# Semrock®

The Standard in Optical Filters for Biotech & Analytical Instrumentation

# 2009 Catalog


Fluorescence Filters

Raman Spectroscopy Filters

Laser Analytical Instrumentation Filters

LASER 2000
The Future of Photonics

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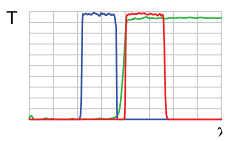
**www.laser2000.de**

# How to Find the Right Filter in This Catalog

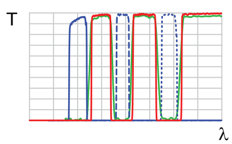
- To search by Function, see table below
- To search by Application, see opposite page
- To search fluorescence filter sets by Fluorophore, see pages 6-7
- To search filters for laser applications by Laser Wavelength, see page 52

Try our **New!** flexible filter plotting tool at www.semrock.com

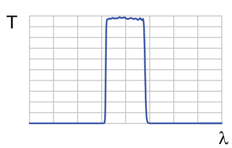
## Filters by Function



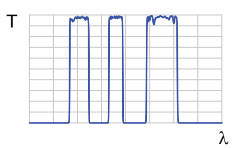


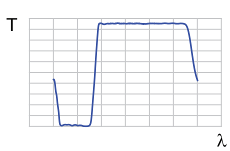


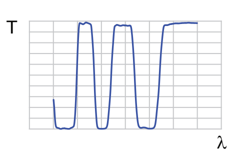


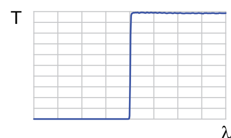


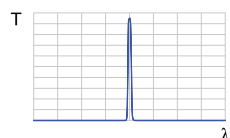


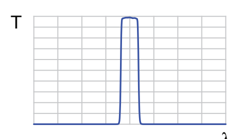


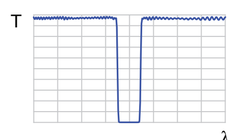


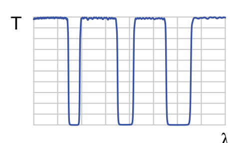


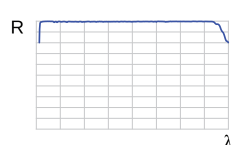






# Filters by Application

## Fluorescence Wideband Excitation

### High-performance Fluorescence Microscopy



### FISH Microscopy



### Routine or Clinical Fluorescence Microscopy



### FRET Imaging



### Calcium Imaging



### Ultraviolet Fluorescence Imaging



## Fluorescence Laser Excitation

### TIRF Microscopy



### Laser-scanning and Spinning-disk Confocal Fluorescence Microscopy



### Nonlinear Laser Microscopy (Multiphoton Fluorescence or Harmonic Generation)



## Raman and Laser Applications

### High Performance Raman Spectroscopy



### Basic or Application-specific Raman Spectroscopy



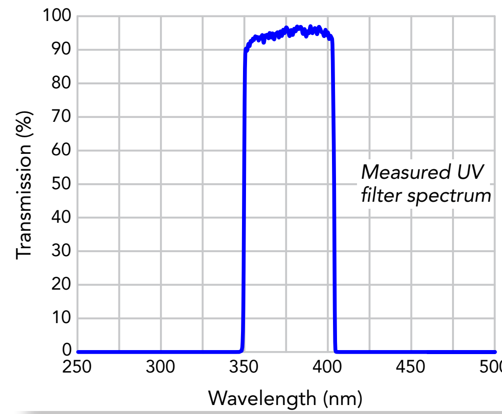
### Mercury Lamp Based Spectroscopy or Analysis



### General Laser-based Analytical Instrumentation

## 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. And 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 glass 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" *(see page 4)* and they can be readily cleaned and handled *(learn how – see page 33).*

**Five Year Warranty**

Semrock confidently backs our filters with a comprehensive industry leading 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.

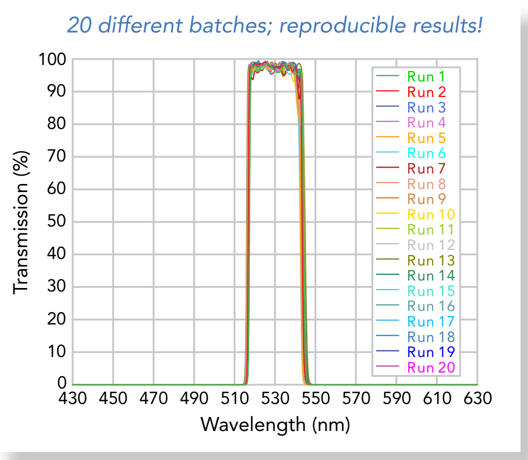
| Environmental Durability Testing | Mil Spec Standard / Procedure |
|---|---|
| Humidity | MIL-STD-810F (507.4) |
| High Temperature | MIL-STD-810F (501.4) |
| Low Temperature | MIL-STD-810F (502.4) |
| **Physical Durability Testing** | **Mil Spec Standard / Procedure** |
| Adhesion | MIL-C-48497A (4.5.3.1) |
| 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.

# Hundreds of Thousands of Ion Beam Sputtered Filters Delivered

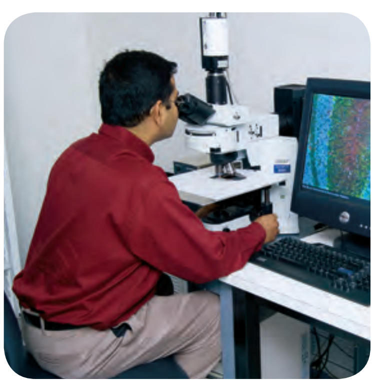
## Repeatable Results

Batch-to-batch reproducibility. Whether you are using a filter from the first run or the last, 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.




## Extensive Inventory

Need optical filters ASAP? No problem. Semrock stocks most of the items in our catalog (look for the "In Stock at Semrock" logo).



## 30-day Return Policy

We have shipped hundreds of thousands of 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 orders.

## Rapid Custom-sizing Service

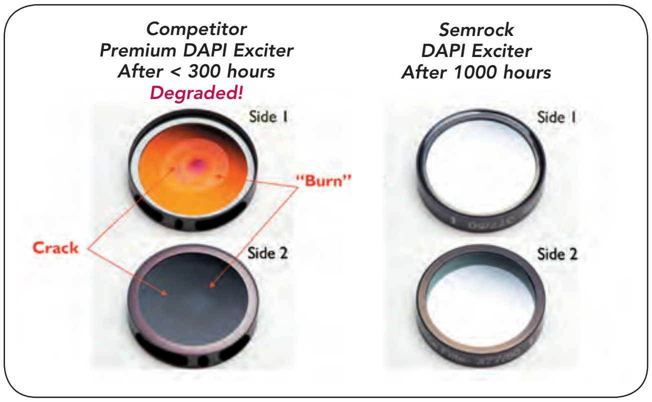
Semrock has refined its manufacturing process for small volumes of custom-sized parts to allow rapid turn-around. Most catalog items are available in a wide range of circular or rectangular custom sizes in one week. Please contact us directly to discuss your specific needs.

# 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

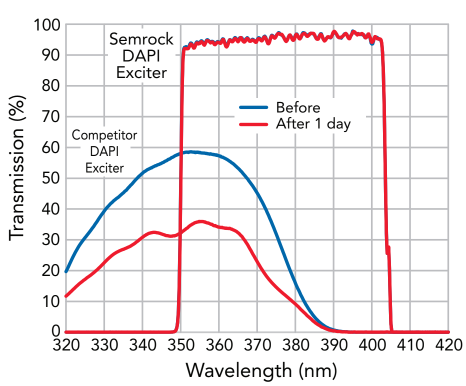



- Stand up to intense xenon, mercury, metal halide, LED, and halogen light sources
- No adhesives in the optical path to darken or degrade
- Made with the same refractory materials as our high "laser damage threshold" laser optics

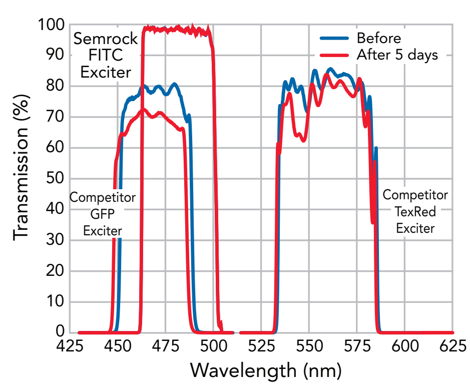
Tests were performed to illustrate the resistance to optical damage of Semrock's hard-coated filters as compared to that of a leading competitor's soft-coated and absorbing glass filters. Continous irradiation from a conventional xenon arc lamp was used for the testing.

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/cm² (over 15 mm diameter) for 1 day.*

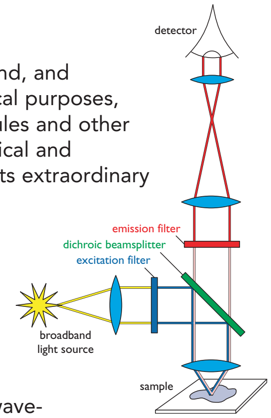



*Transmission spectra of soft-coated exciters (for GFP and Texas Red) compared to a Semrock hard-coated exciter (for FITC) before (blue) and after (red) exposure to 1 W/cm² (over 25 mm diameter) for 5 days.*

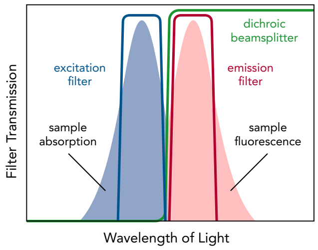
# TECHNICAL NOTE

## Introduction to Fluorescence Filters

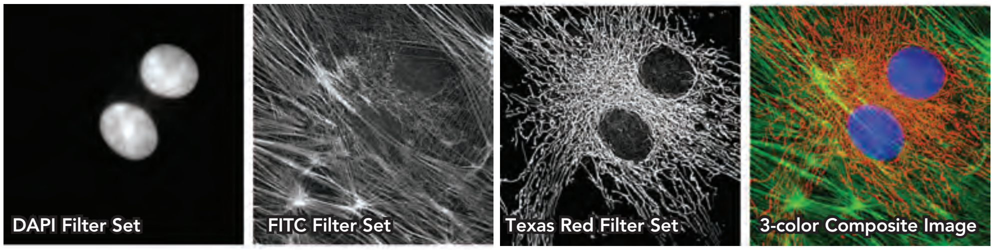
Optical fluorescence occurs when a molecule absorbs light at wavelengths within its absorption band, and then nearly instantaneously emits light at longer wavelengths within its emission band. For analytical purposes, strongly fluorescing molecules known as fluorophores are specifically attached to biological molecules and other targets of interest to enable quantification, identification, 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.



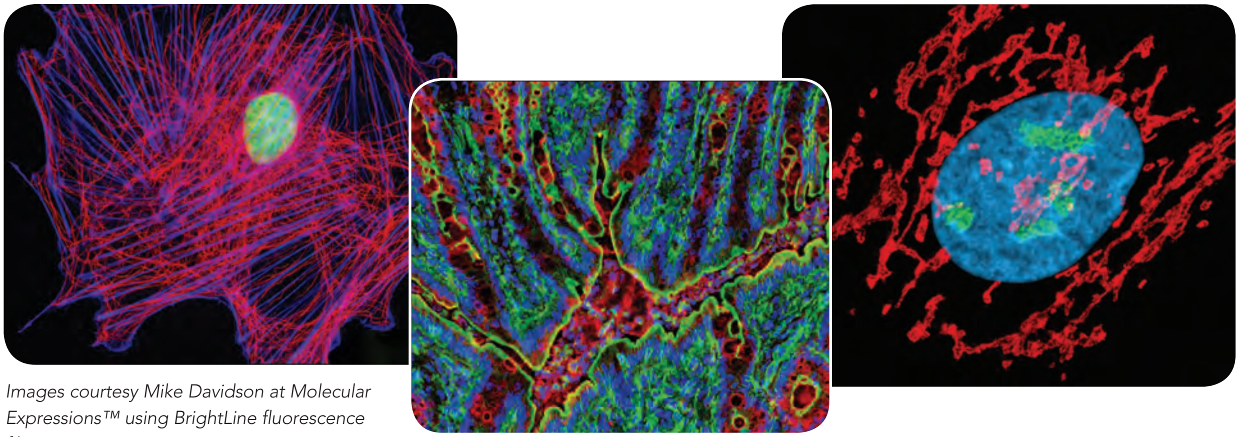

Most fluorescence instruments, including fluorescence microscopes, are based on optical filters. A typical system has three basic filters: an excitation filter (or exciter), a dichroic beamsplitter, and an emission filter (or emitter). The exciter is typically a bandpass filter that passes only the wavelengths absorbed by the fluorophore, thus minimizing excitation of other sources of fluorescence and blocking 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.




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 *(see page 4)*. And this advanced technology is so flexible that users have a choice between the highest-performance flagship BrightLine filter sets *(see page 8)* and the best-value BrightLine Basic™ filter sets *(see page 21)*.




*Multicolor composite images are created by separately capturing monochrome images with a low-noise, cooled CCD camera using individual filter sets, and then combining the images using software. This 3-color composite image was created using BrightLine DAPI-5060B, FITC-3540B, and TxRed-4040B filter sets (see pages 9 & 10).*



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

# BrightLine® Single-band Sets for Popular Fluorophores

For a complete list, see www.semrock.com/Catalog/Fluorophores

| Primary Fluorophores | Peak EX | Peak EM | Recommended BrightLine Sets | Page |
|---|---|---|---|---|
| 5-FAM (5-carboxyfluorescein) | 492 | 518 | FITC-3540B | 9 |
| 5-ROX (carboxy-X-rhodamine) | 580 | 605 | TXRED-4040B or TXRED-A-Basic | 10 23 |
| 5-TAMRA (5-carboxytetramethyl-rhodamine, high pH > 8) | 542 | 568 | TRITC-A | 10 |
| Alexa Fluor® 350 | 346 | 442 | DAPI-1160A or DAPI-5060B or BFP-A-Basic | 9 9 22 |
| Alexa Fluor® 405 | 401 | 421 | DAPI-1160A or DAPI-5060B | 9 9 |
| Alexa Fluor® 488 | 495 | 519 | FITC-3540B or FITC-A-Basic | 9 22 |
| Alexa Fluor® 532 | 532 | 553 | TRITC-A | 10 |
| Alexa Fluor® 546 | 556 | 573 | TRITC-A or TRITC-A-Basic | 10 23 |
| Alexa Fluor® 555 | 555 | 565 | CY3-4040B | 10 |
| Alexa Fluor® 568 | 578 | 603 | TXRED-4040B or TXRED-A-Basic | 10 23 |
| Alexa Fluor® 594 | 590 | 617 | TXRED-4040B or TXRED-A-Basic | 10 23 |
| Alexa Fluor® 647 | 650 | 665 | CY5-4040A | 10 |
| Alexa Fluor® 660 | 663 | 690 | CY5-4040A | 10 |
| Alexa Fluor® 680 | 679 | 702 | CY5.5-A | 10 |
| Alexa Fluor® 750 | 749 | 775 | CY7-A | 11 |
| AMCA / AMCA-X | 350 | 445 | DAPI-1160A or DAPI-5060B or BFP-A-Basic | 9 9 22 |
| AmCyan | 454 | 488 | CFP-2432A | 9 |
| BFP | 382 | 448 | DAPI-1160A or DAPI-5060B or LF405-A or BFP-A-Basic | 9 9 12 22 |
| BODIPY | 505 | 513 | FITC-3540B or FITC-A-Basic | 9 22 |
| Calcofluor White | 350 | 440 | DAPI-1160A or DAPI-5060B or CFW-LP01 or CFW-BP01 | 9 9 22 22 |
| Cascade Blue™ | 377 | 420 | DAPI-1160A or DAPI-5060B | 9 9 |
| CFP (cyan GFP) | 434 | 477 | CFP-2432A or CFP-A-Basic | 9 22 |

| Primary Fluorophores | Peak EX | Peak EM | Recommended BrightLine Sets | Page |
|---|---|---|---|---|
| Cerulean | 434 | 475 | CFP-2432A or CFP-A-Basic | 9 22 |
| CoralHue Kusabira Orange | 548 | 559 | CY3-4040B | 10 |
| Cy2™ | 489 | 506 | GFP-3035B or GFP-A-Basic | 9 22 |
| Cy3™ | 552 | 570 | CY3-4040B or LF561-A | 10 13 |
| Cy3.5™ | 580 | 591 | Cy3.5-A-Basic or TXRED-4040B | 23 10 |
| Cy5™ | 649 | 666 | CY5-4040A or LF635-A | 10 13 |
| Cy5.5™ | 676 | 705 | CY5.5-A | 10 |
| Cy7™ | 743 | 767 | CY7-A | 11 |
| DAPI | 345 | 455 | DAPI-1160A or DAPI-5060B or BFP-A-Basic or LF405-A | 9 9 22 12 |
| DEAC | 432 | 472 | SpAqua-A | 16 |
| DsRed Monomer | 556 | 586 | CY3-4040B | 10 |
| DsRed2 | 563 | 582 | CY3-4040B | 10 |
| DsRed-Express | 557 | 579 | CY3-4040B | 10 |
| dTomato | 554 | 581 | TRITC-A or CY3-4040B or TRITC-A-Basic | 10 10 23 |
| EBFP | 380 | 440 | DAPI-1160A or DAPI-5060B | 9 9 |
| ECFP | 434 | 477 | CFP-2432A | 9 |
| EGFP | 489 | 508 | GFP-3035B or GFP-A-Basic or LF488-A | 9 22 12 |
| Emerald | 490 | 510 | FITC-3540B or GFP-3035B | 9 9 |
| EYFP | 513 | 527 | YFP-2427A or YFP-A-Basic | 10 23 |
| FAM | 492 | 518 | FITC-3540B or FITC-A-Basic | 9 22 |
| Fast Blue | 360 | 440 | DAPI-1160A or DAPI-5060B | 9 9 |
| FITC (Fluorescein) | 492 | 520 | FITC-3540B or FITC-A-Basic or LF488-A | 9 22 12 |
| Fluo-3 | 506 | 526 | YFP-2427A or YFP-A-Basic | 10 23 |
| Fura-2 | 363, 336 | 512, 505 | FURA2-B | 9 |
| Fura Red™ (high pH) | 572 | 657 | TXRED-4040B | 10 |
| GFP (EGFP) | 489 | 508 | GFP-3035B or GFP-A-Basic or LF488-A | 9 22 12 |

# BrightLine® Single-band Sets for Popular Fluorophores

For a complete list, see www.semrock.com/Catalog/Fluorophores

| Primary Fluorophores | Peak EX | Peak EM | Recommended BrightLine Sets | Page |
|---|---|---|---|---|
| HcRed | 590 | 614 | TXRED-4040B | 10 |
| Hoechst 33258 | 345 | 487 | DAPI-1160A or<br>DAPI-5060B or<br>BFP-A-Basic | 9<br>9<br>22 |
| Hoechst 33342 | 347 | 483 | DAPI-1160A or<br>DAPI-5060B or<br>BFP-A-Basic | 9<br>9<br>22 |
| Hoechst 34580 | 392 | 440 | DAPI-1160A or<br>DAPI-5060B or<br>BFP-A-Basic | 9<br>9<br>22 |
| ICG | 768 | 807 | ICG-A | 11 |
| Lidocaine | 265 | 400 | TRP-A | 9 |
| LysoTracker Green | 504 | 511 | FITC-3540B | 9 |
| LysoTracker Red | 577 | 592 | CY3-4040B | 10 |
| mCherry (mRFP) | 587 | 610 | mCherry-A or<br>TXRED-A-Basic<br>or LF561-A | 10<br>23<br>13 |
| mHoneydew | 478 | 561 | FITC-3540B or<br>YFP-2427A | 9<br>10 |
| mOrange | 548 | 568 | TRITC-A or<br>CY3-4040B | 10<br>10 |
| mPlum | 594 | 648 | TXRED-4040B | 10 |
| mStrawberry | 575 | 596 | TRITC-A or<br>CY3-4040B or<br>Cy3.5-A-Basic | 10<br>10<br>23 |
| mTangerine | 568 | 585 | TRITC-A or<br>CY3-4040B | 10<br>10 |
| MitoTracker™ Green | 490 | 516 | FITC-3540B | 9 |
| MitoTracker™ Orange | 551 | 576 | CY3-4040B | 10 |
| MitoTracker™ Red | 578 | 599 | TXRED-4040B | 10 |
| Nicotine | 270 | 390 | TRP-A | 9 |
| Nile Red | 549 | 628 | TRITC-A or<br>TXRED-4040B | 10<br>10 |
| Oregon Green™ | 503 | 522 | FITC-3540B | 9 |
| Oregon Green™ 488 | 492 | 517 | FITC-3540B | 9 |
| Oregon Green™ 500 | 497 | 517 | FITC-3540B | 9 |
| Oregon Green™ 514 | 506 | 526 | FITC-3540B | 9 |
| Phycoerythrin (PE) | 567 | 576 | CY3-4040B | 10 |
| Qdot® 525 Nanocrystals | UV-Blue | 525 | QD525-A | 18 |
| Qdot® 605 Nanocrystals | UV-Blue | 605 | QD605-A | 18 |

| Primary Fluorophores | Peak EX | Peak EM | Recommended BrightLine Sets | Page |
|---|---|---|---|---|
| Qdot® 625 Nanocrystals | UV-Blue | 625 | QD625-A | 18 |
| Qdot® 655 Nanocrystals | UV-Blue | 655 | QD655-A | 18 |
| Rhodamine | 550 | 573 | TRITC-A or<br>TRITC-A-Basic | 10<br>23 |
| Rhodamine Green | 504 | 532 | YFP-2427A | 10 |
| ROX | 568 | 595 | CY3-4040B | 10 |
| SNARF (carboxy) 488 Excitation pH6 | 549 | 589 | CY3-4040B | 10 |
| SNARF (carboxy) 514 Excitation pH6 | 549 | 586 | CY3-4040B | 10 |
| SNARF (carboxy) Excitation pH9 | 576 | 639 | TXRED-4040B | 10 |
| Sodium Green | 506 | 532 | FITC-3540B | 9 |
| SpectrumAqua™ | 433 | 480 | SpAqua-A | 16 |
| SpectrumFRed™ (Far Red) | 655 | 675 | Cy5-4040A | 10 |
| SpectrumGold™ | 530 | 555 | SpGold-A | 16 |
| SpectrumGreen™ | 497 | 538 | SpGr-A | 16 |
| SpectrumOrange™ | 559 | 588 | SpOr-A | 16 |
| SpectrumRed™ | 587 | 612 | SpRed-A | 16 |
| Sulphorhodamine B can C | 520 | 595 | TRITC-A | 10 |
| TAMRA | 565 | 580 | CY3-4040B | 10 |
| Texas Red® | 595 | 620 | TXRED-4040B or<br>TXRED-A-Basic<br>or LF561-A | 10<br>23<br>13 |
| TRITC (Tetramethylrhodamine) | 545 | 563 | TRITC-A | 10 |
| TRITC (Tetramethylrhodamine) - *“reddish” appearance* | 545 | 620 | TRITC-A-Basic | 23 |
| Tryptophan | 295 | 340 | TRP-A | 9 |
| wtGFP | 475 | 509 | WGFP-A-Basic | 22 |
| YFP (yellow GFP) | 513 | 527 | YFP-2427A or<br>YFP-A-Basic | 10<br>23 |
| Zs Yellow1 | 529 | 539 | YFP-2427A or<br>YFP-A-Basic | 10<br>23 |

# BrightLine® Highest Performance Single-band Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.


## 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.

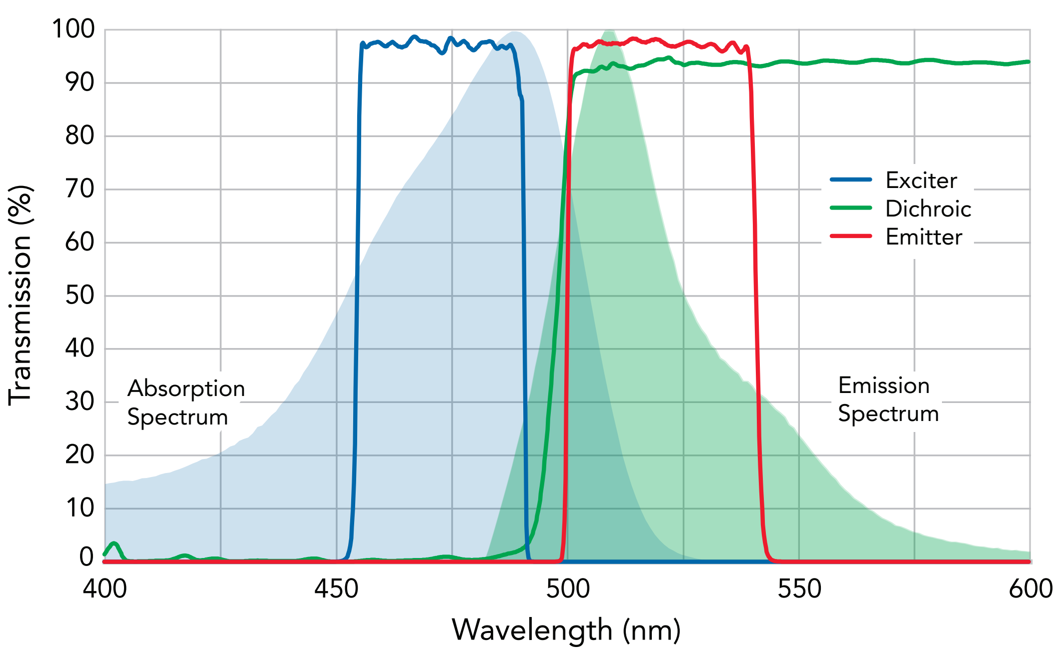
High transmission, steeper edges, precise wavelength accuracy and carefully optimized blocking mean better contrast and faster measurements.

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 *(starting on page 37)*.

### Spectacular Spectra

Typical measured GFP-3035B Filter Set for Green Fluorescent Protein
Hard-coating technology combined with single-substrate filter construction results in the highest transmission on the market.




**Custom Sizing:**
Our manufacturing process allows us to offer custom sizing for most catalog filters. Orders ship within one week. Please contact us directly to discuss your specific needs.

**30 Day Return Policy:**
We have shipped hundreds of thousands of 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.

