The Standard in Optical Filters

2012 Master Catalog

Fluorescence Filters
Raman Spectroscopy Filters
Laser & Analytical Instrumentation Filters

New Online Quoting

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guaranteed in stock

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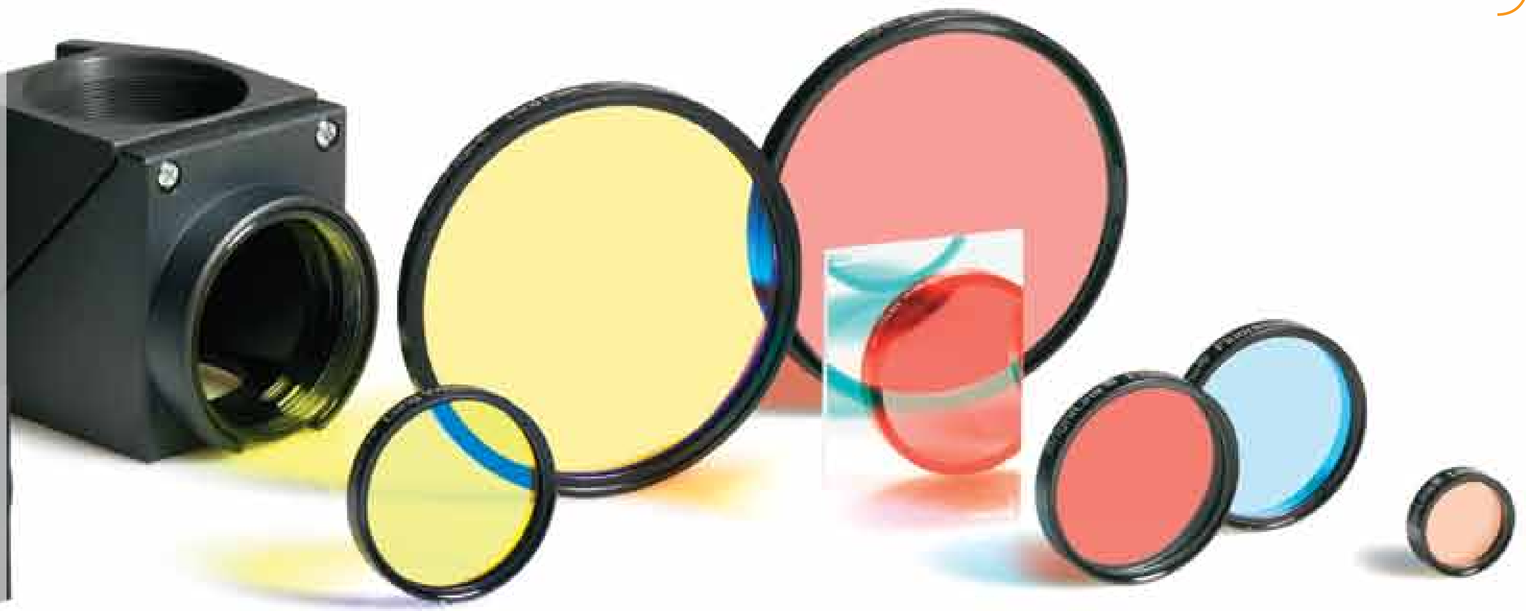
in only two days



The Right Filter. Right Now.

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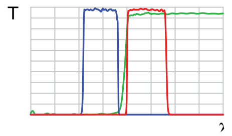
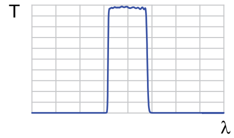
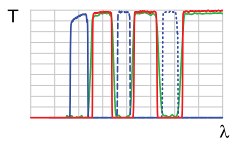
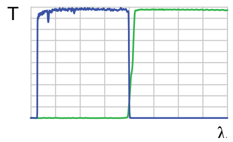
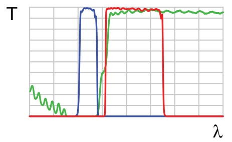
Fluorescence Filters

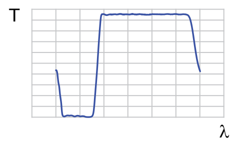


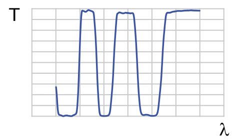




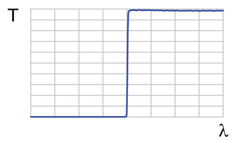


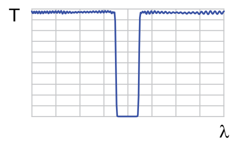


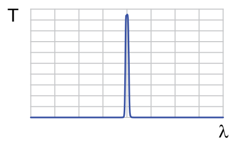


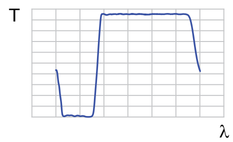


Raman Spectroscopy Filters









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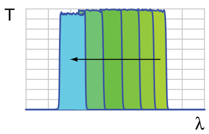
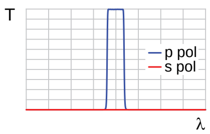
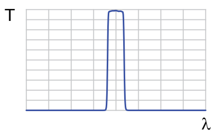
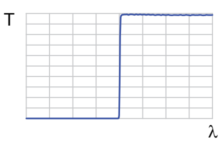
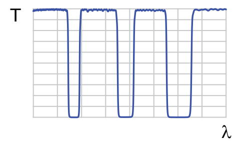
Laser & Optical System Filters

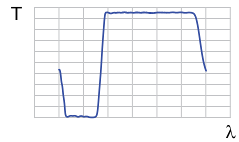


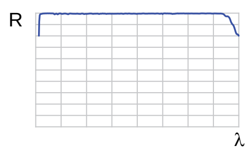












Reference, Technical and Product Notes

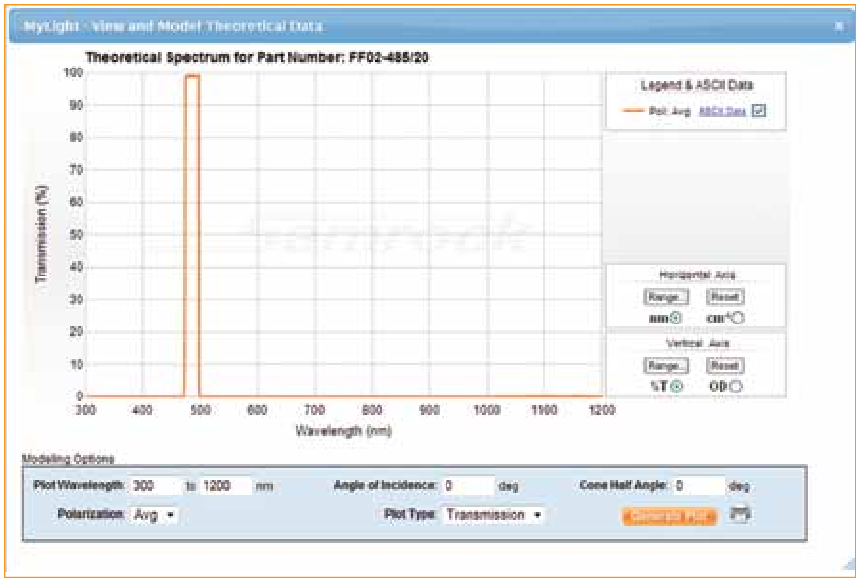
All filter specifications are online.

MyLight™

Gives you the ability to characterize optical filters under varying theoretical conditions in real time. Interested in seeing how a Semrock catalog filter behaves under a particular angle of incidence, polarization or cone half angle?

MyLight can provide you with the theoretical answers by simply entering your parameters and selecting "Generate Plot."

MyLight data can also be saved, re-drawn and printed.

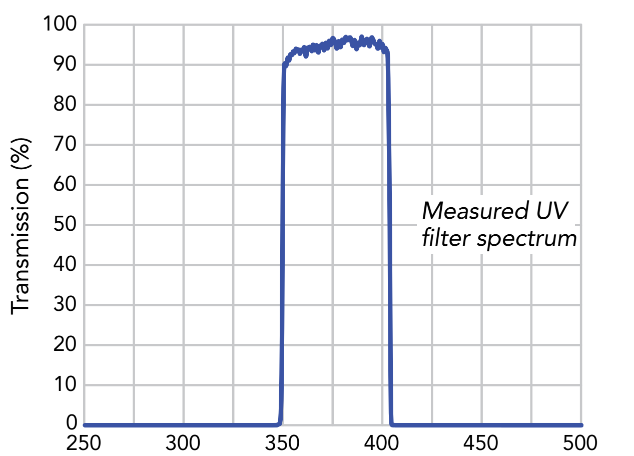


Now you can create a quote online in minutes.
Just add to shopping cart and click "Quote."

Superior Performance

Semrock successfully combines the most sophisticated and modern ion-beam-sputtering deposition systems, renowned for their stability, with its own proprietary deposition control technology, unique predictive algorithms, process improvements, and volume manufacturing capability. The result is optical filters of unsurpassed performance that set the standard for the Biotech and Analytical Instrumentation industries. These filters are so exceptional that they are patented and award-winning. We never stop innovating.

Semrock's no burn-out optical filters are all made with ion-beam sputtering and our exclusively single-substrate construction for the highest transmission on the market. Steeper edges, precise wavelength accuracy, and carefully optimized blocking mean better contrast and faster measurements – even at UV wavelengths.



Proven Reliability

All Semrock filters demonstrate exceptional reliability. The simple all-glass structure, combined with ion-beam-sputtered hard coatings (as hard as the glass on which they are coated) mean they are virtually impervious to humidity and temperature induced degradation. Plus, Semrock filters don't "burn out" and they can be readily cleaned and handled.

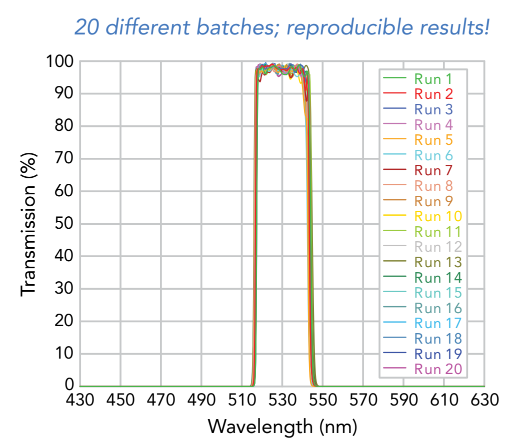
Semrock confidently backs our filters with a comprehensive five-year warranty. Built to preserve their high level of performance in test after test, year after year, our filters reduce your cost of ownership by eliminating the expense and uncertainty of replacement costs.

Environmental Durability Testing	Mil Spec Standard / Procedure
Humidity	MIL-STD-810F (507.4)
High Temperature	MIL-STD-810F (501.4)
Low Temperature	MIL-STD-810F (502.4)
Physical Durability Testing	**Mil Spec Standard / Procedure**
Adhesion	MIL-C-48497A (4.5.3.1)
Humidity	MIL-C-48497A (4.5.3.2)
Moderate Abrasion	MIL-C-48497A (4.5.3.3)
Solubility/Cleanability	MIL-C-48497A (4.5.4.2)
Water Solubility	MIL-C-48497A (4.5.5.3)

Semrock filters have been tested to meet or exceed the requirements for environmental and physical durability set forth in the demanding U.S. Military specifications MIL-STD-810F, MIL-C-48497A, MIL-C-675C, as well as the international standard ISO 9022-2.

Repeatable Results

Batch-to-batch reproducibility. Whether you are using a filter manufactured last year or last week, the results will always be the same. Our highly automated volume manufacturing systems closely monitor every step of our processes to ensure quality and performance of each and every filter. End users never need to worry whether results will vary when setting up a new system, and OEM manufacturers can rely on a secure supply line.



BrightLine® Single-band Sets for Popular Fluorophores

For a complete list, see www.semrock.com

Primary Fluorophores	Peak EX	Peak EM	Recommended BrightLine Sets	Page
5-FAM (5-carboxyfluorescein)	492	518	FITC-3540C	11
5-ROX (carboxy-X-rhodamine)	580	605	TXRED-4040C TXRED-A-Basic	13 24
5-TAMRA (5-carboxytetramethyl-rhodamine, high pH > 8)	542	568	TRITC-B	13
Alexa Fluor® 380	346	442	DAPI-1160B DAPI-5060C BFP-A-Basic	11 11 23
Alexa Fluor® 405	402	421	DAPI-1160B DAPI-5060C	11 11
Alexa Fluor® 488	495	522	FITC-3540C FITC-A-Basic	12 23
Alexa Fluor® 532	531	554	TRITC-B	13
Alexa Fluor® 546	556	573	TRITC-B TRITC-A-Basic	13 24
Alexa Fluor® 555	555	565	Cy3-4040C	13
Alexa Fluor® 568	578	603	TXRED-4040C TXRED-A-Basic	13 24
Alexa Fluor® 594	590	617	TXRED-4040C TXRED-A-Basic	13 24
Alexa Fluor® 647	650	668	Cy5-4040B	13
Alexa Fluor® 660	663	690	Cy5-4040B	13
Alexa Fluor® 680	679	702	Cy5.5-B	14
Alexa Fluor® 750	749	775	Cy7-B	14
AMCA / AMCA-X	380	450	DAPI-1160B DAPI-5060C BFP-A-Basic	11 11 23
AmCyan	454	488	CFP-2432C	11
BFP	380	438	DAPI-1160B DAPI-5060C LF405-A BFP-A-Basic	11 11 39 23
BODIPY	505	513	FITC-3540C FITC-A-Basic	12 23
Calcofluor White	380	440	DAPI-1160B DAPI-5060C CFW-LP01 CFW-BP01	11 11 23 23
Cascade Blue™	401	423	DAPI-1160B DAPI-5060C	11 11
CFP (cyan GFP)	434	477	CFP-2432C CFP-A-Basic	11 23
Cerulean	434	475	CFP-2432C LF442-A CFP-A-Basic	11 39 23
CoralHue Kusabira Orange	548	559	Cy3-4040C	13

Primary Fluorophores	Peak EX	Peak EM	Recommended BrightLine Sets	Page
Cy2™	489	506	GFP-3035D LF488-B GFP-A-Basic	12 40 23
Cy3™	552	570	Cy3-4040C LF561-A	13 40
Cy3.5™	580	591	Cy3.5-A-Basic TXRED-4040C	24 13
Cy5™	649	666	Cy5-4040B LF635-A	13 40
Cy5.5™	676	690	Cy5.5-B	14
Cy7™	753	775	Cy7-B	14
DAPI	389	461	DAPI-1160B DAPI-5060C BFP-A-Basic LF405-A	11 11 23 40
DEAC	432	472	SpAqua-C	17
DsRed Monomer	556	586	Cy3-4040C LF561-A	13 40
DsRed2	563	582	Cy3-4040C LF561-A	13 40
DsRed-Express	557	579	Cy3-4040C LF561-A	13 40
dTomato	554	581	TRITC-B Cy3-4040C LF561-A TRITC-A-Basic	13 13 40 24
DyLight 800	777	794	IRDYE800-33LP-A	14
EBFP	380	440	DAPI-1160B DAPI-5060C LF405-A	11 11 39
Emerald	490	510	FITC-3540C GFP-3035D	12 12
FAM	492	518	FITC-3540C FITC-A-Basic	12 23
Fast Blue	390	440	DAPI-1160B DAPI-5060C	11 11
FITC (Fluorescein)	492	523	FITC-3540C FITC-A-Basic LF488-B	12 23 40
Fluo-3	506	526	YFP-2427B LF514-A YFP-A-Basic	13 40 24
Fura-2	393, 338	512, 505	FURA2-C	11
Fura Red™ (high pH)	572	657	TXRED-4040C	13
GFP (EGFP)	489	508	GFP-3035D GFP-A-Basic LF488-B	12 23 39
HcRed	590	616	TXRED-4040C	13
Hoechst 33258 Hoechst 33342 Hoechst 34580	392 382 392	485 485 440	DAPI-1160B DAPI-5060C BFP-A-Basic	11 11 23

BrightLine® Single-band Sets for Popular Fluorophores

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Primary Fluorophores	Peak EX	Peak EM	Recommended BrightLine Sets	Page
ICG	768	807	ICG-B	14
IRDye800 CW	775	792	IRDYE800-33LP-A	14
LysoTracker Green	504	512	FITC-3540C	12
LysoTracker Red	577	592	Cy3-4040C	13
mApple	587	610	TXRED-A-Basic or LF561-A LF561/ LP-A	24 40 40
mCherry (mRFP)	587	610	mCherry-B TXRED-A-Basic LF561-A or LF594-A	13 24 40 40
mHoneydew	478	561	FITC-3540C YFP-2427B	12 13
mKate2	588	633	mCherry-B TXRED-4040C LF594-A TXRed-A-Basic	13 13 40 24
mOrange	548	568	TRITC-B Cy3-4040C	13 13
mPlum	594	648	TXRED-4040C LF594-A	13 40
mStrawberry	575	596	TRITC-B Cy3-4040C LF561-A Cy3.5-A-Basic	13 13 40 24
mTangerine	568	585	TRITC-B Cy3-4040C LF561-A	13 13 40
MitoTracker™ Green	490	516	FITC-3540C	12
MitoTracker™ Orange	551	576	Cy3-4040C	13
MitoTracker™ Red	578	599	TXRED-4040C	13
Nicotine	270	390	TRP-A	11
Nile Red	549	628	TRITC-B TXRED-4040C	13 13
Oregon Green™	503	522	FITC-3540C	12
Oregon Green™ 488	496	524	FITC-3540C	12
Oregon Green™ 500	497	517	FITC-3540C	12
Oregon Green™ 516	512	530	FITC-3540C	12
Phycoerythrin (PE)	567	576	Cy3-4040C	13
Qdot® 525 Nanocrystals	UV-Blue	525	QD525-B QDLP-B	18 18
Qdot® 605 Nanocrystals	UV-Blue	605	QD605-B QDLP-B	18 18

Primary Fluorophores	Peak EX	Peak EM	Recommended BrightLine Sets	Page
Qdot® 625 Nanocrystals	UV-Blue	625	QD625-B QDLP-B	18 18
Qdot® 655 Nanocrystals	UV-Blue	655	QD655-B QDLP-B	18 18
Rhodamine	550	573	TRITC-B TRITC-A-Basic	13 24
Rhodamine Green	502	527	YFP-2427B	13
ROX	568	595	Cy3-4040C	13
SNARF (carboxy) 488 Excitation pH6	549	589	Cy3-4040C	13
SNARF (carboxy) 516 Excitation pH6	549	586	Cy3-4040C	13
SNARF (carboxy) Excitation pH9	576	639	TXRED-4040C	13
Sodium Green	506	532	FITC-3540C	12
SpectrumAqua™	433	480	SpAqua-C	17
SpectrumFRed™ (Far Red)	655	675	Cy5-4040B	13
SpectrumGold™	530	555	SpGold-B	17
SpectrumGreen™	497	538	SpGr-B	17
SpectrumOrange™	559	588	SpOr-B	17
SpectrumRed™	587	612	SpRed-B	17
Sulphorhodamine B can C	523	595	TRITC-B	13
TAMRA	565	580	Cy3-4040C	13
Texas Red®	595	617	TXRED-4040C TXRED-A-Basic or LF561-A or LF594-A	13 24 40 40
TRITC (Tetramethylrhodamine)	555	580	TRITC-B	13
TRITC (Tetramethylrhodamine) - *"reddish" appearance*	545	623	TRITC-A-Basic	24
Tryptophan	295	340	TRP-A	11
wtGFP	475	509	WGFP-A-Basic or LF488-B	23 40
YFP (yellow GFP) EYFP	513	527	YFP-2427B YFP-A-Basic LF516-A	13 24 39
Zs Yellow1	529	539	YFP-2427B YFP-A-Basic	13 24

BrightLine® Multi-band Sets for Popular Fluorophores

Non- laser Sets

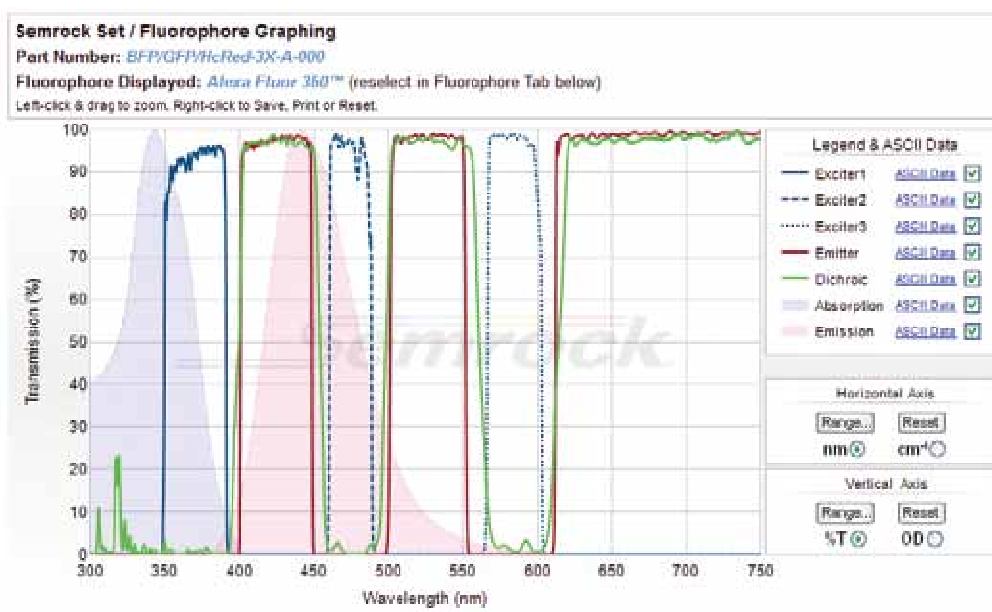
Multiband Filter Set	Page	Set Type	Blue BFP, DAPI, Hoeschst, Alexa Fluor 350	Cyan CFP, AmCyan, BOBO-1, BO-PRO1	Green FITC, GFP, Bodipy, Alexa Fluor 488	Yellow Cy3, DsRed, Alexa Fluor 555	Orange TRITC, DsRed, Cy3, Alexa Fluor 555, YFP	Red Texas Red, mCherry, Alexa Fluor 568 & 594,Cy5	Far Red Cy7
DA/FI-A	27	Full Multi	●		●				
CFP/YFP-A	27	Full Multi		●		●			
GFP/DsRed-A	27	Full Multi			●			●	
FITC/TxRed-A	27	Full Multi			●			●	
Cy3/Cy5-A	27	Full Multi				●		●	
DA/FI/TR-A	28	Full Multi	●		●		●		
DA/FI/TX-B	28	Full Multi	●		●			●	
DA/FI/TR/Cy5-A	28	Full Multi	●		●		●	●	
DA/FI-2X-B	29	Pinkel	●		●				
CFP/YFP-2X-A	29	Pinkel		●		●			
GFP/DsRed-2X-A	29	Pinkel			●			●	
GFP/HcRed-2X-A	29	Pinkel			●			●	
FITC/TxRed-2X-B	29	Pinkel			●			●	
Cy3/Cy5-2X-B	29	Pinkel				●		●	
BFP/GFP/HcRed-3X-A	30	Pinkel	●		●			●	
CFP/YFP/HcRed-3X-B	30	Pinkel		●		●		●	
DA/FI/TR-3X-A	30	Pinkel	●		●		●		
DA/FI/TX-3X-B	30	Pinkel	●		●			●	
DA/FI/TR/Cy5-4X-B	31	Pinkel	●		●		●	●	
Da/FI/TR/Cy5/Cy7-5X-A	31	Pinkel	●		●		●	●	●
DA/FI-2X2M-B	32	Sedat	●		●				
CFP/YFP-2X2M-B	32	Sedat		●		●			
GFP/DsRed-2X2M-C	32	Sedat			●			●	
FITC/TXRed-2X2M-B	32	Sedat			●			●	
Cy3/Cy5-2X2M-B	32	Sedat				●		●	
CFP/YFP/HcRed-3X3M-B	33	Sedat		●		●		●	
DA/FI/TX-3X3M-B	33	Sedat		●		●		●	
DA/FI/TR-3X3M-C	33	Sedat	●		●		●		
DA/FI/TR/Cy5-4X4M-C	34	Sedat	●		●		●	●	
DA/FI/TR/Cy5/Cy7-5X5M-B	34	Sedat	●		●		●	●	●

Laser Sets

Multiband Filter Set	Page	Set Type	Blue BFP, DAPI, Hoeschst, Alexa Fluor 350	Cyan CFP, AmCyan, BOBO-1, BO-PRO1	Green FITC, GFP, Bodipy, Alexa Fluor 488	Yellow Cy3, DsRed, Alexa Fluor 555	Orange TRITC, DsRed, Cy3, Alexa Fluor 555, YFP	Red Texas Red, mCherry, Alexa Fluor 568 & 594,Cy5	Far Red Cy7
LF488/561-A	43	Full Multi			●			●	
LF405/488/594-A	43	Full Multi	●		●			●	
LF405/488/561/635-A	43	Full Multi	●		●		●	●	
LF488/561-2X-B	44	Pinkel			●			●	
LF405/488/594-3X-A	44	Pinkel	●		●			●	
LF442/514/561-3X-A	44	Pinkel		●		●	●		
LF405/488/532/635-4X-A	45	Pinkel	●		●		●	●	
LF405/488/561/635-4X-A	45	Pinkel	●		●		●	●	
LF405/488/543/635-4X-A	45	Pinkel							
LF488/543/635-3X-A	44	Pinkel			●		●	●	
LF488/561-2X2M-B	46	Sedat			●		●		
LF405/488/594-3X3M-B	46	Sedat	●		●			●	
LF405/488/561/635-4X4M-A	46	Sedat	●		●		●	●	

Double check that the set you want is the set you need.

Graph a filter set and a fluorophore at the same time online, in an instant.

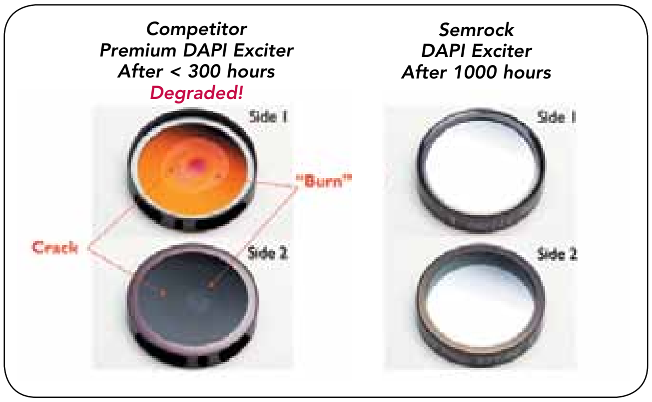


BrightLine® Fluorescence Filters

Hard-coated Durability – The ***no burn-out*** promise

- Can be cleaned and handled, even with acetone
- Impervious to humidity, insensitive to temperature
- *No* soft coatings – *no* exceptions

No burn-out, no periodic replacement needed

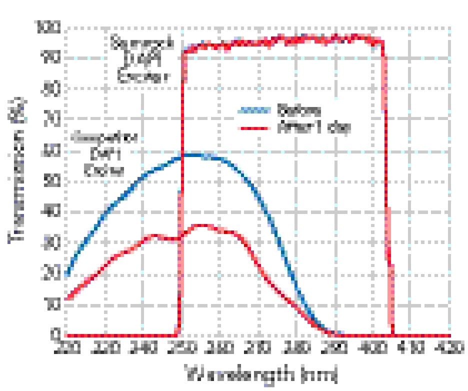


- Stands up to intense xenon, mercury, metal halide, LED, and halogen light sources
- No adhesives in the optical path to darken or degrade
- Made with the same refractory materials as our high "laser damage threshold" laser optics

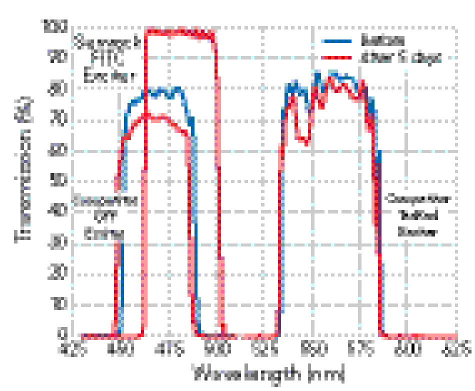
Tests were performed to illustrate the resistance to optical damage of Semrock's hard-coated filters as compared to that of a leading competitor's soft-coated and absorbing glass filters. Continous irradiation from a conventional xenon arc lamp was used for the testing.

The graph on the bottom left shows how a leading competitor's DAPI exciter filter can become severely burned out even after only one day of exposure to 8 W/cm^2 of total intensity – here the transmission has dropped by 42%! By contrast, the Semrock DAPI exciter is unchanged. Exposure of these two filters was continued with 1 W/cm^2 of total intensity (closely simulating the intensity seen by an exciter near the arc lamp source in a typical fluorescence microscope). The photographs above show that the competitor's DAPI exciter failed catastrophically after 300 hours – both the large crack and burn-out degradation go all the way through the filter. The Semrock filter is again unchanged even after more than 1000 hours of exposure.

The graph at bottom right shows that a leading competitor's soft-coated filters for visible wavelengths also show significant degradation after optical exposure, even at the intensity levels typical of most fluorescence microscopes. The transmission of these filters drops, and the spectra shift in wavelength. As always, the *Semrock hard-coated filter shows no change.*



Transmission spectra of DAPI exciters before (blue) and after (red) exposure to 8 W/cm^2 (over 15 mm diameter) for 1 day.



Transmission spectra of soft-coated exciters (for GFP and Texas Red) compared to a Semrock hard-coated exciter (for FITC) before (blue) and after (red) exposure to 1 W/cm^2 (over 25 mm diameter) for 5 days.

When you want the best.

We stock a wide selection of filter sets optimized for the most popular fluorophores and fluorescence microscopes and imaging systems.

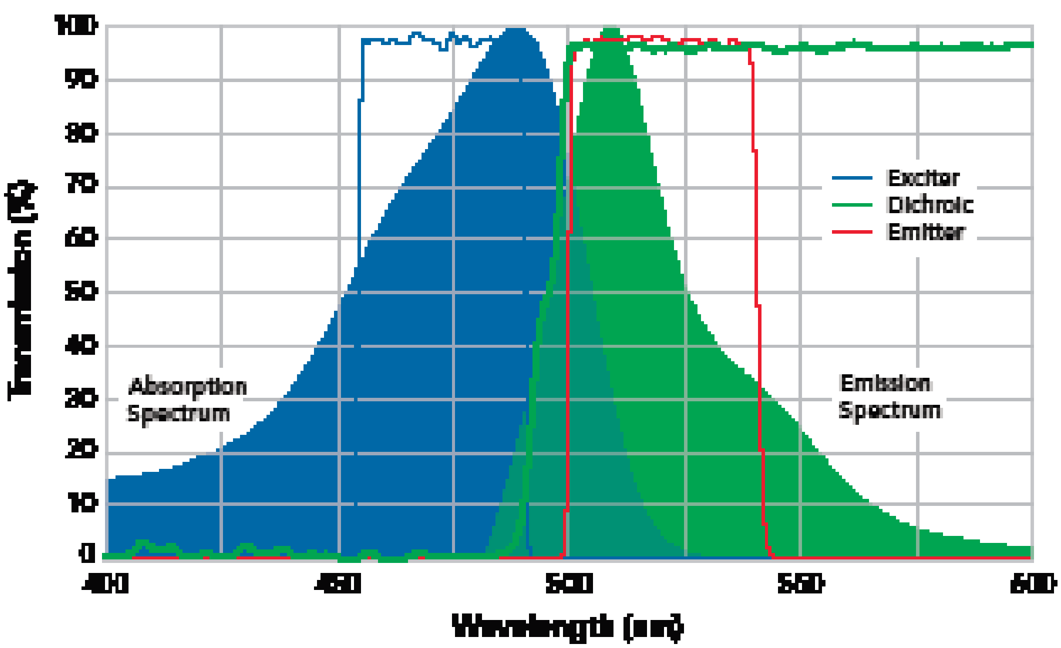
High transmission, steeper edges, precise wavelength accuracy and carefully optimized blocking mean better contrast and faster measurements.

Whether you need the brightest filters available, or the most contrast, these high-performance sets meet all your needs.

We also stock a wide selection of individual bandpass filters and beamsplitters which may be combined for non-standard applications.

Spectacular Spectra

Typical measured GFP-3035D Filter Set for Green Fluorescent Protein. Hard-coating technology combined with single-substrate filter construction results in the highest transmission and steepest edges available.



Custom Sizing:

Our manufacturing process allows us to offer custom sizing for most catalog filters. *Custom sizing requests can be fullfilled and shipped in two days.* Please contact us directly to discuss your specific needs.

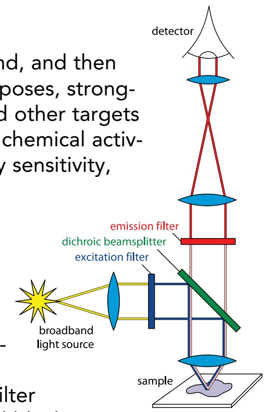
30 Day Return Policy:

We have shipped over half a million ion-beam-sputtered filters to many happy customers, but if you are not fully satisfied with your purchase simply request an RMA number within 30 days from the date of shipment. Does not apply to custom-sized parts.
Full details and our RMA request form may be found online: www.semrock.com/return-policy.apsx

See spectra graphs and ASCII data for all of our filters at www.semrock.com

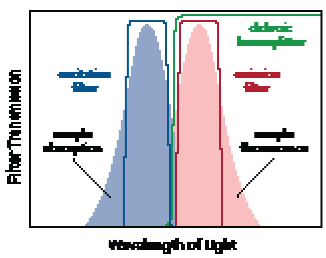
Technical Note

Introduction to Fluorescence Filters



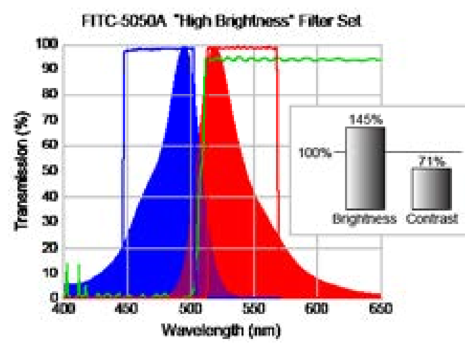
Optical fluorescence occurs when a molecule absorbs light at wavelengths within its absorption band, and then nearly instantaneously emits light at longer wavelengths within its emission band. For analytical purposes, strongly fluorescing molecules known as fluorophores are specifically attached to biological molecules and other targets of interest to enable identification, quantification, and even real-time observation of biological and chemical activity. Fluorescence is widely used in biotechnology and analytical applications due to its extraordinary sensitivity, high specificity, and simplicity.

Most fluorescence instruments, including fluorescence microscopes, are based on optical filters. A typical system has three basic filters: an excitation filter (or exciter), a dichroic beamsplitter (or dichromatic mirror), and an emission filter (or barrier filter). The exciter is typically a bandpass filter that passes only the wavelengths absorbed by the fluorophore, thus minimizing excitation of other sources of fluorescence and blocking excitation light in the fluorescence emission band. The dichroic is an edge filter used at an oblique angle of incidence (typically 45°) to efficiently reflect light in the excitation band and to transmit light in the emission band. The emitter is typically a bandpass filter that passes only the wavelengths emitted by the fluorophore and blocks all undesired light outside this band – especially the excitation light. By blocking unwanted excitation energy (including UV and IR) or sample and system autofluorescence, optical filters ensure the darkest background.

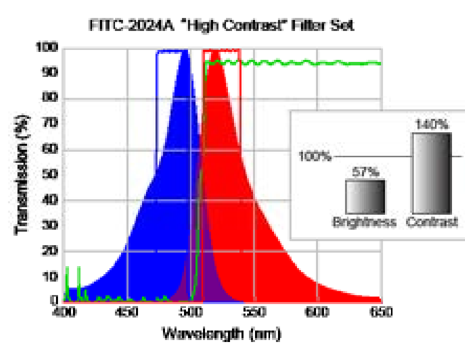


An appropriate combination of optical filters, making up a filter set, enables the visualization of a given fluorophore. See pages 4-7 for a listing of popular fluorophores and corresponding filter sets that can be used to image these fluorophores. A filter set needs to be optimized not only for imaging of distinct fluorophores but also designed to image a given fluorophore under different experimental conditions.

Most of Semrock filter sets are high-brightness and high-contrast sets. These filter sets strike a balance between highest possible brightness while maintaining high contrast and are the best choice of filters under standard imaging conditions. However, when the signal level from a sample is low, sets with wider passbands of the excitation and emission filters enable maximum signal collection efficiency. Studies such as imaging of single molecules typically utilize a filter set with a wide passband or a long pass emission filter. In studies utilizing such filter sets, it is required to maintain very low background autofluorescence signal by means of appropriate sample preparation protocol. However, since the wide passbands of such filter sets occupy a large spectral bandwidth, such filters are not preferred in multiplexing assays when imaging of several fluorophores is required.



Filter sets with narrower passbands are preferred options when imaging a sample labeled with multiple fluorophores. Such filter sets reduce cross-talk between multiple fluorophores. Narrower passbands allow only the strongest portion of the fluorophore emission spectrum to be transmitted, reduce autofluorescence noise and thus improve the signal-to-noise ratio in high background autofluorescence samples. Such filter sets are ideal for samples with ample fluorescent signal level.



In most fluorescence instruments, the best performance is obtained with thin-film filters, which are comprised of multiple alternating thin layers of transparent materials with different indexes of refraction on a glass substrate. The complex layer structure determines the spectrum of light transmission by a filter. Thin-film filters are simple to use, inexpensive, and provide excellent optical performance: high transmission over an arbitrarily determined bandwidth, steep edges, and high blocking of undesired light over the widest possible wavelength range.

Advances in thin-film filter technology pioneered by Semrock, and embodied in all BrightLine® filters, permit even higher performance while resolving the longevity and handling issues that can plague filters made with older soft-coating technology. This advanced technology is so flexible that users have a choice between the highest-performance BrightLine filter sets and the best-value BrightLine Basic™ filter sets.

Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
TRP-A	Exciter	280 nm	> 65% over 20 nm	FF01-280/20-25	$395
Tryptophan	Emitter	357 nm	> 75% over 44 nm	FF01-357/44-25	$295
Designed for UV fluorescence Use with UV LED or filtered Xe arc lamps, or detectors not sensitive to near-IR light.	Dichroic	310 nm (edge)	R_{avg} > 98% 255 – 295 nm T_{avg} > 90% 315 – 600 nm	FF310-Di01-25x36	$425
			Unmounted Full Set:	**TRP-A-000**	**$945**
DAPI-11LP-A	Exciter	387 nm	> 90% over 11 nm	FF01-387/11-25	$295
DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	Emitter	415 nm (edge)	> 93% over 417 – 1100 nm	FF02-409/LP-25	$295
Longpass	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**DAPI-11LP-A-000** DAPI-11LP-A-000-ZERO	**$745** $844
DAPI-50LP-A	Exciter	377 nm	> 85% over 50 nm	FF01-377/50-25	$295
DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	Emitter	415 nm (edge)	> 93% over 417 – 1100 nm	FF02-409/LP-25	$295
Longpass	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**DAPI-50LP-A-000** DAPI-50LP-A-000-ZERO	**$745** $844
DAPI-1160B	Exciter	387 nm	> 90% over 11 nm	FF01-387/11-25	$295
DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	Emitter	447 nm	> 93% over 60 nm	FF02-447/60-25	$295
Highest Contrast	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
Contact Semrock about 32 mm exciter.			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**DAPI-1160B-000** DAPI-1160B-000-ZERO	**$745** $844
DAPI-5060C	Exciter	377 nm	> 85% over 50 nm	FF01-377/50-25	$295
DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	Emitter	447 nm	> 93% over 60 nm	FF02-447/60-25	$295
Highest Brightness	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**DAPI-5060C-000** DAPI-5060C-000-ZERO	**$745** $844
CFP-2432C	Exciter	438 nm	> 93% over 24 nm	FF02-438/24-25	$295
CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1	Emitter	483 nm	> 93% over 32 nm	FF01-483/32-25	$295
	Dichroic	458 nm (edge)	R_{avg} > 98% 350 – 450 nm T_{avg} > 93% 467 – 950 nm	FF458-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**CFP-2432C-000** CFP-2432C-000-ZERO	**$745** $844
FURA2-C	Exciter 1	340 nm	> 75% over 26 nm	FF01-340/26-25	$295
Fura-2 Ca^{2+} indicator, LysoSensor Yellow/Blue	Exciter 2	387 nm	> 90% over 11 nm	FF01-387/11-25	$295
Four Filter Set	Emitter	510 nm	> 93% over 84 nm	FF01-510/84-25	$295
	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**FURA2-C-000** FURA2-C-000-ZERO	**$1075** $1174

Cubes Page 36

(continued) Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

BrightLine® Single-band Sets

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
GFP-1828A	Exciter	482 nm	> 93 % over 18 nm	FF02-482/18-25	$295
GFP, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1	Emitter	520 nm	> 93% over 28 nm	FF02-520/28-25	$295
	Dichroic	495 nm (edge)	R_{avg} > 98% 350 – 488 nm T_{avg} > 93% 502 – 950 nm	FF495-Di03-25x36	$245
Highest Contrast			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**GFP-1828A-000** GFP-1828A-000-ZERO	**$745** $844
GFP-3035D	Exciter	472 nm	> 93% over 30 nm	FF02-472/30-25	$295
GFP, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1	Emitter	520 nm	> 93% over 35 nm	FF01-520/35-25	$295
	Dichroic	495 nm (edge)	R_{avg} > 98% 350 – 488 nm T_{avg} > 93% 502 – 950 nm	FF495-Di03-25x36	$245
All Purpose			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**GFP-3035D-000** GFP-3035D-000-ZERO	**$745** $844
GFP-30LP-B	Exciter	472 nm	> 93% over 30 nm	FF02-472/30-25	$295
GFP, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1	Emitter	501 nm (edge)	> 93% 503 – 1100 nm	FF01-496/LP-25	$295
	Dichroic	495 nm (edge)	R_{avg} > 98% 350 – 488 nm T_{avg} > 93% 502 – 950 nm	FF495-Di03-25x36	$245
Longpass			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**GFP-30LP-B-000** GFP-30LP-B-000-ZERO	**$745** $844
GFP-4050B	Exciter	466 nm	> 93% over 40 nm	FF01-466/40-25	$295
GFP, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1	Emitter	525 nm	> 93% over 50 nm	FF03-525/50-25	$295
	Dichroic	495 nm (edge)	R_{avg} > 98% 350 – 488 nm T_{avg} > 93% 502 – 950 nm	FF495-Di03-25x36	$245
Highest Brightness			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**GFP-4050B-000** GFP-4050B-000-ZERO	**$745** $844
FITC-2024B	Exciter	485 nm	> 93% over 20 nm	FF02-485/20-25	$295
FITC, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488	Emitter	524 nm	> 93% over 24 nm	FF01-524/24-25	$295
	Dichroic	506 nm (edge)	R_{avg} > 98% 350 – 500 nm T_{avg} > 93% 513 – 950 nm	FF506-Di03-25x36	$245
Highest Contrast			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**FITC-2024B-000** FITC-2024B-000-ZERO	**$745** $844
FITC-3540C	Exciter	482 nm	> 93% over 35 nm	FF01-482/35-25	$295
FITC, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488	Emitter	536 nm	> 93% over 40 nm	FF01-536/40-25	$295
	Dichroic	506nm (edge)	R_{avg} > 98% 350 – 500 nm T_{avg} > 93% 513 – 950 nm	FF506-Di03-25x36	$245
All Purpose			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**FITC-3540C-000** FITC-3540C-000-ZERO	**$745** $844
FITC-5050A	Exciter	475 nm	> 93% over 50 nm	FF02-475/50-25	$295
FITC, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488	Emitter	540 nm	> 93% over 50 nm	FF01-540/50-25	$295
	Dichroic	506 nm (edge)	R_{avg} > 98% 350 – 500 nm T_{avg} > 93% 513 – 950 nm	FF506-Di03-25x36	$245
Highest Brightness			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**FITC-5050A-000** FITC-5050A-000-ZERO	**$745** $844

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(continued) Filter Specifications on page 35

BrightLine® Single-band Sets

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
YFP-2427B	Exciter	500 nm	> 93% over 24 nm	FF01-500/24-25	$295
YFP, Calcium Green-1, Eosin, Fluo-3, Rhodamine 123	Emitter	542 nm	> 93% over 27 nm	FF01-542/27-25	$295
	Dichroic	520 nm (edge)	R_{avg} > 98% 350 – 512 nm T_{avg} > 90% 528 – 900 nm	FF520-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**YFP-2427B-000** YFP-2427B-000-ZERO	**$745** $844
TRITC-B	Exciter	543 nm	> 93% over 22 nm	FF01-543/22-25	$295
TRITC, Rhodamine, DiI, 5-TAMRA, Alexa Fluor® 532 & 546	Emitter	593 nm	> 93% over 40 nm	FF01-593/40-25	$295
	Dichroic	562 nm (edge)	R_{avg} > 98% 350 – 555 nm T_{avg} > 93% 569 – 950 nm	FF562-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**TRITC-B-000** TRITC-B-000-ZERO	**$745** $844
Cy3-4040C	Exciter	531 nm	> 93% over 40 nm	FF01-531/40-25	$295
Cy3™, DsRed, PE, TAMRA, Calcium Orange, Alexa Fluor® 555	Emitter	593 nm	> 93% over 40 nm	FF01-593/40-25	$295
	Dichroic	562 nm (edge)	R_{avg} > 98% 350 – 555 nm T_{avg} > 93% 569 – 950 nm	FF562-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**Cy3-4040C-000** Cy3-4040C-000-ZERO	**$745** $844
TXRED-4040C	Exciter	562 nm	> 93% over 40 nm	FF01-562/40-25	$295
Texas Red®, Cy3.5™, 5-ROX, Mitotracker Red, Alexa Fluor® 568 & 594	Emitter	624 nm	> 93% over 40 nm	FF01-624/40-25	$295
	Dichroic	593 nm (edge)	R_{avg} > 98% 350 – 585 nm T_{avg} > 93% 601 – 950 nm	FF593-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**TXRED-4040C-000** TXRED-4040C-000-ZERO	**$745** $844
mCherry-40LP-A	Exciter	562 nm	> 93% over 40 nm	FF01-562/40-25	$295
mCherry (mRFP)	Emitter	601 nm (edge)	> 93% 604 – 1100 nm	FF01-593/LP-25	$295
	Dichroic	593 nm (edge)	R_{avg} > 98% 350 – 585 nm T_{avg} > 93% 601 – 950 nm	FF593-Di03-25x36	$245
Longpass			**Unmounted Full Set:** "ZERO Pixel Shift" Set:	**mCherry-40LP-A-000** mCherry-40LP-000-ZERO	**$745** $844
mCherry-B	Exciter	562 nm	> 93% over 40 nm	FF01-562/40-25	$295
mCherry (mRFP)	Emitter	641 nm	> 93% over 75 nm	FF01-641/75-25	$295
	Dichroic	593 nm (edge)	R_{avg} > 98% 350 – 585 nm T_{avg} > 93% 601 – 950 nm	FF593-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**mCherry-B-000** mCherry-B-000-ZERO	**$745** $844
Cy5-4040C	Exciter	628 nm	> 93% over 40 nm	FF02-628/40-25	$295
Cy5™, APC, DiD, Alexa Fluor® 647 & 660	Emitter	692 nm	> 93% over 40 nm	FF01-692/40-25	$295
	Dichroic	660 nm (edge)	R_{avg} > 98% 350 – 651 nm T_{avg} > 93% 669 – 950 nm	FF660-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**Cy5-4040-C-000** Cy5-4040-C-000-ZERO	**$745** $844

Cubes Page 36

(continued) Filter Specifications on page 35

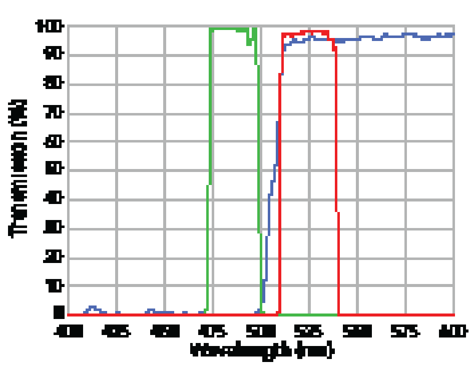
BrightLine® Single-band Sets

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
Cy5.5-B	Exciter	655 nm	> 93% over 40 nm	FF01-655/40-25	$295
Cy5.5™, Alexa Fluor® 680	Emitter	716 nm	> 93% over 40 nm	FF01-716/40-25	$295
	Dichroic	685 nm (edge)	R_{avg} > 98% 350 – 676 nm T_{avg} > 93% 695 – 950 nm	FF685-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**Cy5.5-B-000** Cy5.5-B-000-ZERO	**$745** $844
Cy7-B	Exciter	708 nm	> 93% over 75 nm	FF01-708/75-25	$295
Cy7™, Alexa Fluor® 750	Emitter	809 nm	> 93% over 81 nm	FF02-809/81-25	$295
	Dichroic	757 nm (edge)	R_{avg} > 98% 450 – 746 nm T_{avg} > 93% 768 – 1100 nm	FF757-Di01-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**Cy7-B-000** Cy7-B-000-ZERO	**$745** $844
IRDYE800-33LP-A	Exciter	747 nm	> 93% over 33 nm	FF01-747/33-25	$295
IRDye800 CW	Emitter	785 nm (edge)	> 93% over 789 – 1200 nm	FF01-776/LP-25	$295
	Dichroic	776 nm (edge)	R_{avg} > 98% 450 – 764 nm T_{avg} > 93% 789 – 1100 nm	FF776-Di01-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**IRDYE800-33LP-A-000** IRDYE800-33LP-A-000-ZERO	**$745** $844
ICG-B	Exciter	769 nm	> 93% over 41 nm	FF01-769/41-25	$295
Indocyanin Green	Emitter	832 nm	> 93% over 37 nm	FF01-832/37-25	$295
	Dichroic	801 nm (edge)	R_{avg} > 98% 450 – 790 nm T_{avg} > 93% 813.5 – 1100 nm	FF801-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**ICG-B-000** ICG-B-000-ZERO	**$745** $844

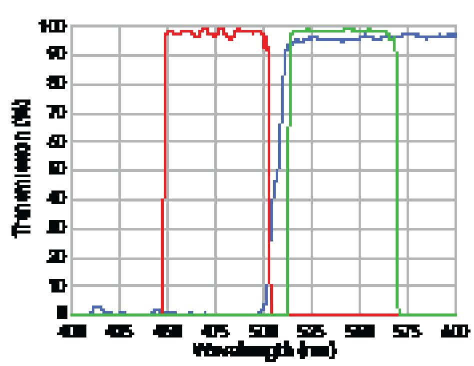
Filter Specifications on page 35

Actual Measured Data

Highest Contrast with FITC-2024B



Highest Brightness with FITC-5050A



Application Note

Crosstalk in FISH and Densely Multiplexed Imaging

When using multiple, densely spaced fluorophores, rapid and accurate results rely on the ability to readily distinguish the fluorescence labels from one another. This dense multiplexing of images is particularly important when doing Fluoresence in Situ Hybridization (FISH) measurements. Thus, it is critical to minimize crosstalk, or the signal from an undesired fluorophore relative to that of a desired fluorophore. The table below quantifies crosstalk values for neighboring fluorophores when using a given BrightLine FISH filter set. Values are determined from the overlap of typical, normalized fluorophore spectra, the filter design spectra, and an intense metal halide lamp.

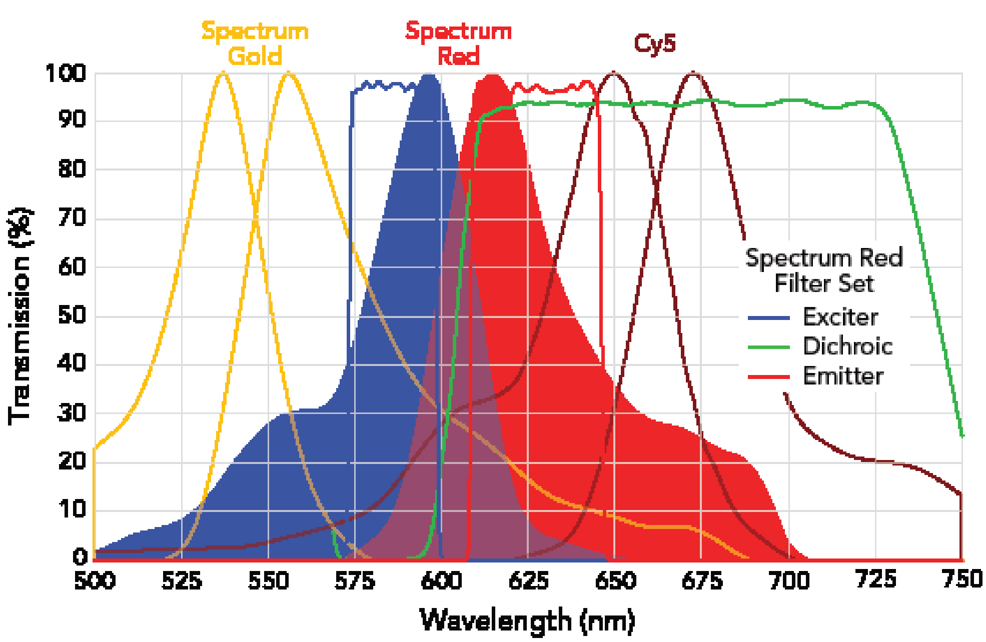
Filter Set \ Fluorophore	Relative Fluorophore Contributions for Each Filter Set								
	DAPI	SpAqua	SpGreen	SpGold	SpOrange	SpRed	Cy5 / FRed	Cy5.5	Cy7
DAPI	100%	30%	0%						
SpAqua	0%	100%	1%	0%					
SpGreen	0%	0%	100%	3%	0%				
SpGold		0%	2%	100%	49%	1%			
SpOrange			0%	36%	100%	11%	0%		
SpRed				0%	15%	100%	1%	0%	
Cy5 / FRed					0%	12%	100%	53%	1%
Cy5.5						0%	53%	100%	6%
Cy7							0%	12%	100%

Grey combinations are not recommended

As an example, when imaging a sample labeled with the SpectrumGreen™, SpectrumGold™, and SpectrumRed™ fluorophores using the SpectrumGold filter set, the undesired SpectrumGreen signal will be less than 2% of the desired SpectrumGold signal, and the SpectrumRed signal will be less than 1%.

