference Filter Terminology | **Interference Filters**

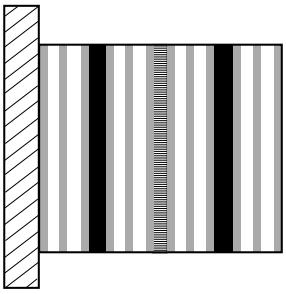


INTERFERENCE FILTER TERMINOLOGY



A = Glass Substrate
B = Multicavity Bandpass Section
C = Blocker Section
D = Color Glass
E = Epoxy
F = Metal Ring

TYPICAL INTERFERENCE FILTER



Glass Substate
High Index Dielectric (1/4)
Low Index Dielectric (1/4)
Color Glass
Epoxy

MULTI CAVITy BANDPASS SECTION

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Interference Filters | Definitions

Absolute Blocking:
The ratio of the largest peak outside the passband to the peak within the passband. Expressed as an area or %T.

Absorbance:
The logarithmic function of transmittance. Sometimes used to express the degree of blocking. A = $\log(I_0/I)$.

Angle of Incidence:
The angle formed by radiation arriving (incident) at the filter surface and the perpendicular to the surface at the point of arrival.

Angstrom (Å):
Unit of length used to measure wavelengths of light. One tenth of a nanometer (nm). One Angstrom is equal to 1 x 10^{-10} meters.

Bandpass Filter:
See interference filter.

Bandwidth:
Specified wavelength interval of transmitted radiation.

Blocking:
The degree to which detectable radiation outside the passband is rejected. Expressed as transmittance, absorbance, optical density, scientific notation, signal-to-noise or rejection ratio. Blocking requirements are specified over a useful wavelength range.

Cavity:
Basic component of an interference filter consisting of two layers of reflective stacks separated by a spacer layer. Also known as a period.

Clear Aperture (CA):
The central, useable area of a filter through which radiation can be transmitted.

Central Wavelength (CWL):
The mean of the two wavelengths corresponding to the half power points.

Half Power Points:
Points on both sides of the passband curve of a filter, with a value 50% of the peak transmittance. Used to calculate HBW and CWL.

Half Bandwidth (HBW):
The wavelength interval of the passband measured at the half power points (50% of peak transmittance). Expressed as halfbandwidth (HBW), full width half maximum (FWHM) or half power bandwidth (HPBW).

Incident radiation (I_0):
The radiation, usually polychromatic, that impinges on a filter.

Interference Filter:
A filter that, operating on the principles of constructive and destructive interference, transmits radiation in a discrete, narrow wavelength range while rejecting other radiation. Also known as a bandpass filter.

Integrated Blocking:
The ratio of the total transmitted radiation (energy) outside the passband to the total transmitted radiation within the passband. Integrated blocking is influenced by the source output and detector response as functions of wavelength.

Micron (µ):
Unit of length used to measure wavelengths of light. One micron is equal to 1,000 nm.

Nanometer (nm):
Unit of length used to measure wavelengths of light. One nanometer is equal to 1 x 10^{-9} meters.

Near Infrared (NIR):
Light from the region of the electromagnetic spectrum with wavelengths between (approximately) 750 nm and 3.0 µ.

Optical Density (OD):
Used to express the degree of blocking or the value of neutral density filters. Also known as Absorbance.

Passband:
A wavelength interval through which incident radiation is transmitted. The first order passband is at the filter design wavelength.

Peak Transmittance:
The highest transmittance value of a filter.

Peak Wavelength:
The wavelength at which a filter has its peak (highest) transmittance.

Period:
See cavity.

Rejection ratio:
The ratio of the maximum transmittance outside the passband to the total transmittance within the passband.

Signal to Noise ratio (S/N):
The ratio of detected energy transmitted through the passband to the detected energy transmitted outside the passband. It is source and detector dependent.

Stray Light:
Unwanted energy transmitted through the filter.

Transmittance (Tx):
The ratio of the transmitted radiation to the incident radiation, expressed as a percent. %T = I/I_0 x 100.

Transmitted radiation (I):
Radiation passing through a filter, either inside or outside the passband.

Ultra-Violet (UV):
Light from the region of the electromagnetic spectrum with wavelengths between 150 nm and 400 nm.

Visible (VIS):
Light from the region of the electromagnetic spectrum with wavelengths between 400 nm and 750 nm.

