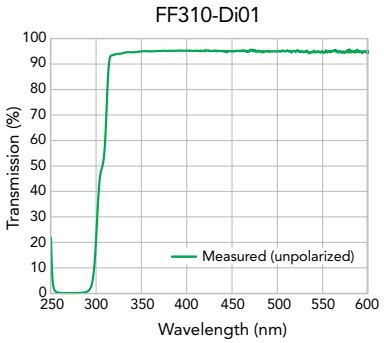
BrightLine® Single-edge Dichroic Beamsplitters



Single-edge General Purpose Dichroic Beamsplitters

(polarization-insensitive; for use at 45°)

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

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

Color	Nominal Edge Wavelength	Avg. Reflection Band	Avg. Transmission Band	Size (L x W)	Glass Thickness	Filter Part Number	Price
	310 nm	> 98% 255 – 295 nm	> 90% 315 – 600 nm	25.2 x 35.6 mm	1.05 mm	FF310-Di01-25x36	$435
	347 nm	> 97% 240 – 325 nm	> 93% 380 – 800 nm	25.2 x 35.6 mm	1.05 mm	FF347-Di01-25x36	$435
	365 nm	> 94% 230 – 360 nm	> 90% 370 – 508 nm	25.2 x 35.6 mm	1.05 mm	FF365-Di01-25x36	$435
	376 nm	> 98% 327 – 371 nm	> 93% 381 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF376-Di01-25x36	$255
New	379 nm	> 98% 327 – 353 nm	> 90% 394 – 687 nm	25.2 x 35.6 mm	1.05 mm	FF379-Di01-25x36	$255
	380 nm	> 95% 350 – 375 nm	> 93% 385 – 450 nm	25.2 x 35.6 mm	1.05 mm	FF380-Di01-25x36	$335
	390 nm	> 95% 335 – 375 nm	> 90% 399 – 500 nm	25.2 x 35.6 mm	1.05 mm	FF390-Di01-25x36	$335
	409 nm	> 98% 327 – 404 nm	> 93% 415 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF409-Di03-25x36	$255
	414 nm	> 98% 327 – 409 nm	> 93% 420 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF414-Di01-25x36	$255
	416 nm	> 90% 360 – 407 nm	> 90% 425 – 575 nm	25.2 x 35.6 mm	1.05 mm	FF416-Di01-25x36	$255
New	435 nm	> 98% 394 – 406 nm	> 90% 449 – 687 nm	25.2 x 35.6 mm	1.05 mm	FF435-Di01-25x36	$255
	452 nm	> 90% 423 – 445 nm	> 90% 460 – 610 nm	25.2 x 35.6 mm	1.05 mm	FF452-Di01-25x36	$255
	458 nm	> 98% 350 – 450 nm	> 93% 467 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF458-Di02-25x36	$255
	482 nm	> 90% 415 – 470 nm	> 90% 490 – 720 nm	25.2 x 35.6 mm	1.05 mm	FF482-Di01-25x36	$235
	495 nm	> 98% 350 – 488 nm	> 93% 502 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF495-Di03-25x36	$255
New	496 nm	> 98% 512 – 900 nm	> 93% 400 – 480 nm	25.2 x 35.6 mm	2.0 mm	FF496-SDi01-25x36x2.0	$335
	497 nm	> 90% 452 – 490 nm	> 90% 505 – 800 nm	25.2 x 35.6 mm	1.05 mm	FF497-Di01-25x36	$235
	499 nm	> 90% 470 – 490 nm	> 90% 508 – 675 nm	25.2 x 35.6 mm	1.05 mm	FF499-Di01-25x36	$255
	500 nm	> 98% 485 – 491 nm	> 90% 510 – 825 nm	25.2 x 35.6 mm	1.05 mm	FF500-Di01-25x36	$335
	505 nm	> 98% 513 – 725 nm	> 90% 446 – 500 nm	25.2 x 35.6 mm	1.05 mm	FF505-SDi01-25x36	$335
	506 nm	> 98% 350 – 500 nm	> 93% 513 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF506-Di03-25x36	$255
	509 nm	> 94% 230 – 502 nm	> 90% 513 – 830 nm	25.2 x 35.6 mm	1.05 mm	FF509-Di01-25x36	$435
	510 nm	> 98% 327 – 488 nm	> 93% 515 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF510-Di02-25x36	$255
	511 nm	> 90% 400 – 495 nm	> 90% 525 – 800 nm	25.2 x 35.6 mm	1.05 mm	FF511-Di01-25x36	$335
	516 nm	> 90% 490 – 510 nm	> 90% 520 – 700 nm	25.2 x 35.6 mm	1.05 mm	FF516-Di01-25x36	$255
	518 nm	> 98% 400 – 512 nm	> 93% 523 – 690 nm	25.2 x 35.6 mm	1.05 mm	FF518-Di01-25x36	$255
	520 nm	> 98% 350 – 512 nm	> 93% 528 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF520-Di02-25x36	$255
	526 nm	> 98% 350 – 519.5 nm	> 93% 532 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF526-Di01-25x36	$335
	535 nm	> 90% 539 – 840 nm	> 95% 524 – 532 nm	25.2 x 35.6 mm	1.05 mm	FF535-SDi01-25x36	$335
	552 nm	> 98% 350 – 544 nm	> 93% 558 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF552-Di02-25x36	$255
	553 nm	> 98% 561 – 725 nm	> 90% 500 – 546 nm	25.2 x 35.6 mm	1.05 mm	FF553-SDi01-25x36	$335
	555 nm	> 98% 493 – 548 nm	> 90% 562 – 745 nm	25.2 x 35.6 mm	1.05 mm	FF555-Di03-25x36	$255
New	556 nm	> 97% 561 – 950 nm	> 93% 480 – 552 nm	25.2 x 35.6 mm	1.05 mm	FF556-SDi01-25x36	$335
	560 nm	> 98% 485 – 545 nm	> 90% 570 – 825 nm	25.2 x 35.6 mm	1.05 mm	FF560-Di01-25x36	$335
	562 nm	> 98% 350 – 555 nm	> 93% 569 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF562-Di03-25x36	$255
	570 nm	> 90% 525 – 556 nm	> 90% 580 – 650 nm	25.2 x 35.6 mm	1.05 mm	FF570-Di01-25x36	$255
	573 nm	> 98% 350 – 566 nm	> 93% 580 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF573-Di01-25x36	$255
	585 nm	> 90% 533 – 580 nm	> 90% 595 – 800 nm	25.2 x 35.6 mm	1.05 mm	FF585-Di01-25x36	$255