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

# BrightLine® Highest Performance Single-band Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **TRP-A** | Exciter | 280 nm | > 65% over 20 nm | FF01-280/20-25 |
| **Tryptophan** | Emitter | 357 nm | > 75% over 44 nm | FF01-357/44-25 |
| *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<br>$T_{avg}$ > 90% 315 – 600 nm | FF310-Di01-25x36 |
| | | | **Unmounted Full Set:** | **TRP-A-000** |
| **DAPI-1160A** | Exciter | 387 nm | > 90% over 11 nm | FF01-387/11-25 |
| **DAPI**, Hoechst, AMCA, BFP, Alexa Fluor® 350 | Emitter | 447 nm | > 93% over 60 nm | FF02-447/60-25 |
| *Highest Contrast* | Dichroic | 409 nm (edge) | $R_{avg}$ > 98% 344 – 404 nm<br>$T_{avg}$ > 90% 415 – 570 nm | FF409-Di02-25x36 |
| Also available with 32 mm exciter See www.semrock.com | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **DAPI-1160A-000**<br>DAPI-1160A-000-ZERO |
| **DAPI-5060B** | Exciter | 377 nm | > 85% over 50 nm | FF01-377/50-25 |
| **DAPI**, Hoechst, AMCA, BFP, Alexa Fluor® 350 | Emitter | 447 nm | > 93% over 60 nm | FF02-447/60-25 |
| *Highest Brightness* | Dichroic | 409 nm (edge) | $R_{avg}$ > 98% 344 – 404 nm<br>$T_{avg}$ > 90% 415 – 570 nm | FF409-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **DAPI-5060B-000**<br>DAPI-5060B-000-ZERO |
| **CFP-2432A** | Exciter | 438 nm | > 93% over 24 nm | FF01-438/24-25 |
| **CFP**, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 | Emitter | 483 nm | > 93% over 32 nm | FF01-483/32-25 |
| | Dichroic | 458 nm (edge) | $R_{avg}$ > 98% 426 – 450 nm<br>$T_{avg}$ > 90% 467 – 600 nm | FF458-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **CFP-2432A-000**<br>CFP-2432A-000-ZERO |
| **FURA2-B** | Exciter 1 | 340 nm | > 75% over 26 nm | FF01-340/26-25 |
| **Fura-2 $Ca^{2+}$ indicator**, LysoSensor Yellow/Blue | Exciter 2 | 387 nm | > 90% over 11 nm | FF01-387/11-25 |
| *Four filter set* | Emitter | 510 nm | > 93% over 84 nm | FF01-510/84-25 |
| | Dichroic | 409 nm (edge) | $R_{avg}$ > 98% 344 – 404 nm<br>$T_{avg}$ > 90% 415 – 570 nm | FF409-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **FURA2-B-000**<br>FURA2-B-000-ZERO |
| **GFP-3035B** | Exciter | 472 nm | > 93% over 30 nm | FF01-472/30-25 |
| **GFP**, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1 | Emitter | 520 nm | > 93% over 35 nm | FF01-520/35-25 |
| | Dichroic | 495 nm (edge) | $R_{avg}$ > 98% 442 – 488 nm<br>$T_{avg}$ > 90% 502 – 730 nm | FF495-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **GFP-3035B-000**<br>GFP-3035B-000-ZERO |
| **FITC-3540B** | Exciter | 482 nm | > 93% over 35 nm | FF01-482/35-25 |
| **FITC**, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488 | Emitter | 536 nm | > 93% over 40 nm | FF01-536/40-25 |
| | Dichroic | 506 nm (edge) | $R_{avg}$ > 98% 446 – 500 nm<br>$T_{avg}$ > 90% 513 – 725 nm | FF506-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **FITC-3540B-000**<br>FITC-3540B-ZERO |

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# BrightLine® Highest Performance Single-band Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **YFP-2427A** | Exciter | 500 nm | > 93% over 24 nm | FF01-500/24-25 |
| **YFP**, Calcium Green-1, Eosin, Fluo-3, Rhodamine 123 | Emitter | 542 nm | > 93% over 27 nm | FF01-542/27-25 |
| | Dichroic | 520 nm (edge) | $R_{avg}$ > 98% 488 – 512 nm<br>$T_{avg}$ > 90% 528 – 655 nm | FF520-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **YFP-2427A-000**<br>YFP-2427A-000-ZERO |
| **TRITC-A** | Exciter | 543 nm | > 93% over 22 nm | FF01-543/22-25 |
| **TRITC**, Rhodamine, DiI, 5-TAMRA, Alexa Fluor® 532 & 546 | Emitter | 593 nm | > 93% over 40 nm | FF01-593/40-25 |
| | Dichroic | 562 nm (edge) | $R_{avg}$ > 98% 499 – 555 nm<br>$T_{avg}$ > 90% 569 – 730 nm | FF562-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **TRITC-A-000**<br>TRITC-A-000-ZERO |
| **Cy3-4040B** | Exciter | 531 nm | > 93% over 40 nm | FF01-531/40-25 |
| **Cy3™**, DsRed, PE, TAMRA, Calcium Orange, Alexa Fluor® 555 | Emitter | 593 nm | > 93% over 40 nm | FF01-593/40-25 |
| | Dichroic | 562 nm (edge) | $R_{avg}$ > 98% 499 – 555 nm<br>$T_{avg}$ > 90% 569 – 730 nm | FF562-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **Cy3-4040B-000**<br>Cy3-4040B-000-ZERO |
| **TXRED-4040B** | Exciter | 562 nm | > 93% over 40 nm | FF01-562/40-25 |
| **Texas Red®**, Cy3.5™, 5-ROX, Mitotracker Red, Alexa Fluor® 568 & 594 | Emitter | 624 nm | > 93% over 40 nm | FF01-624/40-25 |
| | Dichroic | 593 nm (edge) | $R_{avg}$ > 98% 530 – 585 nm<br>$T_{avg}$ > 90% 601 – 800 nm | FF593-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **TXRED-4040B-000**<br>TXRED-4040B-000-ZERO |
| **mCherry-A** | Exciter | 562 nm | > 93% over 40 nm | FF01-562/40-25 |
| **mCherry** (mRFP) | Emitter | 641 nm | > 93% over 75 nm | FF01-641/75-25 |
| *New!* | Dichroic | 593 nm (edge) | $R_{avg}$ > 98% 530 – 585 nm<br>$T_{avg}$ > 90% 601 – 800 nm | FF593-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **mCherry-A-000**<br>mCherry-A-000-ZERO |
| **Cy5-4040A** | Exciter | 628 nm | > 93% over 40 nm | FF01-628/40-25 |
| **Cy5™**, APC, DiD, Alexa Fluor® 647 & 660 | Emitter | 692 nm | > 93% over 40 nm | FF01-692/40-25 |
| | Dichroic | 660 nm (edge) | $R_{avg}$ > 98% 594 – 651 nm<br>$T_{avg}$ > 90% 669 – 726 nm | FF660-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **Cy5-4040A-000**<br>Cy5-4040A-000-ZERO |
| **Cy5.5-A** | Exciter | 655 nm | > 93% over 40 nm | FF01-655/40-25 |
| **Cy5.5™**, Alexa Fluor® 680 | Emitter | 716 nm | > 93% over 40 nm | FF01-716/40-25 |
| | Dichroic | 685 nm (edge) | $R_{avg}$ > 98% 600 – 676 nm<br>$T_{avg}$ > 90% 695 – 810 nm | FF685-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **Cy5.5-A-000**<br>Cy5.5-A-000-ZERO |

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

# BrightLine® Highest Performance Single-band Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **Cy7-A** | Exciter | 710 nm | > 93% over 40 nm | FF01-710/40-25 |
| **Cy7**™, Alexa Fluor® 750 | Emitter | 775 nm | > 93% over 46 nm | FF01-775/46-25 |
| | Dichroic | 741 nm (edge) | $R_{avg}$ > 98% 660 – 731.5 nm<br>$T_{avg}$ > 90% 750.5 – 810 nm | FF741-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>“ZERO Pixel Shift” Set: | **Cy7-A-000**<br>Cy7-A-000-ZERO |
| **ICG-A** | Exciter | 769 nm | > 93% over 41 nm | FF01-769/41-25 |
| **ICG** | Emitter | 832 nm | > 93% over 37 nm | FF01-832/37-25 |
| | Dichroic | 801 nm (edge) | $R_{avg}$ > 98% 749 – 790 nm<br>$T_{avg}$ > 90% 813.5 – 885 nm | FF801-Di01-25x36 |
| ***New!*** | | | **Unmounted Full Set:**<br>“ZERO Pixel Shift” Set: | **ICG-A-000**<br>ICG-A-000-ZERO |

### BrightLine ZERO™ Fluorescence Filter Sets

Ensure 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.

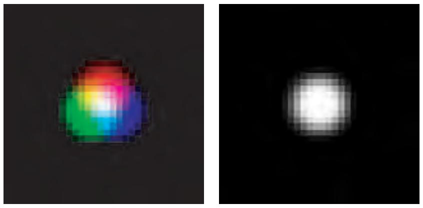
- Allows you to create spacially registered multi-color composite images
- Hard coated for durability and reliability
- Ideal for demanding applications like:

  Co-localization fluorescence measurements – *see page 20*
  Fluorescence In Situ Hybridization (FISH) – *see page 15*
  Comparative Genomic Hybridization (CGH)

| Property | Value | Comment |
|---|---|---|
| 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. |

## TECHNICAL NOTE

### What is Pixel Shift?



*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.*

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. Unlike older, soft-coated fluorescence filters, 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 (U.S. Patent Nos. 6,809,859, 7,411,679, and pending) lower-loss and high-reliability construction inherently enables BrightLine ZERO filter sets to be manufactured, tested and certified to very tight tolerances so as to ensure accurate image registration every time.

# BrightLine® Laser Fluorescence Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

- 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 resulting from intense stray light
- Dichroic beamsplitters offer **sufficient flatness** to eliminate axial focal shift and aberrations for reflected laser light *(See Tech Note on Pg 46)*
- ***New!*** **Long-pass sets** allow for longer wavelengths to be detected and more light to be captured.

## Applications for BrightLine Laser Fluorescence Filter Sets include:

- Any microscope or imaging system that benefits from premium beamsplitter spectral performance and/or flatness
- Laser-scanning confocal microscopes (e.g. Olympus FluoView FV300, FV1000; Nikon Eclipse C1 Plus/si, A1)
- Spinning-disk confocal microscopes (e.g. BD Biosciences CARV II; Olympus DSU)
- Total-internal-reflection fluorescence (TIRF) microscopes (e.g. Olympus TIRF Illuminator, FV1000-EVA; Nikon TIRF)
- Structured illumination microscopes (e.g. Qioptiq OptiGrid®)

BrightLine Laser Fluorescence Filter Sets 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 do 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 brightfield modes).

| Set / Primary Laser Wavelengths | | Center Wavelength / Nominal Edge Wavelength | Avg Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **LF405/LP-A** | Exciter | 390 nm | > 93% over 40 nm | FF01-390/40-25 |
| 375 & 405 nm | Emitter | 418 nm (edge) | > 93% 421.5 – 900 nm | BLP01-405R-25 |
| ***New!*** *Long-pass set* | Dichroic | 415 nm (edge) | $R_{abs}$ > 94% 372 – 410 nm<br>$T_{avg}$ > 93% 420 – 900 nm | Di01-R405-25x36 |
| | | | **Unmounted Full Set:** | **LF405/LP-A-000** |
| **LF405-A** | Exciter | 390 nm | > 93% over 40 nm | FF01-390/40-25 |
| 375 & 405 nm | Emitter | 452 nm | > 93% over 45 nm | FF01-452/45-25 |
| *Bandpass set* | Dichroic | 415 nm (edge) | $R_{abs}$ > 94% 372 – 410 nm<br>$T_{avg}$ > 93% 420 – 900 nm | Di01-R405-25x36 |
| | | | **Unmounted Full Set:** | **LF405-A-000** |
| **LF488/LP-A** | Exciter | 482 nm | > 93% over 18 nm | FF01-482/18-25 |
| 473 & 488 nm | Emitter | 500 nm (edge) | > 93% 504.7 – 900 nm | BLP01-488R-25 |
| ***New!*** *Long-pass set* | Dichroic | 497 nm (edge) | $R_{abs}$ > 94% 471 – 491 nm<br>$T_{avg}$ > 93% 503 – 900 nm | Di01-R488-25x36 |
| | | | **Unmounted Full Set:** | **LF488/LP-A-000** |
| **LF488-A** | Exciter | 482 nm | > 93% over 18 nm | FF01-482/18-25 |
| 473 & 488 nm | Emitter | 525 nm | > 93% over 45 nm | FF01-525/45-25 |
| *Bandpass set* | Dichroic | 497 nm (edge) | $R_{abs}$ > 94% 471 – 491 nm<br>$T_{avg}$ > 93% 503 – 900 nm | Di01-R488-25x36 |
| | | | **Unmounted Full Set:** | **LF488-A-000** |

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

# BrightLine® Laser Fluorescence Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

| Set / Primary Laser Wavelengths | | Center Wavelength / Nominal Edge Wavelength | Avg Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **LF561/LP-A** | Exciter | 561 nm | > 93% over 14 nm | FF01-561/14-25 |
| 559, 561.4, & 568.2 nm | Emitter | 580 nm (edge) | > 93% 583.9 – 900 nm | BLP01-561R-25 |
| **New!** *Long-pass set* | Dichroic | 575 nm (edge) | Rabs > 94% 554 – 568 nm<br>Tavg > 93% 582 – 1200 nm | Di01-R561-25x36 |
| | | | **Unmounted Full Set** | **LF561/LP-A-000** |
| **LF561-A** | Exciter | 561 nm | > 93% over 14 nm | FF01-561/14-25 |
| 559, 561.4, & 568.2 nm | Emitter | 609 nm | > 93% over 54 nm | FF01-609/54-25 |
| *Bandpass set* | Dichroic | 575 nm (edge) | Rabs > 94% 554 – 568 nm<br>Tavg > 93% 582 – 1200 nm | Di01-R561-25x36 |
| | | | **Unmounted Full Set** | **LF561-A-000** |
| **LF635-A** | Exciter | 640 nm | > 93% over 14 nm | FF01-640/14-25 |
| 632.8, 635, & 647.1 nm | Emitter | 676 nm | > 90% over 29 nm | FF01-676/29-25 |
| *Bandpass set* | Dichroic | 654 nm (edge) | Rabs > 94% 632 – 647 nm<br>Tavg > 93% 663 – 1200 nm | Di01-R635-25x36 |
| | | | **Unmounted Full Set** | **LF635-A-000** |

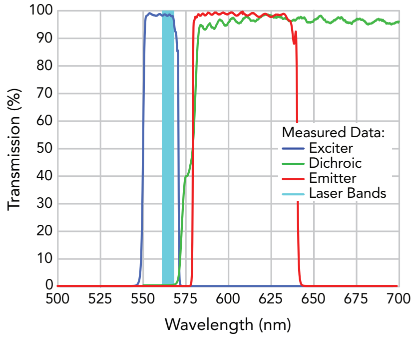
## Summary of compatible lasers and prominent fluorophores

| Prominent Laser Line / Bands | Laser Description | Prominent Compatible Fluorophore(s) | Filter Set |
|---|---|---|---|
| 375 ± 3 nm<br>405 ± 5 nm | GaN diode<br>GaN diode | DAPI, BFP | LF405-A or LF405/LP-A |
| 473 ± 2 nm<br>488 +3/–2 nm<br>491 nm | Doubled DPSS[1], Diode<br>Ar-ion gas, Doubled OPS[2]<br>Doubled DPSS[1] | FITC, GFP | LF488-A or LF488/LP-A |
| 559 ± 5 nm<br>561.4 nm<br>568.2 nm | Diode<br>Doubled DPSS[1]<br>Kr-ion gas | RFP's (mCherry, HcRed, DsRed), Texas Red®, TRITC, and Cy3™ | LF651-A or LF561/LP-A |
| 632.8 nm<br>635 +7/–0 nm<br>647.1 nm | HeNe gas<br>AlGaInP diode,<br>Kr-ion gas | Cy5™ | LF635-A |

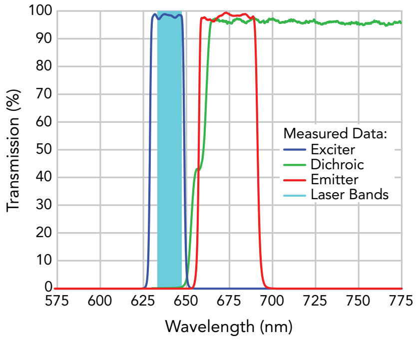
[1] DPSS = Diode-pumped solid-state laser
[2] OPS = Optically pumped semiconductor laser

## Actual Measured Data

LF561-A Set




LF635-A Set



# APPLICATION NOTE

## Crosstalk in 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.

**Relative Fluorophore Contributions for Each Filter Set**

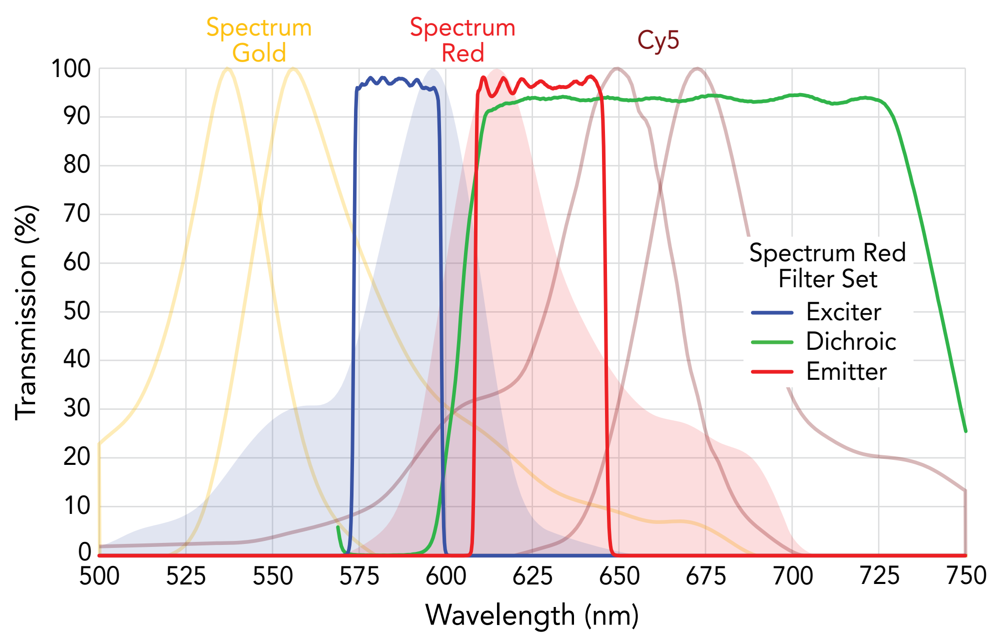
| Filter Set \ Fluorophore | DAPI | SpAqua | SpGreen | SpGold | SpOrange | SpRed | Cy5 / FRed | Cy5.5 | Cy7 |
|---|---|---|---|---|---|---|---|---|---|
| DAPI | 100% | 30% | 0% | | | | | | |
| SpAqua | 0% | 100% | 1% | 0% | | | | | |
| SpGreen | 0% | 0% | 100% | 3% | 0% | | | | |
| SpGold | | 0% | 2% | 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 | | | | | | | | 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%.

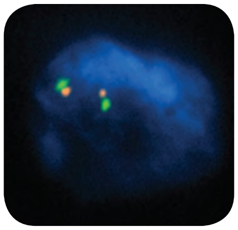
## Amazing Spectra for Minimizing Crosstalk

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

Extensive selection of filter sets in stock.
We have a 30-day return policy.



*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

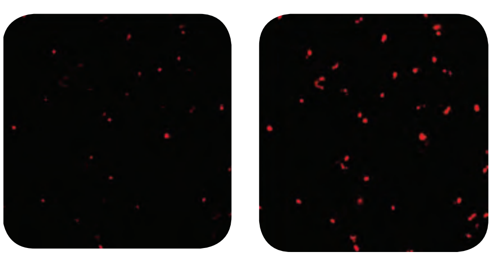
| Single-band Filter Sets | Assay | Purpose |
|---|---|---|
| DAPI, SpGr, SpOr | PathVysion® | Detects amplification of the HER-2 gene for screening and prognosis of breast cancer |
| DAPI, SpAqua, SpGr, SpOr | AneuVysion® | Used as an aid in prenatal diagnosis of chromosomal abnormalities |
| DAPI, 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

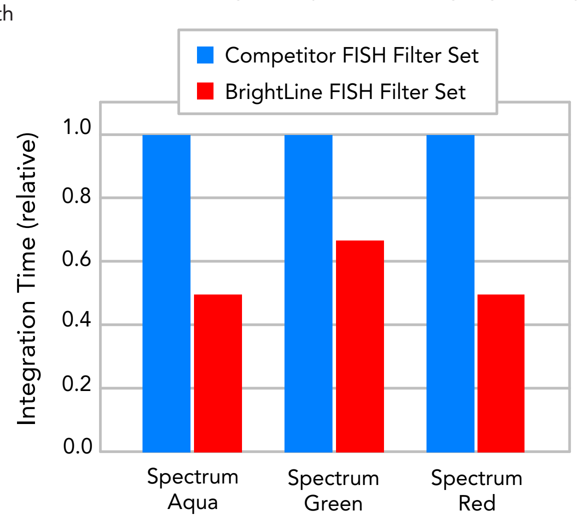
### Can better fluorescence filters really make a difference?

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

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **SpAqua-A** | Exciter | 438 nm | > 93% over 24 nm | FF01-438/24-25 |
| SpectrumAqua™, DEAC | Emitter | 483 nm | > 93% over 32 nm | FF01-483/32-25 |
| | Dichroic | 458 nm (edge) | $R_{avg}$ > 98% 426 – 450 nm<br>$T_{avg}$ > 90% 467 – 600 nm | FF458-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **SpAqua-A-000**<br>SpAqua-A-000-ZERO |
| **SpGr-A** | Exciter | 494 nm | > 93% over 20 nm | FF01-494/20-25 |
| SpectrumGreen™, FITC, Alexa Fluor® 488 | Emitter | 527 nm | > 93% over 20 nm | FF01-527/20-25 |
| | Dichroic | 506 nm (edge) | $R_{avg}$ > 98% 446 – 499.5 nm<br>$T_{avg}$ > 90% 513.5 – 725 nm | FF506-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **SpGr-A-000**<br>SpGr-A-000-ZERO |
| **SpGold-A** | Exciter | 534 nm | > 93% over 20 nm | FF01-534/20-25 |
| SpectrumGold™, Alexa Fluor® 546 | Emitter | 572 nm | > 93% over 28 nm | FF01-572/28-25 |
| | Dichroic | 552 nm (edge) | $R_{avg}$ > 98% 524 – 544 nm<br>$T_{avg}$ > 90% 558 – 725 nm | FF552-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **SpGold-A-000**<br>SpGold-A-000-ZERO |
| **SpOr-A** | Exciter | 543 nm | > 93% over 22 nm | FF01-543/22-25 |
| SpectrumOrange™, Cy3™, Rhodamine, Alexa Fluor® 555 | Emitter | 586 nm | > 93% over 20 nm | FF01-586/20-25x3.5 |
| | Dichroic | 562 nm (edge) | $R_{avg}$ > 98% 499 – 554.5 nm<br>$T_{avg}$ > 90% 569.5 – 730 nm | FF562-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **SpOr-A-000**<br>SpOr-A-000-ZERO |
| **SpRed-A** | Exciter | 586 nm | > 93% over 20 nm | FF01-586/20-25x5 |
| SpectrumRed™, Texas Red, Alexa Fluor® 647 & 660 | Emitter | 628 nm | > 93% over 32 nm | FF01-628/32-25 |
| | Dichroic | 605 nm (edge) | $R_{avg}$ > 98% 576 – 596 nm<br>$T_{avg}$ > 90% 612 – 725 nm | FF605-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **SpRed-A-000**<br>SpRed-A-000-ZERO |

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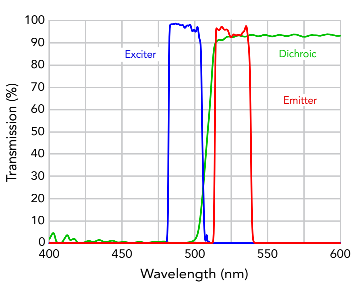
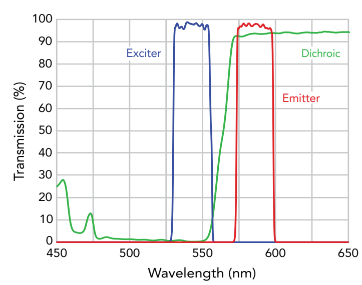
NOTE: For DAPI sets, refer to page 9. For Cy5™, Cy5.5™, or Cy7™, refer to pages 10-11 for BrightLine NIR filter sets.

SpGr-A




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

SpOr-A



# BrightLine® Combination Multiband Sets for FISH

Extensive selection of filter sets in stock.
We have a 30-day return policy.

| Set / Primary Fluorophores | Center Wavelengths | Avg. Transmission / Bandwidths | Filter / Set Part Numbers |
|---|---|---|---|
| **DA/SpGr/SpRed-A Combination Set** | 387 nm | > 90% over 11 nm | Single-band Exciter 1<br>FF01-387/11-25 |
| Blue: DAPI, Alexa Fluor® 350<br>Green: SpectrumGreen™<br>Red: SpectrumRed™ | 494 nm | > 93% over 20 nm | Single-band Exciter 2<br>FF01-494/20-25 |
| | 575 nm | > 90% over 25 nm | Single-band Exciter 3<br>FF01-575/25-25 |
| *Combines a Full Multiband and a Pinkel set required for simultaneous multi-color blue-green-red FISH analysis* | 494 nm<br>576 nm | > 90% over 20 nm<br>> 90% over 20 nm | Dual-band Exciter<br>FF01-494/576-25 |
| | 407 nm<br>494 nm<br>576 nm | > 80% over 14 nm<br>> 85% over 20 nm<br>> 85% over 20 nm | Triple-band Exciter<br>FF01-407/494/576-25 |
| *All configurations offer high brightness, extremely low crosstalk, and superb signal-to-noise ratio performance.* | 457 nm<br>530 nm<br>628 nm | > 80% over 22 nm<br>> 85% over 20 nm<br>> 85% over 28 nm | Triple-band Emitter<br>FF01-457/530/628-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidths** | |
| | > 97.5% 394 – 414 nm<br>> 97.5% 484 – 504 nm<br>> 97.5% 566 – 586 nm | > 90% 446 – 468 nm<br>> 90% 520 – 540 nm<br>> 90% 614 – 642 nm | Triple-band Dichroic<br>FF436/514/604-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/SpGr/SpRed-A-000** |
| **DA-SpAq/SpGr/SpOr-A Combination Set** | 340 nm | > 75% over 26 nm | Single-band Exciter 1<br>FF01-340/26-25 |
| Blue: DAPI, Alexa Fluor® 350<br>Cyan: SpectrumAqua™<br>Green: SpectrumGreen™<br>Red: SpectrumRed™ | 427 nm | > 93% over 10 nm | Single-band Exciter 2<br>FF01-427/10-25 |
| | 504 nm | > 93% over 12 nm | Single-band Exciter 3<br>FF01-504/12-25 |
| *Combines a Full Multiband and a Pinkel set required for simultaneous multi-color FISH analysis with blue, aqua, green, and orange or red labels* | 575 nm | > 90% over 15 nm | Single-band Exciter 4<br>FF01-575/15-25 |
| | 503 nm<br>572 nm | > 90% over 18 nm<br>> 90% over 18 nm | Dual-band Exciter<br>FF01-503/572-25 |
| *All configurations offer high brightness, extremely low crosstalk, and superb signal-to-noise ratio performance.* | 422 nm<br>503 nm<br>572 nm | > 90% over 30 nm<br>> 90% over 18 nm<br>> 90% over 18 nm | Triple-band Exciter<br>FF01-422/503/572-25 |
| | 465 nm<br>537 nm<br>623 nm | > 90% over 30 nm<br>> 90% over 20 nm<br>> 90% over 50 nm | Triple-band Emitter<br>FF01-465/537/623-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidths** | |
| | > 98% over 327 – 437 nm<br>> 98% over 494 – 512 nm<br>> 98% over 562 – 578 nm | > 90% 450 – 480 nm<br>> 90% 527 – 547 nm<br>> 90% 598 – 648 nm | Triple-band Dichroic<br>FF444/520/590-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA-SpAq/SpGr/SpOr-A-000** |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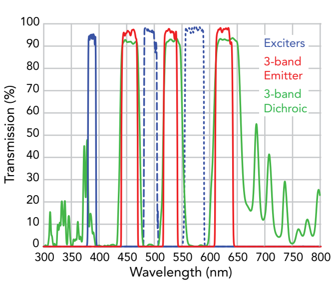
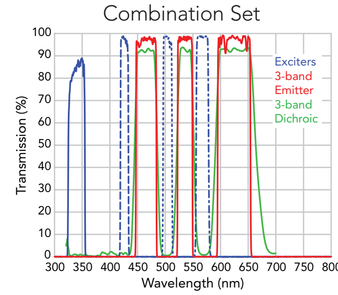
DA/SpGr/SpRed-A Combination Set



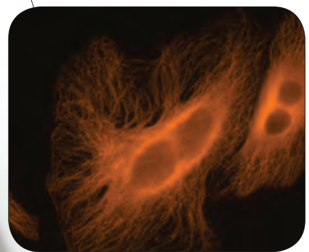

See spectra graphs and ASCII data for all of our filters at www.semrock.com

DA-SpAq/SpGr/SpOr-A Combination Set



# Qdot® Single-band Filter Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.



*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 |
|---|---|---|---|---|
| **QDLP-A** | Exciter | 435 nm | > 90% over 40 nm | FF01-435/40-25 |
| Qdot® 525, 565, 585, 605, 625, 655, 705, & 800 Nanocrystals | Emitter | 515 nm (edge) | > 90% 519 – 700 nm | FF01-500/LP-25 |
| *Versatile and high brightness long-pass filter set for viewing multiple Qdots* | Dichroic | 510 nm (edge) | $R_{avg}$ > 98% 327 – 488 nm<br>$T_{avg}$ > 90% 515 – 850 nm | FF510-Di01-25x36 |
| | | | **Unmounted Full Set:** | **QDLP-A-000** |
| **QD525-A** | Exciter | 435 nm | > 90% over 40 nm | FF01-435/40-25 |
| Qdot® 525 Nanocrystals | Emitter | 525 nm | > 90% over 15 nm | FF01-525/15-25 |
| *High brightness and contrast single-band filter set* | Dichroic | 510 nm (edge) | $R_{avg}$ > 98% 327 – 488 nm<br>$T_{avg}$ > 90% 515 – 850 nm | FF510-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **QD525-A-000**<br>QD525-A-000-ZERO |
| **QD605-A** | Exciter | 435 nm | > 90% over 40 nm | FF01-435/40-25 |
| Qdot® 605 Nanocrystals | Emitter | 605 nm | > 90% over 15 nm | FF01-605/15-25 |
| *High brightness and contrast single-band filter set* | Dichroic | 510 nm (edge) | $R_{avg}$ > 98% 327 – 488 nm<br>$T_{avg}$ > 90% 515 – 850 nm | FF510-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **QD605-A-000**<br>QD605-A-000-ZERO |
| **QD625-A** | Exciter | 435 nm | > 90% over 40 nm | FF01-435/40-25 |
| Qdot® 625 Nanocrystals | Emitter | 625 nm | > 90% over 15 nm | FF01-625/15-25 |
| *High brightness and contrast single-band filter set* | Dichroic | 510 nm (edge) | $R_{avg}$ > 98% 327 – 488 nm<br>$T_{avg}$ > 90% 515 – 850 nm | FF510-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **QD625-A-000**<br>QD625-A-000-ZERO |
| **QD655-A** | Exciter | 435 nm | > 90% over 40 nm | FF01-435/40-25 |
| Qdot® 655 Nanocrystals | Emitter | 655 nm | > 90% over 15 nm | FF01-655/15-25 |
| *High brightness and contrast single-band filter set* | Dichroic | 510 nm (edge) | $R_{avg}$ > 98% 327 – 488 nm<br>$T_{avg}$ > 90% 515 – 850 nm | FF510-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **QD655-A-000**<br>QD655-A-000-ZERO |

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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 in that they 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.

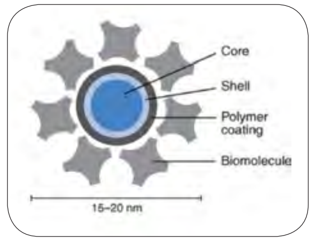
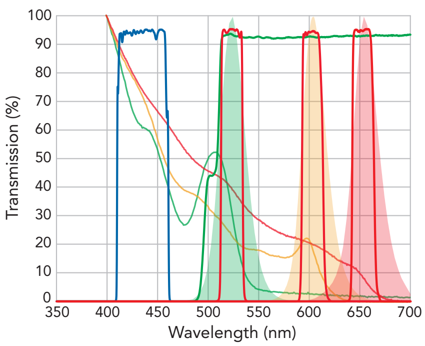



*Figure 1. Structure of a nanocrystal.*

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, for example.  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 18). 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.