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Typical Applications | **Interference Filters**

Optometrics Corp's standard filters are available in the wavelengths shown below. All filters are available as either STANDARD PERFORMANCE (≤0.1% Blocking) or HIGH PERFORMANCE (≤0.01% Blocking) filters. Filters vary in price depending upon wavelength and size and whether they are Standard or High Performance blocking filters.

CWL (nm)	APPLICATION(S)
334	Mercury Emission Line
337	N Laser Line
340	NAD/NADH, NADP/NADPH Chemistries
365	Hg Emission Line
394	S Emission Line
400	Clinical Chemistry, Phosphate
405	Hg Emission Line, Alkaline Phosphatase, Acid Phosphatase, GGT, Amylase
410	H Emission Line, Cholinesterase, Silica
415	Ar Emission Line, Clinical Chemistry
420	Ar Emission Line, Ammonia
430	Ar Emission Line
436	Hg Emission Line
442	HeCd Laser Line
450	He Emission Line, Nickel, Clinical Chemistry
455	Cs Emission Line
458	Ar Laser Line, Chloride, Copper, Hydrazine
467	Xe Emission Line, Chloride
470	Cd Emission Line
480	Cd Emission Line
486	H Emission Line
488	Ar Laser Line
492	Clinical Chemistry
500	He Emission Line, Cholesterol, Glucose, Phenol, Triglycerides
505	He Emission Line
508	Cd Emission Line
510	Creatinine, Water Analysis, Iron, Co Emission Line
515	Ar Laser Line
520	Barium, Triglycerides, Magnesium, Uric Acid, Cholesterol
532	Frequency Doubled, Nd: YAG Laser Line
535	Ti Emission Line
540	Total Protein, Ne Emission Line
546	Hg Emission Line
550	Bilirubin
568	Kr Laser Line, Calcium
580	Hg Emission Line, Cyanide
589	Na, He Emission Lines
600	BUN-Colorimetric, Serum Iron, UIBC
610	Water Analysis
620	Calcium, Albumin
632	HeNe Laser Line
636	Zn Emission Line
640	Ne Emission Line
647	Kr Laser Line
650	Calcium, Total Phosphates
656	H Emission Line
671	Lithium, Laser Diode
676	Kr Laser Line
690	Clinical Chemistry, Hg, O_2 Emission Lines
694	Ruby Laser
700	Clinical Chemistry
730	GaAlAs Laser Diode
766	Potassium
780	GaAlAs Laser Diode
800	Ar Emission Line
830	GaAlAs Laser Diode
850	Mercury Emission Line, Laser Diode
852	Cs Emission Line
855	GaAlAs Laser Diode
880	GaAlAs Laser Diode
905	GaAs Laser Diode
940	GaAs Laser Diode
1064	Nd: yAG Laser Line

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Interference Filters | General Specifications & Types of Filters

GENERAL SPECIFICATIONS

Central Wavelength Tolerances
10nm Bandpass Filters ..... ± 2 nm
Broadband Filters ..... ± 15 nm

Halfbandwidth
10 nm Bandpass Filters ..... 10 nm ± 2 nm
Broadband Filters ..... 80 nm ± 25 nm
Laser Line Filters ..... 6.5 nm to 15.2 nm ± 2 nm

Blocking range ..... X-Ray to 1200 nm

Integrated Blocking:
Standard 10 nm Bandpass and
Broadband Filters ..... ≤ 0.1%
High Performance 10 nm
Bandpass Filters ..... ≤ 0.01%

Transmittance:
Standard 10 nm Bandpass Filters:
334 nm to 365 nm ..... ≥ 25%
394 nm to 400 nm ..... ≥ 30%
405 nm to 442 nm ..... ≥ 40%
450 nm to 647 nm ..... ≥ 45%
650 nm to 1064 nm ..... ≥ 50%
High Performance 10 nm Bandpass Filters:
334 nm to 400 nm ..... ≥ 20%
405 nm to 1.06 µ ..... ≥ 35%
Broadband Filters ..... ≥ 55%

Standard Sizes	**Mounted**	**Unmounted**
Diameters	12.7 mm	11.8 mm
	25.4 mm	24.15 mm
Squares	NA	3/4", 50.8 mm
Rectangles	NA	1/2" x 1"

Dimensional Tolerances (Mounted or Unmounted):
Metric Sizes:
Diameters ..... ± 0.25 mm
Squares/Rectangles ..... ± 0.5 mm

Minimum Clear Aperture
12.7 mounted ..... 8.5 mm
11.8 unmounted ..... 9.2 mm
25.4 mounted ..... 20.0 mm
24.15 unmounted ..... 21.4 mm
50.8 mm sq. ..... 40.0 mm sq.
1/2" x 1" ..... .38" x .88"
3/4" x 3/4" ..... .670" sq.