(continued)

BrightLine® Single-edge Dichroic Beamsplitters

Color	Nominal Edge Wavelength	Avg. Reflection Band	Avg. Transmission Band	Size (L x W)	Glass Thickness	Filter Part Number	Price
	591 nm	> 98% 601 – 800 nm	> 90% 530 – 585 nm	25.2 x 35.6 mm	1.05 mm	FF591-SDi01-25x36	$255
	593 nm	> 98% 350 – 585 nm	> 93% 601 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF593-Di03-25x36	$255
	596 nm	> 98% 350 – 588.6 nm	> 93% 603 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF596-Di01-25x36	$335
	605 nm	> 98% 350 – 596 nm	> 93% 612 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF605-Di02-25x36	$255
	611 nm	> 98% 620 – 800 nm	> 90% 550 – 603 nm	25.2 x 35.6 mm	1.05 mm	FF611-SDi01-25x36	$335
	614 nm	> 97% 635 – 700 nm	> 70% 244 – 300 nm > 90% 300 – 594 nm	25.2 x 35.6 mm	2.0 mm	FF614-SDi01-25x36x2.0	$435
	624 nm	> 95% 528 – 610 nm	> 93% 630 – 750 nm	25.2 x 35.6 mm	2.0 mm	FF624-Di01-25x36x2.0	$335
	625 nm	> 98% 635 – 850 nm	> 90% 400 – 620 nm	25.2 x 35.6 mm	1.05 mm	FF625-SDi01-25x36	$255
	635 nm	> 94% 507 – 622 nm	> 90% 636 – 830 nm	25.2 x 35.6 mm	1.05 mm	FF635-Di01-25x36	$255
	647 nm	> 94% 667 – 1010 nm	> 93% 360 – 640 nm	25.2 x 35.6 mm	1.05 mm	FF647-SDi01-25x36	$335
	648 nm	> 98% 400 – 629 nm	> 90% 658 – 700 nm	25.2 x 35.6 mm	1.05 mm	FF648-Di01-25x36	$255
	649 nm	> 98% 500 – 642 nm	> 90% 654 – 825 nm	25.2 x 35.6 mm	1.05 mm	FF649-Di01-25x36	$335
	650 nm	> 98% 500 – 640 nm	> 90% 660 – 825 nm	25.2 x 35.6 mm	1.05 mm	FF650-Di01-25x36	$335
	652 nm	> 98% 350 – 644 nm	> 93% 659.5 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF652-Di01-25x36	$335
	654 nm	> 95% 660 – 850 nm	> 93% 490 – 650 nm	25.2 x 35.6 mm	1.05 mm	FF654-SDi01-25x36	$335
	655 nm	> 98% 470 – 645 nm	> 90% 665 – 726 nm	25.2 x 35.6 mm	1.05 mm	FF655-Di01-25x36	$255
	660 nm	> 98% 350 – 651 nm	> 93% 669 – 950 nm	25.2 x 35.6 mm	1.05 mm	FF660-Di02-25x36	$255
	665 nm	*See Multiphoton filters, page 40*				FF665-Di02-25x36	
	670 nm	*Short-wave-pass; See Multiphoton filters, page 40*				FF670-SDi01-25x36	
	677 nm	> 98% 400 – 658 nm	> 90% 687 – 830 nm	25.2 x 35.6 mm	1.05 mm	FF677-Di01-25x36	$335