Amazing Spectra for Minimizing Crosstalk

These BrightLine filter sets are meticulously optimized to maximize brightness for popular fluorophores, while simultaneously minimizing unnecessary background as well as crosstalk with adjacent fluorophores. The graph below shows an example of the filter spectra for the SpectrumRed filter set (blue, green, and red solid lines), as well as the absorption and emission curves for SpectrumGold, SpectrumRed, and Cy5™ (left to right). Crosstalk is kept to only a few percent or less, as quantified in the table above.



BrightLine® Single-band Sets for FISH & Dense Multiplexing

PathVysion® assay control sample with CEP 17 and HER-2/neu probes (100X oil-immersion objective).

Help ease the upstream battle against cancer with BrightLine FISH fluorescence filter sets.

Fluorescence In Situ Hybridization, or FISH, is an exciting fluorescence imaging technique that enables clinical-scale genetic screening based on molecular diagnostics. Semrock pioneered hard-coated BrightLine filters that are significantly brighter than and have superior contrast to older, soft-coated fluorescence filters, thus offering faster and more accurate measurements. Independent evaluations have shown that FISH images can be obtained in as little as one half the exposure time using BrightLine filters. And yet the inherent manufacturability of Semrock's patented ion-beam-sputtered filters actually allows them to be priced lower than soft-coated FISH filter sets.

Switching to BrightLine filters is the simplest and least expensive way to dramatically increase the quality of your FISH images!

Full Spectrum of Solutions

Examples of popular assays using BrightLine FISH filter sets

Single-band Filter Sets	Assay	Purpose
DAPI, SpGr, SpOr	PathVysion®	Detects amplification of the HER-2 gene for screening and prognosis of breast cancer
DAPI, SpAqua, SpGr, SpOr	AneuVysion®	Used as an aid in prenatal diagnosis of chromosomal abnormalities
DAPI, SpAqua, SpGr, SpGold, SpRed	UroVysion™	Aid for initial diagnosis of bladder carcinoma and subsequent monitoring for tumor recurrence in previously diagnosed patients
DAPI, SpAqua, SpGr, SpGold, SpRed, Cy5	M-FISH	Permits the simultaneous visualization of all human (or mouse) chromosomes in different colors for karyotype analysis

Product Note

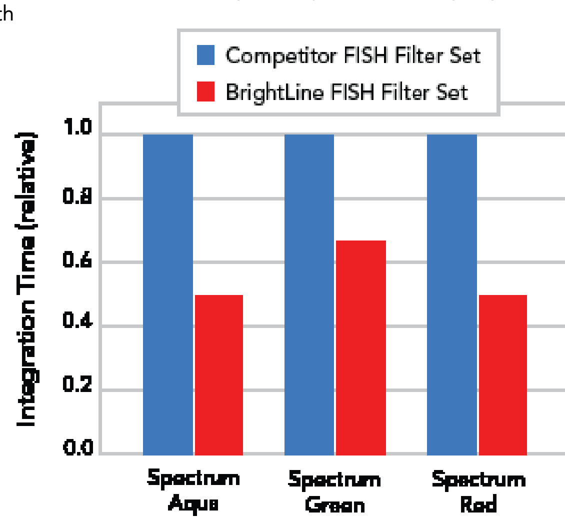
Can better fluorescence filters really make a difference?

BrightLine "no-burn-out" filters have been tested widely in both research and clinical fields over many years of use. Extensive independent testing has also been performed with BrightLine FISH filter sets. A few examples of results are shown here. Whether you are finding and analyzing metaphase spreads or scoring cells by spot counting, significantly improve the speed and accuracy of your FISH analysis with BrightLine filter sets.

Competitor filter set

BrightLine filter set

Side-by-side independent comparison using equal exposure times of images achieved with competitor filter sets (left) and BrightLine filter sets (right), of a human tumor hybridized with CEP 3 probe in Spectrum Red (part of Vysis UroVysion™ assay, 400X magnification). Photo courtesy of Tina Bocker Edmonston, M.D., Thomas Jefferson University.



BrightLine filters allow shorter integration times for faster imaging – especially for automated tasks like metaphase finding. This independent industry test compares integration times required by BrightLine FISH filter sets to those of competitor filter sets. The automated system, based on a Zeiss Axio Imager microscope, found metaphase spreads with identical image intensities.

BrightLine® Single-band Sets for FISH & Dense Multiplexing

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
SpAqua-C	Exciter	438 nm	> 93% over 24 nm	FF02-438/24-25	$295
SpectrumAqua™, DEAC	Emitter	483 nm	> 93% over 32 nm	FF01-483/32-25	$295
	Dichroic	458 nm (edge)	R_{avg} > 98% 350 – 450 nm T_{avg} > 93% 467 – 950 nm	FF458-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**SpAqua-C-000** SpAqua-C-000-ZERO	**$745** $844
SpGr-B	Exciter	494 nm	> 93% over 20 nm	FF01-494/20-25	$295
SpectrumGreen™, FITC, Alexa Fluor® 488	Emitter	527 nm	> 93% over 20 nm	FF01-527/20-25	$295
	Dichroic	506 nm (edge)	R_{avg} > 98% 350 – 500 nm T_{avg} > 93% 513 – 950 nm	FF506-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**SpGr-B-000** SpGr-B-000-ZERO	**$745** $844
SpGold-B	Exciter	534 nm	> 93% over 20 nm	FF01-534/20-25	$295
SpectrumGold™, Alexa Fluor® 546	Emitter	572 nm	> 93% over 28 nm	FF01-572/28-25	$295
	Dichroic	552 nm (edge)	R_{avg} > 98% 350 – 544 nm T_{avg} > 93% 558 – 950 nm	FF552-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**SpGold-B-000** SpGold-B-000-ZERO	**$745** $844
SpOr-B	Exciter	543 nm	> 93% over 22 nm	FF01-543/22-25	$295
SpectrumOrange™, Cy3™, Rhodamine, Alexa Fluor® 555	Emitter	586 nm	> 93% over 20 nm	FF01-586/20-25x3.5	$295
	Dichroic	562 nm (edge)	R_{avg} > 98% 350 – 555 nm T_{avg} > 93% 569 – 950 nm	FF562-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**SpOr-B-000** SpOr-B-000-ZERO	**$745** $844
SpRed-B	Exciter	586 nm	> 93% over 20 nm	FF01-586/20-25x5	$295
SpectrumRed™, Texas Red, Alexa Fluor® 647 & 660	Emitter	628 nm	> 93% over 32 nm	FF01-628/32-25	$295
	Dichroic	605 nm (edge)	R_{avg} > 98% 350 – 596 nm T_{avg} > 93% 612 – 950 nm	FF605-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**SpRed-B-000** SpRed-B-000-ZERO	**$745** $844

Cubes Page 36

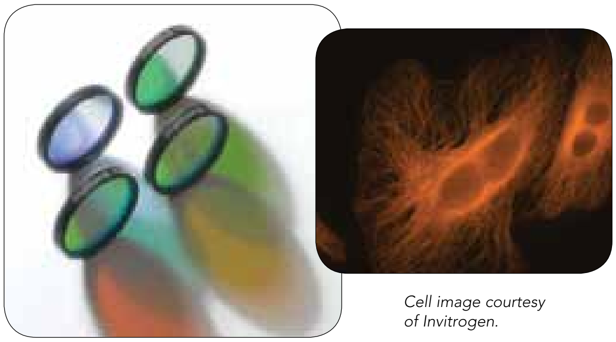
Filter Specifications on page 35

NOTE: For DAPI , Cy5™, Cy5.5™, or Cy7™ sets, refer to pages 11-14.

For **FISH multiband combination filter sets,** see www.semrock.com for a complete listing.

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Qdot® Single-band Filter Sets



Cell image courtesy of Invitrogen.

These single-band filter sets are specially optimized for brilliant, dense multi-color detection with Molecular Probes® (Invitrogen Detection Technologies) quantum dot nanocrystals. The highly transmitting, deep-blue exciter achieves maximum quantum dot excitation efficiency while virtually eliminating any DAPI or Hoechst excitation. And with the no burn-out reliability shared by all BrightLine® filters, the permanent performance of these sets will outlast even your quantum dots!

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
QDLP-C	Exciter	435 nm	> 90% over 40 nm	FF02-435/40-25	$295
Qdot® 525, 565, 585, 605, 625, 655, 705, & 800 Nanocrystals	Emitter	515 nm (edge)	> 90% 519 – 700 nm	FF01-500/LP-25	$245
Versatile and high brightness long-pass filter set for viewing multiple Qdots	Dichroic	510 nm (edge)	R_{avg} > 98% 327 – 488 nm T_{avg} > 93% 515 – 950 nm	FF510-Di02-25x36	$245
			Unmounted Full Set:	**QDLP-C-000**	**$745**
QD525-C	Exciter	435 nm	> 90% over 40 nm	FF02-435/40-25	$295
Qdot® 525 Nanocrystals	Emitter	525 nm	> 90% over 15 nm	FF01-525/15-25	$295
High brightness and contrast single-band filter set	Dichroic	510 nm (edge)	R_{avg} > 98% 327 – 488 nm T_{avg} > 93% 515 – 950 nm	FF510-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**QD525-C-000** QD525-C-000-ZERO	**$745** $844
QD605-C	Exciter	435 nm	> 90% over 40 nm	FF02-435/40-25	$295
Qdot® 605 Nanocrystals	Emitter	605 nm	> 90% over 15 nm	FF01-605/15-25	$295
High brightness and contrast single-band filter set	Dichroic	510 nm (edge)	R_{avg} > 98% 327 – 488 nm T_{avg} > 93% 515 – 950 nm	FF510-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**QD605-C-000** QD605-C-000-ZERO	**$745** $844
QD625-C	Exciter	435 nm	> 90% over 40 nm	FF02-435/40-25	$295
Qdot® 625 Nanocrystals	Emitter	625 nm	> 90% over 15 nm	FF01-625/15-25	$295
High brightness and contrast single-band filter set	Dichroic	510 nm (edge)	R_{avg} > 98% 327 – 488 nm T_{avg} > 93% 515 – 950 nm	FF510-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**QD625-C-000** QD625-C-000-ZERO	**$745** $844
QD655-C	Exciter	435 nm	> 90% over 40 nm	FF02-435/40-25	$295
Qdot® 655 Nanocrystals	Emitter	655 nm	> 90% over 15 nm	FF01-655/15-25	$295
High brightness and contrast single-band filter set	Dichroic	510 nm (edge)	R_{avg} > 98% 327 – 488 nm T_{avg} > 93% 515 – 950 nm	FF510-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**QD655-C-000** QD655-C-000-ZERO	**$745** $844

Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Technical Note

Fluorescence Imaging with Quantum Dot Nanocrystals

Quantum dot nanocrystals are fluorophores that absorb photons of light and then re-emit longer-wavelength photons nearly instantaneously. However, there are some important differences between quantum dots (e.g., Qdot® nanocrystals made by Invitrogen Molecular Probes®) and traditional fluorophores including organic dyes and naturally fluorescing proteins. Quantum dots are nanometer-scale clusters of semiconductor atoms, typically coated with an additional semiconductor shell and then a polymer coating to enable coupling to proteins, oligonucleotides, small molecules, etc., which are then used for direct binding of the quantum dots to targets of interest.

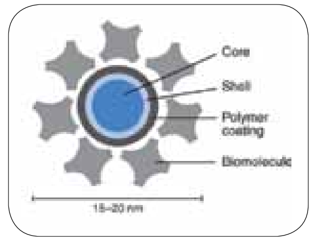
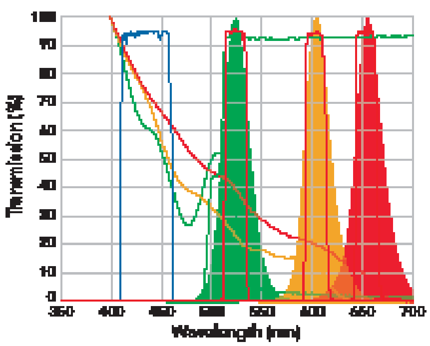


Figure 1. Structure of a nanocrystal.

Nanocrystals are extremely bright and highly photostable, making them ideal for applications that require high sensitivity with minimal label interference, as well as long-term photostability, such as live-cell imaging and dynamic studies. Their excellent photostability also means they are fixable and archivable for permanent sample storage in pathology applications. Because there is a direct relationship between the size of a nanocrystal and the wavelength of the emitted fluorescence, a full range of nanocrystals can be made – each with a narrow, distinct emission spectrum and all excited by a single blue or ultraviolet wavelength. Thus nanocrystals are ideal for dense multiplexing. Some important nanocrystal features that may limit certain applications include their fairly large physical size and long lifetime.



To take advantage of nanocrystal features, it is important to use properly optimized filters. Semrock offers BrightLine® filter sets specially optimized for the most popular quantum dot imaging applications. A universal set with a long-wave-pass emitter enables simultaneous imaging of multiple quantum dots by eye or with a color camera. Additionally, filter sets tailored to individual quantum dots are also available (see page 17). Best of all, these filters share the incredible "no burn-out" reliability of all BrightLine filters, an ideal match for highly photostable quantum dot nanocrystals!

Figure 2. A universal exciter provides superior excitation efficiency while avoiding the excitation of DAPI and undesirable autofluorescence. This filter is combined with a dichroic beamsplitter with extremely wide reflection and transmission bands for maximum flexibility, and narrow, highly transmitting emission filters matched to each of the most important Qdot wavelengths.

Technical Note

Ultraviolet (UV) Fluorescence Applications

Many biological molecules of interest naturally fluoresce when excited by shorter wavelength UV light. This "intrinsic fluorescence" can be a powerful tool as labeling with extrinsic fluorphores is not required. One important application is the direct fluorescence imaging of aromatic amino acids including tryptophan, tyrosine, and phenylalanine, which are building blocks for proteins. The aromatic rings in these molecules give rise to strong fluorescence excitation peaks in the 260 to 280 nm range. Another application is DNA quantitation. Purines and pyrimidines – bases for nucleic acids like DNA and RNA – have strong absorption bands in the 260 to 280 nm range.

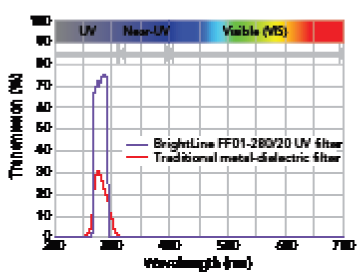


Figure 1. BrightLine FF01-280/20-25 filter

Semrock's UV BrightLine® fluorescence filters offer a powerful tool for direct fluorescence imaging. These unique UV filters are reliable "no burn-out" and offer performance nearly comparable to visible and near-IR filters. Figure 1 shows the spectrum of a high-reliability 280 nm BrightLine excitation filter with the highest commercially available transmission (> 65%), remarkably steep edges, and wideband blocking across the entire UV and visible spectrum. This spectrum is directly compared to a traditional and inferior metal-dielectric filter. In one example system, this filter difference was shown to provide over 100x improvement in signal-to-noise ratio.

Figure 2 shows the spectra from a UV filter set designed for imaging tryptophan, overlaid on the absorption and emission spectra for that amino acid. Note the nearly ideal overlap and high transmission of all three filters in this set.

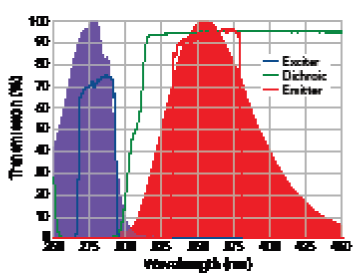


Figure 2. TRP-A single-band fluorescence filter set is ideal for imaging tryptophan *(see page 10).*

BrightLine® FRET Single-band Sets

These filter sets offer our simplest solution for dual-wavelength FRET imaging.
Also see our multiband "Sedat" filter sets for high-performance FRET imaging starting on page 31.

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
FRET-BFP/GFP-B	Exciter	387 nm	> 90% over 11 nm	FF01-387/11-25	$295
Blue: BFP, DAPI, Hoechst, Alexa Fluor® 350	Emitter 1	447 nm	> 93% over 60 nm	FF02-447/60-25	$295
Green: GFP, EGFP, FITC, Cy2™, Alexa Fluor® 488	Emitter 2	520 nm	> 93% over 35 nm	FF01-520/35-25	$295
	Dichroic	409 nm (edge)	R_{avg} > 98% 327 – 404 nm T_{avg} > 93% 415 – 950 nm	FF409-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**FRET-BFP/GFP-B-000** FRET-BFP/GFP-B-000-ZERO	**$1075** $1174
FRET-CFP/YFP-C	Exciter	438 nm	> 93% over 24 nm	FF02-438/24-25	$295
Cyan: CFP, CyPet, AmCyan Yellow: YFP, YPet, Venus	Emitter 1	483 nm	> 93% over 32 nm	FF01-483/32-25	$295
	Emitter 2	542 nm	> 93% over 27 nm	FF01-542/27-25	$295
	Dichroic	458 nm (edge)	R_{avg} > 98% 350 – 450 nm T_{avg} > 93% 467 – 950 nm	FF458-Di02-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**FRET-CFP/YFP-C-000** FRET-CFP/YFP-C-000-ZERO	**$1075** $1174
FRET-GFP/RFP-C	Exciter	472 nm	> 93% over 30 nm	FF02-472/30-25	$295
Green: GFP, EGFP, FITC, Cy2™, Alexa Fluor® 488	Emitter 1	520 nm	> 93% over 35 nm	FF01-520/35-25	$295
Red: mCherry, mStrawberry, dTomato, DsRed, TRITC, Cy3™	Emitter 2	641 nm	> 93% over 75 nm	FF01-641/75-25	$295
	Dichroic	495 nm (edge)	R_{avg} > 98% 350 – 488 nm T_{avg} > 93% 502 – 950 nm	FF495-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**FRET-GFP/RFP-C-000** FRET-GFP/RFP-C-000-ZERO	**$1075** $1174
FRET-CY3/CY5-A	Exciter	531 nm	> 93% over 40 nm	FF01-531/40-25	$295
Yellow: Cy3™, Alexa Fluor® 555 Red: Cy5™, Alexa Fluor® 647	Emitter 1	593 nm	> 93% over 40 nm	FF01-593/40-25	$295
	Emitter 2	676 nm	> 93% over 29 nm	FF01-676/29-25	$295
	Dichroic	562 nm (edge)	R_{avg} > 98% 350 – 555 nm T_{avg} > 93% 569 – 950 nm	FF562-Di03-25x36	$245
			Unmounted Full Set: "ZERO Pixel Shift" Set:	**FRET-CY3/CY5-A-000** FRET-CY3/CY5-A-000-ZERO	**$1075** $1174

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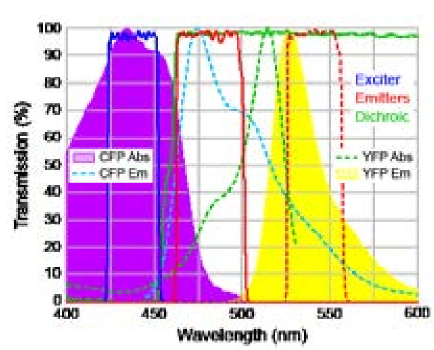
Technical Note

Fluorescence Resonance Energy Transfer (FRET)

Fluorescence (or Förster) Resonance Energy Transfer (FRET) is a powerful technique for characterizing distance-dependent interactions on a molecular scale. FRET starts with the excitation of a "donor" fluorophore molecule by incident light within its absorption spectrum. If another fluorophore molecule (the "acceptor") is in close proximity to the donor and has an absorption spectrum that overlaps the donor emission spectrum, nonradiative energy transfer may occur between donor and acceptor. For example, CFP and YFP support a strong FRET interaction. FRET can measure distances on the order of the "Förster distance" – typically 20 to 90 Å. This length scale is far below the Rayleigh-criterion resolution limit of an optical microscope (about 2500 Å for visible light and high numerical aperture), thus illustrating the power of FRET for measuring extremely small distance interactions.



The figure at the right shows as an example the CFP and YFP absorption and emission spectra, along with the transmission spectra of the filters in the FRET-CFP/YFP-A set. Sets like this one and those listed above are optimized for the FRET-cube method of imaging.

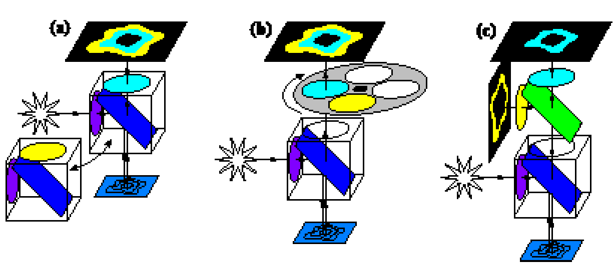
Start with a FRET fluorophore pair	For imaging with emission filter wheel only, using a FRET single-band filter set	For imaging utilizing emission signal splitting, add an image splitting dichroic	For imaging with excitation and emission filter wheels, "Sedat" multiband filter sets	For imaging with exitation filter wheel and with emission signal splitting, add image splitting dichroic
BFP/GFP	FRET-BFP/GFP-B	FRET-BFP/GFP-C FF484-FDi01-25x36	DA/FI-2X2M-C	DA/FI-2X2M-B FF484-FDi01-25x36
CFP/YFP	FRET-CFP/YFP-C	FRET-CFP/YFP-C FF509-FDi01-25x36	CFP/YFP-2X2M-B	CFP/YFP-2X2M-B FF509-FDi01-25x36
GFP/RFP	FRET-GFP/RFP-C	FRET-GFP/RFP-C FF580-FDi01-25x36	FITC/TxRed-2X2M-B	FITC/TxRed-2X2M-B FF580-FDi01-25x36
Cy3/Cy5	FRET-Cy3/Cy5-A	FRET-Cy3/Cy5-A FF662-FDi01-25x36	Cy3/Cy5-2X2M-B	Cy3/Cy5-2X2M-B FF662-FDi01-25x36

Technical Note

Optical filter configurations for FRET

The classical approach to FRET measurements involves changing filter cubes (see Figure (a) and page 19 for filters and more information on FRET). For example, in the acceptor-photobleaching method, a donor-specific cube is first used to collect the emission from the donor (e.g., CFP). Then a filter cube for the acceptor is used to visualize and photobleach the acceptor (e.g., YFP). Intensity measurements of the donor before and then again after photobleaching the acceptor are used to calculate FRET efficiency. Steep spectral edges of the filters ensure that only the acceptor is photobleached and minimize the signal contamination due to bleedthrough in multiply labeled FRET samples. This technique suffers from several drawbacks, including: slow speed (changing filter cubes takes typically a second or more) and imaging artifacts (due to the movement of the filter turret and other vibrations).

The most popular approach to FRET imaging, shown in Figure (b), is often called the FRET-cube method. A single-band exciter and a single-edge dichroic beamsplitter, each specific to the donor, are placed in a cube in the microscope turret, and a filter wheel with single-band emission filters is used to select the emission from either the donor or the acceptor. Filter wheels cause minimal vibrations and have much faster switching times (as low as 10's of ms) compared to filter turrets, and are therefore better suited for live-cell FRET applications.



Many researchers prefer to utilize a Sedat filter set configuration (see page 32 for filters). This approach provides additional flexibility in the visualization of the sample as well as to perform control experiments – such as finding regions or samples labeled with only the donor or acceptor and collection of pure spectral contributions from each. The added flexibility also enables the donor photobleaching method for calculation of FRET efficiency.

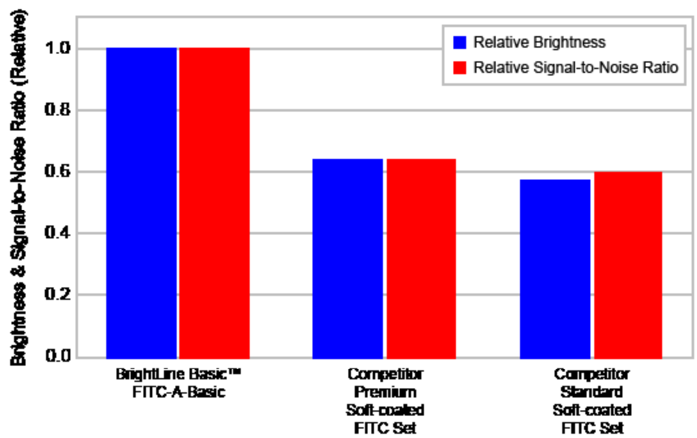
However, the most demanding FRET applications, such as live-cell imaging and imaging of single molecules may require "simultaneous" imaging of the emission signal from both the donor and the acceptor. Figure (c) shows a configuration for simultaneous imaging, in which an image-splitting dichroic beamsplitter (see page 67) placed in the emission channel of the microscope is used to separate the signals from the donor and the acceptor and steer them onto two different CCDs or two distinct regions of the same CCD. Since there are no moving parts, motion-based imaging artifacts are also eliminated.

BrightLine Basic™ Best-value Single-band Sets

How can you do great research on a tight budget?
BrightLine Basic fluorescence filter sets!
Hard-coated performance at soft-coated prices.™

These value-priced single-band filter sets combine the proven durability of BrightLine® research sets with optical performance that exceeds premium soft-coated fluorescence filters, yet are offered at soft-coated prices. In fact, BrightLine Basic filter sets are brighter than soft-coated filter sets of comparable contrast, but don't burn out, further lowering the total cost of ownership. Ideal for routine applications that require cost-effective, high volume capabilities and no burn-out such as: clinical microscopy (mycological and fungal staining, immunofluorescent testing), routine analysis, and education.

Measured data taken on an Olympus BX microscope using a 40X objective and a QImaging Retiga camera. Sample is Invitrogen / Molecular Probes FluoCells #2 sample (BODIPY FL fluorophore).



BrightLine® (Highest Performance) set compared to BrightLine Basic (Best value) set

Semrock's highest-performance BrightLine filter sets offer the best fluorescence filters available, while the value-priced BrightLine Basic filter sets provide a high level of performance and same proven durability at an outstanding price.

BrightLine Filter Set	BrightLine Basic Filter Set	BrightLine Filter Set Compared to BrightLine Basic Filter Set*
$745	$545	
DAPI-1160B	BFP-A-Basic	>10% higher brightness; >10% higher contrast (using BFP)
DAPI-5060C		Several times brighter; comparable contrast (using BFP)
CFP-2432C	CFP-A-Basic	Tens of percent higher brightness; comparable contrast
GFP-3035D	GFP-A-Basic	Tens of percent higher contrast; brightness slightly lower
FITC-3540C	FITC-A-Basic	>10% higher brightness; >10% higher contrast
YFP-2427B	YFP-A-Basic	Tens of percent higher brightness; comparable contrast
TRITC-B	TRITC-A-Basic	Tens of percent higher brightness and contrast; Basic set intentionally designed for traditional deep-red TRITC emission
TXRED-4040C	TXRED-A-Basic	>10% higher brightness; >10% higher contrast

- Only sets which have corresponding BrightLine and BrightLine Basic sets are listed.
- Brightness is based on relative throughput using the primary fluorophore and assuming typical metal-halide lamp and CCD camera spectral responses.
- Contrast is the signal-to-noise ratio (SNR), assuming the background noise is dominated by broadband autofluorescence (as is typically the case in moderate to higher fluorophore concentration samples).

* Actual results may vary depending on instrumentation and the exact sample preparation, which can substantially impact the spectra and relative intensities of the fluorophore and background.

Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
CFW-LP01-Clinical	Exciter	387 nm	> 90% over 11 nm	CFW-Ex01-Clin-25	$245
Calcofluor White, DAPI	Emitter	416 nm (edge)	> 90% 419 – 700 nm	CFW-LP01-Clin-25	$245
Long-pass set *Mycological and fungal staining tests*	Dichroic	409 nm (edge)	R_{avg} > 98% 362 – 396 nm T_{avg} > 90% 419 – 700 nm	CFW-Di01-Clin-25x36	$225
			Unmounted Full Set:	**CFW-LP01-Clinical-000**	**$545**
CFW-BP01-Clinical	Exciter	387 nm	> 90% over 11 nm	CFW-EX01-Clin-25	$245
Calcofluor White, DAPI	Emitter	442 nm	> 90% over 46 nm	CFW-BP01-Clin-25	$245
Mycological and fungal staining tests	Dichroic	409 nm (edge)	R_{avg} > 98% 362 – 396 nm T_{avg} > 90% 419 – 700 nm	CFW-Di01-Clin-25x36	$225
			Unmounted Full Set:	**CFW-BP01-Clinical-000**	**$545**
BFP-A-Basic	Exciter	390 nm	> 90% over 18 nm	FF01-390/18-25	$245
BFP, DAPI, Hoechst, AMCA, Alexa Fluor® 350	Emitter	460 nm	> 90% over 60 nm	FF01-460/60-25	$245
	Dichroic	416 nm (edge)	R_{avg} > 90% 360 – 407 nm T_{avg} > 90% 425 – 575 nm	FF416-Di01-25x36	$225
			Unmounted Full Set:	**BFP-A-Basic-000**	**$545**
CFP-A-Basic	Exciter	434 nm	> 90% over 17 nm	FF01-434/17-25	$245
CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1	Emitter	479 nm	> 90% over 40 nm	FF01-479/40-25	$245
	Dichroic	452 nm (edge)	R_{avg} > 90% 423 – 445 nm T_{avg} > 90% 460 – 610 nm	FF452-Di01-25x36	$225
			Unmounted Full Set:	**CFP-A-Basic-000**	**$545**
WGFP-A-Basic	Exciter	445 nm	> 90% over 45 nm	FF01-445/45-25	$245
wtGFP	Emitter	510 nm	> 90% over 42 nm	FF01-510/42-25	$245
	Dichroic	482 nm (edge)	R_{avg} > 90% 415 – 470 nm T_{avg} > 90% 490 – 720 nm	FF482-Di01-25x36	$225
			Unmounted Full Set:	**WGFP-A-Basic-000**	**$545**
GFP-A-Basic	Exciter	469 nm	> 90% over 35 nm	FF01-469/35-25	$245
GFP, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1	Emitter	525 nm	> 90% over 39 nm	FF01-525/39-25	$245
	Dichroic	497 nm (edge)	R_{avg} > 90% 452 – 490 nm T_{avg} > 90% 505 – 800 nm	FF497-Di01-25x35	$225
			Unmounted Full Set:	**GFP-A-Basic-000**	**$545**
FITC-A-Basic	Exciter	475 nm	> 90% over 35 nm	FF01-475/35-25	$245
FITC, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488	Emitter	530 nm	> 90% over 43 nm	FF01-530/43-25	$245
	Dichroic	499 nm (edge)	R_{avg} > 90% 470 – 490 nm T_{avg} > 90% 508 – 675 nm	FF499-Di01-25x36	$225
			Unmounted Full Set:	**FITC-A-Basic-000**	**$545**

Cubes Page 36

(continued) Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

BrightLine Basic™ Best-value Single-band Sets

Set / Primary Fluorophores		Center Wavelength / Nominal Edge Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Prices
FITC-LP01-Clinical	Exciter	475 nm	> 90% over 28 nm	FITC-Ex01-Clin-25	$245
FITC, Acridine Orange	Emitter	515 nm (edge)	> 90% 519 - 700 nm	FITC-LP01-Clin-25	$245
Long-pass set *Immunofluorescent clinical tests*	Dichroic	500 nm (edge)	R_{avg} > 98% 461.5 – 489.5 nm T_{avg} > 90% 519 – 700 nm	FITC-Di01-Clin-25x36	$225
			Unmounted Full Set:	**FITC-LP01-Clinical-000**	**$545**
YFP-A-Basic	Exciter	497 nm	> 90% over 16 nm	FF01-497/16-25	$245
YFP, Calcium Green-1, Eosin, Fluo-3, Rhodamine 123	Emitter	535 nm	> 90% over 22 nm	FF01-535/22-25	$245
	Dichroic	516 nm (edge)	R_{avg} > 90% 490 – 510 nm T_{avg} > 90% 520 – 700 nm	FF516-Di01-25x36	$225
			Unmounted Full Set:	**YFP-A-Basic-000**	**$545**
TRITC-A-Basic	Exciter	542 nm	> 90% over 20 nm	FF01-542/20-25	$245
TRITC, Rhodamine, DiI, 5-TAMRA, Alexa Fluor® 532 & 546	Emitter	620 nm	> 90% over 52 nm	FF01-620/52-25	$245
	Dichroic	570 nm (edge)	R_{avg} > 90% 525 – 556 nm T_{avg} > 90% 580 – 650 nm	FF570-Di01-25x36	$225
			Unmounted Full Set:	**TRITC-A-Basic-000**	**$545**
Cy3.5-A-Basic	Exciter	565 nm	> 90% over 24 nm	FF01-565/24-25	$245
Cy3.5™, mStrawberry	Emitter	620 nm	> 90% over 52 nm	FF01-620/52-25	$245
	Dichroic	585 nm (edge)	R_{avg} > 90% 533 – 580 nm T_{avg} > 90% 595 – 800 nm	FF585-Di01-25x36	$225
			Unmounted Full Set:	**CY3.5-A-Basic-000**	**$545**
TXRED-A-Basic	Exciter	559 nm	> 90% over 34 nm	FF01-559/34-25	$245
Texas Red®, mCherry, 5-ROX, Alexa Fluor® 568 & 594	Emitter	630 nm	> 90% over 69 nm	FF01-630/69-25	$245
	Dichroic	585 nm (edge)	R_{avg} > 90% 533 – 580 nm T_{avg} > 90% 595 – 800 nm	FF585-Di01-25x36	$225
			Unmounted Full Set:	**TXRED-A-Basic-000**	**$545**

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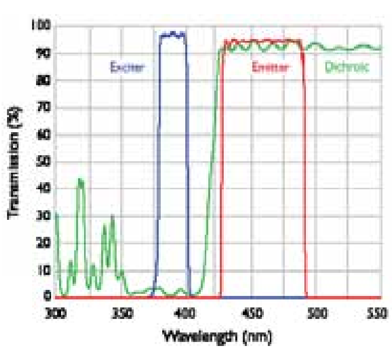
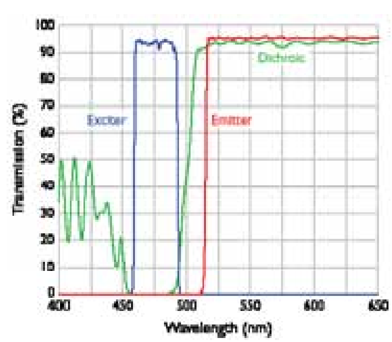
See spectra graphs and ASCII data for all of our filters at www.semrock.com

BFP-A Basic Spectra



FITC-LP01-Clinical Spectra



Technical Note

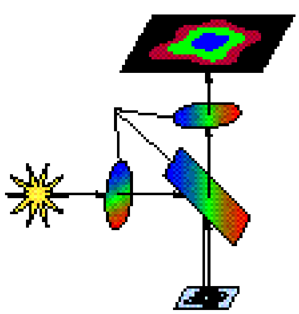
Multiband Filter Set Configurations

The ability to label multiple, distinct objects of interest in a single sample greatly enhances the power of fluorescence imaging. One way to achieve high-quality images of such samples has been to take multiple photographs while switching single-band filter cubes between photographs, and then later to combine these photographs electronically. Limitations to this approach historically included "pixel shift" among the multiple monochrome images, and the speed with which a complete multicolor image could be captured. Semrock solved the problem of "pixel shift" with its BrightLine ZERO™ technology, and the single-band filter cube approach remains the best technique for achieving images with the highest contrast and lowest bleedthrough possible. But with the increasing demand for high-speed imaging, especially for live-cell real-time analysis using fluorescent protein labels, there is a need for an alternative to the single-band filter cube approach that does not sacrifice too much image fidelity. Now Semrock's advanced multiband optical filter technology brings simultaneous multicolor imaging to a new level.

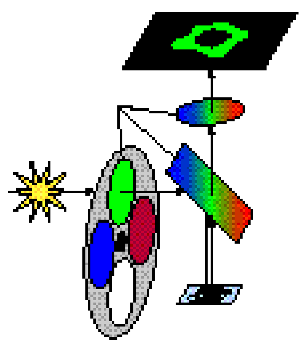
There are three types of multiband filter sets for simultaneous multicolor imaging. The "full multiband" configuration uses all multiband filters – exciter, emitter, and dichroic beamsplitter – and is ideal for direct visualization, such as locating areas of interest on a sample. This approach is quick and easy to implement, and is compatible with all standard fluorescence microscopes. However, it requires a color camera for electronic imaging and cannot eliminate fluorophore bleedthrough. The "Pinkel" configuration uses single-band exciters in a filter wheel with multiband emitter and dichroic filters. It offers an economical way to achieve very high-speed, high-contrast, simultaneous multi-color imaging. This approach is based on a monochrome CCD camera, which is less expensive and offers better noise performance than color cameras. While bleedthrough is reduced relative to the full-multiband approach, some bleedthrough is still possible since all emission bands are imaged simultaneously. The "Sedat" configuration uses single-band exciters and single-band emitters in synchronized filter wheels, with a multiband dichroic beamsplitter. This approach provides the best image fidelity for high-speed simultaneous multi-color imaging, though it requires a larger investment in system hardware.

In fact, Semrock is your only source of "full multiband" quad-band filter sets and the unique penta "Sedat" set.

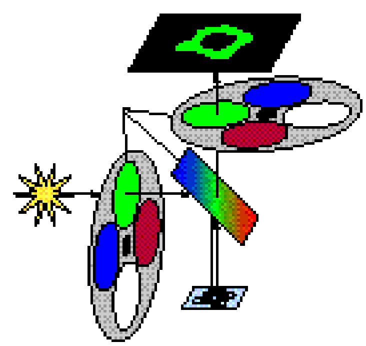
"Full Multiband" Configuration
(Multiband exciter, multiband emitter, & multiband dichroic)



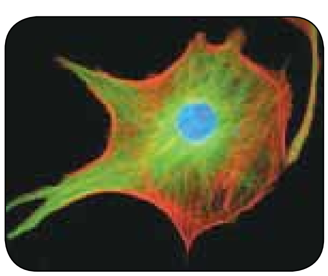
"Pinkel" Configuration
(Multiband emitter, multiband dichroic, & single-band exciters)



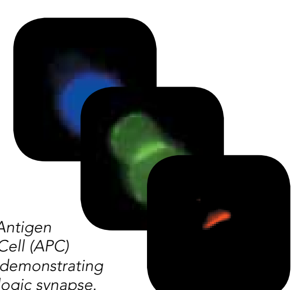
"Sedat" Configuration
(Multiband dichroic, single-band exciters, & single-band emitters)

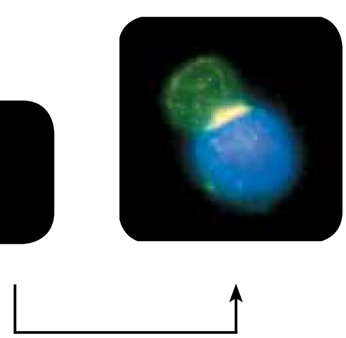


"Full Multiband" Image
Multi-color image captured with a color CCD camera



"Pinkel" and "Sedat" Composite Image
Single-color images are combined electronically to produce one high-fidelity, multi-color image.



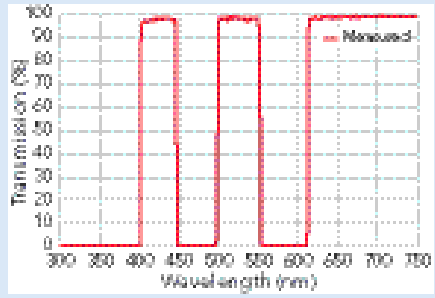


T-Cell and Antigen Presenting Cell (APC) conjugates demonstrating an immunologic synapse. Samples courtesy of Beth Graf and Dr. Jim Miller at the University of Rochester Medical Center.

BrightLine® Multiband Fluorescence Sets

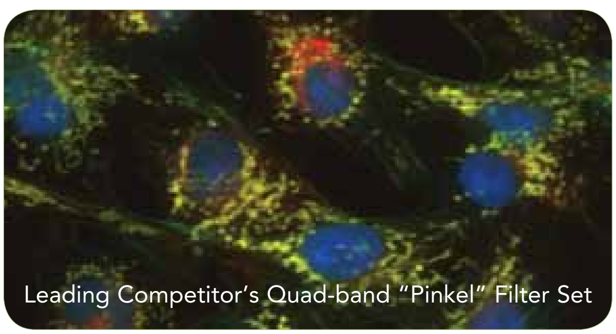
Semrock manufactures multiband fluorescence filters with passband, edge steepness, and blocking performance that rival the best single-band filters, and all with the superior, "no burn-out" durability of hard coatings. In fact, every filter in every BrightLine filter set, including these multiband sets, is made with the same, durable hard-coating technology. So you will always see…

- The highest transmission and steepest edges for dazzling digital and visual brightness
- Deep blocking for striking contrast – visually and digitally
- *ALL* hard dielectric coatings, including blue and UV filters, for long-lasting "no burn-out" performance

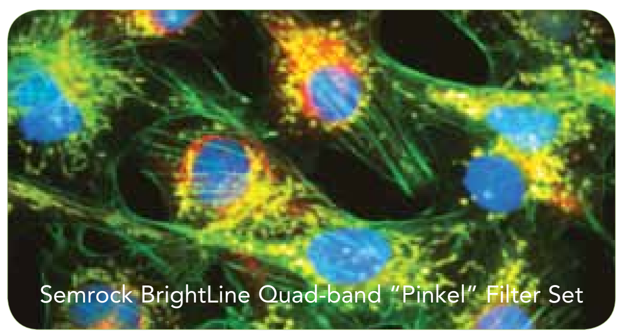


Graph above shows typical measured transmission of the FF01-425/527/685-25 filter

Independent test findings – four times brighter and twice the contrast

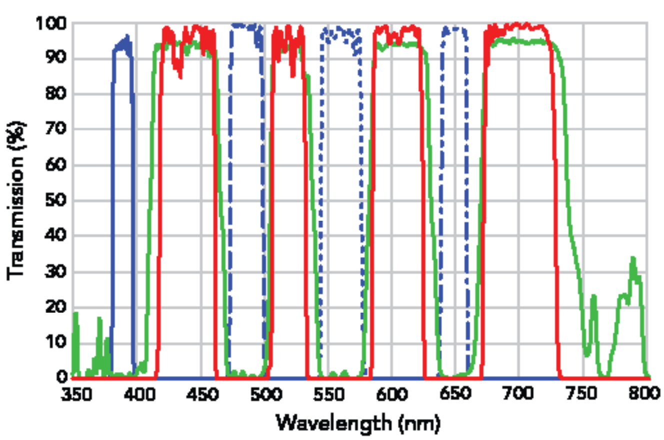


Leading Competitor's Quad-band "Pinkel" Filter Set



Semrock BrightLine Quad-band "Pinkel" Filter Set

Comparisons done under identical imaging conditions using an Olympus BX61WI microscope outfitted with DSU spinning-disk confocal unit and Hamamatsu ORCA-ER monochrome CCD camera. Sample of Rat Kidney Mesangial Cells courtesy of Mike Davidson, Molecular Expressions™, using: Hoechst 33258, Alexa Fluor® 488 – Phalloidin, MitoTracker Red CMXRos, and Vimentin (Ms) – Cy5™. Semrock DA/FI/TR/Cy5-4X-A filter set *(see page 30)*.



DA/FI/TR/Cy5-4X-B "Pinkel" Set Spectra

This 6-filter quad-band set is designed for high-speed, sequential imaging of DAPI, FITC, TRITC, and Cy5. The complete set is comprised of a quad-band beamsplitter with one quadband emitter and four "no burn-out" single-band exciters. The single-band filters are intended to be mounted in filter wheels. For a "Sedat" version of this filter set, see the DA/FI/TR/Cy5-4X4M-B set on page 33.

"Full Multiband" Dual-band Filter Sets – multiband exciters, emitters and beamsplitters

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI-A Full Multiband Set	387 nm 480 nm	> 80% over 11 nm > 90% over 29 nm	Dual-band Exciter FF01-387/480-25	$375
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488	433 nm 530 nm	> 90% over 38 nm > 90% over 40 nm	Dual-band Emitter FF01-433/530-25	$375
	Avg. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 97.5% 370 – 393 nm > 97.5% 466 – 495 nm	> 90% 414 – 452 nm > 90% 510 – 550 nm	Dual-band Dichroic FF403/502-Di01-25x36	$325
		Unmounted Full Set:	**DA/FI-A-000**	**$975**
CFP/YFP-A Full Multiband Set	416 nm 501 nm	> 90% over 25 nm > 90% over 18 nm	Dual-band Exciter FF01-416/501-25	$375
Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 Yellow: YFP, Calcium Green-1, Eosin, Rhodamine 123	464 nm 547 nm	> 90% over 23 nm > 90% over 31 nm	Dual-band Emitter FF01-464/547-25	$375
	Avg. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 95% 415 – 432 nm > 95% 493 – 511 nm	> 90% 449 – 483 nm > 90% 530 – 569 nm	Dual-band Dichroic FF440/520-Di01-25x36	$325
		Unmounted Full Set:	**CFP/YFP-A-000**	**$975**
GFP/DsRed-A Full Multiband Set	468 nm 553 nm	> 90% over 34 nm > 90% over 24 nm	Dual-band Exciter FF01-468/553-25	$375
Green: GFP, rsGFP, FITC, Alexa Fluor® 488 Red: DsRed, TRITC, Cy3™, Texas Red®, Alexa Fluor® 568 & 594	512 nm 630 nm	> 90% over 23 nm > 90% over 91 nm	Dual-band Emitter FF01-512/630-25	$375
	Avg. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 95% 456 – 480 nm > 95% 541 – 565 nm	> 90% 500 – 529 nm > 90% 584 – 679 nm	Dual-band Dichroic FF493/574-Di01-25x36	$325
		Unmounted Full Set:	**GFP/DsRed-A-000**	**$975**
FITC/TxRed-A Full Multiband Set	479 nm 585 nm	> 90% over 38 nm > 90% over 27 nm	Dual-band Exciter FF01-479/585-25	$375
Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488 Red: Texas Red®, mCherry, Alexa Fluor® 568 & 594	524 nm 628 nm	> 90% over 29 nm > 90% over 33 nm	Dual-band Emitter FF01-524/628-25	$375
	Avg. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 95% 458 – 499 nm > 95% 570 – 600 nm	> 90% 509 – 541 nm > 90% 612 – 647 nm	Dual-band Dichroic FF505/606-Di01-25x36	$325
		Unmounted Full Set:	**FITC/TxRed-A-000**	**$975**
Cy3/Cy5-A Full Multiband Set	534 nm 635 nm	> 90% over 36 nm > 90% over 31 nm	Dual-band Exciter FF01-534/635-25	$375
Yellow: Cy3™, DsRed, Alexa Fluor® 555 Red: Cy5™, SpectrumFRed™, Alexa Fluor® 647 & 660	577 nm 690 nm	> 90% over 24 nm > 90% over 50 nm	Dual-band Emitter FF01-577/690-25	$375
	Avg. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 95% 514 – 553 nm > 95% 617 – 652 nm	> 90% 564 – 591 nm > 90% 665 – 718 nm	Dual-band Dichroic FF560/659-Di01-25x36	$325
		Unmounted Full Set:	**Cy3/Cy5-A-000**	**$975**

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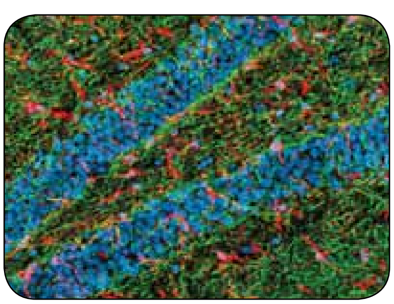
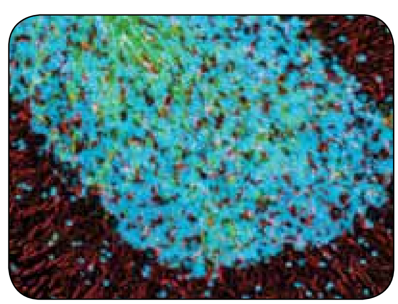
(continued) Filter Specifications on page 35



Images courtesy of Mike Davidson at Molecular Expressions™ using BrightLine fluorescence filter sets.



See spectra graphs and ASCII data for all of our filters at www.semrock.com

BrightLine® Multiband Fluorescence Sets

"Full Multiband" Triple- and Quad-band Filter Sets

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI/TR-A Full Multiband Set	387 nm 478 nm 555 nm	> 80% over 11 nm > 90% over 24 nm > 90% over 19 nm	Triple-band Exciter FF01-387/478/555-25	$405
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488 Orange: TRITC (Tetramethylrhodamine), DsRed, Cy3™, Alexa Fluor® 555	433 nm 517 nm 613 nm	> 90% over 36 nm > 90% over 23 nm > 90% over 61 nm	Triple-band Emitter FF01-433/517/613-25	$405
Triple-band	**Avg. Reflection / Bandwidths**	**Avg. Transmission / Bandwidth**		
	> 97.5% 386 – 393 nm > 97.5% 466 – 490 nm > 97.5% 546 – 565 nm	> 90% 414 – 450 nm > 90% 505 – 528 nm > 90% 584 – 645 nm	Triple-band Dichroic FF403/497/574-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TR-A-000**	**$1145**
DA/FI/TX-B Full Multiband Set	407 nm 494 nm 576 nm	> 80% over 14 nm > 85% over 20 nm > 85% over 20 nm	Triple-band Exciter FF01-407/494/576-25	$405
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488 Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	457 nm 530 nm 628 nm	> 80% over 22 nm > 85% over 20 nm > 85% over 28 nm	Triple-band Emitter FF01-457/530/628-25	$405
Triple-band	**Avg. Reflection / Bandwidths**	**Avg. Transmission / Bandwidth**		
	> 97.5% 394 – 414 nm > 97.5% 484 – 504 nm > 97.5% 566 – 586 nm	> 90% 446 – 468 nm > 90% 520 – 540 nm > 90% 614 – 642 nm	Triple-band Dichroic FF436/514/604-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TX-B-000**	**$1145**
DA/FI/TR/Cy5-A Full Multiband Set	387 nm 485 nm 559 nm 649 nm	> 85% over 11 nm > 90% over 20 nm > 90% over 25 nm > 90% over 13 nm	Quad-band Exciter FF01-387/485/559/649-25	$475
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488 Orange: TRITC (Tetramethylrhodamine), DsRed, Cy3™, Alexa Fluor® 555 Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	440 nm 521 nm 607 nm 700 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 45 nm	Quad-band Emitter FF01-440/521/607/700-25	$475
Quad-band	**Avg. Reflection / Bandwidths**	**Avg. Transmission / Bandwidth**		
	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm	> 90% 420 - 460 nm > 90% 510 - 531 nm > 90% 589 - 623 nm > 90% 677 - 722 nm	Quad-band Dichroic FF410/504/582/669-Di01-25x36	$495
		Unmounted Full Set:	**DA/FI/TR/Cy5-A-000**	**$1295**

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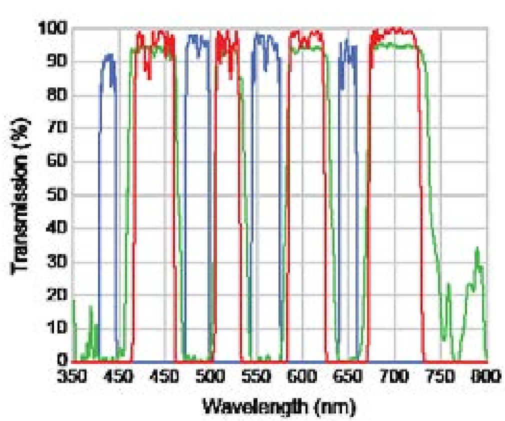
Filter Specifications on page 35

A "full multiband" filter set consists of one exciter, one emitter and one dichroice to visualize all colors simultaneously. Full multiband sets are excellent for direct visualization with the human eye or color cameras.