Mounting:
Diameters ..... Black anodized metal ring

Thickness:
Diameters:
Mounted ..... 9.65 mm ± 0.15 mm
Unmounted ..... 7.0 mm max.
Squares/Rectangles ..... 9.78 mm max.

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10nm BANDPASS FILTERS

This type of interference filter finds wide application in spectral analysis, particularly those in clinical chemistry, spectral radiometry, environmental testing, laser line separation, flame photometry and color separation where the required wavelengths are well known.

10nm BANDPASS • 334 to 430 nm

CWL (nm)	12.7 mm DIA. (Mounted) STANDARD PERFORMANCE	12.7 mm DIA. (Mounted) HIGH PERFORMANCE	25.4 mm DIA. (Mounted) STANDARD PERFORMANCE	25.4 mm DIA. (Mounted) HIGH PERFORMANCE	50.8 mm SQ. (Unmounted) STANDARD PERFORMANCE	50.8 mm SQ. (Unmounted) HIGH PERFORMANCE
334	2-3341	2-3344	2-3342	2-3345	—	—
337	2-3371	2-3374	2-3372	2-3375	—	—
340	2-3401	2-3404	2-3402	2-3405	2-3403	2-3406
365	2-3651	2-3654	2-3652	2-3655	2-3653	2-3656
394	2-3941	2-3944	2-3942	2-3945	—	—
400	2-4001	2-4004	2-4002	2-4005	2-4003	2-4006
405	2-4051	2-4054	2-4052	2-4055	2-4053	2-4056
410	2-4101	2-4104	2-4102	2-4105	2-4103	2-4106
415	2-4151	2-4154	2-4152	2-4155	2-4153	2-4156
420	2-4201	2-4204	2-4202	2-4205	2-4203	2-4206
430	2-4301	2-4304	2-4302	2-4305	2-4303	2-4306

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Interference Filters | BandPass Filters

10nm BANDPASS • 436 to 694 nm

CWL (nm)	12.7 mm DIA. (Mounted) STANDARD PERFORMANCE	12.7 mm DIA. (Mounted) HIGH PERFORMANCE	25.4 mm DIA. (Mounted) STANDARD PERFORMANCE	25.4 mm DIA. (Mounted) HIGH PERFORMANCE	50.8 mm SQ. (Unmounted) STANDARD PERFORMANCE	50.8 mm SQ. (Unmounted) HIGH PERFORMANCE
436	2-4361	2-4364	2-4362	2-4365	2-4363	2-4366
442	2-4421	2-4424	2-4422	2-4425	2-4423	2-4426
450	2-4501	2-4504	2-4502	2-4505	2-4503	2-4506
455	2-4551	2-4554	2-4552	2-4555	—	—
458	2-4581	2-4584	2-4582	2-4585	2-4583	2-4586
467	2-4671	2-4674	2-4672	2-4675	2-4673	2-4676
470	2-4701	2-4704	2-4702	2-4705	2-4703	2-4706
480	2-4801	2-4804	2-4802	2-4805	2-4803	2-4806
486	2-4861	2-4864	2-4862	2-4865	—	—
488	2-4881	2-4884	2-4882	2-4885	2-4883	2-4886
492	2-4921	2-4924	2-4922	2-4925	—	—
500	2-5001	2-5004	2-5002	2-5005	2-5003	2-5006
505	2-5051	2-5054	2-5052	2-5055	2-5053	2-5056
508	2-5081	2-5084	2-5082	2-5085	—	—
510	2-5101	2-5104	2-5102	2-5105	2-5103	2-5106
515	2-5151	2-5154	2-5152	2-5155	2-5153	2-5156
520	2-5201	2-5204	2-5202	2-5205	2-5203	2-5206
532	2-5321	2-5324	2-5322	2-5325	2-5323	2-5326
535	2-5351	2-5354	2-5352	2-5355	2-5353	2-5356
540	2-5401	2-5404	2-5402	2-5405	2-5403	2-5406
546	2-5461	2-5464	2-5462	2-5465	2-5463	2-5466
550	2-5501	2-5504	2-5502	2-5505	2-5503	2-5506
568	2-5681	2-5684	2-5682	2-5685	2-5683	2-5686
580	2-5801	2-5804	2-5802	2-5805	2-5803	2-5806
589	2-5891	2-5894	2-5892	2-5895	2-5893	2-5896
600	2-6001	2-6004	2-6002	2-6005	2-6003	2-6006
610	2-6101	2-6104	2-6102	2-6105	2-6103	2-6106
620	2-6201	2-6204	2-6202	2-6205	2-6203	2-6206
632	2-6321	2-6324	2-6322	2-6325	2-6323	2-6326
636	2-6361	2-6364	2-6362	2-6365	2-6363	2-6366
640	2-6401	2-6404	2-6402	2-6405	2-6403	2-6406