	685 nm	> 98% 350 – 676 nm	> 93% 695 – 939 nm	25.2 x 35.6 mm	1.05 mm	FF685-Di02-25x36	$255
	695 nm	> 98% 450 – 680 nm	> 90% 710 – 850 nm	25.2 x 35.6 mm	1.05 mm	FF695-Di01-25x36	$335
	697 nm	> 97% 705 – 900 nm	> 93% 532 – 690 nm	25.2 x 35.6 mm	1.05 mm	FF697-SDi01-25x36	$255
	700 nm	> 97% 532 – 690 nm	> 93% 705 – 800 nm	25.2 x 35.6 mm	1.05 mm	FF700-Di01-25x36	$255
	700 nm	*Short-wave-pass; See Multiphoton filters, page 40*				FF700-SDi01-25x36	
	705 mm	*See Multiphoton filters, page 40*				FF705-Di01-25x36	
	720 nm	*Short-wave-pass; See Multiphoton filters, page 40*				FF720-SDi01-25x36	
	725 nm	> 90% 750 – 1140 nm	> 90% 430 – 700 nm	25.2 x 35.6 mm	3.5 mm	FF725-SDi01-25x36x3.5	$335
	735 nm	*See Multiphoton filters, page 40*				FF735-Di02-25x36	
	740 nm	> 98% 480 – 720 nm	> 90% 750 – 825 nm	25.2 x 35.6 mm	1.05 mm	FF740-Di01-25x36	$335
	749 nm	> 96% 770 – 1100 nm	> 93% 400 – 730 nm	25.2 x 35.6 mm	3.0 mm	FF749-SDi01-25x36x3.0	$335
	750 nm	> 96% 770 – 920 nm	> 93% 450 – 730 nm	25.2 x 35.6 mm	1.05 mm	FF750-SDi02-25x36	$255
	756 nm	> 90% 780 – 820 nm	> 88% 300 – 315 nm > 93% 315 – 700 nm	25.2 x 35.6 mm	1.05 mm	FF756-SDi01-25x36	$435
	757 nm	> 98% 450 – 746 nm	> 93% 768 – 1100 nm	25.2 x 35.6 mm	1.05 mm	FF757-Di01-25x36	$255
	765 nm	> 95% 450 – 750 nm	> 93% 780 – 950 nm	25.2 x 35.6 mm	2.0 mm	FF765-Di01-25x36x2.0	$335
	775 nm	*See Multiphoton filters, page 40*				FF775-Di01-25x36	
	776 nm	> 98% 450 – 764 nm	> 88% 789 – 1100 nm	25.2 x 35.6 mm	1.05 mm	FF776-Di01-25x36	$335
	791 nm	> 90% 795 – 940 nm	> 90% 687 – 787 nm	25.2 x 35.6 mm	1.05 mm	FF791-SDi01-25x36	$335
	801 mm	> 98% 450 – 790 nm	> 90% 813.5 – 1100 nm	25.2 x 35.6 mm	1.05 mm	FF801-Di02-25x36	$335
	825 nm	> 95% 850 – 1650 nm	> 90% 565 – 800 nm	25.2 x 35.6 mm	2.0 mm	FF825-SDi01-25x36x2.0	$565
	872 nm	> 92% 240 – 840 nm	> 90% 903 – 1100 nm	25.2 x 35.6 mm	2.0 mm	FF872-Di01-25x36x2.0	$435
	875 nm	*See Multiphoton filters, page 40*				FF875-Di01-25x36	
	925 nm	*See Multiphoton filters, page 40*				FF925-Di01-25x36	
	930 nm	> 98% 980 – 1140 nm	> 93% 750 – 880 nm	25.2 x 35.6 mm	2.0 mm	FF930-SDi01-25x36x2.0	$335
	989 nm	*Short-wave-pass; See Multiphoton filters, page 40*				FF989-SDi01-25x36	