For graphs, ASCII data and full fluorophore list, go to www.semrock.com



"Pinkel" Dual-band Filter Sets – individual exciters, one dual-band emitter and one beamsplitter

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI-2X-B Pinkel Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
	433 nm 530 nm	> 90% over 38 nm > 90% over 40 nm	Dual-band Emitter FF01-433/530-25	$375
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 97.5% 370 – 393 nm > 97.5% 466 – 495 nm	> 90% 414 – 452 nm > 90% 510 – 550 nm	Dual-band Dichroic FF403/502-Di01-25x36	$325
		Unmounted Full Set:	**DA/FI-2X-B-000**	**$1195**
CFP/YFP-2X-A Pinkel Set	427 nm	> 93% over 10 nm	Exciter 1 FF01-427/10-25	$295
Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 Yellow: YFP, Calcium Green-1, Eosin, Rhodamine 123	504 nm	> 93% over 12 nm	Exciter 2 FF01-504/12-25	$295
	464 nm 547 nm	> 90% over 23 nm > 90% over 31 nm	Dual-band Emitter FF01-464/547-25	$375
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 415 – 432 nm > 95% 493 – 511 nm	> 90% 449 – 483 nm > 90% 530 – 569 nm	Dual-band Dichroic FF440/520-Di01-25x36	$325
		Unmounted Full Set:	**CFP/YFP-2X-A-000**	**$1195**
GFP/DsRed-2X-A Pinkel Set	470 nm	> 93% over 22 nm	Exciter 1 FF01-470/22-25	$295
Green: GFP, rsGFP, FITC, Alexa Fluor® 488 Red: DsRed, TRITC, Cy3™, Texas Red®, Alexa Fluor® 568 & 594	556 nm	> 93% over 20 nm	Exciter 2 FF01-556/20-25	$295
	512 nm 630 nm	> 90% over 23 nm > 90% over 91 nm	Dual-band Emitter FF01-512/630-25	$375
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
Dual-band	> 95% 456 – 480 nm > 95% 541 – 565 nm	> 90% 500 – 529 nm > 90% 584 – 679 nm	Dual-band Dichroic FF493/574-Di01-25x36	$325
		Unmounted Full Set:	**GFP/DsRed-2X-A-000**	**$1195**
GFP/HcRed-2X-A Pinkel Set	474 nm	> 90% over 23 nm	Exciter 1 FF01-474/23-25	$295
Green: GFP, rsGFP, FITC, Alexa Fluor® 488 Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594	585 nm	> 90% over 29 nm	Exciter 2 FF01-585/29-25	$295
	527 nm 645 nm	> 90% over 42 nm > 90% over 49 nm	Dual-band Emitter FF01-527/645-25	$375
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 454 – 485 nm > 95% 570 – 598 nm	> 90% 505 – 550 nm > 90% 620 – 675 nm	Dual-band Dichroic FF495/605-Di01-25x36	$325
		Unmounted Full Set:	**GFP/HcRed-2X-A-000**	**$1195**
FITC/TxRed-2X-B Pinkel Set	485 nm	> 93% over 20 nm	Exciter 1 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488 Red: Texas Red®, mCherry, Alexa Fluor® 568 & 594	586 nm	> 93% over 20 nm	Exciter 2 FF01-586/20-25x5	$295
	524 nm 628 nm	> 90% over 29 nm > 90% over 33 nm	Dual-band Emitter FF01-524/628-25	$375
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 458 – 499 nm > 95% 570 – 600 nm	> 90% 509 – 541 nm > 90% 612 – 647 nm	Dual-band Dichroic FF505/606-Di01-25x36	$325
		Unmounted Full Set:	**FITC/TxRed-2X-B-000**	**$1195**
Cy3/Cy5-2X-B Pinkel Set	534 nm	> 93% over 30 nm	Exciter 1 FF02-534/30-25	$295
Yellow: Cy3™, DsRed, Alexa Fluor® 555 Red: Cy5™, SpectrumFRed™, Alexa Fluor® 647 & 660	628 nm	> 93% over 40 nm	Exciter 2 FF02-628/40-25	$295
	577 nm 690 nm	> 90% over 24 nm > 90% over 50 nm	Dual-band Emitter FF01-577/690-25	$375
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 514 – 553 nm > 95% 617 – 652 nm	> 90% 564 – 591 nm > 90% 665 – 718 nm	Dual-band Dichroic FF560/659-Di01-25x36	$325
		Unmounted Full Set:	**Cy3/Cy5-2X-B-000**	**$1195**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(continued)

Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

BrightLine® Multiband Fluorescence Sets

"Pinkel" Triple-band Filter Sets

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
BFP/GFP/HcRed-3X-A Pinkel Set	370 nm	> 90% over 36 nm	Exciter 1 FF01-370/36-25	$295
Blue: BFP, DAPI, Hoechst, AMCA, Alexa Fluor® 350 Green: GFP, rsGFP, FITC, Alexa Fluor® 488 Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594	474 nm	> 93% over 23 nm	Exciter 2 FF01-474/23-25	$295
	585 nm	> 93% over 29 nm	Exciter 3 FF01-585/29-25	$295
Triple-band	425 nm 527 nm 685 nm	> 90% over 35 nm > 90% over 42 nm > 90% over 130 nm	Triple-band Emitter FF01-425/527/685-25	$405
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 354 – 385 nm > 95% 465 – 483 nm > 95% 570 – 596 nm	> 90% 403 – 446 nm > 90% 502 – 552 nm > 90% 620 – 750 nm	Triple-band Dichroic FF395/495/610-Di01-25x36	$425
		Unmounted Full Set:	**BFP/GFP/HcRed-3X-A-000**	**$1495**
CFP/YFP/HcRed-3X-A Pinkel Set	427 nm	> 93% over 10 nm	Exciter 1 FF01-427/10-25	$295
Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 Yellow: YFP, Calcium Green-1, Fluo-3, Rhodamine 123 Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594	504 nm	> 93% over 12 nm	Exciter 2 FF01-504/12-25	$295
	589 nm	> 93% over 15 nm	Exciter 3 FF01-589/15-25	$295
Triple-band	464 nm 542 nm 639 nm	> 90% over 23 nm > 90% over 27 nm > 90% over 42 nm	Triple-band Emitter FF01-464/542/639-25	$405
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 420 – 430 nm > 95% 496 – 510 nm > 95% 579 – 596 nm	> 90% 451 – 480 nm > 90% 530 – 561 nm > 90% 618 – 664 nm	Triple-band Dichroic FF444/521/608-Di01-25x36	$425
		Unmounted Full Set:	**CFP/YFP/HcRed-3X-A-000**	**$1495**
DA/FI/TR-3X-A Pinkel Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI Green: FITC (Fluorescein), GFP (EGFP) Orange: TRITC (Tetramethylrhodamine)	480 nm	> 92% over 17 nm	Exciter 1 FF01-480/17-25	$295
	556 nm	> 93% over 20 nm	Exciter 1 FF01-556/20-25	$295
Triple-band	433 nm 517 nm 613 nm	> 90% over 36 nm > 90% over 23 nm > 90% over 61 nm	Triple-band Emitter FF01-433/517/613-25	$405
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 97.5% 386 - 393 nm > 97.5% 466 - 490 nm > 97.5% 546 - 565 nm	> 90% 414 – 450 nm > 90% 505 – 528 nm > 90% 584 – 645 nm	Triple-band Dichroic FF403/497/574-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TR-3X-A-000**	**$1495**
DA/FI/TX-3X-B Pinkel Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350 Green: FITC, GFP, rsGFP, BoDipy, Alexa Fluor® 488 Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	494 nm	> 93% over 20 nm	Exciter 2 FF01-494/20-25	$295
	575 nm	> 93% over 25 nm	Exciter 3 FF02-575/25-25	$295
	457 nm 530 nm 628 nm	> 80% over 22 nm > 85% over 20 nm > 85% over 28 nm	Triple-band Emitter FF01-457/530/628-25	$405
Triple-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 97.5% 394 – 414 nm > 97.5% 484 – 504 nm > 97.5% 566 – 586 nm	> 90% 446 – 468 nm > 90% 520 – 540 nm > 90% 614 – 642 nm	Triple-band Dichroic FF436/514/604-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TX-3X-B-000**	**$1495**


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Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

"Pinkel" Quad-band and Penta-band Filter Sets

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI/TR/Cy5-4X-B Pinkel Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, Alexa Fluor® 350	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, Bodipy, AlexaFluor® 488	560 nm	> 93% over 25 nm	Exciter 3 FF01-560/25-25	$295
Orange: TRITC, Cy3™, Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	650 nm	> 93% over 13 nm	Exciter 4 FF01-650/13-25	$295
Red: Cy5™, APC, TOTO-3, TO-PRO-3, Alexa Fluor® 647 & 660 *Quad-band*	440 nm 521 nm 607 nm 700 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 45 nm	Quad-band Emitter FF01-440/521/607/700-25	$475
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 722 nm	Quad-band Dichroic FF410/504/582/669-Di01-25x36	$495
		Unmounted Full Set:	**DA/FI/TR/Cy5-4X-B-000**	**$1945**
DA/FI/TR/Cy5/Cy7-5X-A Pinkel Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, Alexa Fluor® 350	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, Bodipy, AlexaFluor® 488	560 nm	> 93% over 25 nm	Exciter 3 FF01-560/25-25	$295
Orange: TRITC, Cy3™, Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	650 nm	> 93% over 13 nm	Exciter 4 FF01-650/13-25	$295
Red: Cy5™, APC, TOTO-3, TO-PRO-3, Alexa Fluor® 647 & 660 Deep Red: Cy7™	740 nm	> 93% over 13 nm	Exciter 5 FF01-740/13-25	$345
Penta-band NEW	440 nm 521 nm 607 nm 694 nm 809 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 34.5 nm > 90% over 81 nm	Penta-band Emitter FF01-440/521/607/694/809-25	$545
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm > 95% 733 – 746 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 711 nm > 90% 768 – 849 nm	Penta-band Dichroic FF408/504/581/667/762-Di01-25x36	$575
		Unmounted Full Set:	**DA/FI/TR/Cy5/Cy7-4X-A-000**	**$2295**

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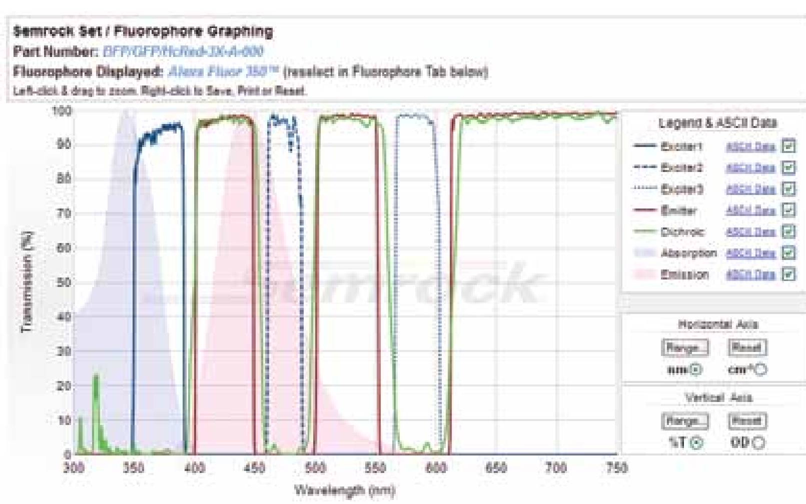
Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Double check that the set you want is the set you need.

Graph a filter set and a fluorophore at the same time online, in an instant.



BrightLine® Multiband Fluorescence Sets

"Sedat" Dual-band Filter Sets – individual exciters and emitters and one multiband beamsplitter

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI-2X2M-B Sedat Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488	435 nm	> 90% over 40 nm	Emitter 1 FF02-435/40-25	$295
	531 nm	> 93% over 40 nm	Emitter 2 FF01-531/40-25	$295
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 97.5% 370 – 393 nm > 97.5% 466 – 495 nm	> 90% 414 – 452 nm > 90% 510 – 550 nm	Dual-band Dichroic FF403/502-Di01-25x36	$325
		Unmounted Full Set:	**DA/FI-2X2M-B-000**	**$1375**
CFP/YFP-2X2M-B Sedat Set	427 nm	> 93% over 10 nm	Exciter 1 FF01-427/10-25	$295
Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1	504 nm	> 93% over 12 nm	Exciter 2 FF01-504/12-25	$295
Yellow: YFP, Calcium Green-1, Eosin, Rhodamine 123	472 nm	> 93% over 30 nm	Emitter 1 FF02-472/30-25	$295
	542 nm	> 93% over 27 nm	Emitter 2 FF01-542/27-25	$295
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 415 – 432 nm > 95% 493 – 511 nm	> 90% 449 – 483 nm > 90% 530 – 569 nm	Dual-band Dichroic FF440/520-Di01-25x36	$325
		Unmounted Full Set:	**CFP/YFP-2X2M-B-000**	**$1375**
GFP/DsRed-2X2M-C Sedat Set	470 nm	> 93% over 22 nm	Exciter 1 FF01-470/22-25	$295
Green: GFP, rsGFP, FITC, Alexa Fluor® 488	556 nm	> 93% over 20 nm	Exciter 2 FF01-556/20-25	$295
Red: DsRed, TRITC, Cy3™, Texas Red®, Alexa Fluor® 568 & 594	514 nm	> 93% over 30 nm	Emitter 1 FF01-514/30-25	$295
	617 nm	> 90% over 73 nm	Emitter 2 FF02-617/73-25	$345
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 456 – 480 nm > 95% 541 – 565 nm	> 90% 500 – 529 nm > 90% 584 – 679 nm	Dual-band Dichroic FF493/574-Di01-25x36	$325
		Unmounted Full Set:	**GFP/DsRed-2X2M-C-000**	**$1375**
FITC/TxRed-2X2M-B Sedat Set	485 nm	> 93% over 20 nm	Exciter 1 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, BoDipy, Alexa Fluor® 488	586 nm	> 93% over 20 nm	Exciter 2 FF01-586/20-25x5	$295
Red: Texas Red®, mCherry, Alexa Fluor® 568 & 594	536 nm	> 93% over 40 nm	Emitter 1 FF01-536/40-25	$295
	628 nm	> 93% over 32 nm	Emitter 2 FF01-628/32-25	$295
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 458 – 499 nm > 95% 570 – 600 nm	> 90% 509 – 541 nm > 90% 612 – 647 nm	Dual-band Dichroic FF505/606-Di01- 25x36	$325
		Unmounted Full Set:	**FITC/TxRed-2X2M-B-000**	**$1375**
Cy3/Cy5-2X2M-B Sedat Set	534 nm	> 93% over 30 nm	Exciter 1 FF02-534/30-25	$295
	628 nm	> 93% over 40 nm	Exciter 2 FF02-628/40-25	$295
Yellow: Cy3™, DsRed, Alexa Fluor® 555	585 nm	> 90% over 40 nm	Emitter 1 FF01-585/40-25	$295
Red: Cy5™, SpectrumFRed™, Alexa Fluor® 647 & 660	692 nm	> 93% over 40 nm	Emitter 2 FF01-692/40-25	$295
Dual-band	**Avg. Reflection / Bandwidth**	**Avg. Transmission / Bandwidth**		
	> 95% 514 – 553 nm > 95% 617 – 652 nm	> 90% 564 – 591 nm > 90% 665 – 718 nm	Dual-band Dichroic FF560/659-Di01-25x36	$325
		Unmounted Full Set:	**Cy3/Cy5-2X2M-B-000**	**$1375**

Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

All Semrock Pinkel and Sedat sets now available with Sutter Threaded Rings compatible with Sutter filter wheels. The threaded ring replaces the standard filter housing and also the cup/retaining ring system in the filter wheel. The result is reduced weight for maximum filter wheel speed. See our website for particular Sutter set part numbers when ordering.

"Sedat" Triple-band Filter Sets

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
CFP/YFP/HcRed-3X3M-B Sedat Set	427 nm	> 93% over 10 nm	Exciter 1 FF01-427/10-25	$295
Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1	504 nm	> 93% over 12 nm	Exciter 2 FF01-504/12-25	$295
Yellow: YFP, Calcium Green-1, Fluo-3, Rhodamine 123	589 nm	> 93% over 15 nm	Exciter 3 FF01-589/15-25	$295
Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594	472 nm	> 93% over 30 nm	Emitter 1 FF02-472/30-25	$295
Triple-band	542 nm	> 93% over 27 nm	Emitter 2 FF01-542/27-25	$295
	632 nm	> 93% over 22 nm	Emitter 3 FF02-632/22-25	$295
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 420 – 430 nm > 95% 496 – 510 nm > 95% 579 – 596 nm	> 90% 451 – 480 nm > 90% 530 – 561 nm > 90% 618 – 664 nm	Triple-band Dichroic FF444/521/608-Di01-25x36	$425
		Unmounted Full Set:	**CFP/YFP/HcRed-3X3M-B-000**	**$1995**
DA/FI/TX-3X3M-B Sedat Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
	494 nm	> 93% over 20 nm	Exciter 2 FF01-494/20-25	$295
Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350	575 nm	> 93% over 25 nm	Exciter 3 FF02-575/25-25	$295
Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488	447 nm	> 93% over 60 nm	Emitter 1 FF02-447/60-25	$295
Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	531 nm	> 93% over 22 nm	Emitter 2 FF02-531/22-25	$295
Triple-band	624 nm	> 93% over 40 nm	Emitter 3 FF01-624/40-25	$295
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 97.5% 394 – 414 nm > 97.5% 484 – 504 nm > 97.5% 566 – 586 nm	> 90% 446 – 468 nm > 90% 520 – 540 nm > 90% 614 – 642 nm	Triple-band Dichroic FF436/514/604-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TX-3X3M-B-000**	**$1995**
DA/FI/TR-3X3M-C Sedat Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI	480 nm	> 92% over 17 nm	Exciter 2 FF01-480/17-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	556 nm	> 93% over 20 nm	Exciter 3 FF01-556/20-25	$295
Orange: TRITC (Tetramethylrhodamine)	435 nm	> 90% over 40 nm	Emitter 1 FF02-435/40-25	$295
Triple-band	520 nm	> 93% over 28 nm	Emitter 2 FF02-520/28-25	$295
	617 nm	> 90% over 73 nm	Emitter 3 FF02-617/73-25	$295
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 97.5% 386 – 393 nm > 97.5% 466 – 490 nm > 97.5% 546 – 565 nm	> 90% 414 – 450 nm > 90% 505 – 528 nm > 90% 584 – 645 nm	Triple-band Dichroic FF403/497/574-Di01-25x36	$425
		Unmounted Full Set:	**DA/FI/TR-3X3M-C-000**	**$1995**

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Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

If you use a Leica microscope, all BrightLine single-band bandpass filters in "Pinkel" and "Sedat" sets come with standard 25 mm (32 mm optional) exciters and 25 mm emitters, which are packaged separately for convenient mounting in standard filter wheels. For set part numbers for Leica microscopes, see www.semrock.com.

BrightLine® Multiband Fluorescence Sets

"Sedat" Quad- and Penta-band Filter Sets

Set / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
DA/FI/TR/Cy5-4X4M-C Sedat Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI, Hoechst, AMCA, Alexa Fluor® 350	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488	560 nm	> 93% over 25 nm	Exciter 3 FF01-560/25-25	$295
Orange: TRITC, Cy3™, Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594	650 nm	> 93% over 13 nm	Exciter 4 FF01-650/13-25	$295
Red: Cy5™, APC, TOTO-3, TO-PRO-3, Alexa Fluor® 647 & 660	440 nm	> 93% over 40 nm	Emitter 1 FF01-440/40-25	$295
Quad-band	525 nm	> 90% over 30 nm	Emitter 2 FF01-525/30-25	$295
	607 nm	> 93% over 36 nm	Emitter 3 FF01-607/36-25	$295
	684 nm	> 93% over 24 nm	Emitter 4 FF02-684/24-25	$295
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 722 nm	Quad-band Dichroic FF410/504/582/669-Di01-25x36	$495
		Unmounted Full Set:	**DA/FI/TR/Cy5-4X4M-C-000**	**$2445**
DA/FI/TR/Cy5/Cy7-5X5M-B Sedat Set	387 nm	> 90% over 11 nm	Exciter 1 FF01-387/11-25	$295
Blue: DAPI,	485 nm	> 93% over 20 nm	Exciter 2 FF02-485/20-25	$295
Green: FITC, GFP	560 nm	> 93% over 25 nm	Exciter 3 FF01-560/25-25	$295
Orange: TRITC	650 nm	> 93% over 13 nm	Exciter 4 FF01-650/13-25	$295
Red: Cy5™	740 nm	> 93% over 13 nm	Exciter 5 FF01-740/13-25	$345
Red/Near -IR: Cy7™	440 nm	> 93% over 40 nm	Emitter 1 FF01-440/40-25	$295
Penta-band	525 nm	> 90% over 30 nm	Emitter 2 FF01-525/30-25	$295
	607 nm	> 93% over 36 nm	Emitter 3 FF01-607/36-25	$295
	684 nm	> 93% over 24 nm	Emitter 4 FF02-684/24-25	$295
	809 nm	> 93% over 81 nm	Emitter 5 FF02-809/81-25	$295
	Avg. Reflection / Bandwidth	**Avg. Transmission / Bandwidth**		
	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm > 95% 733 – 746 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 711 nm > 90% 768 – 849 nm	Penta-band Dichroic FF408/504/581/667/762-Di01-25x36	$575
		Unmounted Full Set:	**DA/FI/TR/Cy5/Cy7-5X5M-B-000**	**$2945**

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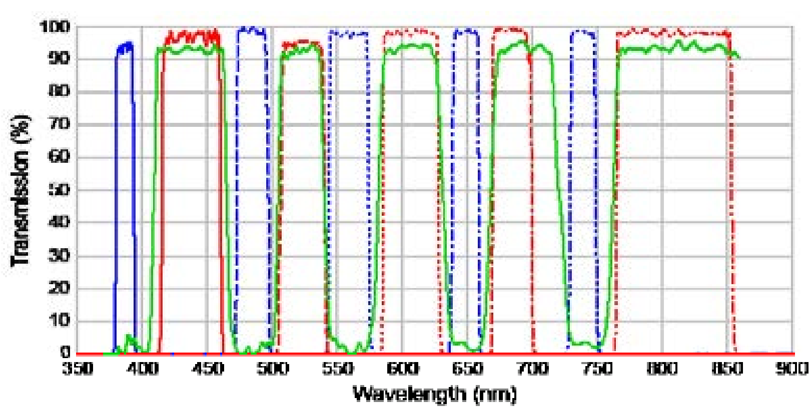
Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Actual Measured Data of DA/FI/TR/Cy5/Cy7-5X5M-B

The Penta-Sedat set allows for imaging five bands simultaneously. ONLY available from Semrock.



BrightLine® Filter Common Specifications
(for filters in sets pages 11–34)

Exciter and Emitter Specifications (except where otherwise noted)

Property	Specification	Comment
Guaranteed Transmission	> 93%	Except BrightLine Basic™ and Qdot®: > 90%; Except Multiband *(see set tables)* Averaged over the passband
Typical Transmission	> 97%	Except BrightLine Basic and Qdot: > 94% Averaged over the passband
Angle of Incidence	0° ± 5°	Range of angles over which optical specs are guaranteed for collimated light
Cone Half-angle	7°	Filter performance is likely to remain satisfactory up to 10° Centered around the nominal Angle of Incidence
Autofluorescence	Low	
Transverse Dimensions	25.0 mm	Except Leica sizes, see www.semrock.com
Transverse Tolerance	+ 0.0 / - 0.1 mm	
Exciter Thickness	5.0 mm	Black-anodized aluminium ring
Emitter Thickness	3.5 mm	Black-anodized aluminium ring
Thickness Tolerance	± 0.1 mm	Black-anodized aluminium ring
Exciter Clear Aperture	> 21 mm	Except Leica filters: > 85%
Emitter Clear Aperture	> 22 mm	Except BrightLine Basic & Qdot: > 21 mm; Except Leica filters: > 85%
Scratch-Dig	60-40	Except BrightLine Basic: 80-50 Measured within clear aperture
Ring Housing Material	Aluminum, black anodized	
Blocking	BrightLine filters have blocking far exceeding OD 6 (except BrightLine Basic: OD 5) as needed to ensure the blackest background, even when using modern low-noise CCD cameras. The blocking is optimized for microscopy applications using our exclusive SpecMaker™ fluorescence filter design software.	
Orientation	Arrow on ring indicates preferred direction of propagation of light *(see page 47)*	

Dichroic Beamsplitter Specifications (except where otherwise noted)

Property	Specification	Comment
Guaranteed Transmission	> 93%	Averaged over the specified band
Typical Transmission	> 97%	Averaged over the specified band
Reflection	> 98%	Except BrightLine Basic: > 90%; and Multiband *(see set tables)* Averaged over the specified band
Angle of Incidence	45° ± 1.5°	Range of angles over which optical specs are guaranteed for collimated light
Cone Half-angle	2°	Filter performance is likely to remain satisfactory up to 3° Centered around the nominal Angle of Incidence
Autofluorescence	Ultra-low	
Transverse Dimensions	25.2 x 35.6 mm	Except Leica sizes, see www.semrock.com
Transverse Tolerance	± 0.1 mm	
Thickness	1.05 mm	Except where otherwise noted
Thickness Tolerance	± 0.05 mm	
Clear Aperture	> 80%	Elliptical
Surface Quality	60-40	Except BrightLine Basic: 80-50 Measured within clear aperture
Edge Chipping	Per ANSI/OEOSC OP1.002-2006, American Standard	
Orientation	Reflective coating side should face toward light source and sample *(see page 47)*	

For Laser Dichroic Specifications, see page 69

General Filter Specifications (all BrightLine filters)

Property	Specification
Coating Type	"Hard" ion-beam-sputtered
Reliability and Durability	Hard-coated technology with epoxy-free, single-substrate construction for unrivaled filter life span and no "burn-out" even when subjected to high optical intensities for a prolonged period of time. BrightLine filters are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.
Microscope Compatibility	All BrightLine filters are available to fit Leica, Nikon, Olympus, Zeiss and Aperio microscopes.

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Fluorescence Filter Cubes and Holders

View online video tutorials on installing filters in your own cube.

	Microscope Brand / Compatible Microscopes	Semrock Cube Designation	Cube Price*	Cube Part Number	Filter Set Part Number Mounted in Cube
	Aperio				
	ScanScope FL	AMF	$420	AMF	<Set Part Number>-AMF
	Nikon				
	TE2000, 80i, 90i, 50i, 55i, Eclipse Ti and any using the Epi-fluor Illuminator	TE2000	$385	See online video NTE	<Set Part Number>-NTE
	E200, E400, E600, E800, E1000, TS100, TS100F, TE200, TE300, ME600L, L150A, and some Labophot, Optiphot, and Diaphot series	Quadfluor	$385	NQF	<Set Part Number>-NQF
	Olympus				
	AX, BX2, and IX series	U-MF2	$420	See online video OMF	<Set Part Number>-OMF
	MVX10 (and other large optical path microscopes)	U-MF/XL	$385	OXL	<Set Part Number>-OXL
	BX3 series	U-FF	$420	OFF	<Set Part Number>-OFF
	Zeiss				
	Axio Imager, Axiostar Plus, Axioskop 40, Axio Observer, Axioplan2i, Axioplan2ie, Axiovert200, and Axioskop2 (post-2001), Axiovert 40, Axio Examiner, & Axio Scope A1	FL CUBE EC P&C	$325	See online video ZHE	<Set Part Number>-ZHE
	Axioplan (pre-version 2), Axiovert100, and Axioskop2 (pre-2002)	Threaded Filter Cube	$325	ZAT	<Set Part Number>-ZAT
	Leica - BrightLine Basic™, TRP-A, QDLP-B, and Laser Fluorescence sets are not sold as -ZERO compatible sets.				
	DM-2000, DM-2500, DM-3000, DMI3000 B, DM-4000, DMI-4000 B, DM-5000, DM-5500, DM-6000 and DMI6000 B	DM-K	$420	LDMK**	<Set Part Number>-LDMK-ZERO
	Aristomet, Aristoplan, DM-LB, DM-LM, DM-LP, DM-RB, and DM-R HCRF4	DM-R	$420	LLC**	<Set Part Number>-LLC-ZERO
	DM-750, DM-1000, DM-IL, DM-IL-LED, DM-IRB, DM-IRE2, DM-LS, DM-LSP, DM-R HCRF8, DM-R XARF8, and Older Models (like Diavert) with Ploem-OPAK	DM-IRB	$420	LSC**	<Set Part Number>-LSC-ZERO
	Semrock				
	Designed for single, 25.2 x 35.6 x 1.0 to 2.0 mm beamsplitters in laboratory bench-top set ups.	BSM	$225	BSM	Not for use with sets
	Designed for single, 25.2 x 35.6 x 1.0 to 2.0 mm dichroic beamsplitters, fits on motor for rotating tunable filters.	FH1	$95	FH1	Not for use with sets

* Cube price when purchased separately or with a set. To have your set mounted at no charge, replace "-000" in the set part number with the cube part number from above (e.g. use FITC-3540C-NTE).

****Non-standard sets:** Filter sets mounted in cubes that require non-standard filter shapes and sizes (25 x 36 mm) are not be available for same-day shipping.

Multi-exciter sets are also available with 32 mm diameter exciters. *See website for current pricing.*

BrightLine ZERO™ Fluorescence Filter Sets

Only $99 ensures exact image registration when making multi-color composite images with BrightLine® single-band sets. Not sure you need this? Keep in mind that BrightLine filters do not burn out, and the -ZERO option requires no calibration or special alignment, so why not cost-effectively future-proof your system? Join your many colleagues and demand the "-ZERO option" for certified image registration. To order, just add "-ZERO" to the end of the filter set part number.

- Allows you to create spatially registered multi-color composite images
- Hard coated for durability and reliability
- Ideal for demanding applications like:
  - Co-localization fluorescence measurements
  - Fluorescence In Situ Hybridization (FISH)
  - Comparative Genomic Hybridization (CGH)

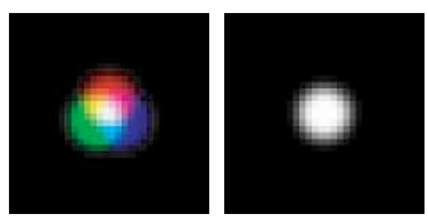
Property	Value	Comment	Price
Set-to-set Image Shift	< ± 1 pixel	Worst case image shift when interchanging BrightLine ZERO filter sets, as measured relative to the mean image position for a large sample of filter sets. Analysis assumes collimated light in a standard microscope with a 200 mm focal length tube lens and 6.7 micron pixel size. Tested in popular microscope cubes.	+ $99 to the set price

Available as a ZERO Set	NOT Available as a ZERO Set
BrightLine Single-band and Long-pass Sets	BrightLine Basic Sets
BrightLine FISH Sets	BrightLine Laser Fluorescence Sets
Qdot Sets	BrightLine Multiband Sets
FRET Sets	Customer Selected Custom Sets
Bright-field Set	

Technical Note

What is Pixel Shift?

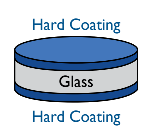
Pixel shift results when a filter in an imaging path (the emitter and/or dichroic beamsplitter in a fluorescence microscope) with a non-zero wedge angle deviates the light rays to cause a shift of the image detected on a high-resolution CCD camera. When two or more images of the same object acquired using different filter sets are overlaid (in order to simultaneously view fluorescence from multiple fluorophores), any significant non-zero filter wedge angle means that the images will not be registered to identical pixels on the CCD camera. Hence, images produced by different fluorophores will not be accurately correlated or combined.



Composite images produced from conventional filter sets (above left), which typically have significant pixel shift, are distorted, whereas BrightLine ZERO pixel shift filter sets (above right) yield precise multi-color images.

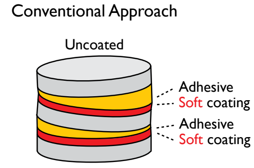
Poor image registration, or pixel shift, results from the almost inevitable non-zero filter wedge angle. But low pixel shift is critical to obtain the best imaging performance when exchanging filters during any measurements that involve multiple exposures.

BrightLine ZERO



Semrock's advanced ion-beam-sputtering coating technology makes it possible for all BrightLine filters to be uniquely constructed from a single piece of glass, with the permanent hard coatings applied directly to the outside. This patented lower-loss and high-reliability construction inherently offers superior imaging performance. BrightLine ZERO filter substrates are further manufactured and tested to the most exacting tolerances for certified "zero pixel shift" performance.

Conventional Approach



With older soft-coated fluorescence filters, one is forced to use multiple substrates that are typically bonded together with adhesive, generally resulting in significant wedge angle and therefore pixel shift. To improve the imaging registration, extra processing steps, alignment steps, and/or compensating optics are required, resulting in added cost. By contrast, BrightLine ZERO filters are inherently manufacturable and thus very affordable.

Bright-field Set NEW

Problem: When combining fluorescence and bright-field microscope images we noted that the DIC or phase image did not have ZERO registration with the blue, green and red fluorescence images.

Our solution: We now offer a unique Bright-field cube that is designed to be inserted into the lightpath when collecting your transmitted light image(s) and will allow –ZERO pixel shift alignment when overlaid with your fluorescence images. The Bright-field cube is designed specifically for the visible spectrum and transmitted light applications only. Taking ZERO pixel shift to all of your imaging modalities has never been easier.

Set		Center Wavelength /Edge	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
BRFLD-A	Exciter	–	Blocker only	MOMC16	$25
	Emitter	415 nm (edge)	> 93% 417-1100 nm	FF02-409/LP-25	$295
	Dichroic	409 nm (edge)	R_{avg} >98% 327-404 nm T_{avg} >93% 415-950 nm	FF409-Di03-25x36	$245
				-ZERO Certification	$99
			"Zero Pixel Shift" Set:	**BRFLD-A-000-ZERO**	**$595** NEW

Cubes Page 36

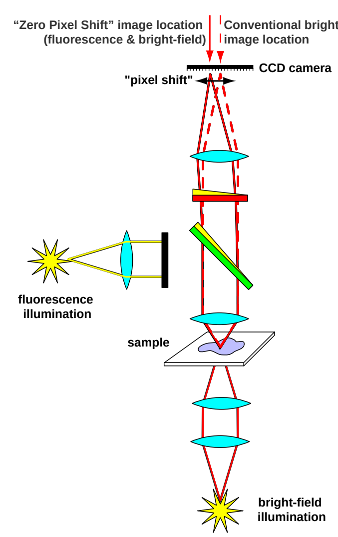
See our new general purpose mirrors on pg 105

Product Note

NEW

Bright-field Sets

We are pleased to introduce our Bright-field filter set that is designed to bring –ZERO pixel shift imaging performance to your bright-field/transmitted light techniques.



Background: The major imperfection in optical filters that causes beam deviation, referred to as 'pixel shift ' as noted in the final composite image as a misalignment of the different color fluorescence channels, is created by a nonzero wedge angle ("nonparallelism") of either the dichroic beamsplitter and/or the emission filter. When there is variation in filter parallelism across the fluorescence filter sets installed in a microscope imaging system, there will be a difference in emission beam deflection that will produce this pixel shift. Our –ZERO pixel filter sets are manufactured with a minimal and known wedge angle that is consistent across filter sets.

Prior to the Bright-field filter set introduction, it was noted that –ZERO pixel fluorescence images did not align correctly (did not exhibit –ZERO pixel performance) with a bright-field/transmitted light image such as phase or DIC. The reason: imaging during fluorescence places a dichroic beamsplitter and emission filter in the lightpath, while transmitted light imaging is performed without any of these filters installed. Our Bright-field filter set consists of a long-wave-pass dichroic and emitter designed with –ZERO pixel specifications for beam deviation that also allow only the visible wavelengths of light to transmit. The Bright-field set also includes an opaque disc to be used in the exciter position to ensure that no fluorescence excitation light reaches the specimen during bright-field/transmitted light imaging.

The Bright-field filter is recommended for anyone wanting to obtain –ZERO pixel performance for their fluorescence *and* transmitted light imaging techniques. The Bright-field filter set can be ordered pre-installed in any of the popular microscope fluorescence cubes.

Fluorescence Filter Sets Optimized for Lasers

*Refer to page 25 for details on multiband filter set configurations

		Single-band Laser Sets		Multiband Laser Sets		
Laser Line	**Popular Fluorophores**	**Bandpass Pages 40-41**	**Long-pass Pages 40-41**	**"Full Multiband"* Page 43**	**"Pinkel"* Page 44**	**"Sedat"* Page 45**
375 ± 3 nm 405 ± 5 nm	DAPI, BFP	LF405-A	LF405/LP-A	LF405/488/594-A LF405/488/561/635-A	LF405/488/594-3X-A LF405/488/532/635-4X-A LF405/488/543/635-4X-A LF405/488/561/635-4X-A	LF405/488/594-3X3M-A LF405/488/561/635-4X4M-A
~ 440 nm 441.6 nm	CFP	LF442-A			LF442/514/561-3X-A	
473 ± 2 nm 488 +3/–2 nm 491 nm	FITC, GFP	LF488-B	LF488/LP-B	LF488/561-A LF405/488/594-A LF405/488/561/635-A	LF488/561-2X-B LF405/488/594-3X-A LF488/543/635-3X-A LF405/488/532/635-4X-A LF405/488/543/635-4X-A LF405/488/561/635-4X-A	LF488/561-2X2M-B LF405/488/594-3X3M-A LF405/488/561/635-4X4M-A
514.5 nm 515 nm	YFP	LF514-A			LF442/514/561-3X-A	
543 nm	TRITC, Cy3™				LF488/543/635-3X-A	
559 ± 5 nm 561.4 nm 568.2 nm	RFP's (mCherry HcRed, DsRed) Texas Red®	LF561-A	LF561/LP-A	LF488/561-A LF405/488/561/635-A	LF488/561-2X-A LF442/514/561-3X-A LF405/488/561/635-4X-A LF488/543/635-3X-A	LF488/561-2X2M-A LF405/488/561/635-4X4M-A
593.5 nm 594 ± 0.3 nm 594.1 nm	mCherry, mKate2, Alexa Fluor 594™ Texas Red®	LF594-A	LF594/LP-A	LF405/488/594-A	LF405/488/594-3X-A	LF405/488/594-3X3M-A

Individual Fluorescence Filters Optimized for Lasers

Laser Line	Laser Description	Single-Edge Laser Dichroics Page 69	Multi-Edge Laser Dichroic Page 72	Laser Combiners/ Separators Page 74	Yokogawa CSU Filters Page 73	Laser Long-pass Filters Page 84
~ 375	GaN diode	●	●	●		
~ 405	GaN diode	●	●	●	●	●
~ 440	Diode	●		●	●	
441.6	HeNe gas	●		●	●	
457.9	Ar-ion gas	●		●	●	
~ 470	Diode	●		●	●	
473.0	Doubled DPSS	●	●	●	●	
488.0	Ar-ion gas	●	●	●	●	●
~ 488	Doubled OPS	●	●	●	●	●
491.0	Doubled DPSS	●		●	●	●
505.0		●				
514.5	Ar-ion gas	●		●	●	●
515.0	Doubled DPSS	●		●	●	●
532.0	Doubled DPSS	●	●	●	●	●
543.5	HeNe gas		●	●		
~559			●			
561.4	Doubled DPSS	●	●	●	●	●
568.2	Kr-ion gas	●	●	●	●	●
593.5	Doubled DPSS	●	●	●	●	●
594.1	HeNe gas	●	●	●	●	●
632.8	HeNe gas	●	●	●	●	●
~ 635	Diode	●	●	●	●	●
647.1	Kr-ion gas		●	●	●	●

Multiphoton laser fluorescence filters are available for blocking ranges of 680-1080 nm, see page 49.

Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

BrightLine® Laser Fluorescence Single-band & Long-pass Sets

- **Filter wavelengths precisely keyed** to popular laser lines, with steep transitions from laser blocking to fluorescence transmission
- **Exceptionally high transmission** to maximize system throughput, thus reducing acquisition time
- **Deep blocking** at laser wavelengths to minimize noise background
- Dichroic beamsplitters supress axial focal shift and aberrations for reflected laser light
- **Long-pass sets** allow for longer wavelengths to be detected and more light to be captured

NOTE: BrightLine Laser Fluorescence filter sets are optimized for laser excitation and inherently provide excellent image registration performance – when interchanging these sets with one another, minimal pixel shift is observed. Note that the laser filter sets are not designed to exhibit "zero pixel shift" performance when interchanging with BrightLine ZERO™ filter sets. Images obtained with the laser filter sets exhibit excellent image registration not only with one another, but also with images obtained when no fluorescence filters are present (e.g., DIC or other bright-field modes).

Set / Primary Laser Wavelengths		Center Wavelength / Nominal Edge Wavelength	Avg Transmission / Bandwidth	Filter / Set Part Numbers	Price
LF405/LP-A	Exciter	390 nm	> 93% over 40 nm	FF01-390/40-25	$295
375 & 405 nm	Emitter	418 nm (edge)	> 93% 421.5 – 900 nm	BLP01-405R-25	$325
Long-pass set	Dichroic	415 nm (edge)	R_{abs} > 94% 372 – 410 nm T_{avg} > 93% 420 – 900 nm	Di01-R405-25x36	$395
			Unmounted Full Set:	**LF405/LP-A-000**	**$895**
LF405-A	Exciter	390 nm	> 93% over 40 nm	FF01-390/40-25	$295
375 & 405 nm	Emitter	452 nm	> 93% over 45 nm	FF01-452/45-25	$295
Bandpass set	Dichroic	415 nm (edge)	R_{abs} > 94% 372 – 410 nm T_{avg} > 93% 420 – 900 nm	Di01-R405-25x36	$395
			Unmounted Full Set:	**LF405-A-000**	**$895**
LF442-A	Exciter	448 nm	> 93% over 20 nm	FF01-448/20-25	$295
~ 440 & 441.6 nm	Emitter	482 nm	> 93% over 25 nm	FF01-482/25-25	$295
Bandpass set	Dichroic	463 nm (edge)	R_{abs} > 94% 439 – 458 nm T_{avg} > 93% 469 – 900 nm	Di01-R442-25x36	$395
			Unmounted Full Set:	**LF442-A-000**	**$895**
LF488/LP-B	Exciter	482 nm	> 93% over 18 nm	FF02-482/18-25	$295
473 & 488 nm	Emitter	500 nm (edge)	> 93% 504.7 – 900 nm	BLP01-488R-25	$325
Long-pass set	Dichroic	497 nm (edge)	R_{abs} > 94% 471 – 491 nm T_{avg} > 93% 503 – 900 nm	Di01-R488-25x36	$395
			Unmounted Full Set:	**LF488/LP-B-000**	**$895**
LF488-B	Exciter	482 nm	> 93% over 18 nm	FF02-482/18-25	$295
473 & 488 nm	Emitter	525 nm	> 93% over 45 nm	FF01-525/45-25	$295
Bandpass set	Dichroic	497 nm (edge)	R_{abs} > 94% 471 – 491 nm T_{avg} > 93% 503 – 900 nm	Di01-R488-25x36	$395
			Unmounted Full Set:	**LF488-B-000**	**$895**
LF514-A	Exciter	510 nm	> 93% over 10 nm	FF02-510/10-25	$295
514.5 & 515.0 nm	Emitter	542 nm	> 93% over 27 nm	FF01-542/27-25	$295
Bandpass set	Dichroic	521 nm (edge)	R_{abs} > 94% 505 – 515 nm T_{avg} > 93% 528 – 900 nm	Di01-R514-25x36	$395
			Unmounted Full Set:	**LF514-A-000**	**$895**

Filter Specifications on page 35 (continued)

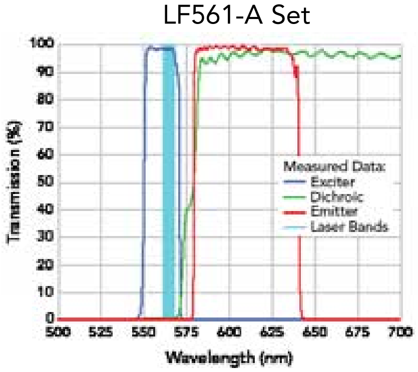
See spectra graphs and ASCII data for all of our filters at www.semrock.com

Set / Primary Laser Wavelengths		Center Wavelength / Nominal Edge Wavelength	Avg Transmission / Bandwidth	Filter / Set Part Numbers	Price
LF561/LP-A	Exciter	561 nm	> 93% over 14 nm	FF01-561/14-25	$295
559, 561.4, & 568.2 nm	Emitter	580 nm (edge)	> 93% 583.9 – 900 nm	BLP01-561R-25	$325
Long-pass set	Dichroic	575 nm (edge)	R_{abs} > 94% 554 – 568 nm T_{avg} > 93% 582 – 1200 nm	Di01-R561-25x36	$395
			Unmounted Full Set	**LF561/LP-A-000**	**$895**
LF561-A	Exciter	561 nm	> 93% over 14 nm	FF01-561/14-25	$295
559, 561.4, & 568.2 nm	Emitter	609 nm	> 93% over 54 nm	FF01-609/54-25	$295
Bandpass set	Dichroic	575 nm (edge)	R_{abs} > 94% 554 – 568 nm T_{avg} > 93% 582 – 1200 nm	Di01-R561-25x36	$395
			Unmounted Full Set	**LF561-A-000**	**$895**
LF594/LP-A	Exciter	586 nm	> 90% over 15 nm	FF01-586/15-25	$345
593.5,594, 594.1 nm	Emitter	607 nm (edge)	> 93% 611 – 1200 nm	BLP01-594R-25	$325
Long-pass set	Dichroic	605 nm (edge)	R_{abs} > 94% 593.5 – 594.3 nm T_{avg} > 93% 609 – 1200 nm	Di01-R594-25x36	$395
			Unmounted Full Set	**LF594/LP-A-000**	**$895**
LF594-A	Exciter	586 nm	> 90% over 15 nm	FF01-586/15-25	$345
593.5,594, 594.1 nm	Emitter	647 nm	> 92% over 57 nm	FF01-647/57-25	$295
Bandpass set	Dichroic	605 nm (edge)	R_{abs} > 94% 593.5 – 594.3 nm T_{avg} > 93% 609 – 1200 nm	Di01-R594-25x36	$395
			Unmounted Full Set	**LF594-A-000**	**$895**
LF635/LP-A	Exciter	640 nm	> 93% over 14 nm	FF01-640/14-25	$345
632.8, 635, & 647.1 nm	Emitter	655 nm (edge)	> 93% 660 – 1200 nm	BLP01-635R-25	$325
Long-pass set	Dichroic	654 nm (edge)	R_{abs} > 94% 632 – 647 nm T_{avg} > 93% 663 – 1200 nm	Di01-R635-25x36	$395
			Unmounted Full Set	**LF635/LP-A-000**	**$895**
LF635-A	Exciter	640 nm	> 93% over 14 nm	FF01-640/14-25	$345
632.8, 635, & 647.1 nm	Emitter	676 nm	> 90% over 29 nm	FF01-676/29-25	$295
Bandpass set	Dichroic	654 nm (edge)	R_{abs} > 94% 632 – 647 nm T_{avg} > 93% 663 – 1200 nm	Di01-R635-25x36	$395
			Unmounted Full Set	**LF635-A-000**	**$895**

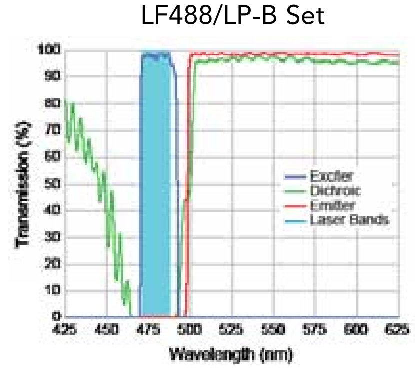
Filter Specifications on page 35

Actual Measured Data

LF561-A Set



LF488/LP-B Set



BrightLine® Laser Fluorescence Filters

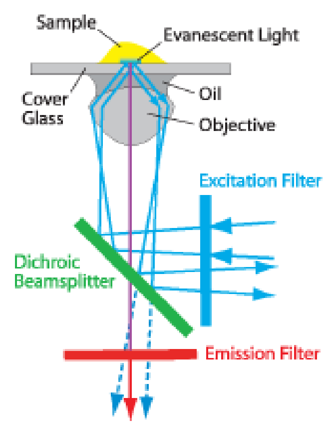
Technical Note

Optical Filters for Laser-based Fluorescence Microscopes

The advent of lasers as light sources for fluorescence imaging imposes new constraints on imaging systems and their components. For example, optical filters used in laser-based imaging systems have specific requirements that are unique compared to those filters used in broadband light source based instruments.

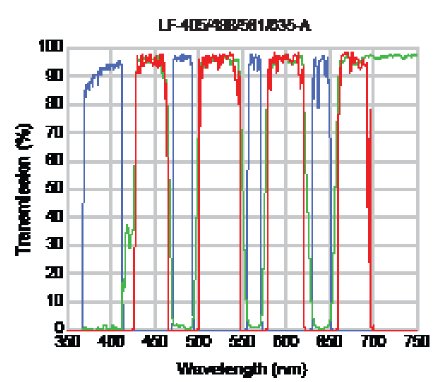
Despite varying opinions, optical source clean-up filters (excitation filters) are important for laser sources to block the unwanted light at wavelengths away from the actual laser line, including spontaneous emission observed in solid-state lasers and the plasma lines of gas lasers. Additionally, these filters should be durable enough to withstand the high intensity of laser beams. Unlike the traditional soft-coated fluorescence filters used for decades, newer hard-coated thin-film filters made with ion-beam sputtering have high laser damage threshold (LDT) ratings. High optical durability, combined with the robust environmental reliability of hard-coated filters—which are virtually impervious to thermal and humidity induced degradation—eliminates the need to ever replace the filters for most fluorescence microscopy applications.

Excitation filters for laser applications also have unique wavelength requirements. Some lasers, like gas lasers and DPSS lasers, have very precise and narrow laser lines. However, selection of a narrow laser line cleanup filter is not a good match for systems that might use multiple lasers with similar wavelengths (such as 473 nm and 488 nm for exciting GFP). The spectral output from diode and optically pumped semiconductor lasers can vary appreciably from laser to laser, with temperature, and as the lasers age. Therefore for most laser microscopy systems broader excitation filters that appear similar to those used for broadband light source (e.g., arc lamp) microscopy systems are a good solution. For example, the UV excitation band of the Semrock laser quad-band set is designed to be used with both 375 and 405 nm lasers, with the long-wavelength edge taking into account a ± 5 nm uncertainty in the wavelength of the 405 nm laser.



A typical emission filter should provide high blocking (> OD 6) at all possible laser lines that might be used with the filter set, thus ensuring the darkest background signal level, while at the same time providing excellent transmission of the emission signal. It should be noted that not all emission filters for broadband light sources provide sufficient blocking at laser lines and therefore they can lead to an appreciable compromise in imaging contrast.

Dichroics for laser applications should not only be made such that their reflection and transmission bands are compatible with the excitation and emission filters, but they also need to be coated with antireflection coatings in order to maximize transmission of the emission signal and eliminate coherent interference artifacts. Since the dichroic beamsplitter is directly exposed to the powerful excitation beam, even weak autofluorescence from the filter will contaminate the emission signal. Therefore, a substrate with ultra-low autofluorescence, such as fused silica, should be used.



The dichroic beamsplitter can have a significant impact on the image quality in certain applications, especially if the flatness (or curvature) of the dichroic is not suitable. For most laser microscope applications, the dichroic should be flat enough such that there is no noticeable shift in the focal spot of the illumination laser beam, where focal shift is typically defined by the Rayleigh range. This is critical for applications such as TIRF microscopy and structured illumination.

Demanding applications such as imaging of single molecules using TIRF may impose unprecedented constraints on the blocking of laser beams in the emission channel while maximizing the collection of every possible photon from the fluorophores. In such situations, conventional bandpass emission filters may be replaced by a long-wave-pass filter keyed to the specific laser line. In our observation, TIRF systems even benefit from using a second emission filter in conjunction with all the filters of a laser set. The main purpose of the second filter, which should be physically separated from the first emission filter, is to ensure that higher-angle scattered excitation light does not make it through the entire imaging path to the detector.

Overall, the designs of the excitation and emission filters as well as that of the dichroic beamsplitter should be complimentary to each other to obtain the highest fidelity fluorescence visualization. Optical filters play a vital role in obtaining maximum performance from complex, expensive, laser-based microscopes and it only makes sense to invest in optical filters that match the performance of the imaging system.

BrightLine® Laser Fluorescence Multiband Sets

Unlock the full potential of your laser fluorescence imaging system. Crafted to take advantage of the superior resolution, higher sensitivity, and better image fidelity offered by today's state-of-the-art laser-based microscopes – including laser-scanning and spinning-disk confocal and TIRF microscopes. These sets are optimized for the most popular lasers used in fluorescence imaging, including newer all-solid-state lasers that are rapidly replacing older gas-laser technology.

"Full Multiband" Laser Filter Sets - multiband exciter, emitter and beamsplitter

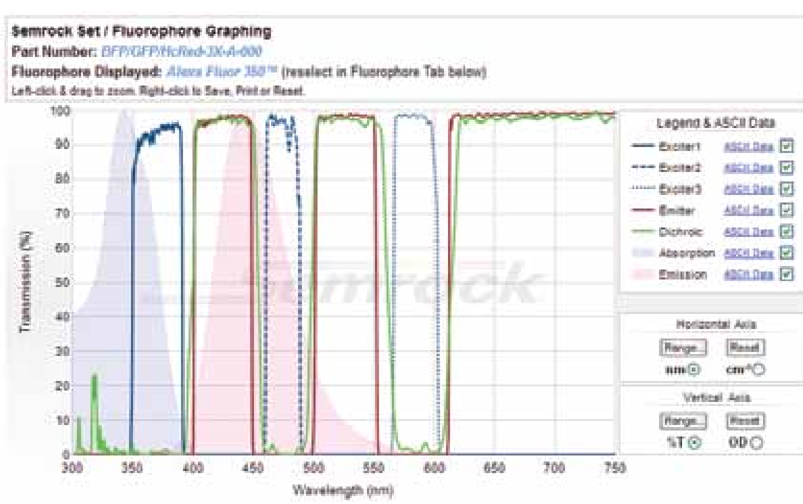
Set / Laser Lines / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidth	Filter / Set Part Numbers	Price
LF488/561-A	482 nm 563 nm	> 93% over 18 nm > 93% over 9 nm	Dual-band Exciter FF01-482/563-25	$375
Green: GFP (EGFP), FITC (Fluorescein) Red: mCherry (RFP)	523 nm 610 nm	> 93% over 40 nm > 93% over 52 nm	Dual-band Emitter FF01-523/610-25	$375
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
Dual-band	> 94% 471 – 491 nm > 94% 559 – 568 nm	>93% 503 – 543 nm >93% 582 – 800 nm	Dual-band Dichroic Di01-R488/561-25x36	$445
		Unmounted Full Set:	**LF488/561-A-000**	**$1095**
LF405/488/594-A	390 nm 482 nm 587 nm	> 85% over 40 nm > 93% over 18 nm > 93% over 15 nm	Triple-band Exciter FF01-390/482/587-25	$405
Blue: DAPI Green: FITC (Fluorescein), GFP (EGFP) Red: mCherry, mCherry, Texas Red® *Triple-band*	446 nm 532 nm 646 nm	> 93% over 32.5 nm > 93% over 58.5 nm > 93% over 68 nm	Triple-band Emitter FF01-446/532/646-25	$405
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 588.3 – 594.3 nm	> 93% 429.5 – 462 nm > 93% 502.5 – 574.5 nm > 93% 612 – 800 nm	Triple-band Dichroic Di01-R405/488/594-25x36	$495
		Unmounted Full Set:	**LF405/488/594-A-000**	**$1245**
LF405/488/561/635-A	390 nm 482 nm 563 nm 640 nm	> 85% over 40 nm > 90% over 18 nm > 90% over 9 nm > 90% over 14 nm	Quad-band Exciter FF01-390/482/563/640-25	$475
Blue: DAPI Green: FITC (Fluorescein), GFP (EGFP) Orange: mCherry (RFP) Red: Cy5™ *Quadband*	446 nm 523 nm 600 nm 677 nm	> 90% over 32.5 nm > 90% over 42 nm > 90% over 35.5 nm > 90% over 27.5 nm	Quad-band Emitter FF01-446/523/600/677-25	$475
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 559 – 568 nm > 94% 633 – 647 nm	> 93% 429.5 – 462 nm > 93% 502.5 – 544 nm > 93% 582 – 617 nm > 93% 663 – 800 nm	Quad-band Dichroic Di01-R405/488/561/635-25x36	$545
		Unmounted Full Set:	**LF405/488/561/635-A-000**	**$1445**

Cubes Page 36

Filter Specifications on page 35

Double check that the set you want is the set you need.