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10nm BANDPASS • 436 to 694 nm (continued)

CWL (nm)	12.7 mm DIA. (Mounted) STANDARD PERFORMANCE	12.7 mm DIA. (Mounted) HIGH PERFORMANCE	25.4 mm DIA. (Mounted) STANDARD PERFORMANCE	25.4 mm DIA. (Mounted) HIGH PERFORMANCE	50.8 mm SQ. (Unmounted) STANDARD PERFORMANCE	50.8 mm SQ. (Unmounted) HIGH PERFORMANCE
647	2-6471	2-6474	2-6472	2-6475	2-6473	2-6476
650	2-6501	2-6504	2-6502	2-6505	2-6503	2-6506
656	2-6561	2-6564	2-6562	2-6565	2-6563	2-6566
671	2-6711	2-6714	2-6712	2-6715	2-6713	2-6716
676	2-6761	2-6764	2-6762	2-6765	2-6763	2-6766
690	2-6901	2-6904	2-6902	2-6905	2-6903	2-6906
694	2-6941	2-6944	2-6942	2-6945	2-6943	2-6946

10nm BANDPASS • 730 to 1064 nm

CWL (nm)	12.7 mm DIA. (Mounted) STANDARD PERFORMANCE	12.7 mm DIA. (Mounted) HIGH PERFORMANCE	25.4 mm DIA. (Mounted) STANDARD PERFORMANCE	25.4 mm DIA. (Mounted) HIGH PERFORMANCE	50.8 mm SQ. (Unmounted) STANDARD PERFORMANCE	50.8 mm SQ. (Unmounted) HIGH PERFORMANCE
730	2-7301	2-7304	2-7302	2-7305	2-7303	2-7306
766	2-7661	2-7664	2-7662	2-7665	2-7663	2-7666
780	2-7801	2-7804	2-7802	2-7805	2-7803	2-7806
800	2-8001	2-8004	2-8002	2-8005	2-8003	2-8006
830	2-8301	2-8304	2-8302	2-8305	2-8303	2-8306
852	2-8521	2-8524	2-8522	2-8525	2-8523	2-8526
855	2-8551	2-8554	2-8552	2-8555	2-8553	2-8556
880	2-8801	2-8804	2-8802	2-8805	2-8803	2-8806
905	2-9051	2-9054	2-9052	2-9055	2-9053	2-9056
940	2-9401	2-9404	2-9402	2-9405	2-9403	2-9406
1064	2-1061	2-1064	2-1062	2-1065	2-1063	2-1066

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Interference Filters | Broadband Filters and Astronomy Filters

BROADBAND FILTERS

This line of interference filters covers the region from 400 to 700 nm, stepped every 50 nm and each has a halfbandwidth of 80 nm. Broadband filters are useful in applications where input energy levels are low and where a wide viewing field is needed.