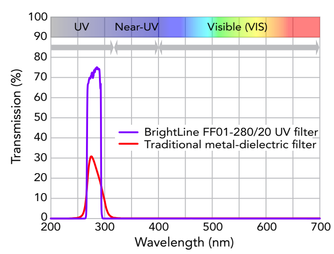



*Figure 1. BrightLine FF01-280/20-25 filter*

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.

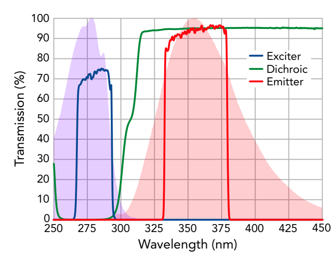



*Figure 2.  TRP-A single-band fluorescence filter set is ideal for imaging tryptophan (see page 9).*

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.

# BrightLine® FRET Single-band Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Band-width | Filter / Set Part Numbers |
|---|---|---|---|---|
| **FRET-BFP/GFP-A** | Exciter | 387 nm | > 90% over 11 nm | FF01-387/11-25 |
| Blue: BFP, DAPI, Hoechst, Alexa Fluor® 350 | Emitter 1 | 447 nm | > 93% over 60 nm | FF02-447/60-25 |
| Green: GFP, EGFP, FITC, Cy2™, Alexa Fluor® 488 | Emitter 2 | 520 nm | > 93% over 35 nm | FF01-520/35-25 |
| | Dichroic | 409 nm (edge) | $R_{avg}$ > 98% 344 – 404 nm<br>$T_{avg}$ > 90% 415 – 570 nm | FF409-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **FRET-BFP/GFP-A-000**<br>FRET-BFP/GFP-A-000-ZERO |
| **FRET-CFP/YFP-A** | Exciter | 438 nm | > 93% over 24 nm | FF01-438/24-25 |
| Cyan: CFP, CyPet, AmCyan | Emitter 1 | 483 nm | > 93% over 32 nm | FF01-483/32-25 |
| Yellow: YFP, YPet, Venus | Emitter 2 | 542 nm | > 93% over 27 nm | FF01-542/27-25 |
| | Dichroic | 458 nm (edge) | $R_{avg}$ > 98% 426 – 450 nm<br>$T_{avg}$ > 90% 467 – 600 nm | FF458-Di01-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **FRET-CFP/YFP-A-000**<br>FRET-CFP/YFP-A-000-ZERO |
| **FRET-GFP/RFP-A** | Exciter | 472 nm | > 93% over 30 nm | FF01-472/30-25 |
| Green: GFP, EGFP, FITC, Cy2™, Alexa Fluor® 488 | Emitter 1 | 520 nm | > 93% over 35 nm | FF01-520/35-25 |
| Red: mCherry, mStrawberry, dTomato, DsRed, TRITC, Cy3™ | Emitter 2 | 607 nm | > 93% over 36 nm | FF01-607/36-25 |
| | Dichroic | 495 nm (edge) | $R_{avg}$ > 98% 442 – 488 nm<br>$T_{avg}$ > 90% 502 – 730 nm | FF495-Di02-25x36 |
| | | | **Unmounted Full Set:**<br>"ZERO Pixel Shift" Set: | **FRET-GFP/RFP-A-000**<br>FRET-GFP/RFP-A-000-ZERO |

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

## TECHNICAL NOTE

### Fluorescence Resonance Energy Transfer (FRET)

Fluorescence 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.

A simple approach for observing FRET requires merely an exciter and a dichroic beamsplitter for the donor fluorophore, and some means for exchanging emitters optimized for the donor and acceptor fluorophores. Figure 1 shows CFP absorption and emission spectra and the transmission spectra for three of the four filters from the FRET-CFP/YFP-A set (for quantifying the fluorescence from the CFP donor). Figure 2 shows the YFP emission spectrum and spectra for the same exciter and dichroic, but with the YFP emitter for quantifying the fluorescence from the YFP acceptor. For the highest performance and flexibility, a multiband beamsplitter with single-band exciter and emitter filters may be used in a microscope equipped with dual, synchronized filter wheels. Our multiband "Sedat" filter sets, such as the CFP/YFP-2X2M-A set, are ideal for this approach – *see page 30.*

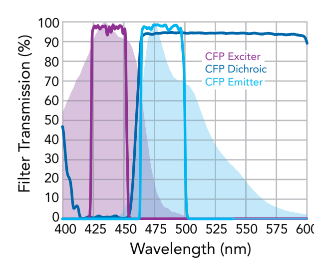



*Figure 1: CFP exciter, dichroic, and emitter filters (from FRET-CFP/YFP-A set) for measuring donor emission.*

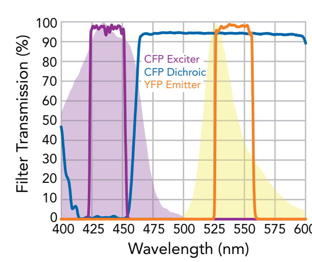



*Figure 2: CFP exciter and dichroic filters with YFP emitter filter (from FRET-CFP/YFP-A set) for measuring acceptor emission.*

# BrightLine Basic™ Best-value Single-band Sets

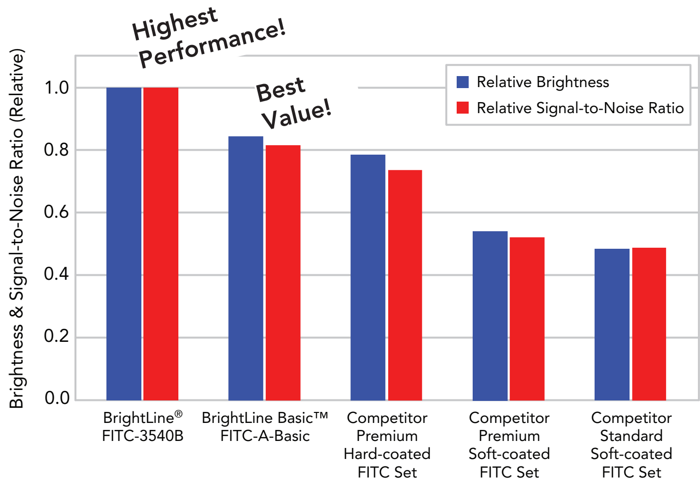
Extensive selection of filter sets in stock.
We have a 30-day return policy.

## How can you do great research on a tight budget? BrightLine Basic™ fluorescence filter sets.

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.

### Hard-coated performance at soft-coated prices™

*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* |
|---|---|---|
| DAPI-1160A | BFP-A-Basic | >10% higher brightness; >10% higher contrast (using BFP) |
| DAPI-5060B | | Several times brighter; comparable contrast (using BFP) |
| CFP-2432A | CFP-A-Basic | Tens of percent higher brightness; comparable contrast |
| GFP-3035B | GFP-A-Basic | Tens of percent higher contrast; brightness slightly lower |
| FITC-3540B | FITC-A-Basic | >10% higher brightness; >10% higher contrast |
| YFP-2427A | YFP-A-Basic | Tens of percent higher brightness; comparable contrast |
| TRITC-A | TRITC-A-Basic | Tens of percent higher brightness and contrast;<br>Basic set intentionally designed for traditional deep-red TRITC emission |
| TXRED-4040B | 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.

# BrightLine Basic™ Best-value Single-band Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **CFW-LP01-Clinical** | Exciter | 387 nm | > 90% over 11 nm | **Sold as set only** |
| **Calcofluor White**, DAPI | Emitter | 416 nm (edge) | > 90% 419 – 700 nm | |
| *Long-pass set* *Mycological and fungal staining tests* | Dichroic | 412 nm (edge) | $R_{avg}$ > 90% 362 – 396 nm $T_{avg}$ > 90% 419 – 700 nm | |
| | | | **Unmounted Full Set:** | **CFW-LP01-Clinical-000** |
| **CFW-BP01-Clinical** | Exciter | 387 nm | > 90% over 11 nm | **Sold as set only** |
| **Calcofluor White**, DAPI | Emitter | 442 nm | > 90% over 46 nm | |
| *Mycological and fungal staining tests* | Dichroic | 412 nm (edge) | $R_{avg}$ > 90% 362 – 396 nm $T_{avg}$ > 90% 419 – 700 nm | |
| | | | **Unmounted Full Set:** | **CFW-BP01-Clinical-000** |
| **BFP-A-Basic** | Exciter | 390 nm | > 90% over 18 nm | FF01-390/18-25 |
| **BFP**, DAPI, Hoechst, AMCA, Alexa Fluor® 350 | Emitter | 460 nm | > 90% over 60 nm | FF01-460/60-25 |
| | Dichroic | 416 nm (edge) | $R_{avg}$ > 90% 360 – 407 nm $T_{avg}$ > 90% 425 – 575 nm | FF416-Di01-25x36 |
| | | | **Unmounted Full Set:** | **BFP-A-Basic-000** |
| **CFP-A-Basic** | Exciter | 434 nm | > 90% over 17 nm | FF01-434/17-25 |
| **CFP**, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 | Emitter | 479 nm | > 90% over 40 nm | FF01-479/40-25 |
| | Dichroic | 452 nm (edge) | $R_{avg}$ > 90% 423 – 445 nm $T_{avg}$ > 90% 460 – 610 nm | FF452-Di01-25x36 |
| | | | **Unmounted Full Set:** | **CFP-A-Basic-000** |
| **WGFP-A-Basic** | Exciter | 445 nm | > 90% over 45 nm | FF01-445/45-25 |
| **wtGFP** | Emitter | 510 nm | > 90% over 42 nm | FF01-510/42-25 |
| | Dichroic | 482 nm (edge) | $R_{avg}$ > 90% 415 – 470 nm $T_{avg}$ > 90% 490 – 720 nm | FF482-Di01-25x36 |
| | | | **Unmounted Full Set:** | **WGFP-A-Basic-000** |
| **GFP-A-Basic** | Exciter | 469 nm | > 90% over 35 nm | FF01-469/35-25 |
| **GFP**, EGFP, DiO, Cy2™, YOYO-1, YO-PRO-1 | Emitter | 525 nm | > 90% over 39 nm | FF01-525/39-25 |
| | Dichroic | 497 nm (edge) | $R_{avg}$ > 90% 452 – 490 nm $T_{avg}$ > 90% 505 – 800 nm | FF497-Di01-25x35 |
| | | | **Unmounted Full Set:** | **GFP-A-Basic-000** |
| **FITC-A-Basic** | Exciter | 475 nm | > 90% over 35 nm | FF01-475/35-25 |
| **FITC**, rsGFP, Bodipy, FAM, Fluo-4, Alexa Fluor® 488 | Emitter | 530 nm | > 90% over 43 nm | FF01-530/43-25 |
| | Dichroic | 499 nm (edge) | $R_{avg}$ > 90% 470 – 490 nm $T_{avg}$ > 90% 508 – 675 nm | FF499-Di01-25x36 |
| | | | **Unmounted Full Set:** | **FITC-A-Basic-000** |

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NOTE: BrightLine Basic dichroics are not sold separately

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

# BrightLine Basic™ Best-value Single-band Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

| Set / Primary Fluorophores | | Center Wavelength / Nominal Edge Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|---|
| **FITC-LP01-Clinical** | Exciter | 475 nm | > 90% over 28 nm | **Sold as set only** |
| **FITC**, Acridine Orange | Emitter | 515 nm (edge) | > 90% 519 - 700 nm | |
| *Long-pass set* *Immunofluorescent clinical tests* | Dichroic | 502 nm (edge) | $R_{avg}$ > 90% 461.5 – 489.5 nm $T_{avg}$ > 90% 519 – 700 nm | |
| | | | **Unmounted Full Set:** | **FITC-LP01-Clinical-000** |
| **YFP-A-Basic** | Exciter | 497 nm | > 90% over 16 nm | FF01-497/16-25 |
| **YFP**, Calcium Green-1, Eosin, Fluo-3, Rhodamine 123 | Emitter | 535 nm | > 90% over 22 nm | FF01-535/22-25 |
| | Dichroic | 516 nm (edge) | $R_{avg}$ > 90% 490 – 510 nm $T_{avg}$ > 90% 520 – 700 nm | FF516-Di01-25x36 |
| | | | **Unmounted Full Set:** | **YFP-A-Basic-000** |
| **TRITC-A-Basic** | Exciter | 542 nm | > 90% over 20 nm | FF01-542/20-25 |
| **TRITC**, Rhodamine, DiI, 5-TAMRA, Alexa Fluor® 532 & 546 | Emitter | 620 nm | > 90% over 52 nm | FF01-620/52-25 |
| | Dichroic | 570 nm (edge) | $R_{avg}$ > 90% 525 – 556 nm $T_{avg}$ > 90% 580 – 650 nm | FF570-Di01-25x36 |
| | | | **Unmounted Full Set:** | **TRITC-A-Basic-000** |
| **CY3.5-A-Basic** | Exciter | 565 nm | > 90% over 24 nm | FF01-565/24-25 |
| **Cy3.5™**, mStrawberry | Emitter | 620 nm | > 90% over 52 nm | FF01-620/52-25 |
| | Dichroic | 585 nm (edge) | $R_{avg}$ > 90% 533 – 580 nm $T_{avg}$ > 90% 595 – 800 nm | FF585-Di01-25x36 |
| | | | **Unmounted Full Set:** | **CY3.5-A-Basic-000** |
| **TXRED-A-Basic** | Exciter | 559 nm | > 90% over 34 nm | FF01-559/34-25 |
| **Texas Red®**, mCherry, 5-ROX, Alexa Fluor® 568 & 594 | Emitter | 630 nm | > 90% over 69 nm | FF01-630/69-25 |
| | Dichroic | 585 nm (edge) | $R_{avg}$ > 90% 533 – 580 nm $T_{avg}$ > 90% 595 – 800 nm | FF585-Di01-25x36 |
| | | | **Unmounted Full Set:** | **TXRED-A-Basic-000** |

Cubes
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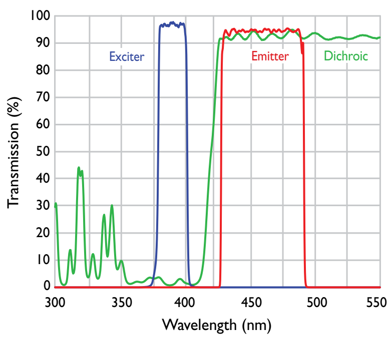
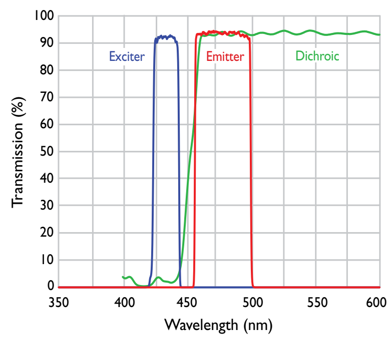
NOTE: BrightLine Basic dichroics are not sold separately

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

BFP-A Basic Spectra




CFP-A Basic Spectra



# TECHNICAL NOTE

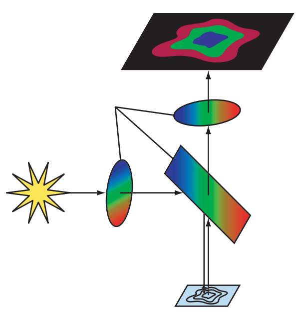
## Multiband Filter Set Terminology

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 (see page 11 for a complete explanation), 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.
See www.semrock.com for our 2006 BioPhotonics International article.

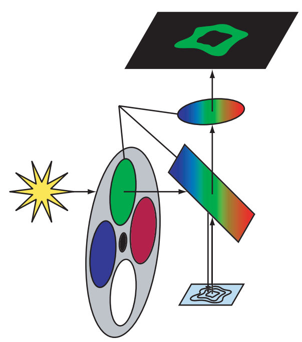
### "Full Multiband" Configuration

*(Multiband exciter, multiband emitter, & multiband dichroic)*



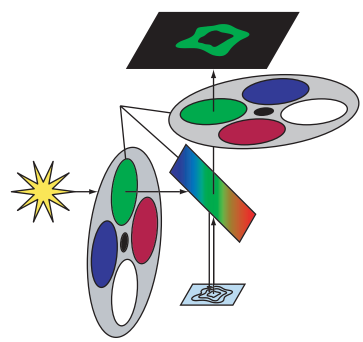
### "Pinkel" Configuration

*(Multiband emitter, multiband dichroic, & single-band exciters)*



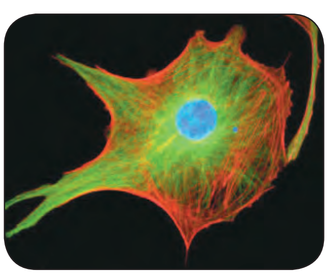
### "Sedat" Configuration

*(Multiband dichroic, single-band exciters, & single-band emitters)*



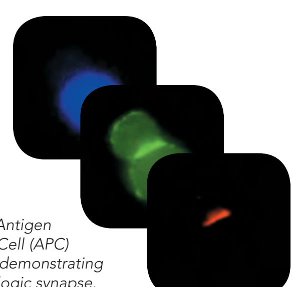
### "Full Multiband" Image

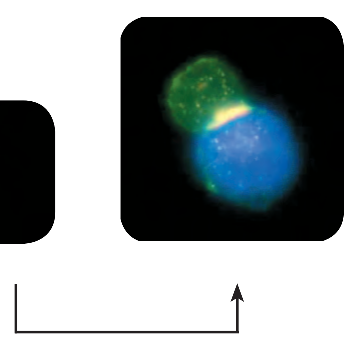
*Multi-color image captured with a color CCD camera*



### "Pinkel" and "Sedat" Composite Image

*Single-color images are combined electronically to produce one high-fidelity, multi-color image.*





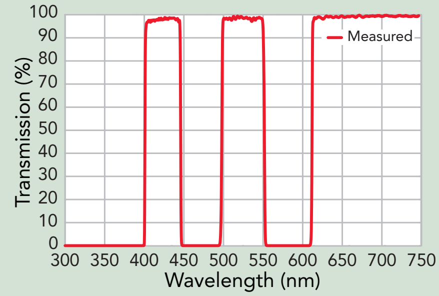
*T-Cell and Antigen Presenting Cell (APC) conjugates demonstrating an immunologic synapse. Samples courtesy of Beth Graf and Dr. Jim Miller at the University of Rochester Medical Center.*

# BrightLine® Multiband Fluorescence Sets

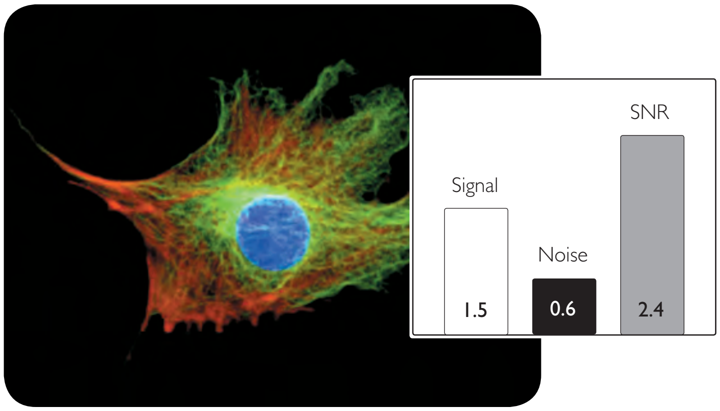
Extensive selection of filter sets in stock.
We have a 30-day return policy.

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 brightness – visually and digitally
- Deep blocking for striking contrast – visually and digitally
- *ALL* hard dielectric coatings, including blue and UV filters, for long-lasting “no burn-out” performance



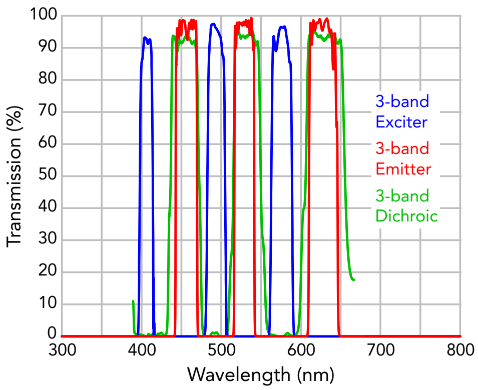

*Graph above shows typical measured transmission of the FF01-425/527/685-25 filter*




Semrock’s award-winning multiband filter sets are uniquely optimized to provide brilliant colors and a very black back-ground. In this example, the relative signal, noise, and signal-to-noise ratio achieved by a BrightLine DA/FI/TX-B filter set was compared side-by-side with the performance of the compa-rably priced premium soft-coated Full Multiband set of a leading competitor. The BrightLine filters are 50% brighter and provide a stunning 2.4 times higher contrast.

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. DA/FI/TX-B filter set is shown.

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



# BrightLine® Multiband Fluorescence Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

## "Full Multiband" Filter Sets *(See page 24 for definitions)*

| Set / Primary Fluorophores | Center Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|
| **CFP/YFP-A Full Multiband Set** | 416 nm<br>501 nm | > 90% over 25 nm<br>> 90% over 18 nm | Dual-band Exciter<br>FF01-416/501-25 |
| Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1<br>Yellow: YFP, Calcium Green-1, Eosin, Rhodamine 123 | 464 nm<br>547 nm | > 90% over 23 nm<br>> 90% over 31 nm | Dual-band Emitter<br>FF01-464/547-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidth** | |
| *Dual-band* | > 95% 415 – 432 nm<br>> 95% 493 – 511 nm | > 90% 449 – 483 nm<br>> 90% 530 – 569 nm | Dual-band Dichroic<br>FF440/520-Di01-25x36 |
| | | **Unmounted Full Set:** | **CFP/YFP-A-000** |
| **GFP/DsRed-A Full Multiband Set** | 468 nm<br>553 nm | > 90% over 34 nm<br>> 90% over 24 nm | Dual-band Exciter<br>FF01-468/553-25 |
| Green: GFP, rsGFP, FITC, Alexa Fluor® 488<br>Red: DsRed, TRITC, Cy3™, Texas Red®, Alexa Fluor® 568 & 594 | 512 nm<br>630 nm | > 90% over 23 nm<br>> 90% over 91 nm | Dual-band Emitter<br>FF01-512/630-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidth** | |
| *Dual-band* | > 95% 456 – 480 nm<br>> 95% 541 – 565 nm | > 90% 500 – 529 nm<br>> 90% 584 – 679 nm | Dual-band Dichroic<br>FF493/574-Di01-25x36 |
| | | **Unmounted Full Set:** | **GFP/DsRed-A-000** |
| **FITC/TxRed-A Full Multiband Set** | 479 nm<br>585 nm | > 90% over 38 nm<br>> 90% over 27 nm | Dual-band Exciter<br>FF01-479/585-25 |
| Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488<br>Red: Texas Red®, mCherry, Alexa Fluor® 568 & 594 | 524 nm<br>628 nm | > 90% over 29 nm<br>> 90% over 33 nm | Dual-band Emitter<br>FF01-524/628-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidth** | |
| *Dual-band* | > 95% 458 – 499 nm<br>> 95% 570 – 600 nm | > 90% 509 – 541 nm<br>> 90% 612 – 647 nm | Dual-band Dichroic<br>FF505/606-Di01-25x36 |
| | | **Unmounted Full Set:** | **FITC/TxRed-A-000** |
| **Cy3/Cy5-A Full Multiband Set** | 534 nm<br>635 nm | > 90% over 36 nm<br>> 90% over 31 nm | Dual-band Exciter<br>FF01-534/635-25 |
| Yellow: Cy3™, DsRed, Alexa Fluor® 555<br>Red: Cy5™, SpectrumFRed™, Alexa Fluor® 647 & 660 | 577 nm<br>690 nm | > 90% over 24 nm<br>> 90% over 50 nm | Dual-band Emitter<br>FF01-577/690-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidth** | |
| *Dual-band* | > 95% 514 – 553 nm<br>> 95% 617 – 652 nm | > 90% 564 – 591 nm<br>> 90% 665 – 718 nm | Dual-band Dichroic<br>FF560/659-Di01-25x36 |
| | | **Unmounted Full Set:** | **Cy3/Cy5-A-000** |
| **DA/FI/TX-B Full Multiband Set** | 407 nm<br>494 nm<br>576 nm | > 80% over 14 nm<br>> 85% over 20 nm<br>> 85% over 20 nm | Triple-band Exciter<br>FF01-407/494/576-25 |
| Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350<br>Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488<br>Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594 | 457 nm<br>530 nm<br>628 nm | > 80% over 22 nm<br>> 85% over 20 nm<br>> 85% over 28 nm | Triple-band Emitter<br>FF01-457/530/628-25 |
| | **Avg. Reflection / Bandwidths** | **Avg. Transmission / Bandwidth** | |
| *Triple-band* | > 97.5% 394 – 414 nm<br>> 97.5% 484 – 504 nm<br>> 97.5% 566 – 586 nm | > 90% 446 – 468 nm<br>> 90% 520 – 540 nm<br>> 90% 614 – 642 nm | Triple-band Dichroic<br>FF436/514/604-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/FI/TX-B-000** |

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*(continued)*

**Coming Soon – DAPI/FITC/TRITC Full Multiband filter set!**

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

# BrightLine® Multiband Fluorescence Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

## "Pinkel" Multiband Filter Sets *(See page 24 for definitions)*

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

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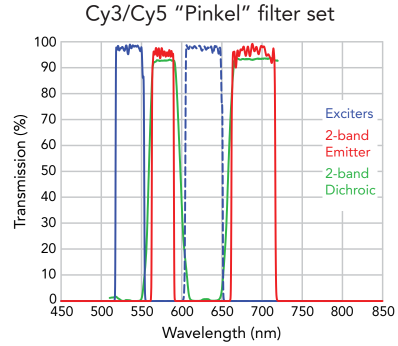
*(continued)*

Cy3/Cy5 "Pinkel" filter set




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

# BrightLine® Multiband Fluorescence Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

## "Pinkel" Multiband Filter Sets *(continued)*

| Set / Primary Fluorophores | Center Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|
| **BFP/GFP/HcRed-3X-A Pinkel Set** | 370 nm | > 90% over 36 nm | Exciter 1 FF01-370/36-25 |
| Blue: BFP, DAPI, Hoechst, AMCA, Alexa Fluor® 350<br>Green: GFP, rsGFP, FITC, Alexa Fluor® 488<br>Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594 | 474 nm | > 90% over 23 nm | Exciter 2 FF01-474/23-25 |
| | 585 nm | > 90% over 29 nm | Exciter 3 FF01-585/29-25 |
| *Triple-band* | 425 nm<br>527 nm<br>685 nm | > 90% over 35 nm<br>> 90% over 42 nm<br>> 90% over 130 nm | Triple-band Emitter<br>FF01-425/527/685-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 97% 354 – 385 nm<br>> 97% 465 – 483 nm<br>> 97% 570 – 596 nm | > 95% 403 – 446 nm<br>> 95% 502 – 552 nm<br>> 95% 620 – 750 nm | Triple-band Dichroic<br>FF395/495/610-Di01-25x36 |
| | | **Unmounted Full Set:** | **BFP/GFP/HcRed-3X-A-000** |
| **CFP/YFP/HcRed-3X-A Pinkel Set** | 427 nm | > 93% over 10 nm | Exciter 1 FF01-427/10-25 |
| Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1<br>Yellow: YFP, Calcium Green-1, Fluo-3, Rhodamine 123<br>Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594 | 504 nm | > 93% over 12 nm | Exciter 2 FF01-504/12-25 |
| | 589 nm | > 93% over 15 nm | Exciter 3 FF01-589/15-25 |
| *Triple-band* | 464 nm<br>542 nm<br>639 nm | > 90% over 23nm<br>> 90% over 27 nm<br>> 90% over 42 nm | Triple-band Emitter<br>FF01-464/542/639-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 420 – 430 nm<br>> 95% 496 – 510 nm<br>> 95% 579 – 596 nm | > 90% 451 – 480 nm<br>> 90% 530 – 561 nm<br>> 90% 618 – 664 nm | Triple-band Dichroic<br>FF444/521/608-Di01-25x36 |
| | | **Unmounted Full Set:** | **CFP/YFP/HcRed-3X-A-000** |

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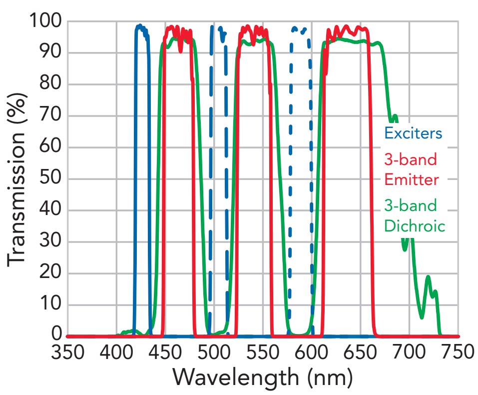
*(continued)*

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

Typical measured spectra of the CFP/YFP/HcRed "Pinkel" filter set




### If you use a Leica microscope . . .

All BrightLine single-band bandpass filters in "Pinkel" and "Sedat" sets, including for Leica microscopes, come with standard 25 mm (32 mm optional) exciters and 25 mm emitters, and are packaged separately for convenient mounting in standard filter wheels.

For part numbers for Leica microscopes, see www.semrock.com.

