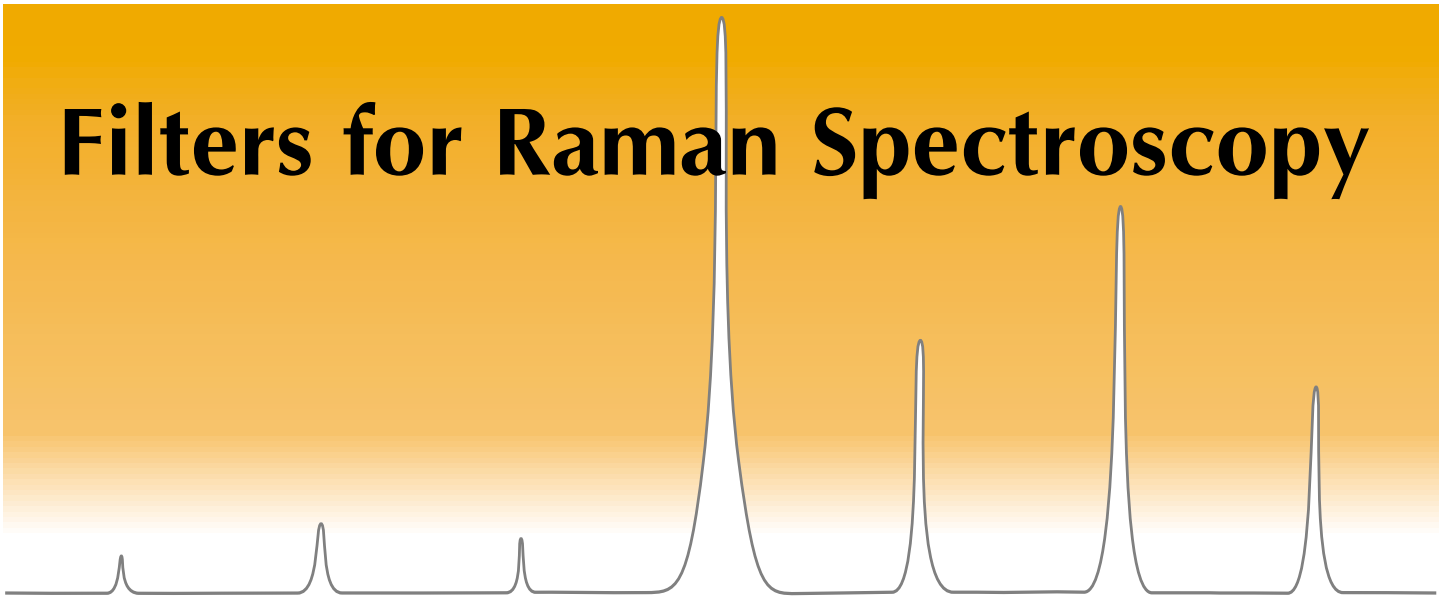
Filters for Raman Spectroscopy



For over 25 years, Omega Optical has been a leading manufacturer of high performance filters for a wide range of applications in Raman spectroscopy. We have recently developed the Alpha-Epsilon series edge filter, which provides performance superior to a holographic notch filter at a much lower cost. Combined with advances in laser and detector technology, our Raman filters are part of a revolution in Raman spectroscopy, expanding the use and applications of this analytical method.

Raman spectroscopy provides valuable structural information about materials. When laser light is incident upon a sample, a small percentage of the scattered light may be shifted in frequency. The frequency shift of the Raman scattered light is directly related to the structural properties of the material. A Raman spectrum provides a "fingerprint" that is unique to the material. Raman spectroscopy is employed in many applications including mineralogy, pharmacology, corrosion studies, analysis of semiconductors and catalysts, in situ measurements on biological systems, and even single molecule detection. Applications will continue to increase rapidly along with further improvements in the technology.

A Raman signature provides positive material identification of unknown specimens to a degree that is unmatched by other spectroscopies. Raman spectroscopy presents demanding requirements for the detection and resolution of narrow bands of light with very low intensity and minimal frequency shift relative to the source. Omega Optical is committed to supporting this science with optical coatings of the highest phase thickness and resulting superior performance.