Broadband • 80nm HBW, Stepped every 50nm from 400 - 700nm

CWL (nm)	11.8 mm DIA. (Unmounted)	24.15 mm DIA. (Unmounted)	12.7 mm DIA (Mounted)	25.4 mm DIA. (Mounted)
400	2-4020	2-4022	2-4021	2-4023
450	2-4520	2-4522	2-4521	2-4523
500	2-5020	2-5022	2-5021	2-5023
550	2-5520	2-5522	2-5521	2-5523
600	2-6020	2-6022	2-6021	2-6023
650	2-6520	2-6522	2-6521	2-6523
700	2-7020	2-7022	2-7021	2-7023

ASTRONOMY FILTERS

Designed to minimize the consequences of urban light pollution, these narrow band filters obtain good deep sky images and perform imaging in the same wavelengths as professional astronomers. Narrowband interference filters capture emission line images with much less pollution noise than conventional filters. They have the ability to elicit the delicate structure of emission objects such as planetary and deep-sky emission nebulae.

Features

- Precision Wavelength Selection
- Rejects all other wavelengths (including urban light pollution)
- Produces superior contrast
- Standard 1.25” filter ring mount for ease fo use
- Designed for CCD Camera sensitivity
- Selection include many of the filters previously unavailable to the amateur astronomer including many of the bands used by Hubble
- Same high quality as demanded by professional scientist

Amateur astronomers can now:

- Virtually eliminate interference from skyglow caused by light pollution, natural atmospheric emmission or a bright moon
- Prevent or greatly reduce bright star overexposure problems where faint background nebulousity is being captured using very long exposure times
- Elicit exotic complex structures of nebula and planetaries by isolating light from different emission lines in separate exposures which are then assigned different colors

The Oxygen III Filter is designed for imaging emission nebula. It isolates the bands of doubly and triply ionized oxygen emitted by planetary and emission nebulae while blocking other wavelengths. The contrast between the black background of space and the OIII light allow for views of the Veil, Ring, Dumbbell and Orion nebulae.

The Hydrogen Alpha Filter is designed for non-solar imaging and is used to image deep-sky objects that emit in the H-alpha passband. It is too wide for solar-prominence viewing, but is ideal for deep sky.

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LASER COMPONENTS

Astronomy Filters | **Interference Filters**

The Hydrogen Beta Filter isolates only the Hydrogen-beta line of the spectrum while blocking the rest of the overall spectrum of light. It is designed specifically for viewing extremely faint nebulae with hydrogen beta emission such as the California Nebulae in Perseus and the Horsehead in Orion.

The Sulfur Filter is designed to cut the glare of urban light pollution allowing for views of Saturn and Jupiter. Images of the Ring Nebula M57 and the Eagle Nebula M16 can be obtained by using this filter with the Hydrogen alpha and the Oxygen III filters.

Specifications

	HYDROGEN ALPHA	HYDROGEN BETA	OXYGEN 3	SULPHUR
CWL (nm)	656.3 ± 2	486.1 ± 2	497.7 ± 2	672.5 ± 2
HBW (nm)	10 ± 2	8 ± 2	12 ± 2	10 ± 2
Blocking	0.01%	0.01%	0.01%	0.01%
% Transmission	65% min	60% min	60% min	65% mim

Astronomy Filters

2-9656	Hydrogen Alpha	10 nm HBW 1.25” mounted	
2-9486	Hydrogen Beta	10 nm HBW 1.25” mounted	
2-9497	Oxygen3	10 nm HBW 1.25” mounted	
2-9672	Sulphur 1	10 nm HBW 1.25” mounted	
2-2112	Set of all four		

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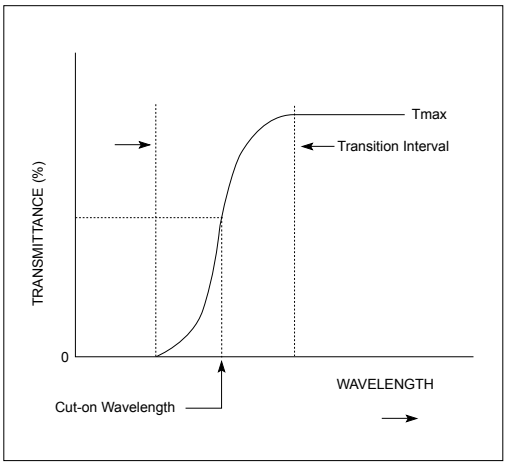
Interference Filters | Long Pass Cut-on Filters

Optometrics' long pass cut-on filters are cored from selected color glasses which transmit radiation above and block radiation below a specified wavelength. The wavelength interval (transition interval) from blocking to maximum transmission is sharp, typically 25 to 35 nm. Long pass cut-on filters are identified by a cut-on wavelength, i.e. the wavelength at 50% of maximum transmission.