Graph a filter set and a fluorophore at the same time online, in an instant.



BrightLine® Laser Fluorescence Multiband Sets

"Pinkel" Multiband Laser Filter Sets - single-band exciters, multiband emitter and beamsplitter

Set / Laser Lines / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidths	Filter / Set Part Numbers	Price
LF488/561-2X-B	482 nm	> 93% over 18 nm	Exciter 1 FF02-482/18-25	$295
Green: GFP (EGFP), FITC (Fluorescein)	563 nm	> 93% over 9 nm	Exciter 2 FF01-563/9-25	$295
Red: mCherry (RFP)	523 nm 610 nm	> 93% over 40 nm > 93% over 52 nm	Dual-band Emitter FF01-523/610-25	$345
Dual-band	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidths**		
	> 94% 471 – 491 nm > 94% 559 – 568 nm	> 93% 503 – 543 nm > 93% 582 – 800 nm	Dual-band Dichroic Di01-R488/561-25x36	$445
		Unmounted Full Set:	**LF488/561-2X-B-000**	**$1295**
LF405/488/594-3X-B	390 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: FITC (Fluorescein), GFP (EGFP) Red: mCherry, Texas Red®	592 nm	> 93% over 8 nm	Exciter 3 FF02-592/8-25	$345
Triple-band	446 nm 532 nm 646 nm	> 93% over 32.5 nm > 93% over 58.5 nm > 93% over 68 nm	Triple-band Emitter FF01-446/532/646-25	$405
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidths**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 588.3 – 594.3 nm	> 93% 429.5 – 462 nm > 93% 502.5 – 574.5 nm > 93% 612 – 800 nm	Triple-band Dichroic Di01-R405/488/594-25x36	$495
		Unmounted Full Set:	**LF405/488/594-3X-B-000**	**$1625**
LF442/514/561-3X-A	448 nm	> 93% over 20 nm	Exciter 1 FF01-448/20-25	$295
Cyan: CFP Yellow: YFP	514 nm	> 93% over 3 nm	Exciter 2 FF01-514/3-25	$295
Orange: mCherry	563 nm	> 93% over 9 nm	Exciter 3 FF01-563/9-25	$295
Triple-band	483 nm 536 nm 627 nm	> 93% over 27 nm > 93% over 17.5 nm > 93% over 90 nm	Triple-band Emitter FF01-485/537/627-25	$405
NEW	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidths**		
	> 94% 438 – 458 nm > 94% 509 – 515 nm > 94% 559 – 568.2 nm	> 93% 469.5 – 496.5 nm > 93% 527.5 – 545 nm > 93% 582 – 800 nm	Triple-band Dichroic Di01-R442/514/561-25x36	$495
		Unmounted Full Set:	**LF442/514/561-3X-A-000**	**$1625**
LF488/543/635-3X-A	482 nm	> 93% over 18 nm	Exciter 1 FF02-482/18-25	$295
Green: FITC, GFP	543 nm	> 93% over 3 nm	Exciter 2 FF01-543/3-25	$295
Orange: Cy3 Red: Cy5	640 nm	> 93% over 14 nm	Exciter 3 FF01-640/14-25	$345
Triple-band	515 nm 588 nm 700 nm	> 93% over 23 nm > 93% over 55.5 nm > 93% over 70 nm	Triple-band Emitter FF01-515/588/700-25	$405
NEW	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidths**		
	> 94% 471 – 491 nm > 94% 541.5 – 544.5 nm > 94% 632.8 – 647.1 nm	> 93% 503 – 526.5 nm > 93% 560 – 615.5 nm > 93% 665.5 – 800 nm	Triple-band Dichroic Di01-R488/543/635-25x36	$495
		Unmounted Full Set:	**LF488/543/635-3X-A-000**	**$1625**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See spectra graphs and ASCII data for all of our filters at www.semrock.com

"Pinkel" Multiband Laser Filter Sets - single-band exciters, multiband emitter and beamsplitter

Set / Laser Lines / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidths	Filter / Set Part Numbers	Price
LF405/488/561/635-4X-A	390 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	563 nm	> 93% over 9 nm	Exciter 3 FF01-563/9-25	$295
Orange: mCherry, mRFP1 Red: Cy5™	640 nm	> 93% over 14 nm	Exciter 4 FF01-640/14-25	$345
Quad-band	446 nm 523 nm 600 nm 677 nm	> 90% over 32.5 nm > 90% over 42 nm > 90% over 35.5 nm > 90% over 27.5 nm	Quad-band Emitter FF01-446/523/600/677-25	$475
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidths**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 559 – 568.2 nm > 94% 632.8 – 647.1 nm	> 93% 429.5 – 462.0 nm > 93% 502.5 – 544.5 nm > 93% 582 – 617.5 nm > 93% 663 – 800 nm	Quad-band Dichroic Di01-R405/488/561/635-25x36	$545
		Unmounted Full Set:	**LF405/488/561/635-4X-A-000**	**$2045**
LF405/488/532/635-4X-A	380 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	532 nm	> 93% over 3 nm	Exciter 3 FF01-532/3-25	$295
Orange: mCherry, mRFP1 Red: Cy5™	640 nm	> 93% over 14 nm	Exciter 4 FF01-640/14-25	$345
Quad-band	446 nm 510 nm 581 nm 703 nm	> 93% over 32.5 nm > 93% over 16 nm > 93% over 63 nm > 93% over 80 nm	Quad-band Emitter FF01-446/510/581/703-25	$475
NEW	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidths**		
	> 94% 390-410 nm > 94% 473-491 nm > 94% 530.5 -533.5 nm > 94% 632.8-647.1 nm	> 93% 429.5-462 nm > 93% 503.5-526.5 nm > 93% 560-615.5 nm > 93% 665-800 nm	Quad-band Dichroic Di01-R405/488/543/635-25x36	$545
		Unmounted Full Set:	**LF405/488/532/635-4X-A-000**	**$2045**
LF405/488/543/635-4X-A	380 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	532 nm	> 93% over 3 nm	Exciter 3 FF01-532/3-25	$295
Orange: mCherry, mRFP1 Red: Cy5™	640 nm	> 93% over 14 nm	Exciter 4 FF01-640/14-25	$345
Quad-band	446 nm 515 nm 500 nm 700 nm	> 93% over 32.5 nm > 93% over 23 nm > 93% over 55.5 nm > 70% over 70 nm	Quad-band Emitter FF01-446/515/500/700-25	$475
NEW	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidths**		
	> 94% 390-410 nm > 94% 473-491 nm > 94% 530.5 -533.5 nm > 94% 632.8-647.1 nm	> 93% 429.5-462 nm > 93% 503.5-526.5 nm > 93% 560-615.5 nm > 93% 665-800 nm	Quad-band Dichroic Di01-R405/488/543/635-25x36	$545
		Unmounted Full Set:	**LF405/488/543/635-4X-A-000**	**$2045**

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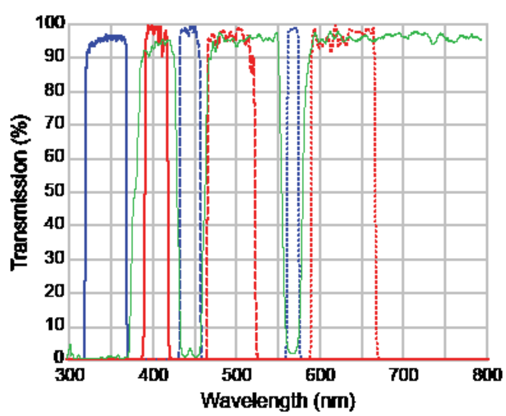
Actual Measured Data for LF405/488/594-3X3M-A



BrightLine® Laser Fluorescence Multiband Sets

"Sedat" Multiband Laser Filter Sets - single-band exciters and emitters, multiband beamsplitter

Set / Laser Lines / Primary Fluorophores	Center Wavelength	Avg. Transmission / Bandwidths	Filter / Set Part Numbers	Price
LF488/561-2X2M-B	482 nm	> 93% over 18 nm	Exciter 1 FF02-482/18-25	$295
Green: GFP (EGFP), FITC (Fluorescein)	563 nm	> 93% over 9 nm	Exciter 2 FF01-563/9-25	$295
Red: mCherry (RFP)	525 nm	> 93% over 45 nm	Emitter 1 FF01-525/45-25	$295
Dual-band	609 nm	> 93% over 54 nm	Emitter 2 FF01-609/54-25	$295
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
	> 94% 471 – 491 nm > 94% 559 – 568 nm	> 93% 503 – 543 nm > 93% 582 – 800 nm	Dual-band Dichroic Di01-R488/561-25x36	$445
		Unmounted Full Set:	**LF488/561-2X2M-B-000**	**$1495**
LF405/488/594-3X3M-B	390 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	592 nm	> 93% over 8 nm	Exicter 3 FF02-592/8-25	$345
Red: mCherry, Texas Red®	445 nm	> 93% over 20 nm	Emitter 1 FF01-445/20-25	$295
Triple-band	525 nm	> 93% over 45 nm	Emitter 2 FF01-525/45-25	$295
	647 nm	> 92% over 57 nm	Emitter 3 FF01-647/57-25	$295
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 588.3 – 594.3 nm	> 93% 429.5 – 462 nm > 93% 502.5 – 574.5 nm > 93% 612 – 800 nm	Triple-band Dichroic Di01-R405/488/594-25x36	$495
		Unmounted Full Set:	**LF405/488/594-3X3M-B-000**	**$2125**
LF488/543/594/3X3M-A	482 nm	> 93% over 18 nm	Exciter 1 FF02-482/18-25	$295
	543 nm	> 93% over 3 nm	Exciter 2 FF01-543/3-25	$295
Blue: DAPI	591 nm	> 93% over 6 nm	Exciter 3 FF01-591/6-25	$295
Green: FITC (Fluorescein), GFP (EGFP)	517 nm	> 90% over 20 nm	Emitter 1 FF01-517/20-25	$345
Red: mCherry, Texas Red®	567 nm	> 90% over 15 nm	Emitter 2 FF01-647/57-25	$295
Triple-band	647 nm	> 92% over 57 nm	Emitter 3 FF01-647/57-25	$295
NEW	**Abs. Reflection / Bandwidths**	**Avg. Transmission / Bandwidth**		
	> 94% 471 – 491 nm > 94% 541.5 – 544.5 nm > 94% 388 – 594.5 nm	> 93% 503-528.5 nm > 93% 558-574 nm > 93% 609-800 nm	Triple-band Dichroic Di01-R488/543/594-25x36	$495
		Unmounted Full Set:	**LF488/543/594/3X3M-A-000**	**$2125**
LF405/488/561/635-4X4M-A	390 nm	> 93% over 40 nm	Exciter 1 FF01-390/40-25	$295
Blue: DAPI	482 nm	> 93% over 18 nm	Exciter 2 FF02-482/18-25	$295
Green: GFP (EGFP), FITC (Fluorescein)	563 nm	> 93% over 9 nm	Exciter 3 FF01-563/9-25	$295
Orange: mCherry, mRFP1	640 nm	> 93% over 14 nm	Exciter 4 FF01-640/14-25	$345
Red: Cy5™	445 nm	> 93% over 20 nm	Emitter 1 FF01-445/20-25	$295
Quad-band	525 nm	> 90% over 30 nm	Emitter 2 FF01-525/30-25	$295
	605 nm	> 90% over 15 nm	Emitter 3 FF01-605/15-25	$295
	676 nm	> 90% over 29 nm	Emitter 4 FF01-676/29-25	$295
	Abs. Reflection / Bandwidths	**Avg. Transmission / Bandwidth**		
	> 94% 370 – 410 nm > 94% 473 – 491 nm > 94% 559 – 568.2 nm > 94% 632.8 – 647.1 nm	> 93% 429.5 – 462 nm > 93% 502.5 – 544.5 nm > 93% 582 – 617.5 nm > 93% 663 – 800 nm	Quadband Dichroic Di01-R405/488/561/635-25x36	$545
		Unmounted Full Set:	**LF405/488/561/635-4X4M-A-000**	**$2595**

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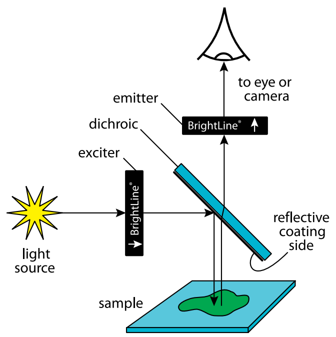
Filter Specifications on page 35

See spectra graphs and ASCII data for all of our filters at www.semrock.com

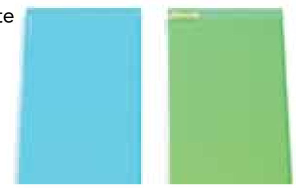
Product Note

Orientation of Filters in a Microscope

Because BrightLine® filters are so durable, you can readily populate your own cubes, sliders, and filter wheels. To obtain the optimal performance from the filters, they should be oriented properly.



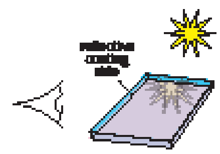
The exciter and emitter should be oriented so that the arrow on the side of the aluminum ring points in the direction of propagation of the desired light – from the light source to dichroic for the exciter and from the dichroic to eye or camera for the emitter. The dichroic must be oriented such that the reflective coating side faces toward the exciter or light source and the sample.



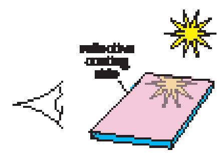
Marked Dichroics

If the dichroic has an engraved Semrock logo, a small linear mark, or a corner chamfered, the reflective coating side is facing you when the dichroic long axis is vertical and the logo, mark, or chamfer is in the upper left (or lower right) corner.

Unmarked Dichroics



When viewing the dichroic with the reflective coating side down, you can see a double-reflection of a bright object and the thickness of the filter at the far edge is apparent.



When viewing the dichroic with the reflective coating side up, you can see a predominantly single reflection of a bright object and the thickness of the filter at the far edge is not visible.

Technical Note

You *Can* Clean Semrock Optical Filters!

Semrock manufactures the most durable optical filters available. However, it is important to note that while all optical components should be handled with care, soft-coated filters are especially susceptible to damage by handling and cleaning. Fortunately, Semrock supplies only hard-coated filters, so all of Semrock's filters may be readily cleaned using the following recommended method.

The following are recommended to properly clean your filters:

- **Unpowdered laboratory gloves** – prevent finger oils from contaminating the glass and keep solvents from contacting skin;
- **Eye protection** – critical for avoiding getting any solvent in your eyes;
- **Compressed air** – clean, filtered laboratory compressed nitrogen or air is ideal, but "canned" compressed air or even a rubber "bulb blower" in a relatively clean environment is acceptable;
- **Lint-free swab** – cotton-based swabs work best;
- **Lens cleaning tissue** – lint-free tissue paper is also acceptable;
- **Cleaning solvent** – we recommend Isopropyl Alcohol (IPA) and/or Acetone. Care should be taken when handling these solvents, especially to avoid ingestion.

1. **Blow off contaminants**. Many contaminants are loosely attached to the surface and can be blown off. Using laboratory gloves, hold the filter in one hand and aim the air stream away from the filter. Start the air stream using a moderate air flow. Maintaining an oblique angle to the part – never blow straight on the filter surface – now bring the air stream to the filter, and slowly move it across the surface. Repeat until no more loose particles are disappearing.

2. **Clean filter.** If dust or debris remains, it is probably "stuck" to the surface and must be removed with mechanical force and/or chemical action. Create a firm but "pointy" tip with the lint-free wipe or lens tissue by folding it multiple times into a triangular shape or wrapping it around a swab. Lint-free swabs may also be used directly in place of a folded wipe. Moisten the wipe or swab with either IPA or Acetone, but avoid too much excess solvent.

Watch the video tutorial on how to clean your optical filters at www.semrock.com

The key to cleaning the optic is to maintain one continuous motion at as constant a speed as possible. Some people prefer to clean using a "figure 8" pattern while others choose to start in the center of the part and wipe outward in a spiral pattern. Do not stop the wipe on the surface – keep the wipe moving at a constant speed, lifting the moving wipe off the part when you reach the end of the pattern.

3. **Inspect filter.** Use a room light or any bright light source to inspect the optic to ensure that it is clean. Tip, tilt, and rotate the optic while viewing it as close to your eye as you can focus. If contamination remains, start with a brand new wipe or swab and repeat step 2 above.

4. **Repeat** steps 1 – 3 for the other side of the filter if contamination exists.

Note: *IPA and Acetone each have pros and cons, so choose the solvent that works best for you after trying both. Generally, the more active the solvent the better, to attack a broader range of contaminants more quickly. However, it is critical to ensure that the solvent is wiped into a very thin film before it evaporates. IPA strikes a good balance between cleaning action and level of skill required. It is not very aggressive, and thus may require more cleaning attempts or greater mechanical pressure, but it dries relatively slowly, thus allowing more time to ensure that every part of the surface is wiped. Acetone has excellent cleaning action and attacks a wide range of contaminants quickly, but it dries very quickly and is thus much more susceptible to leaving behind residue on the surface of the optic where it was not wiped. Furthermore, care should be taken when using Acetone around certain plastics and most adhesives, as these can also be dissolved rather quickly.*

Technical Note

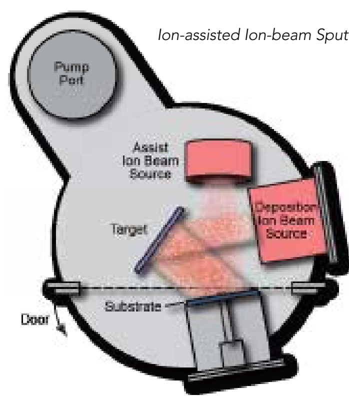
Ion-beam-sputtered Thin-film Coatings

Optical thin-film coatings can be deposited by a variety of methods. Traditionally the most popular methods for depositing multilayer coatings – required for higher-performance mirrors and filters – include thermal and electron-beam (e-beam) evaporation and ion-assisted e-beam evaporation (IAD). These have been in use for many decades. Films evaporated without ion-assist have several significant short-comings that largely stem from the porosity of the resulting films. They are often referred to as "soft" coatings, because they are not very durable, they absorb water vapor which results in wavelength shifting, they also shift with temperature changes, and they can exhibit noticeable scattering. With additional energy from an ion gun directed at the substrate during the physical vapor deposition process, IAD coatings are sometimes referred to as "semihard" since they are appreciably more dense, resulting in significantly better durability and lower moisture absorption, temperature shifting, and scattering. With all evaporated film processes, variations in the vapor "plume" during the deposition process make it challenging to control the rate and uniformity with high precision, thus making it difficult to manufacture large volumes of complex filters with a high number of precise-thickness layers.

	Electron-beam / Thermal Evaporation	Ion-assisted Electron-beam Evaporation (IAD)	Ion-assisted Ion-beam Sputtering (IBS)
Deposition Process	Physical Vapor Deposition	Energetic Physical Vapor Deposition	Energetic Physical Vapor Deposition
	Variable deposition rates	Variable deposition rates	Extremely stable deposition rates
	Variable spatial uniformity	Variable spatial uniformity	Controllable spatial uniformity
Resulting Thin Films	Soft coatings	Semi-hard coatings	Hard, dense coatings
	Low durability	Moderate to high durability	Very high durability
	Hygroscopic (absorb moisture)	Minimally hygroscopic	Impervious to humidity
	Appreciable temperature shifting	Low temperature shifting	Very low temperature shifting
	Some scattering	Low scattering	Very low scattering
	Some absorption	Low absorption	Very low absorption
	Low film stress	Film stress	Reproducible film stress

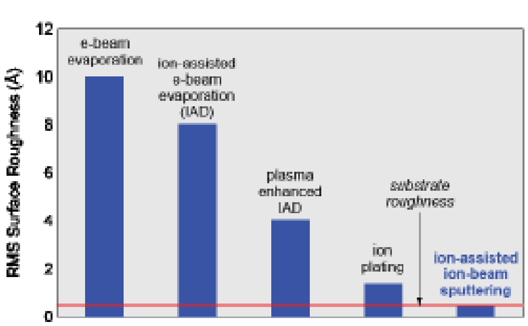
In contrast, Semrock manufacturers all of its optical filters with a deposition process called ion-assisted ion-beam sputtering (IBS). This state-of-the-art technology was originally developed for coating precise ferrite thin films for magnetic disk drive heads, and then gained a reputation in the optics arena for fabrication of extremely low-loss mirrors for ring-laser gyroscope applications. In the late-1990's it was adapted to manufacture the highest-performance optical filters for wavelength-division multiplexing in the booming fiber-optic telecommunications industry. IBS produces hard refractory oxide thin films – as hard as the glass substrates on which they are coated. This stable process is renowned for its ability to reproducibly deposit many hundreds of low-loss, reliable thin-film layers with high optical-thickness precision.

Ion-assisted Ion-beam Sputtering



One way to clearly see the difference among soft evaporated films, the more robust films produced with IAD, and the very dense, low-scattering films resulting from the IBS process is to study the film surface morphology closely. Atomic force microscopy reveals surface characteristics indicative of the packing density of the films. The graph on the right shows results from a study that compared the three main deposition methods as well as two other less-common modified processes [1]. Films were coated on substrates with a starting root-mean-square (RMS) surface roughness below 0.5 Å. Only IBS produces highly multi-layered films with sufficient packing density to result in surface roughness comparable to that of the starting substrate.

A perceived limitation of the IBS process has always been throughput – the excellent performance came at the expense of slow deposition rates and limited coating areas. For the established applications of disk drive heads and telecom filters with dimensions of only one to several mm at most this limitation was not too severe. However, it was considered a show-stopper for cost-effective production of larger filters in higher volumes. Semrock broke through this limitation by turning IBS into a true high-volume manufacturing platform for large (dimensions of inches) very high layer count optical filters. And we did this without compromising the optical performance for which IBS was renowned, resulting from dense, low-scattering thin film layers of extreme optical-thickness precision. Semrock made ground-breaking developments in process technology to boost rates and uniformity, and we are continually improving the process even today. And our highly advanced deposition-control technology based on the proprietary hardware, algorithms, and software of Semrock's "optical monitoring" system enables repeatable deposition of many hundreds of thin film layers of even arbitrary thickness for complex filters with superb spectral features.



[1] "Optical Morphology: Just How Smooth Is That Surface?," C. Langhorn and A. Howe, Photonics Spectra (Laurin Publishing), June 1998.

BrightLine® Multiphoton Fluorescence Filters

These BrightLine multiphoton ultrahigh-performance fluorescence filters serve a full range of applications, accommodating the wide range of fluorescent dyes that are the essential tools of the modern researcher. The transmission bands of the emitters are so wide that they appear clear at normal incidence. The long-wave-pass dichroic reflection bands are so wide that they look like mirrors when viewed at 45°. These filters virtually eliminate excitation laser noise at the detector. To reduce undesired fluorescence noise outside a desired band, simply add a BrightLine bandpass filter *(see pages 53-59)*.

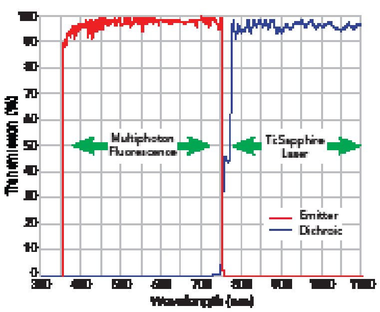
Product Description	Avg. Transmission / Reflection Bandwidth and Range	Filter Part Numbers	Price
Emission Filters			
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 350 – 650 nm Laser Blocking Range .... OD_{avg} > 8: 680 – 1040 nm OD_{avg} > 6: 1040 – 1080 nm	FF01-680/SP-25	$1095
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 350 – 690 nm Laser Blocking Range .... OD_{avg} > 6: 720 – 1100 nm	FF01-720/SP-25	$875
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 380 – 720 nm Laser Blocking Range .... OD_{avg} > 6: 750 – 1100 nm	FF01-750/SP-25	$875
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 380 – 740 nm Laser Blocking Range .... OD_{avg} > 6: 770 – 1400 nm	FF01-770/SP-25	$1095
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 380 – 760 nm Laser Blocking Range .... OD_{avg} > 6: 790 – 1400 nm	FF01-790/SP-25	$1095
Short Wave Pass Emitter *Laser Blocking Emission Filter*	T_{avg} > 90% .... 380 – 860 nm Laser Blocking Range .... OD_{avg} > 6: 890 – 1400 nm	FF01-890/SP-25	$1095 NEW
Long Wave Pass Dichroic Beamsplitters			
Long Wave Pass Dichroic Beamsplitter	T_{avg} > 93% .... 680 – 1600 nm R_{avg} > 98% .... 350 – 650 nm	FF665-Di02-25x36	$545
Long Wave Pass Dichroic Beamsplitter	T_{avg} > 93% .... 720 – 1600 nm R_{avg} > 98% .... 350 – 690 nm	FF705-Di01-25x36	$545
Long Wave Pass Dichroic Beamsplitter	T_{avg} > 93% .... 750 – 1100 nm R_{avg} > 98% .... 350 – 720 nm	FF735-Di01-25x36	$545
Long Wave Pass Dichroic Beamsplitter	T_{avg} > 93% .... 790 – 1600 nm R_{avg} > 98% .... 350 – 760 nm	FF775-Di01-25x36	$545
Long Wave Pass Dichroic Beamsplitter	T_{avg} > 93% .... 892.5 – 1600 nm R_{avg} > 98% .... 350 – 857.5 nm	FF875-Di01-25x36	$545 NEW
Short Wave Pass Dichroic Beamsplitters			
Short Wave Pass Dichroic Beamsplitter	T_{avg} > 90% .... 360 – 650 nm R_{avg} > 98% (s-polarization).... 680 – 1080 nm R_{avg} > 90% (p-polarization).... 700 – 1010 nm	FF670-SDi01-25x36	$545
Short Wave Pass Dichroic Beamsplitter *Ideal for Second Harmonic Generation (SHG)*	T_{avg} > 85% (avg. polarization) 370 – 690 nm T > 90% (s- & p-polarizations) 400 – 410 nm R_{avg} > 95% (avg. polarization) 750 – 875 nm R > 99% (s- & p-polarizations) 800 – 820 nm	FF720-SDi01-25x36	$545

See spectra graphs and ASCII data for all of our filters at www.semrock.com

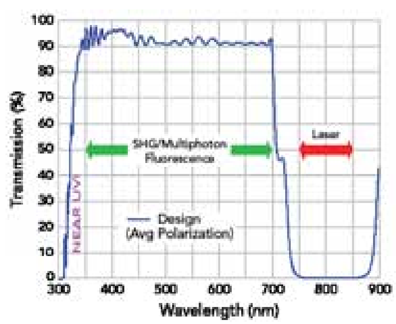
BrightLine® CRS Fluorescence Filters

Product Description	Avg. Transmission & Blocking Ranges	Filter Part Numbers	Price
SRS Filters			
SRS Imaging Emission Filter	T_{avg} > 93% .... 695 – 1005 nm Laser Blocking Range ...... OD_{avg} > 6: 300 – 680 nm OD_{avg} > 6: 1027.5 – 1700 nm Laser Blocking Range ...... OD > 7: 1064 nm	FF01-850/310-25	$875

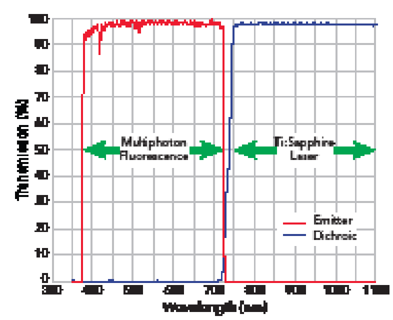
Product Description	Avg. Transmission / Reflection or Blocking Ranges	Filter Part Numbers	Price
CARS Filters			
CARS Bandpass Emission Filter	T_{avg} > 93% .... 580 – 670 nm Blocking Ranges .... OD_{avg} > 5: 200 – 567 nm OD_{avg} > 6: 685 – 1400 nm OD_{avg} > 7: 800 & 1064 nm	FF01-625/90-25	$875
StopLine Notch Dichroic Beamspiltter	T_{avg} > 90% .... 350 – 1015 nm, 1140 – 1600 nm R > 98% .... 1064 nm	NFD01-1064-25x36	$645



FF01-720/SP-25 and FF705-Di01-25x36 Spectra
Tune your Ti:Sapphire laser down to 720 nm and transmit signals up to 690 nm. Dichroic has extended passband out to 1600 nm for nonlinear laser fluorescence applications.



FF720-SDi01-25x36 Spectrum
Short-wave-pass Dichroic Beamsplitter for SHG Low dispersion for minimal pulse broadening. Preserves polarization of both excitation and signal beams.



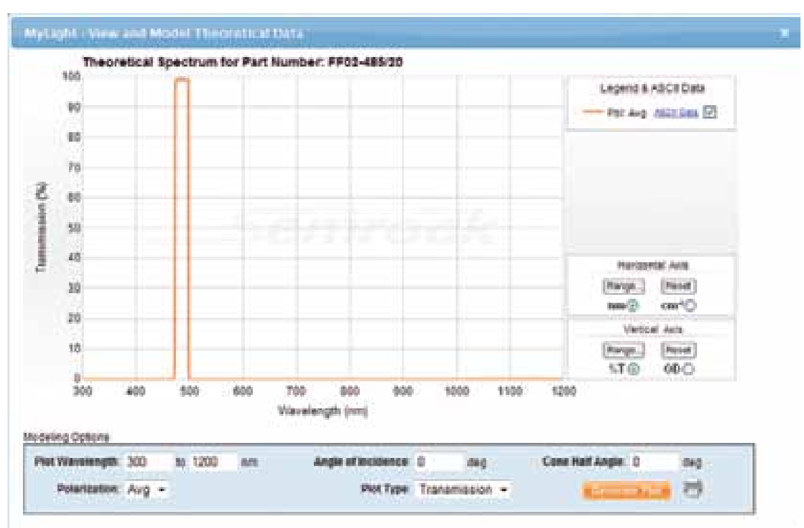
FF01-750/SP-25 and FF735-Di01-25x36 Spectra
Transmits Full Visible – Deep IR Blocking
These filters provide excellent detection of fluorescence throughout the full visible wavelength range, including red fluorophores like Cy5™.

MyLight™

Gives you the ability to characterize optical filters under varying theoretical conditions in real time. Interested in seeing how a Semrock catalog filter behaves under a particular angle of incidence, polarization or cone half angle?

MyLight can provide you with the theoretical answers by simply entering your parameters and selecting "Generate Plot."

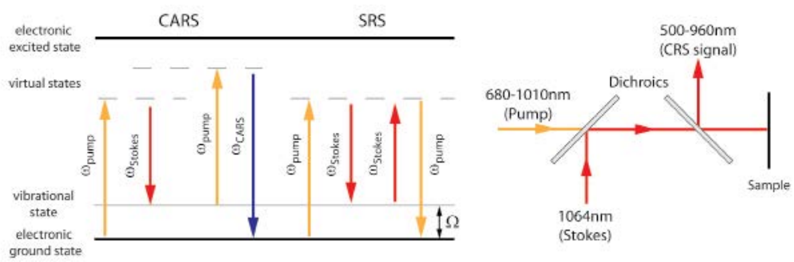
MyLight data can also be saved, re-drawn and printed.



Technical Note

Coherent Raman Scattering (CRS, CARS and SRS)

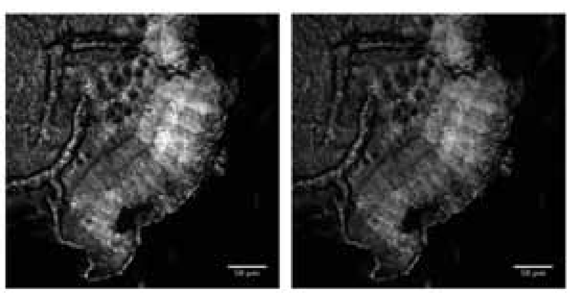
With coherent Raman scattering (CRS) it is possible to perform highly specific, label-free chemical and biological imaging with orders of magnitude higher sensitivity at video-rate speeds compared with traditional Raman imaging. CRS is a nonlinear four-wave mixing process that is used to enhance the weak spontaneous Raman signal associated with specific molecular vibrations. Two different types of CRS that are exploited for chemical and biological imaging are coherent anti-Stokes Raman scattering (CARS) and stimulated Raman scattering (SRS).



Coherent Raman scattering energy diagrams for both CARS and SRS (left), and a schematic of a typical experimental setup (right).

In CRS, two lasers are used to excite the sample. The wavelength of a first laser (often a fixed-wavelength, 1064 nm laser) is set at the Stokes frequency, ω_{Stokes}. The wavelength of the second laser is tuned to the pump frequency, ω_{pump}. When the frequency difference $\omega_{pump} - \omega_{Stokes}$ between these two lasers matches an intrinsic molecular vibration of frequency Ω both CARS and SRS signals are generated within the sample.

In CARS, the coherent Raman signal is generated at a new, third wavelength, given by the anti-Stokes frequency $\omega_{CARS} = 2\omega_{pump} - \omega_{Stokes} = \omega_{pump} + \Omega$. In SRS there is no signal at a wavelength that is different from the laser excitation wavelengths. Instead, the intensity of the scattered light at the pump wavelength experiences a stimulated Raman loss (SRL), with the intensity of the scattered light at the Stokes wavelength experiencing a stimulated Raman gain (SRG). The key advantage of SRS microscopy over CARS microscopy is that it provides background-free chemical imaging with improved image contrast, both of which are important for biomedical imaging applications where water represents the predominant source of nonresonant background signal in the sample.



Coherent anti-Stokes Raman (CARS) imaging of cholesteryl palmitate. The image on the left was obtained using Semrock filter FF01-625/90. The image on the right was obtained using a fluorescence bandpass filter having a center wavelength of 650 nm and extended blocking. An analysis of the images revealed that the FF01-625/90 filter provided greater than 2.6 times CARS signal. Images courtesy of Prof. Eric Potma (UC Irvine).

Harmonic Generation Microscopy

Harmonic generation microscopy (HGM) is a label-free imaging technique that uses high-peak power ultrafast lasers to generate appreciable image contrast in biological imaging applications. Harmonic generation microscopy exploits intrinsic energy-conserving second and third order nonlinear optical effects. In second-harmonic generation (SHG) two incident photons interact at the sample to create a single emission photon having twice the energy i.e., 2wi = wSHG. A prerequisite for SHG microscopy is that the sample must exhibit a significant degree of noncentrosymmetric order at the molecular level before an appreciable SHG signal can be generated. In third-harmonic generation (THG), three incident photons interact at the sample to create a single emission photon having three times the energy i.e., 3wi = wTHG. Both SHG and THG imaging techniques can be combined with other nonlinear optical imaging (NLO) modalities, such as multiphoton fluorescence and coherent Raman scattering imaging. Such a multimodal approach to biological imaging allows a comprehensive analysis of a wide variety of biological entities, such as individual cells, lipids, collagen fibrils, and the integrity of cell membranes at the same time.

Multiphoton Filters Common Specifications

Common Specifications

Property		Emitter	LWP Dichroic	Comment
Passband Transmission	Guaranteed	> 90%	> 93%	Averaged over any 50 nm (emitter) or 10 nm (dichroic) window within the passband. For SWP dichroic specifications, *see page 46*.
	Typical	> 95%	> 95%	
Dichroic Reflection	LWP	N/A	> 98%	Averaged over any 30 nm window within the reflection band. For SWP dichroic specifications, *see page 46*.
Autofluorescence		Ultra-low	Ultra-low	Fused silica substrate
Blocking		Emitter filters have exceptional blocking over the Ti:Sapphire laser range as needed to achieve superb signal-to-noise ratios even when using an extended-response PMT or a CCD camera or other silicon-based detector; see www.semrock.com for detailed specifications.		
Pulse Dispersion		LWP dichroic beamsplitters are suitable for use with 100 femtosecond gaussian laser pulses. For SWP dichroic beamsplitters, see Group Delay Dispersion and Polarization Technical Note at www.semrock.com		
Emitter Orientation		The emitter orientation does not affect its performance; therefore there is no arrow on the ring to denote a preferred orientation.		
Dichroic Orientation		For the LWP dichroic, the reflective coating side should face toward detector and sample. For the SWP dichroic, the reflective coating side should face towards laser as shown in the diagram on page 45.		
Microscope Compatibility		These filters fit most standard-sized microscope cubes from Nikon, Olympus, and Zeiss and may also be mounted in optical-bench mounts. Contact Semrock for special filter sizes.		

Technical Note

Multiphoton Filters

In multiphoton fluorescence microscopy, fluorescent molecules that tag targets of interest are excited and subsequently emit fluorescent photons that are collected to form an image. However, in a two-photon microscope, the molecule is not excited with a single photon as it is in traditional fluorescence microscopy, but instead, two photons, each with twice the wavelength, are absorbed simultaneously to excite the molecule.

As shown in Figure 1, a typical system is comprised of an excitation laser, scanning and imaging optics, a sensitive detector (usually a photomultiplier tube), and optical filters for separating the fluorescence from the laser (dichroic beamsplitter) and blocking the laser light from the detector (emission filter).

The advantages offered by multiphoton imaging systems include: true three-dimensional imaging like confocal microscopy; the ability to image deep inside of live tissue; elimination of out-of-plane fluorescence; and reduction of photobleaching away from the focal plane to increase sample longevity. Now Semrock has brought enhanced performance to multiphoton users by introducing optical filters with ultra-high transmission in the passbands, steep transitions, and guaranteed deep blocking everywhere it is needed. Given how much investment is typically required for the excitation laser and other complex elements of multiphoton imaging systems, these filters represent a simple and inexpensive upgrade to substantially boost system performance.

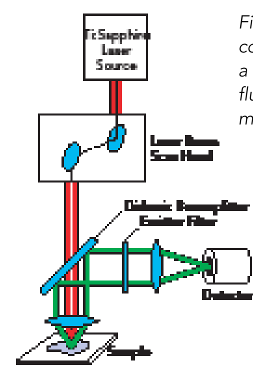
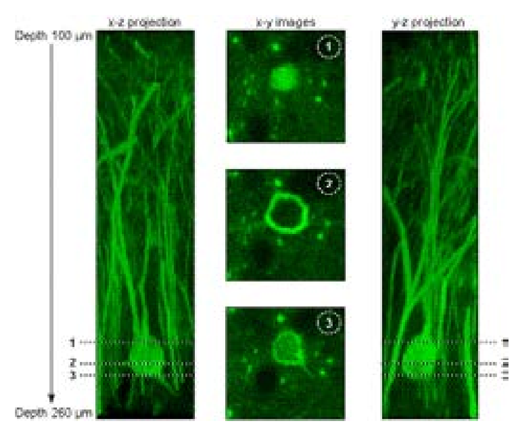
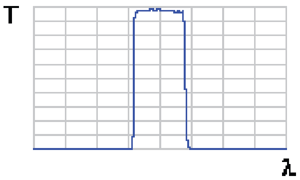


Figure 1: Typical configuration of a multiphoton fluorescence microscope



Exciting research using Semrock multiphoton filters demonstrates the power of fluorescent Ca^{2+} indicator proteins (FCIPs) for studying Ca^{2+} dynamics in live cells using two-photon microscopy. Three-dimensional reconstructions of a layer 2/3 neuron expressing a fluorescent protein CerTN-L15. Middle: 3 selected images (each taken at depth marked by respective number on the left and right).
Image courtesy of Prof. Dr. Olga Garaschuk of the Institute of Neuroscience at the Technical University of Münich. (Modified from Heim et al., Nat. Methods, 4(2): 127-9, Feb. 2007.)



Semrock stocks an exceptional range of high-performance, high-reliability individual fluorescence bandpass filters that have been optimized for use in a variety of fluorescence instruments. These filters exclusively utilize our patented single-substrate construction for the highest performance and reliability.

Unless otherwise noted, all filters are housed in a standard 25 mm round black-anodized aluminum ring with thickness as indicated, and a clear aperture of at least 21 mm. *Parts denoted with a "-D" are unmounted.*

Passband Color	Filter	Center Wavelength	Avg. Transmission and Bandwidth[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price
	Hg01-254-25	254 nm		*See Mercury Line filters, page 97*		
	FF01-260/16-25	260 nm	> 55% over 16 mn	25 mm x 3.5 mm	1.1 mm	$395
	FF01-280/10-25	280 nm	> 60% over 10 nm	25 mm x 3.5 mm	1.1 mm	$395
	FF01-280/20-25	280 nm	> 65% over 20 nm	25 mm x 5.0 mm	2.0 mm	$395
	FF01-285/14-25	285 nm	> 60% over 14 nm	25 mm x 5.0 mm	3.0 mm	$395
	FF01-292/27-25	292 nm	> 70% over 27 nm	25 mm x 3.5 mm	2.0 mm	$395
	FF01-315/15-25	315 nm	> 75% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-320/40-25	320 nm	> 70% over 40 nm	25 mm x 5.0 mm	2.0 mm	$395
	FF01-335/7-25	335 nm	> 75% over 7 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-340/12-25	340 nm	> 75% over 12 nm	25 mm x 3.5 mm	2.0 mm	$345
	FF01-340/26-25	340 nm	> 75% over 26 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-355/40-25	355 nm	> 80% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-357/44-25	357 nm	> 75% over 44 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-360/12-25	360 nm	> 75% over 12 nm	25 mm x 5.0 mm	3.5 mm	$295
	Hg01-365-25	365 nm		*See Mercury Line filters, page 97*		
	FF01-370/6-25	370 nm	> 90% over 6 nm	25 mm x 5.0 mm	3.0 mm	$295
	FF01-370/10-25	370 nm	> 90% over 10 nm	25 mm x 5.0 mm	3.0 mm	$295
	FF01-370/36-25	370 nm	> 90% over 36 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-375/6-25	375 nm	> 90% over 6 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-376/20-25	376 nm	> 85% over 20 nm	25 mm x 3.5 mm	1.1 mm	$295
	FF01-377/50-25	377 nm	> 85% over 50 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-379/34-25	379 nm	> 90% over 34 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-380/14-25	380 nm	> 80% over 14 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-386/23-25	386 nm	> 90% over 23 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-387/11-25	387 nm	> 90% over 11 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-390/18-25	390 nm	> 90% over 18 nm	25 mm x 5.0 mm	2.0 mm	$245
	FF01-390/40-25	390 nm	> 93% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-395/11-25	395 nm	> 85% over 11 nm	25 mm x 3.5 mm	2.0 mm	$295
	LD01-405/10-25	405 nm		*See Laser Diode Clean-Up filters, page 95*		
	FF01-405/10-25	405 nm	> 87% over 10 nm	25 mm x 5.0 mm	3.5 mm	$345
	FF01-406/15-25	406 nm	> 85% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-407/17-25	407 nm	> 90% over 17 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-414/46-25	414 nm	> 90% over 46 nm	25 mm x 3.5 mm	2.0 mm	$245
	FF01-417/60-25	417 nm	> 90% over 60 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-425/30-25	425 nm	> 90% over 30 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-427/10-25	427 nm	> 93% over 10 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-434/17-25	434 nm	> 90% over 17 nm	25 mm x 5.0 mm	2.0 mm	$245

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

For graphs, ASCII data and blocking information, go to www.semrock.com

BrightLine® Single-band Bandpass Filters

Passband Color	Filter	Center Wavelength	Avg. Transmission and Bandwidth[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price
	FF02-435/40-25	435 nm	> 90% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF02-438/24-25	438 nm	> 93% over 24 nm	25 mm x 5.0 mm	2.0 mm	$295
	LD01-439/8-25	439 nm	*See Laser Diode Clean-Up filters, page 95*			
	FF01-439/154-25	439 nm	> 93% over 154 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-440/40-25	440 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-442/46-25	442 nm	> 90% over 46 nm	25 mm x 3.5 mm	2.0 mm	$245
	FF01-445/20-25	445 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-445/45-25	445 nm	> 90% over 45 nm	25 mm x 5.0 mm	2.0 mm	$245
	FF02-447/60-25	447 nm	> 93% over 60 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-448/20-25	448 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-452/45-25	452 nm	> 93% over 45 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-457/50-25	457 nm	> 90% over 50 nm	25 mm x 5.0 mm	3.5 mm	$345
	FF01-460/60-25	460 nm	> 90% over 60 nm	25 mm x 3.5 mm	2.0 mm	$245
	FF02-460/80-25	460 nm	> 90% over 80 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-465/30-25	465 nm	> 90% over 30 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-466/40-25	466 nm	> 93% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-469/35-25	469 nm	> 90% over 35 nm	25 mm x 5.0 mm	2.0 mm	$245
	FF01-470/22-25	470 nm	> 93% over 22 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-470/28-25	470 nm	> 90% over 28 nm	25 mm x 5.0 mm	3.5 mm	$345
	FF02-470/100-25	470 nm	> 93% over 100 nm	25 mm x 5.0 mm	2.0 mm	$295 IMPROVED
	FF02-472/30-25	472 nm	> 93% over 30 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-473/10-25	473 nm	> 90% over 10 nm	25 mm x 3.5 mm	2.0 mm	$245
	FF01-474/23-25	474 nm	> 93% over 23 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-475/20-25	475 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-475/23-25	475 nm	> 92% over 23 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-475/28-25	475 nm	> 90% over 28 nm	25 mm x 5.0 mm	2.0 mm	$245
	FF01-475/35-25	475 nm	> 90% over 35 nm	25 mm x 5.0 mm	2.0 mm	$245
	FF01-475/42-25	475 nm	> 90% over 42 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF02-475/50-25	475 nm	> 93% over 50 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-479/40-25	479 nm	> 90% over 40 nm	25 mm x 3.5 mm	2.0 mm	$245
	FF01-480/17-25	480 nm	> 92% over 17 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-480/40-25	480 nm	> 90% over 40 nm	25 mm x 3.5 mm	1.1 mm	$345 NEW
	FF02-482/18-25	482 nm	> 93% over 18 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-482/25-25	482 nm	> 93% over 25 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-482/35-25	482 nm	> 93% over 35 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-483/32-25	483 nm	> 93% over 32 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF02-485/20-25	485 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-488/6-25	488 nm	> 90% over 6 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-488/10-25	488 nm	> 93% over 10 nm	25 mm x 3.5 mm	2.0 mm	$295 NEW
	FF01-494/20-25	494 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-494/41-25	494 nm	> 90% over 41 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-497/16-25	497 nm	> 90% over 16 nm	25 mm x 5.0 mm	2.0 mm	$245

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

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Passband Color	Filter	Center Wavelength	Avg. Transmission and Bandwidth[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price	
	FF01-500/10-25	500 nm	> 90% over 10 nm	25 mm x 3.5 mm	1.1 mm	$295	NEW
	FF01-500/15-25	500 nm	> 93% over 15 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-500/24-25	500 nm	> 93% over 24 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-504/12-25	504 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF02-510/10-25	510 nm	> 93% over 10 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF03-510/20-25	510 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$345	IMPROVED
	FF01-510/42-25	510 nm	> 90% over 42 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-510/84-25	510 nm	> 93% over 84 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-512/25-25	512 nm	> 92% over 25 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-513/17-25	513 nm	> 90% over 17 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-514/3 -25	514 nm	> 93% over 3 nm	25 mm x 5.0 mm	2.0 mm	$295	NEW
	FF01-514/30-25	514 nm	> 93% over 30 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-517/20-25	517 nm	> 90% over 20 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-520/5-25	520 nm	> 93% over 5 nm	25 mm x 3.5 mm	2.0 mm	$345	NEW
	FF01-520/15-25	520 nm	> 93% over 15 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF02-520/28-25	520 nm	> 93% over 28 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-520/35-25	520 nm	> 93% over 35 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-520/44-25	520 nm	> 90% over 44 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-523/20-25	523 nm	> 93% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-524/24-25	524 nm	> 93% over 24 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-525/15-25	525 nm	> 90% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-525/20-25	525 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-525/30-25	525 nm	> 90% over 30 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-525/39-25	525 nm	> 90% over 39 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF02-525/40-25	525 nm	> 90% over 40 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-525/45-25	525 nm	> 93% over 45 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF03-525/50-25	525 nm	> 93% over 50 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-527/20-25	527 nm	> 93% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-529/24-25	529 nm	> 90% over 24 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-529/28-25	529 nm	> 90% over 28 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-530/11-25	530 nm	> 90% over 11 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-530/43-25	530 nm	> 90% over 43 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-530/55-25	530 nm	> 90% over 55 nm	25 mm x 3.5 mm	2.0 mm	$295	IMPROVED
	FF01-530/200-25-D	530 nm	> 90% over 200 nm	25 mm x 3.0 mm (unmounted)	3.0 mm	$295	
	FF02-531/22-25	531 nm	> 93% over 22 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-531/40-25	531 nm	> 93% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-531/46-25	531 nm	> 94% over 46 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-532/3-25	531 nm	> 93% over 3 nm	25 mm x 5.0 mm	2.0 mm	$295	NEW
	FF01-534/20-25	534 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF02-534/30-25	534 nm	> 93% over 30 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-534/42-25	534 nm	> 90% over 42 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-535/22-25	535 nm	> 90% over 22 nm	25 mm x 3.5 mm	2.0 mm	$245	

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

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Single-band Sets
Multiband Sets
Cubes
Laser Sets
NLO Filters
Individual Filters
Dichroic Beamsplitters
LaserMUX Filters
Flow Cytometry
Tunable Filters

BrightLine® Single-band Bandpass Filters

Passband Color	Filter	Center Wavelength	Avg. Transmission and Bandwidth[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price	
	FF01-535/50-25	535 nm	> 90% over 50 nm	25 mm x 3.5 mm	1.1 mm	$295	NEW
	FF01-536/40-25	536 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-537/26-25	537 nm	> 90% over 26 nm	25 mm x 5.0 mm	3.0 mm	$345	
	FF01-538/40-25	538 nm	> 90% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-539/278-25	539 nm	> 93% over 238 nm	25 mm x 3.5 mm	2.0 mm	$295	NEW
	FF01-540/15-25	540 nm	> 93% over 15 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-540/50-25	540 nm	> 93% over 50 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-542/20-25	542 nm	> 90% over 20 nm	25 mm x 5.0 mm	2.0 mm	$245	
	FF01-542/27-25	542 nm	> 93% over 27 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-542/50-25	542 nm	> 93% over 50 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-543/3-25	543 nm	> 93% over 3 nm	25 mm x 5.0 mm	2.0 mm	$295	NEW
	FF01-543/22-25	543 nm	> 93% over 22 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-545/55-25	545 nm	> 90% over 55 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-546/6-25	546 nm	> 90% over 6 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-549/15-25	549 nm	> 90% over 15 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-550/32-25	550 nm	> 90% over 32 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-550/49-25	550 nm	> 90% over 49 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-550/88-25	550 nm	> 92% over 88 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-550/200-25	550 nm	> 90% over 200 nm	25 mm x 3.5 mm	2.0 mm	$295	NEW
	FF01-556/20-25	556 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-558/20-25	558 nm	> 90% over 20 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-559/34-25	559 nm	> 90% over 34 nm	25 mm x 5.0 mm	2.0 mm	$245	
	FF01-560/14-25	560 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-560/25-25	560 nm	> 93% over 25 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-561/4-25	561 nm	> 93% over 4 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-561/14-25	561 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-562/40-25	562 nm	> 93% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-563/9-25	563 nm	> 93% over 9 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-565/24-25	565 nm	> 90% over 24 nm	25 mm x 5.0 mm	2.0 mm	$245	
	FF01-567/15-25	567 nm	> 95% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-572/15-25	572 nm	> 92% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-572/28-25	572 nm	> 93% over 28 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-574/19-25	574 nm	> 93% over 19 nm	25 mm x 3.5 mm	1.1 mm	$295	
	FF01-575/15-25	575 nm	> 90% over 15 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF02-575/25-25	575 nm	> 93% over 25 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-576/10-25	576 nm	> 90% over 10 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-578/16-25	578 nm	> 90% over 16 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-578/105-25	578 nm	> 90% over 105 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-579/34-25	579 nm	> 90% over 34 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-580/14-25	580 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-580/23-25	580 nm	> 90% over 23 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-580/60-25-D	580 nm	> 90% over 60 nm	25 mm x 4.0 mm (unmounted)	4.0 mm	$295	
	FF01-582/15-25	582 nm	> 90% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