Filter Products

- Laser Line Interference Filters
- Alpha-Epsilon Series Longpass and Shortpass Edge Filters
- XR Raman Filter Set
- UV Raman Edge Filters
- Rejection Band Filters
- Raman Notch Filters
- Tunable Narrow Band Filters
- Raman Microscope Laser Reflectors

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LASER LINE INTERFERENCE FILTERS

These filters pass a limited band centered on the resonance of the laser and attenuate the background plasma and secondary emissions that can interfere with Raman spectra. In the case of diode lasers, these filters can be used to make the light output more monochromatic. Laser line filters provide 70-90% throughput with spectral control from 0.85 to 1.15 of the central wavelength. An accessory blocker can be ordered to control a much wider spectral range from the deep UV to the IR. This additional blocker results in a minor (20%) loss of throughput.

				Narrow Band Filter			Filter With Blocking	
Laser Line	Omega Number	Central Wavelength	FWHM	Typical T	Blocking Range	Product Number	Blocking Range	Product Number
4th Nd YAG	266 BP15	266 +2.2-1.5 nm	15 ± .3nm	≥20%	UV-FIR	XL01	-	-
HeCd	325 NB2	325 +.3-.2 nm	2 ± .4nm	≥25%	.9-1.1 X CWL	XL02	UV-2500 nm	XLK02
3rd Nd YAG	355 NB3	355 +.4-.3 nm	3 ± .6nm	≥60%	.9-1.1 X CWL	XL03	UV-2500 nm	XLK03
HeCd	442 NB2	442 +.3-.2 nm	2 ± .4nm	≥60%	.85-1.15 X CWL	XL04	UV-2500 nm	XLK04
Argon	457 NB2	457 +.3-.2 nm	2 ± .4nm	≥60%	.85-1.15 X CWL	XL05	UV-2500 nm	XLK05
Argon	488 NB3	488 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL06	UV-2500 nm	XLK06
Argon	515 NB3	515 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL07	UV-1500 nm	XLK07
2nd Nd YAG	532 NB3	532 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL08	UV-1500 nm	XLK08
HeNe	543 NB3	543 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL09	UV-1500 nm	XLK09
HeNe	594 NB3	594 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL10	UV-1150 nm	XLK10
HeNe	612 NB3	612 +.4-.3 nm	3 ± .6nm	≥80%	.85-1.15 X CWL	XL11	UV-1150 nm	XLK11
HeNe	633 NB4	633 +.6-.4 nm	4 ± .8nm	≥80%	.85-1.15 X CWL	XL12	UV-1150 nm	XLK12
Krypton	647 NB4	647 +.6-.4 nm	4 ± .8nm	≥80%	.85-1.15 X CWL	XL13	UV-1150 nm	XLK13
AlGaAs	665 WB25	665 + 3.7-2.5 nm	25 ± 5nm	≥80%	.85-1.15 X CWL	XL15	UV-1150 nm	XLK15
Krypton	676 NB4	676 +.6-.4 nm	4 ± .8nm	≥80%	.85-1.15 X CWL	XL14	UV-1150 nm	XLK14
Ruby	694 NB4	694 +.6-.4 nm	4 ± .8nm	≥80%	.85-1.15 X CWL	XL16	UV-1150 nm	XLK16
AlGaAs	775 WB25	775 +3.7-2.5 nm	25 ± 5nm	≥85%	.85-1.15 X CWL	XL17	UV-2500 nm	XLK17
AlGaAs	825 WB25	825 +3.7-2.5 nm	25 ± 5nm	≥85%	.85-1.15 X CWL	XL18	UV-2500 nm	XLK18
AlGaAs	850 WB25	850 +3.7-2.5 nm	25 ± 5nm	≥85%	.85-1.15 X CWL	XL19	UV-2500 nm	XLK19
AlGaAs	875 WB25	875 +3.7-2.5 nm	25 ± 5nm	≥85%	.85-1.15 X CWL	XL20	UV-2500 nm	XLK20
1st Nd YAG	1064 NB8	1064 +1.2-.8 nm	8 ± 1.6nm	≥80%	.85-1.15 X CWL	XL22	UV-1500 nm	XLK22

ALPHA-EPSILON SERIES LONGPASS AND SHORTPASS EDGE FILTERS

We now offer Alpha-Epsilon longpass edge filters (for Stokes measurements) and Alpha-Epsilon shortpass edge filters (for anti-Stokes measurements). The new Alpha technology offers the following features:

- Performance that exceeds holographic notch in edge steepness, depth of blocking, and transmittance in the passband.
- Extremely sharp transitions from stopband to passband.
- Precise repeatable location of cut-on wavelengths.
- Smooth cut-on.
- Near unity transmittance across the passband.
- Deep attenuation over the stopband.
- Wide free spectral ranges in both stopband and passband.
- Thin component assemblies for optical quality transmitted wavefront.
- Acceptance half-cone-angles up to 15° for improved performance in fast optical systems.
- Tunable to slightly shorter wavelengths by tilting to an off-normal angle to the incident light.
- Capability for stacking two or more filters in series to greatly increase laser attenuation without significant loss in throughput.

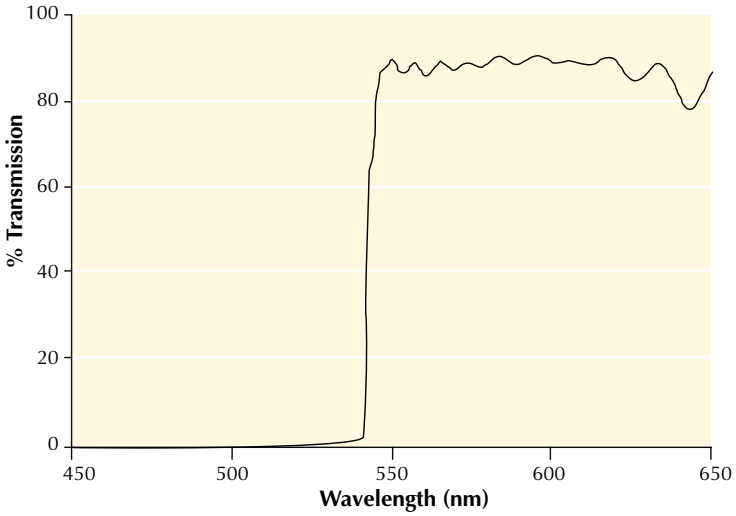
XR RAMAN FILTER SETS

We currently offer stock filter sets for three different Raman laser wavelengths. Each set comes with a laser line interference filter for removing spurious background from the probe laser, and an Alpha-Epsilon longpass edge filter to provide deep blocking of the Rayleigh scattering. The laser line filter is designed to provide >60% transmission of the laser line, and broadband blocking from the UV to the IR. The longpass edge filter provides OD>5 blocking (0.001% T) of the laser line, with a very steep edge slope and high transmission in the passband (>85% average).

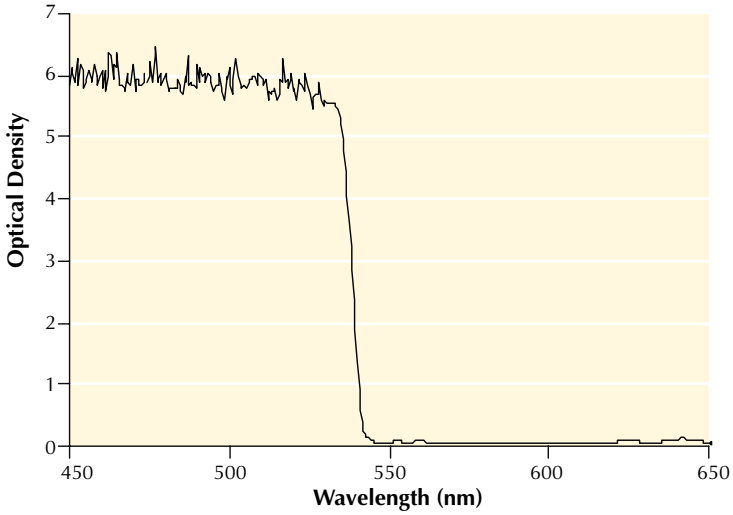
Filter set product number	Laser wavelength	Laser line filter product number	Alpha-Epsilon longpass edge filter product number*	Wavelength of OD 5 blocking	Cut-On wavelength of 50% transmission
XR01	488 nm	XLK06	XR3000	488 nm	493 nm
XR02	514.5 nm	XLK07	XR3001	514.5 nm	520 nm
XR03	532 nm	XLK08	XR3002	532 nm	537 nm