# BrightLine® Multiband Fluorescence Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

## "Pinkel" Multiband Filter Sets *(continued)*

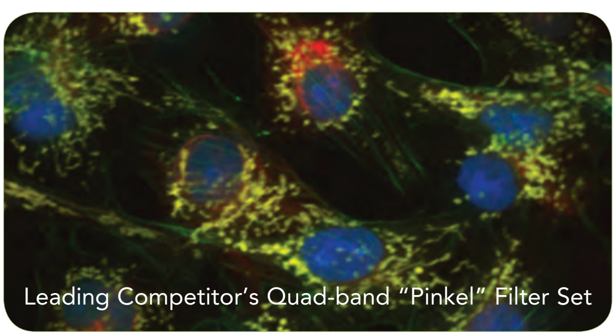
| Set / Primary Fluorophores | Center Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|
| **DA/FI/TX-3X-A Pinkel Set** | 387 nm | > 90% over 11 nm | Exciter 1 FF01-387/11-25 |
| Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350<br>Green: FITC, GFP, rsGFP, BoDipy, Alexa Fluor® 488<br>Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594 | 494 nm | > 93% over 20 nm | Exciter 2 FF01-494/20-25 |
| | 575 nm | > 93% over 25 nm | Exciter 3 FF01-575/25-25 |
| | 457 nm<br>530 nm<br>628 nm | > 80% over 22 nm<br>> 85% over 20 nm<br>> 85% over 28 nm | Triple-band Emitter FF01-457/530/628-25 |
| *Triple-band* | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 97.5% 394 – 414 nm<br>> 97.5% 484 – 504 nm<br>> 97.5% 566 – 586 nm | > 90% 446 – 468 nm<br>> 90% 520 – 540 nm<br>> 90% 614 – 642 nm | Triple-band Dichroic FF436/514/604-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/FI/TX-3X-A-000** |
| **DA/FI/TR/Cy5-4X-A Pinkel Set** | 387 nm | > 90% over 11 nm | Exciter 1 FF01-387/11-25 |
| Blue: DAPI, Hoechst, AMCA, Alexa Fluor® 350<br>Green: FITC, GFP, rsGFP, Bodipy, AlexaFluor® 488<br>Orange: TRITC, Cy3™, Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594<br>Red: Cy5™, APC, TOTO-3, TO-PRO-3, Alexa Fluor® 647 & 660 | 485 nm | > 93% over 20 nm | Exciter 2 FF01-485/20-25 |
| | 560 nm | > 93% over 25 nm | Exciter 3 FF01-560/25-25 |
| | 650 nm | > 93% over 13 nm | Exciter 4 FF01-650/13-25 |
| *Quad-band* | 440 nm<br>521 nm<br>607 nm<br>700 nm | > 90% over 40 nm<br>> 90% over 21 nm<br>> 90% over 34 nm<br>> 90% over 45 nm | Quad-band Emitter FF01-440/521/607/700-25 |
| *The flagship of multiband sets!* | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 381 – 392 nm<br>> 95% 475 – 495 nm<br>> 95% 547 – 572 nm<br>> 95% 643 – 656 nm | > 90% 420 – 460 nm<br>> 90% 510 – 531 nm<br>> 90% 589 – 623 nm<br>> 90% 677 – 722 nm | Quad-band Dichroic FF410/504/582/669-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/FI/TR/Cy5-4X-A-000** |

Cubes Page 32

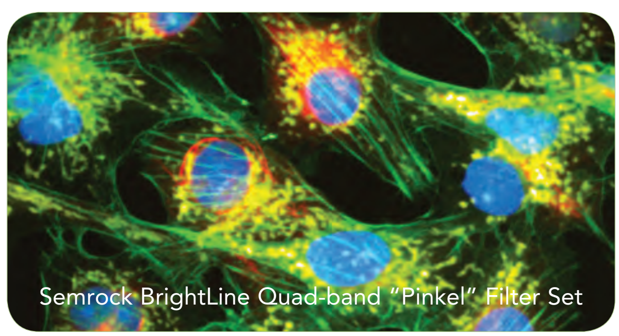
*(continued)*

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

## 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.

# BrightLine® Multiband Fluorescence Sets

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

## "Sedat" Multiband Filter Sets *(See page 24 for definitions)*

| Set / Primary Fluorophores | Center Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|
| **CFP/YFP-2X2M-A Sedat Set** | 427 nm | > 93% over 10 nm | Exciter 1 FF01-427/10-25 |
| Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 | 504 nm | > 93% over 12 nm | Exciter 2 FF01-504/12-25 |
| Yellow: YFP, Calcium Green-1, Eosin, Rhodamine 123 | 472 nm | > 93% over 30 nm | Emitter 1 FF01-472/30-25 |
| *Dual-band* | 542 nm | > 93% over 27 nm | Emitter 2 FF01-542/27-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 415 – 432 nm<br>> 95% 493 – 511 nm | > 90% 449 – 483 nm<br>> 90% 530 – 569 nm | Dichroic<br>FF440/520-Di01-25x36 |
| | | **Unmounted Full Set:** | **CFP/YFP-2X2M-A-000** |
| **GFP/DsRed-2X2M-B Sedat Set** | 470 nm | > 93% over 22 nm | Exciter 1 FF01-470/22-25 |
| Green: GFP, rsGFP, FITC, Alexa Fluor® 488 | 556 nm | > 93% over 20 nm | Exciter 2 FF01-556/20-25 |
| Red: DsRed, TRITC, Cy3™, Texas Red®, Alexa Fluor® 568 & 594 | 514 nm | > 93% over 30 nm | Emitter 1 FF01-514/30-25 |
| *Dual-band* | 617 nm | > 90% over 73 nm | Emitter 2 FF01-617/73-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 456 – 480 nm<br>> 95% 541 – 565 nm | > 90% 500 – 529 nm<br>> 90% 584 – 679 nm | Dichroic<br>FF493/574-Di01-25x36 |
| | | **Unmounted Full Set:** | **GFP/DsRed-2X2M-B-000** |
| **FITC/TxRed-2X2M-A Sedat Set** | 485 nm | > 93% over 20 nm | Exciter 1 FF01-485/20-25 |
| Green: FITC, GFP, rsGFP, BoDipy, Alexa Fluor® 488 | 586 nm | > 93% over 20 nm | Exciter 2 FF01-586/20-25x5 |
| Red: Texas Red®, mCherry, Alexa Fluor® 568 & 594 | 536 nm | > 93% over 40 nm | Emitter 1 FF01-536/40-25 |
| *Dual-band* | 628 nm | > 93% over 32 nm | Emitter 2 FF01-628/32-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 458 – 499 nm<br>> 95% 570 – 600 nm | > 90% 509 – 541 nm<br>> 90% 612 – 647 nm | Dichroic<br>FF505/606-Di01- 25x36 |
| | | **Unmounted Full Set:** | **FITC/TxRed-2X2M-A-000** |
| **Cy3/Cy5-2X2M-A Sedat Set** | 534 nm | > 90% over 30 nm | Exciter 1 FF01-534/30-25 |
| Yellow: Cy3™, DsRed, Alexa Fluor® 555 | 628 nm | > 93% over 40 nm | Exciter 2 FF01-628/40-25 |
| Red: Cy5™, SpectrumFRed™, Alexa Fluor® 647 & 660 | 585 nm | > 90% over 40 nm | Emitter 1 FF01-585/40-25 |
| *Dual-band* | 692 nm | > 93% over 40 nm | Emitter 2 FF01-692/40-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 514 – 553 nm<br>> 95% 617 – 652 nm | > 90% 564 – 591 nm<br>> 90% 665 – 718 nm | Dichroic<br>FF560/659-Di01-25x36 |
| | | **Unmounted Full Set:** | **Cy3/Cy5-2X2M-A-000** |
| **CFP/YFP/HcRed-3X3M-A Sedat Set** | 427 nm | > 93% over 10 nm | Exciter 1 FF01-427/10-25 |
| Cyan: CFP, AmCyan, SYTOX Blue, BOBO-1, BO-PRO-1 | 504 nm | > 93% over 12 nm | Exciter 2 FF01-504/12-25 |
| Yellow: YFP, Calcium Green-1, Fluo-3, Rhodamine 123 | 589 nm | > 93% over 15 nm | Exciter 3 FF01-589/15-25 |
| Red: HcRed, Cy3.5™, Texas Red®, Alexa Fluor® 594 | 472 nm | > 93% over 30 nm | Emitter 1 FF01-472/30-25 |
| *Triple-band* | 542 nm | > 93% over 27 nm | Emitter 2 FF01-542/27-25 |
| | 632 nm | > 93% over 22 nm | Emitter 3 FF01-632/22-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 420 – 430 nm<br>> 95% 496 – 510 nm<br>> 95% 579 – 596 nm | > 90% 451 – 480 nm<br>> 90% 530 – 561 nm<br>> 90% 618 – 664 nm | Dichroic<br>FF444/521/608-Di01-25x36 |
| | | **Unmounted Full Set:** | **CFP/YFP/HcRed-3X3M-A-000** |

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*(continued)*

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

# BrightLine® Multiband Fluorescence Sets

Extensive selection of filter sets in stock.
We have a 30-day return policy.

## "Sedat" Multiband Filter Sets *(continued)*

| Set / Primary Fluorophores | Center Wavelength | Avg. Transmission / Bandwidth | Filter / Set Part Numbers |
|---|---|---|---|
| Blue: DAPI, Hoechst, AMCA, BFP, Alexa Fluor® 350<br>Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488<br>Red: Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594<br>**DA/FI/TX-3X3M-A Sedat Set**<br>*Triple-band* | 387 nm | > 90% over 11 nm | Exciter 1 FF01-387/11-25 |
| | 494 nm | > 93% over 20 nm | Exciter 2 FF01-494/20-25 |
| | 575 nm | > 93% over 25 nm | Exciter 3 FF01-575/25-25 |
| | 447 nm | > 93% over 60 nm | Emitter 1 FF02-447/60-25 |
| | 531 nm | > 90% over 22 nm | Emitter 2 FF01-531/22-25 |
| | 624 nm | > 93% over 40 nm | Emitter 3 FF01-624/40-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 394 – 414 nm<br>> 95% 484 – 504 nm<br>> 95% 566 – 586 nm | > 90% 446 – 468 nm<br>> 90% 520 – 540 nm<br>> 90% 614 – 642 nm | Dichroic<br>FF436/514/604-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/FI/TX-3X3M-A-000** |
| Blue: DAPI, Hoechst, AMCA, Alexa Fluor® 350<br>Green: FITC, GFP, rsGFP, Bodipy, Alexa Fluor® 488<br>Orange: TRITC, Cy3™, Texas Red®, MitoTracker Red, Alexa Fluor® 568 & 594<br>Red: Cy5™, APC, TOTO-3, TO-PRO-3, Alexa Fluor® 647 & 660<br>**DA/FI/TR/Cy5-4X4M-B Sedat Set**<br>*Quad-band* | 387 nm | > 90% over 11 nm | Exciter 1 FF01-387/11-25 |
| | 485 nm | > 93% over 20 nm | Exciter 2 FF01-485/20-25 |
| | 560 nm | > 93% over 25 nm | Exciter 3 FF01-560/25-25 |
| | 650 nm | > 93% over 13 nm | Exciter 4 FF01-650/13-25 |
| | 440 nm | > 93% over 40 nm | Emitter 1 FF01-440/40-25 |
| | 525 nm | > 90% over 30 nm | Emitter 2 FF01-525/30-25 |
| | 607 nm | > 93% over 36 nm | Emitter 3 FF01-607/36-25 |
| | 684 nm | > 90% over 24 nm | Emitter 4 FF01-684/24-25 |
| | **Avg. Reflection / Bandwidth** | **Avg. Transmission / Bandwidth** | |
| | > 95% 381 – 392 nm<br>> 95% 475 – 495 nm<br>> 95% 547 – 572 nm<br>> 95% 643 – 656 nm | > 90% 420 – 460 nm<br>> 90% 510 – 531 nm<br>> 90% 589 – 623 nm<br>> 90% 677 – 722 nm | Dichroic<br>FF410/504/582/669-Di01-25x36 |
| | | **Unmounted Full Set:** | **DA/FI/TR/Cy5-4X4M-B-000** |

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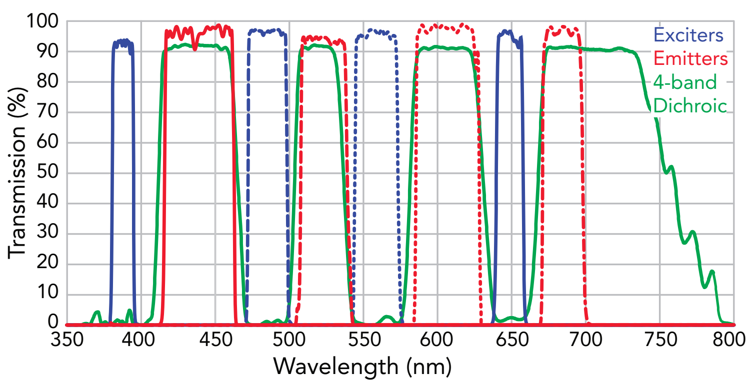
See spectra graphs and ASCII data for all of our filters at www.semrock.com

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




DA/FI/TR/Cy5-A "Sedat" Set Spectra

*This 9-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 four single-band emitters and four "no burn-out" single-band exciters. The single-band filters are intended to be mounted in filter wheels. For a "Pinkel" version of this filter set (replaces the single-band emitters with one quad-band emitter), see the DA/FI/TR/Cy5-4X-A set on page 29.*

# Fluorescence Filter Cubes and Filter Orientation

| Microscope Brand / Compatible Microscopes | Semrock Cube Designation | Cube Part Number | Filter Set Part Number Mounted in Cube |
|---|---|---|---|
| **Nikon** | | | |
| TE2000, 80i, 90i, 50i, and any using the Epi-fluor Illuminator | TE2000 | NTE | <Set Part Number>-NTE |
| E200, E400, E600, E800, E1000, TS100, TS100F, TE200, TE300, ME600L, L150A, and some Labophot, Optiphot, and Diaphot series | Quadfluor | NQF | <Set Part Number>-NQF |
| **Olympus** | | | |
| AX, BX, and IX series | U-MF2 | OMF | <Set Part Number>-OMF |
| MVX10 (and other large optical path microscopes) | U-MF/XL | OXL | <Set Part Number>-OXL |
| **Zeiss** | | | |
| Axio Imager, Axio Observer, Axioplan2i, Axioplan2ie, Axiovert200, and Axioskop2 (post-2001) | FL CUBE EC P&C | ZHE | <Set Part Number>-ZHE |
| Axioplan (pre-version 2), Axiovert100, and Axioskop2 (pre-2002) | Threaded Filter Cube | ZAT | <Set Part Number>-ZAT |
| **Leica** | | | |
| DM-4000, DM-5000, and DM-6000 | DM-K | LDMK | <Set Part Number>-LDMK |
| DM-LB, DM-LM, DM-LP, DM-RB, and DM-R HCRF4 | DM-R | LLC | <Set Part Number>-LLC |
| DM-IL, DM-IRB, DM-LS, DM-LSP, DM-R HCRF8, and DM-R XARF8 | DM-IRB | LSC | <Set Part Number>-LSC |

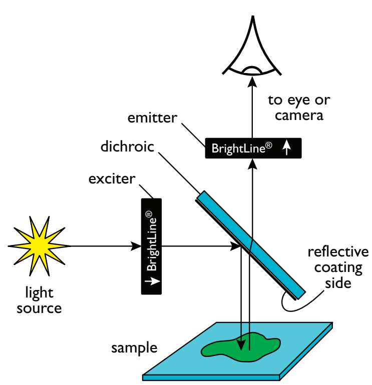
For a cube mounted set, replace "-000" with the cube part number from above (e.g. use FITC-3540B-NTE).

*Nikon, NTE* *Nikon, NQF* *Olympus, OMF* *Olympus, OXL* *Zeiss, ZHE* *Zeiss, ZAT* *Leica, LDMK* *Leica, LLC*

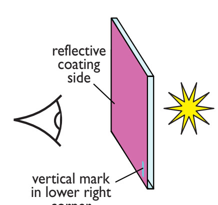
PRODUCT NOTE

## 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.

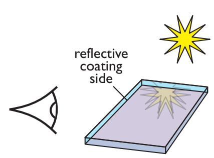


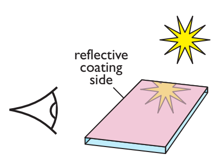

*The exciter and emitter should be oriented so that the arrow on the side of the aluminum ring points in the direction of propagation of the desired light – from the light source to dichroic for the exciter and from the dichroic to eye or camera for the emitter. The dichroic must be oriented such that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




### Marked Dichroics

*If the dichroic has a small linear mark (or one corner champfered), the reflective coating side is facing you when the mark is vertical (parallel to the long side) and the mark or champfer is in the 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.*

### Nikon, Olympus & Zeiss Microscopes

- Prices on pages 9-31 are for filters that fit most standard cubes for these microscopes. *See page 34 for dimensions.*
- For filters and set pricing based on Olympus U-MF/XL ("-OXL") cubes, *see www.semrock.com.*
- Multi-exciter sets are also available with 32 mm diameter exciters.

### Leica Microscopes

- Leica single-band, FURA-2, and FRET sets are available only as BrightLine ZERO™ sets (except for BrightLine Basic™, TRP-A, and QDLP-A and Laser Fluorescence sets).
- Prices in this catalog apply to current Leica "large format" filter sets. When building your complete part number, add "-L01-ZERO" after the set part number to indicate an unmounted "large format" set (or add "-LDMK-ZERO" or "-LLC-ZERO" for sets mounted in cubes).
- When building your complete part number for legacy "small-format" filter sets. add "- L02-ZERO" after the set part number to indicate an umounted "small format" set (or add "-LSC-ZERO" for a set mounted in a cube).

### For Certified BrightLine ZERO Upgrades

- Obtain "zero pixel shift" performance by adding a ZERO upgrade for sets with the zero option indicated *(see page 11).*

## 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** is critical to avoid 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.

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.*

# BrightLine® Filter Common Specifications (for filters in sets)

## 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)<br>Averaged over the passband |
| Typical Transmission | > 97% | Except BrightLine Basic, and Qdot: > 94%<br>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° |
| 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 | |
| Emitter Thickness | 3.5 mm | |
| Thickness Tolerance | ± 0.1 mm | |
| 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<br>Measured within clear aperture |
| Ring Housing Material | Aluminum, black anodized | |
| Blocking | BrightLine filters have blocking far exceeding OD 6 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 32)* | |

## Dichroic Beamsplitter Specifications

| Property | Specification | Comment |
|---|---|---|
| Guaranteed Transmission | > 90% | Averaged over the specified band |
| Typical Transmission | > 93% | Averaged over the specified band |
| Reflection | > 98% | Except BrightLine Basic and multiband *(see set tables)*<br>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° |
| 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<br>Measured within clear aperture |
| Edge Chipping | < 0.1 mm | |
| Orientation | Reflective coating side should face toward light source and sample *(see page 32)* | |

## General Filter Specifications (all BrightLine filters)

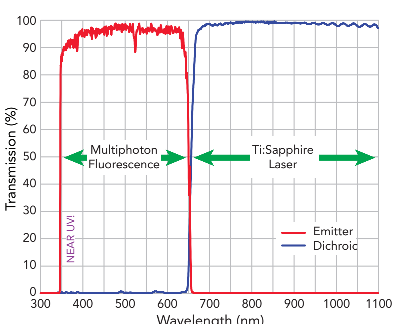
| Property | Specification |
|---|---|
| Coating Type | "Hard" ion-beam-sputtered |
| Reliability and Durability | Ion-beam-sputtered, hard-coated technology with epoxy-free, single-substrate construction for unrivaled filter life and no "burn-out" even when subjected to high optical intensities for 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, and Zeiss microscopes. |

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

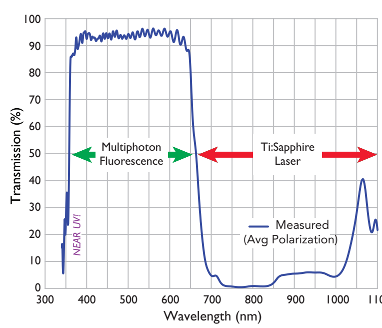
# BrightLine® Multiphoton Fluorescence Filters


These BrightLine multiphoton ultrahigh-performance fluorescence filters serve a full range of applications with just two sets of filters, 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°.

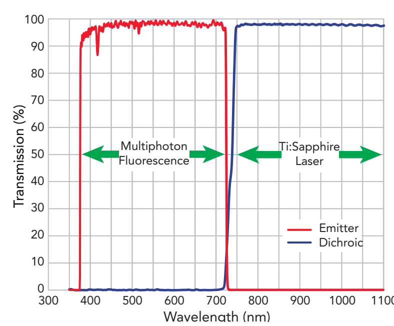
| Product Description | Avg. Transmission / Reflection Bandwidth and Range | Filter Part Numbers |
|---|---|---|
| **Transmits Near-UV – Deepest IR Blocking** | | |
| Short Wave Pass Emitter<br>*Laser Blocking Emission Filter* | $T_{avg}$ > 90% . . . . . . . . . . . . . . . . . 350 – 650 nm<br>Laser Blocking Range . . . . . . . OD > 8: 680 – 1040 nm<br>OD > 6: 1040 – 1080 nm | FF01-680/SP-25 |
| Long Wave Pass Dichroic Beamsplitter | $T_{avg}$ > 93% . . . . . . . . . . . . . . . . 680 – 1600 nm<br>$R_{avg}$ > 98% . . . . . . . . . . . . . . . . 350 – 650 nm | FF665-Di02-25x36 |
| Short Wave Pass Dichroic Beamsplitter | $T_{avg}$ > 90% . . . . . . . . . . . . . . . . . 360 – 650 nm<br>$R_{avg}$ > 98% (s-polarization). . . . 680 – 1080 nm<br>$R_{avg}$ > 90% (p-polarization). . . . 700 – 1010 nm | FF670-SDi01-25x36 |
| **Transmits Full Visible – Deep IR Blocking** | | |
| Short Wave Pass Emitter<br>*Laser Blocking Emission Filter* | $T_{avg}$ > 90% . . . . . . . . . . . . . . . . . 380 – 720 nm<br>Laser Blocking Range . . . . . . . . OD > 6: 750 – 1100 nm | FF01-750/SP-25 |
| Long Wave Pass Dichroic Beamsplitter | $T_{avg}$ > 93% . . . . . . . . . . . . . . . . . 750 – 1100 nm<br>$R_{avg}$ > 98% . . . . . . . . . . . . . . . . . 350 – 720 nm | FF735-Di01-25x36 |
| Short Wave Pass Dichroic Beamsplitter<br>*Ideal for Second Harmonic Generation (SHG)* | $T_{avg}$ > 85% (avg. polarization) 370 – 690 nm<br>T > 90% (s- & p-polarizations) 400 – 410 nm<br>$R_{avg}$ > 95% (avg. polarization) 750 – 875 nm<br>R > 99% (s- & p-polarizations) 800 – 820 nm | FF720-SDi01-25x36 |




**FF01-680/SP-25 and FF665-Di02-25x36 Spectra**
***Transmits Near-UV – Deepest IR Blocking***
*Provides exceptional OD > 8 blocking for detecting the lowest fluorophore concentrations, with transmission even down to near-UV wavelengths.*




**FF670-SDi01-25x36 Spectrum**

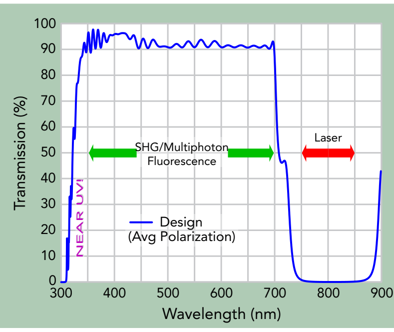



**FF01-750/SP-25 and FF735-Di01-25x36 Spectra**
***Transmits Full Visible – Deep IR Blocking***
*These filters provide excellent detection of fluorescence throughout the full visible wavelength range, including red fluorophores like Cy5™.*

## Second Harmonic Generation Dichroic Beamsplitter

*See details above for FF720-SDi01*

- Low dispersion for minimal pulse broadening
- Preserves polarization of both excitation and signal beams




**Coming soon –**
**Multiphoton short-wave-pass emitter and matching long-wave-pass dichroic with cut-off between the corresponding filters above.**

# Multiphoton Filters 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 35. |
| | 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 35. |
| 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 32. | | |
| 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, for example, 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.

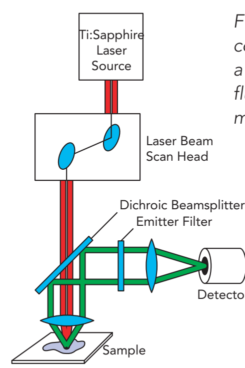
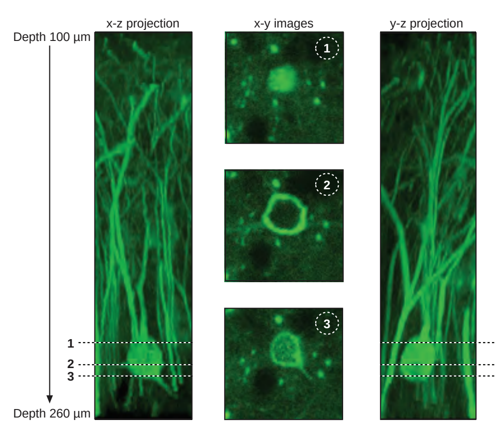


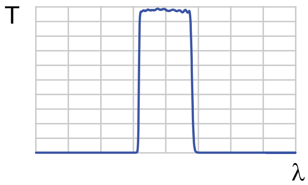

*Figure 1: Typical configuration of a multiphoton fluorescence microscope*




*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.)*

# Single-band Bandpass Filters

Custom-sized filters are available in one week.




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.

| Passband Color | Filter | Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| | Hg01-254-25 | 254 nm | *See Mercury Line filters, page 66* | |
| | FF01-280/20-25 | 280 nm | > 65% over 20 nm | 25 mm x 5 mm |
| New! | FF01-292/15-25 | 292 nm | > 40% over 15 nm | 25 mm x 3.5 mm |
| | FF01-295/15-25 | 295 nm | > 60% over 15 nm | 25 mm x 3.5 mm |
| | FF01-320/40-25 | 320 nm | > 70% over 40 nm | 25 mm x 5 mm |
| | FF01-335/7-25 | 335 nm | > 75% over 7 nm | 25 mm x 5 mm |
| New! | FF01-340/12-25 | 340 nm | > 75% over 12 nm | 25 mm x 3.5 mm |
| | FF01-340/26-25 | 340 nm | > 75% over 26 nm | 25 mm x 5 mm |
| | FF01-355/40-25 | 355 nm | > 80% over 40 nm | 25 mm x 3.5 mm |
| | FF01-357/44-25 | 357 nm | > 75% over 44 nm | 25 mm x 3.5 mm |
| | FF01-360/12-25 | 360 nm | > 75% over 12 nm | 25 mm x 5 mm |
| | Hg01-365-25 | 365 nm | *See Mercury Line filters, page 66* | |
| | FF01-370/36-25 | 370 nm | > 90% over 36 nm | 25 mm x 5 mm |
| | LD01-375/6-25 | 375 nm | *See Laser Diode Clean-Up filters, page 65* | |
| | FF01-377/50-25 | 377 nm | > 85% over 50 nm | 25 mm x 5 mm |
| | FF01-379/34-25 | 379 nm | > 90% over 34 nm | 25 mm x 5 mm |
| | FF01-380/14-25 | 380 nm | > 80% over 14 nm | 25 mm x 5 mm |
| | FF01-386/23-25 | 386 nm | > 90% over 23 nm | 25 mm x 5 mm |
| | FF01-387/11-25 | 387 nm | > 90% over 11 nm | 25 mm x 5 mm |
| | FF01-390/18-25 | 390 nm | > 90% over 18 nm | 25 mm x 5 mm |
| | FF01-390/40-25 | 390 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-395/11-25 | 395 nm | > 85% over 11 nm | 25 mm x 3.5 mm |
| | LD01-405/10-25 | 405 nm | *See Laser Diode Clean-Up filters, page 65* | |
| New! | FF01-405/10-25 | 405 nm | > 87% over 10 nm | 25 mm x 5 mm |
| | FF01-406/15-25 | 406 nm | > 85% over 15 nm | 25 mm x 3.5 mm |
| | FF01-417/60-25 | 417 nm | > 90% over 60 nm | 25 mm x 5 mm |
| | FF01-427/10-25 | 427 nm | > 93% over 10 nm | 25 mm x 5 mm |
| | FF01-434/17-25 | 434 nm | > 90% over 17 nm | 25 mm x 5 mm |
| | FF01-435/40-25 | 435 nm | > 90% over 40 nm | 25 mm x 5 mm |
| | FF01-438/24-25 | 438 nm | > 93% over 24 nm | 25 mm x 5 mm |
| | FF01-439/154-25 | 439 nm | > 93% over 154 nm | 25 mm x 5 mm |
| | LD01-439/8-25 | 439 nm | *See Laser Diode Clean-Up filters, page 65* | |
| | FF01-440/40-25 | 440 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-442/46-25 | 442 nm | > 90% over 46 nm | 25 mm x 3.5 mm |
| | FF01-445/20-25 | 445 nm | > 90% over 20 nm | 25 mm x 5 mm |
| | FF01-445/45-25 | 445 nm | > 90% over 45 nm | 25 mm x 5 mm |
| | FF02-447/60-25 | 447 nm | > 93% over 60 nm | 25 mm x 3.5 mm |
| | FF01-452/45-25 | 452 nm | > 93% over 45 nm | 25 mm x 3.5 mm |
| | FF01-457/50-25 | 457 nm | > 90% over 50 nm | 25 mm x 5 mm |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.