For graphs, ASCII data and blocking information, go to www.semrock.com

Passband Color	Filter	Center Wavelength	Avg. Transmission[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price	
	FF01-582/75-25	582 nm	> 90% over 75 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-583/22-25	583 nm	> 92% over 22 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-585/29-25	585 nm	> 93% over 29 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-585/40-25	585 nm	> 90% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-586/15-25	586 nm	> 90% over 15 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-586/20-25x3.5	586 nm	> 93% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-586/20-25x5	586 nm	> 93% over 20 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-587/11-25	587 nm	> 93% over 11 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-587/35-25	587 nm	> 90% over 35 nm	25 mm x 5.0 mm	3.0 mm	$345	
	FF01-588/21-25	588 nm	> 93% over 21 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-589/15-25	589 nm	> 93% over 15 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-589/18-25	589 nm	> 93% over 18 nm	25 mm x 3.5 mm	1.1 mm	$295	
	FF01-590/10-25	590 nm	> 90% over 10 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-590/20-25	590 nm	> 93% over 20 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-591/6-25	591 nm	> 93% over 6 nm	25 mm x 5.0 mm	2.0 mm	$295	NEW
	FF02-592/8-25	592 nm	> 93% over 8 nm	25 mm x 5.0 mm	2.0 mm	$345	IMPROVED
	FF01-593/40-25	593 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-593/46-25	593 nm	> 94% over 46 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-600/14-25	600 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-600/37-25	600 nm	> 93% over 37 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-605/15-25	605 nm	> 90% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-605/64-25	605 nm	> 90% over 64 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-607/36-25	607 nm	> 93% over 36 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-607/70-25	607 nm	> 92% over 70 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-609/54-25	609 nm	> 93% over 54 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-609/57-25	609 nm	> 94% over 57 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-609/181-25	609 nm	> 93% over 181 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-612/-69-25	612 nm	> 90% over 69 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-615/20-25	615 nm	> 90% over 20 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-615/24-25	615 nm	> 90% over 24 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-615/45-25	615 nm	> 90% over 45 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-617/73-25	617 nm	> 90% over 73 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-620/14-25	620 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-620/52-25	620 nm	> 90% over 52 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-623/18-25	623 nm	> 90% over 18 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-623/24-25	623 nm	> 90% over 24 nm	25 mm x 5.0 mm	3.5 mm	$345	NEW
	FF01-624/40-25	624 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-625/15-25	625 nm	> 90% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-625/20-25	625 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-625/26-25	625 nm	> 93% over 26 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-625/90-25	625 mm	> 93% over 90 nm	*see multiphoton filters, pg 50*			NEW
	FF01-628/32-25	628 nm	> 93% over 32 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF02-628/40-25	628 nm	> 93% over 40 nm	25 mm x 5.0 mm	2.0 mm	$295	IMPROVED

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

BrightLine® Single-band Bandpass Filters

Passband Color	Filter	Center Wavelength	Avg. Transmission[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price	
	FF01-629/53-25	629 nm	> 90% over 53 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-629/56-25	629 nm	> 90% over 56 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-630/20-25	630 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-630/69-25	630 nm	> 90% over 69 nm	25 mm x 3.5 mm	2.0 mm	$245	
	FF01-630/92-25	630 nm	> 92% over 92 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-631/36-25	631 nm	> 90% over 36 nm	25 mm x 3.5 mm	1.1 mm	$345	
	FF02-632/22-25	632 nm	> 93% over 22 nm	25 mm x 5.0 mm	2.0 mm	$295	IMPROVED
	FF01-636/8-25	636 nm	> 90% over 8 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-637/7-25	637 nm	> 93% over 7 nm	25 mm x 3.5 mm	2.0 mm	$295	NEW
	FF01-640/14-25	640 nm	> 93% over 14 nm	25 mm x 5.0 mm	2.0 mm	$345	
	LD01-640/8-25	640 nm	*See Laser Diode Clean-Up filters, page 95*				
	FF01-640/40-25	640 nm	> 90% over 40 nm	25 mm x 5.0 mm	3.5 mm	$295	NEW
	FF01-641/75-25	641 nm	> 93% over 75 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-642/10-25	642 nm	> 93% over 10 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-647/57-25	647 nm	> 92% over 57 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-650/13-25	650 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-650/60-25	650 nm	> 95% over 60 nm	25 mm x 3.5 mm	2.0 mm	$345	NEW
	FF01-650/100-25	650 nm	> 93% over 100 nm	25 mm x 5.0 mm	3.5 mm	$345	NEW
	FF01-650/150-25	650 nm	> 93% over 150 nm	25 mm x 5.0 mm	3.5 mm	$345	NEW
	FF01-655/15-25	655 nm	> 90% over 15 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-655/40-25	655 nm	> 93% over 40 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF01-660/13-25	660 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-660/52-25	660 nm	> 90% over 52 nm	25 mm x 3.5 mm	2.0 mm	$295	NEW
	FF01-661/11-25	661 nm	> 93% over 11 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-661/20-25	661 nm	> 90% over 20 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-670/30-25	670 nm	> 95% over 30 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-675/67-25	675 nm	> 90% over 67 nm	25 mm x 5.0 mm	3.0 mm	$345	
	FF01-676/29-25	676 nm	> 90% over 29 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-676/37-25	676 nm	> 94% over 37 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-677/20-25	677 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-680/13-25	680 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-680/26-25	680 nm	> 90% over 26 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-680/30-25	680 nm	> 90% over 30 nm	25 mm x 5.0 mm	3.5 mm	$295	
	FF02-684/24-25	684 nm	> 93% over 24 nm	25 mm x 5.0 mm	2.0 mm	$295	
	FF01-685/40-25	685 nm	> 93% over 40 nm	25 mm x 5.0 mm	3.5 mm	$345	
	FF01-688/31-25	688 nm	> 90% over 31 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-690/14-25	690 nm	> 93% over 14 nm	25 mm x 3.5 mm	2.0 mm	$345	
	FF01-692/40-25	692 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295	
	FF01-693/43-25	963 nm	> 93% over 43 nm	25 mm x 3.5 mm	1.1 mm	$295	
	FF01-697/58-25	697 nm	> 90% over 58 nm	25 mm x 3.5 mm	1.1 mm	$345	
	FF01-697/75-25-D	697 nm	> 90% over 75 nm	25 mm x 4.0 mm (unmounted)	4.0 mm	$295	
	FF01-700/13-25	700 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$345	
	FF01-708/75-25	708 nm	> 93% over 75 nm	25 mm x 5.0 mm	2.0 mm	$295	

(continued)

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

BrightLine® Single-band Bandpass Filters

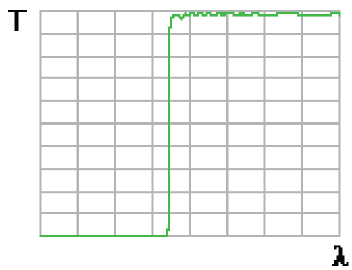
Passband Color	Filter	Center Wavelength	Avg. Transmission[1]	Housed Size (Diameter x Thickness)	Glass Thickness	Price
	FF01-710/40-25	710 nm	> 93% over 40 nm	25 mm x 5.0 mm	3.5 mm	$295
	FF01-711/25-25	711 nm	> 90% over 25 nm	25 mm x 5.0 mm	3.5 mm	$345
	FF01-716/40-25	716 nm	> 93% over 40 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-716/43-25	716 nm	> 90% over 43 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-720/13-25	720 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-731/137-25	731 nm	> 90% over 137 nm	25 mm x 3.5 mm	1.1 mm	$345
	FF01-732/68-25	732 nm	> 90% over 68 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-736/128-25	736 nm	> 90% over 128 nm	25 mm x 3.5 mm	1.1 mm	$295
	FF01-740/13-25	740 nm	> 93% over 13 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-747/33-25	747 nm	> 93% over 33 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-760/12-25	760 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-769/41-25	769 nm	> 93% over 41 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-775/46-25	775 nm	> 93% over 46 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-780/12-25	780 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$345
	LD01-785/10-25	785 mm		*See Laser Diode Clean-Up filters, page 95*		
	FF01-785/62-25	785 nm	> 94% over 62 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-786/22-25	786 nm	> 93% over 22 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-794/160-25	794 nm	> 93% over 160 nm	25 mm x 5.0 mm	2.0 mm	$295
	FF01-800/12-25	800 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF02-809/81-25	809 nm	> 93% over 81 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-820/12-25	820 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-832/37-25	832 nm	> 93% over 37 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-840/12-25	840 nm	> 93% over 12 nm	25 mm x 5.0 mm	2.0 mm	$345
	FF01-842/56-25	842 nm	> 90% over 56 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-850/310-25	850 nm	> 93% over 310 nm	See multiphoton filters, page 50		NEW
	FF01-855/210-25	855 nm	> 90% over 210 nm	25 mm x 3.5 mm	2.0 mm	$345
	FF01-857/30-25	857 nm	> 90% over 30 nm	25 mm x 3.5 mm	1.1 mm	$345
	FF01-910/5-25	910 nm	> 90% over 5 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-924/10-25	924 nm	> 90% over 10 nm	25 mm x 3.5 mm	2.0 mm	$295
	FF01-1060/13-25	1060 nm	> 90% over 13 nm	25 mm x 5.0 mm	3.5 mm	$345
	FF01-1074/20-25	1074 nm	> 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	$345 NEW
	NIR01-1535/3-25	1535 nm		*See Near-IR Bandpass Filters, page 96*		
	NIR01-1550/3-25	1550 nm		*See Near-IR Bandpass Filters, page 96*		
	NIR01-1570/3-25	1570 nm		*See Near-IR Bandpass Filters, page 96*		

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

For graphs, ASCII data and blocking information, go to www.semrock.com

BrightLine® Long / Short pass Single-edge Filters

Actual Measured Data
FF01-519/LP-25

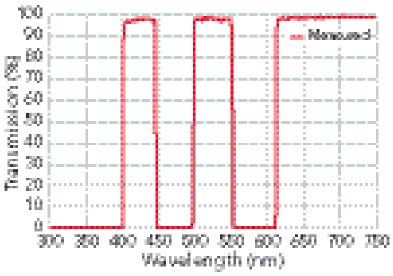


Semrock stocks an exceptional range of high-performance, high-reliability individual fluorescence edge filters that have been optimized for use in a variety of fluorescence instruments. These filters exclusively utilize our patented single-substrate construction for the highest performance and reliability. For additional offerings, see EdgeBasic™ long-wave-pass filters.

Unless otherwise noted, all filters are housed in a standard 25 mm round black-anodized aluminum ring with thickness as indicated, and a clear aperture of at least 21 mm. Parts with a "/LP" in the part number are long-wave-pass edge filters and parts with a "/SP" are short-wave-pass edge filters.

Edge Color	Edge Wavelength	Avg. Transmission / Bandwidth [1]	Housed Size (Diameter x Thickness)	Glass Thickness	Filter Part Number	Price
	274 nm	> 85% 277 - 358 nm	25 mm x 3.5 mm	2.0 mm	FF01-267/LP-25	$395
	294 nm	> 70% 255 - 290 nm	25 mm x 3.5 mm	1.1 mm	FF01-300/SP-25	$395
	306 nm	> 85% 308 - 420 nm	25 mm x 5.0 mm	2.0 mm	FF01-300/LP-25	$295
	347 nm	> 90% 350 - 500 nm	25 mm x 3.5 mm	2.0 mm	FF01-341/LP-25	$295
	415 nm	> 93% 417 - 1100 nm	25 mm x 3.5 mm	2.0 mm	FF02-409/LP-25	$295
	430 nm	> 93% 380 - 427 nm	25 mm x 5.0 mm	3.5 mm	FF01-440/SP-25	$295
	483 nm	> 90% 400 - 480 nm	25 mm x 5.0 mm	3.0 mm	FF01-492/SP-25	$345
	501 nm	> 93% 503 -1100 nm	25 mm x 3.5 mm	2.0 mm	FF01-496/LP-25	$295
	515 nm	> 90% 519 - 700 nm	25 mm x 3.5 mm	2.0 mm	FF01-500/LP-25	$245
	522 nm	> 90% 525 - 800 nm	25 mm x 3.5 mm	2.0 mm	FF01-515/LP-25	$295
	488 nm	> 90% 445 - 485 nm	25 mm x 3.5 mm	2.0 mm	FF01-518/SP-25	$295
	530 nm	> 92% 534 - 653 nm	25 mm x 3.5 mm	2.0 mm	FF01-519/LP-25	$295
	522 nm	> 90% 380 - 520 nm	25 mm x 3.5 mm	2.0 mm	FF01-533/SP-25	$295
	605 nm	> 90% 612 - 718 nm	25 mm x 5.0 mm	3.5 mm	FF01-591/LP-25	$295
	601 nm	> 93% 604 - 1100 nm	25 mm x 3.5 mm	2.0 mm	FF01-593/LP-25	$295
	599 nm	> 90% 509 - 591 nm	25 mm x 5.0 mm	3.5 mm	FF01-612/SP-25	$295
	638 nm	> 85% 360 - 634 nm	25 mm x 3.5 mm	1.1 mm	FF01-650/SP-25	$345
	646 nm	> 93% 531 - 642 nm	25 mm x 3.5 mm	2.0 mm	FF01-655/SP-25	$295
	654 nm	*See Multiphoton Filters, page 49*			FF01-680/SP-25	
	702 nm	> 93% 707 - 752 nm	25 mm x 3.5 mm	2.0 mm	FF01-692/LP-25	$295
	681 nm	> 93% 481 - 676 nm	25 mm x 3.5 mm	2.0 mm	FF01-694/SP-25	$295
	696 nm	*See Multiphoton Filters, page 49*			FF01-720/SP-25	
	754 nm	> 90% 761 - 850 nm	25 mm x 3.5 mm	2.0 mm	FF01-736/LP-25	$295
	727 nm	*See Multiphoton Filters, page 49*			FF01-750/SP-25	
	747 nm	*See Multiphoton Filters, page 49*			FF01-770/SP-25	
	785 nm	> 93% 789 - 1200 nm	25 mm x 3.5 mm	2.0 mm	FF01-776/LP-25	$295
	765 nm	*See Multiphoton filters, page 49*			FF01-790/SP-25	
	802 nm	> 93% 807 - 852 nm	25 mm x 3.5 mm	2.0 mm	FF01-793/LP-25	$295
	812 nm	> 90% 815 - 915 nm	25 mm x 3.5 mm	2.0 mm	FF01-800/LP-25	$295
	840 nm	> 97% 842 - 935 nm	25 mm x 3.5 mm	2.0 mm	FF01-834/LP-25	$345
	848 nm	> 93% 850 - 950 nm	25 mm x 3.5 mm	1.1 mm	FF01-835/LP-25	$345
	835 nm	> 95% 485 - 831 nm	25 mm x 3.5 mm	2.0 mm	FF01-842/SP-25	$345
	890 nm	*See Multiphoton filters, page 49*			FF01-890/SP-25	
	938 nm	> 90% 600 - 935 nm	25 mm x 3.5 mm	2.0 mm	FF01-945/SP-25	$295
	1057 nm	> 93% 1064 - 1087 nm	25 mm x 3.5 mm	2.0 mm	FF01-1020/LP-25	$295

Actual Measured Data
FF01-425/527/685-25



Semrock offers a unique selection of individual high-performance multiband fluorescence bandpass filters that have been optimized for use in a variety of fluorescence instruments. These filters all utilize our exclusively single-substrate, low-autofluorescence glass construction. All filters are housed in a standard 25 mm round black-anodized aluminum ring with thickness as indicated, and have a clear aperture of at least 21 mm. These filters have extremely high transmission, steep and well-defined edges, and outstanding blocking between the passbands.

Center Wavelength	Avg. Transmission / Bandwidth [1]	Housed Size (Diameter x Thickness)	Glass Thickness	Filter Part Number	Price
Dual-band Filters					
387 nm 480 nm	> 80% over 11 nm > 90% over 29 nm	25 mm x 5.0 mm	2.0 mm	FF01-387/480-25	$375
416 nm 501 nm	> 90% over 25 nm > 90% over 18 nm	25 mm x 5.0 mm	2.0 mm	FF01-416/501-25	$375
433 nm 530 nm	> 90% over 38 nm > 90% over 40 nm	25 mm x 3.5 mm	2.0 mm	FF01-433/530-25	$375
464 nm 547 nm	> 90% over 23 nm > 90% over 31 nm	25 mm x 3.5 mm	2.0 mm	FF01-464/547-25	$375
468 nm 553 nm	> 90% over 34 nm > 90% over 24 nm	25 mm x 5.0 mm	3.5 mm	FF01-468/553-25	$375
470 nm 556 nm	> 90% over 21 nm > 90% over 19 nm	25 mm x 5.0 mm	2.0 mm	FF01-470/556-25	$375
479 nm 585 nm	> 90% over 38 nm > 90% over 27 nm	25 mm x 5.0 mm	3.5 mm	FF01-479/585-25	$375
482 nm 563 nm	> 93% over 18 nm > 93% over 9 nm	25 mm x 5.0 mm	2.0 mm	FF01-482/563-25	$375
494 nm 576 nm	> 90% over 20 nm > 90% over 20 nm	25 mm x 5.0 mm	2.0 mm	FF01-494/576-25	$375
503 nm 572 nm	> 90% over 18 nm > 90% over 18 nm	25 mm x 5.0 mm	2.0 mm	FF01-503/572-25	$375
512 nm 630 nm	> 90% over 23 nm > 90% over 91 nm	25 mm x 3.5 mm	2.0 mm	FF01-512/630-25	$375
523 nm 610 nm	> 93% over 40 nm > 93% over 52 nm	25 mm x 3.5 mm	2.0 mm	FF01-523/610-25	$375
524 nm 628 nm	> 90% over 29 nm > 90% over 33 nm	25 mm x 3.5 mm	2.0 mm	FF01-524/628-25	$375
527 nm 645 nm	> 90% over 42 nm > 90% over 49 nm	25 mm x 3.5 mm	2.0 mm	FF01-527/645-25	$375
532 nm 834 nm	> 90% over 1 nm > 90% over 11 nm	25 mm x 5.0 mm	3.5 mm	FF01-532/834-25	$375
534 nm 635 nm	> 90% over 36 nm > 90% over 31 nm	25 mm x 5.0 mm	3.5 mm	FF01-534/635-25	$375
535 nm 675 nm	> 90% over 70 nm > 90% over 50 nm	25 mm x 5.0 mm	3.5 mm	FF01-535/675-25	$375
542 nm 672 nm	> 90% over 30 nm > 90% over 30 nm	25 mm x 3.5 mm	2.0 mm	FF01-542/672-25	$375
577 nm 690 nm	> 90% over 24 nm > 90% over 50 nm	25 mm x 3.5 mm	2.0 mm	FF01-577/690-25	$375
609 nm 852 nm	> 92% over 222 nm > 92% over 96 nm	25 mm x 3.5 mm	2.0 mm	FF01-609/852-25	$375
1064 nm 1550 nm	> 90% over 10 nm > 90% over 20 nm	25 mm x 3.5 mm	2.0 mm	FF01-1064/1550-25	$375

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

BrightLine® Multiband Bandpass Filters

Center Wavelength	Avg. Transmission / Bandwidth [1]	Housed Size (Diameter x Thickness)	Glass Thickness	Filter Part Number	Price
Triple-band Filters					
387 nm 478 nm 555 nm	> 80% over 11 nm > 90% over 24 nm > 90% over 19 nm	25 mm x 5.0 mm	2.0 mm	FF01-387/478/555-25	$405
390 nm 482 nm 587 nm	> 85% over 40 nm > 93% over 18 nm > 93% over 15 nm	25 mm x 5.0 mm	2.0 mm	FF01-390/482/587-25	$405
407 nm 494 nm 576 nm	> 80% over 14 nm > 85% over 20 nm > 85% over 20 nm	25 mm x 5.0 mm	2.0 mm	FF01-407/494/576-25	$405
422 nm 503 nm 572 nm	> 90% over 30 nm > 90% over 18 nm > 90% over 18 nm	25 mm x 5.0 mm	2.0 mm	FF01-422/503/572-25	$405
425 nm 527 nm 685 nm	> 90% over 35 nm > 90% over 42 nm > 90% over 130 nm	25 mm x 3.5 mm	2.0 mm	FF01-425/527/685-25	$405
433 nm 517 nm 613 nm	> 90% over 36 nm > 90% over 23 nm > 90% over 61 nm	25 mm x 3.5 mm	2.0 mm	FF01-433/517/613-25	$405
446 nm 532 nm 646 nm	> 93% over 32.5 nm > 93% over 58.5 nm > 93% over 68 nm	25 mm x 3.5 mm	2.0 mm	FF01-446/532/646-25	$405
457 nm 530 nm 628 nm	> 80% over 22 nm > 85% over 20 nm > 85% over 28 nm	25 mm x 3.5 mm	2.0 mm	FF01-457/530/628-25	$405
465 nm 537 nm 623 nm	> 90% over 30 nm > 90% over 20 nm > 90% over 50 nm	25 mm x 3.5 mm	2.0 mm	FF01-465/537/623-25	$405
480 nm 535 nm 610 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 80 nm	25 mm x 3.5 mm	2.0 mm	FF01-480/535/610-25	$405
480 nm 546 nm 685 nm	> 90% over 10 nm > 90% over 22 nm > 90% over 130 nm	25 mm x 3.5 mm	2.0 mm	FF01-480/546/685-25	$405
480 nm 585 nm 685 nm	> 90% over 40 nm > 90% over 50 nm > 90% over 50 nm	25 mm x 3.5 mm	2.0 mm	FF01-480/585/685-25	$405
485 nm 537 nm 627 nm	> 93% over 27 nm > 93% over 17.5 nm > 93% over 90 nm	25 mm x 3.5 mm	2.0 mm	FF01-485/537/627-25	$405
505 nm 585 nm 685 nm	> 90% over 20 nm > 90% over 40 nm > 90% over 60 nm	25 mm x 3.5 mm	2.0 mm	FF01-505/585/685-25	$405
515 nm 588 nm 700 nm	> 93% over 23 nm > 93% over 55.5 nm > 93% over 70 nm	25 mm x 3.5 mm	2.0 mm	FF01-515/588/700-25	$405
650 nm 780 nm 880 nm	> 90% over 5 nm > 90% over 5 nm > 90% over 5 nm	25 mm x 3.5 mm	2.0 mm	FF01-650/780/880-25	$405 NEW

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

(continued)

Center Wavelength	Avg. Transmission / Bandwidth [1]	Housed Size (Diameter x Thickness)	Glass Thickness	Filter Part Number	Price	
Quadruple-band Filters						
387 nm 485 nm 559 nm 649 nm	> 85% over 11 nm > 90% over 20 nm > 90% over 25 nm > 90% over 13 nm	25 mm x 5.0 mm	2.0 mm	FF01-387/485/559/649-25	$475	
390 nm 482 nm 563 nm 640 nm	> 85% over 40 nm > 90% over 18 nm > 90% over 9 nm > 90% over 14 nm	25 mm x 5.0 mm	2.0 mm	FF01-390/482/563/640-25	$475	NEW
440 nm 521 nm 607 nm 700 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 45 nm	25 mm x 3.5 mm	2.0 mm	FF01-440/521/607/700-25	$475	NEW
446 nm 510 nm 581 nm 703 nm	> 93% over 32.5 nm > 93% over 16 nm > 93% over 63 nm > 93% over 80 nm	25 mm x 3.5 mm	2.0 mm	FF01-446/510/581/703-25	$475	NEW
446 nm 515 nm 588 nm 700 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 81 nm	25 mm x 3.5 mm	2.0 mm	FF01-446/515/588/700-25	$475	NEW
446 nm 523 nm 600 nm 677 nm	> 90% over 32.5 nm > 90% over 42 nm > 90% over 35.5 nm > 90% over 27.5 nm	25 mm x 3.5 mm	2.0 mm	FF01-446/523/600/677-25	$475	
Pentaband Filters						
440 nm 521.5 nm 606.5 nm 694 nm 809 nm	> 90% over 40 nm > 90% over 21 nm > 90% over 34 nm > 90% over 34.5 nm > 90% over 81 nm	25 mm x 3.5 mm	2.0 mm	FF01-440/521/607/694/809-25	$545	NEW

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; See Technical Note on page 63.

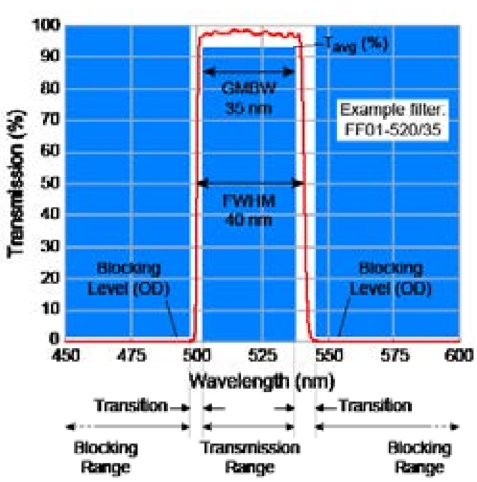
Technical Note

What Does "Bandwidth" Mean?

Semrock uses a "manufacturable specification" approach to define the bandwidth of our BrightLine bandpass filters. We believe this approach more accurately reflects the performance of the filter in an optical system.

As shown in the diagram, the filter spectrum (red line) must lie within the unshaded regions. The average transmission must exceed the specification Tavg (%) in the Transmission Region, which has a certain center wavelength (CWL) and a width called the Guaranteed Minimum Bandwidth (GMBW). The filter part number has the form FF01-{CWL}/{GMBW}.

The transmission must lie below the blocking level specifications (OD) in the Blocking Regions. The precise shape of the spectrum is unspecified in the Transition regions. However, typically the filter passband has a Full Width at Half Maximum (FWHM) that is about 1% of the CWL wider than the GMBW bandwidth, or FWHM ~ GMBW + 0.01 x CWL. So, for the example shown in the diagram, the FF01-520/35 filter has a GMBW of 35 nm and a FWHM of 35 nm + 1% of 520 nm, or 40 nm.



Technical Note

Choosing the Right Dichroic Beamsplitter

Semrock makes a wide variety of 45° dichroic beamsplitters optimized for different purposes. Every dichroic utilizes our advanced hard, ion-beam-sputtered coating technology for exceptional environmental and handling durability and no degradation even under the most intense illumination conditions. The dichroics are broadly categorized by the light source with which they are intended be used and the spectral edge steepness and physical flatness values required for various applications. The table below lists five broad families of Semrock dichroic beamsplitters according to these requirements.

Light Source	Edge Steepness	Flatness	Family	Page
Broadband	Standard	Standard*	Multi-purpose Dichroic	65
Broadband	Standard	Imaging flatness***	Image Splitting Dichroics	67
Laser lines	Steep	Laser flatness**	Laser Dichroics	69
Laser lines	Standard	Laser flatness**	Laser Beam Combining	74
Precise laser lines	Ultrasteep	Laser flatness**	Ultrasteep Laser Dichroics	89

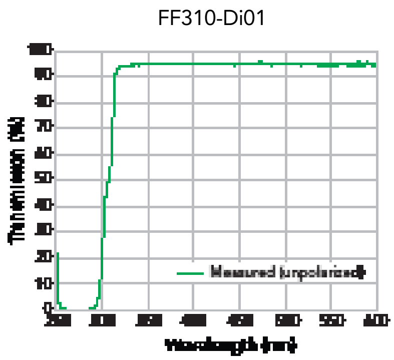
Dichroic beamsplitters designed to be used with broadband light sources generally ensure the highest average value of reflection over a band of source wavelengths often chosen for best overlap with a particular fluorophore absorption spectrum. Dichroics for laser light sources ensure high absolute reflection performance at specified laser lines, with precise spectral edges that are keyed to these lines and anti-reflection (AR) coatings on the filter backsides to minimize any coherent interference artifacts.

While all Semrock dichroics are among the steepest available 45° edge filters on the market, those optimized for laser-based epifluorescence and Raman applications are exceptionally steep to enable signal collection as close as possible to the laser line.

Flatter dichroic beamsplitters minimize wavefront errors that can result in defocus and imaging aberrations of the light reflected off of these filters. Semrock classifies dichroic beamsplitters into three categories of flatness, as described in the table below.

Flatness of Semrock Dichroic Beamsplitters

Flatness Classification	Nominal Radius of Curvature	Application Specification
*Standard	~ 6 meters	**Transmission:** does not cause signficant aberrations to a transmitted beam over the full clear aperture **Reflection:** designed to reflect broadband excitation light that is not focused or imaged
**Laser	~ 30 meters	**Transmission:** does not cause significant aberrations to a transmitted beam over the full clear aperture **Reflection:** contributes less than one Rayleigh Range of shift in focus (relative to a perfectly flat mirror) at the focal plane of a lens after reflecting a laser beam with a diameter up to 2.5 mm
***Imaging	~ 100 meters	**Transmission:** does not cause significant aberrations to a transmitted beam over the full clear aperture **Reflection:** contributes less than1.5 x Airy Disk diameter to the RMS spot size of a focused, reflected beam with a diameter up to 10 mm



Single-edge General Purpose Dichroic Beamsplitters

(polarization-insensitive; for use at 45°)

Most beamsplitters are long-wave-pass (LWP) filters (reflect shorter wavelengths and transmit longer wavelengths).

Semrock offers a wide range of polarization-insensitive dichroic beamsplitters that exhibit steep edges with very high and flat reflection and transmission bands. More complete reflection and transmission mean less stray light for lower background and improved signal-to-noise ratio. These filters are optimized for fluorescence microscopes and instrumentation, and may also be used for a variety of other applications that require beam combining and separation based on wavelength. All Semrock filters are made with our reliable hard-coating technology and utilize high-optical-quality, ultralow-autofluorescence glass substrates. These filters are excellent for epifluorescence, TIRF and diverse laser applications (see page 69).

Color	Nominal Edge Wavelength	Avg. Reflection Band	Avg. Transmission Band	Size (L x W or Diameter)	Glass Thickness	Filter Part Number	Price
	310 nm	> 98% 255 – 295 nm	> 90% 315 – 600 nm	25.2 mm x 35.6 mm	1.1 mm	FF310-Di01-25x36	$425
	347 nm	> 97% 240 – 325 nm	> 93% 380 – 800 nm	25.2 mm x 35.6 mm	1.1 mm	FF347-Di01-25x36	$425
	380 nm	> 95% 350 – 375 nm	> 93% 385 – 450 nm	25.2 mm x 35.6 mm	1.1 mm	FF380-Di01-25x36	$245
	409 nm	> 98% 327 – 404 nm	> 93% 415 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF409-Di03-25x36	$245
	416 nm	> 90% 360 – 407 nm	> 90% 425 – 575 nm	25.2 mm x 35.6 mm	1.1 mm	FF416-Di01-25x36	$225
	452 nm	> 90% 423 – 445 nm	> 90% 460 – 610 nm	25.2 mm x 35.6 mm	1.1 mm	FF452-Di01-25x36	$225
	458 nm	> 98% 350 – 450 nm	> 93% 467 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF458-Di02-25x36	$245
	472 nm	> 98% 485 – 493 nm	> 90% 400 – 464 nm	25.2 mm x 35.6 mm	1.1 mm	FF472-SDi01-25x36	$245
	482 nm	> 90% 415 – 470 nm	> 90% 490 – 720 nm	25.2 mm x 35.6 mm	1.1 mm	FF482-Di01-25x36	$225
	495 nm	> 98% 350 – 488 nm	> 93% 502 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF495-Di03-25x36	$245
	497 nm	> 90% 452 – 490 nm	> 90% 505 – 800 nm	25.2 mm x 35.6 mm	1.1 mm	FF497-Di01-25x36	$225
	499 nm	> 90% 470 – 490 nm	> 90% 508 – 675 nm	25.2 mm x 35.6 mm	1.1 mm	FF499-Di01-25x36	$225
	500 nm	> 98% 485 – 491 nm	> 90% 510 – 825 nm	25.2 mm x 35.6 mm	1.1 mm	FF500-Di01-25x36	$245
	505 nm	> 98% 513 – 725 nm	> 90% 446 – 500 nm	25.2 mm x 35.6 mm	1.1 mm	FF505-SDi01-25x36	$245
	506 nm	> 98% 350 – 500 nm	> 93% 513 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF506-Di03-25x36	$245
	510 nm	> 98% 327 – 488 nm	> 93% 515 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF510-Di02-25x36	$245
	511 nm	> 90% 400 – 495 nm	> 90% 525 – 800 nm	25.2 mm x 35.6 mm	1.1 mm	FF511-Di01-25x36	$245
	516 nm	> 90% 490 – 510 nm	> 90% 520 – 700 nm	25.2 mm x 35.6 mm	1.1 mm	FF516-Di01-25x36	$225
	518 nm	> 98% 400 – 512 nm	> 93% 523 – 690 nm	25.2 mm x 35.6 mm	1.1 mm	FF518-Di01-25x36	$245
	520 nm	> 98% 350 – 512 nm	> 93% 528 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF520-Di02-25x36	$245
	525 nm	> 95% 480 – 519 nm	> 93% 530 – 750 nm	25.2 mm x 35.6 mm	2.0 mm	FF525-Di01-25x36x2.0	$325
	541 nm	> 98% 570 – 710 nm	> 90% 500 – 530 nm	25.2 mm x 35.6 mm	1.1 mm	FF541-SDi01-25x36	$245
	550 nm	> 98% 509 – 537 nm	> 90% 559 – 850 nm	25.0 mm (unmounted)	2.0 mm	FF550-Di01-25x2.0-D	$245
	552 nm	> 98% 350 – 544 nm	> 93% 558 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF552-Di02-25x36	$245
	555 nm	> 98% 493 – 548 nm	> 90% 562 – 745 nm	25.2 mm x 35.6 mm	1.1 mm	FF555-Di03-25x36	$245
	560 nm	> 98% 485 – 545 nm	> 90% 570 – 825 nm	25.2 mm x 35.6 mm	1.1 mm	FF560-Di01-25x36	$245
	562 nm	> 98% 350 – 555 nm	> 93% 569 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF562-Di03-25x36	$245
	568 nm	> 97% 405 – 555 nm	> 93% 575 – 650 nm	25.2 mm x 35.6 mm	1.1 mm	FF568-Di01-25x36	$245
	570 nm	> 90% 525 – 556 nm	> 90% 580 – 650 nm	25.2 mm x 35.6 mm	1.1 mm	FF570-Di01-25x36	$225
	585 nm	> 90% 533 – 580 nm	> 90% 595 – 800 nm	25.2 mm x 35.6 mm	1.1 mm	FF585-Di01-25x36	$225

(continued)

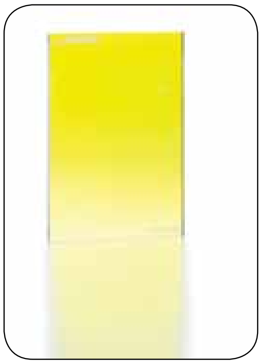
For graphs, ASCII data and blocking information, go to www.semrock.com

BrightLine® Single-edge Dichroic Beamsplitters

Single-edge Dichroic Beamsplitters *(continued)*

Edge Color	Nominal Edge Wavelength	Avg. Reflection Band	Avg. Transmission Band	Size (LxW or Diameter)	Glass Thickness	Filter Part Number	Price
	591 nm	> 98% 601 – 800 nm	> 90% 530 – 585 nm	25.2 mm x 35.6 mm	1.1 mm	FF591-SDi01-25x36	$245
	593 nm	> 98% 350 – 585 nm	> 93% 601 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF593-Di03-25x36	$245
	599 nm	> 98% 567 – 585 nm	> 90% 609 – 850 nm	25.0 mm (unmounted)	2.0 mm	FF599-Di01-25x2.0-D	$245
	605 nm	> 98% 350 – 596 nm	> 93% 612 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF605-Di02-25x36	$245
	624 nm	> 95% 528 – 610 nm	> 93% 630 – 750 nm	25.2 mm x 35.6 mm	2.0 mm	FF624-Di01-25x36x2.0	$325
	648 nm	> 98% 400 – 629 nm	> 90% 658 – 700 nm	25.2 mm x 35.6 mm	1.1 mm	FF648-Di01-25x36	$245
	649 nm	> 98% 500 – 642 nm	> 90% 654 – 825 nm	25.2 mm x 35.6 mm	1.1 mm	FF649-Di01-25x36	$245
	650 nm	> 98% 500 – 640 nm	> 90% 660 – 825 nm	25.2 mm x 35.6 mm	1.1 mm	FF650-Di01-25x36	$245
	655 nm	> 98% 470 – 645 nm	> 90% 665 – 726 nm	25.2 mm x 35.6 mm	1.1 mm	FF655-Di01-25x36	$245
	660 nm	> 98% 350 – 651 nm	> 93% 669 – 950 nm	25.2 mm x 35.6 mm	1.1 mm	FF660-Di02-25x36	$245
	665 nm	*See Multiphoton Filters, page 49*				FF665-Di02-25x36	
	669 nm	> 98% 350 – 660 nm	> 90% 677 – 800 nm	25.2 mm x 35.6 mm	3.0 mm	FF669-Di01-25x36x3.0	$245
	670 nm	*Short-wave-pass; See Multiphoton Filters, page 49*				FF670-SDi01-25x36	
	677 nm	> 98% 400 – 658 nm	> 90% 687 – 830 nm	25.2 mm x 35.6 mm	1.1 mm	FF677-Di01-25x36	$245
	678 nm	> 89% 440 – 650 nm	> 88% 700 – 2500 nm	25.2 mm x 35.6 mm	2.0 mm	FF678-Di01-25x36x2.0	$245
	685 nm	> 98% 350 – 676 nm	> 93% 695 – 939 nm	25.2 mm x 35.6 mm	1.1 mm	FF685-Di02-25x36	$245
	700 nm	> 97% 532 - 690 nm	> 93% 705 - 800 nm	25.2 mm x 35.6 mm	1.1 mm	FF700-Di01-25x36	$245
	705 mm	*See Multiphoton Filters, page 49*				FF705-Di01-25x36	
	709 nm	> 98% 661 – 692 nm	> 90% 720.5 – 850 nm	25.0 mm (unmounted)	2.0 mm	FF709-Di01-25x2.0-D	$245
	720 nm	*Short-wave-pass; See Multiphoton Filters, page 49*					
	731 nm	> 98% 625 – 710 nm	> 90% 742 – 850 nm	25.2 mm x 35.6 mm	1.1 mm	FF731-Di01-25x36	$245
	735 nm	*See Multiphoton Filters, page 49*				FF735-Di01-25x36	
	740 nm	> 98% 480 – 720 nm	> 90% 750 – 825 nm	25.2 mm x 35.6 mm	1.1 mm	FF740-Di01-25x36	$245
	741 nm	> 98% 660 – 731.5 nm	> 90% 750.5 – 810 nm	25.2 mm x 35.6 mm	1.1 mm	FF741-Di01-25x36	$245
	746 nm	> 95% 760 - 800 nm	> 90% 500 – 730 nm	25.2 mm x 35.6 mm	3.0 mm	FF746-SDi01-25x36x3.0	$245
	750 nm	> 96% 770 – 920 nm	> 93% 450 – 730 nm	25.2 mm x 35.6 mm	1.1 mm	FF750-SDi02-25x36	$245
	757 nm	> 98% 450 – 746 nm	> 93% 768 – 1100 nm	25.2 mm x 35.6 mm	1.1 mm	FF757-Di01-25x36	$245
	775 nm	*See Multiphoton Filters, page 49*				FF775-Di01-25x36	
	776 nm	> 98% 450 – 764 nm	> 88% 789 – 1100 nm	25.2 mm x 35.6 mm	1.1 mm	FF776-Di01-25x36	$245
	791 nm	> 90% 795 – 940 nm	> 90% 687 – 787 nm	25.2 mm x 35.6 mm	1.1 mm	FF791-SDi01-25x36	$245
	801 mm	> 98% 450 – 1100 nm	> 90% 813.5 – 1100 nm	25.2 mm x 35.6 mm	1.1 mm	FF801-Di02-25x36	$245
	875 nm	*See Multiphoton Filters, page 49*				FF875-Di01-25x36	NEW
	885 nm	> 95% 800 – 870 nm	> 95% 900 – 960 nm	25.2 mm x 35.6 mm	1.1 mm	FF885-Di01-25x36	$245

BrightLine® Image Splitting Dichroic Beamsplitters



These beamsplitters offer superb image quality for both transmitted and reflected light when separating beams of light by color for simultaneous capture of multiple images. For applications such as (FRET) and real-time live-cell imaging, users can now separate two, four or even more colors onto as many cameras or regions of a single camera sensor. The exceptional flatness of these filters virtually eliminates aberrations in the reflected beam for most common imaging systems *(see Technical Note on page 68)*.

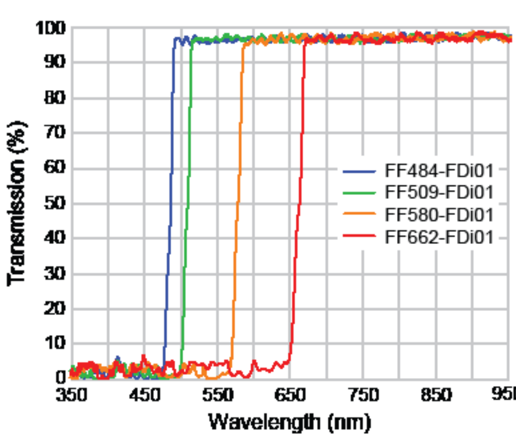
Nominal Edge Wavelength	Common Fluorophore Pairs to Split	Average Reflection Band	Average Transmission Band	Size (L x W x H)	Filter Part Number	Price
484 nm	DAPI/FITC (or BFP/GFP)	350 – 475 nm	492 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF484-FDi01-25x36	$325
509 nm	CFP/YFP	350 – 500 nm	518 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF509-FDi01-25x36	$325
560 nm	YFP/dTomato	350 – 550 nm	570 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF560-FDi01-25x36	$325
580 nm	GFP/mCherry (or FITC/TxRed)	350 – 570 nm	591 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF580-FDi01-25x36	$325
640 nm	Cy3/Cy5	350 – 629 nm	652 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF640-FDi01-25x36	$325 NEW
662 nm	Cy3/Cy5 (or TxRed/Cy5)	350 – 650 nm	674 – 950 nm	25.2 mm x 35.6 mm x 1.1 mm	FF662-FDi01-25x36	$325

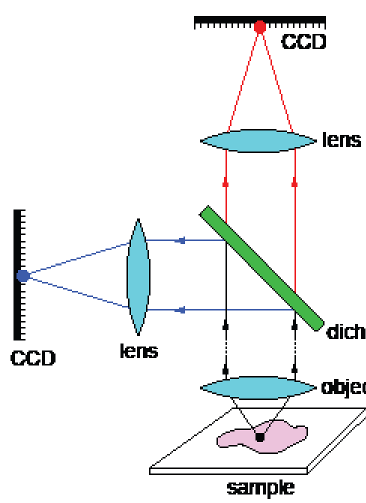
Image Splitting Dichroic Beamsplitters Common Specifications

Property	Value	Comment
Transmission	> 93%	Averaged over the specified band
Reflection	> 95%	Averaged over the specified band
Flatness	< λ / 4 Peak-to-valley at λ = 633 nm	Spherical error measured over a 10 mm aperture[1]

[1] A 10 mm spot size in typical assuming common microscope values. See www.semrock.com. All other mechanical specifications are the same as BrightLine dichroic specifications on page 35

Actual Measured Data





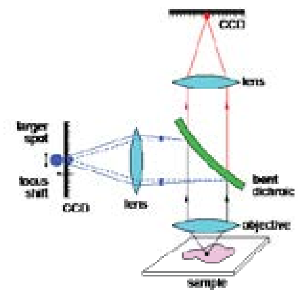
A flat dichroic prevents aberrations - see details on next page.

BrightLine® Dichroic Beamsplitters

Technical Note

Flatness of Dichroic Beamsplitters Affects Focus and Image Quality

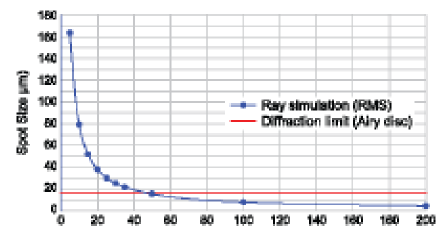
Optical filters are generally comprised of multi-layered thin-film coatings on plane, parallel glass substrates. All Semrock filters use a single substrate with coatings on one or both sides to maximize transmission and reliability and minimize artifacts associated with multiple interfaces. The glass substrate is not always perfectly flat, especially after it is coated, sometimes resulting in a slight bending of the substrate. Fortunately, this bending has no noticeable effect on light transmitted through an optical filter at or near normal incidence. For light incident at high angles of incidence, as is the case for a 45° dichroic beamsplitter, the only effect of a bent substrate on transmitted light is a slight divergence of the beam axis.



A bent dichroic can introduce aberrations.

However, a bent filter substrate can have noticeable impact on reflected light. Examples include an excitation beam reflected off of a dichroic before impinging on a sample object, or an imaging beam that is split into two colors using a dichroic. Two main effects may occur: the position of the focal plane shifts and the size of the focused spot or the quality of the image is compromised.

Often a small shift of the focal plane is not a problem, because a lens or camera adjustment can be made to compensate. But in some cases the focal shift may be too large to compensate – focusing a laser beam onto the back focal plane of the objective in a Total Internal Reflection Fluorescence (TIRF) microscope, or imaging the grid onto the sample plane in a structured illumination microscope represent cases where care should be taken to use a flat dichroic, such as those designed for laser applications *(for example, see page 69).*



Dichroic's radius of curvature affects spot size.

When light incident at 45° is reflected off of a dichroic with a slight bend, the resulting optical aberrations (such as astigmatism) can degrade the quality of an image after an imaging lens. As an example, the graph on the right shows the spot size at an image plane that results from a perfect point source after reflecting off of a dichroic with various radii of curvature.

This plot is based on a typical epifluorescence microscope configuration, assuming a perfect point source at the sample location, imaged onto the image plane (e.g., CCD surface) by an ideal 40X, 0.75 NA objective and a tube lens with a 200 mm typical focal length (industry standard tube length focal lengths range between 160 and 200 mm). The resulting beam diameter is 6.75 mm. The reflection off of the dichroic is assumed to occur mid-way between the objective and the tube lens. The field of view of the system is assumed to be limited by a 20 mm diameter field size at the camera plane. The light is assumed to have a wavelength of 510 nm (peak of GFP emission). For comparison, the diffraction-limited spot size that would result from a perfect objective and tube lens and a perfectly flat dichroic is 16.6 µm (red line on plot).

A sufficient criterion for an imaging beam (i.e., focused onto a detector array such as a CCD) reflected off a dichroic, is that the diffraction-limited spot size should not change appreciably due to reflection off of the beamsplitter. The required minimum radius of curvature for a number of objective-tube lens combinations (with standard tube lenses) that are common in fluorescence microscopes are summarized in the following figure. The required minimum radii vary from a few tens of meters for the higher magnification objectives (with smaller beam diameter) to as high as about 50 to 100 meters for the lower magnification objectives (with larger beam diameter).

While reflected image quality can be worse than the ideal diffraction-limited response for dichroics that are not perfectly flat, it should be noted that the true spot size at the image plane can be appreciably larger than the diffraction-limited spot size in an actual system. Nevertheless, care should be taken to select properly optimized, flatter dichroic beamsplitters when working with reflected light. Dichroics designed to reflect laser light ("laser dichroics," see pages 69 and 72) are generally flat enough to ensure negligible focal shift for laser beams up to several mm in diameter. Dichroics designed to reflect imaging beams ("imaging dichroics", see page 67 have the most extreme flatness requirements, since they must effectively eliminate the effects of astigmatism for beams as large as 1 cm or more.

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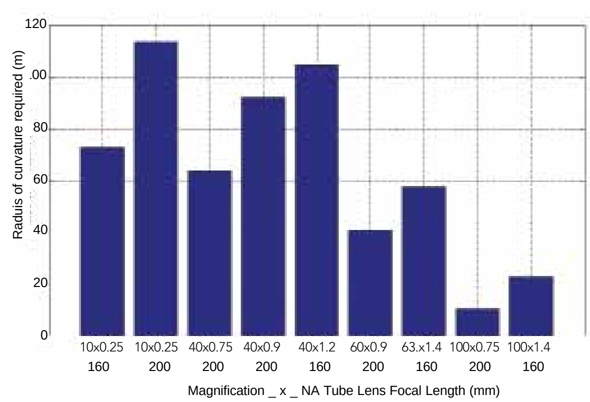


Desired radii of curvature of dichroics suitable for image splitting applications for a number of common microscope objectives. Each objective is labeled with its magnification, numerical aperture (NA), and associated tube lens focal length (in mm).

BrightLine® Single-edge Laser Dichroic Beamsplitters

These dichroic beamsplitters are optimized for the most popular lasers used for fluorescence imaging, including newer all-solid-state lasers (see table on page 37). Reflection is guaranteed to be > 98% (s-polarization) and > 94% (average polarization) at the laser wavelengths, plus > 93% average transmission and very low ripple over extremely wide passbands – out to 900 and even 1200 nm.

Laser Dichroic Beamsplitters *(polarization-insensitive; for use at 45°)*

For multiedge laser-optimized dichroic beamsplitters, see page 72

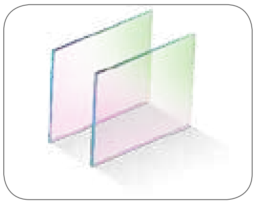
Nominal Edge Wavelength	Laser Wavelengths	Reflection Band	Avg. Transmission Band	Size (L x W x H)	Filter Part Number	Price
415 nm	375 ± 3 nm 405 ± 5 nm	372.0 – 410.0 nm	420.3 – 900.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R405-25x36	$395
463 nm	440 +3/-1 nm 442.0 nm 457.9 nm	439.0 – 457.9 nm	469.3 – 900.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R442-25x36	$395
497 nm	473 ± 2 nm 488 +3/–2 nm	471.0 – 491.0 nm	503.3 – 900.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R488-25x36	$395
521 nm	505.0 nm 514.5 nm 515.0 nm	505.0 – 515.0 nm	527.9 – 900.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R514-25x36	$395
542 nm	514.5 nm 532.0 nm	514.0 – 532.0 nm	545.3 – 1200.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R532-25x36	$395
575 nm	559 ± 5 nm 561.4 nm 568.2 nm	554.0 – 568.2 nm	582.4 – 1200.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R561-25x36	$395
605 nm	593.5 nm 594.1 nm 594.0 ± 0.3 nm	593.5 – 594.3 nm	609.2 – 1200.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R594-25x36	$395
654 nm	632.8 nm 635 +7/–0 nm 647.1 nm	632.8 – 647.1 nm	663.3 – 1200.0 nm	25.2 mm x 35.6 mm x 1.1 mm	Di01-R635-25x36	$395

Laser Dichroic Beamsplitters Common Specifications

Property	Value	Comment
Reflection	> 98% (s-polarization) > 90% (p-polarization) > 94% (average polarization)	Absolute reflectivity over the specified laser wavelengths/bands
Transmission	> 93%	Averaged over the transmission band above
Angle of Incidence	45.0°	Range for above optical specifications Based on a collimated beam of light
Dependence of Wavelength on Angle of Incidence (Edge Shift)	0.35% / degree	Linear relationship valid between about 40°- 50°
Cone Half Angle (for non-collimated light)	< 0.5°	Rays uniformly distributed and centered at 45°
Transmitted Wavefront Error	< λ / 4 RMS at λ = 633 nm	Peak-to-valley error < 5 x RMS
Beam Deviation	≤ 10 arc seconds	
Second Surface	Anti-reflection (AR) coated	
Flatness	Reflection of a collimated, gaussian laser beam with waist diameter up to 2.5 mm causes less than one Rayleigh Range of focal shift after the objective or a focusing lens.	
Reliability and Durability	Ion-beam-sputtered, hard-coated technology with epoxy-free, single-substrate construction for unrivaled filter life and no “burn-out” even when subjected to high optical intensities for a prolonged period of time. BrightLine filters are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	
Filter Orientation	Reflective coating side should face toward light source and sample *(see page 47)*	
Microscope Compatibility	BrightLine filters are available to fit Leica, Nikon, Olympus, and Zeiss microscopes.	

All other mechanical specifications are the same as BrightLine dichroic specifications on page 35.