New

BrightLine® Image Splitting Dichroic Beamsplitters

These beamsplitters offer superb image quality for both transmitted and reflected light when separating beams of light by color for simultaneous capture of multiple images. For applications such as (FRET) and real-time live-cell imaging, users can now separate two, four or even more colors onto as many cameras or regions of a single camera sensor. The exceptional flatness of these filters virtually eliminates aberrations in the reflected beam for most common imaging systems *(see Technical Note on page 63).*

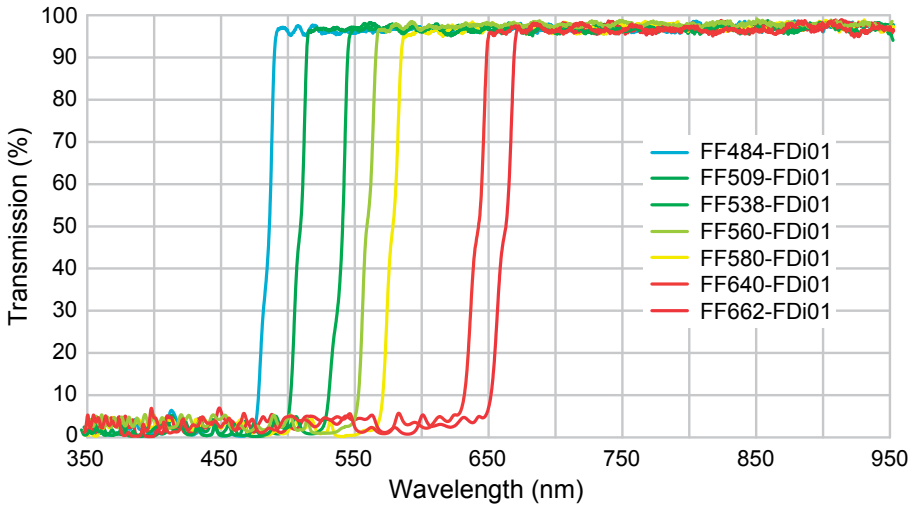
Nominal Edge Wavelength	Common Fluorophore Pairs to Split	Average Reflection Band	Average Transmission Band	Size (L x W x H)	Filter Part Number	Price
484 nm	DAPI/FITC (or BFP/GFP)	350 – 475 nm	492.3 – 950 nm	25.2 x 35.6 x 1.05 mm	FF484-FDi01-25x36	$335
509 nm	CFP/YFP	350 – 500 nm	518.3 – 950 nm	25.2 x 35.6 x 1.05 mm	FF509-FDi01-25x36	$335
538 nm	GFP/mOrange	350 – 528.4 nm	547.7 – 950 nm	25.2 x 35.6 x 1.05 mm	FF538-FDi01-25x36	$335
560 nm	YFP/dTomato	350 – 550 nm	570.1 – 950 nm	25.2 x 35.6 x 1.05 mm	FF560-FDi01-25x36	$335
580 nm	GFP/mCherry (or FITC/TxRed)	350 – 570 nm	590.8 – 950 nm	25.2 x 35.6 x 1.05 mm	FF580-FDi01-25x36	$335
640 nm	Cy3/Cy5	350 – 629.5 nm	652 – 950 nm	25.2 x 35.6 x 1.05 mm	FF640-FDi01-25x36	$335
662 nm	TxRed/Cy5	350 – 650 nm	673.7 – 950 nm	25.2 x 35.6 x 1.05 mm	FF662-FDi01-25x36	$335

Image Splitting Dichroic Beamsplitters Common Specifications

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

[1] A 10 mm spot size is typical assuming common microscope values. See www.semrock.com. All other mechanical specifications are the same as BrightLine dichroic specifications on page 30.

ACTUAL MEASURED DATA



BrightLine® Multiedge Dichroic Beamsplitters

Our BrightLine multiedge dichroic beamsplitters are available in dual, triple, quad, and the world's only penta band designs. Optimized for general broadband excitation sources or laser lines, high performance, multi-color fluorescence imaging is easily attainable with Semrock's BrightLine dichroic beamsplitters.

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

For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 65.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
403 nm 502 nm	> 97.5% 370 – 393 nm > 97.5% 466 – 495 nm	> 90% 414 – 452 nm > 90% 510 – 550 nm	25.2 mm x 35.6 mm x 1.05 mm	FF403/502-Di01-25x36	$335
440 nm 520 nm	> 95% 415 – 432 nm > 95% 493 – 511 nm	> 90% 449 – 483 nm > 90% 530 – 569 nm	25.2 mm x 35.6 mm x 1.05 mm	FF440/520-Di01-25x36	$335
493 nm 574 nm	> 95% 456 – 480 nm > 95% 541 – 565 nm	> 90% 500 – 529 nm > 90% 584 – 679 nm	25.2 mm x 35.6 mm x 1.05 mm	FF493/574-Di01-25x36	$335
495 nm 605 nm	> 95% 454 – 485 nm > 95% 570 – 598 nm	> 90% 505 – 550 nm > 90% 620 – 675 nm	25.2 mm x 35.6 mm x 1.05 mm	FF495/605-Di01-25x36	$335
505 nm 606 nm	> 95% 458 – 499 nm > 95% 570 – 600 nm	> 90% 509 – 541 nm > 90% 612 – 647 nm	25.2 mm x 35.6 mm x 1.1 mm	FF505/606-Di01-25x36	$335
545 nm 650 nm	> 95% 532.0 nm > 95% 632.8 nm	> 90% 554 – 613 nm > 90% 658 – 742 nm	25.2 mm x 35.6 mm x 1.05 mm	FF545/650-Di01-25x36	$335
560 nm 659 nm	> 95% 514 – 553 nm > 95% 617 – 652 nm	> 90% 564 – 591 nm > 90% 665 – 718 nm	25.2 mm x 35.6 mm x 1.05 mm	FF560/659-Di01-25x36	$335

MyLight

Interested in seeing how a Semrock standard filter behaves at a particular angle of incidence, state of polarization or cone half angle of illumination? Simply click the

Click for MyLight Tool

button located above the spectral graph and the MyLight window will access our theoretical design data and allow you to see spectral shifts in filter performance under varying illumination conditions. You can also expand (or contract) the displayed spectral range and assess filter performance in real time that previously required you to contact us and iterate towards an answer. MyLight data can be downloaded as an ASCII file and the graphs printed or saved as PDFs.