*(continued)*

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

# Single-band Bandpass Filters *(continued)*

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Passband Color | Filter | Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| | FF01-460/60-25 | 460 nm | > 90% over 60 nm | 25 mm x 3.5 mm |
| | FF02-460/80-25 | 460 nm | > 90% over 80 nm | 25 mm x 5 mm |
| | FF01-465/30-25 | 465 nm | > 90% over 30 nm | 25 mm x 5 mm |
| | FF01-469/35-25 | 469 nm | > 90% over 35 nm | 25 mm x 5 mm |
| | FF01-470/22-25 | 470 nm | > 93% over 22 nm | 25 mm x 5 mm |
| | FF01-472/30-25 | 472 nm | > 93% over 30 nm | 25 mm x 5 mm |
| | LD01-473/10-25 | 473 nm | *See Laser Diode Clean-Up filters, page 65* | |
| | FF01-474/23-25 | 474 nm | > 90% over 23 nm | 25 mm x 5 mm |
| | FF01-475/20-25 | 475 nm | > 90% over 20 nm | 25 mm x 3.5 mm |
| | FF01-475/28-25 | 475 nm | > 90% over 28 nm | 25 mm x 5 mm |
| | FF01-475/35-25 | 475 nm | > 90% over 35 nm | 25 mm x 5 mm |
| | FF01-475/42-25 | 475 nm | > 90% over 42 nm | 25 mm x 5 mm |
| | FF01-475/50-25 | 475 nm | > 90% over 50 nm | 25 mm x 5 mm |
| | FF01-475/64-25 | 475 nm | > 90% over 64 nm | 25 mm x 3.5 mm |
| | FF01-479/40-25 | 479 nm | > 90% over 40 nm | 25 mm x 3.5 mm |
| | FF01-480/17-25 | 480 nm | > 92% over 17 nm | 25 mm x 3.5 mm |
| | FF01-482/18-25 | 482 nm | > 93% over 18 nm | 25 mm x 5 mm |
| | FF01-482/35-25 | 482 nm | > 93% over 35 nm | 25 mm x 5 mm |
| | FF01-483/32-25 | 483 nm | > 93% over 32 nm | 25 mm x 3.5 mm |
| | FF01-485/20-25 | 485 nm | > 93% over 20 nm | 25 mm x 5 mm |
| | FF01-485/70-25 | 485 nm | > 90% over 70 nm | 25 mm x 5 mm |
| | FF01-488/6-25 | 488 nm | > 90% over 6 nm | 25 mm x 3.5 mm |
| | FF01-494/20-25 | 494 nm | > 93% over 20 nm | 25 mm x 5 mm |
| | FF01-494/41-25 | 494 nm | > 90% over 41 nm | 25 mm x 5 mm |
| | FF01-497/16-25 | 497 nm | > 90% over 16 nm | 25 mm x 5 mm |
| | FF01-500/15-25 | 500 nm | > 90% over 15 nm | 25 mm x 5 mm |
| | FF01-500/24-25 | 500 nm | > 93% over 24 nm | 25 mm x 5 mm |
| | FF01-504/12-25 | 504 nm | > 93% over 12 nm | 25 mm x 5 mm |
| | FF01-510/10-25 | 510 nm | > 90% over 10 nm | 25 mm x 5 mm |
| | FF02-510/20-25 | 510 nm | > 90% over 20 nm | 25 mm x 5 mm |
| | FF01-510/42-25 | 510 nm | > 90% over 42 nm | 25 mm x 3.5 mm |
| | FF01-510/84-25 | 510 nm | > 93% over 84 nm | 25 mm x 3.5 mm |
| | FF01-512/25-25 | 512 nm | > 92% over 25 nm | 25 mm x 3.5 mm |
| | FF01-513/17-25 | 513 nm | > 95% over 17 nm | 25 mm x 3.5 nm |
| | FF01-514/30-25 | 514 nm | > 93% over 30 nm | 25 mm x 3.5 mm |
| | FF01-520/15-25 | 520 nm | > 90% over 15 nm | 25 mm x 5 mm |
| | FF01-520/35-25 | 520 nm | > 93% over 35 nm | 25 mm x 3.5 mm |
| | FF01-523/20-25 | 523 nm | > 93% over 20 nm | 25 mm x 3.5 mm |
| | FF01-525/15-25 | 525 nm | > 90% over 15 nm | 25 mm x 3.5 mm |
| | FF01-525/20-25 | 525 nm | > 90% over 20 nm | 25 mm x 3.5 mm |
| | FF01-525/30-25 | 525 nm | > 90 % over 30 nm | 25 mm x 3.5 mm |
| | FF01-525/39-25 | 525 nm | > 90% over 39 nm | 25 mm x 3.5 mm |
| | FF02-525/40-25 | 525 nm | > 90% over 40 nm | 25 mm x 5 mm |
| | FF01-525/45-25 | 525 nm | > 93% over 45 nm | 25 mm x 3.5 mm |
| | FF01-525/50-25 | 525 nm | > 90% over 50 nm | 25 mm x 5 mm |
| | FF01-527/20-25 | 527 nm | > 93% over 20 nm | 25 mm x 3.5 mm |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.

*(continued)*

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

# Single-band Bandpass Filters *(continued)*

Custom-sized filters are available in one week.

| Passband Color | Filter | Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| | FF01-528/38-25 | 528 nm | > 90% over 38 nm | 25 mm x 5 mm |
| | FF01-529/24-25 | 529 nm | > 90% over 24 nm | 25 mm x 5 mm |
| | FF01-529/28-25 | 529 nm | > 90% over 28 nm | 25 mm x 3.5 mm |
| New! | FF01-530/11-25 | 530 nm | > 90% over 11 nm | 25 mm x 5 mm |
| | FF01-530/23-25 | 530 nm | > 93% over 23 nm | 25 mm x 3.5 mm |
| | FF01-530/43-25 | 530 nm | > 90% over 43 nm | 25 mm x 3.5 mm |
| | FF01-530/200-25-D | 530 nm | > 90% over 200 nm (UV/IR blocking filter) | 25 mm x 3 mm (unmounted) |
| | FF01-531/22-25 | 531 nm | > 90% over 22 nm | 25 mm x 5 mm |
| | FF01-531/40-25 | 531 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-534/20-25 | 534 nm | > 93% over 20 nm | 25 mm x 5 mm |
| | FF01-534/30-25 | 534 nm | > 90% over 30 nm | 25 mm x 5 mm |
| | FF01-534/42-25 | 534 nm | > 90% over 42 nm | 25 mm x 3.5 mm |
| | FF01-535/22-25 | 535 nm | > 90% over 22 nm | 25 mm x 3.5 mm |
| | FF01-536/40-25 | 536 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-537/26-25 | 537 nm | > 90% over 26 nm | 25 mm x 5 mm |
| | FF01-538/40-25 | 538 nm | > 90% over 40 nm | 25 mm x 3.5 mm |
| | FF01-540/15-25 | 540 nm | > 90% over 15 nm | 25 mm x 5 mm |
| | FF01-542/20-25 | 542 nm | > 90% over 20 nm | 25 mm x 5 mm |
| | FF01-542/27-25 | 542 nm | > 93% over 27 nm | 25 mm x 3.5 mm |
| | FF01-542/50-25 | 542 nm | > 93% over 50 nm | 25 mm x 5 mm |
| | FF01-543/22-25 | 543 nm | > 93% over 22 nm | 25 mm x 5 mm |
| | FF01-546/6-25 | 546 nm | > 90% over 6 nm | 25 mm x 3.5 mm |
| | FF01-550/32-25 | 550 nm | > 90% over 32 nm | 25 mm x 3.5 mm |
| | FF01-550/88-25 | 550 nm | > 92% over 88 nm | 25 mm x 3.5 mm |
| | FF01-554/211-25 | 554 nm | > 90% over 211 nm (UV/IR blocking filter) | 25 mm x 5 mm |
| | FF01-556/20-25 | 556 nm | > 93% over 20 nm | 25 mm x 5 mm |
| | FF01-559/34-25 | 559 nm | > 90% over 34 nm | 25 mm x 5 mm |
| | FF01-560/14-25 | 560 nm | > 90% over 14 nm | 25 mm x 5 mm |
| | FF01-560/25-25 | 560 nm | > 93% over 25 nm | 25 mm x 5 mm |
| New! | FF01-561/4-25 | 561 nm | > 93% over 4 nm | 25 mm x 5 mm |
| | FF01-561/14-25 | 561 nm | > 93% over 14 nm | 25 mm x 5 mm |
| | FF01-562/40-25 | 562 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-565/24-25 | 565 nm | > 90% over 24 nm | 25 mm x 5 mm |
| | FF01-567/15-25 | 567 nm | > 95% over 15 nm | 25 mm x 3.5 mm |
| | FF01-572/15-25 | 572 nm | > 92% over 15 nm | 25 mm x 3.5 mm |
| | FF01-572/28-25 | 572 nm | > 93% over 28 nm | 25 mm x 3.5 mm |
| | FF01-575/15-25 | 575 nm | > 90% over 15 nm | 25 mm x 5 mm |
| | FF01-575/25-25 | 575 nm | > 93% over 25 nm | 25 mm x 5 mm |
| | FF01-576/10-25 | 576 nm | > 90% over 10 nm | 25 mm x 3.5 mm |
| | FF01-579/34-25 | 579 nm | > 90% over 34 nm | 25 mm x 3.5 mm |
| | FF01-580/14-25 | 580 nm | > 90% over 14 nm | 25 mm x 5 mm |
| | FF01-580/23-25 | 580 nm | > 90% over 23 nm | 25 mm x 3.5 mm |
| | FF01-580/60-25-D | 580 nm | > 90% over 60 nm | 25 mm x 4 mm (unmounted) |
| | FF01-582/15-25 | 582 nm | > 90% over 15 nm | 25 mm x 3.5 mm |
| | FF01-582/75-25 | 582 nm | > 90% over 75 nm | 25 mm x 5 mm |
| | FF01-583/22-25 | 583 nm | > 92% over 22 nm | 25 mm x 3.5 mm |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.

*(continued)*

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

# Single-band Bandpass Filters *(continued)*

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

| Passband Color | Filter | Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| | FF01-583/120-25 | 583 nm | > 90% over 120 nm | 25 mm x 3.5 mm |
| | FF01-585/29-25 | 585 nm | > 90% over 29 nm | 25 mm x 5 mm |
| | FF01-585/40-25 | 585 nm | > 90% over 40 nm | 25 mm x 3.5 mm |
| | FF01-586/20-25x3.5 | 586 nm | > 93% over 20 nm | 25 mm x 3.5 mm |
| | FF01-586/20-25x5 | 586 nm | > 93% over 20 nm | 25 mm x 5 mm |
| | FF01-587/11-25 | 587 nm | > 90% over 11 nm | 25 mm x 5 mm |
| | FF01-588/21-25 | 588 nm | > 90% over 21 nm | 25 mm x 5 mm |
| | FF01-589/15-25 | 589 nm | > 93% over 15 nm | 25 mm x 5 mm |
| | FF01-590/10-25 | 590 nm | > 90% over 10 nm | 25 mm x 3.5 mm |
| | FF01-590/20-25 | 590 nm | > 90% over 20 nm | 25 mm x 5 mm |
| *New!* | FF01-592/8-25 | 592 nm | > 93% over 8 nm | 25 mm x 5 mm |
| | FF01-593/40-25 | 593 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-600/14-25 | 600 nm | > 90% over 14 nm | 25 mm x 5 mm |
| | FF01-605/15-25 | 605 nm | > 90% over 15 nm | 25 mm x 3.5 mm |
| | FF01-605/64-25 | 605 nm | > 90% over 64 nm | 25 mm x 3.5 mm |
| | FF01-607/36-25 | 607 nm | > 93% over 36 nm | 25 mm x 3.5 mm |
| | FF01-607/70-25 | 607 nm | > 92% over 70 nm | 25 mm x 3.5 mm |
| | FF01-609/54-25 | 609 nm | > 93% over 54 nm | 25 mm x 3.5 mm |
| | FF01-609/152-25 | 609 nm | > 93% over 152 nm | 25 mm x 5 mm |
| | FF01-615/24-25 | 615 nm | > 90% over 24 nm | 25 mm x 3.5 mm |
| | FF01-617/73-25 | 617 nm | > 90% over 73 nm | 25 mm x 5 mm |
| | FF01-620/14-25 | 620 nm | > 90% over 14 nm | 25 mm x 5 mm |
| | FF01-620/52-25 | 620 nm | > 90% over 52 nm | 25 mm x 3.5 mm |
| | FF01-623/18-25 | 623 nm | > 90% over 18 nm | 25 mm x 3.5 mm |
| | FF01-624/40-25 | 624 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-625/15-25 | 625 nm | > 90% over 15 nm | 25 mm x 3.5 mm |
| | FF01-625/26-25 | 625 nm | > 93% over 26 nm | 25 mm x 5 mm |
| | FF01-628/32-25 | 628 nm | > 93% over 32 nm | 25 mm x 3.5 mm |
| | FF01-628/40-25 | 628 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-629/53-25 | 629 nm | > 90% over 53 nm | 25 mm x 3.5 mm |
| | FF01-630/20-25 | 630 nm | > 90% over 20 nm | 25 mm x 3.5 mm |
| | FF01-630/69-25 | 630 nm | > 90% over 69 nm | 25 mm x 3.5 mm |
| | FF01-630/92-25 | 630 nm | > 92% over 92 nm | 25 mm x 3.5 mm |
| | FF01-632/22-25 | 632 nm | > 93% over 22 nm | 25 mm x 5 mm |
| | FF01-640/14-25 | 640 nm | > 90% over 14 nm | 25 mm x 5 mm |
| | LD01-640/8-25 | 640 nm | *See Laser Diode Clean-Up filters, page 65* | |
| *New!* | FF01-641/75-25 | 641 nm | > 93% over 75 nm | 25 mm x 3.5 mm |
| *New!* | FF01-642/10-25 | 642 nm | > 93% over 10 nm | 25 mm x 5 mm |
| | FF01-647/57-25 | 647 nm | > 92% over 57 nm | 25 mm x 3.5 mm |
| | FF01-650/13-25 | 650 nm | > 93% over 13 nm | 25 mm x 5 mm |
| | FF01-655/12-25 | 655 nm | > 90% over 12 nm | 25 mm x 3.5 mm |
| | FF01-655/15-25 | 655 nm | > 90% over 15 nm | 25 mm x 3.5 mm |
| | FF01-655/40-25 | 655 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-660/13-25 | 660 nm | > 90% over 13 nm | 25 mm x 5 mm |
| | FF01-670/30-25 | 670 nm | > 95% over 30 nm | 25 mm x 3.5 mm |
| | FF01-676/29-25 | 676 nm | > 90% over 29 nm | 25 mm x 3.5 mm |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.

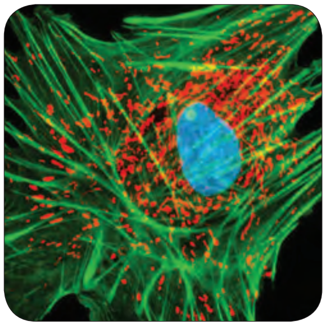
*(continued)*

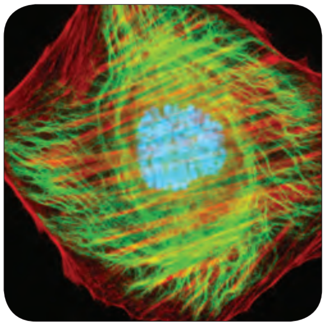
# Single-band Bandpass Filters *(continued)*

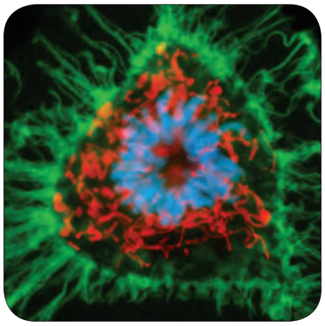
Custom-sized filters are available in one week.

| Passband Color | Filter | Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| | FF01-677/20-25 | 677 nm | > 90% over 20 nm | 25 mm x 3.5 mm |
| | FF01-680/13-25 | 680 nm | > 90% over 13 nm | 25 mm x 5 mm |
| | FF01-680/26-25 | 680 nm | > 92% over 26 nm | 25 mm x 3.5 mm |
| | FF01-684/24-25 | 684 nm | > 90% over 24 nm | 25 mm x 5 mm |
| | FF01-685/40-25 | 685 nm | > 90% over 40 nm | 25 mm x 5 mm |
| | FF01-688/31-25 | 688 nm | > 90% over 31 nm | 25 mm x 3.5 mm |
| | FF01-692/40-25 | 692 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-697/75-25-D | 697 nm | > 90% over 75 nm | 25 mm x 4 mm (unmounted) |
| | FF01-700/13-25 | 700 nm | > 90% over 13 nm | 25 mm x 5 mm |
| | FF01-710/40-25 | 710 nm | > 93% over 40 nm | 25 mm x 5 mm |
| | FF01-716/40-25 | 716 nm | > 93% over 40 nm | 25 mm x 3.5 mm |
| | FF01-716/43-25 | 716 nm | > 90% over 43 nm | 25 mm x 3.5 mm |
| | FF01-720/13-25 | 720 nm | > 90% over 13 nm | 25 mm x 5 mm |
| | FF01-725/150-25 | 725 nm | > 95% over 150 nm | 25 mm x 5 mm |
| | FF01-740/13-25 | 740 nm | > 90% over 13 nm | 25 mm x 5 mm |
| | FF01-760/12-25 | 760 nm | > 90% over 12 nm | 25 mm x 5 mm |
| New! | FF01-769/41-25 | 769 nm | > 93% over 41 nm | 25 mm x 5 mm |
| | FF01-775/46-25 | 775 nm | > 93% over 46 nm | 25 mm x 3.5 mm |
| | FF01-780/12-25 | 780 nm | > 90% over 12 nm | 25 mm x 5 mm |
| | FF01-785/62-25 | 785 nm | > 94% over 62 nm | 25 mm x 3.5 mm |
| | FF01-786/22-25 | 786 nm | > 93% over 22 nm | 25 mm x 3.5 mm |
| | FF01-794/160-25 | 794 nm | > 93% over 160 nm | 25 mm x 5 mm |
| | FF01-800/12-25 | 800 nm | > 90% over 12 nm | 25 mm x 5 mm |
| | FF01-820/12-25 | 820 nm | > 90% over 12 nm | 25 mm x 5 mm |
| New! | FF01-832/37-25 | 832 nm | > 93% over 37 nm | 25 mm x 3.5 mm |
| | FF01-839/270-25 | 839 nm | > 93% over 270 nm | 25 mm x 5 mm |
| | FF01-840/12-25 | 840 nm | > 90% over 12 nm | 25 mm x 5 mm |
| New! | FF01-970/20-25 | 970 nm | > 93% over 20 nm | 25 mm x 3.5 mm |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.





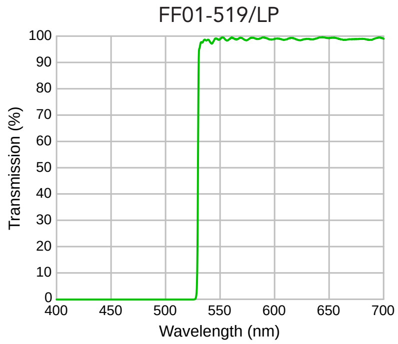


*Images courtesy of Mike Davidson at Molecular Expressions™, using BrightLine® fluorescence filter sets.*

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

# Single-edge Filters

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.




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. See EdgeBasic™ long-wave-pass filters on page 53.

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-pass edge filters and parts with a "/SP" are short-pass edge filters.

| Edge Color | Filter | Edge Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) |
|---|---|---|---|---|
| *New!* ● | FF01-280/SP-25 | 276 nm | > 70% 270 - 275 nm | 25 mm x 3.5 mm |
| ● | FF01-300/LP-25 | 306 nm | > 85% 308 - 420 nm | 25 mm x 5 mm |
| ● | FF01-310/SP-25 | 293 nm | > 70% 270 - 290 nm | 25 mm x 3.5 mm |
| ● | FF01-341/LP-25 | 347 nm | > 90% 350 - 500 nm | 25 mm x 3.5 mm |
| ● | FF01-409/LP-25 | 416 nm | > 90% 419 - 700 nm | 25 mm x 3.5 mm |
| ● | FF01-490/LP-25 | 497 nm | > 90% 500 - 800 nm | 25 mm x 5 mm |
| ● | FF01-492/SP-25 | 483 nm | > 90% 400 - 480 nm | 25 mm x 5 mm |
| ● | FF01-500/LP-25 | 515 nm | > 90% 519 - 700 nm | 25 mm x 3.5 mm |
| ● | FF01-518/SP-25 | 488 nm | > 90% 445 - 485 nm | 25 mm x 3.5 mm |
| ● | FF01-519/LP-25 | 530 nm | > 92% 534 - 653 nm | 25 mm x 3.5 mm |
| ● | FF01-676/LP-25 | 792 nm | > 95% 805 - 877 nm | 25 mm x 5 mm |
| ● | FF01-680/SP-25 | 654 nm | *See Multiphoton filters, page 35* | |
| ● | FF01-694/SP-25 | 681 nm | > 93% 481 - 676 nm | 25 mm x 3.5 mm |
| ● | FF01-736/LP-25 | 754 nm | > 90% 761 - 850 nm | 25 mm x 3.5 mm |
| ● | FF01-750/SP-25 | 727 nm | *See Multiphoton filters, page 35* | |
| ● | FF01-775/SP-25 | 761 nm | > 93% 481 - 756 nm | 25 mm x 3.5 mm |
| ● | FF01-800/LP-25 | 812 nm | > 90% 815 - 915 nm | 25 mm x 3.5 mm |
| ● | FF01-834/LP-25 | 840 nm | > 97% 842 - 935 nm | 25 mm x 3.5 mm |
| ● | FF01-842/SP-25 | 835 nm | > 95% 485 - 831 nm | 25 mm x 3.5 mm |

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

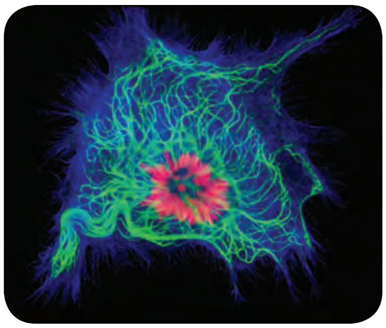
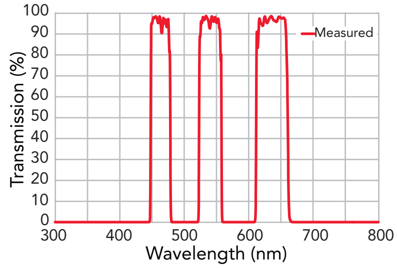


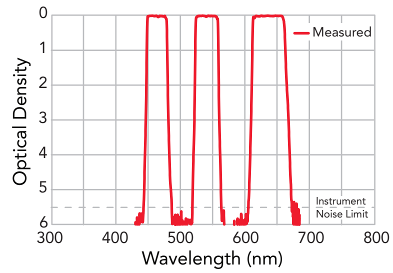
*Image courtesy of Mike Davidson at Molecular Expressions™, using BrightLine® fluorescence filter sets.*

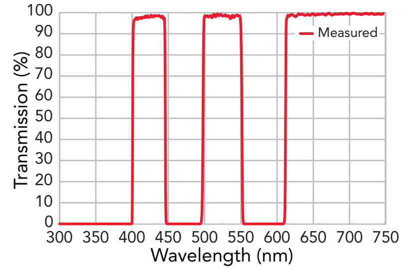
# Multiband Bandpass Filters

Custom-sized filters are available in one week.

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. Examples of triple-band filters FF01-464/542/639-25 and FF01-425/527/685-25 are shown below. See page 70 for a Technical Note on optical density.




| Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) | Filter Part Number |
|---|---|---|---|
| Dual-band Filters | | | |
| 416 nm<br>501 nm | > 90% over 25 nm<br>> 90% over 18 nm | 25 mm x 5 mm | FF01-416/501-25 |
| 448 nm<br>523 nm | > 90% over 55 nm<br>> 90% over 47 nm | 25 mm x 5 mm | FF01-448/523-25 |
| 464 nm<br>547 nm | > 90% over 23 nm<br>> 90% over 31 nm | 25 mm x 3.5 mm | FF01-464/547-25 |
| 468 nm<br>553 nm | > 90% over 34 nm<br>> 90% over 24 nm | 25 mm x 5 mm | FF01-468/553-25 |
| 477 nm<br>522 nm | > 90% over 45 nm<br>> 90% over 35 nm | 25 mm x 5 mm | FF01-477/522-25 |
| 479 nm<br>585 nm | > 90% over 38 nm<br>> 90% over 27 nm | 25 mm x 5 mm | FF01-479/585-25 |
| 480 nm<br>593 nm | > 90% over 10 nm<br>> 90% over 120 nm | 25 mm x 3.5 mm | FF01-480/593-25 |
| 494 nm<br>576 nm | > 90% over 20 nm<br>> 90% over 20 nm | 25 mm x 5 mm | FF01-494/576-25 |
| 503 nm<br>572 nm | > 90% over 18 nm<br>> 90% over 18 nm | 25 mm x 5 mm | FF01-503/572-25 |
| 507 nm<br>582 nm | > 90% over 15 nm<br>> 90% over 55 nm | 25 mm x 5 mm | FF01-507/582-25 |
| 508 nm<br>585 nm | > 90% over 26 nm<br>> 90% over 72 nm | 25 mm x 5 mm | FF01-508/585-25 |
| 512 nm<br>630 nm | > 90% over 23 nm<br>> 90% over 91 nm | 25 mm x 3.5 mm | FF01-512/630-25 |
| 524 nm<br>628 nm | > 90% over 29 nm<br>> 90% over 33 nm | 25 mm x 3.5 mm | FF01-524/628-25 |
| 527 nm<br>645 nm | > 90% over 42 nm<br>> 90% over 49 nm | 25 mm x 3.5 mm | FF01-527/645-25 |
| 534 nm<br>635 nm | > 90% over 36 nm<br>> 90% over 31 nm | 25 mm x 5 mm | FF01-534/635-25 |
| 538 nm<br>685 nm | > 90% over 50 nm<br>> 90% over 45 nm | 25 mm x 3.5 mm | FF01-538/685-25 |
| 577 nm<br>690 nm | > 90% over 24 nm<br>> 90% over 50 nm | 25 mm x 3.5 mm | FF01-577/690-25 |
| 594 nm<br>730 nm | > 90% over 42 nm<br>> 90% over 140 nm | 25 mm x 5 mm | FF01-594/730-25 |

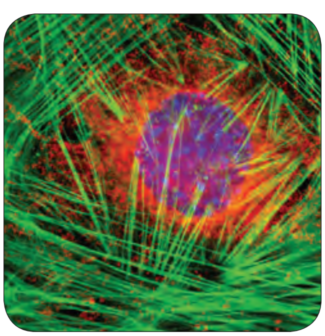
# Multiband Bandpass Filters *(continued)*

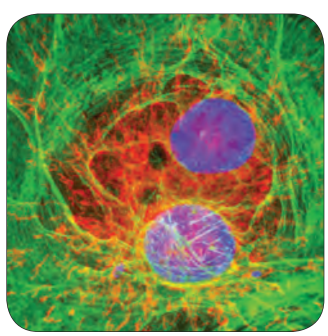
Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

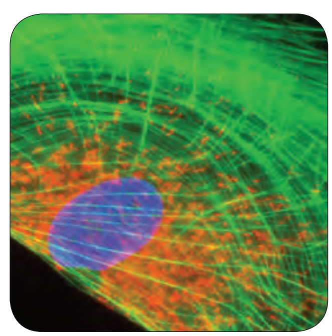
| Center Wavelength | Avg. Transmission / Bandwidth [1] | Size (Diameter x Thickness) | Filter Part Number |
|---|---|---|---|
| Triple-band Filters | | | |
| 407 nm<br>494 nm<br>576 nm | > 80% over 14 nm<br>> 85% over 20 nm<br>> 85% over 20 nm | 25 mm x 5 mm | FF01-407/494/576-25 |
| 422 nm<br>503 nm<br>572 nm | > 90% over 30 nm<br>> 90% over 18 nm<br>> 90% over 18 nm | 25 mm x 5 mm | FF01-422/503/572-25 |
| 425 nm<br>527 nm<br>685 nm | > 90% over 35 nm<br>> 90% over 42 nm<br>> 90% over 130 nm | 25 mm x 3.5 mm | FF01-425/527/685-25 |
| 457 nm<br>530 nm<br>628 nm | > 80% over 22 nm<br>> 85% over 20 nm<br>> 85% over 28 nm | 25 mm x 3.5 mm | FF01-457/530/628-25 |
| 464 nm<br>542 nm<br>639 nm | > 90% over 23 nm<br>> 90% over 27 nm<br>> 90% over 42 nm | 25 mm x 3.5 mm | FF01-464/542/639-25 |
| 465 nm<br>537 nm<br>623 nm | > 90% over 30 nm<br>> 90% over 20 nm<br>> 90% over 50 nm | 25 mm x 3.5 mm | FF01-465/537/623-25 |
| 480 nm<br>535 nm<br>610 nm | > 90% over 40 nm<br>> 90% over 21 nm<br>> 90% over 80 nm | 25 mm x 3.5 mm | FF01-480/535/610-25 |
| 480 nm<br>546 nm<br>685 nm | > 90% over 10 nm<br>> 90% over 22 nm<br>> 90% over 130 nm | 25 mm x 3.5 mm | FF01-480/546/685-25 |
| Quadruple-band Filters | | | |
| 440 nm<br>521 nm<br>607 nm<br>700 nm | > 90% over 40 nm<br>> 90% over 21 nm<br>> 90% over 34 nm<br>> 90% over 45 nm | 25 mm x 3.5 mm | FF01-440/521/607/700-25 |

[1] Bandwidth is the minimum width over which the average transmission exceeds the specified passband transmission; the nominal full-width-at-half-maximum (FWHM) is approximately the Bandwidth + 1% of the Center Wavelength.