Long pass cut-on filters have an average high transmission of 85% from 15 to 20 nm above their cut-on wavelength to 2000 nm. Attenuation of radiation below the cut-on wavelength is due to absorption of the colorants in the glass and the thickness of the glass. Superior blocking in Optometrics filters (0.001%) is due to the use of 3 mm thick color glass.

Long pass cut-on filters are widely used for additional blocking of UV radiation and for high transmission of a broad spectral region above a specified wavelength.

Optometrics' long pass cut-on filters are all epoxied in a black metal ring for easy mounting and handling and are 25.4 mm dia. x 9.65 mm thick. The cut-on wavelength is marked on all filters.



CUT-ON FILTER TERMINOLOGY

GENERAL SPECIFICATIONS

Cut-on Wavelength .....± 5 nm
Blocking (Short wavelengths) 0.001%
Transmission (High ≥ average) 85%
Transmission Range.....Cut-on to 2000 nm

Dimensions and Tolerances:
Diameter (Mounted) ..... 25.4 mm ± 0.25 mm
Thickness (Mounted)..... 9.65 mm ± 0.15 mm
Clear Aperture .....20.0 mm ± 0.25 mm

Long Pass Cut-on Filters

CATALOG NO.	CUT-ON WAVELENGTH (nm)	
7-1201	375	
7-1202	420	
7-1203	420	
7-1204	630	
7-1205	1200	
7-1206	1200	

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REFLECTIVE NEUTRAL DENSITY FILTERS

Reflective Neutral Density filters possess level spectral transmittance characteristics across the visible region. Reflective Neutral density filters control light intensity without selectively absorbing energies at specific wavelengths. They are, therefore, generally used to attenuate the intensity of a beam of light over a broad spectral region. This property is often required to prevent saturation or damage to a wide variety of detectors and even the human eye.

Reflective Neutral density filters are available in standard densities of 0.3, 0.5, 1.0, 1.3, 1.5 and 2.0.

Stack them and the total density is the sum of the density of each filter in the stack, permitting the creation of intermediate neutral density values.

SPECIFICATIONS

Material ..... Lime soda glass
Dimensional tolerance ..... ± 0.02”
Thickness ..... 0.06”
Surface quality ..... 80/50 Scratch Dig
Design wavelength range ..... 400 - 700 nm
Density tolerance ..... ± 5% of density
Parallelism ..... < 3 min of arc

Neutral Density Filters

OPTICAL DENSITy	Tx %	12.5 mm DIA. (Unmounted)	25 mm DIA. (Unmounted)	50 mm SQUARE (Unmounted)
0.3	50.0	2-1220	2-1300	2-1350
0.5	32.0	2-1221	2-1301	2-1351
1.0	10.0	2-1222	2-1302	2-1352
1.3	5.0	2-1223	2-1303	2-1353
1.5	3.2	2-1224	2-1304	2-1354
2.0	1.0	2-1225	2-1305	2-1355
6 piece ND set (1 of each OD)		2-1240	2-1320	2-1370

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LASER COMPONENTS

Interference Filters | Laser Line Filters

LASER LINE FILTERS

Laser line filters are designed to isolate laser lines. Standard filters are manufactured for use with Cadmium, Argon, YAG, He-Ne and Ruby lasers and are available in 1/2" x 1", 3/4" square and 25.4 mm diameter sizes.

Central wavelength tolerance ..... ± 2 nm
Half bandwidths ..... 6.8 to 15.2 nm
Half bandwidth tolerance ..... ± 1.5 nm
Blocking range ..... far UV to IR
Blocking ..... < 0.1%
Dimensional tolerances ..... ± 0.02"

SPECIFICATIONS

Laser Line Filters

CWL (nm)	HBW (nm)	TRANSMISSION (%)	USE WITH LASER	1/2" x 1" (Unmounted)	3/4" SQUARE (Unmounted)	25.4 MM DIA. (Mounted)
457.9	6.8	35	Cadmium	2-0107	2-0108	2-0109
488.0	7.2	35	Argon	2-0207	2-0208	2-0209
514.5	8.0	40	Argon	2-0307	2-0308	2-0309
532.0	8.6	40	yAG	2-0407	2-0408	2-0409
632.8	11.1	45	He-Ne	2-0507	2-0508	2-0509
694.3	12.4	45	Ruby	2-0607	2-0608	2-0609
1064.0	15.2	45	yAG	2-0707	2-0708	2-0709

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APPLICATION SPECIFIC FILTER KITS

Optometrics' filter sets are comprised of interference filters that can be used for a variety of spectroscopic tests within a specific area of interest.