See spectra graphs and ASCII data for these filter sets at www.semrock.com

BrightLine® Multiedge Dichroic Beamsplitters

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

For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 67.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
395 nm 495 nm 610 nm	> 97% 354 – 385 nm > 97% 465 – 483 nm > 97% 570 – 596 nm	> 95% 403 – 446 nm > 95% 502 – 552 nm > 95% 620 – 750 nm	25.2 x 35.6 x 1.05 mm	FF395/495/610-Di01-25x36	$435
403 nm 497 nm 574 nm	> 97% 386 – 393 nm > 97% 466 – 490 nm > 97% 546 – 565 nm	> 90% 414 – 450 nm > 90% 505 – 528 nm > 90% 584 – 645 nm	25.2 x 35.6 x 1.05 mm	FF403/497/574-Di01-25x36	$435
409 nm 493 nm 596 nm	> 95% 381 - 404 nm > 95% 461 - 487.5 nm > 95% 559.5 - 589.5 nm	> 93% 414 – 450 nm > 93% 499.5 – 546 nm > 93% 604 – 800 nm	25.2 x 35.6 x 1.05 mm	FF409/493/596-Di01-25x36	$435
436 nm 514 nm 604 nm	> 97.5% 394 – 414 nm > 97.5% 484 – 504 nm > 97.5% 566 – 586 nm	> 90% 446 – 468 nm > 90% 520 – 540 nm > 90% 614 – 642 nm	25.2 x 35.6 x 1.05 mm	FF436/514/604-Di01-25x36	$435
444 nm 520 nm 590 nm	> 98% 327 – 437 nm > 98% 494 – 512 nm > 98% 562 – 578 nm	> 90% 450 – 480 nm > 90% 527 – 547 nm > 90% 598 – 648 nm	25.2 x 35.6 x 1.05 mm	FF444/520/590-Di01-25x36	$435
444 nm 521 nm 608 nm	> 95% 420 – 430 nm > 95% 496 – 510 nm > 95% 579 – 596 nm	> 90% 451 – 480 nm > 90% 530 – 561 nm > 90% 618 – 664 nm	25.2 x 35.6 x 1.05 mm	FF444/521/608-Di01-25x36	$435
459 nm 526 nm 596 nm	> 95% 350 – 450 nm > 95% 497.6 – 519.5 nm > 95% 567.4 – 588.6 nm	> 93% 464 – 486 nm > 93% 532 – 554 nm > 93% 603 – 800 nm	25.2 x 35.6 x 1.05 mm	FF459/526/596-Di01-25x36	$435

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

For multiedge laser-optimized fluorescence dichroic beamsplitters, see page 65.

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
409 nm 493 nm 573 nm 652 nm	> 95% 380 – 404 nm > 95% 461 – 487.5 nm > 95% 543 – 566 nm > 95% 626 – 644 nm	> 93% 414 – 450 nm > 93% 499.5 – 530 nm > 93% 580 – 611 nm > 93% 659.5 – 800 nm	25.2 x 35.6 x 1.05 mm	FF409/493/573/652-Di01-25x36	$515
410 nm 504 nm 582 nm 669 nm	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 722 nm	25.2 x 35.6 x 1.05 mm	FF410/504/582/669-Di01-25x36	$515

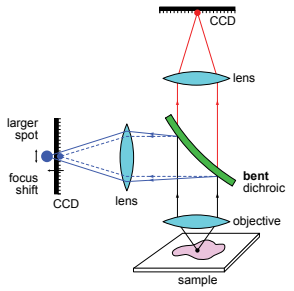
Penta-edge Dichroic Beamsplitter *(polarization-insensitive; for use at 45°)*

Nominal Edge Wavelength	Avg. Reflection Bands	Avg. Transmission Bands	Size (L x W x H)	Filter Part Number	Price
408 nm 504 nm 581 nm 667 nm 762 nm	> 95% 381 – 392 nm > 95% 475 – 495 nm > 95% 547 – 572 nm > 95% 643 – 656 nm > 95% 733 – 746 nm	> 90% 420 – 460 nm > 90% 510 – 531 nm > 90% 589 – 623 nm > 90% 677 – 711 nm > 90% 768 – 849 nm	25.2 x 35.6 x 1.05 mm	FF408/504/581/667/762-Di01-25x36	$605

TECHNICAL NOTE

Flatness of Dichroic Beamsplitters Affects Focus and Image Quality

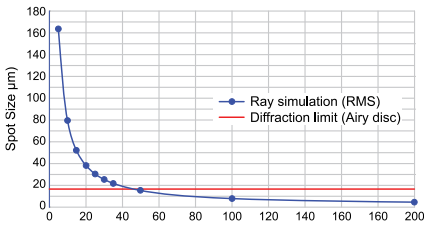
Optical filters are generally comprised of multi-layered thin-film coatings on plane, parallel glass substrates. All Semrock filters use a single substrate with coatings on one or both sides to maximize transmission and reliability and minimize artifacts associated with multiple interfaces. The glass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



A bent dichroic can introduce aberrations.

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

Often a small shift of the focal plane is not a problem, because a lens or camera adjustment can be made to compensate. But in some cases the focal shift may be too large to compensate – focusing a laser beam onto the back focal plane of the objective in a Total Internal Reflection Fluorescence (TIRF) microscope, or imaging the grid onto the sample plane in a structured illumination microscope represent cases where care should be taken to use a flat dichroic, such as those designed for laser applications (for example, see page 64).



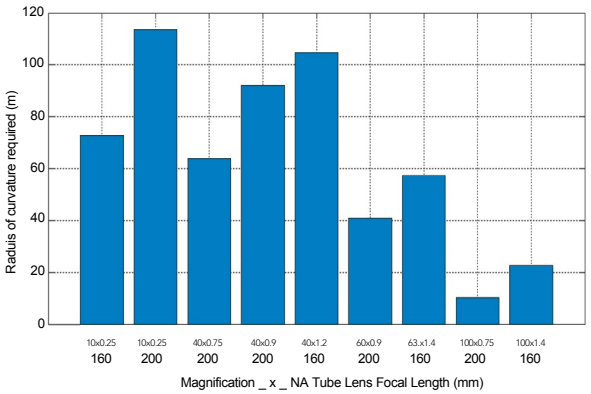
Dichroic radius of curvature affects spot size.