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

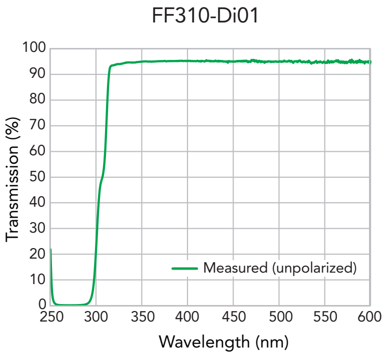






*Images courtesy of Mike Davidson at Molecular Expressions™, using BrightLine® fluorescence filter sets.*

Custom-sized filters are available in one week.




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. Our dichroics utilize high-optical-quality, ultralow-auto-fluorescence glass substrates. These filters are excellent for epifluorescence. For TIRF and diverse laser applications, see page 47.

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

Most beamsplitters are long-wave-pass (LWP) filters (reflect shorter wavelengths and transmit longer wavelengths). Short-wave-pass (SWP) beamsplitters (SDi01) are indicated in the special features column.

| Edge Color | Nominal Edge Wavelength | Avg. Reflection Band [1] | Avg. Transmission Band [1] | Special Features | Size (L x W x H or Diameter x Thickness) | Filter Part Number |
|---|---|---|---|---|---|---|
| | 310 nm | 255 – 295 nm | 315 – 600 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF310-Di01-25x36 |
| | 409 nm | 344 – 404 nm | 415 – 570 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF409-Di02-25x36 |
| | 458 nm | 426 – 450 nm | 467 – 600 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF458-Di01-25x36 |
| | 472 nm | 485 – 493 nm | 400 – 464 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF472-SDi01-25x36 |
| | 495 nm | 442 – 488 nm | 502 – 730 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF495-Di02-25x36 |
| | 500 nm | 485 – 491 nm | 510 – 825 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF500-Di01-25x36 |
| | 505 nm | 513 – 725 nm | 446 – 500 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF505-SDi01-25x36 |
| | 506 nm | 446 – 500 nm | 513 – 725 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF506-Di02-25x36 |
| | 510 nm | 327 – 488 nm | 515 – 850 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF510-Di01-25x36 |
| | 520 nm | 488 – 512 nm | 528 – 655 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF520-Di01-25x36 |
| | 541 nm | 570 – 710 nm | 500 – 530 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF541-SDi01-25x36 |
| | 550 nm | 509 – 537 nm | 559 – 850 nm | | 25.0 mm x 2.0 mm (unmounted) | FF550-Di01-25x2.0-D |
| | 552 nm | 524 – 544 nm | 558 – 725 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF552-Di01-25x36 |
| | 555 nm | 493 – 548 nm | 562 – 745 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF555-Di02-25x36 |
| | 560 nm | 485 – 545 nm | 570 – 825 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF560-Di01-25x36 |
| | 562 nm | 499 – 555 nm | 569 – 730 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF562-Di02-25x36 |
| | 591 nm | 601 – 800 nm | 530 – 585 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF591-SDi01-25x36 |
| | 593 nm | 530 – 585 nm | 601 – 800 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF593-Di02-25x36 |
| | 599 nm | 567 – 585 nm | 609 – 850 nm | | 25.0 mm x 2.0 mm (unmounted) | FF599-Di01-25x2.0-D |
| | 605 nm | 576 – 596 nm | 612 – 725 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF605-Di01-25x36 |
| | 648 nm | 400 – 629 nm | 658 – 700 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF648-Di01-25x36 |
| | 650 nm | 500 – 640 nm | 660 – 825 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF650-Di01-25x36 |
| | 655 nm | 470 – 645 nm | 665 – 726 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF655-Di01-25x36 |
| | 660 nm | 594 – 651 nm | 669 – 726 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF660-Di01-25x36 |
| | 665 nm | *See Multiphoton Filters, page 35* | | | | FF665-Di02-25x36 |
| | 669 nm | 350 – 660 nm | 677 – 800 nm | | 25.2 mm x 35.6 mm x 3.0 mm | FF669-Di01-25x36x3.0 |
| | 670 nm | *short-wave-pass; See Multiphoton Filters, page 35* | | | | FF670-SDi01-25x36 |

[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 98% and 90%, respectively.

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

# BrightLine® Fluorescence Dichroic Beamsplitters

Every Semrock filter is hard-coated for *no burn-out* performance and carries our five-year warranty.

### Single-edge Dichroic Beamsplitters *(continued)*

| Edge Color | Nominal Edge Wavelength | Avg. Reflection Band [1] | Avg. Transmission Band [1] | Special Features | Size (L x W x H or Diameter x Thickness) | Filter Part Number |
|---|---|---|---|---|---|---|
| | 677 nm | 400 – 658 nm | 687 – 830 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF677-Di01-25x36 |
| | 685 nm | 600 – 676 nm | 695 – 810 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF685-Di01-25x36 |
| | 709 nm | 661 – 692 nm | 720.5 – 850 nm | | 25.0 mm x 2.0 mm (unmounted) | FF709-Di01-25x2.0-D |
| | 721 nm | 805 – 877 nm | 668 – 674 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF721-SDi01-25x36 |
| | 731 nm | 625 – 710 nm | 742 – 850 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF731-Di01-25x36 |
| | 735 nm | *See Multiphoton Filters, page 35* | | | | FF735-Di01-25x36 |
| | 740 nm | 480 – 720 nm | 750 – 825 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF740-Di01-25x36 |
| | 741 nm | 660 – 731.5 nm | 750.5 – 810 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF741-Di01-25x36 |
| ***New!*** | 750 nm | 770 – 920 nm | 450 – 730 nm | short-wave-pass | 25.2 mm x 35.6 mm x 1.1 mm | FF750-SDi01-25x36x2.0 |
| ***New!*** | 801 mm | 749 – 790 nm | 813.5 – 885 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF801-Di01-25x36 |

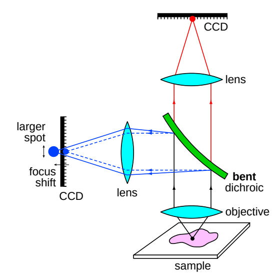
[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 98% and 90%, respectively.

## TECHNICAL NOTE

### Flatness of Dichroic Beamsplitters Affects Focus and Image Quality

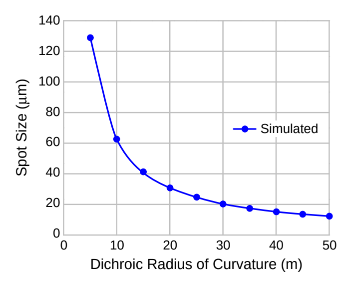
Optical filters are generally comprised of multi-layered thin-film coatings on plane, parallel glass substrates. All Semrock filters use a single substrate with coatings on one or both sides to maximize transmission and reliability and minimize artifacts associated with multiple interfaces. The glass 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. *(Note that all Smrock dichroice allow superb image quality wjhen used in transmission, as is common in almost all widedbanc, epifluorescence microscopes.)*

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.

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 below 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.

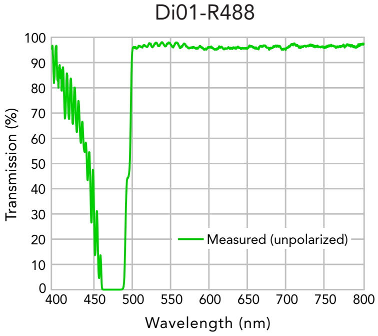



In this example the reflection occurs mid-way between a 40X, 0.75 NA objective and a 200 mm focal length tube lens, and the field of view is assumed to be limited by a 20 mm diameter field size at the image plane. Similar results are achieved with a 10X, 0.3 NA objective, or a 100X, 1.3 NA oil-immersion objective. For comparison, the diffraction-limited spot size that would result from perfect objective and tube lenses and a perfectly flat dichroic is approximately 12 μm.

Reflected image quality can be compromised for dichroics that are not perfectly flat, so in the most intolerant cases flatter dichroics, such as those designed for laser applications, should be used for imaging reflected light.

# BrightLine® Laser Fluorescence Dichroic Beamsplitters

Custom-sized filters are available in one week.




These dichroic beamsplitters are optimized for the most popular lasers used for fluorescence imaging, including newer all-solid-state lasers. 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°)*

| Nominal Edge Wavelength | Laser Wavelengths | Reflection Band | Avg. Transmission Band | Size (L x W x H) | Filter Part Number |
|---|---|---|---|---|---|
| 415 nm | 375 ± 3 nm<br>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 |
| 497 nm | 473 ± 2 nm<br>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 |
| 542 nm<br>New! | 514.5 nm<br>532 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 |
| 575 nm | 559 ± 5 nm<br>561.4 nm<br>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 |
| 654 nm | 632.8 nm<br>635 +7/–0 nm<br>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 |

## Laser Dichroic Beamsplitters Common Specifications

| Property | Value | Comment |
|---|---|---|
| Reflection | > 98% (s-polarization)<br>> 90% (p-polarization)<br>> 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<br>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 | < $\lambda$ / 4 RMS at $\lambda$ = 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 32)* | |
| 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 34.

Fluorescence Filters

# BrightLine® Fluorescence Dichroic Beamsplitters

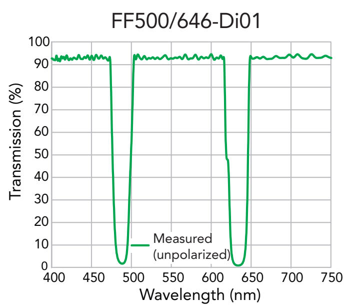


## Dual-edge Dichroic Beamsplitters *(polarization-insensitive; for use at 45°)*

| Nominal Edge Wavelength | Reflection Bands [1] | Transmission Bands [1] | Special Features | Size (L x W x H ) | Filter Part Number |
|---|---|---|---|---|---|
| 440 nm<br>520 nm | 415 – 432 nm<br>493 – 511 nm | 449 – 483 nm<br>530 – 569 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF440/520-Di01-25x36 |
| 462 nm<br>523 nm | 430 – 453 nm<br>508 – 512 nm | 471 – 489 nm<br>534 – 650 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF462/523-Di01-25x36 |
| 493 nm<br>574 nm | 456 – 480 nm<br>541 – 565 nm | 500 – 529 nm<br>584 – 679 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF493/574-Di01-25x36 |
| 495 nm<br>605 nm | 454 – 485 nm<br>570 – 598 nm | 505 – 550 nm<br>620 – 675 nm | Designed for dual-laser excitation (532 and 633 nm) of Cy3 and Cy5 | 25.2 mm x 35.6 mm x 1.1 mm | FF495/605-Di01-25x36 |
| 502 nm<br>670 nm | 350 – 494 nm<br>641 – 660 nm | 505 – 621 nm<br>677 – 800 nm | | 25.2 mm x 35.6 mm x 3.0 mm | FF502/670-Di01-25x36x3.0 |
| 505 nm<br>606 nm | 458 – 499 nm<br>570 – 600 nm | 509 – 541 nm<br>612 – 647 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF505/606-Di01-25x36 |
| 545 nm<br>650 nm | 532.0 nm<br>632.8 nm | 554 – 613 nm<br>658 – 742 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF545/650-Di01-25x36 |
| 560 nm<br>659 nm | 514 – 553 nm<br>617 – 652 nm | 564 – 591 nm<br>665 – 718 nm | | 25.2 mm x 35.6 mm x 1.1 mm | FF560/659-Di01-25x36 |

[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 95% and 90%, respectively.

## Narrow Notch Beamsplitters *(for reflecting laser lines at 45°)*




In addition to our standard single- and multi-notch filters, we offer these unique notch beamsplitters that reflect light incident at 45° over a narrow range of wavelengths centered on popular laser lines, and transmit light at wavelengths on both sides of the laser line efficiently. Each beamsplitter reflects two different laser lines for a variety of multi-laser instruments. Applications include laser-based fluorescence instruments, confocal and multiphoton fluorescence microscopes, and Raman spectroscopy systems.

| Nominal Edge Wavelength | Reflection Bands [1] | Transmission Bands [1] | Special Features | Size (L x W x H) | Filter Part Number |
|---|---|---|---|---|---|
| 497 nm<br>554 nm | 486 – 490 nm<br>542 – 544 nm | 420 – 471 nm<br>505 – 525 nm<br>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 |
| 497 nm<br>661 nm | 486 – 490 nm<br>646 – 648 nm | 420 – 471 nm<br>505 – 626 nm<br>668 – 750 nm | Reflects laser wavelengths 488 nm and 647 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF497/661-Di01-25x36 |
| 498 nm<br>581 nm | 486 – 490 nm<br>567 – 569 nm | 420 – 471 nm<br>505 – 549 nm<br>587 – 700 nm | Reflects laser wavelengths 488 nm and 568 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF498/581-Di01-25x36 |
| 500 nm<br>646 nm | 486 – 490 nm<br>632 – 634 nm | 420 – 471 nm<br>505 – 613 nm<br>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 |
| 553 nm<br>659 nm | 542 – 544 nm<br>646 – 648 nm | 420 – 525 nm<br>561 – 626 nm<br>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 |
| 555 nm<br>646 nm | 542 – 544 nm<br>632 – 634 nm | 420 – 525 nm<br>561 – 613 nm<br>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 |
| 576 nm<br>661 nm | 567 – 569 nm<br>646 – 648 nm | 420 – 549 nm<br>587 – 626 nm<br>668 – 750 nm | Reflects laser wavelengths 568 nm and 647 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF576/661-Di01-25x36 |
| 579 nm<br>644 nm | 567 – 569 nm<br>632 – 634 nm | 420 – 549 nm<br>587 – 613 nm<br>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 |

[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 95% and 90%, respectively.

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

# BrightLine® Fluorescence Dichroic Beamsplitters

Custom-sized filters are available in one week.

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

| Nominal Edge Wavelength | Reflection Bands [1] | Transmission Bands [1] | Size (L x W x H) | Filter Part Number |
|---|---|---|---|---|
| 395 nm<br>495 nm<br>610 nm | 354 – 385 nm<br>465 – 483 nm<br>570 – 596 nm | 403 – 446 nm<br>502 – 552 nm<br>620 – 750 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF395/495/610-Di01-25x36 |
| 436 nm<br>514 nm<br>604 nm | 394 – 414 nm<br>484 – 504 nm<br>566 – 586 nm | 446 – 468 nm<br>520 – 540 nm<br>614 – 642 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF436/514/604-Di01-25x36 |
| 444 nm<br>520 nm<br>590 nm | 327 – 437 nm<br>494 – 512 nm<br>562 – 578 nm | 450 – 480 nm<br>527 – 547 nm<br>598 – 648 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF444/520/590-Di01-25x36 |
| 444 nm<br>521 nm<br>608 nm | 420 – 430 nm<br>496 – 510 nm<br>579 – 596 nm | 451 – 480 nm<br>530 – 561 nm<br>618 – 664 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF444/521/608-Di01-25x36 |
| 462 nm<br>522 nm<br>607 nm | 430 – 453 nm<br>507 – 512 nm<br>580 – 595 nm | 471 – 489 nm<br>532 – 560 nm<br>619 – 750 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF462/522/607-Di01-25x36 |
| 494 nm<br>540 nm<br>650 nm | 488 nm<br>(s polarization only)<br>532 nm<br>633 – 642 nm | 500 – 519 nm<br>545 – 610 nm<br>655 – 700 nm | 25.2 mm x 35.6 mm x 3.5 mm<br>(NBK7 substrate) | FF494/540/650-Di01-25x36x3.5 |

[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 95% and 90%, respectively.

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

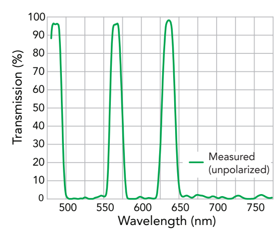
| Nominal Edge Wavelength | Reflection Bands [1] | Transmission Bands [1] | Size (L x W x H) | Filter Part Number |
|---|---|---|---|---|
| 410 nm<br>504 nm<br>582 nm<br>669 nm | 381 – 392 nm<br>475 – 495 nm<br>547 – 572 nm<br>643 – 656 nm | 420 – 460 nm<br>510 – 531 nm<br>589 – 623 nm<br>677 – 722 nm | 25.2 mm x 35.6 mm x 1.1 mm | FF410/504/582/669-Di01-25x36 |
| 416 nm<br>500 nm<br>582 nm<br>657 nm | 400 – 410 nm<br>486 – 491 nm<br>560 – 570 nm<br>633 – 647 nm | 422 – 473 nm<br>506 – 545 nm<br>586 – 617 nm<br>666 – 750 nm | 25.2 mm x 35.6 mm x 1.5 mm | FF416/500/582/657-Di01-25x36x1.5 |

[1] Wavelength ranges over which average reflection and transmission are guaranteed to be above 95% and 90%, respectively.

### Narrow Beamsplitters for Transmitting Multiple Laser Lines *(for use at 45°)*

In applications such as laser-based fluorescence imaging systems it is desirable to transmit the excitation laser light through a beamsplitter and separate the returning fluorescence by reflection off of the beamsplitter. This configuration is optimal because optical filters are generally more efficient in reflection than transmission, and fluorescence photons are more precious than excitation photons.

Di01-T488/568/638




| Reflection Bands [1] | Transmission Bands [1] | Size (L x W x H) | Filter Part Number |
|---|---|---|---|
| 499 – 521 nm<br>543 – 623 nm<br>653 – 755 nm | 488 nm<br>532 nm<br>636 – 640 nm | 25.2 mm x 35.6 mm x 5.0 mm | Di01-T488/532/638-25x36x5.0 |
| 499 – 556 nm<br>580 – 622 nm<br>652 – 755 nm | 488 nm<br>568 nm<br>636 – 640 nm | 25.2 mm x 35.6 mm x 5.0 mm | Di01-T488/568/638-25x36x5.0 |
| 499 – 521 nm<br>543 – 556 nm<br>580 – 622 nm<br>652 – 755 nm | 488 nm<br>532 nm<br>568 nm<br>636 – 640 nm | 25.2 mm x 35.6 mm x 5.0 mm | Di01-T488/532/568/638-25x36x5.0 |
| 499 – 521 nm<br>543 – 580 nm<br>608 – 623 nm<br>653 – 755 nm | 488 nm<br>532 nm<br>594 nm<br>636 – 640 nm | 25.2 mm x 35.6 mm x 5.0 mm | Di01-T488/532/594/638-25x36x5.0 |

[1] Wavelength ranges over which the transmission and average reflection are guaranteed to be above 90%.

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

# 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 from the sample. Because the filters are precisely positioned between the spinning microlens array and pinhole array discs, 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 CSU22 may be performed only by certain Yokogawa-authorized personnel.)

| Transmitted Laser Wavelengths | Reflection Bands | Semrock Part Number |
|---|---|---|
| 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 |
| 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 |
| 400-410 nm, 488 nm, 561 nm | 422-473 nm, 503-544 nm, 578-750 nm | Di01-T405/488/561-13x15x0.5 *New!* |
| 400-457 nm, 513-515 nm, 633-647 nm | 471-498 nm, 535-616 nm, 666-750 nm | Di01-T457/514/647-13x15x0.5 |
| 405-442 nm, 514 nm, 638-647 nm | 458-497 nm, 533-620 nm, 665-750 nm | Di01-T442/514/647-13x15x0.5 |
| 405-442 nm, 502-508 nm, 630-641 nm | 458-484 nm, 527-607 nm, 664-750 nm | Di01-T442/505/635-13x15x0.5 |
| 441-449 nm, 513-517 nm, 559-563 nm | 462-501 nm, 532-544 nm, 578-630 nm | Di01-T445/515/561-13x15x0.5 *New!* |
| 488 nm, 532 nm | 442-473 nm, 503-510 nm, 554-750 nm | Di01-T488/532-13x15x0.5 |
| 488 nm, 568 nm | 422-473 nm, 503-545 nm, 586-750 nm | Di01-T488/568-13x15x0.5 |
| 405-488 nm | 508-700 nm | Di01-T488-13x15x0.5 |

## Emission Filters for the Yokogawa CSU confocal scanners

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

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

## 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 CSU22 may be performed only by certain Yokogawa-authorized personnel.)

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

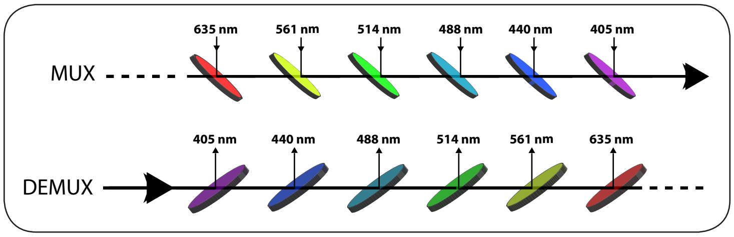
For graphs & ASCII data, go to www.semrock.com

New!

# LaserMUX™ Beam Combining Filters

## Custom-sized filters are available in one week.

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 | |
|---|---|---|---|---|---|---|
| 375 ± 3 nm<br>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 | New! |
| 440 +3/-1 nm<br>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 | New! |
| 473 +5/-0 nm<br>488 +3/-2 nm<br>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 | New! |
| 514.5 nm<br>515 nm<br>532 nm<br>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 | New! |
| 561.4 nm<br>568.2 nm<br>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 | New! |
| 632.8 nm<br>635 +7/-0 nm<br>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 | New! |

## LaserMUX Common Specifications

| Property | Value | Comment |
|---|---|---|
| Absolute Reflection | > 99% (s-polarization)<br>> 96% (p-polarization)<br>> 98% (average polarization) | For reflected laser wavelenghts |
| Average Reflection | > 98% (average polarization) | For reflection band |
| Absolute Transmission | > 94% (s-polarization)<br>> 95% (p-polarization)<br>> 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 | Aluminium, Black-anodized |
| Overall Mounted Thickness | 3.5 mm + 0.0 / - 0.1 mm | |
| Unmounted Thickness | 2.0 mm +/- 0.1mm | |
| Beam Deviation | < 30 arc seconds | Based on 20 arc second substrate wedge angle |

# Laser Wavelength Reference Table

| Laser Line | Laser Type | Prominent Applications | RazorEdge (LWP) Pg 55 | RazorEdge (LWP) E-grade Pg 55 | RazorEdge (SWP) Pg 57 | MaxLine Pg 61 | MaxDiode Pg 65 | StopLine Pg 67 | EdgeBasic Pg 53 | BrightLine Laser Dichroics Pg 47 | LaserMUX Pg 51 | MaxMirror Pg 71 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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) | ● | | | | | ● | | | ● | ● |
| 532.1 | 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 | | | | ● | | | | | | ● |
| 1064.2 | 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

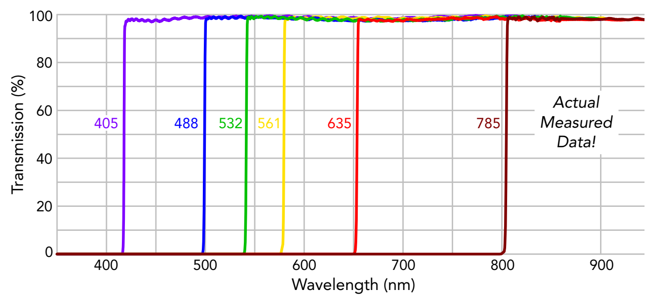
# EdgeBasic™ Long-wave-pass Filters

Extensive selection of filters in stock.
Custom-sized filters are available in one week.

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 *(see page 55)*

| Nominal Laser Wavelength | Laser Wavelength Range | | Passband | Part Number |
|---|---|---|---|---|
| | $\lambda_{short}$ | $\lambda_{long}$ | | |
| **New!** 405 nm | 400.0 nm | 410.0 nm | 421.5 – 900.0 nm | BLP01-405R-25 |
| 488 nm | 486.0 nm | 491.0 nm | 504.7 – 900.0 nm | BLP01-488R-25 |
| 532 nm | 532.0 nm | 532.0 nm | 546.9 – 900.0 nm | BLP01-532R-25 |
| **New!** 561 nm | 561.0 nm | 568.0 nm | 583.9 – 900.0 nm | BLP01-561R-25 |
| 635 nm | 632.8 nm | 642.0 nm | 660.0 – 1200.0 nm | BLP01-635R-25 |
| 785 nm | 780.0 nm | 790.0 nm | 812.1 – 1200.0 nm | BLP01-785R-25 |




| Property | Value | Comments |
|---|---|---|
| Edge Steepness (typical) | 1.5% of $\lambda_{long}$ | Measured from OD 6 to 50% |
| Blocking at Laser Wavelengths | OD > 6 from $\lambda_{short}$ to $\lambda_{long}$<br>OD > 5 from 270 nm to 80% of $\lambda_{short}$ | OD = – $\log_{10}$ (transmission) |
| Transition Width | < 2.5% of $\lambda_{long}$ | From $\lambda_{long}$ 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 | |
| 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

Technical 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

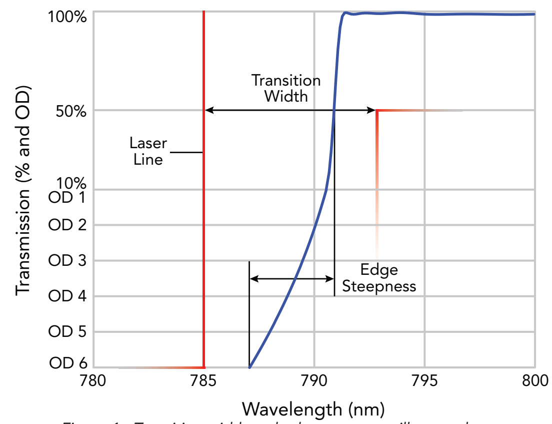



*Figure 1: Transition width and edge steepness illustrated.*

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) |
|---|---|---|
| RazorEdge "E-grade" | < 0.5% (< 90 $cm^{-1}$ for 532) | 0.2% (1.1 nm for 532) |
| RazorEdge "U-grade" | < 1.0% (< 186 $cm^{-1}$ for 532) | 0.5% (2.7 nm for 532) |
| RazorEdge "S-grade" | < 2.0% (< 369 $cm^{-1}$ for 532) | 0.5% (2.7 nm for 532) |
| EdgeBasic | < 2.5% (< 458 $cm^{-1}$ for 532) | 1.5% (8 nm for 532) |

* 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 2.5x narrower – only 0.2% of the laser wavelength, or 1.6 nm (25 $cm^{-1}$) for a 785 nm filter.

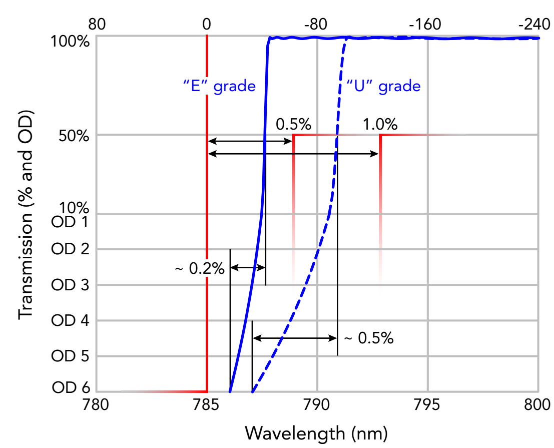



*Figure 2: Transition widths and edge steepnesses for LP02-785RE and LP02-785RU filters.*

# RazorEdge® Long Wave Pass Raman Edge Filters

Extensive selection of filters in stock.
Custom-sized filters are available in one week.

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 pending.