BrightLine® Multiedge Dichroic Beamsplitters



Dual-edge General Purpose Dichroic Beamsplitters *(polarization-insensitive; for use at 45°)*

For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 72.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
403 nm 502 nm	> 97.5% 370 – 393 nm > 97.5% 466 – 495 nm	> 90% 414 – 452 nm > 90% 510 – 550 nm	25.2 mm x 35.6 mm x 1.1 mm	FF403/502-Di01-25x36	$325
440 nm 520 nm	> 95% 415 – 432 nm > 95% 493 – 511 nm	> 90% 449 – 483 nm > 90% 530 – 569 nm	25.2 mm x 35.6 mm x 1.1 mm	FF440/520-Di01-25x36	$325
459 nm 533 nm	> 90% 400 – 454 nm > 90% 496 – 528 nm	> 90% 463 – 487 nm > 90% 537 – 559 nm	25.2 mm x 35.6 mm x 1.1 mm	FF459/533-Di01-25x36	$325
483 nm 639 nm	> 98% 390 – 460 nm > 98% 565 – 625 nm	> 90% 490 – 548 nm > 90% 644 – 790 nm	25.2 mm x 35.6 mm x 1.1 mm	FF483/639-Di01-25x36	$325
493 nm 574 nm	> 95% 456 – 480 nm > 95% 541 – 565 nm	> 90% 500 – 529 nm > 90% 584 – 679 nm	25.2 mm x 35.6 mm x 1.1 mm	FF493/574-Di01-25x36	$325
495 nm 605 nm	> 95% 454 – 485 nm > 95% 570 – 598 nm	> 90% 505 – 550 nm > 90% 620 – 675 nm	25.2 mm x 35.6 mm x 1.1 mm	FF495/605-Di01-25x36	$325
505 nm 606 nm	> 95% 458 – 499 nm > 95% 570 – 600 nm	> 90% 509 – 541 nm > 90% 612 – 647 nm	25.2 mm x 35.6 mm x 1.1 mm	FF505/606-Di01-25x36	$325
505 nm 651 nm	> 90% 450 – 499 nm > 90% 620 – 640 nm	> 90% 510 – 604 nm > 90% 662 – 580 nm	25.2 mm x 35.6 mm x 1.1 mm	FF505/651-Di01-25x36	$325 NEW
545 nm 650 nm	> 95% 532.0 nm > 95% 632.8 nm	> 90% 554 – 613 nm > 90% 658 – 742 nm	25.2 mm x 35.6 mm x 1.1 mm	FF545/650-Di01-25x36	$325
560 nm 659 nm	> 95% 514 – 553 nm > 95% 617 – 652 nm	> 90% 564 – 591 nm > 90% 665 – 718 nm	25.2 mm x 35.6 mm x 1.1 mm	FF560/659-Di01-25x36	$325
547 nm 651 nm	> 90% 450 – 540 nm > 90% 620 – 640 nm	> 90% 555 – 605 nm > 90% 662 – 850 nm	25.2 mm x 35.6 mm x 1.1 mm	FF547/651-Di01-25x36	$325 NEW

Narrow Notch Beamsplitters - notches keyed to popular laser lines *(polarization-insensitive; for use at 45°)*

Nominal Edge Wavelength	Reflection Bands	Transmission Bands	Special Features	Size (L x W x H)	Filter Part Number	Price
497 nm 554 nm	> 95% 486 – 490 nm > 95% 542 – 544 nm	> 90% 420 – 471 nm > 90% 505 – 525 nm > 90% 561 – 700 nm	Reflects laser wavelengths 488 nm and 543 nm	25.2 mm x 35.6 mm x 1.1 mm	FF497/554-Di01-25x36	$325
500 nm 646 nm	> 95% 486 – 490 nm > 95% 632 – 634 nm	> 90% 420 – 471 nm > 90% 505 – 613 nm > 90% 653 – 750 nm	Reflects laser wavelengths 488 nm and 633 nm	25.2 mm x 35.6 mm x 1.1 mm	FF500/646-Di01-25x36	$325
553 nm 659 nm	> 95% 542 – 544 nm > 95% 646 – 648 nm	> 90% 420 – 525 nm > 90% 561 – 626 nm > 90% 668 – 750 nm	Reflects laser wavelengths 543 nm and 647 nm	25.2 mm x 35.6 mm x 1.1 mm	FF553/659-Di01-25x36	$325
555 nm 646 nm	> 95% 542 – 544 nm > 95% 632 – 634 nm	> 90% 420 – 525 nm > 90% 561 – 613 nm > 90% 653 – 750 nm	Reflects laser wavelengths 543 nm and 633 nm	25.2 mm x 35.6 mm x 1.1 mm	FF555/646-Di01-25x36	$325
579 nm 644 nm	> 95% 567 – 569 nm > 95% 632 – 634 nm	> 90% 420 – 549 nm > 90% 587 – 613 nm > 90% 653 – 750 nm	Reflects laser wavelengths 568 nm and 633 nm	25.2 mm x 35.6 mm x 1.1 mm	FF579/644-Di01-25x36	$325

For graphs and ASCII data, go to www.semrock.com

Triple-edge General Purpose Dichroic Beamsplitters *(polarization-insensitive; for use at 45°)*

For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 72.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
395 nm 495 nm 610 nm	> 97% 354 – 385 nm > 97% 465 – 483 nm > 97% 570 – 596 nm	> 95% 403 – 446 nm > 95% 502 – 552 nm > 95% 620 – 750 nm	25.2 mm x 35.6 mm x 1.1 mm	FF395/495/610-Di01-25x36	$425
403 nm 497 nm 574 nm	> 97% 386 – 393 nm > 97% 466 – 490 nm > 97% 546 – 565 nm	> 90% 414 – 450 nm > 90% 505 – 528 nm > 90% 584 – 645 nm	25.2 mm x 35.6 mm x 1.1 mm	FF403/497/574-Di01-25x36	$425
436 nm 514 nm 604 nm	> 97.5% 394 – 414 nm > 97.5% 484 – 504 nm > 97.5% 566 – 586 nm	> 90% 446 – 468 nm > 90% 520 – 540 nm > 90% 614 – 642 nm	25.2 mm x 35.6 mm x 1.1 mm	FF436/514/604-Di01-25x36	$425
444 nm 520 nm 590 nm	> 98% 327 – 437 nm > 98% 494 – 512 nm > 98% 562 – 578 nm	> 90% 450 – 480 nm > 90% 527 – 547 nm > 90% 598 – 648 nm	25.2 mm x 35.6 mm x 1.1 mm	FF444/520/590-Di01-25x36	$425
444 nm 521 nm 608 nm	> 95% 420 – 430 nm > 95% 496 – 510 nm > 95% 579 – 596 nm	> 90% 451 – 480 nm > 90% 530 – 561 nm > 90% 618 – 664 nm	25.2 mm x 35.6 mm x 1.1 mm	FF444/521/608-Di01-25x36	$425

Quadruple-edge Dichroic Beamsplitters *(polarization-insensitive; for use at 45°)*

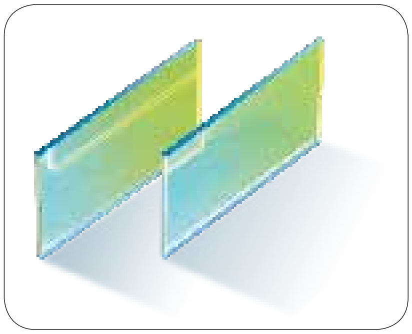
For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 72.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
405 nm 496 nm 560 nm 651 nm	> 90% 381 – 401 nm > 90% 464 – 492 nm > 90% 532 – 555 nm > 90% 620 – 643 nm	> 90% 409 – 455 nm > 90% 501 – 522 nm > 90% 565 – 609 nm > 90% 654 – 700 nm	25.2 mm x 35.6 mm x 1.1 mm	FF405/496/560/651-Di01-25x36	$495
405 nm 496 nm 593 nm 649 nm	> 90% 381 – 401 nm > 90% 464 – 492 nm > 90% 562 – 589 nm > 90% 626 – 643 nm	> 90% 409 – 455 nm > 90% 501 – 552 nm > 90% 600 – 615 nm > 90% 654 – 700 nm	25.2 mm x 35.6 mm x 1.1 mm	FF405/496/593/649-Di01-25x36	$495
410 nm 504 nm 582 nm 669 nm	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 722 nm	25.2 mm x 35.6 mm x 1.1 mm	FF410/504/582/669-Di01-25x36	$495
416 nm 500 nm 582 nm 657 nm	> 95% 400 – 410 nm > 95% 486 – 491 nm > 95% 560 – 570 nm > 95% 633 – 647 nm	> 90% 422 – 473 nm > 90% 506 – 545 nm > 90% 586 – 617 nm > 90% 666 – 750 nm	25.2 mm x 35.6 mm x 1.5 mm	FF416/500/582/657-Di01-25x36x1.5	$495

Penta-edge Dichroic Beamsplitter *(polarization-insensitive; for use at 45°)*

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
408 nm 504 nm 581 nm 667 nm 762 nm	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm > 95% 733 – 746 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 711 nm > 90% 768 – 849 nm	25.2 mm x 35.6 mm x 1.1 mm	FF408/504/581/667/762-Di01-25x36	$575

BrightLine® Laser Multiedge Dichroic Beamsplitters

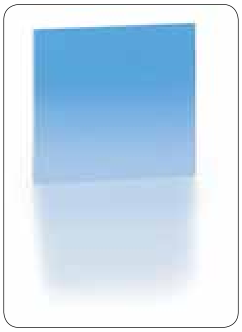


Optimized for the most popular lasers used for fluorescence imaging, including the new all-solid-state lasers that are replacing older gas-laser technology. Laser Multiedge Dichroic Beamsplitters offer exceptionally high reflection at the laser wavelengths combined with very steep transitions from high reflection to high transmission (< 2.5% of the longest laser wavelength). They also offer sufficient flatness for laser applications *(see Technical Note on page 64).*

Laser Multiedge Dichroic Beamsplitters

Nominal Edge Wavelengths	Laser Wavelengths (nm)	Reflection Band (nm)	Avg. Transmission Band (nm)	Size (L x W x H) mm	Filter Part Number	Price
499 nm 575 nm	473 ± 2 , 488 +3 /-2	> 94% 471 – 491	> 93% 503.3 – 543	25.2 x 35.6 x 1.1	Di01-R488/561-25x36	$445
	559 +5/-0, 561.4, 568.2	> 94% 559 – 568.2	> 93% 582.4 – 800			
420 nm 497 nm 602 nm	375 +/- 3, 405 +/- 5	> 94% 370 – 410	> 93% 429.5 – 462.0	25.2 x 35.6 x 1.1	Di01-R405/488/594-25x36	$495
	473 +2/-0, 488 +3/-2	> 94% 473 – 491	> 93% 502.5 – 574.5			
	593.5 , 594.1, 594 +/- 0.3	> 94% 588.3 – 594.3	> 93% 612.0 – 800.0			
463 nm 521 nm 575 nm	440 +3/-1, 442.0, 457.9	> 94% 438 – 458	> 93% 469.5 – 496.5	25.2 x 35.6 x 1.1	Di01-R442/514/561-25x36	$495
	514.5, 515.0	> 94% 512.5 – 515.5	> 93% 528 – 545.5			
	559 +/-5, 561.4, 568.2	> 94% 559 – 568.2	> 93% 582 – 800			
497 nm 552 nm 602 nm	473 +2 /-2, 488 +3 /-2	> 94% 471 – 491	> 93% 503 – 523.5	25.2 x 35.6 x 1.1	Di01-R488/543/594-25x36	$495
	543 +/- 1	> 94% 541.5 – 544.5	> 93% 558 – 574			
	589.0, 593.5, 594.1, 594 +/- 0.3	> 94% 588.0 – 594.5	> 93% 609 – 800			
497 nm 552 nm 656 nm	473 +2 /-2, 488 +3 /-2	> 94% 471 – 491	> 93% 503.5 – 526.5	25.2 x 35.6 x 1.1	Di01-R488/543/635-25x36	$495
	543 +/- 1	> 94% 541.5 – 544.5	> 93% 560.0 – 615.5			
	632.8, 635 +7/-0, 647.1	> 94% 632.8 – 647.1	> 93% 665.5 – 800.0			
422 nm 498 nm 542 nm 656 nm	375 +/- 3, 405 ±5	> 94% 370 – 410	> 93% 429.5 – 462	25.2 x 35.6 x 1.1	Di01-R405/488/532/635-25x36	$545 NEW
	473+ 2/-0, 488 +3-2	> 94% 473 – 491	> 93% 502.5 – 518.5			
	532	> 94% 530.5 – 533.5	> 93% 550 – 613			
	632.8, 635 +7/-0, 647.1	> 94% 632.8 – 647.1	> 93% 663 – 800			
422 nm 498 nm 553 nm 656 nm	375 +/-3, 405 +/-5	> 94% 370 – 410	> 93% 429.5 – 462	25.2 x 35.6 x 1.1	Di01-R405/488/543/635-25x36	$545 NEW
	473 +2/-0, 488 +3/-2	> 94% 473 – 491	> 93% 503.5 – 526.5			
	543.5	> 94% 539.5 – 546.5	> 93% 560 – 615.5			
	632.8, 635 +7/-0, 647.1	> 94% 632.8 – 647.1	> 93% 665 – 800			
426 nm 498 nm 575 nm 655 nm	375 ±3, 405 ±5	> 94% 370 – 410	> 93% 429.5 – 462	25.2 x 35.6 x 1.1	Di01-R405/488/561/635-25x36	$545
	473 +2/-0, 488 +3/-2	> 94% 473 – 491	> 93% 502.5 – 544.5			
	559 +5/-0, 561.4, 568.2	> 94% 559 – 568.2	> 93% 582 – 617.5			
	632.8, 635 +7/-0, 647.1	> 94% 632.8 – 647.1	> 93% 663 – 800			

Filters for Yokogawa CSU Confocal Scanners



Semrock offers fluorescence filters that enable you to achieve superior performance from your real-time confocal microscope system based on the Yokogawa CSU scanner. Like all BrightLine® filters, they are made exclusively with hard, ion-beam-sputtered coatings to provide unsurpassed brightness and durability. These filters are compatible with all scan head system configurations, regardless of the microscope, camera, and software platforms you have chosen.

Dichroic Beamsplitters for the Yokogawa CSU confocal scanners

These beamsplitters transmit the excitation laser light and reflect the fluorescence signal from the sample. Because the filters are precisely positioned between the spinning microlens disc and the pinhole array disc, they have been manufactured to exacting physical and spectral tolerances. The filter dimensions are 13.0 mm x 15.0 mm x 0.5 mm. (Installation in the CSU should be performed only by Yokogawa-authorized personnel.)

Transmitted Laser Wavelengths	Reflection Bands	Semrock Part Number	Price
400-410 nm, 486-491 nm, 531-533 nm, 633-647 nm	422-473 nm, 503.5-517 nm, 548-610 nm, 666-750 nm	Di01-T405/488/532/647-13x15x0.5	$655
405 nm, 488 nm, 561-568 nm, 638-647 nm	422-473 nm, 503-545 nm, 586-620 nm, 665-750 nm	Di01-T405/488/568/647-13x15x0.5	$655
400-410 nm, 488 nm, 561 nm	422-473 nm, 503-544 nm, 578-750 nm	Di01-T405/488/561-13x15x0.5	$625
405-442 nm, 502-508 nm, 630-641 nm	458-484 nm, 527-607 nm, 664-750 nm	Di01-T442/505/635-13x15x0.5	$625
405-442 nm, 514 nm, 638-647 nm	458-497 nm, 533-620 nm, 665-750 nm	Di01-T442/514/647-13x15x0.5	$625
400-445 nm, 513-515 nm, 592-595 nm	458-498 nm, 530-575.5 nm, 612.5-750 nm	Di01-T445/514/593-13x15x0.5	$625
441-449 nm, 513-517 nm, 559-563 nm	462-501 nm, 532-544 nm, 578-630 nm	Di01-T445/515/561-13x15x0.5	$625
400-457 nm, 513-515 nm, 633-647 nm	471-498 nm, 535-616 nm, 666-750 nm	Di01-T457/514/647-13x15x0.5	$625
473 nm, 561 nm	487-542 nm, 584-750 nm	Di01-T473/561-13x15x0.5	$585
488 nm, 532 nm	442-473 nm, 503-510 nm, 554-750 nm	Di01-T488/532-13x15x0.5	$585
488 nm, 568 nm	422-473 nm, 503-545 nm, 586-750 nm	Di01-T488/568-13x15x0.5	$585
405-488 nm	508-700 nm	Di01-T488-13x15x0.5	$545

Emission Filters for the Yokogawa CSU confocal scanners

These filters mount outside the CSU head in a filter wheel, and provide the utmost in transmission of the desired fluorescence signal while blocking the undesired scattered laser light and autofluorescence. The filters are 25.0 mm in diameter and are typically housed in black-anodized aluminum rings.

Blocked Laser Wavelengths	Transmission Bands	Semrock Part Number	Price
405 nm, 488 nm, 561-568 nm	418-472 nm, 583-650 nm	Em01-R405/568-25	$395
405 nm, 442 nm, 561-568 nm, 638-647 nm	458-512 nm, 663-750 nm	Em01-R442/647-25	$395
405 nm, 488 nm	503-552 nm	Em01-R488-25	$345
514 nm	528-650 nm	Em01-R514-25	$345

Laser-blocking Emission Filters for the Yokogawa CSU22 and CSU-X1 confocal scanner

(inside the scan head)

These filters go inside the CSU22 and CSU-X1 heads in the motorized emission-filter slider. The purpose is primarily to block undesired laser light, preventing it from exiting the scan head to the camera. The filters are 15.0 mm in diameter and are housed in black anodized aluminum rings. (Installation in the CSU should only be performed by Yokogawa-authorized personnel.)

Blocked Laser Wavelengths	Transmission Bands	Semrock Part Number	Price
405 nm, 442 nm, 514 nm, 638 – 647 nm	458 – 497 nm, 529 – 620 nm, 667 – 750 nm	Em01-R442/514/647-15	$445
405 nm, 442 nm, 488 nm, 561 – 568 nm	503 – 546 nm, 583 – 700 nm	Em01-R488/568-15	$395

For graphs and ASCII data, go to www.semrock.com

LaserMUX™ Beam Combining Filters

LaserMUX filters are designed to efficiently combine or separate multiple laser beams at a 45° angle of incidence. These dichroic laser beam combiners are optimized to multiplex (MUX) popular laser lines, and can also be used in reverse to demultiplex (DEMUX). The ultra-low autofluorescence filters are ideally suited for OEM multi-laser fluorescence imaging and measurement applications including laser microscopy and flow cytometry, as well as for myriad end-user applications in a laboratory environment.

With high reflection and transmission performance at popular laser lines, these filters allow combining multiple different laser beams with exceptionally low loss. LaserMUX filters are hard-coated and come in an industry-standard 25 mm diameter x 3.5 mm thick black-anodized aluminum ring with a generous 22 mm clear aperture. Custom-sized filters are available in one week. Semrock also stocks a wide variety of other single-edge dichroic beamsplitters and multiedge dichroic beamsplitters.

Reflected Laser Wavelengths	Reflection Band	Transmission Laser Wavelengths	Passband	Size (Diameter x Thickness)	Filter Part Number	Price
375 ± 3 nm 405 +10/-5 nm	372.0 nm – 415.0 nm	440 +3/-1, 457.9, 473 +5/-0, 488 +3/-2, 514.5, 515, 532, 543.5, 561.4, 568.2, 594.1, 632.8, 635 +7/-0, 647.1 nm	439.0 nm – 647.1 nm	25 mm x 3.5 mm	LM01-427-25	$225
440 +3/-1 nm 457.9 nm	439.0 nm – 457.9 nm	473 +5/-0, 488 +3/-2, 514.5, 515, 532, 543.5, 561.4, 568.2, 594.1, 632.8, 635 +7/-0, 647.1 nm	473.0 nm – 647.1 nm	25 mm x 3.5 mm	LM01-466-25	$225
457.9 nm 473 nm	457.9 nm – 473.0 nm	488 +3/-0, 514.5, 515, 532, 543.5, 561.4, 568.2, 594.1, 632.8, 635 +7/-0, 647.1 nm	488.0 nm – 647.1 nm	25 mm x 3.5 mm	LM01-480-25	$225
473 +5/-0 nm 488 +3/-2 nm 1064.2 nm	473.0 nm – 491.0 nm	514.5, 515, 532, 543.5, 561.4, 568.2, 594.1, 632.8, 635 +7/-0, 647.1 nm	514.5 nm – 647.1 nm	25 mm x 3.5 mm	LM01-503-25	$225
514.5 nm 515 nm 532 nm 543.5 nm	514.5 nm – 543.5 nm	561.4, 568.2, 594.1, 632.8, 635 +7/-0, 647.1, 671, 676.4, 785 ± 5 nm	561.4 nm – 790.0 nm	25 mm x 3.5 mm	LM01-552-25	$225
561.4 nm 568.2 nm 594.1 nm	561.4 nm – 594.1 nm	632.8, 635 +7/-0, 647.1, 671, 676.4, 785 ± 5 nm	632.8 nm – 790.0 nm	25 mm x 3.5 mm	LM01-613-25	$225
632.8 nm 635 +7/-0 nm 647.1 nm	632.8 nm – 647.1 nm	671, 676.4, 785 ± 5 nm	671.0 nm – 790.0 nm	25 mm x 3.5 mm	LM01-659-25	$225

LaserMUX Common Specifications

Property	Value	Comment
Absolute Reflection	> 99% (s-polarization) > 96% (p-polarization) > 98% (average polarization)	For reflected laser wavelenghts
Average Reflection	> 98% (average polarization)	For reflection band
Absolute Transmission	> 94% (s-polarization) > 95% (p-polarization) > 95% (average polarization)	For transmitted laser wavelengths
Average Transmission	> 95% (average polarization)	For nominal passband
Angle of Incidence	45.0°	Based on a collimated beam of light
Performance for Non-collimated Light	The high-transmission portion of the long-wavelength edge and the low-transmission portion of the short-wavelength edge exhibit a small "blue shift" (shift toward shorter wavelengths). Even for cone half angles as large as 15° at normal incidence, the blue shift is only several nm.	
Clear Aperture	≥ 22 mm	For all optical specifications
Overall Mounted Diameter	25.0 mm + 0.0 / - 0.1 mm	Black anodized aluminium ring
Overall Mounted Thickness	3.5 mm + 0.0 +/- 0.1 mm	Black anodized aluminium ring
Unmounted Thickness	2.0 mm +/- 0.1mm	
Beam Deviation	< 30 arc seconds	Based on 20 arc second substrate wedge angle
Laser Damage Threshold	1 J/cm^2 @ 532 nm (10 ns pulse width)	Tested for LM01-552 nm filter only (see page 106)

While most flow cytometers are supplied by the manufacturer with optical filters pre-installed, there are numerous reasons to consider adding or upgrading filters to your instrument. Often the original filters are soft-coated, and are therefore subject to degraded performance over time. When new applications require new fluorophores or even a new laser to be installed, usually at least some of the filters must also be replaced. Fortunately most flow cytometers are designed so that replacement is of the filters is straightforward. Because the sizes and angles of incidence associated with dichroic beamsplitters tend to vary widely, care should be taken in verifying the availability of these filters. The chart on the opposite page lists some of the most common bandpass emission filters for popular laser lines. These are available in standard sizes to fit the most common flow cytometers on the market.

Product Note

Why consider Semrock filters for your flow cytometer?

In flow cytometry getting more information about each cell in less time and with less sample is the name of the game. You want higher sensitivity without sacrificing performance and accuracy. Choosing the right optical components – especially your optical filters – can make a significant difference.

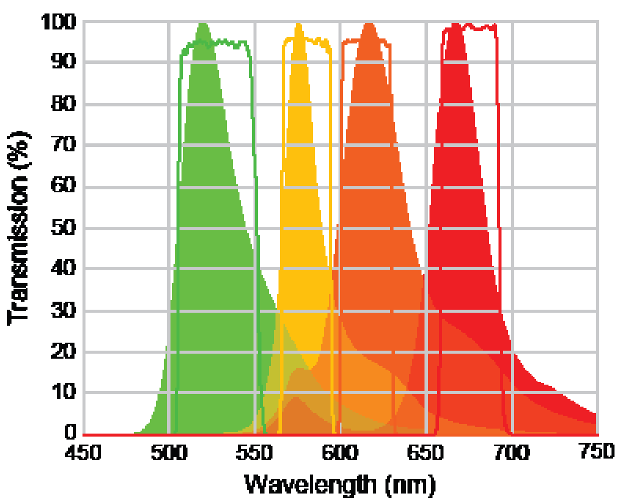
Soft-coated filters exhibiting typical moisture damage.

With the trend in high-performance flow cytometers moving toward multiple lasers and huge numbers of detection channels at both visible and near-IR wavelengths, older filter technology can limit the performance of your instrument. Semrock optical filters have the highest transmission of any filters on the market, which means you can achieve better sensitivity. Semrock filters also have the steepest edges with deep optimized blocking and superior wavelength accuracy, which means you can discriminate more fluorophores more completely.

Semrock pioneered hard-coated optical filters for fluorescence applications. By successfully combining the most sophisticated ion-beam sputtering thin-film deposition technology, renowned for its stability, with our proprietary deposition control technology, Semrock made volume manufacturing of hard-coated filters a reality. The result is unsurpassed performance that has set the standard for life sciences and analytical instrumentation applications.

All Semrock filters demonstrate exceptional reliability. The simple, all-glass construction combined with ion-beam-sputtered coatings (as hard as the glass on which they are coated) mean our filters are virtually impervious to humidity and temperature induced degradation. Plus, Semrock filters never "burn out," even under the most intense optical illumination, and they can be readily cleaned and handled.

In addition to an extensive selection of BrightLine® bandpass filters optimally designed for popular fluorophores, Semrock also stocks a wide array of filters specifically optimized for common lasers, especially the recent and popular all-solid-state lasers. MaxLine® and MaxDiode™ laser clean-up filters ensure no laser noise outside the line itself contaminates the fluorescence signal, while ultrasteep RazorEdge® filters and StopLine® notch filters provide exceptional laser-line blocking to ensure no laser light reaches the photomultiplier tubes dedicated to precious signal photons.



Real measured filter data and fluorophores for (L to R) FITC, PE, PE-Texas Red, and PE-Cy5

Flow Cytometry Filters

Laser	Fluorophore	Emission Filter Part #	†Filter Size
355 nm	Hoechst	FF01-452/45-25	A
	Hoechst Blue	FF01-452/45-25	A
	Hoechst Red	FF01-676/29-25	A
	Indo-1 bound	FF01-405/10-25*	A
	Indo-1 free	FF01-530/43-25	A
405 nm	Pacific Blue	FF01-452/45-25	A
	AmCyan	FF01-520/35-25	A
440 nm, 457 nm	CFP	FF01-479/40-25	A
	Chromomycin	FF01-550/49-25	A
	CFP	FF01-479/40-25	A
	Primary Chlorophyll	BLP01-635R-25	A
488 nm	FITC	FF01-530/43-25	A
	PE	FF01-580/23-25	A
	GFP	FF01-513/17-25*	A
	YFP	FF01-542/27-25	A
	FITC/GFP	FF01-530/43-25	A
	Chlorophyll	FF01-692/40-25	A
	FITC	FF01-530/43-25	A
	PI	FF01-615/20-25	B
	FITC	FF01-530/43-25	A
	PerCP	FF01-676/29-25	A
	PerCP-CY™ 5.5	FF01-710/40-25	A
	FITC	FF01-530/43-25	A
	PE	FF01-585/29-25	B
	PE-TexasRed®/ Propidium Iodide	FF01-615/20-25	B
	PE-Cy™ 5	FF01-676/29-25	A
	FITC	FF01-530/43-43	A
	PE	FF01-585/29-25	B
	PE-Cy™ 5	FF01-676/29-25	A
	PE-Cy™ 7	FF01-736/LP-25*	A
	FITC/SYBR® Green	FF01-530/43-25	A
	PE	FF01-580/23-25	A
	PE-TexasRed®/ Propidium Iodide	FF01-615/20-25	B
	Chlorophyll	FF01-692/40-25	A
	FITC/SYBR® Green	FF01-520/15-25	B
	SYBR® Gold	FF01-542/27-25	A
	PE	FF01-585/40-25	A
	Chlorophyll	FF01-692/40-25	A
	FITC	FF01-530/43-25	A
	PE	FF01-580/23-25	A
	PE-TexasRed®/ Propidium Iodide	FF01-615/20-25	B
	PE-Cy™ 5.5	FF01-692/40-25	A
	PE-Cy™ 7	FF01-736/LP-25*	A

Laser	Fluorophore	Emission Filter Part #	†Filter Size
532 nm	Primary PE	FF01-585/40-25	A
	PE-Cy™ 5	FF01-676/29-25	A
	PE	FF01-580/23-25	A
	PE-Cy™ 5	FF01-661/20-25	B
	PE-Cy™ 5	FF01-710/40-25	B
	PE	FF01-585/29-25	B
	PE-TexasRed®/ Propidium Iodide	FF01-615/20-25	B
	PE-Cy™ 5	FF01-676/29-25	A
	PE-Cy™ 7	FF01-736/LP-25*	A
561 nm	DsRed	FF01-593/40-25	A
	mCherry	FF01-624/40-25	A
	PE	FF01-593/40-25	A
	PE-Cy™ 5	FF01-670/30-25	A
	PE	FF01-593/40-25	A
	PE-Cy™ 5	FF01-676/29-25	A
	PE-Cy™ 7	FF01-736/LP-25*	A
	PE	FF01-585/29-25	B
	PE-TexasRed®	FF01-615/20-25	B
	PE-Cy™ 5	FF01-676/29-25	A
	PE-Cy™ 7	FF01-736/LP-25*	A
	PE	FF01-593/40-25	A
	PE-Cy™ 5	FF01-676/29-25	A
	PE-Cy™ 5.5	FF01-710/40-25	B
	PE-Cy™ 7	FF01-736/LP-25*	A
633, 635 640, or 642 nm	APC	FF01-676/29-25	A
	APC-Cy7	FF01-736/LP-25*	A
	Chlorophyll / APC	FF01-692/40-25	A
	APC-Cy7	FF01-736/LP-25*	A
	APC	FF01-676/29-25	A
	Alexa Fluor® 700	FF01-716/40-25	A
	APC-Cy7	FF01-736/LP-25*	A

†Standard Filter Dimension A measures 25 mm x 3.5 mm
Standard Filter Dimension B measures 25 mm x 5.0 mm

* Indicates that a separate laser-blocking filter is required in addition to the emission filter listed. Many instruments incorporate laser-blocking filters. Please verify that such a filter is present, or contact the manufacturer

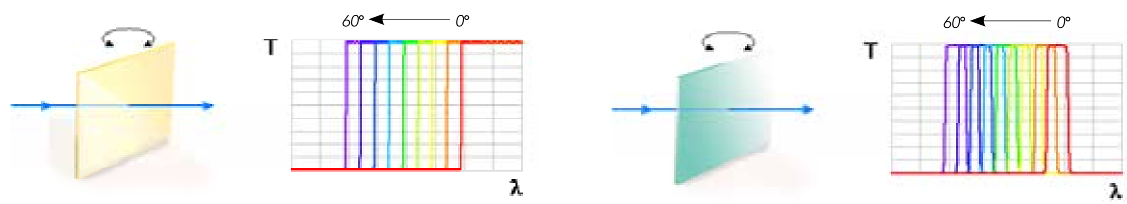
Product Note

Tunable Bandpass Filters

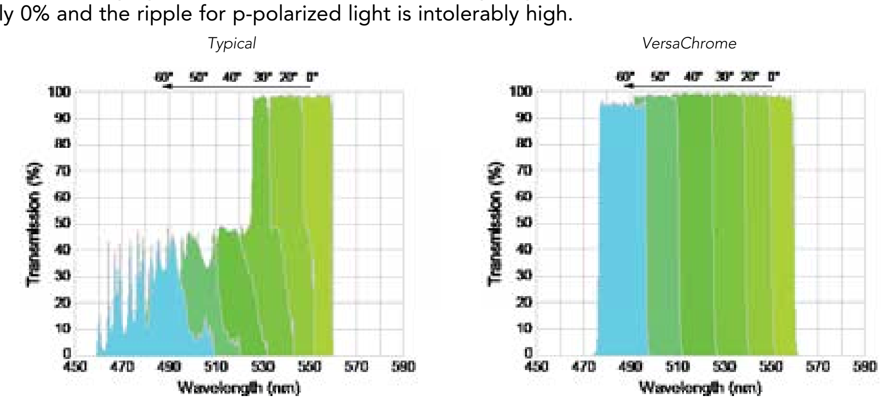
Thin-film filters are the ideal solution for wavelength selection in most optical systems due to exceptionally high transmission at passband wavelengths (close to 100%), very steep spectral edges, and blocking of optical density 6 or higher over wide spectral regions for maximum noise suppression. However, thin-film filters are considered to be "fixed" filters only, such that changing the spectral characteristics requires swapping filters, thus constraining system size, speed, and flexibility for systems that require dynamic filtering. Diffraction gratings are often used when wavelength tuning is required, but gratings exhibit inadequate spectral discrimination, have limited transmission, are polarization dependent, and are not capable of transmitting a beam carrying a two-dimensional image since one spatial dimension carries spectral information.

Fluorescence microscopy and other fluorescence imaging and quantitation applications, hyperspectral imaging, high-throughput spectroscopy, and fiber-optic telecommunications systems can all benefit from tunable optical filters with the spectral and two-dimensional imaging performance characteristics of thin-film filters and the center wavelength tuning flexibility of a diffraction grating. There exist several technologies that combine some of these characteristics, including liquid-crystal tunable filters, acousto-optic tunable filters, and linear-variable filters, but none are ideal and all have significant additional limitations.

Semrock has now developed a revolutionary new optical filter technology: thin-film optical filters that are tunable over a very wide range of wavelengths by adjusting the angle of incidence with essentially no change in spectral performance. As the diagrams (below right) indicate, both edge filters and bandpass filters with wide tunability are possible.

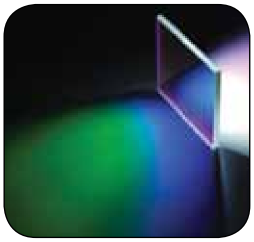


It is well-known that the spectrum of any thin-film filter shifts toward shorter wavelengths when the angle of incidence of light upon the filter is increased from 0° (normal incidence) to larger angles. In general, however, the filter spectrum becomes highly distorted at larger angles, and the shift can be significantly different for s- and p-polarized light, also leading to a strong polarization dependence at higher angles. The graph on the left shows the spectrum of a typical fluorescence filter at six different angles of incidence ranging from 0° to 60°. Note that for angles greater than about 30° transmission for s-polarized light is approximately 0% and the ripple for p-polarized light is intolerably high.



In contrast, the spectrum of a Semrock VersaChrome bandpass filter (right) maintains high transmission, steep edges, and excellent out-of-band blocking over the full range of angles from 0 to 60°. At the heart of this invention is Semrock's discovery of a way to make very steep edge filters (both long-wave-pass, or "cut-on," and short-wave-pass, or "cut-off," type filters) at very high angles of incidence with essentially no polarization splitting and nearly equal edge steepnesses for both polarizations of light. An equally significant and related property is that the high edge steepness values for both polarizations and the lack of polarization splitting apply at all angles of incidence from normal incidence (0°) to very high angles. As a consequence, it is possible to angle tune the edge filter, or a combination of edge filters, over this full range of angles with little to no change in the properties of the edges regardless of the state of polarization of the light passing through the filter. And thus it is now possible to make tunable thin-film filters which operate over a very wide range of wavelengths – Semrock's VersaChrome series of filters are specified with a tuning range of at least 12% of the filter edge or center wavelength at normal incidence.

VersaChrome® Tunable and High Overlap Filters



These game-changing optical filters do what no thin-film filter has ever done before: offer wavelength tunability over a very wide range of wavelengths by adjusting the angle of incidence with essentially no change in spectral performance. VersaChrome filters combine the highly desirable spectral characteristics and two-dimensional imaging capability of thin-film optical filters with the wavelength tuning flexibility of a diffraction grating. They are so innovative, they are patent pending.

With a tuning range of greater than 12% of the normal-incidence wavelength (by varying the angle of incidence from 0 to 60°), only five filters are needed to cover the full visible spectrum. They are ideal for applications ranging from fluorescence imaging and measurements to hyperspectral imaging and high-throughput spectroscopy. With their excellent polarization insensitivity and high optical quality and damage threshold, they are well-suited for a wide range of laser applications as well.

Standard Overlap Tunable Filters

Standard overlap allows for use in well-characterized setups.
OD 6 blocking at normal incidence to OD 5 at 60° allows angle blocking for common applications.

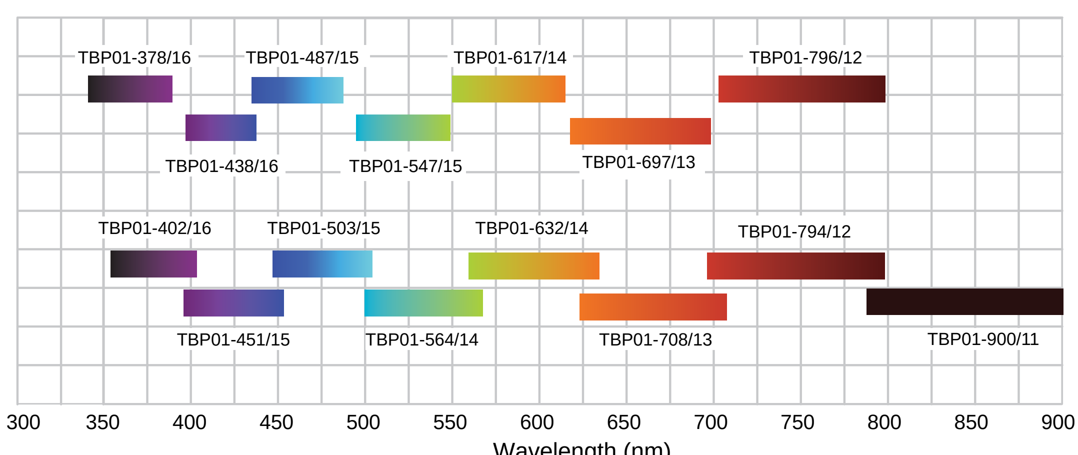
Tunable Color Range	At 60° CWL ≤	At 60° Average Transmission / Bandwidth	At 0° CWL ≥	At 0° Average Transmission / Bandwidth	Size (L x W x H)	Part Number	Price
	340.0	> 60% over 16 nm	378.0	> 80% over 16 nm	25.2 x 35.6 x 2.0 mm	TBP01-378/16-25x36	$795
	390.5	> 80% over 16 nm	438.0	> 90% over 16 nm	25.2 x 35.6 x 2.0 mm	TBP01-438/16-25x36	$795
	431.5	> 85% over 15 nm	487.5	> 90% over 15 nm	25.2 x 35.6 x 2.0 mm	TBP01-487/15-25x36	$795
	489.0	> 85% over 15 nm	547.0	> 90% over 15 nm	25.2 x 35.6 x 2.0 mm	TBP01-547/15-25x36	$795
	550.0	> 85% over 14 nm	617.0	> 90% over 14 nm	25.2 x 35.6 x 2.0 mm	TBP01-617/14-25x36	$795
	618.5	> 85% over 13 nm	697.0	> 90% over 13 nm	25.2 x 35.6 x 2.0 mm	TBP01-697/13-25x36	$795
	702.0	> 85% over 12 nm	796.0	> 90% over 12 nm	25.2 x 35.6 x 2.0 mm	TBP01-796/12-25x36	$795

Standard Overlap Common Specifications

Property	Value	Comment
Guaranteed Transmission	See table above	Averaged over the passband centered on the CWL
Blocking	OD > 6 UV – 1100 nm (0°) OD > 5 UV – 925 nm (60°)	Excluding passband
Effective Index of Refraction (n_{eff})*	1.85	See website for specific filter n_{eff}
Substrate Material	Fused Silica	
Dimensions and Tolerance	25.2 mm x 35.6 mm x 2.0 mm ± 0.1 mm	

See technical note on effective index on page 102

Standard Overlap Tunable Filters



Extended Overlap Tunable Filters

Extended Overlap Tunable Filters NEW

Between 4-12 nm of additional overlap designed to allow for system variations such as AOI accuracy, cone-half angles, etc. OD 6 blocking over full tuning range for the most sensitive of measurements.

Tunable Color Range	At 60° CWL ≤	Average Transmission / Bandwidth	At 0° CWL ≤	Average Transmission / Bandwidth	Size (L x W x H)	Part Number	Price	
	357.0	> 60% over 16 nm	402.0	> 85% over 16 nm	25.2 x 35.6 x 2.0 mm	TBP01-402/16	$895	NEW
	398.0	> 80% over 15 nm	451.0	> 90% over 15 nm	25.2 x 35.6 x 2.0 mm	TBP01-451/15	$895	NEW
	446.5	> 85% over 15 nm	503.0	> 90% over 15 nm	25.2 x 35.6 x 2.0 mm	TBP01-503/15	$895	NEW
	498.0	> 85% over 14 nm	564.0	> 90% over 14 nm	25.2 x 35.6 x 2.0 mm	TBP01-564/14	$895	NEW
	557.5	> 80% over 14 nm	632.0	> 90% over 14 nm	25.2 x 35.6 x 2.0 mm	TBP01-632/14	$895	NEW
	622.5	> 85% over 13 nm	708.0	> 90% over 13 nm	25.2 x 35.6 x 2.0 mm	TBP01-708/13	$895	NEW
	696.0	> 85% over 12 nm	794.0	> 90% over 12 nm	25.2 x 35.6 x 2.0 mm	TBP01-794/12	$895	NEW
	787.0	> 85% over 11 nm	796.0	> 90% over 11 nm	25.2 x 35.6 x 2.0 mm	TBP01-900/11	$895	NEW

Extended Overlap Filter Specifications

Property	Value	Comment
Guaranteed Transmission	See table above	Averaged over the passband centered on the CWL
Blocking	OD_{avg} > 6 UV - 1100 nm (0°)	Excluding passband
Effective Index of Refraction n_{eff}*	1.83	Nominal value, see website for specific n_{eff}
Substrate Material	Fused Silica	
Dimensions and Tolerance	25.2.mm x 36.6. mm x 2.0 mm ± 0.1 mm	

**See technical note on effective index on page 102*

All VersaChrome Filters Common Specifications

Property	Value	Comment
Substrate Material	Low autofluorescence NBK7 or better	
Coating Type	"Hard" ion-beam-sputtered	
Dimensions and Tolerance	25.2 mm x 35.6 mm x 2.0 mm ± 0.1 mm	
Clear Aperture	> 80%	Elliptical, for all optical specifications
Transmitted Wavefront Error	< λ/4 RMS at λ = 633 mm	Peak-to-valley error < 5 x RMS
Beam Deviation	≤ 10 arcseconds	Measured per inch
Surface Quality	60-40 scratch-dig	Measured within clear aperture
Orientation	Coating (text) towards light	See page 47 for marking diagram

FH1 - Tunable filter holder
Fits easily on top of motor for rotation.

Price: $95

VersaChrome® Tunable Filters

Technical Note

Spectral Imaging with VersaChrome® Filters

Conventional spectral imaging systems are generally not able to offer the key advantages of thin-film interference filters, i.e., high transmission combined with steep spectral edges and high out-of-band blocking. Now with VersaChrome filters, these advantages can be realized in simple spectral imaging systems for applications ranging from fluorescence microscopy to hyperspectral imaging.

To demonstrate spectral imaging in a fluorescence microscope, a "lambda stack" of images (corresponding to a nearly continuous series of emission wavelengths) was acquired of a sample labeled with three spectrally overlapping fluorophores using a Semrock VersaChrome tunable filter (TBP01-620/14) placed in the emission channel of a standard upright microscope. Figure 1 shows six of the 61 images taken at 1 nm intervals, and Figure 2 shows measured intensity spectra taken from parts of the image where only a single fluorophore is present. The nucleus labeled with SYTOX® Orange can be easily discriminated from the other cellular structures (Fig. 1). However, since the F-actin and mitochondria are labeled with fluorophores that are highly overlapping (Alexa Fluor™ 568 and MitoTracker® Red, respectively), linear unmixing is necessary to discern the corresponding cellular constituents. Images deconvolved with linear unmixing are shown in Figure 3.

It is important to note that the spectral properties of these tunable filters are almost identical for both s and p polarizations of light – a feature that cannot be easily obtained using liquid-crystal and acousto-optic tunable filters. Polarization independence is highly desirable for spectral imaging systems, and yet polarization limitations of current tunable filters account for a loss of at least half of the signal in most instruments. Therefore VersaChrome filters not only enhance the throughput in spectral imaging but they also greatly simplify the complexity of instrumentation.

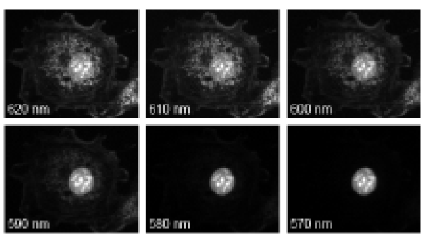


Figure 1

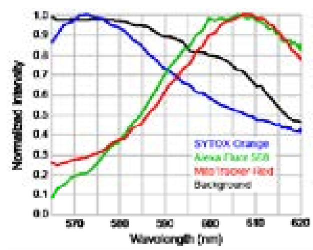


Figure 2

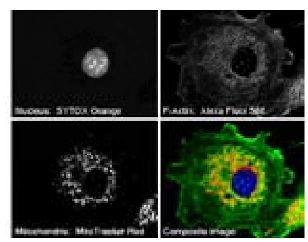


Figure 3

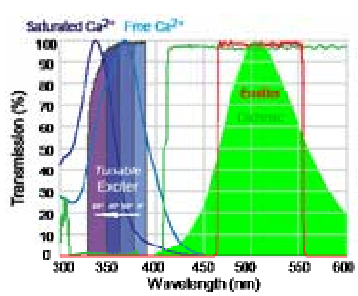
Technical Note

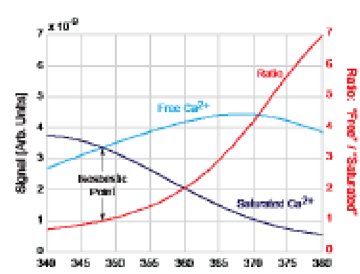
Using Fura-2 to Track Ca^{2+} Using VersaChrome® Filters

The fluorophore Fura-2 has an absorption spectrum that varies markedly depending on the concentration of calcium (Ca^{2+}) that is present near the fluorophore molecule. By measuring the ratio of intensities on digital images captured using two different excitation wavelengths, the variation of calcium concentration as a function of location on the sample can be tracked.

The conventional approach to ratiometric imaging with Fura-2 is based on exchanging two excitation filters in a filter wheel (see page 11 for the FURA2-C set). Now with Semrock's VersaChrome TBP01-380/16 tunable excitation filter, ratiometric imaging with Fura-2 can be more carefully optimized to your specific experimental conditions. This filter makes it possible to monitor the Fura-2 signal corresponding to virtually any excitation wavelength between 340 and 380 nm – continuous tuning like a monochromator, yet with the high transmission, steep edges, and high out-of-band blocking available only with optical filters. And, wavelength tuning of a VersaChrome filter can be 2 to 3 times faster than exchanging filters with even the highest-speed filter wheel.

The added flexibility of a tunable excitation source can even enable new types of experiments. For example, the same excitation filter used for high-contrast ratiometric imaging can be tuned to excite Fura-2 at its isosbestic point, thus enabling monitoring of the Fura-2 signal independent of calcium concentration.





Laser Wavelength Reference Table

Laser Line	Laser Type	Prominent Applications	Polarization Filters Pg 82	RazorEdge® (LWP) Pg 86	MaxLine® Pg 92	MaxDiode™ Pg 95	StopLine® Pg 98	EdgeBasic™ Pg 84	BrightLine® Laser Dichroics Pg 69	LaserMUX™ Pg 74	MaxMirror® Pg 103
224.3	HeAg gas	Raman		●							
248.6	NeCu gas	Raman		●	●						
257.3	Doubled Ar-ion gas	Raman		●							
266.0	Quadrupled DPSS	Raman		●	●						
325.0	HeCd gas	Raman		●	●						
355.0	Tripled DPSS	Raman		●	●						●
363.8	Ar-ion gas	Raman		●	●						●
~ 375	Diode	Fluorescence (DAPI)				●			●	●	●
~ 405	Diode	Fluorescence (DAPI)	●			●	●	●	●	●	●
~ 440	Diode	Fluorescence (CFP)				●			●	●	●
441.6	HeCd gas	Raman, Fluorescence (CFP)		●	●				●	●	●
457.9	Ar-ion gas	Fluorescence (CFP)		●	●				●	●	●
~ 470	Diode	Fluorescence (GFP)				●			●	●	●
473.0	Doubled DPSS	Fluorescence (GFP), Raman		●		●			●	●	●
488.0	Ar-ion gas	Raman, Fluorescence (FITC, GFP)		●	●		●	●	●	●	●
~ 488	Doubled OPS	Fluorescence (FITC, GFP)					●	●	●	●	●
491.0	Doubled DPSS	Fluorescence (FITC, GFP)			●			●	●	●	●
514.5	Ar-ion gas	Raman, Fluorescence (YFP)		●	●		●	●	●	●	●
515.0	Doubled DPSS	Fluorescence (YFP)					●	●	●	●	●
532.0	Doubled DPSS	Raman, Fluorescence	●	●	●		●	●	●	●	●
543.5	HeNe gas	Fluorescence (TRITC, Cy3)			●					●	●
561.4	Doubled DPSS	Fluorescence (RFP, Texas Red®)		●	●		●	●	●	●	●
568.2	Kr-ion gas	Fluorescence (RFP, Texas Red)		●	●			●	●	●	●
593.5	Doubled DPSS	Fluorescence (RFP, Texas Red)					●	●	●	●	●
594.1	HeNe gas	Fluorescence (RFP, Texas Red)					●	●	●	●	●
632.8	HeNe gas	Raman, Fluorescence (Cy5)	●	●	●		●	●	●	●	●
~ 635	Diode	Fluorescence (Cy5)	●			●		●	●	●	●
647.1	Kr-ion gas	Fluorescence (Cy5)	●	●	●				●	●	●
664.0	Doubled DPSS	Raman		●							●
671.0	Doubled DPSS	Raman, Fluorescence (Cy5.5, Cy7)			●						●
780.0	EC diode	Raman		●	●			●			●
~ 785	Diode	Raman				●		●			●
785.0	EC Diode	Raman		●	●	●	●	●			●
~ 808	Diode	DPSS pumping, Raman		●	●		●				●
830.0	EC diode	Raman		●	●						●
976.0	EC diode	Raman		●	●						●
980.0	EC diode	Raman		●	●						●
1047.1	DPSS	Raman	●		●						●
1064.0	DPSS	Raman	●	●	●						●
1319.0	DPSS	Raman		●							

Key: Diode = semiconductor diode laser
DPSS = diode-pumped solid-state laser
EC diode = wavelength-stablized external-cavity diode laser
OPS = optically pumped semiconductor laser
Doubled, Tripled, Quadrupled = harmonic frequency upconversion using nonlinear optics

Polarization Filters

Unique to Semrock, these filters combine a highly efficient polarizer and a bandpass filter in a single optical component! These patent-pending filters are superb linear polarizers with a contrast ratio exceeding 1,000,000-to-1. In addition, with high-performance bandpass characteristics (including high transmission and steep edges), they make an excellent laser source clean-up filter (eliminating undesired polarization and light noise away from the laser wavelength) as well as detection filters to pass a laser wavelength range and block background noise.

Semrock's polarizing bandpass filters are ideal for a wide variety of laboratory laser applications, especially those involving holographic and interferometric systems, as well as fluorescence polarization assays and imaging, second-harmonic- generation imaging, polarization diversity detection in communications and range finding, laser materials processing, and laser intensity control.

- Contrast ratio > 1,000,000:1
- High transmission (> 95%) within optimized passband (for p-polarization light)
- Superior optical quality – low scatter, wavefront distortion, and beam deviation
- Hard-coating reliability and high laser damage threshold (1 J/cm^2)
- Naturally offers large aperture sizes and 90° beamsplitter functionality

Nominal Laser Wavelength	Wavelength Range for AOI = 45°± 0.5°	AOI Range for Nominal Laser Wavelength	OD 2 Avg. Polarization Blocking Range[1]	OD 6 S-Pol Blocking Range	OD 6 P-Pol Blocking Range	Part Number	Price
405 nm	400 – 410 nm	41° – 51°	300 – 332 nm 490 – 1100 nm	320 – 516 nm	332 – 388 nm 422 – 490 nm	PBP01-405/10-25x36	$795
532 nm	518 – 541 nm	38° – 52°	300 – 418 nm 664 – 1100 nm	400 – 695 nm	418 – 502 nm 557 – 664 nm	PBP01-529/23-25x36	$795
640 nm	628.5 – 650 nm	40.5° – 51°	300 – 511 nm 795 – 1100 nm	488 – 840 nm	511 – 602 nm 675 – 795 nm	PBP01-639/21-25x36	$795
1064 nm	1038 – 1081 nm	39° – 51°	300 – 851 nm 1307 – 1750 nm	720 – 1393 nm	851 – 996 nm 1120 – 1307 nm	PBP01-1059/43-25x36	$895

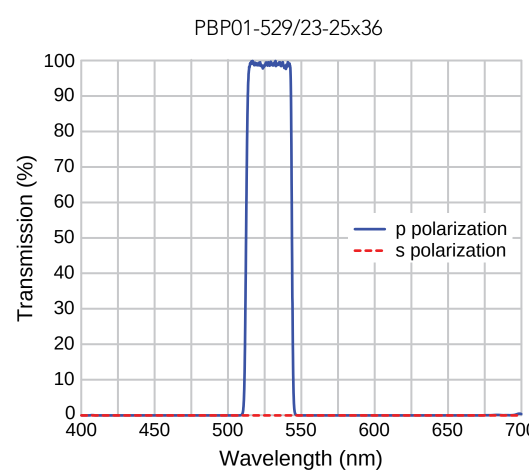
[1] OD 2.5 Average for PBP01-1059/43 filter

See spectra graphs and ASCII data for all of our filters at www.semrock.com

NOTE: When ordering a Polarizing Bandpass filter installed in a Beamsplitter Mount, please specify whether you are using the filter as a polarizer or an analyzer for proper orientation during assembly.

Downloadable assembly and mechanical drawings of the mount are available at www.semrock.com

Specify "BSM" when ordering the Beamsplitter Mount designed for 25.2 x 35.6 x 1.0 to 2.0 mm beamsplitters in laboratory bench-top setups. $225



These unique polarizing bandpass filters offer a superb linear polarizer and optimized bandpass filter in a single optical component.

Common Specifications

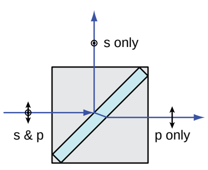
Property	Value	Comments
Guaranteed Transmission	> 95%	p-polarized light
Contrast	1,000,000:1	Ratio of transmission through two identical aligned polarizers to transmission through same pair of crossed polarizers
Blocking	*See table on page 82*	
Nominal Angle of Incidence	45°	AOI tolerance *(See table on page 82)*
Laser Damage Threshold	1 J/cm^2 @ 532 nm	10 ns pulse width P-pol *(See page 106)*
Substrate Material	Ultra-low autofluorescence fused silica	
Dimensions & Tolerance	25.2 mm x 35.6 mm x 2.0 mm ± 0.1 mm	Mount options on page 36
Clear Aperture	≥ 85%	Ellipitcal, for all optical specifications
Transmitted Wavefront Error	< λ/4 RMS at λ = 633 nm	Peak-to-valley error < 5 x RMS
Beam Deviation	≤ 10 arc seconds	Measured per inch
Surface Quality	40-20 scratch-dig	Measured within clear aperture
Orientation	Coating (Text) towards from light	For use as a polarizer
	Coating (Text) away light	For use as an analyzer

Technical Note

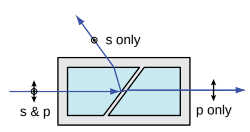
Thin-film Plate Polarizers

A "polarizer" transmits a single state of polarization of light while absorbing, reflecting, or deviating light with the orthogonal state of polarization. Applications include fluorescence polarization assays and imaging, second-harmonic-generation imaging, polarization diversity detection in communications and rangefinding, and laser materials processing, to name a few. Polarizers are characterized by the "contrast ratio," or the ratio of the transmission through a pair of identical aligned polarizers to the transmission through the same pair of crossed polarizers. Contrast ratios typically vary from about 100:1 to as large as 100,000:1.

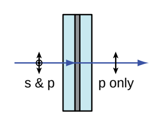
Three of the most common high-contrast polarizers are shown in the diagram on the right. Thin-film plate polarizers, like those made by Semrock, are based on interference within a dielectric optical thin-film coating on a thin glass substrate. In birefringent crystal polarizers, different polarization orientations of light rays incident on an interface are deviated by different amounts. In "Glan" calcite polarizers, extinction is achieved by total internal reflection of s-polarized light at a crystal-air gap (Glan-laser) or crystal-epoxy gap (Glan-Thompson). Glass film polarizers selectively absorb one orientation of linearly polarized light more strongly than the other.