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

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

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

While reflected image quality can be worse than the ideal diffraction-limited response for dichroics that are not perfectly flat, it should be noted that the true spot size at the image plane can be appreciably larger than the diffraction-limited spot size in an actual system. Nevertheless, care should be taken to select properly optimized, flatter dichroic beamsplitters when working with reflected light. Dichroics designed to reflect laser light ("laser dichroics," see pages 64 and 65) are generally flat enough to ensure negligible focal shift for laser beams up to several mm in diameter. Dichroics designed to reflect imaging beams ("imaging dichroics", see page 59 have the most extreme flatness requirements, since they must effectively eliminate the effects of astigmatism for beams as large as 1 cm or more.



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

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BrightLine® Dichroic Beamsplitters

TECHNICAL NOTE

Choosing the Right Dichroic Beamsplitter

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

Light Source	Edge Steepness	Flatness	Family	Page
Broadband	Standard	Standard	General Purpose Dichroics	58
Broadband	Standard	Imaging flatness	Image Splitting Dichroics	60
Laser lines	Steep	Laser flatness	Laser Dichroics	66
Laser lines	Steep	1λ RWE	Super-resolution Dichroics	65
Laser lines	Steep	λ/5 RWE	Super-resolution Dichroics	65
Laser lines	Standard	Laser flatness	Laser Notch Dichroics	68
Laser lines	Standard	Laser flatness	Laser Beam Combining	69
Laser lines	Standard	1λ RWE	Multiphoton Laser Beam Combining	41
Precise laser lines	Ultrasteep	Laser flatness	Ultrasteep Laser Dichroics	90

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

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

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

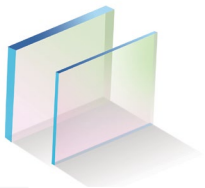
NOTE: Mounting can impact flatness performance. Values below apply to unmounted parts.

Flatness of Semrock Dichroic Beamsplitters

Flatness Classification	Nominal Radius of Curvature	Application Specification
Standard	~ 6 meters	Transmission: does not cause significant aberrations to a transmitted beam over the full clear aperture Reflection: designed to reflect broadband excitation light that is not focused or imaged
Laser	~ 30 meters	Transmission: does not cause significant aberrations to a transmitted beam over the full clear aperture Reflection: contributes less than one Rayleigh Range of shift in focus (relative to a perfectly flat mirror) at the focal plane of a lens after reflecting a laser beam with a diameter up to 2.5 mm
Imaging	~ 100 meters	Transmission: does not cause significant aberrations to a transmitted beam over the full clear aperture Reflection: contributes less than 1.5 x Airy Disk diameter to the RMS spot size of a focused, reflected beam with a diameter up to 10 mm
1λ RWE	~ 255 meters	Transmission: does not cause significant aberrations to a transmitted beam over the full clear aperture Reflection: contributes less than one Rayleigh Range of shift in focus (relative to a perfectly flat mirror) at the focal plane of a lens after reflecting a laser beam with a diameter up to 10 mm; contributes less than 1.5 x Airy Disk diameter to the RMS spot size of a focused, reflected beam with a diameter up to 16.7 mm
λ/5 RWE	~ 1275 meters	Transmission: does not cause significant aberrations to a transmitted beam over the full clear aperture Reflection: contributes less than one Rayleigh Range of shift in focus (relative to a perfectly flat mirror) at the focal plane of a lens after reflecting a laser beam with a diameter up to 22.5 mm; contributes less than 1.5 x Airy Disk diameter to the RMS spot size of a focused, reflected beam with a diameter up to 37 mm

BrightLine® Super-Resolution Laser Dichroic Beamsplitters

ALL BEAMSPLITTERS IMPROVED



Semrock's industry leading laser dichroic beamsplitters just got flatter.
We're setting a new standard for super-resolution microscopy with λ/5 P-V RWE on our new 3 mm thick dichroics and improved 1λ P-V RWE on our improved 1 mm dichroics. Each one comes with our Semrock guaranteed steepest edges, short wavelength reflectivity down to 350 nm, and long wavelength transmission optimized out to 1200 nm or 1600 nm.

- λ/5 P-V RWE on 3 mm
- 1λ P-V RWE on 1 mm
- Minimal reflected wavefront distortion for large diameter illumination beams
- The steepest edges for higher throughput and signal collection
- Wider reflection bands — into UV for photoactivation and super-resolution techniques
- Wider transmission regions — into IR to 1200 or 1600 nm