Specifications*		
Laser Attenuation	Optical Density	> 5.0
Spectral Edgewidth	Wavenumbers between OD 0.3 (50% T) and OD 5.0 points	< 200 wavenumbers
	Nanometers between OD 0.3 and OD 5.0 points for filter that blocks 532 nm	< 6 nm
Transmission in Passband	Average value	> 85%

Transmission vs. Wavelength for XR3002



Optical Density vs. Wavelength for XR3002



UV RAMAN EDGE FILTERS

UV Raman spectroscopy is a very powerful technique that demands high quality optical filters. We are currently pushing the limits of optical thin film technology to produce environmentally stable edge filters for UV Raman applications using our proprietary Alpha technology. To date we have accomplished blocking of OD>4 and blocking wavelengths as low as 228.9 nm. The high throughput, deep blocking, and steep edges of the UV Raman edge filter coatings provide performance features superior to low throughput monochromators, at far less cost.

REJECTION BAND FILTERS

For applications that require simultaneous measurement of Stokes and anti-Stokes Raman shifts, we offer rejection band filters and baffle-style Raman notch filters. Rejection Band (RB) filters attenuate the laser line while transmitting light at both Stokes and anti-Stokes shifted Raman frequencies. The width of the rejection band is between 15 nm and 40 nm at 10% transmission, and reaches a maximum attenuation of approximately 10^{-3} (OD 3). The average transmission outside the stop band is 75% with the exception of higher and lower harmonics where high reflectivity occurs.

RAMAN NOTCH FILTERS

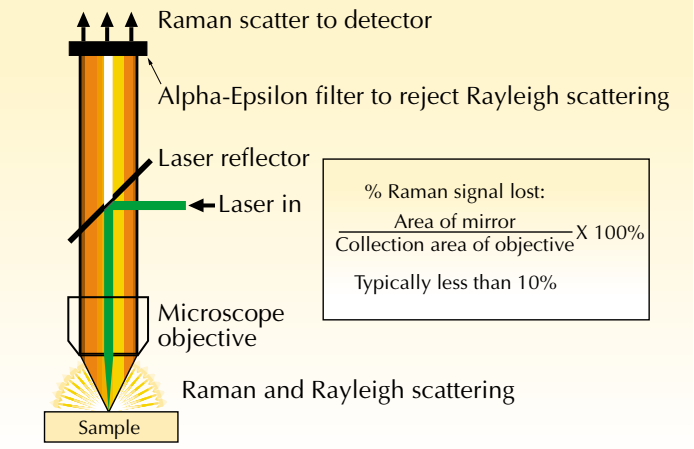
The Raman Notch (RN) baffle filter is a high-performance rejection band filter, consisting of four precisely aligned interference filters arranged in a chevron baffle configuration and sealed in a rectangular housing. It deeply attenuates the laser light to a minimum of 10^{-6} and has a ripple-free transmission region on both sides of the rejection band. Transmission is typically >10% at 150 cm^{-1} from the laser line, and >50% from 225 cm^{-1} to 3200 cm^{-1}. Well-collimated light is necessary for proper use of Raman Notch baffle filters.

TUNABLE NARROW BAND FILTERS

These filters are designed for Raman imaging applications in which a high signal throughout is required for a specific Raman mode. The concept is based on the fact that the central wavelength of a narrow bandpass filter blue-shifts with increasing angle of incidence. An entire Raman spectral region can be scanned by selecting a series of tunable narrow band filters with different bandpass wavelengths and continuously tuning their angles of incidence. These filters provide high throughput, high resolution, and low image distortion, superior to the dispersive or diffractive filtering of images. They can be mounted in a patented scanning filter wheel that allows for nearly continuous, linear wavelength tuning.

RAMAN MICROSCOPE LASER REFLECTOR

Designed for use in an epi-illumination geometry Raman microscope, the laser reflector is an image quality AR-coated glass element with a centered 2 mm diameter aluminum mirror. Mounted at 45°, it reflects the laser into the objective, and then transmits all but a small fraction of the Rayleigh and Raman scattered light collected with the objective. For example, using a 40X objective having a numerical aperture of 0.8 and a focal length of 4 mm, only 3% of the Raman signal is lost upon transmission through the laser reflector. This loss is related only to the size of the mirror and the collection properties of the microscope objective. Used with an Alpha-Epsilon edge filter for Rayleigh rejection, this allows the measurement of Raman lines very close to the laser wavelength with little loss in signal throughput.



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