- **The steepest edge filters on the market – RazorEdge E-grade filters** *(See just how steep on page 54)*
- For **long-wave-pass edge filters** for normal incidence, see below
- For **short-wave-pass edge filters** for normal incidence, *see page 57*
- For **ultrasteep 45° beamsplitters,** *see page 58*
- For a suitably matched **MaxLine® filter**, *see page 61*

## 25 mm Diameter

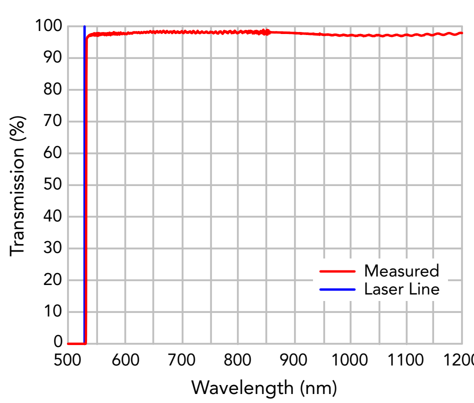
See www.semrock.com for additional E-grade offerings.

| Laser Line | Transition Width [1] | Passband | Part Number |
|---|---|---|---|
| 224.3 nm | < 1920 cm$^{-1}$ | 235.0-505.9 nm | LP02-224R-25 |
| 248.6 nm | < 805 cm$^{-1}$ | 261.0-560.8 nm | LP02-248RS-25 |
| 257.3 nm | < 385 cm$^{-1}$<br>< 762 cm$^{-1}$ | 263.0-580.4 nm<br>265.5-580.4 nm | LP02-257RU-25<br>LP02-257RS-25 |
| 266.0 nm | < 372 cm$^{-1}$<br>< 737 cm$^{-1}$ | 272.4-600.0 nm<br>275.0-600.0 nm | LP02-266RU-25<br>LP02-266RS-25 |
| 325.0 nm | < 305 cm$^{-1}$<br>< 603 cm$^{-1}$ | 329.2-733.1 nm<br>332.5-432.5 nm | LP03-325RU-25<br>LP02-325RS-25 |
| 355.0 nm | < 279 cm$^{-1}$<br>< 552 cm$^{-1}$ | 359.6-800.8 nm<br>363.2-800.8 nm | LP02-355RU-25<br>LP02-355RS-25 |
| 363.8 nm | < 272 cm$^{-1}$<br>< 539 cm$^{-1}$ | 368.5-820.6 nm<br>372.2-820.6 nm | LP02-364RU-25<br>LP02-364RS-25 |
| 441.6 nm | < 224 cm$^{-1}$<br>< 444 cm$^{-1}$ | 447.3-996.1 nm<br>451.8-996.1 nm | LP02-442RU-25<br>LP02-442RS-25 |
| 457.9 nm | < 216 cm$^{-1}$<br>< 428 cm$^{-1}$ | 463.9-668.4 nm<br>468.4-668.4 nm | LP02-458RU-25<br>LP02-458RS-25 |
| 473.0 nm | < 209 cm$^{-1}$<br>< 415 cm$^{-1}$ | 479.1-1066.9 nm<br>483.9-1066.9 nm | LP02-473RU-25<br>LP02-473RS-25 |
| 488.0 nm | < 102 cm$^{-1}$<br>< 203 cm$^{-1}$<br>< 402 cm$^{-1}$ | 491.2-1100.8 nm<br>494.3-1100.8 nm<br>499.2-1100.8 nm | LP02-488RE-25<br>LP02-488RU-25<br>LP02-488RS-25 |
| 514.5 nm | < 97 cm$^{-1}$<br>< 192 cm$^{-1}$<br>< 381 cm$^{-1}$ | 517.8-1160.5 nm<br>521.2-1160.5 nm<br>526.3-1160.5 nm | LP02-514RE-25<br>LP02-514RU-25<br>LP02-514RS-25 |
| 532.0 nm | < 90 cm$^{-1}$<br>< 186 cm$^{-1}$<br>< 369 cm$^{-1}$ | 535.4-1200.0 nm<br>538.9-1200.0 nm<br>544.2-1200.0 nm | LP03-532RE-25<br>LP03-532RU-25<br>LP03-532RS-25 |
| 568.2 nm | < 174 cm$^{-1}$<br>< 345 cm$^{-1}$ | 575.6-1281.7 nm<br>581.3-1281.7 nm | LP02-568RU-25<br>LP02-568RS-25 |
| 632.8 nm | < 79 cm$^{-1}$<br>< 156 cm$^{-1}$<br>< 310 cm$^{-1}$ | 636.9-1427.4 nm<br>641.0-1427.4 nm<br>647.4-1427.4 nm | LP02-633RE-25<br>LP02-633RU-25<br>LP02-633RS-25 |
| 647.1 nm | < 153 cm$^{-1}$<br>< 303 cm$^{-1}$ | 655.5-1459.6 nm<br>662.0-1459.6 nm | LP02-647RU-25<br>LP02-647RS-25 |

| Laser Line | Transition Width [1] | Passband | Part Number |
|---|---|---|---|
| 664.0 nm | < 149 cm$^{-1}$<br>< 295 cm$^{-1}$ | 672.6-1497.7 nm<br>679.3-1497.7 nm | LP02-664RU-25<br>LP02-664RS-25 |
| 780.0 nm | < 127 cm$^{-1}$<br>< 251 cm$^{-1}$ | 790.1-1008.0 nm<br>797.9-1008.0 nm | LP01-780RU-25<br>LP01-780RS-25 |
| 785.0 nm | < 63 cm$^{-1}$<br>< 126 cm$^{-1}$<br>< 250 cm$^{-1}$ | 790.1-1770.7 nm<br>795.2-1770.7 nm<br>803.1-1770.7 nm | LP02-785RE-25<br>LP02-785RU-25<br>LP02-785RS-25 |
| 808.0 nm | < 123 cm$^{-1}$<br>< 243 cm$^{-1}$ | 818.5-1822.6 nm<br>826.6-1822.6 nm | LP02-808RU-25<br>LP02-808RS-25 |
| 830.0 nm | < 119 cm$^{-1}$<br>< 236 cm$^{-1}$ | 840.8-1872.2 nm<br>849.1-1872.2 nm | LP02-830RU-25<br>LP02-830RS-25 |
| 980.0 nm | < 101 cm$^{-1}$<br>< 200 cm$^{-1}$ | 992.7-2000.0 nm<br>1002.5-2000.0 nm | LP02-980RU-25<br>LP02-980RS-25 |
| 1064.0 nm | < 93 cm$^{-1}$<br>< 184 cm$^{-1}$ | 1077.8-2000.0 nm<br>1088.5-2000.0 nm | LP02-1064RU-25<br>LP02-1064RS-25 |
| 1319.0 nm | < 75 cm$^{-1}$<br>< 149 cm$^{-1}$ | 1336.1-2000.0 nm<br>1349.3-2000.0 nm | LP02-1319RU-25<br>LP02-1319RS-25 |

[1] See pages 51 and 60 for more on Transition Width and wavenumbers

*Actual measured data (532 nm E-grade filter)*



# RazorEdge® Long Wave Pass Raman Edge Filters

Every Semrock filter is hard-coated for durable performance and carries our five-year warranty.

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

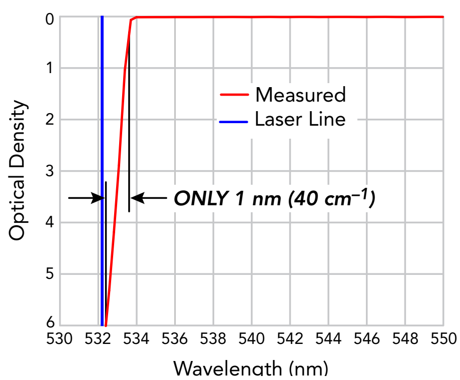
The "-25" in the part numbers on the previous page indicates these filters are 25 mm in diameter. All visible and near-IR U- and S-grade wavelengths are available in 50 mm diameters. See the table below for changes to the part numbers and prices.

| Laser Line | Part Number |
|---|---|
| Long Wave Pass Edge Filters For wavelengths listed above[1] | LP0_-___RU-50 |
| | LP0_-___RS-50 |

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

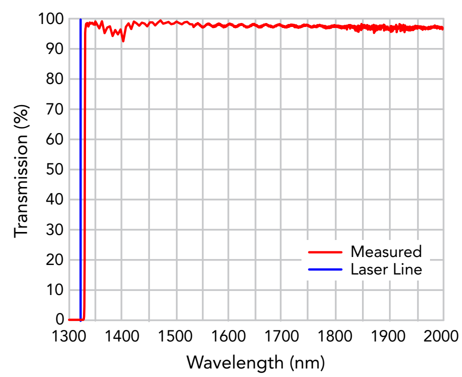
### RazorEdge Raman Filter Spectra

*Actual measured OD for a 532 nm E-grade filter*




### Expand deeper into the IR

*Actual measured 1319 U-grade filter*



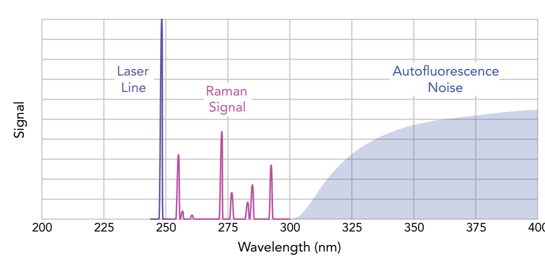

## TECHNICAL NOTE

### 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

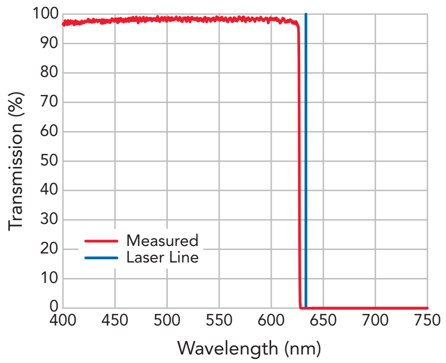
Extensive selection of filters in stock.
Custom-sized filters are available in one week.

### 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 |
|---|---|---|---|
| 532.0 nm | < 186 $cm^{-1}$ | 350.0 – 525.2 nm | SP01-532RU-25 |
| 632.8 nm | < 160 $cm^{-1}$ | 350.0 – 624.6 nm | SP01-633RU-25 |
| 785.0 nm | < 129 $cm^{-1}$ | 400.0 – 774.8 nm | SP01-785RU-25 |

*Actual measured data from a 632.8 nm RazorEdge filter*




### 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 |
|---|---|
| Short Wave Pass Edge Filters For wavelengths listed above | SP01-___RU-50 |

**Coming Soon – RazorEdge short-pass filter for 561.4 nm lasers.**

## PRODUCT NOTE

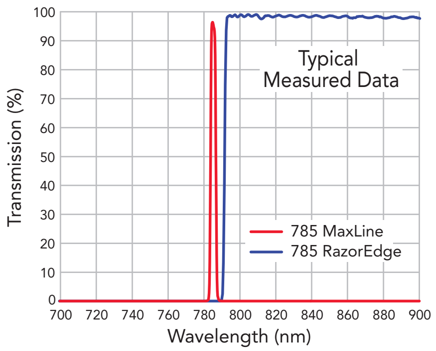
### RazorEdge and MaxLine® are a Perfect Match

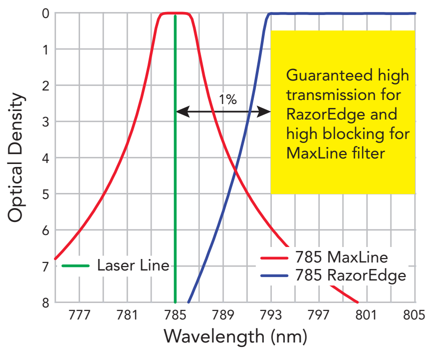
The MaxLine (see page 61) and RazorEdge U- and S-grade *(see page 55)* filters make an ideal filter pair for applications like Raman spectroscopy – they fit together like hand-in-glove. The MaxLine filter spectrally "cleans up" the excitation laser light before it reaches the sample under test – allowing 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 70)* 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 MaxLine filter, please contact Semrock.




Raman Edge Filters

# RazorEdge Dichroic™ Beamsplitters

## Every Semrock filter is hard-coated for durable performance and carries our five-year warranty.

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 (see page 55). These beamsplitters are so innovative that they are patent pending.

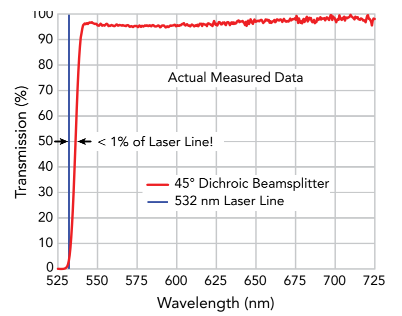
### 25 mm Diameter

Mounted in 25 mm diameter x 3.5 mm thick black-anodized aluminum ring

| Laser Line | Transition Width [1] | Passband | Part Number |
|---|---|---|---|
| 488.0 nm | < 203 cm$^{-1}$<br>< 402 cm$^{-1}$ | 494.3-756.4 nm<br>499.2-756.4 nm | LPD01-488RU-25<br>LPD01-488RS-25 |
| 514.5 nm | < 192 cm$^{-1}$<br>< 381 cm$^{-1}$ | 521.2-797.5 nm<br>526.3-797.5 nm | LPD01-514RU-25<br>LPD01-514RS-25 |
| 532.0 nm | < 186 cm$^{-1}$<br>< 369 cm$^{-1}$ | 538.9-824.8 nm<br>544.2-824.8 nm | LPD01-532RU-25<br>LPD01-532RS-25 |
| 632.8 nm | < 156 cm$^{-1}$<br>< 310 cm$^{-1}$ | 641.0-980.8 nm<br>647.4-980.8 nm | LPD01-633RU-25<br>LPD01-633RS-25 |
| 785.0 nm | < 126 cm$^{-1}$<br>< 250 cm$^{-1}$ | 795.2-1213.8 nm<br>803.1-1213.8 nm | LPD01-785RU-25<br>LPD01-785RS-25 |

[1] See page 63 for more on wavenumbers.

*Actual data from a 532.0 nm RazorEdge Dichroic Beamsplitter*




### 25 mm x 36 mm x 2.0 mm Rectangular

| Laser Line | Part Number |
|---|---|
| RazorEdge Dichroic Beamsplitters<br>*For wavelengths listed above* | LPD01-_ _ _RU-25x36x2.0<br>LPD01-_ _ _RS-25x36x2.0 |

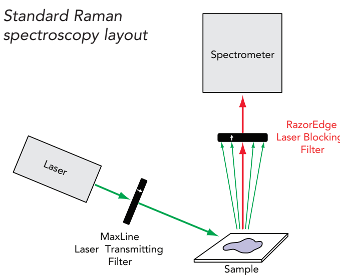
## TECHNICAL NOTE

### RazorEdge Filter Layouts

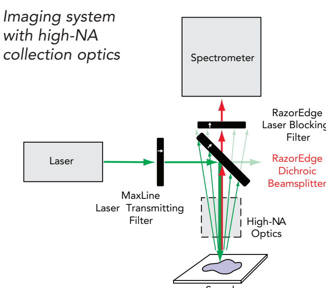
Only the unique RazorEdge Dichroic beamsplitter reflects a standard laser line incident at 45° while transmitting longer Raman-shifted wavelengths with an ultrasteep transition far superior to anything else available on the open market. The guaranteed transition width of < 1% of the laser wavelength for U-grade (regardless of polarization) makes these filters a perfect match to our popular normal-incidence RazorEdge ultrasteep long-wave-pass filters (*see page 55*). These beamsplitters are so innovative that they are patent pending.

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 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 55 for LWP and page 54 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 filter) | Wavelength "blue shift" attained by increasing angle from 0° to 8° |
| Laser Damage Threshold | | 0.5 $J/cm^2$ @ 266 nm<br>1 $J/cm^2$ @ 532 nm | 10 ns pulse width<br>Tested for 266 and 532 nm filters only *(see page 72)* |
| 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 |
| Overall Thickness | | 3.5 ± 0.1 mm | Black-anodized aluminum |
| 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 $\lambda_L$ x $\theta^2$ and the wavenumber shift is $\Delta$(wavenumbers) ($cm^{-1}$) = 500 x $\theta^2$ / $\lambda_L$, where $\lambda_L$ (in nm) is the laser wavelength. *See technical note on wavenumbers on page 63.*

## Dichroic Beamsplitter Specifications

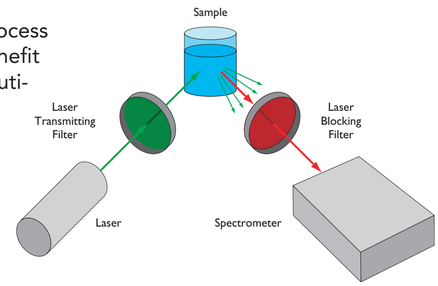
| Property | | Specification | Comment |
|---|---|---|---|
| Edge Steepness (typical) | | 0.5% of laser wavelength (2.5 nm or 90 $cm^{-1}$ for 532 nm filter) | Measured from 5% to 50% transmission for light with average polarization |
| Transition Width | "U-grade" | < 1% of laser wavelength | Measured 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)<br>> 90% (p-polarization) | |
| Average Passband Transmission | | > 90% | Averaged over the Passband (*Passband wavelengths detailed on page 55*) |
| 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 |
| | Overall Thickness | 3.5 ± 0.1 mm | Black-anodized Aluminum |
| Size of Rectangular Dichroics | Clear Aperture | > 80% | Elliptical |
| | Size | 25.2 mm x 35.6 mm (± 0.1 mm) | |
| | Thickness | 2.0 ± 0.1 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 | < $\lambda$/ 4 RMS at $\lambda$ = 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.<br>For rectangular dichroics, reflective coating side should face toward light source and sample | |

# TECHNICAL NOTE

## Filter Types for Raman Spectroscopy Applications



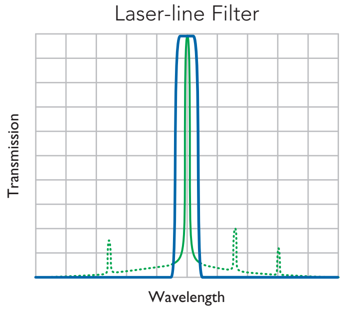

Raman spectroscopy is widely used today for applications ranging from industrial process control to laboratory research to bio/chemical defense measures. Industries that benefit from this highly specific analysis technique include the chemical, polymer, pharmaceutical, semiconductor, gemology, computer 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.

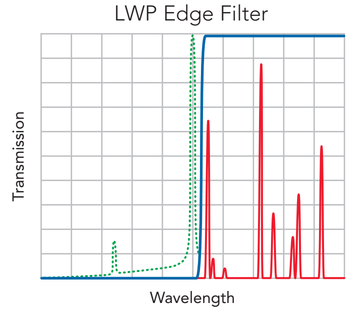
Optical filters are critical components in Raman spectroscopy systems to prevent all undesired light from reaching the spectrometer and swamping the relatively weak Raman signal. Laser Transmitting Filters inserted between the laser and the sample block all undesired light from the laser (such as broadband 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 58)*.

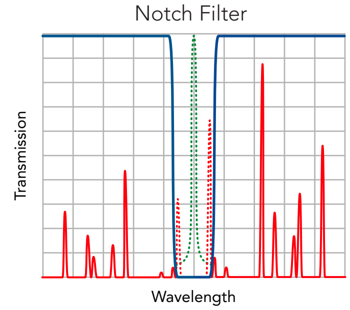
There are three basic types of filters used in systems with separate excitation and emission paths: Laser-line filters, Edge Filters, and Notch Filters. The examples below show how the various filters are used. In these graphs the blue lines represent the filter transmission spectra, the green lines 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 70.*

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.

Only Semrock stocks high-performance MaxLine® Laser-line filters *(see page 61)*, RazorEdge® long-wave-pass and short-wave-pass filters *(see pages 55 and 57)*, EdgeBasic™ value long-wave-pass filters *(see page 53)*, ultrasteep RazorEdge Dichroic™ beamsplitter filters *(see page 58)*, and StopLine® notch filters *(see page 67)* as standard catalog products. Non-standard wavelengths and specifications for these filters are routinely manufactured for volume OEM applications.

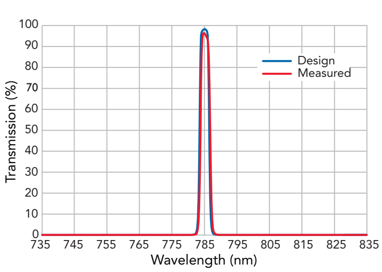
# MaxLine® Laser-line Filters

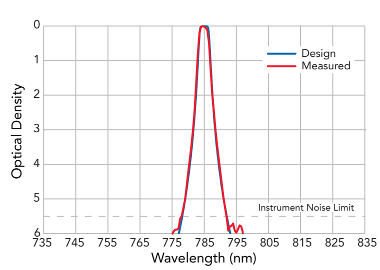
Extensive selection of filters in stock.
Custom-sized filters are available in one week.

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® filters *(see page 55)*
- Ideal complement to StopLine® deep notch filters for fluorescence and other applications *(see page 67)*
- Hard dielectric coatings for proven reliability and durability
- For diode lasers, use our MaxDiode™ Laser Clean-up filters *(see page 65)*
- We also offer unique 45° multi-laser-line beamsplitters *(see page 49)*

| | 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 |
| | 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 | 816.1-1269.6 | 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 | 838.3-1324.8 | LL01-830-12.5 | LL01-830-25 |
| | 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 |



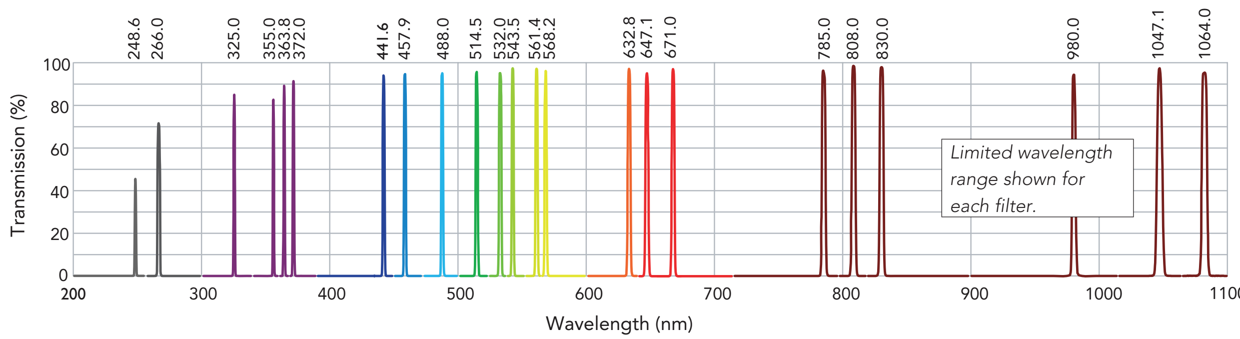




*These graphs demonstrate the outstanding performance of the 785 nm MaxLine laser-line filter, which has transmission guaranteed to exceed 90% at the laser line and OD > 5 blocking less than 1% away from the laser line. Note the excellent agreement with the design curves.*

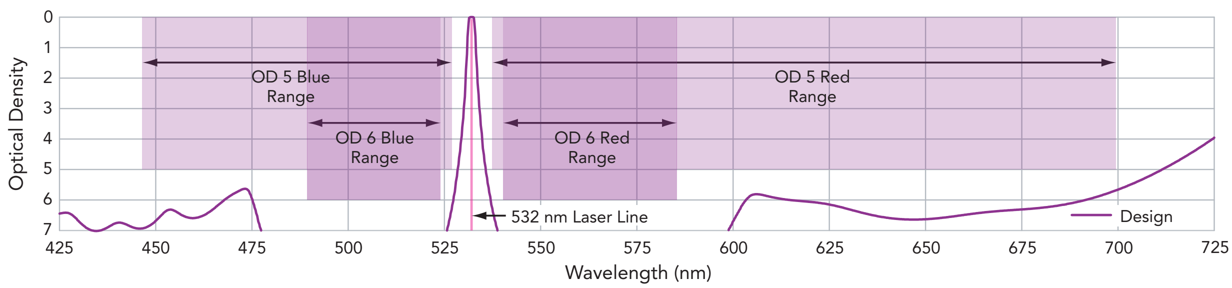
# MaxLine® Laser-line Spectra and Specifications

Every Semrock filter is hard-coated for durable performance
and carries our five-year warranty.

*Actual measured data from typical filters shown*




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




## Common Specifications

| Property | | Value | Comment |
|---|---|---|---|
| Laser Wavelength $\lambda_L$ | | Standard laser wavelengths available | *See page 61* |
| Transmission at Laser Line | | > 90% | Except $\lambda_L$ < 400 nm; Will typically be even higher |
| Bandwidth | Typical | 0.38% of $\lambda_L$ | Full Width at Half Maximum (FWHM)<br>Typical 0.7% and Maximum 0.9% for 248.6 & 266 nm |
| | Maximum | 0.7% of $\lambda_L$ | |
| Blocking[1] | | OD > 5 from $\lambda_L$ ± 1% to 4500 $cm^{-1}$ (red shift) and 3600 $cm^{-1}$ (blue shift);<br>OD > 6 from $\lambda_L$± 1.5% to 0.92 and 1.10 × $\lambda_L$ | OD = – $\log_{10}$ (Transmission) |
| Angle of Incidence | | 0.0° ± 2.0° | *See technical note on page 64* |
| 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 72)* |
| Substrate Material | | Low autofluorescence NBK7 or better | Fused silica for 248.6, 266, and 325 nm filters |
| Coating Type | | "Hard" ion-beam-sputtered | |
| Outer Diameter | | 12.5 + 0.0 / – 0.1 mm<br>(or 25.0 + 0.0 / – 0.1 mm) | Black-anodized aluminum ring |
| Overall Thickness | | 3.5 ± 0.1 mm | |
| 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 $\lambda_L$ 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 63.*

# MaxLine® UV Narrowband Laser-line Clean-up Filters

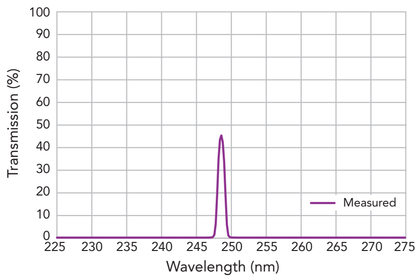
Extensive selection of filters in stock.
Custom-sized filters are available in one week.

Semrock's highly acclaimed MaxLine thin-film filters (U.S. Patent No. 7,119,960) are uniquely available for the popular UV lasers such as 266 nm quadrupled Nd:YAG laser. These hard-coated UV filters have:


- Unprecedented UV transmission – *stop wasting expensive UV laser light*
- The same rapid roll-off and deep blocking of our visible and near-IR MaxLine filters
- A perfect match to our ultraviolet RazorEdge filters
- Proven reliability

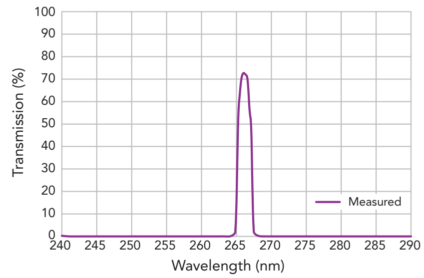
### 248.6 nm Narrowband Laser-line Filter

*Ideal for new, compact NeCu lasers*




### 266.0 nm Narrowband Laser-line Filter

*Ideal for 4th Harmonic of Nd:YAG lasers*




## 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 $\lambda$. 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:

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

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" $\Delta w$, 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 $\lambda_1$ to a second known wavelength $\lambda_2$, the resulting wavelength shift $\Delta\lambda$ is given by

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

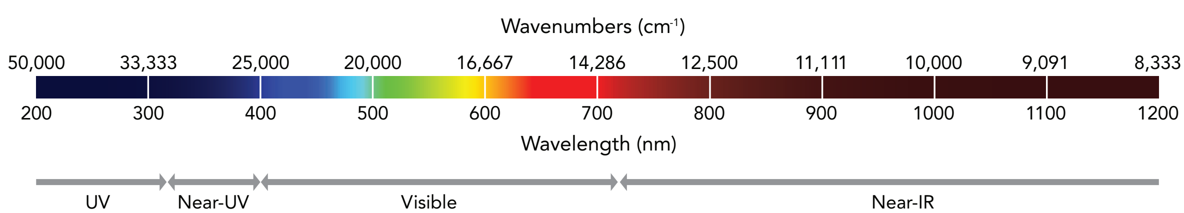
whereas the resulting wavenumber shift $\Delta w$ is given by

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

When speaking of a known wavenumber shift $\Delta w$ from a first known wavelength $\lambda_1$, the resulting second wavelength $\lambda_2$ is given by

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

Note that when the final wavelength $\lambda_2$ is longer than the initial wavelength $\lambda_1$, 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 $\lambda_2$ is shorter than the initial wavelength $\lambda_1$, which corresponds to a "blue shift," $\Delta w > 0$, consistent with a shift toward larger values of w.



# TECHNICAL NOTE

## Filter Spectra at Non-normal Angles of Incidence

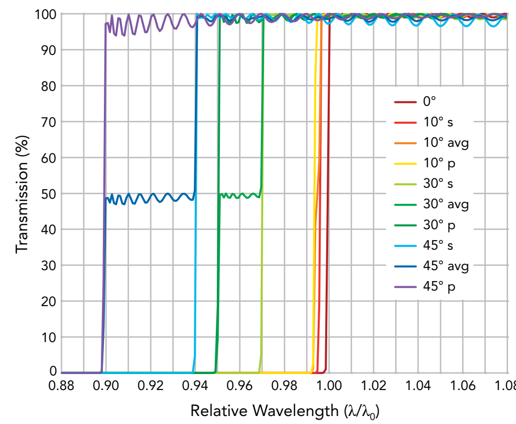
Many of the filters in this catalog (with the exception of dichroic beamsplitters and the MaxMirror®) are optimized for use with light at or near normal incidence. However, for some applications it is desirable to understand how the spectral properties change for a non-zero angle of incidence (AOI).

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 52)*, the set of curves in the graph can be applied approximately to any of the filters. Here the wavelength $\lambda$ is compared to the wavelength $\lambda_0$ 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

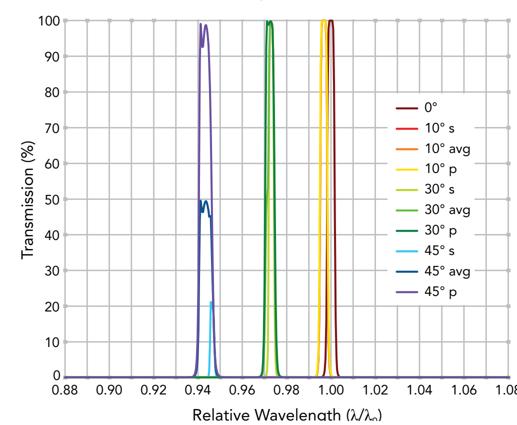



The shift of almost any spectral feature can be approximately quantified by a simple model of the wavelength $\lambda$ of the feature vs. angle of incidence $\theta$, given by the equation:

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

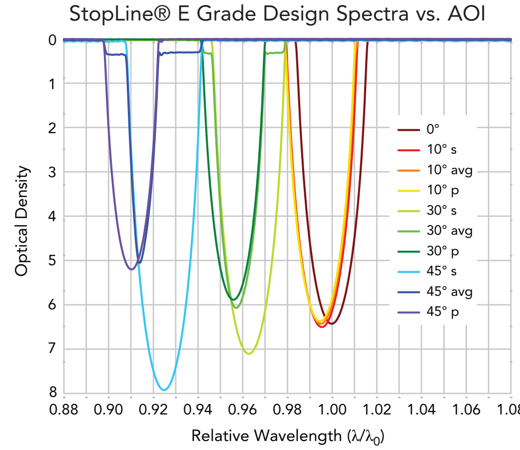
where neff is called the effective index of refraction, and l0 is the wavelength of the spectral feature of interest at normal incidence. Different shifts that occur for different spectral features and different filters are described by a different effective index. For the RazorEdge example above, the 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 58)*. 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 67*). 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.