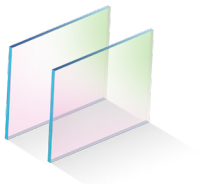
Nominal Edge Wavelength	Laser Wavelengths	Extended Avg. Reflection Band	Absolute Reflection Band	Avg. Transmission Band	1λ RWE: 1 mm Thickness Filter Part Number	1λ RWE: Price	λ/5 RWE: 3 mm Thickness Filter Part Number	λ/5 RWE: Price
414 nm	375.0 ± 3 nm 405.0 ± 5 nm	350.0–372.0 nm	372.0 – 410.0 nm	417.4 – 1200.0 nm	Di03-R405-t1-25x36	$445	Di03-R405-t3-25x36	$545
465 nm	440.0 +3/-1 nm 442.0 nm 457.9 nm	350.0–439.0 nm	439.0 – 457.9 nm	466.1 – 1200.0 nm	Di03-R442-t1-25x36	$445	Di03-R442-t3-25x36	$545
496 nm	473.0 ± 2 nm 488.0 +3/–2 nm	350.0–471.0 nm	471.0 – 491.0 nm	499.8 – 1200.0 nm	Di03-R488-t1-25x36	$445	Di03-R488-t3-25x36	$545
520 nm	505.0 nm 514.5 nm 515.0 nm	350.0–505.0 nm	505.0 – 515.0 nm	524.3 – 1200.0 nm	Di03-R514-t1-25x36	$445	Di03-R514-t3-25x36	$545
538 nm	514.5 nm 532.0 nm	350.0–514.0 nm	514.0 – 532.0 nm	541.6 – 1200.0 nm	Di03-R532-t1-25x36	$445	Di03-R532-t3-25x36	$545
576 nm	561.4 nm 568.2 nm	350.0–554.0 nm	554.0 – 568.2 nm	578.4 – 1200.0 nm	Di03-R461-t1-25x36	$445	Di03-R561-t3-25x36	$545
599 nm	593.5 nm 594.1 nm 594.0 ± 0.3 nm	350.0–593.5 nm	593.5 – 594.3 nm	605.0 – 1200.0 nm	Di03-R594-t1-25x36	$445	Di03-R594-t3-25x36	$545
656 nm	632.8 nm 635.0 +7/–3 nm 647.1 nm	350.0–632.8 nm	632.8 – 647.1 nm	658.8 – 1200.0 nm	Di03-R635-t1-25x36	$445	Di03-R635-t3-25x36	$545
800 nm	785.0 ± 5 nm	350.0–780.0 nm	780.0 – 790.0 nm	804.3 – 1600.0 nm	Di03-R785-t1-25x36	$545	Di03-R785-t3-25x36	$645
499 nm 575 nm	473 ± 2 , 488 +3 /-2 559 +5/-0, 561.4, 568.2	350.0–471.0 nm	471.0 – 491.0 nm 559.0 – 568.2 nm	503.3 – 543.0 nm 582.4 – 1200.0 nm	Di03-R488/561-t1-25x36	$495	Di03-R488/561-t3-25x36	$595
419 nm 498 nm 542 nm 659 nm	375 ± 3, 405 ± 5 473 +2/-0 , 488 +3 /-2 532 632.8, 635 +7/-0, 647.1	350.0–370.0 nm	370.0 – 410.0 nm 473.0 – 491.0 nm 530.5 – 533.5 nm 632.8 – 647.1 nm	426.0 – 462.0 nm 502.5 – 518.5 nm 550.0 – 613.0 nm 663.0 – 1200.0 nm	Di03-R405/488/532/635-t1-25x36	$595	Di03-R405/488/532/635-t3-25x36	$695
419 nm 498 nm 575 nm 655 nm	375 ± 3, 405 ± 5 473 +2/-0 , 488 +3 /-2 559 +5/-0, 561.4, 568.2 632.8, 635 +7/-0, 647.1	350.0–370.0 nm	370.0 – 410.0 nm 473.0 – 491.0 nm 559.0 – 568.2 nm 632.8 – 647.1 nm	426.0 – 462.0 nm 502.5 – 544.5 nm 582.0 – 617.5 nm 663.0 – 1200.0 nm	Di03-R405/488/561/635-t1-25x36	$595	Di03-R405/488/561/635-t3-25x36	$695

Super-Resolution Laser Dichroic Beamsplitters Common Specifications

Property	Value	Comment
Flatness (Di03)	< 1λ P-V RWE (1 mm thickness) < λ/5 P-V RWE (3 mm thickness)	Measured at λ = 633 nm

All other optical & mechanical specifications are the same as BrightLine Laser Dichroic specifications on page 66.

BrightLine® Single-edge Laser Dichroic Beamsplitters



BrightLine laser dichroic beamsplitters have extended reflection down to 350 nm to enable photoactivation. These dichroic beamsplitters are optimized for the most popular lasers used for fluorescence imaging, including 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.

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

Nominal Edge Wavelength	Laser Wavelengths	Extended Avg. Reflection Band	Absolute Reflection Band	Avg. Transmission Band	Size (mm) (L x W x H)	Filter Part Number	Price
273 nm	266.0 nm	230.0 – 245.0 nm	245.0 – 266.0 nm	277.0 – 1200.0 nm	25.2 x 35.6 x 1.05	Di01-R266-25x36	$495
331 nm	325.0 nm	230.0 – 300.0 nm	300.0 – 325.0 nm	336.0 – 1200.0 nm	25.2 x 35.6 x 1.05	Di01-R325-25x36	$495
363 nm	355.0 nm	230.0 – 325.0 nm	325.0 – 355.0 nm	367.0 – 1200.0 nm	25.2 x 35.6 x 1.05	Di01-R355-25x36	$495
840 nm	785.0 ± 5 nm 808.0 + 2 nm 830.0 nm	350.0 – 780.0 nm	780.0 – 830.0 nm	845.0 – 1600.0 nm	25.2 x 35.6 x 1.05	Di02-R830-25x36	$495
New 993 nm	975.0 ± 5 nm 976.0 nm 980.0 nm	350.0 – 970.0 nm	970.0 – 980.0 nm	998.0 – 1600.0 nm	25.2 x 35.6 x 1.05	Di02-R980-25x36	$495
1078 nm	1030.0 nm 1047.1 nm 1064.0 nm	350.0 – 1030.0 nm	1030.0 – 1064.0 nm	1083.2 – 1600.0 nm	25.2 x 35.6 x 1.05	Di02-R1064-25x36	$495