Thin-film Plate Polarizer



Birefringent Crystal Polarizer

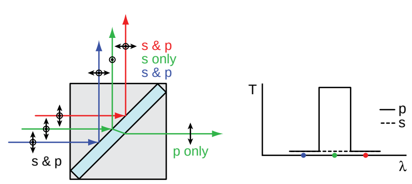


Glass Film Polarizer

Thin-film plate polarizers have a number of unique advantages relative to other types of polarizers, including superior transmission and optical quality, low scattering, wavefront distortion, and beam deviation that can cause beam walk during rotation. They can be made with excellent environmental reliability, the highest laser damage thresholds, and large aperture sizes (inches). And they naturally function as beamsplitters with a 90° beam deviation of the blocked polarization. Unlike birefringent crystal polarizers, thin-film plate polarizers tend to function over only a range of wavelengths since they are based on multiwave interference, and thus they are best suited for laser applications or for systems with limited signal band.

Birefringent crystal polarizers tend to have very limited aperture size due to the high cost of growing good optical-quality crystals, and they are not well suited for imaging applications. Besides a somewhat limited wavelength range, the main limitations of glass film polarizers are low transmission of the desired light and low optical damage threshold, making them unsuitable for many laser applications.

Semrock's ion beam sputtering technology has enabled breakthrough improvements in performance of traditional thin-film plate polarizers. Foremost among these is contrast – Semrock polarizers are guaranteed to achieve higher than 1,000,000:1 contrast, rivaled only by the lower-transmission and low optical damage-threshold glass film polarizers. And, only Semrock polarizers can achieve unique spectral performance like our patent-pending "polarizing bandpass filters" (see figure on the right).



Polarizing Bandpass Filter

EdgeBasic™ Long Wave Pass Filters

EdgeBasic long-wave-pass filters offer a superb combination of performance and value for applications in Raman spectroscopy and fluorescence imaging and measurements. This group of filters is ideal for specific Raman applications that do not require measuring the smallest possible Raman shifts, yet demand exceptional laser-line blocking and high transmission over a range of Raman lines.

- Deep laser-line blocking – for maximum laser rejection (OD > 6)
- Extended short-wavelength blocking – for high-fidelity fluorescence imaging
- High signal transmission – to detect the weakest signals (> 98% typical)
- Proven **no burn-out** durability – for lasting and reliable performance
- For the ultimate performance, upgrade to state-of-the-art RazorEdge® Raman filters

Nominal Laser Wavelength	Laser Wavelength Range		Passband	Part Number	Price
	λ_{short}	λ_{long}			
405 nm	400.0 nm	410.0 nm	421.5 – 900.0 nm	BLP01-405R-25	$325
458 nm	439.0 nm	457.9 nm	470.0 – 900.0 nm	BLP01-458R-25	$325
488 nm	486.0 nm	491.0 nm	504.7 – 900.0 nm	BLP01-488R-25	$325
515 nm	505.0 nm	515.0 nm	529.4 – 900.0 nm	BLP01-514R-25	$325
532 nm	532.0 nm	532.0 nm	546.9 – 900.0 nm	BLP01-532R-25	$325
561 nm	561.0 nm	568.0 nm	583.9 – 900.0 nm	BLP01-561R-25	$325
594 nm	593.5 nm	594.1 nm	610.6 – 900.0 nm	BLP01-594R-25	$325
635 nm	632.8 nm	642.0 nm	660.0 – 1200.0 nm	BLP01-635R-25	$325
785 nm	780.0 nm	790.0 nm	812.1 – 1200.0 nm	BLP01-785R-25	$325

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Common Specifications

Property	Value	Comments
Edge Steepness (typical)	1.5% of λ_{long}	Measured from OD 6 to 50%
Blocking at Laser Wavelengths	OD > 6 from 80% of λ_{short} to λ_{long} OD > 5 from 270 nm to 80% of λ_{short}	OD = – $\log_{10}$ (transmission)
Transition Width	< 2.5% of λ_{long}	From λ_{long} to the 50% transmission wavelength
Guaranteed Transmission	> 93%	Averaged over the passband
Typical Transmission	> 98%	Averaged over the passband
Minimum Transmission	> 90%	Over the passband
Angle of Incidence	0.0° ± 2.0°	Range for above optical specifications
Cone Half Angle	< 5°	Rays uniformly distributed about 0°
Angle Tuning Range	– 0.3% of Laser Wavelength	Wavelength "blue shift" increasing angle from 0° to 8°
Substrate Material	Low-autofluorescence optical quality glass	
Clear Aperture	> 22 mm	
Outer Diameter	25.0 + 0.0 / – 0.1 mm	Black-anodized aluminum ring
Overall Thickness	3.5 ± 0.1 mm	Black-anodized aluminum ring
Beam Deviation	< 10 arc seconds	
Surface Quality	60-40 scratch-dig	
Filter Orientation	Arrow on ring indicates preferred direction of propagation of light	

Product Note

Edge Steepness and Transition Width

Semrock edge filters – including our steepest RazorEdge® Raman filters as well as our EdgeBasic™ filters for application-specific Raman systems and fluorescence imaging – are specified with a guaranteed "Transition Width."

Transition Width = maximum allowed spectral width between the laser line (where OD > 6) and the 50% transmission point

Any given filter can also be described by its "Edge Steepness," which is the actual steepness of the filter, regardless of the precise wavelength placement of the edge.

Edge Steepness = actual steepness of a filter measured from the OD 6 point to the 50% transmission point

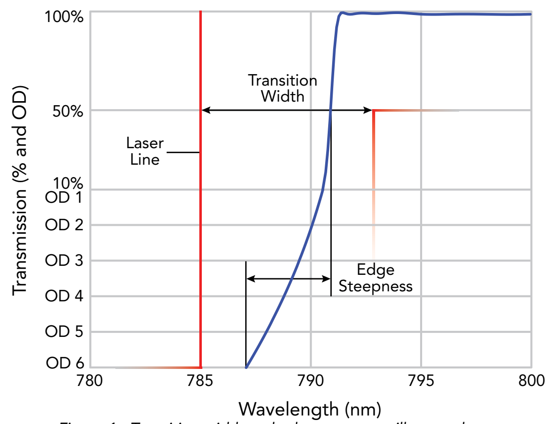


Figure 1: Transition width and edge steepness illustrated.

Figure 1 illustrates Transition Width and Edge Steepness for an edge filter designed to block the 785 nm laser line (example shows a "U-grade" RazorEdge filter). Table 1 below lists the guaranteed Transition Width, typical Edge Steepness, and price (for 25 mm diameter parts) for Semrock edge filters.

Edge Filter Type	Guaranteed Transition Width (% of laser wavelength)	Typical Edge Steepness (% of laser wavelength)	Price* (25 mm)
RazorEdge "E-grade"	< 0.5% (< 90 cm^{-1} for 532)	0.2% (1.1 nm for 532)	$995
RazorEdge "U-grade"	< 1.0% (< 186 cm^{-1} for 532)	0.5% (2.7 nm for 532)	$765
RazorEdge "S-grade"	< 2.0% (< 369 cm^{-1} for 532)	0.5% (2.7 nm for 532)	$465
EdgeBasic	< 2.5% (< 458 cm^{-1} for 532)	1.5% (8.0 nm for 532)	$325

* except UV filters

All RazorEdge filters provide exceptional steepness to allow measurement of signals very close to the blocked laser line with high signal-to-noise ratio. However, the state-of-the-art "E-grade" RazorEdge filters take closeness to an Extreme level.

The graph at the right illustrates that "U-grade" RazorEdge filters have a transition width that is 1% of the laser wavelength – thus a 785 nm filter is guaranteed to have > 50% transmission by 792.9 nm, corresponding to a maximum wavenumber shift of 126 cm^{-1}. "E-grade" filters have a Transition Width that is twice as narrow, or 0.5% of the laser line! So a 785 nm filter is guaranteed to have > 50% transmission by 788.9 nm, corresponding to a maximum wavenumber shift of 63 cm^{-1}.

"Edge steepness" is the actual steepness of the filter, regardless of the precise wavelength placement of the edge. "U-grade" RazorEdge filters are designed to have a steepness of 0.5% of the laser wavelength, or 3.9 nm (63 cm^{-1}) for a 785 nm filter. The "E-grade" filters are designed to have an edge steepness that is 2.5x narrower – only 0.2% of the laser wavelength, or 1.6 nm (25 cm^{-1}) for a 785 nm filter.

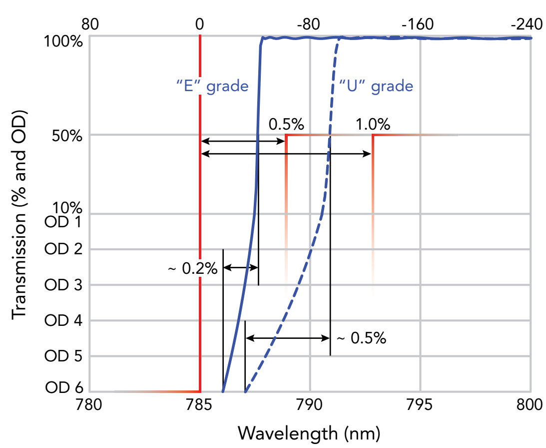


Figure 2: Transition widths and edge steepnesses for LP02-785RE and LP02-785RU filters (see page 85).

RazorEdge® Long Wave Pass Raman Edge Filters

Semrock stocks an unsurpassed selection of the highest performance edge filters available for Raman Spectroscopy, with edge wavelengths from 224 to 1319 nm. Now you can see the weakest signals closer to the laser line than you ever have before. With their deep laser-line blocking, ultra-wide and low-ripple passbands, proven hard-coating reliability, and high laser damage threshold, they offer performance that lasts. U.S. Patent No. 7,068,430 and additional patents pending.

- **The steepest edge filters on the market – RazorEdge E-grade filters** *See how steep on page 85*
- For **long-wave-pass edge filters** for normal incidence, see below
- For **short-wave-pass edge filters** for normal incidence, *see page 88*
- For **ultrasteep 45° beamsplitters,** *see page 89*
- For a suitably matched **laser-line filter**, *see page 92*

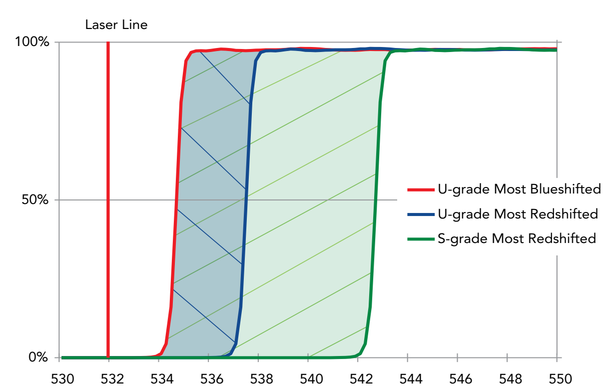
25 mm Diameter

Laser Line	Transition Width [1]	Passband	Part Number	Price
224.3 nm	< 1920 cm^{-1}	235.0-505.9 nm	LP02-224R-25	$995
248.6 nm	< 805 cm^{-1}	261.0-560.8 nm	LP02-248RS-25	$995
257.3 nm	< 385 cm^{-1} < 762 cm^{-1}	263.0-580.4 nm 265.5-580.4 nm	LP02-257RU-25 LP02-257RS-25	$995 $545
266.0 nm	< 372 cm^{-1} < 737 cm^{-1}	272.4-600.0 nm 275.0-600.0 nm	LP02-266RU-25 LP02-266RS-25	$995 $545
325.0 nm	< 305 cm^{-1} < 603 cm^{-1}	329.2-733.1 nm 332.5-733.1 nm	LP03-325RU-25 LP03-325RS-25	$765 $465
355.0 nm	< 140 cm^{-1} < 279 cm^{-1} < 552 cm^{-1}	357.3-800.8 nm 359.6-800.8 nm 363.2-800.8 nm	LP02-355RE-25 LP02-355RU-25 LP02-355RS-25	$995 $765 $465
363.8 nm	< 272 cm^{-1} < 539 cm^{-1}	368.5-820.6 nm 372.2-820.6 nm	LP02-364RU-25 LP02-364RS-25	$765 $465
441.6 nm	< 224 cm^{-1} < 444 cm^{-1}	447.3-996.1 nm 451.8-996.1 nm	LP02-442RU-25 LP02-442RS-25	$765 $465
457.9 nm	< 216 cm^{-1} < 428 cm^{-1}	463.9-668.4 nm 468.4-668.4 nm	LP02-458RU-25 LP02-458RS-25	$765 $465
473.0 nm	< 209 cm^{-1} < 415 cm^{-1}	479.1-1066.9 nm 483.9-1066.9 nm	LP02-473RU-25 LP02-473RS-25	$765 $465
488.0 nm	< 102 cm^{-1} < 203 cm^{-1} < 402 cm^{-1}	491.2-1100.8 nm 494.3-1100.8 nm 499.2-1100.8 nm	LP02-488RE-25 LP02-488RU-25 LP02-488RS-25	$995 $765 $465
514.5 nm	< 97 cm^{-1} < 192 cm^{-1} < 381 cm^{-1}	517.8-1160.5 nm 521.2-1160.5 nm 526.3-1160.5 nm	LP02-514RE-25 LP02-514RU-25 LP02-514RS-25	$995 $765 $465
532.0 nm	< 90 cm^{-1} < 186 cm^{-1} < 369 cm^{-1}	535.4-1200.0 nm 538.9-1200.0 nm 544.2-1200.0 nm	LP03-532RE-25 LP03-532RU-25 LP03-532RS-25	$995 $765 $465
561.4 nm	< 176 cm^{-1} < 349 cm^{-1}	568.7-1266.3 nm 574.0-1266.3 nm	LP02-561RU-25 LP02-561RS-25	$765 $465
568.2 nm	< 174 cm^{-1} < 345 cm^{-1}	575.6-1281.7 nm 581.3-1281.7 nm	LP02-568RU-25 LP02-568RS-25	$765 $465
632.8 nm	< 79 cm^{-1} < 156 cm^{-1} < 310 cm^{-1}	636.9-1427.4 nm 641.0-1427.4 nm 647.4-1427.4 nm	LP02-633RE-25 LP02-633RU-25 LP02-633RS-25	$995 $765 $465

Laser Line	Transition Width [1]	Passband	Part Number	Price
664.0 nm	< 149 cm^{-1} < 295 cm^{-1}	672.6-1497.7 nm 679.3-1497.7 nm	LP02-664RU-25 LP02-664RS-25	$765 $465
780.0 nm	< 127 cm^{-1} < 251 cm^{-1}	790.1-1759.4 nm 797.9-1759.4 nm	LP02-780RU-25 LP02-780RS-25	$765 $465
785.0 nm	< 63 cm^{-1} < 126 cm^{-1} < 250 cm^{-1}	790.1-1770.7 nm 795.2-1770.7 nm 803.1-1770.7 nm	LP02-785RE-25 LP02-785RU-25 LP02-785RS-25	$995 $765 $465
808.0 nm	< 123 cm^{-1} < 243 cm^{-1}	818.5-1822.6 nm 826.6-1822.6 nm	LP02-808RU-25 LP02-808RS-25	$765 $465
830.0 nm	< 119 cm^{-1} < 236 cm^{-1}	840.8-1872.2 nm 849.1-1872.2 nm	LP02-830RU-25 LP02-830RS-25	$765 $465
980.0 nm	< 101 cm^{-1} < 200 cm^{-1}	992.7-2000.0 nm 1002.5-2000.0 nm	LP02-980RU-25 LP02-980RS-25	$765 $465
1064.0 nm	< 93 cm^{-1} < 184 cm^{-1}	1077.8-2000.0 nm 1088.5-2000.0 nm	LP02-1064RU-25 LP02-1064RS-25	$765 $465
1319.0 nm	< 75 cm^{-1} < 149 cm^{-1}	1336.1-2000.0 nm 1349.3-2000.0 nm	LP02-1319RU-25 LP02-1319RS-25	$765 $465

[1] See pages 85 and 96 for more informationon transition width and wavenumbers

The spectral response of an S-grade filter is located anywhere between the red and green lines below. The spectral response of a U-grade filter is located anywhere between the red and blue lines below.



50 mm Diameter – *Same Performance over 4x the Area*

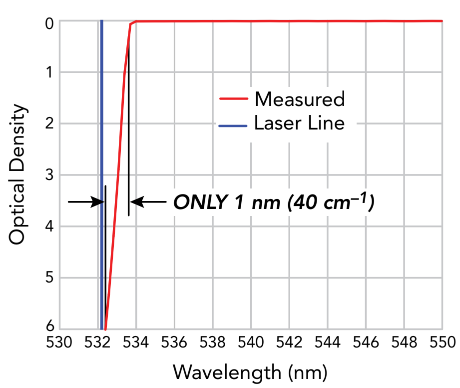
The "-25" in the part numbers on the previous page indicates these filters are 25 mm in diameter. All visible and near-IR U- and S-grade wavelengths are available in 50 mm diameters. See the table below for changes to the part numbers and prices.

Laser Line	Part Number	Price
Long Wave Pass Edge Filters For wavelengths listed on page 80[1]	LP0_-___RU-50	$2175
	LP0_-___RS-50	$1315

[1] U- and S-grade filters only, except 224.3, 248.6, 257.3, and 266 nm filters – call for availability.

RazorEdge Raman Filter Spectra

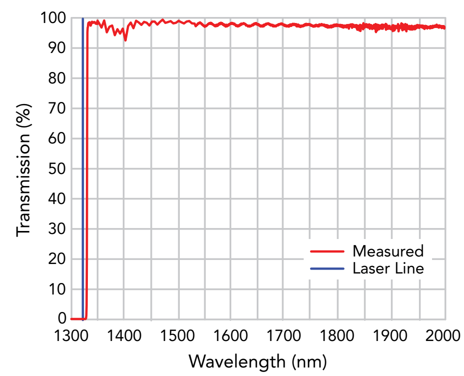
Actual measured OD for a 532 nm E-grade filter



Expand deeper into the IR

(see page 96 for Near-IR bandpass filters)

Actual measured 1319 U-grade filter



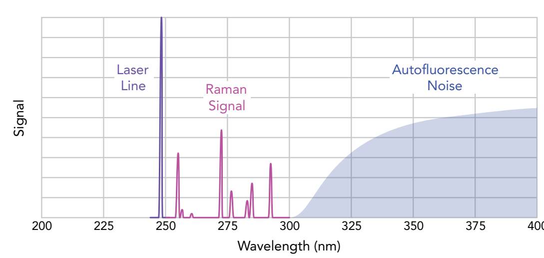
Technical Note

Ultraviolet (UV) Raman Spectroscopy

Raman spectroscopy measurements generally face two limitations: (1) Raman scattering cross sections are tiny, requiring intense lasers and sensitive detection systems just to achieve enough signal; and (2) the signal-to-noise ratio is further limited by fundamental, intrinsic noise sources like sample autofluorescence. Raman measurements are most commonly performed with green, red, or near-infrared (IR) lasers, largely because of the availability of established lasers and detectors at these wavelengths. However, by measuring Raman spectra in the ultraviolet (UV) wavelength range, both of the above limitations can be substantially alleviated.

Visible and near-IR lasers have photon energies below the first electronic transitions of most molecules. However, when the photon energy of the laser lies within the electronic spectrum of a molecule, as is the case for UV lasers and most molecules, the intensity of Raman-active vibrations can increase by many orders of magnitude – this effect is called "resonance-enhanced Raman scattering."

Further, although UV lasers tend to excite strong autofluorescence, it typically occurs only at wavelengths above about 300 nm, independent of the UV laser wavelength. Since even a 4000 cm^{-1} (very large) Stokes shift leads to Raman emission below 300 nm when excited by a common 266 nm laser, autofluorescence simply does not interfere with the Raman signal making high signal-to-noise ratio measurements possible.



Recently, an increasing number of compact, affordable, and high-power UV lasers have become widely available, such as quadrupled, diode-pumped Nd:YAG lasers at 266 nm and NeCu hollow-cathode metal-ion lasers at 248.6 nm, making ultra-sensitive UV Raman spectroscopy a now widely accessible technique.

RazorEdge® Short Wave Pass Raman Edge Filters

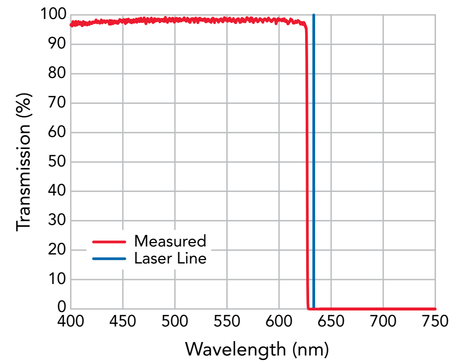
25 mm Diameter

These unique filters (U.S. patent No. 7,068,430) are ideal for Anti-Stokes Raman applications. An addition to the popular high-performance RazorEdge family of steep edge filters, these short-wave-pass filters are designed to attenuate a designated laser-line by six orders of magnitude, and yet maintain a typical edge steepness of only 0.5% of the laser wavelength. Both short- and long-wave-pass RazorEdge filters are perfectly matched to Semrock's popular MaxLine® laser-line cleanup filters.

Laser Line	Transition Width	Passband	Part Number	Price
532.0 nm	< 186 cm^{-1}	350.0 – 525.2 nm	SP01-532RU-25	$765
561.4 nm	< 176 cm^{-1}	400.0 – 554.1 nm	SP01-561RU-25	$765
632.8 nm	< 160 cm^{-1}	372.0 – 624.6 nm	SP01-633RU-25	$765
785.0 nm	< 129 cm^{-1}	400.0 – 774.8 nm	SP01-785RU-25	$765

For S-grade pricing and availability, please call.

Actual measured data from a 632.8 nm RazorEdge filter



See spectra graphs and ASCII data for all of our filters at www.semrock.com

50 mm Diameter — *Same Performance over 4x the Area*

All above wavelengths are also available in 50 mm diameter. See the table below for changes to the part numbers and prices.

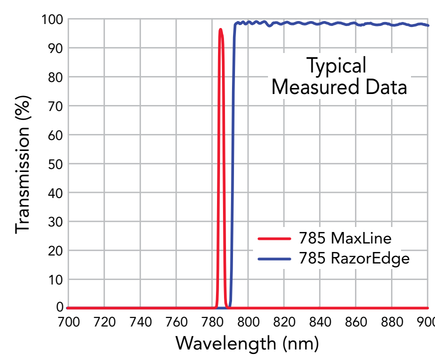
Laser Line	Part Number	Price
Short Wave Pass Edge Filters *For wavelengths listed above*	SP01-___RU-50	$2175

For S-grade pricing and availability, please call.

Product Note

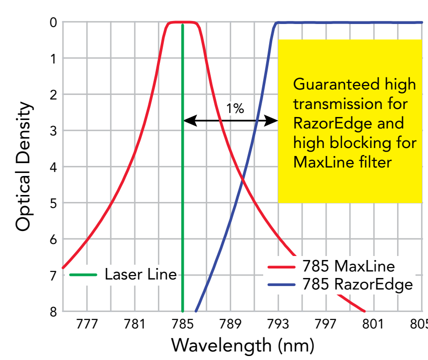
RazorEdge and MaxLine® are a Perfect Match

The MaxLine *(see page 92)* and RazorEdge U- and S-grade *(see page 86)* filters make an ideal filter pair for applications like Raman spectroscopy – they fit together like hand-in-glove. The MaxLine filter spectrally "cleans up" the excitation laser light before it reaches the sample under test – allowing only the desired laser line to reach the sample – and then the RazorEdge filter removes the laser line from the light scattered off of the sample, while efficiently transmitting desired light at wavelengths very close to the laser line.



Typical measured spectral curves of 785 nm filters on a linear transmission plot demonstrate how the incredibly steep edges and high transmission exhibited by both of these filters allow them to be spectrally positioned very close together, while still maintaining complementary transmission and blocking characteristics.

The optical density plot *(for explanation of OD, see page 101)* illustrates the complementary nature of these filters on a logarithmic scale using the theoretical design spectral curves. The MaxLine filter provides very high transmission (> 90%) of light immediately in the vicinity of the laser line, and then rapidly rolls off to achieve very high blocking (> OD 5) at wavelengths within 1% of the laser line. The RazorEdge filter provides extremely high blocking (> OD 6) of the laser line itself, and then rapidly climbs to achieve very high transmission (> 90%) of the desired signal light at wavelengths only 1% away from the laser line.



If you are currently using an E-grade RazorEdge filter and need a laser clean-up filter, please contact Semrock.

RazorEdge Dichroic™ Beamsplitters

The unique RazorEdge Dichroic beamsplitters exhibit unparalleled performance. Each filter reflects a standard laser line incident at 45° while efficiently passing the longer Raman-shifted wavelengths. They exhibit ultrasteep transition from reflection to transmission, far superior to anything else available on the open market. The guaranteed transition width of < 1% of the laser wavelength for U-grade (regardless of polarization) makes these filters a perfect match to our popular normal-incidence RazorEdge ultrasteep long-wave-pass filters. These beamsplitters are so innovative that they are patent pending.

Available as either mounted in 25 mm diameter x 3.5 mm thick black-anodized aluminum ring or unmounted as 25.2 x 35.6 x 1.1 mm

Laser Line	Transition Width	Passband	25 mm Mounted Part Number	Price	Unmounted Part Number	Price
488.0 nm	< 203 cm^{-1}	494.3 - 756.4 nm	LPD01-488RU-25	$545	LPD01-488RU-25x36x1.1	$765
	< 402 cm^{-1}	499.2 - 756.4 nm	LPD01-488RS-25	$375	LPD01-488RS-25x36x1.1	$465
514.5 nm	< 192 cm^{-1}	521.2 - 797.5 nm	LPD01-514RU-25	$545	LPD01-514RU-25x36x1.1	$765
	< 381 cm^{-1}	526.3 - 797.5 nm	LPD01-514RS-25	$375	LPD01-514RS-25x36x1.1	$465
532.0 nm	< 186 cm^{-1}	538.9 - 824.8 nm	LPD01-532RU-25	$545	LPD01-532RU-25x36x1.1	$765
	< 369 cm^{-1}	544.2 - 824.8 nm	LPD01-532RS-25	$375	LPD01-532RS-25x36x1.1	$465
632.8 nm	< 156 cm^{-1}	641.0 - 980.8 nm	LPD01-633RU-25	$545	LPD01-633RU-25x36x1.1	$765
	< 310 cm^{-1}	647.4 - 980.8 nm	LPD01-633RS-25	$375	LPD01-633RS-25x36x1.1	$465
785.0 nm	< 126 cm^{-1}	795.2 -1213.8 nm	LPD01-785RU-25	$545	LPD01-785RU-25x36x1.1	$765
	< 250 cm^{-1}	803.1 - 1213.8 nm	LPD01-785RS-25	$375	LPD01-785RS-25x36x1.1	$465
830.0 nm	< 119 cm^{-1}	840.8 - 1286.5 nm	LPD01-830RU-25	$545	LPD01-830RU-25x36x1.1	$765
	< 236 cm^{-1}	849.1 - 1286.5 nm	LPD01-830RS-25	$375	LPD01-830RS-25x36x1.1	$465
1064.0 mm	< 93 cm^{-1}	1077.8 - 1650.8 nm	LPD01-1064RU-25	$545	LPD01-1064RU-25x36x1.1	$765
	< 184 cm^{-1}	1088.5 - 1650.8 nm	LPD01-1064RS-25	$375	LPD01-1064RS-25x36x1.1	$465

See spectra graphs and ASCII data for all of our filters at www.semrock.com

Available in 1.1 mm thicknesses for microscopes

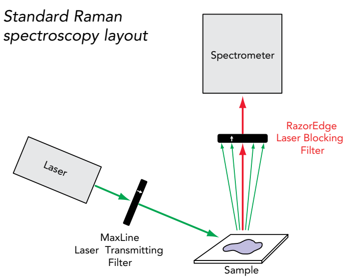
Technical Note

RazorEdge Filter Layouts

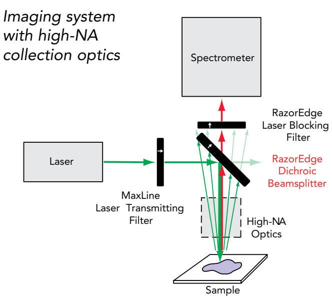
Only the unique RazorEdge Dichroic beamsplitter reflects a standard laser line incident at 45° while transmitting longer Raman-shifted wavelengths with an ultrasteep transition far superior to anything else available on the open market. The guaranteed transition width of < 1% of the laser wavelength for U-grade (regardless of polarization) makes these filters a perfect match to our popular normal-incidence RazorEdge ultrasteep long-wave-pass filters.

In order for the two-filter configuration to work, the 45° beamsplitter must be as steep as the laser-blocking filter. Traditionally thin-film filters could not achieve very steep edges at 45° because of the "polarization splitting" problem – the edge position tends to be different for different polarizations of light. However, through continued innovation in thin-film filter technology, Semrock has been able to achieve ultrasteep 45° beamsplitters with the same steepness of our renowned RazorEdge laser-blocking filters: the transition from the laser line to the passband of the filter is guaranteed to be less than 1% of the laser wavelength (for U-grade filters).

Standard Raman spectroscopy layout



Imaging system with high-NA collection optics



RazorEdge® Common Specifications

RazorEdge Specifications

Properties apply to all long-wave-pass and short-wave-pass edge filters unless otherwise noted

Property		Specification	Comment
Edge Steepness (typical)	"E-grade"	0.2% of laser wavelength	Measured from OD 6 to 50%; Up to 0.8% for 248-300 nm filters and 3.3% for 224 nm filter
	"U- & S-grades"	0.5% of laser wavelength	
Blocking at Laser Wavelength		> 6 OD	OD = – $\log_{10}$ (transmission)
Transition Width	"E-grade"	< 0.5% of laser wavelength	Measured from laser wavelength to 50% transmission wavelength; < 4.5% for 224 nm filter
	"U-grade"	< 1% of laser wavelength	
	"S-grade"	< 2% of laser wavelength	
Guaranteed Passband Transmission		> 93%	Except > 90% for 224 - 325 nm filters; Averaged over the Passband *(Passband wavelengths on page 86 for LWP and page 88 for SWP filters)*
Typical Passband Transmission		> 98%	
Angle of Incidence		0.0° ± 2.0°	Range for above optical specifications
Cone Half Angle		< 5°	Rays uniformly distributed about 0°
Angle Tuning Range [1]		– 0.3% of Laser Wavelength (-1.6 nm or + 60 cm^{-1} for 532 nm)	Wavelength "blue shift" attained by increasing angle from 0° to 8°
Laser Damage Threshold		0.5 J/cm^2 @ 266 nm 1 J/cm^2 @ 532 nm	10 ns pulse width Tested for 266 and 532 nm filters only *(see page 106)*
Clear Aperture		≥ 22 mm (or ≥ 45 mm)	
Outer Diameter		25.0 + 0.0 / – 0.1 mm (or 50.0 + 0.0 /-0.1 nm)	Black-anodized aluminum ring
Overall Thickness		3.5 ± 0.1 mm	Black-anodized aluminum ring (thickness measured unmounted)
Beam Deviation		≤ 10 arc seconds	

[1] For small angles (in degrees), the wavelength shift near the laser wavelength is $\Delta\lambda$ (nm) = – 5.0 x 10^{-5} x λ_L x θ^2 and the wavenumber shift is Δ(wavenumbers) (cm^{-1}) = 500 x θ^2 / λ_L, where λ_L (in nm) is the laser wavelength. See Wavenumbers Techincal Note on page 96.

Dichroic Beamsplitter Specifications

Property		Specification	Comment
Edge Steepness (typical)		0.5% of laser wavelength (2.5 nm or 90 cm^{-1} for 532 nm filter)	Measured from 5% to 50% transmission for light with average polarization
Transition Width	"U-grade"	< 1% of laser wavelength	Measured from laser wavelength to 50% transmission wavelength for light with average polarization
	"S-grade"	< 2% of laser wavelength	
Reflection at Laser Wavelength		> 98% (s-polarization) > 90% (p-polarization)	
Average Passband Transmission		> 93%	Averaged over the Passband (*Passband wavelengths detailed on page 89*)
Dependence of Wavelength on Angle of Incidence (Edge Shift)		0.35% / degree	Linear relationship valid between about 40° & 50°
Cone Half Angle (for non-collimated light)		< 0.5°	Rays uniformly distributed and centered at 45°
Size of Round Dichroics	Clear Aperture	≥ 22 mm	
	Outer Diameter	25.0 + 0.0 / – 0.1 mm	Black-anodized aluminum ring
	Overall Thickness	3.5 ± 0.1 mm	Black-anodized aluminum ring
Size of Rectangular Dichroics	Clear Aperture	> 80%	Elliptical
	Size	25.2 mm x 35.6 mm ± 0.1 mm	
	Unmounted Thickness	1.05 ± 0.05 mm	
Wedge Angle		≤ 20 arc seconds	
Flatness		Reflection of a collimated, gaussian laser beam with waist diameter up to 3 mm causes less than one Rayleigh Range of focal shift after a focusing lens.	

General Specifications (all RazorEdge filters)

Property	Specification	Comment
Coating Type	"Hard" ion-beam-sputtered	
Reliability and Durability	Ion-beam-sputtered, hard-coated technology with epoxy-free, single-substrate construction for unrivaled filter life. RazorEdge filters are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	
Transmitted Wavefront Error	< λ/ 4 RMS at λ = 633 nm	Peak-to-valley error <5 x RMS measured within clear aperture
Surface Quality	60-40 scratch-dig	
Temperature Dependence	< 5 ppm / °C	
Substrate Material	Ultra-low autofluorescence fused silica (NBK7 or equivalent for LP01 filters)	
Filter Orientation	For mounted filters, arrow on ring indicates preferred direction of propagation of transmitted light. For rectangular dichroics, reflective coating side should face toward light source and sample.	

Technical Note

Measurement of Optical Filter Spectra

Due to limitations of standard metrology techniques, the measured spectral characteristics of thin-film interference filters are frequently not determined accurately, especially when there are steep and deep edges. The actual blocking provided by an optical filter is determined not only by its designed spectrum, but also by physical imperfections of the filter, such as pinholes generated during the thin-film coating process, dirt and other surface defects, or flaws in the filter mounting. Generally commercially available spectrophotometers are used to measure the transmission and OD spectral performance of optical filters. However, these instruments can have significant limitations when the optical filters have high edge steepness and/or very deep blocking.

As a result of these limitations, three main discrepancies appear between an actual filter spectrum and its measured representation (see Fig. 1). The first discrepancy is the "rounding" of sharp spectral features. This effect results from the non-zero bandwidth of the spectrophotometer probe beam. The second measurement discrepancy arises from limited sensitivity of the spectrophotometer. The third discrepancy is unique to measurements of very steep transitions from high blocking to high transmission, and is referred to as a "sideband measurement artifact." This artifact arises from the non-monochromatic probe beam that also has weak sidebands at wavelengths outside of its bandwidth.

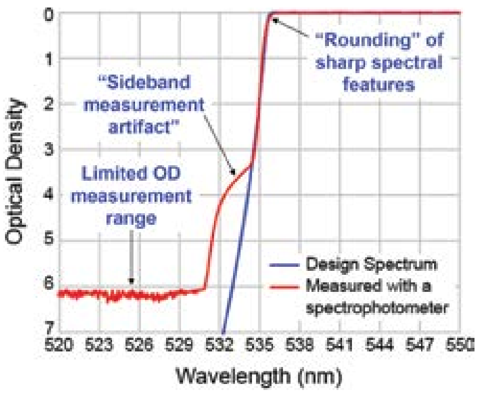


Figure 1: Measurement artifacts observed using a commmercial spectrophotometer.

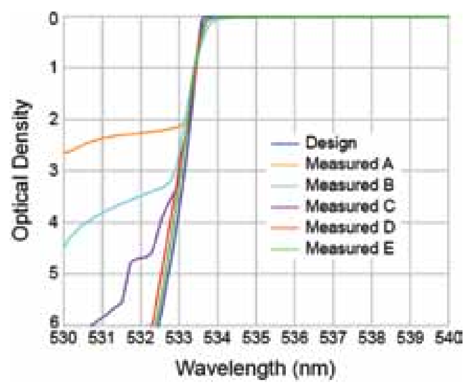


Figure 2: Design and measurement spectra of the same filter (specified in Fig. 1) using different measurement approaches as explained in the text.

Semrock utilizes different measurement approaches to evaluate filter spectra. As an example, Figure 2 shows five measured spectra of the steep edge of an "E-grade" RazorEdge® filter that is guaranteed to block a laser line at 532 nm with OD > 6 and transition to high transmission within 0.5% of the laser wavelength (by 534.7 nm). The measured spectra are overlaid on the design spectrum of the filter (blue line). As observed in this figure, choice of a particular measurement instrument and technique greatly influences the measured spectrum of a filter. Measurement method "A" in this graph is from a custom-built spectrophotometer. This measurement uses instrument settings – such as short detector integration time and low resolution – that are optimized for very rapid data collection from a large number of sample filters during thin-film filter manufacturing process. However this method has poor sensitivity and resolution. Measurement method "B" uses a standard commercial spectrophotometer (Perkin Elmer Lambda 900 series). All of the discrepancies between the actual filter spectrum and the measured spectrum as noted above are apparent in this measurement. Measurement methods "C" and "D" utilize the same custom-built spectrophotometer from method "A." The basic principle of operation of this spectrophotometer is shown in Fig. 3. This instrument uses a low-noise CMOS camera (i.e., detector array) capable of measuring a wide range of wavelengths simultaneously. Measurement method "C" uses instrument settings (primarily integration time and resolution) designed to provide enhanced measurement of the steep and deep edge. However, the "sideband measurement artifact" is still apparent. Measurement method "D" is a modification of method "C" that applies additional filtering to remove this artifact. Method "E" shows the results of a very precise measurement made with a carefully filtered 532 nm laser and angle tuning of the filter itself. Experimentally acquired transmission vs. angle data is converted into transmission vs. wavelength results, using a theoretical model. Clearly, this measurement method comes closest to the actual design curve; however it is not as suitable for quality assurance of large volumes of filters.

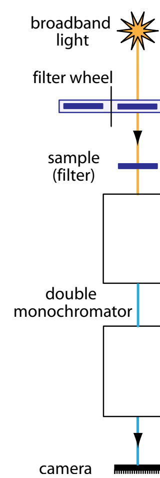


Figure 3: A custom-built spectrophotometer that enables faster and more accurate measurements

In summary, it is important to understand the measurement techniques used to generate optical filter spectra, as these techniques are not perfect. Use of the appropriate measurement approach for a given filter or application can reduce errors as well as over-design of experiments and systems that use filters, thus optimizing performance, results, and even filter cost.

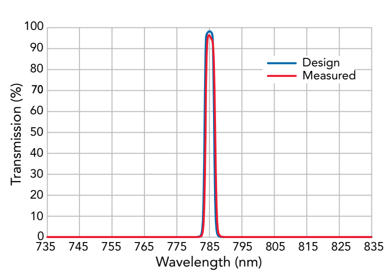
For additional information on this topic visit our website: www.semrock.com

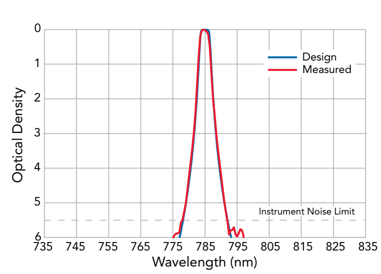
MaxLine® Laser-line Filters

Semrock MaxLine Laser-line Filters have an unprecedented high transmission exceeding 90% at the laser line, while rapidly rolling off to an optical density (OD) > 5 at wavelengths differing by only 1% from the laser wavelength, and OD > 6 at wavelengths differing by only 1.5% from the laser wavelength. U.S. patent No. 7,119,960.

- Highest laser-line transmission – stop wasting expensive laser light
- Steepest edges – perfect match to RazorEdge® U-grade filters *(see page 86)*
- Ideal complement to StopLine® deep notch filters for fluorescence and other applications *(see page 98)*
- Hard dielectric coatings for proven reliability and durability
- For diode lasers, use our MaxDiode™ Laser Clean-up filters *(see page 95)*

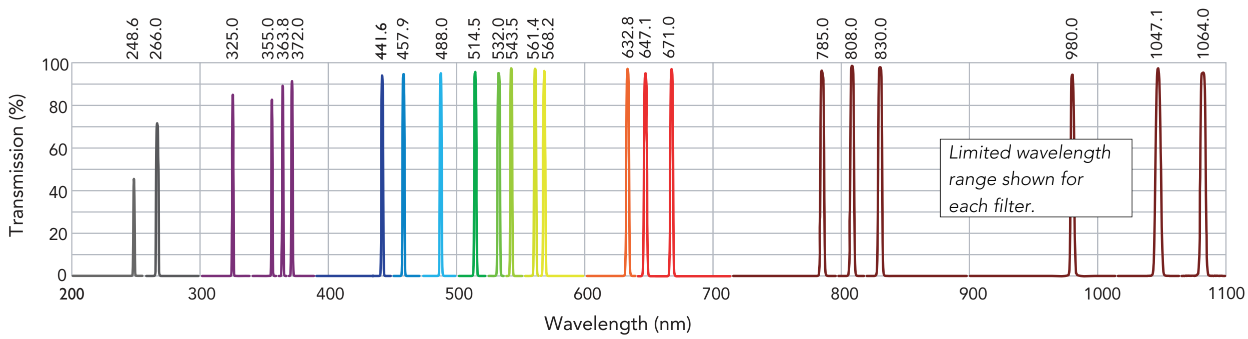
	Wavelength	Guaranteed Transmission	Typical Bandwidth	OD 5 Blue Range (nm)	OD 6 Blue Range (nm)	OD 6 Red Range (nm)	OD 5 Red Range (nm)	12.5 mm Diameter Part Number	25 mm Diameter Part Number
Ultraviolet	248.6 nm	> 40%	1.7 nm	228.2-246.1	228.7-244.9	252.3-273.5	251.1-279.9	LL01-248-12.5	LL01-248-25
	266.0 nm	> 55%	1.9 nm	242.8-263.3	244.7-262.0	270.0-292.6	268.7-302.2	LL01-266-12.5	LL01-266-25
	325.0 nm	> 80%	1.2 nm	291.0-321.8	299.0-320.1	329.9-357.5	328.3-380.7	LL01-325-12.5	LL01-325-25
	355.0 nm	> 80%	1.3 nm	314.8-351.5	326.6-349.7	360.3-390.5	358.6-422.5	LL01-355-12.5	LL01-355-25
	363.8 nm	> 85%	1.4 nm	321.7-360.2	334.7-358.3	369.3-400.2	367.4-435.0	LL01-364-12.5	LL01-364-25
	372.0 nm	> 85%	1.4 nm	328.1-368.3	342.0-366.4	377.6-409.2	375.7-446.8	LL01-372-12.5	LL01-372-25
Visible	441.6 nm	> 90%	1.7 nm	381.0-437.2	406.3-435.0	448.2-485.8	446.0-551.1	LL01-442-12.5	LL01-442-25
	457.9 nm	> 90%	1.7 nm	393.1-453.3	421.3-451.0	464.8-503.7	462.5-576.7	LL01-458-12.5	LL01-458-25
	488.0 nm	> 90%	1.9 nm	415.1-483.1	449.0-480.7	495.3-536.8	492.9-625.3	LL01-488-12.5	LL01-488-25
	491.0 nm	> 90%	1.9 nm	417.2-486.1	451.7-483.6	498.4-540.1	495.9-630.3	LL01-491-12.5	LL01-491-25
	514.5 nm	> 90%	2.0 nm	434.1-509.4	473.3-506.8	522.2-566.0	519.6-669.5	LL01-514-12.5	LL01-514-25
	532.0 nm	> 90%	2.0 nm	446.5-526.7	489.4-524.0	540.0-585.2	537.3-699.4	LL01-532-12.5	LL01-532-25
	543.5 nm	> 90%	2.1 nm	454.6-538.1	500.0-535.3	551.7-597.9	548.9-719.5	LL01-543-12.5	LL01-543-25
	561.4 nm	> 90%	2.1 nm	467.0-555.8	516.5-553.0	569.8-617.5	567.0-751.2	LL02-561-12.5	LL02-561-25
	568.2 nm	> 90%	2.2 nm	471.7-562.5	522.7-559.7	576.7-625.0	573.9-763.4	LL01-568-12.5	LL01-568-25
	632.8 nm	> 90%	2.4 nm	515.4-626.5	582.2-623.3	642.3-696.1	639.1-884.7	LL01-633-12.5	LL01-633-25
	647.1 nm	> 90%	2.5 nm	524.8-640.6	595.3-637.4	656.8-711.8	653.6-912.9	LL01-647-12.5	LL01-647-25
	671.0 nm	> 90%	2.6 nm	540.4-664.3	617.3-660.9	681.1-738.1	677.7-961.2	LL01-671-12.5	LL01-671-25
Near-Infrared	780.0 nm	> 90%	3.0 nm	609.0-772.2	717.6-768.3	791.7-858.0	787.8-1201.8	LL01-780-12.5	LL01-780-25
	785.0 nm	> 90%	3.0 nm	612.0-777.2	722.2-773.2	796.8-863.5	792.9-1213.8	LL01-785-12.5	LL01-785-25
	808.0 nm	> 90%	3.1 nm	625.9-799.9	743.4-795.9	820.1-888.8	816.1-1033.5	LL01-808-12.5	LL01-808-25
	830.0 nm	> 90%	3.2 nm	639.1-821.7	763.6-817.6	842.5-913.0	838.3-1067.9	LL01-830-12.5	LL01-830-25
	852.0 nm	> 90%	3.2 nm	652-843.5	783.8-839.2	864.8-937.2	860.5-1106.6	LL01-852-12.5	LL01-852-25 NEW
	976.0 nm	> 90%	3.7 nm	722.2-966.2	897.9-961.4	990.6-1073.6	985.8-1325.2	LL01-976-12.5	LL01-976-25
	980.0 nm	> 90%	3.7 nm	724.4-970.2	901.6-965.3	994.7-1078.0	989.8-1332.6	LL01-980-12.5	LL01-980-25
	1047.1 nm	> 90%	4.0 nm	963.3-1036.6	963.3-1031.4	1062.8-1151.8	1057.6-1398.6	LL01-1047-12.5	LL01-1047-25
	1064.0 nm	> 90%	4.0 nm	978.9-1053.4	978.9-1048.0	1080.0-1170.4	1074.6-1428.9	LL01-1064-12.5	LL01-1064-25
							Price	$295	$590



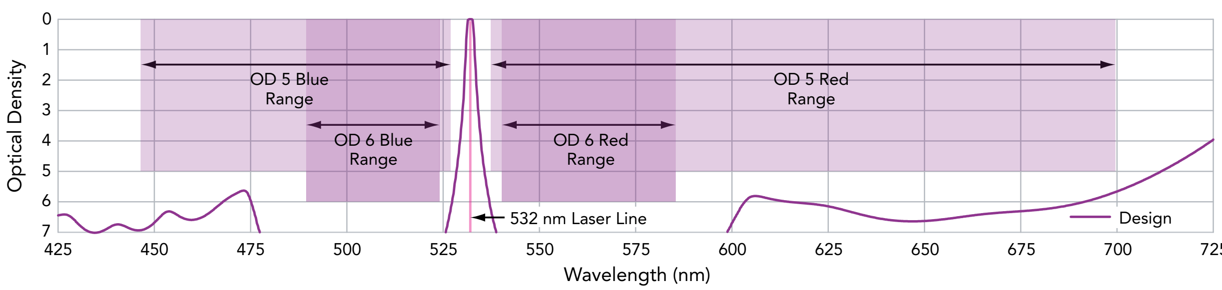


These graphs demonstrate the outstanding performance of the 785 nm MaxLine laser-line filter, which has transmission guaranteed to exceed 90% at the laser line and OD > 5 blocking less than 1% away from the laser line. Note the excellent agreement with the design curves.

Actual measured data from typical filters shown



MaxLine Filter Blocking Performance *(532 nm filter shown)*



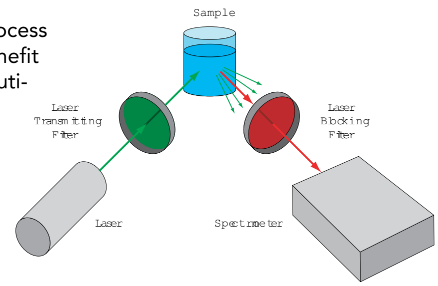
Common Specifications

Property		Value	Comment
Laser Wavelength λ_L		Standard laser wavelengths available	*See page 92*
Transmission at Laser Line		> 90%	Except λ_L < 400 nm; Will typically be even higher
Bandwidth	Typical	0.38% of λ_L	Full Width at Half Maximum (FWHM) Typical 0.7% and Maximum 0.9% for 248.6 & 266 nm
	Maximum	0.7% of λ_L	
Blocking[1]		OD > 5 from λ_L ± 1% to 4500 cm^{-1} (red shift) and 3600 cm^{-1} (blue shift); OD > 6 from λ_L ± 1.5% to 0.92 and 1.10 × λ_L	OD = – $\log_{10}$ (Transmission)
Angle of Incidence		0.0° ± 2.0°	*See technical note on page 102*
Temperature Dependence		< 5 ppm / °C	< 0.003 nm / °C for 532 nm filter
Laser Damage Threshold		0.1 J/cm^2 @ 532 nm (10 ns pulse width)	Tested for 532 nm filter only *(see page 106)*
Substrate Material		Low autofluorescence NBK7 or better	Fused silica for 248.6, 266, and 325 nm filters
Substrate Thickness		2.0 ± 0.1 mm	
Overall Thickness		3.5 ± 0.1 mm	Black-anodized aluminum ring
Coating Type		"Hard" ion-beam-sputtered	
Outer Diameter		12.5 + 0.0 / – 0.1 mm (or 25.0 + 0.0 / – 0.1 mm)	Black-anodized aluminum ring
Clear Aperture		≥ 10 mm (or ≥ 22 mm)	For all optical specifications
Transmitted Wavefront Error		< λ / 4 RMS at λ = 633 nm	Peak-to-valley error < 5 × RMS
Beam Deviation		≤ 11 arc seconds	
Surface Quality		60-40 scratch-dig	Measured within clear aperture
Reliability and Durability		Ion-beam-sputtered, hard-coating technology with epoxy-free, single-substrate construction for unrivaled filter life. MaxLine filters are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	

[1] The wavelengths associated with these red and blue shifts are given by $\lambda = 1/(1/\lambda_L - \text{red shift} \times 10^{-7})$ and $\lambda = 1/(1/\lambda_L + \text{blue shift} \times 10^{-7})$, respectively, where λ and λ_L are in nm, and the shifts are in cm^{-1}. Note that the red shifts are 3600 cm^{-1} for the 808 and 830 nm filters and 2700 cm^{-1} for the 980 nm filter, and the red and blue shifts are 2400 and 800 cm^{-1}, respectively, for the 1047 and 1064 nm filters. *See Technical Note on wavenumbers on page 96.*

Technical Note

Filter Types for Raman Spectroscopy Applications



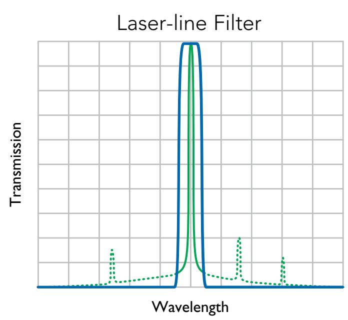
Raman spectroscopy is widely used today for applications ranging from industrial process control to laboratory research to bio/chemical defense measures. Industries that benefit from this highly specific analysis technique include the chemical, polymer, pharmaceutical, semiconductor, gemology, computer hard disk, and medical fields. In Raman spectroscopy, an intense laser beam is used to create Raman (inelastic) scattered light from a sample under test. The Raman "finger print" is measured by a dispersive or Fourier Transform spectrometer.

There are three basic types of Raman instrumentation. Raman microscopes, also called micro-Raman spectrophotometers, are larger-scale laboratory analytical instruments for making fast, high-accuracy Raman measurements on very small, specific sample areas. Traditional laboratory Raman spectrometers are primarily used for R&D applications, and range from "home-built" to flexible commercial systems that offer a variety of laser sources, means for holding solid and liquid samples, and different filter and spectrometer types. Finally, a rapidly emerging class of Raman instrumentation is the Raman micro-probe analyzer. These complete, compact and often portable systems are ideal for use in the field or in tight manufacturing and process environments. They utilize a remote probe tip that contains optical filters and lenses, connected to the main unit via optical fiber.

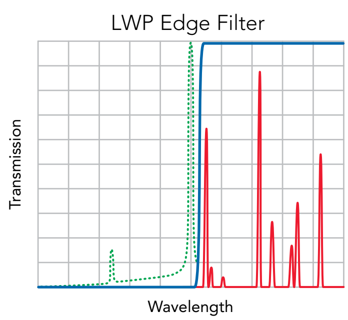
Optical filters are critical components in Raman spectroscopy systems to prevent all undesired light from reaching the spectrometer and swamping the relatively weak Raman signal. Laser Transmitting Filters inserted between the laser and the sample block all undesired light from the laser (such as broadband spontaneous emission or plasma lines) as well as any Raman scattering or fluorescence generated between the laser and the sample (as in a fiber micro-probe system). Laser Blocking Filters inserted between the sample and the spectrometer block the Rayleigh (elastic) scattered light at the laser wavelength.

The illustration above shows a common system layout in which the Raman emission is collected along a separate optical path from the laser excitation path. Systems designed for imaging (e.g., Raman microscopy systems) or with remote fiber probes are often laid out with the excitation and emission paths coincident, so that both may take advantage of the the same fiber and lenses *(see Technical Note on page 83)*.

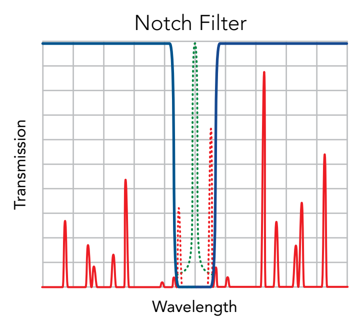
There are three basic types of filters used in systems with separate excitation and emission paths: Laser-line filters, Edge Filters, and Notch Filters. The examples below show how the various filters are used. In these graphs the blue lines represent the filter transmission spectra, the green lines represent the laser spectrum, and the red lines represent the Raman signal (not to scale).