Optometrics offers its filter kits with High Performance blocking. High Performance filters block off the radiation outside the passband to 0.01% of the radiation outside the passband and is preferable for applications that require lower stray light.

GENERAL SPECIFICATIONS

Central Wavelength .....± 2nm
Halfbandwidth .....10 nm ± 2nm
Blocking range .....X-Ray to 1200 nm
Integrated Blocking:
High Performance..... ≤ 0.01%
Dimensions (Mounted):
Diameters .....12.7 mm ± 0.25 mm
Thickness.....9.65 mm ± 0.15 mm
Clear Aperture.....8.5 mm minimum
Mounting..... Black anodized metal ring

LASER DIODE FILTER SET

Catalog No. 2-2107

Application

Designed for use with photodetector systems with S/N in excess of 1000:1, these filters can be used to separate specific laser lines in optical experiments where only a single wavelength is required.

This set of 4 interference filters for laser diode applications includes filter wavelengths of 671nm, 780nm, 850nm and 870nm. Filters are ring mounted with an external diameter of 12.7mm.

CWL (nm)	TX (%)
671	≥35
780	≥ 35
850	≥ 35
870	≥ 35

FLAME PHOTOMETRY FILTER SET

Catalog No. 2-2109

Application

These filters are used for the determination of electrolytes in clinical chemistry applications using flame photometry. Measurements can be made in any aqueous solution including plasma, serum or urine.

This set of 5 filters is designed specifically for the measurement of Barium (520nm), Sodium (589nm), Calcium (620nm), Lithium (671nm) and Potassium (766nm). Filters are ring mounted with an external diameter of 12.7mm.

CWL (nm)	Test	TX (%)
520	Barium	≥ 40
589	Sodium	≥ 40
620	Calcium	≥ 40
671	Lithium	≥ 40
766	Potassium	≥ 40

LASER LINE FILTER SET

Catalog No. 2-2108

Applications

These filters can be used to isolate single wavelengths from the spectrum of specific lasers (e.g. Argon or Nd:YAG lasers) in optical experiments where a single laser wavelength is required.

This set of 7 interference filters for laser line separation includes filter wavelengths 488nm (Argon), 515nm (Argon), 532nm (Nd:YAG), 632nm (Helium Neon), 694nm (Ruby), 905nm (Gallium-Arsenide) and 1064nm (Nd:YAG). Filters are ring mounted with an external diameter of 12.7nm.

CWL (nm)	Laser	TX (%)
488	Ar	≥ 35
515	Ar	≥ 35
532	ND: (YAG)	≥35
632	HeNe	≥35
694	Ruby	≥ 35
905	GaAs	≥35
1064	ND: YAG	≥

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LASER COMPONENTS

Interference Filters | Application Specific Filter Kits

IMMUNOCHEMISTRY FILTER SET

Catalog No. 2-2111

Applications

These filters are designed for the determination of specific biochemical compounds using colorimetry of fluorescence in laboratories where compounds are being measured as substrates or products of biochemical reactions. The filters can be used when these compounds are measured using spectrophotometric or flourometric techniques in chemical or immunochemical experiments.

This set of 5 filters is designed to measure NAD and NAPD (340nm), ALP (450nm), TMB (450nm), OPD (492nm) and reference (632nm). Filters are ring mounted with an external diameter of 12.7mm.

CWL (nm)	Test	TX (%)
340	NAD/NADP	≥ 30
405	Alkaline Phosphatase (ALP)	≥ 40
450	Tetramethylbenzidine (TMB)	≥ 40
492	O-phenylenediamine (OPD)	≥ 40
632	Reference	≥ 40

Filter Kits

Catalog No .	Kit Application	No. of filters in Set	Blocking	
2-2107	Laser Diode	4	≤ 0.01% Abs	
2-2108	Laser Line	7	≤ 0.01% Abs	
2-2109	Flame Photometry	5	≤ 0.01% Abs	
2-2111	Immunochemistry	5	≤ 0.01% Abs	

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