# MaxDiode™ Laser Diode Clean-up Filters

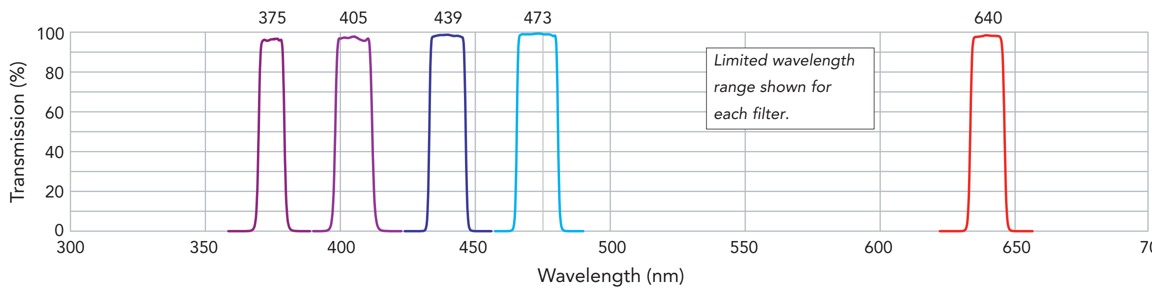
Extensive selection of filters in stock.
Custom-sized filters are available in one week.

Keep the desirable laser light while eliminating the noise. The 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.

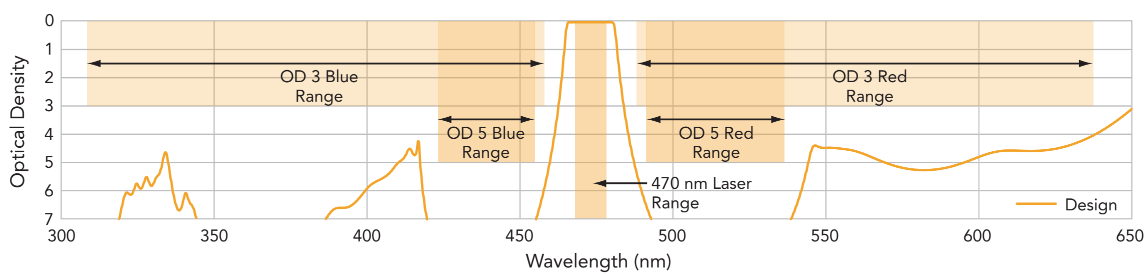
- **Square low-ripple passband** for total consistency as the laser ages, over temperature, or when replacing a laser
- Highest transmission, exceeding 90% over each diode's possible laser wavelengths
- Extremely steep edges transitioning to very high blocking to filter out the undesired out-of-band noise
- For narrow-line lasers, use our MaxLine laser-line filters *(see page 58)*

| Laser Diode Wavelength | Transmission & Bandwidth | Center Wavelength | OD 3 Color Range | OD 5 Color 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 |
| 635 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 |

*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 62.

# MaxLamp™ Mercury Line Filters

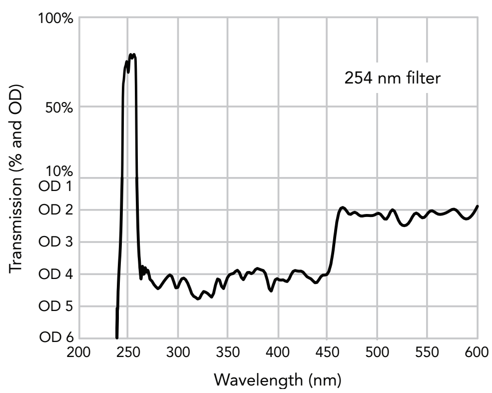
## Every Semrock filter is hard-coated for durable performance and carries our five-year warranty.

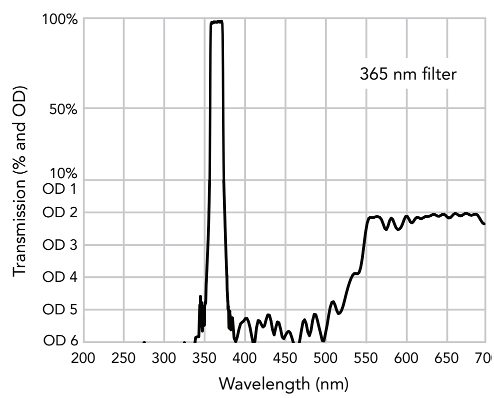
These ultrahigh-performance MaxLamp mercury line filters are ideal for use with high-power mercury arc lamps for applications including spectroscopy, optical metrology, and photolithography mask-aligner and stepper systems. Maximum throughput is obtained by careful optimization of the filter design to 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 | 50 mm Diameter Part Number |
|---|---|---|---|---|---|---|
| 253.7 nm | > 65%<br>244 - 256 nm | $OD_{avg}$ > 6:<br>200 - 236 nm | $OD_{avg}$ > 4:<br>263 - 450 nm | $OD_{avg}$ > 2:<br>450 - 600 nm | Hg01-254-25 | Hg01-254-50 |
| 365.0 nm | > 93%<br>360 - 372 nm | $OD_{avg}$ > 6:<br>200 - 348 nm | $OD_{avg}$ > 5:<br>382 - 500 nm | $OD_{avg}$ > 2:<br>500 - 700 nm | Hg01-365-25 | Hg01-365-50 |

*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 |
| Transverse Dimensions | 25.0 + 0.0 / - 0.1 mm<br>(or 50.0 + 0.0 / -0.1 mm) | | |
| Clear Aperture | ≥ 22 mm (or ≥ 45 mm) | | For all optical specifications |
| Thickness | 3.5 mm ± 0.1mm | | |
| Surface Quality | 80-50 scratch-dig | | Measured within clear aperture |

All other mechanical specifications are the same as MaxLine® specifications on page 62.

# StopLine® Single-notch Filters

## Extensive selection of filters in stock.
## Custom-sized filters are available in one week.

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.

- High transmission to detect the weakest signals – now over ultra-wide passbands (UV to 1600 nm) with the new StopLine E-grade filters!
- 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 69*)

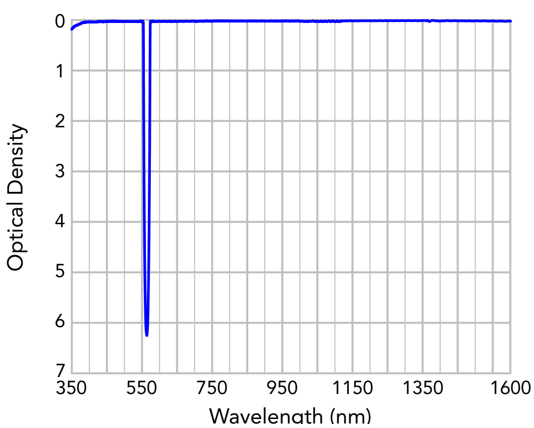
Semrock introduces a breakthrough invention in thin-film optical filters: our new StopLine "E-grade" thin-film notch filters have ultra-wide passbands with deep and narrow laser-line blocking. Unheard of previously in a thin-film notch filter made with multiple, discrete layers, these new patent-pending 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 |
|---|---|---|---|---|
| 405.0 nm | 330 – 1600 nm<br>330 – 540 nm | 9 nm<br>12 nm | OD > 6<br>OD > 4 | NF03-405E-25 *New!*<br>NF02-405S-25 |
| 441.6 nm | 331.2 – 588.8 nm<br>331.2 – 588.8 nm | 11 nm<br>14 nm | OD > 6<br>OD > 4 | NF01-442U-25<br>NF02-442S-25 |
| 488.0 nm | 350 – 1600 nm | 14 nm | OD > 6 | NF03-488E-25 *New!* |
| 514.5 nm | 385.9 – 686 nm | 16 nm | OD > 6 | NF01-514U-25 |
| 526.5 nm | 394.9 – 702 nm | 17 nm | OD > 6 | NF01-526U-25 |
| 532.0 nm | 350 – 1600 nm<br>399 – 709.3 nm | 17 nm<br>17 nm | OD > 6<br>OD > 6 | NF03-532E-25 *New!*<br>NF01-532U-25 |
| 561.4 nm | 350 – 1600 nm | 19 nm | OD > 6 | NF03-561E-25 *New!* |
| 568.2 nm | 426.2 – 757.6 nm | 20 nm | OD > 6 | NF01-568U-25 |
| 594.1 nm | 445.6 – 792.1 nm<br>445.6 – 792.1 nm | 22 nm<br>25 nm | OD > 6<br>OD > 4 | NF01-594U-25<br>NF02-594S-25 |
| 632.8 nm | 350.0 – 1600.0 nm | 25 nm | OD > 6 | NF01-633E-25 *New!* |
| 785.0 nm | 588.8 – 1046.7 nm | 39 nm | OD > 6 | NF01-785U-25 |
| 808.0 nm | 350 – 1600 nm<br>606 – 1077.3 nm | 41 nm<br>41 nm | OD > 6<br>OD > 6 | NF03-808E-25 *New!*<br>NF01-808U-25 |
| 830.0 nm | 622.5 – 1106.7 nm | 44 nm | OD > 6 | NF01-830U-25 |

**Looking for a 1064 nm notch filter? Try the NF03-532/1064-25 on page 69.**

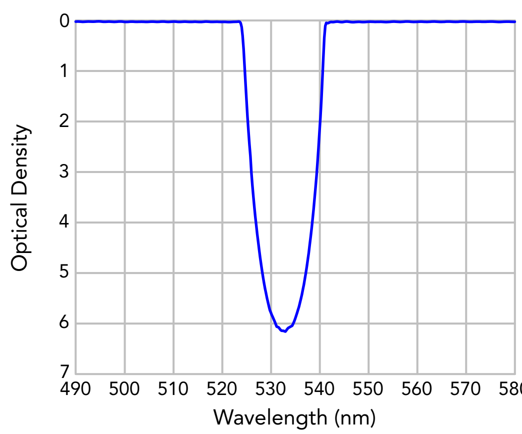
**NF03-561E**

*Typical Measured Data*




**NF03-532E**

*Typical Measured Data*

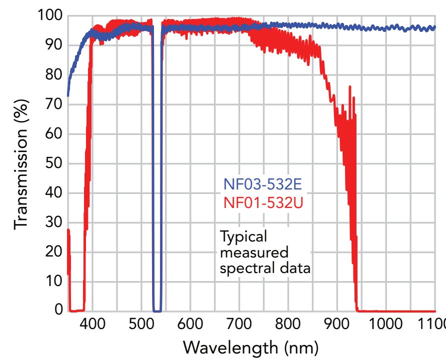


# StopLine® Single-notch Filter Common Specifications



## 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/cm2), 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.

Now Semrock's new "E-grade" StopLine notch filters offer a breakthrough in optical notch filter technology, bringing together all the advantages of hard-coated standard thin-film notch filters with the ultrawide passbands that were previously possible only with holographic and Rugate notch filters! The spectral performance of the E-grade StopLine filters is virtually identically to that of Semrock's renowned "U-grade" StopLine filters, but with passbands that extend from the UV (< 350 nm) to the near-IR (> 1600 nm).

| Property | | Value | Comment |
|---|---|---|---|
| Laser Line Blocking: | "E" &"U" grade | > 6 OD | At the design laser wavelength; OD = – $\log_{10}$ (transmission) |
| | "S" grade | > 4 OD | |
| Typical 50% Notch Bandwidth | "E" &"U" grade | NBW = 55 × 10$^{-6}$ × $\lambda_L^2$ + 14 × 10$^{-3}$ ×$\lambda_L$ – 5.9<br>e.g. 17 nm (600 cm$^{-1}$) for 532.0 nm filter | Full width at 50% transmission; $\lambda_L$ is design laser wavelength (NBW and $\lambda_L$ in nm) |
| | "S" grade | NBW = 10 × 10$^{-5}$ × $\lambda_L^2$ – 29 × 10$^{-3}$ ×$\lambda_L$ + 7.2<br>e.g. 20 nm (700 cm$^{-1}$) for 532.0 nm filter | |
| 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<br>$\lambda_L$ is design laser wavelength (nm) |
| | "U" & "S" grade | from 0.75 × $\lambda_L$ to $\lambda_L$ / 0.75 [1] | |
| Average Passband Transmission | "E" grade | > 80% 350 – 400 nm, 93% 400 – 1600 nm | Lowest wavelength is 330 nm for NF03-405E<br>Excluding notch |
| | "U" & "S" grade | > 90% | |
| Passband Transmission Ripple | | < 2.5% | Calculated as standard deviation |
| Angle of Incidence | | 0.0° ± 5.0° | *See technical note on page 61* |
| Angle Tuning Range [2] | | – 1% of laser wavelength<br>(– 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 72)* |
| 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 | |

All other General Specifications are the same as the RazorEdge® specifications on the bottom of page 59.

[1] For NF02-405 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$^{-5}$ × $\lambda_L$ × $\theta^2$ and the wavenumber shift is $\Delta$(wavenumbers) (cm$^{-1}$) = 500 × $\theta^2$ / $\lambda_L$, where $\lambda_L$ (in nm) is the laser wavelength. See Technical Note on wavenumbers on page 63.

# StopLine® Multi-notch Filters

Extensive selection of filters in stock.
Custom-sized filters are available in one week.

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:

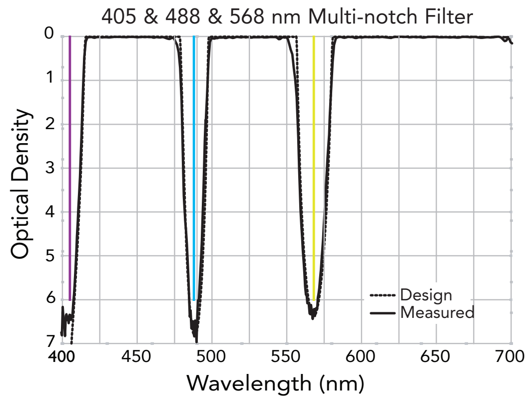
- Laser-based fluorescence instruments
- Confocal and multi-photon fluorescence microscopes
- Analytical and medical laser systems

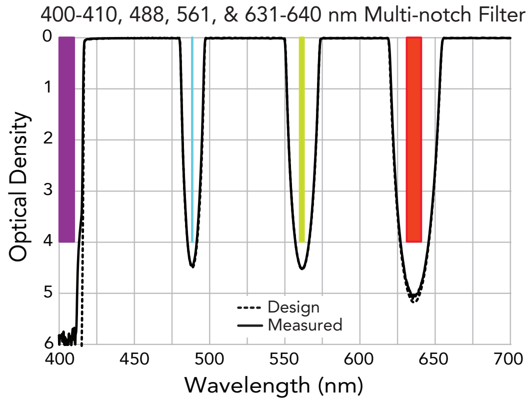
Our advanced manufacturing process means that these filters can be made with notch wavelengths that are not integer multiples of each other!

| Laser Wavelengths | Laser-line Blocking | Part Number | Dimensions |
|---|---|---|---|
| Dual-notch Filters | | | |
| 488 & 532 nm | OD > 6 | NF01-488/532-25x5.0 | 25 mm x 5.0 mm |
| 488 & 543 nm | OD > 6 | NF01-488/543-25x5.0 | 25 mm x 5.0 mm |
| 486 – 490 & 631 – 640 nm | OD > 4 | NF01-488/635-25x5.0 | 25 mm x 5.0 mm |
| 488 & 647 nm | OD > 6 | NF01-488/647-25x5.0 | 25 mm x 5.0 mm |
| *New!* 532 & 1064 nm | OD > 6 | NF03-532/1064-25 | 25 mm x 3.5 mm |
| 543 & 647 nm | OD > 6 | NF01-543/647-25x5.0 | 25 mm x 5.0 mm |
| 568 & 638 nm | OD > 6 | NF01-568/638-25x5.0 | 25 mm x 5.0 mm |
| 568 & 647 nm | OD > 6 | NF01-568/647-25x5.0 | 25 mm x 5.0 mm |
| 594 & 638 nm | OD > 6 | NF01-594/638-25x5.0 | 25 mm x 5.0 mm |
| Triple-notch Filters | | | |
| 405, 488, & 568 nm | OD > 6 | NF01-405/488/568-25 | 25 mm x 3.5 mm |
| 488, 532, & 631-640 nm | OD > 4 | NF01-488/532/635-25x5.0 | 25 mm x 5.0 mm |
| 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 |
| 400 – 410, 488, 561, & 631 – 640 nm | OD > 4 | NF01-405/488/561/635-25x5.0 | 25 mm x 5.0 mm |

StopLine filters are housed in a 25 mm black-anodized aluminum ring unless indicated otherwise.
All filters are on low-autofluorescence NBK7 or ultra-low-autofluorescence fused silica substrates.

*Actual measured data from typical filters is shown*



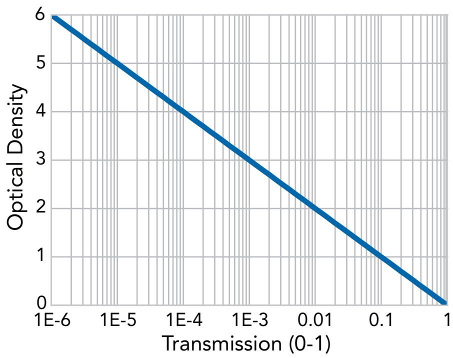

We also offer unique 45° multi-notch beamsplitters – *see page 48*

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 |
| 0.05 | 1.3 |
| 0.02 | 1.7 |
| 0.01 | 2 |
| 0.005 | 2.3 |
| 0.002 | 2.7 |
| 0.001 | 3 |

**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

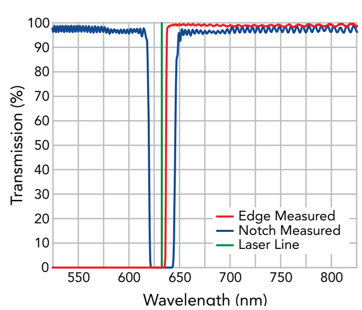
## Edge Filters vs. Notch Filters for Raman Instrumentation

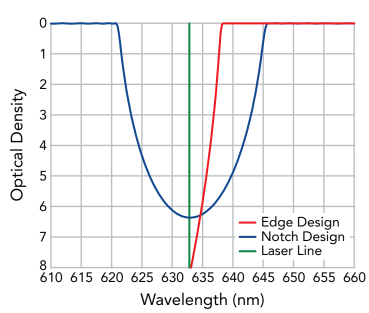
**RazorEdge® Filter Advantages:**
- Steepest possible edge for looking at the smallest Stokes shifts
- Largest blocking of the laser line for maximum laser rejection

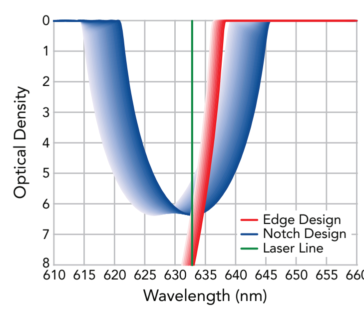
**StopLine® Notch Filter Advantages:**
- Measure Stokes and Anti-Stokes signals simultaneously
- Greater angle-tunability and bandwidth for use with variable laser lines

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°.



# MaxMirror® Ultra-broadband Mirror

Extensive selection of filters in stock.
Custom-sized filters are available in one week.

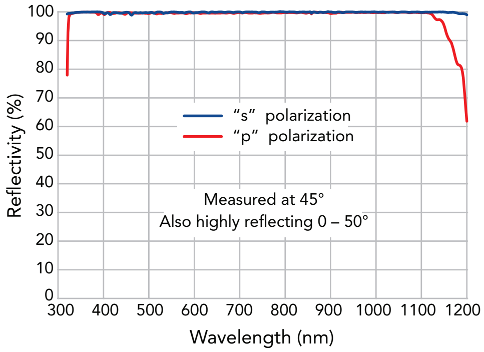
The MaxMirror is a unique high-performance laser mirror that covers an ultra-broad range of wavelengths – it can replace three or more conventional laser mirrors. In fact, it is so unique that it is patented (U.S. patent No. 6,894,838). The MaxMirror is a winner of the prestigious Photonics Circle of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

- **Very highly reflecting over:**
  - 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*

| Diameter | Absolute Surface Flatness | Mirror Side Part Number |
|---|---|---|
| 25.0 mm | < λ / 10 | MM1-311-25.0 |
| 25.4 mm (1.00”) | < λ / 10 | MM1-311-25.4 |
| 25.4 mm (1.00”) | < λ / 5 | MM1-311S-25.4 |
| 50.8 mm (2.00”) | < λ / 4 | MM1-311-50.8 |
| 50.8 mm (2.00”) | < λ / 2 | MM1-311S-50.8 |

Typical MaxMirror spectrum
*Actual measured data shown.*




## Common Specifications

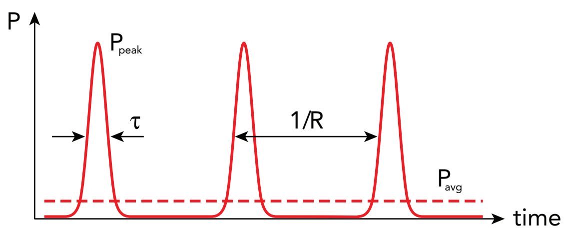
| Property | Value | Comment |
|---|---|---|
| Wavelength Range | 350-1100 nm | *All specifications apply* |
| Wide Angle of Incidence Range | 0-50° | Range over which Wide Angle Reflectivity specifications are met |
| Wide Angle Reflectivity | > 98.5% | For unpolarized light |
| | > 98.0% | For “s” polarization |
| | > 98.0% | For “p” polarization |
| Standard Angle of Incidence | 45.0 ± 2.5°<br>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<br>2 J/cm$^2$ @ 532 nm<br>6 J/cm$^2$ @ 1064 nm | ~ 10 ns pulse width. *(see page 72)* |
| 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. | |

## Laser Damage Threshold

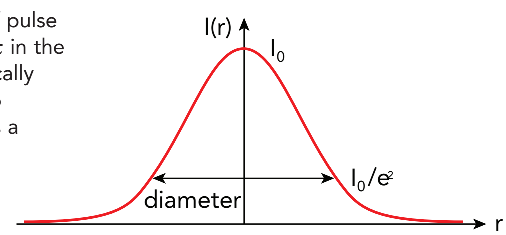
Laser damage to optical filters is strongly dependent on many factors, and thus it is difficult to guarantee the performance of a filter in all possible circumstances. Nevertheless, it is useful to identify a Laser Damage Threshold (LDT) of pulse fluence or intensity below which no damage is likely to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

**Pulsed vs. continuous-wave lasers:** Pulsed lasers emit light in a series of pulses of duration $\tau$ at a repetition rate R, with peak power $P_{peak}$. Continuous-wave (cw) lasers emit a steady beam of light with a constant power. Pulsed-laser average power $P_{avg}$ and cw laser constant power typically range from several milli-Watts (mW) to Watts (W) for most lasers. The diagram and table below illustrate and summarize the key parameters that are used to characterize the output of pulsed lasers.

| Symbol | Definition | Units | Key Relationships |
|---|---|---|---|
| $\tau$ | 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 / $cm^2$ | $F = E / A$; $F = I_{peak} \times \tau$; $F = I_{avg} / R$ |




Note that because fluence and intensity on the surface of the component are the critical parameters, the area of the laser spot is also critical. Even very high-power lasers may be transmitted through, or reflected off of, a durable optical filter if the spot size is sufficiently large to minimize the fluence and/or intensity. The diameter of a laser spot with a Gaussian profile is most commonly measured at the $1/e^2$ intensity points as shown in the diagram below.




**Long-pulse lasers:** LDT is perhaps most accurately specified in terms of pulse fluence for "long-pulse lasers." Long-pulse lasers have pulse durations $\tau$ in the nanosecond (ns) to microsecond (ms) range, with repetition rates R typically ranging from about 1 to 100 Hz. 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 optical field effects. Usually damage results from surface or volume imperfections in the material and the associated irregular optical field properties near these sites, rather than catastrophic destruction of the fundamental material structure. Most Semrock filters have LDT values on the order of 1 J/$cm^2$, and are thus considered "high-power laser quality" components. An important exception is a High-Q laser-line filter in which the internal field strength is strongly magnified, resulting in an LDT that may be an order of magnitude smaller.

As an example, suppose a frequency-doubled Nd:YAG laser at 532 nm emits 10 ns pulses at a 10 Hz repetition rate with 1 W of average power. This laser has a duty cycle of $1 \times 10^{-7}$, a pulse energy of 100 mJ, and a peak power of 10 MW. If the beam is focused down to a 100 µm diameter spot on the surface of a component, the pulse fluence is 1.3 kJ/$cm^2$, and thus it will almost surely damage a component with a 1 J/$cm^2$ LDT. However, if the spot diameter is 5 mm, the pulse fluence is only 0.5 J/$cm^2$, and thus the component should not be damaged.

**cw lasers:** The LDT for cw lasers is more difficult to measure, and therefore is not specified as often as the long-pulse laser LDT. Damage from cw lasers tends to result from thermal (heating) effects. At this time Semrock does not test nor specify cw LDT for its filters. As a very rough rule of thumb, many all-glass components like dielectric thin-film mirrors and filters have a cw LDT (specified as intensity in kW/$cm^2$) that is 10 – 100 times the long-pulse laser LDT (specified as fluence in J/$cm^2$).

**Quasi-cw lasers:** Quasi-cw lasers are pulsed lasers with pulse durations $\tau$ 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.

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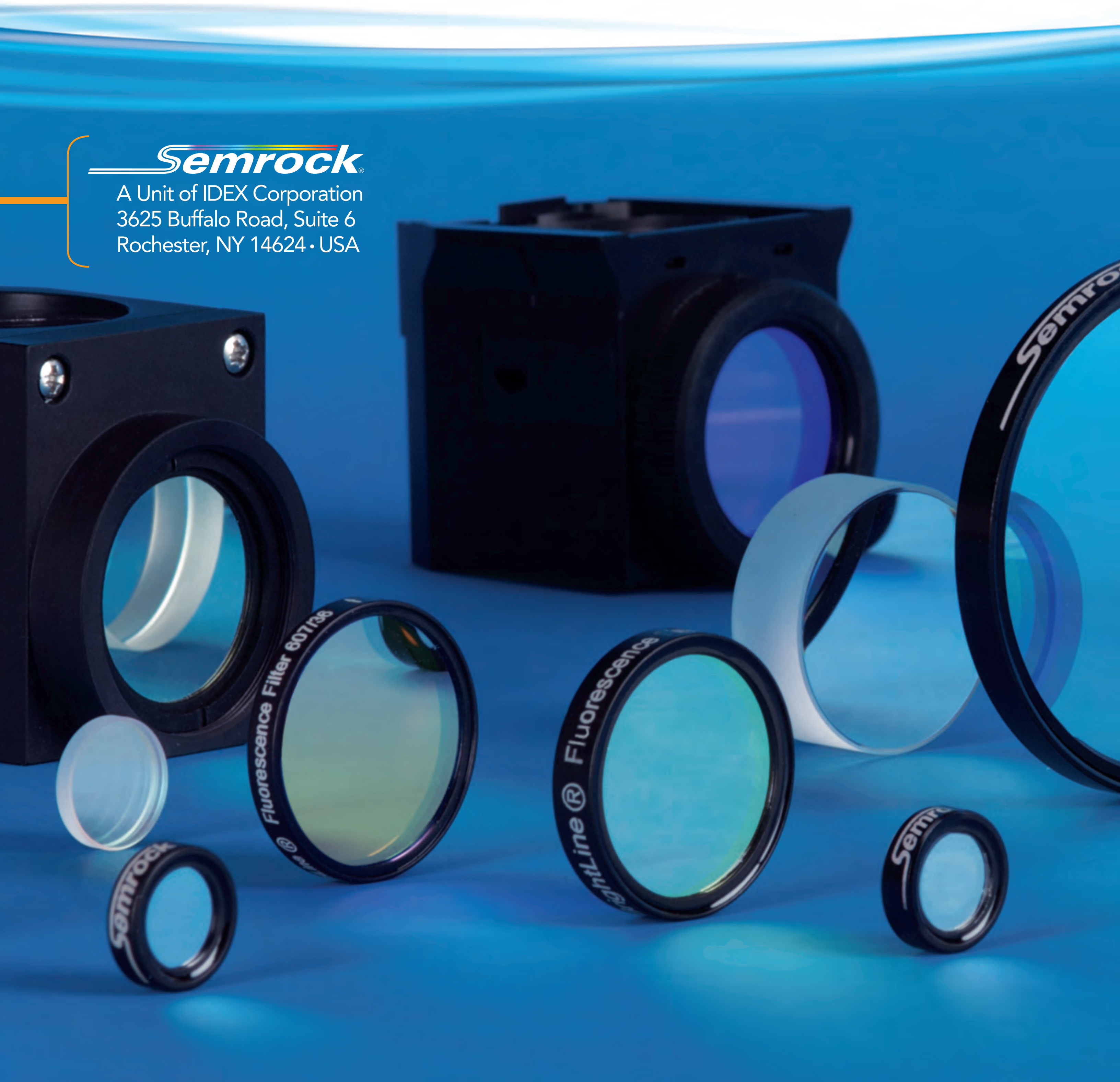


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