Laser-transmitting filter for both Stokes and Anti-Stokes measurements



Laser-blocking steep edge filter for superior Stokes measurements



Versatile laser-blocking notch filter for both Stokes and Anti-Stokes measurements

Laser-Line Filters are ideal for use as Laser Transmitting Filters, and Notch Filters are an obvious choice for Laser Blocking Filters. In systems using these two filter types, both Stokes and Anti-Stokes Raman scattering can be measured simultaneously. However, in many cases Edge Filters provide a superior alternative to notch filters. For example, a long-wave-pass (LWP) Edge Filter used as a Laser Blocking Filter for measuring Stokes scattering offers better transmission, higher laser-line blocking, and the steepest edge performance to see Raman signals extremely close to the laser line. For more details on choosing between edge filters and notch filters, *see the Technical Note "Edge Filters vs. Notch Filters for Raman Instrumentation" on page 101.*

In systems with a common excitation and emission path, the laser must be introduced into the path with an optic that also allows the Raman emission to be transmitted to the detection system. A 45° dichroic beamsplitter is needed in this case. If this beamsplitter is not as steep as the edge filter or laser-line filter, the ability to get as close to the laser line as those filters allow is lost.

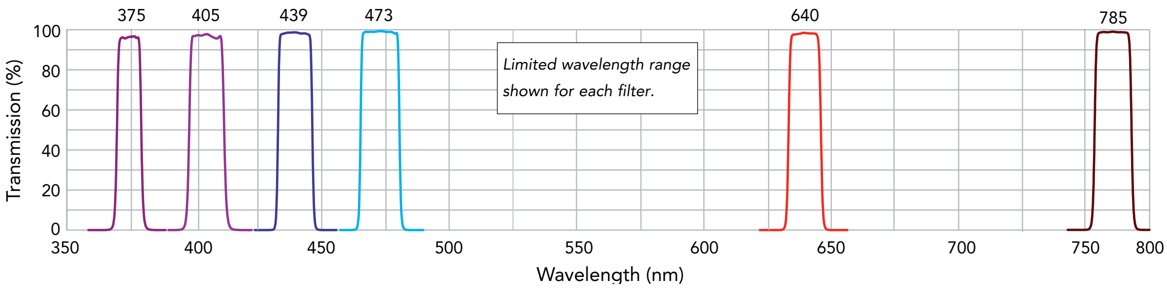
Semrock manufactures high-performance MaxLine® Laser-line filters *(page 95)*, RazorEdge® long-wave-pass and short-wave-pass filters *(page 86*, EdgeBasic™ value long-wave-pass filters *(page 84)*, ultrasteep RazorEdge Dichroic™ beamsplitter filters *(page 89*, and StopLine® notch filters *(page 98)* as standard catalog products. Non-standard wavelengths and specifications for these filters are routinely manufactured for volume OEM applications.

Our MaxDiode filters are ideal for both volume OEM manufacturers of laser-based fluorescence instrumentation and laboratory researchers who use diode lasers for fluorescence excitation and other types of spectroscopic applications. Keep the desirable laser light while eliminating the noise with MaxDiode filters.

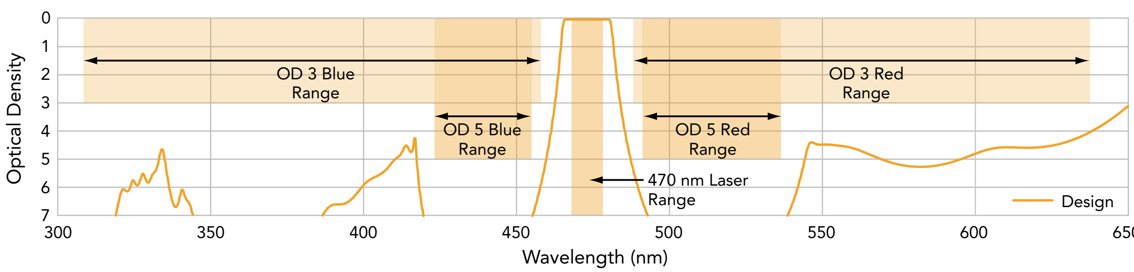
- **Square low-ripple passband** for total consistency as the laser ages, over temperature, or when replacing a laser
- Highest transmission, exceeding 90% over each diode's possible laser wavelengths
- Extremely steep edges transitioning to very high blocking to filter out the undesired out-of-band noise
- For narrow-line lasers, use our MaxLine® laser-line filters *(see page 92)*

Laser Diode Wavelength	Transmission & Bandwidth	Center Wavelength	OD 3 Blocking Range	OD 5 Blocking Range	12.5 mm Part Number	25 mm Part Number
375 nm	> 90% over 6 nm	375 nm	212-365 & 385-554 nm	337-359 & 393-415 nm	LD01-375/6-12.5	LD01-375/6-25
405 nm	> 90% over 10 nm	405 nm	358-389 & 420-466 nm	361-384 & 428-457 nm	LD01-405/10-12.5	LD01-405/10-25
440 nm	> 90% over 8 nm	439 nm	281-425 & 453-609 nm	392-422 & 456-499 nm	LD01-439/8-12.5	LD01-439/8-25
470 nm	> 90% over 10 nm	473 nm	308-458 & 488-638 nm	423-455 & 491-537 nm	LD01-473/10-12.5	LD01-473/10-25
640 nm	> 90% over 8 nm	640 nm	400-625 & 655-720 nm	580-622 & 658-717 nm	LD01-640/8-12.5	LD01-640/8-25
785 nm	> 90% over 10 nm	785 nm	475-768 & 800-888 nm	705-765 & 803-885 nm	LD01-785/10-12.5	LD01-785/10-25
				Price	$250	$500

Actual measured data shown



MaxDiode Filter Blocking Performance *(470 nm filter shown)*

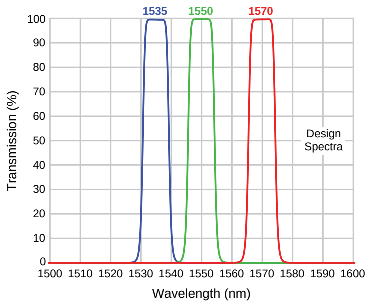


Common Specifications

Property	Value	Comment
Transmission over Full Bandwidth	> 90%	Will typically be even higher
Transmission Ripple	< ± 1.5%	Measured peak-to-peak across bandwidth
Blocking Wavelength Ranges	Optimized to eliminate spontaneous emission	*See table above*
Angle of Incidence	0.0° ± 5.0°	Range for above optical specifications
Performance for Non-collimated Light	The high-transmission portion of the long-wavelength edge and the low-transmission portion of the short-wavelength edge exhibit a small "blue shift" (shift toward shorter wavelengths). Even for cone half angles as large as 15° at normal incidence, the blue shift is only several nm.	

All other mechanical specifications are the same as MaxLine® specifications on page 93.

Near Infrared Bandpass Filters



Semrock's industry-leading ion-beam-sputtering manufacturing is now available for making optical filters with precise spectral features (sharp edges, passbands, etc.) at near-IR wavelengths, with features out to ~ 1700 nm, and high transmission to wavelengths > 2000 nm. The bandpass filters on this page are ideal as laser source clean-up filters and as detection filters which pass particular laser wavelengths and virtually eliminate background over the full InGaAs detector range (850 – 1750 nm). They are optimized for the most popular "retina-safe" lasers in the 1.5 µm wavelength range, where maximum permissible eye exposures are much higher than in the visible or at the 1.06 µm neodymium line. Applications include laser radar, remote sensing, rangefinding, and laser-induced breakdown spectroscopy (LIBS).

Near-IR bandpass filters are a good match for Er-doped fiber and Er-doped glass lasers at 1535 nm, r-doped fiber and InGaAsP semiconductor lasers at 1550 nm, and Nd:YAG-pumped optical parametric oscillators (OPO's) at 1570 nm.

Center Wavelength	Transmission & Bandwidth	Nominal Full-width, Half-Maximum	OD 5 Blocking Range	OD 6 Blocking Range	Part Number	Price
1535 nm	> 90% over 3 nm	6.8 nm	850 – 1519 nm 1550 – 1750 nm	1412 – 1512 nm 1558 – 1688 nm	NIR01-1535/3-25	$395
1550 nm	> 90% over 3 nm	8.8 nm	850 – 1534 nm 1565 – 1750 nm	1426 – 1526 nm 1573 – 1705 nm	NIR01-1550/3-25	$395
1570 nm	> 90% over 3 nm	8.9 nm	850 – 1554 nm 1585 – 1750 nm	1444 – 1546 nm 1593 – 1727 nm	NIR01-1570/3-25	$395
LDT specification = 1J/cm² @1570 nm (10ns pulse width)						

Except for the transmission, bandwidth, and blocking specifications listed above, all other specifications are identical to MaxLine® specifications on page 93.

For graphs, ASCII data and blocking information, go to www.semrock.com

Technical Note

Measuring Light with Wavelengths and Wavenumbers

The "color" of light is generally identified by the distribution of power or intensity as a function of wavelength λ.
For example, visible light has a wavelength that ranges from about 400 nm to just over 700 nm. However, sometimes it is convenient to describe light in terms of units called "wavenumbers," where the wavenumber w is typically measured in units of cm^{-1} ("inverse centimeters") and is simply equal to the inverse of the wavelength:

$$w\left(\text{cm}^{-1}\right)=\frac{10^7}{\lambda\ (\text{nm})}$$

In applications like Raman spectroscopy, often both wavelength and wavenumber units are used together, leading to potential confusion. For example, laser lines are generally identified by wavelength, but the separation of a particular Raman line from the laser line is generally given by a "wavenumber shift" Δw, since this quantity is fixed by the molecular properties of the material and independent of which laser wavelength is used to excite the line.

When speaking of a "shift" from a first known wavelength λ_1 to a second known wavelength λ_2, the resulting wavelength shift $\Delta\lambda$ is given by

$$\Delta\lambda = \lambda_2 - \lambda_1$$

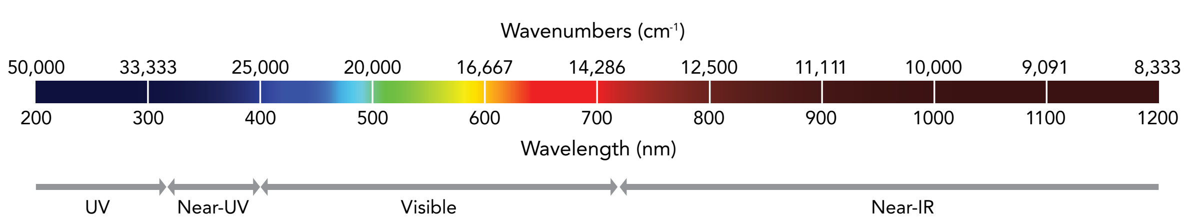
whereas the resulting wavenumber shift Δw is given by

$$\Delta w = \left(\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right)\times 10^7 = -\frac{\Delta\lambda}{\lambda_1\lambda_2}\times 10^7$$

When speaking of a known wavenumber shift Δw from a first known wavelength λ_1, the resulting second wavelength λ_2 is given by

$$\lambda_2 = \frac{1}{1/\lambda_1 + \Delta w \times 10^{-7}}$$

Note that when the final wavelength λ_2 is longer than the initial wavelength λ_1, which corresponds to a "red shift," in the above equations $\Delta w < 0$, consistent with a shift toward smaller values of w. However, when the final wavelength λ_2 is shorter than the initial wavelength λ_1, which corresponds to a "blue shift," $\Delta w > 0$, consistent with a shift toward larger values of w.



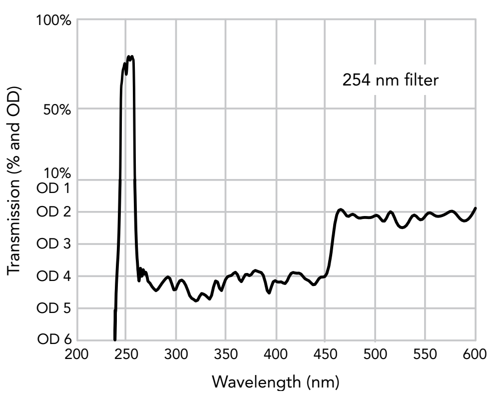
MaxLamp™ Mercury Line Filters

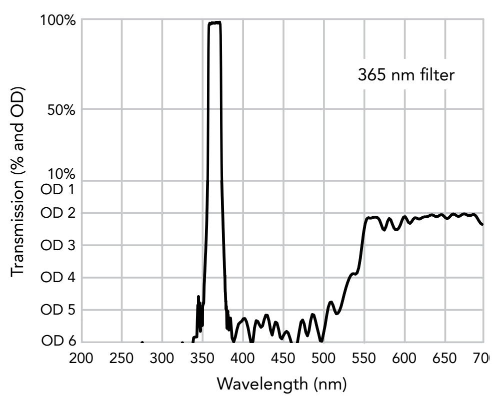
These ultrahigh-performance MaxLamp mercury line filters are ideal for use with high-power mercury arc lamps for applications including spectroscopy, optical metrology, and photolithography mask-aligner and stepper systems. Maximum throughput is obtained by careful optimization of the filter design to allow for use in a variety of different applications. The non-absorbing blocking ensures that all other mercury lines as well as intra-line intensity are effectively eliminated.

- High transmission > 65% in the UV and > 93% in the Near-UV
- Steep edges for quick transitions
- Exceptional blocking over large portions of visible spectrum

Mercury Line	Transmission and Passband	UV Blocking	Blue Blocking	Red Blocking	25 mm Diameter Part Number	Price	50 mm Diameter Part Number	Price
253.7 nm	> 65% 244 - 256 nm	OD_{avg} > 6: 200 - 236 nm	OD_{avg} > 4: 263 - 450 nm	OD_{avg} > 2: 450 - 600 nm	Hg01-254-25	$425	Hg01-254-50	$995
365.0 nm	> 93% 360 - 372 nm	OD_{avg} > 6: 200 - 348 nm	OD_{avg} > 5: 382 - 500 nm	OD_{avg} > 2: 500 - 700 nm	Hg01-365-25	$295	Hg01-365-50	$695

Actual measured data shown





Common Specifications

Property	Value		Comment
Guaranteed Transmission	253.7 nm	> 65%	Averaged over the passband, *see table above*
	365.0 nm	> 93%	
Angle of Incidence	0˚ ± 7˚		Range of angles over which optical specifications are given for collimated light
Cone Half Angle	10˚		For uniformly distributed non-collimated light
Autofluorescence	Ultra-low		Fused silica substrate
Outer Diameter	25.0 + 0.0 / - 0.1 mm (or 50.0 + 0.0 / -0.1 mm)		Black anodized aluminium ring
Overall Thickness	3.5 mm ± 0.1mm		Black anodized aluminium ring
Clear Aperture	≥ 22 mm (or ≥ 45 mm)		For all optical specifications
Surface Quality	80-50 scratch-dig		Measured within clear aperture

All other mechanical specifications are the same as MaxLine® specifications on page 93

Polarizers
Edge Filters
Dichroic Beamsplitters
Laser-line Filters
Laser Diode Filters
NIR Filters
Lamp Clean-up Filters
Notch Filters
Mirrors

StopLine® Single-notch Filters

StopLine deep notch filters rival the performance of holographic notch filters but in a less expensive, more convenient, and more reliable thin-film filter format (U.S. Patents No. 7,123,416 and pending). These filters are ideal for applications including Raman spectroscopy, laser-based fluorescence instruments, and biomedical laser systems.

- The stunning StopLine E-grade notch filters offer high transmission over ultra-wide passbands (UV to 1600 nm)
- Deep laser-line blocking for maximum laser rejection (OD > 6)
- High laser damage threshold and proven reliability
- Rejected light is reflected, for convenient alignment and best stray-light control
- Multi-notch filters are available for blocking multiple laser lines (*see page 100*)

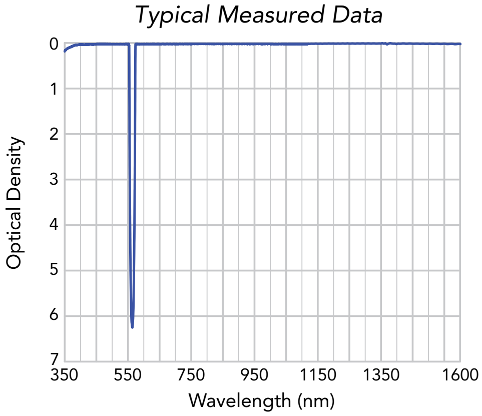
Semrock introduced a breakthrough invention in thin-film optical filters: our StopLine "E-grade" thin-film notch filters have ultrawide passbands with deep and narrow laser-line blocking. Unheard of previously in a thin-film notch filter made with multiple, discrete layers, these new patent-pending notch filters attenuate the laser wavelength with OD > 6 while passing light from the UV well into the near-infrared (1600 nm). They are especially suited for optical systems addressing multiple regions of the optical spectrum (e.g., UV, Visible, and Near-IR), and for systems based on multiple detection modes (e.g., fluorescence, Raman spectroscopy, laser-induced breakdown spectroscopy, etc.).

Wavelength	Passband Range	Typical 50% Notch Bandwidth	Laser-line Blocking	Part Number	Price
405.0 nm	330.0 – 1600.0 nm	9 nm	OD > 6	NF03-405E-25	$795
488.0 nm	350.0 – 1600.0 nm	14 nm	OD > 6	NF03-488E-25	$795
514.5 nm	350.0 – 1600.0 nm	16 nm	OD > 6	NF03-514E-25	$795
532.0 nm	350.0 – 1600.0 nm 399.0 – 709.3 nm	17 nm 17 nm	OD > 6 OD > 6	NF03-532E-25 NF01-532U-25	$795 $625
561.4 nm	350.0 – 1600.0 nm	19 nm	OD > 6	NF03-561E-25	$795
594.1 nm	350.0 – 1600.0 nm	22 nm	OD > 6	NF03-594E-25	$795
632.8 nm	350.0 – 1600.0 nm	25 nm	OD > 6	NF03-633E-25	$795
658.0 nm	350.0 – 1600.0 nm	27 nm	OD > 6	NF03-658E-25	$795
785.0 nm	350.0 – 1600.0 nm	39 nm	OD > 6	NF03-785E-25	$795
808.0 nm	350.0 – 1600.0 nm	41 nm	OD > 6	NF03-808E-25	$795

Looking for a 1064 nm notch filter? Try the NF03-532/1064E on page 100.

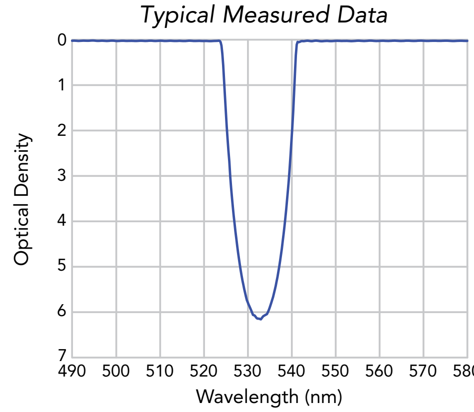
NF03-561E

Typical Measured Data



NF03-532E

Typical Measured Data



StopLine® Single-notch Filter Common Specifications

Property		Value	Comment
Laser Line Blocking:	"E" &"U" grade	> 6 OD	At the design laser wavelength; OD = – $\log_{10}$ (transmission)
Typical 50% Notch Bandwidth	"E" &"U" grade	NBW = 55 × 10^{-6} × λ_L^2 + 14 × 10^{-3} × λ_L – 5.9 e.g. 17 nm (600 cm^{-1}) for 532.0 nm filter	Full width at 50% transmission; λ_L is design laser wavelength (NBW and λ_L in nm)
Maximum 50% Notch Bandwidth		< 1.1 × NBW	
90% Notch Bandwidth		< 1.3 × NBW [1]	Full width at 90% transmission
Passband	"E" grade	350 –1600 nm	Excluding notch λ_L is design laser wavelength (nm)
	"U" grade	from 0.75 × λ_L to λ_L / 0.75 [1]	
Average Passband Transmission	"E" grade	> 80% 350 – 400 nm, > 93% 400 – 1600 nm	Excluding notch Lowest wavelength is 330 nm for NF03-405E
	"U" grade	> 90%	
Passband Transmission Ripple		< 2.5%	Calculated as standard deviation
Angle of Incidence		0.0° ± 5.0°	*See technical note on page 102*
Angle Tuning Range [2]		– 1% of laser wavelength (– 5.3 nm or + 190 cm^{-1} for 532 nm filter)	Wavelength "blue-shift" attained by increasing angle from 0° to 14°
Laser Damage Threshold		1 J/cm^2 @ 532 nm (10 ns pulse width)	Tested for 532 nm filter only (*see page 106)*
Coating Type		"Hard" ion-beam-sputtered	
Clear Aperture		≥ 22 mm	For all optical specifications
Outer Diameter		25.0 + 0.0 / – 0.1 mm	Black-anodized aluminum ring
Overall Thickness		3.5 ± 0.1 mm	Black-anodized aluminum ring

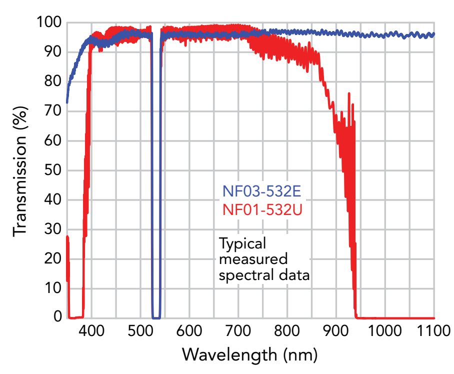
All other General Specifications are the same as the RazorEdge® specifications on page 90.

[1] For NF03-405 filter, 90% bandwidth is < 1.3 × Maximum 50% Bandwidth, and Passband short wavelength is 330 nm.

[2] For small angles θ (in degrees), the wavelength shift near the laser wavelength is $\Delta\lambda$ (nm) = – 5.0 × 10^{-5} × λ_L × θ^2 and the wavenumber shift is Δ(wavenumbers) (cm^{-1}) = 500 × θ^2 / λ_L, where λ_L (in nm) is the laser wavelength. See Technical Note on wavenumbers on page 96.

Product Note

Notch filters are ideal for applications that require nearly complete rejection of a laser line while passing as much non-laser light as possible. Hard-coated thin-film notch filters offer a superior solution due to their excellent transmission (> 90%), deep laser-line blocking (OD > 6) with a narrow notch bandwidth (~ 3% of the laser wavelength), environmental reliability, high laser damage threshold (> 1 J/cm^2), and compact format with convenient back-reflection of the rejected laser light. However, until now, the main drawback of standard thin-film notch filters has been a limited passband range due to the fundamental and higher-harmonic spectral stop bands (see red curve on graph at right).



To achieve a wider passband than standard thin-film notch filters could provide, optical engineers had to turn to "holographic" or "Rugate" notch filters. Unfortunately, holographic filters suffer from lower reliability and transmission (due to the gelatin-based, laminated structure), higher cost (resulting from the sequential production process), and poorer system noise performance and/or higher system complexity. Rugate notch filters, based on a sinusoidally varying index of refraction, generally suffer from lower transmission, especially at shorter wavelengths, and less deep notches.

StopLine® Multi-notch Filters

Semrock's unique multi-notch filters meet or exceed even the most demanding requirements of our OEM customers. These include dual-, triple-, and even quadruple-notch filters for a variety of multi-laser instruments. Applications include:

- Laser-based fluorescence instruments
- Confocal and multi-photon fluorescence microscopes
- Analytical and medical laser systems

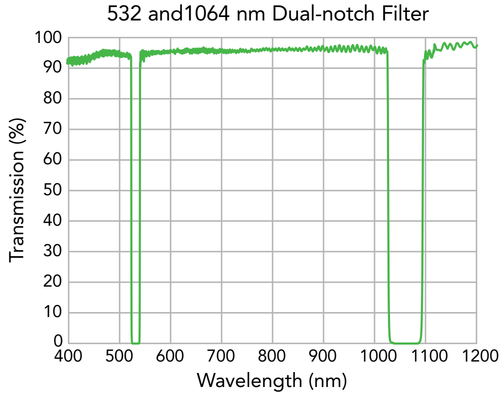
Our advanced manufacturing process means that these filters can be made with notch wavelengths that are not integer multiples of each other!

Laser Wavelengths	Laser-line Blocking	Part Number	Dimensions	Price
Dual-notch Filters				
488 & 532 nm	OD > 6	NF01-488/532-25x5.0	25 mm x 5.0 mm	$875
488 & 543 nm	OD > 6	NF01-488/543-25x5.0	25 mm x 5.0 mm	$875
486 – 490 & 631 – 640 nm	OD > 4	NF01-488/635-25x5.0	25 mm x 5.0 mm	$775
488 & 647 nm	OD > 6	NF01-488/647-25x5.0	25 mm x 5.0 mm	$875
532 & 1064 nm	OD > 6	NF03-532/1064E-25	25 mm x 3.5 mm	$875
543 & 647 nm	OD > 6	NF01-543/647-25x5.0	25 mm x 5.0 mm	$875
568 & 638 nm	OD > 6	NF01-568/638-25x5.0	25 mm x 5.0 mm	$875
568 & 647 nm	OD > 6	NF01-568/647-25x5.0	25 mm x 5.0 mm	$875
594 & 638 nm	OD > 6	NF01-594/638-25x5.0	25 mm x 5.0 mm	$875
Triple-notch Filters				
488, 532, & 631-640 nm	OD > 4	NF01-488/532/635-25x5.0	25 mm x 5.0 mm	$875
Quadruple-notch Filters				
400 – 410, 488, 532, & 631 – 640 nm	OD > 4	NF01-405/488/532/635-25x5.0	25 mm x 5.0 mm	$995
400 – 410, 488, 561, & 631 – 640 nm	OD > 4	NF01-405/488/561/635-25x5.0	25 mm x 5.0 mm	$995
400– 410, 488 – 490, 555 – 559, & 640 nm	OD > 4	NF01-405/488/557/640-25x5.0-D	25 mm x 5.0 mm	$995

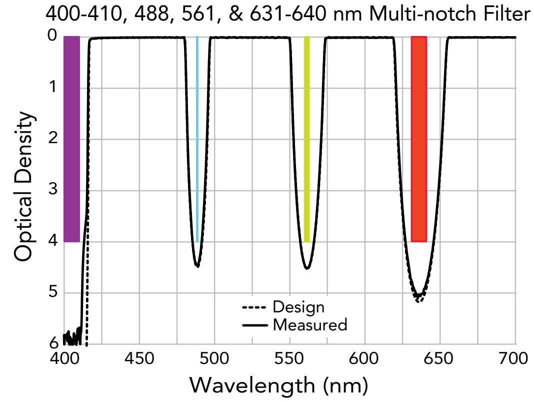
For Multi-notch common specifications, please see www.semrock.com for full details.

Actual measured data from typical filters is shown

532 and1064 nm Dual-notch Filter



400-410, 488, 561, & 631-640 nm Multi-notch Filter

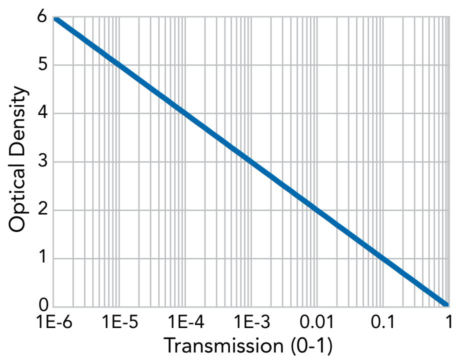


For complete graphs, ASCII data, and the latest offerings, go to www.semrock.com.

Technical Note

Working with Optical Density

Optical Density – or OD, as it is commonly called – is a convenient tool to describe the transmission of light through a highly blocking optical filter (when the transmission is extremely small). OD is simply defined as the negative of the logarithm (base 10) of the transmission, where the transmission varies between 0 and 1 ($OD = -\log_{10}(T)$). Therefore, the transmission is simply 10 raised to the power of minus the OD ($T = 10^{-OD}$). The graph below left demonstrates the power of OD: a variation in transmission of six orders of magnitude (1,000,000 times) is described very simply by OD values ranging between 0 and 6. The table of examples below middle, and the list of "rules" below right, provide some handy tips for quickly converting between OD and transmission. Multiplying and dividing the transmission by two and ten is equivalent to subtracting and adding 0.3 and 1 in OD, respectively.



Transmission	OD
1	0
0.5	0.3
0.2	0.7
0.1	1.0
0.05	1.3
0.02	1.7
0.01	2.0
0.005	2.3
0.002	2.7
0.001	3.0

The "1" Rule
T = 1 → OD = 0

The "x 2" Rule
T x 2 → OD – 0.3

The "÷ 2" Rule
T ÷ 2 → OD + 0.3

The "x 10" Rule
T x 10 → OD – 1

The "÷ 10" Rule
T ÷ 10 → OD + 1

Technical Note

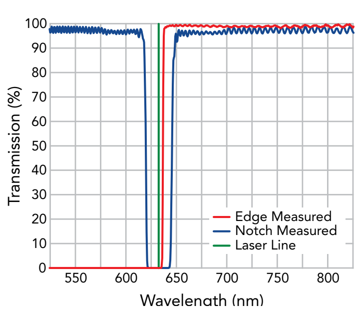
Edge Filters vs. Notch Filters for Raman Instrumentation

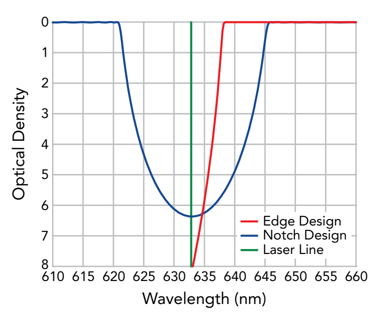
RazorEdge® Filter Advantages:
- Steepest possible edge for looking at the smallest Stokes shifts
- Largest blocking of the laser line for maximum laser rejection

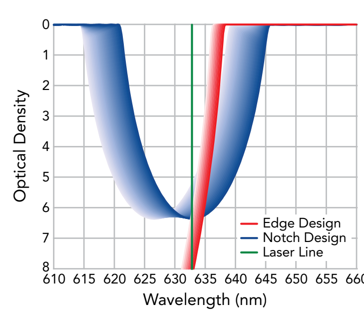
StopLine® Notch Filter Advantages:
- Measure Stokes and Anti-Stokes signals simultaneously
- Greater angle-tunability and bandwidth for use with variable laser lines

The graph below left illustrates the ability of a long-wave-pass (LWP) filter to get extremely close to the laser line. The graph in the center compares the steepness of an edge filter to that of a notch filter. A steeper edge means a narrower transition width from the laser line to the high-transmission region of the filter. With transition widths guaranteed to be below 1% of the laser wavelength (on Semrock U-grade edge filters), these filters don't need to be angle-tuned!

The graph on the right shows the relative tuning ranges that can be achieved for edge filters and notch filters. Semrock edge filters can be tuned up to 0.3% of the laser wavelength. The filters shift toward shorter wavelengths as the angle of incidence is increased from 0° to about 8°. Semrock notch filters can be tuned up to 1.0% of the laser wavelength. These filters also shift toward shorter wavelengths as the angle of incidence is increased from 0° up to about 14°.







Technical Note

Filter Spectra at Non-normal Angles of Incidence

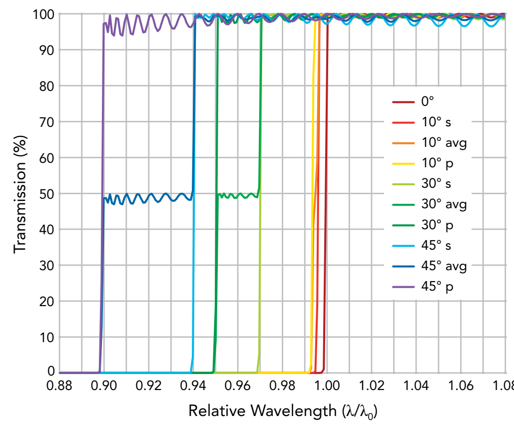
Many of the filters in this catalog (with the exception of dichroic beamsplitters, polarization, and the MaxMirror®) are optimized for use with light at or near normal incidence. However, for some applications it is desirable to understand how the spectral properties change for a non-zero angle of incidence (AOI).

There are two main effects exhibited by the filter spectrum as the angle is increased from normal:

1. the features of the spectrum shift to shorter wavelengths;
2. two distinct spectra emerge – one for s-polarized light and one for p-polarized light.

As an example, the graph at the right shows a series of spectra derived from a typical RazorEdge long-wave-pass (LWP) filter design. Because the designs are so similar for all of the RazorEdge filters designed for normal incidence *(see page 65)*, the set of curves in the graph can be applied approximately to any of the filters. Here the wavelength λ is compared to the wavelength λ_0 of a particular spectral feature (in this case the edge location) at normal incidence. As can be seen from the spectral curves, as the angle is increased from normal incidence the filter edge shifts toward shorter wavelengths and the edges associated with s- and p-polarized light shift by different amounts. For LWP filters, the edge associated with p-polarized light shifts more than the edge associated with s-polarized light, whereas for short-wave-pass (SWP) filters the opposite is true. Because of this polarization splitting, the spectrum for unpolarized light demonstrates a "shelf" near the 50% transmission point when the splitting significantly exceeds the edge steepness. However, the edge steepness for polarized light remains very high.

RazorEdge® Design Spectra vs. AOI

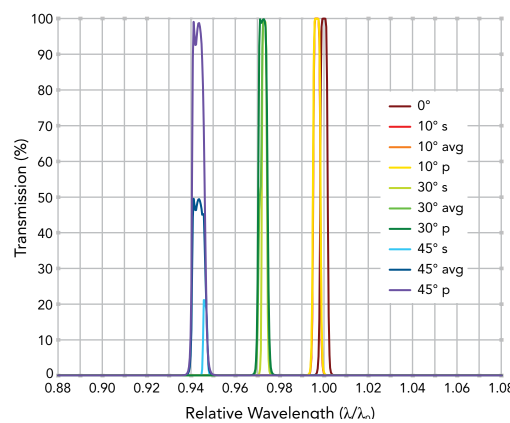


The shift of almost any spectral feature can be approximately quantified by a simple model of the wavelength λ of the feature vs. angle of incidence θ, given by the equation:

$$\lambda(\theta) = \lambda_0 \sqrt{1 - (\sin\theta / n_{eff})^2}$$

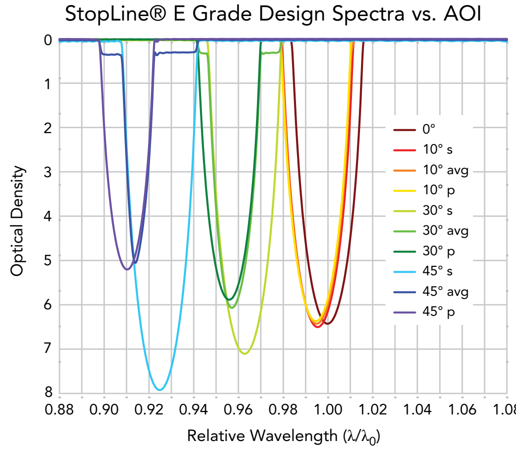
where neff is called the effective index of refraction, and λ_0 is the wavelength of the spectral feature of interest at normal incidence. Different shifts that occur for different spectral features and different filters are described by a different effective index. For the RazorEdge example above, the shift of the 90% transmission point on the edge is described by this equation with n_{eff} = 2.08 and 1.62 for s- and p-polarized light, respectively.

MaxLine® Design Spectra vs. AOI



Other types of filters don't necessarily exhibit such a marked difference in the shift of features for s- and p-polarized light. For example, the middle graph shows a series of spectra derived from a typical MaxLine laser-line filter design curve *(see page 72)*. As the angle is increased from normal incidence, the center wavelength shifts toward shorter wavelengths and the bandwidth broadens slightly for p-polarized light while narrowing for s-polarized light. The center wavelength shifts are described by the above equation with n_{eff} = 2.19 and 2.13 for s- and p-polarized light, respectively. The most striking feature is the decrease in transmission for s-polarized light, whereas the transmission remains quite high for p-polarized light.

StopLine® E Grade Design Spectra vs. AOI



As another example, the graph at the right shows a series of spectra derived from a typical E-grade StopLine notch filter design curve (*see page 77*). As the angle is increased from normal incidence, the notch center wavelength shifts to shorter wavelengths; however, the shift is greater for p-polarized light than it is for s-polarized light. The shift is described by the above equation with n_{eff} = 1.71 and 1.86 for p- and s-polarized light, respectively. Further, whereas the notch depth and bandwidth both decrease as the angle of incidence is increased for p-polarized light, in contrast the notch depth and bandwidth increase for s-polarized light. Note that it is possible to optimize the design of a notch filter to have a very deep notch even at a 45° angle of incidence.

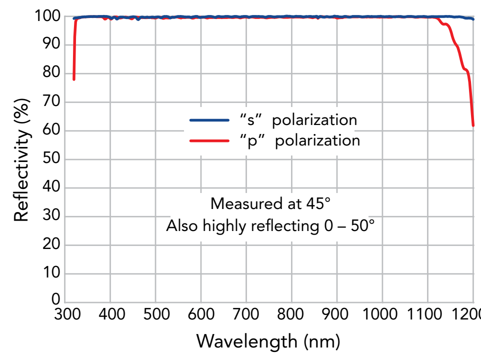
MaxMirror® Ultra-broadband Mirror

The MaxMirror is a unique high-performance laser mirror that covers an ultra-broad range of wavelengths – it can replace three or more conventional laser mirrors. In fact, it is so unique that it is patented (U.S. patent No. 6,894,838). The MaxMirror is a winner of the prestigious Photonics Circle of Excellence award, reserved for the most innovative new products of the year. And there is still nothing else like it on the market!

- **Very high reflectivity for:**
  - Near-UV, all Visible, and Near-IR wavelengths
  - All states of polarization
  - All angles from 0 to 50° inclusive – simultaneously
- High laser damage threshold and proven reliability
- Low-scattering

Winner of the 2003 Photonics Circle of Excellence award

Typical MaxMirror spectrum
Actual measured data shown.



Diameter	Absolute Surface Flatness	Mirror Side Part Number	Price
25.0 mm	< λ / 10	MM1-311-25	$275
25.0 mm	< λ / 5	MM1-311S-25	$165
25.4 mm (1.00")	< λ / 10	MM1-311-25.4	$275
25.4 mm (1.00")	< λ / 5	MM1-311S-25.4	$165
50.8 mm (2.00")	< λ / 4	MM1-311-50.8	$985
50.8 mm (2.00")	< λ / 2	MM1-311S-50.8	$495

Common Specifications

Property	Value	Comment
Wavelength Range	350 -1100 nm	*All specifications apply*
Wide Angle of Incidence Range	0 - 50°	Range over which Wide Angle Reflectivity specifications are met
Wide Angle Reflectivity	> 98.5%	For unpolarized light
	> 98.0%	For "s" polarization
	> 98.0%	For "p" polarization
Standard Angle of Incidence	45.0 ± 2.5° 0.0 ± 5.0°	Range over which Standard Reflectivity specifications are met
Standard Reflectivity	> 99.0%	For unpolarized light
	> 98.5% (> 99% typical)	For "s" polarization
	> 98.5% (> 99% typical)	For "p" polarization
Laser Damage Threshold	1 J/cm^2 @ 355 nm 2 J/cm^2 @ 532 nm 6 J/cm^2 @ 1064 nm	10 ns pulse width. *(see page 106)*
Substrate Material	NBK7 or better	
Coating Type	"Hard" ion-beam-sputtered	
Clear Aperture	> 80% of Outer Diameter	
Outer Diameter	25.0 or 25.4 or 50.8 mm + 0.0 / – 0.25 mm	
Thickness	9.52 ± 0.25 mm	Nominally 3/8"
Mirror Side Surface Flatness	See table above	Measured at λ = 633 nm
Mirror Side Surface Quality	20-10 scratch-dig (standard grade) or 40-20 (S-grade)	Measured within clear aperture
Mirror Side Bevel	0.75 mm maximum	
Pulse Dispersion	The MaxMirror will not introduce appreciable pulse broadening for most laser pulses that are > 1 picosecond; however, pulse distortion is likely for significantly shorter laser pulses, including femtosecond pulses.	
Reliability and Durability	Ion-beam-sputtered, hard-coating technology with unrivaled filter life. MaxMirror ultra-broadband mirrors are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	

ATFilms Ultra-high Reflectivity Mirrors NEW

Semrock now offers ultra-high performance mirrors produced by ATFilms. These ultra-high reflectivity mirrors are manufactured with cutting-edge ion beam sputtering technology for use in demanding laser applications. The mirrors have reflectivities ranging from 99.97% to 99.999% depending on wavelength and can be used for cavities with finesses of more than 300,000 (wavelength dependent).

Using ATFilms' renowned market-leading substrate polishing capabilities applied with hard coatings, these mirrors are able to provide very low absorption scatter losses (as low as 1ppm) and high laser damage threshold levels. Semrock offers five prominent laser wavelengths from 355 – 1550 nm.

Contact ATFilms for additional wavelengths at www.atfilms.com.

- Ultra-high reflectivity for common laser wavelengths
- Scatter & absorption as low as 1ppm
- Ideal for cavity ring-down (CRD) spectroscopy applications
- Available in flat (∞) or curved (50cm or 100cm radius of curvature) surfaces

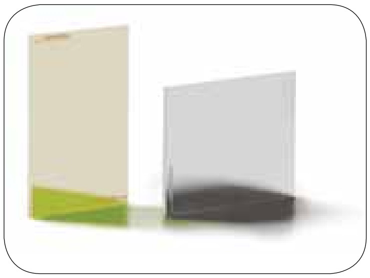
Laser Line	Reflectivity	Curvature	Part Number	Price	
355 nm	99.97%	∞	HRM01-355RINF-25.4	$895	NEW
		50 cm	HRM01-355R50-25.4	$895	NEW
		100 cm	HRM01-R100-25.4	$895	NEW
405 nm	99.995%	∞	HRM01-405RINF-25.4	$895	NEW
		50 cm	HRM01-405R50-25.4	$895	NEW
		100 cm	HRM01-405R100-25.4	$895	NEW
532 nm	99.997%	∞	HRM01-532RINF-25.4	$895	NEW
		50 cm	HRM01-532R50-25.4	$895	NEW
		100 cm	HRM01-532R0-25.4	$895	NEW
1064 nm	99.999%	∞	HRM01-1064RINF-25.4	$945	NEW
		50 cm	HRM01-1064R50-25.4	$945	NEW
		100 cm	HRM01-1064R100-25.4	$945	NEW
1550 nm	99.999%	50 cm	HRM01-1550R50-25.4	$945	NEW
		100 cm	HRM01-1550R100-25.4	$945	NEW

Common Specifications

Property	Value	Comment
Angle of Incidence	$0.0^{\circ} \pm 1.5^{\circ}$	
Surface Figure	λ/10	Side 1, per inch with radius of curvature removed
RMS Surface Roughness	< 1Å	Side 1
Wedge	< 10 arcmin	
Substrate Material	Fused Silica	
Coating Type	"Hard" ion-beam-sputtered	
Clear Aperture	> 80% of outer diameter	
Outer Diameter	25.4 mm +0/-0.1 mm	
Thickness	6.35 nm +/- 0.25 mm	
Surface Quality	10-5 (Side1) 20-10 (Side 2)	Measured within clear aperture
Reliability and Durability	Ion-beam-sputtered, hard-coating technology with unrivaled filter life. Ultra-high reflectivity mirrors are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	

NEW

General Purpose Mirrors

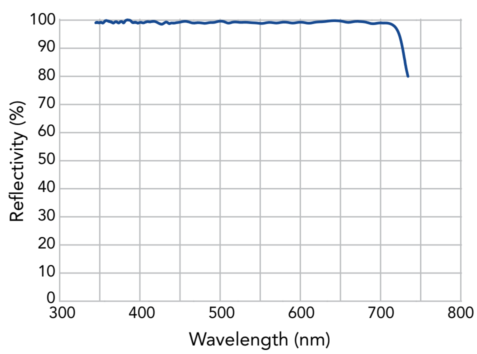


Semrock general purpose mirrors offer the ability to have hard-coated mirrors in a thinner-than-standard thickness. These mirrors can be used in microscopes or by researchers looking to do beam steering. With high reflectivity and convenient 25.2 mm x 35.6 mm x 1.05mm size, these MGP mirrors allow the flexibility needed in a laboratory or research setting.

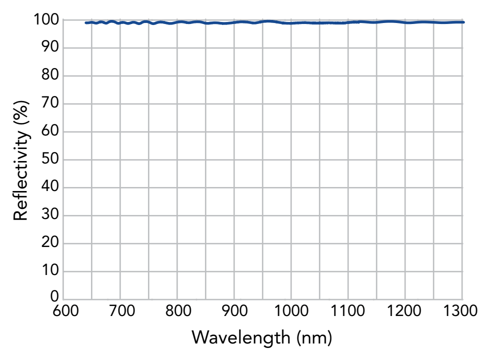
- High reflectivity over the visible or near-infrared region
- Ideal mirror for photo-bleaching samples
- Imaging flat (~ 100 m radius of curvature)
- Proven no burn-out durability – for lasting and reliable performance

Reflection Band	Flatness	Size	Glass Thickness	Part Number	Price	
R_{avg} > 98% 350-700 nm	Imaging	25.2 x 35.6 mm	1.1 mm	MGP01-350-700-25x36	$345	NEW
R_{avg} > 98% 650-1300 nm	Imaging	25.2 x 35.6 mm	1.1 mm	MPG01-650-1300-25x36	$345	NEW

Actual measured data from typical filters is shown



MGP01-350-700



MGP01-650-1300

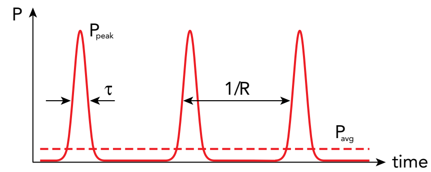
Common Specifications

Property	Value	Comment
Angle of Incidence	45°± 1.5°	
Surface Figure	Imaging Flat	Contributes less than 1.5x Airy Disk diameter to the RMS spot size of a focused, reflected beam with a diameter up to 10 mm.
Substrate	Fused Silica	
Coating Type	"Hard" ion-beam-sputtered	
Clear Aperture	80% of glass dimension	
Glass Size	25.2 mm x 35.6 ± 0.1mm	
Glass Thickness	1.05 mm ± 0.05 mm	
Pulse Dispersion	The General Purpose Mirrors will not introduce appreciable pulse broadening for most laser pulses that are > 1 picosecond; however, pulse distortion is likely for significantly shorter laser pulses, including femtosecond pulses.	
Reliability & Durability	Ion-beam-sputtered, hard-coating technology with unrivaled filter life. General Purpose Mirrors are rigorously tested and proven to MIL-STD-810F and MIL-C-48497A environmental standards.	

Technical Note: Laser Damage Threshold

Laser damage to optical filters is strongly dependent on many factors, and thus it is difficult to guarantee the performance of a filter in all possible circumstances. Nevertheless, it is useful to identify a Laser Damage Threshold (LDT) of pulse fluence or intensity below which no damage is likely to occur.

Pulsed vs. continuous-wave lasers: Pulsed lasers emit light in a series of pulses of duration τ at a repetition rate R with peak power P_{peak}. Continuous-wave (cw) lasers emit a steady beam of light with a constant power P. Pulsed-laser average power P_{avg} and cw laser constant power for most lasers typically range from several milliWatts (mW) to Watts (W). The table at the end of this Note summarizes the key parameters that are used to characterize the output of pulsed lasers.



The table below summarizes the conditions under which laser damage is expected to occur for three main types of lasers.

Units: P in Watts; R in Hz; diameter in cm; LDT_{LP} in J/cm^2.

Note: λ_{spec} and τ_{spec} are the wavelength and pulse width, respectively, at which LDT_{LP} is specified.
** The cw and quasi-cw cases are rough estimates, and should not be taken as guaranteed specifications.*

Type of Laser	Typical Pulse Properties	When Laser Damage is Likely
Long-pulse	τ ~ ns to µs R ~ 1 to 100 Hz	$\frac{P_{avg}}{R \times (\pi/4) \times diameter^2} > \frac{\lambda}{\lambda_{spec}} \times \sqrt{\frac{\tau}{\tau_{spec}}} \times LDT_{LP}$
cw	Continuous output	$\frac{P}{(\pi/4) \times diameter^2} > \sim 10{,}000\left(\frac{W}{J}\right) \times \frac{\lambda}{\lambda_{spec}} \times LDT_{LP}$ *
Quasi-cw	τ ~ fs to ps R ~ 10 to 100 MHz	$\frac{P_{avg}}{(\pi/4) \times diameter^2} > \sim 10{,}000\left(\frac{W}{J}\right) \times \frac{\lambda}{\lambda_{spec}} \times LDT_{LP}$ *

Long-pulse lasers:
Damage Threshold Long Pulse is generally specified in terms of pulse fluence for "long-pulse lasers." Because the time between pulses is so large (milliseconds), the irradiated material is able to thermally relax—as a result damage is generally not heat-induced, but rather caused by nearly instantaneous dielectric breakdown. Usually damage results from surface or volume imperfections in the material and the associated irregular optical field properties near these sites. Most Semrock filters have LDT_{LP} values on the order of 1 J/cm^2, and are thus considered "high-power laser quality" components. An important exception is a narrowband laser-line filter in which the internal field strength is strongly concentrated in a few layers of the thin-film coating, resulting in an LDT_{LP} that is about an order of magnitude smaller.

cw lasers: Damage from cw lasers tends to result from thermal (heating) effects. For this reason the LDT_{CW} for cw lasers is more dependent on the material and geometric properties of the sample, and therefore, unlike for long-pulse lasers, it is more difficult to specify with a single quantity. For this reason Semrock does not test nor specify LDT_{CW} for its filters. As a very rough rule of thumb, many all-glass components like dielectric thin-film mirrors and filters have a LDT_{CW} (specified as intensity in kW/cm^2) that is at least 10 times the long-pulse laser LDT_{LP} (specified as fluence in J/cm^2).

Quasi-cw lasers: Quasi-cw lasers are pulsed lasers with pulse durations τ in the femtosecond (fs) to picosecond (ps) range, and with repetition rates R typically ranging from about 10 – 100 MHz for high-power lasers. These lasers are typically mode-locked, which means that R is determined by the round-trip time for light within the laser cavity. With such high repetition rates, the time between pulses is so short that thermal relaxation cannot occur. Thus quasi-cw lasers are often treated approximately like cw lasers with respect to LDT, using the average intensity in place of the cw intensity.

Example: Frequency-doubled Nd:YAG laser at 532 nm. Suppose τ = 10 ns, R = 10 Hz, and Pavg = 1 W. Therefore D = 1 x 10^{-7}, E = 100 mJ, and Ppeak = 10 MW. For diameter = 100µm, F = 1.3 kJ/cm^2, so a part with LDT_{LP} = 1 J/cm^2 will likely be damaged. However, for diameter = 5 mm, F = 0.5 J/cm^2, so the part will likely not be damaged.

Symbol	Definition	Units	Key Relationships
τ	Pulse duration	sec	$\tau = D / R$
R	Repetition rate	Hz = sec^{-1}	$R = D / \tau$
D	Duty cycle	dimensionless	$D = R \times \tau$
P	Power	Watts = Joules / sec	$P_{peak} = E / \tau$; $P_{avg} = P_{peak} \times D$; $P_{avg} = E \times R$
E	Energy per pulse	Joules	$E = P_{peak} \times \tau$; $E = P_{avg} / R$
A	Area of laser spot	cm^2	$A = (\pi / 4) \times diameter^2$
I	Intensity	Watts / cm^2	$I = P / A$; $I_{peak} = F / \tau$; $I_{avg} = I_{peak} \times D$; $I_{avg} = F \times R$
F	Fluence per pulse	Joules / cm^2	$F = E / A$; $F = I_{peak} \times \tau$; $F = I_{avg} / R$

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Optical Filters for Laser-based Fluorescence Microscopes

Lasers are increasingly and advantageously replacing broadband light sources for many fluorescence imaging applications. However, fluorescence applications based on lasers impose new constraints on imaging systems and their components. For example, optical filters used confocal and Total Internal Reflection Fluorescence (TIRF) microscopes have specific requirements that are unique compared to those filters used in broadband light source based instruments.

Flatness of Dichroic Beamsplitters Affects Focus & Image Quality

Dichroic beamsplitters are now used as "image-splitting" elements for many applications, such as live-cell imaging and FRET, in which both the transmitted and reflected signals are imaged onto a camera. The optical quality of such dichroics is critical to achieving high-quality images, especially for the reflected light. If the beamsplitter is not sufficiently flat then significant optical aberrations may be introduced and the imaging may be severely compromised.

Super-resolution Microscopy

The latest incarnation of the modern fluorescence microscope has led to a paradigm shift. This wave is about breaking the diffraction limit first proposed in 1873 by Ernst Abbe and the implications of this development are profound. This new technology, called super-resolution microscopy, allows for the visualization of cellular samples with a resolution similar to that of an electron microscope, yet it retains the advantages of an optical fluorescence microscope.

Semrock VersaChrome® The First Widely Tunable Thin-film Optical Filters

Many optical systems can benefit from tunable filters with the spectral and two-dimensional imaging performance characteristics of thin-film filters and the center wavelength tuning speed and flexibility of a diffraction grating.

Fluorescent Proteins: Theory, Applications and Best Practices

There are now dozens of fluorescent proteins that differ in spectral characteristics, environmental sensitivity, photostability, and other parameters. The history and development is discussed, along with what they are and how they work. Applications of fluorescent proteins are covered, as are considerations for optical systems.

Spectral Imaging with VersaChrome®

Spectral imaging with linear unmixing is necessary in multicolor fluorescence imaging when fluorophore spectra are highly overlapping. Tunable fluorescence filters now enable spectral imaging with all the advantages of thin-film filters, including high transmission with steep spectral edges and high out-of-band blocking.

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