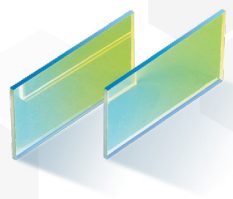
For multiedge laser-optimized dichroic beamsplitters, see page 65 and 67

Laser Dichroic Beamsplitters Common Specifications

Property	Value	Comment
Absolute Reflection	> 98% (s-polarization) > 90% (p-polarization) > 94% (average polarization)	Absolute reflectivity over the specified laser wavelengths/bands
Average Reflection	> 90% (average polarization)	Averaged over extended reflection range
Transmission	> 93%	Averaged over the transmission band above
Angle of Incidence	45.0°	Range for above optical specifications Based on a collimated beam of light
Dependence of Wavelength on Angle of Incidence (Edge Shift)	0.2% / degree	Linear relationship valid between about 40°- 50° (See MyLight for actual performance)
Cone Half Angle (for non-collimated light)	< 0.5°	Rays uniformly distributed and centered at 45°
Transmitted Wavefront Error	< λ / 4 RMS at λ = 633 nm	Peak-to-valley error < 5 x RMS
Beam Deviation	≤ 10 arcseconds	
Second Surface	Anti-reflection (AR) coated	
Flatness (Di01 & Di02)	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.	
Filter Orientation	Reflective coating side should face toward light source and sample (see page 38)	
Microscope Compatibility	BrightLine filters are available to fit Leica, Nikon, Olympus, and Zeiss microscopes.	

All other mechanical and reliability specifications are the same as BrightLine dichroic specifications on page 30.

BrightLine® Laser Multiedge Dichroic Beamsplitters



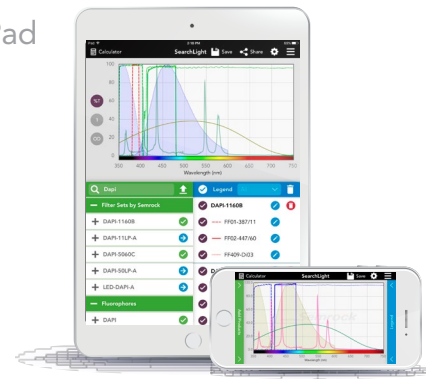
Optimized for the most popular lasers used for fluorescence imaging, including all-solid-state lasers that are replacing older gas-laser technology. Laser Multiedge Dichroic Beamsplitters offer exceptionally high reflection at the laser wavelengths combined with very steep transitions from high reflection to high transmission (< 2.5% of the longest laser wavelength). They also offer sufficient flatness for laser applications *(see Technical Note on page 63)*.

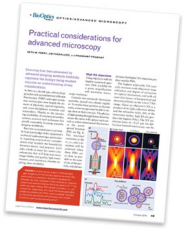
Laser Multiedge Dichroic Beamsplitters

Nominal Edge Wavelength	Laser Wavelengths (nm)	Absolute Reflection Band (nm)	Average Transmission Band (nm)	Size (mm) (L x W x H)	Filter Part Number	Price
420 nm	375 ± 3, 405 ± 5	> 94% 370.0 – 410.0	> 93% 429.5 – 462.0	25.2 x 35.6 x 1.05	Di01-R405/488/594-25x36	$515
497 nm	473 +2/-0, 488 +3/-2	> 94% 473.0 – 491.0	> 93% 502.5 – 574.5			
602 nm	593.5 , 594.1, 594 ± 0.3	> 94% 588.3 – 594.3	> 93% 612.0 – 800.0			
463 nm	440 +3/-1, 442.0, 457.9	> 94% 438.0 – 458.0	> 93% 469.5 – 496.5	25.2 x 35.6 x 1.05	Di01-R442/514/561-25x36	$515
521 nm	514.5, 515.0	> 94% 512.5 – 515.5	> 93% 528 – 545.5			
575 nm	559 ± 5, 561.4, 568.2	> 94% 559.0 – 568.2	> 93% 582 – 800			
497 nm	473 +2 /-2, 488 +3 /-2	> 94% 471.0 – 491.0	> 93% 503 – 523.5	25.2 x 35.6 x 1.05	Di01-R488/543/594-25x36	$515
552 nm	543 ± 1	> 94% 541.5 – 544.5	> 93% 558 – 574			
602 nm	589.0, 593.5, 594.1, 594 ± 0.3	> 94% 588.0 – 594.5	> 93% 609 – 800			
497 nm	473 +2 /-2, 488 +3 /-2	> 94% 471.0 – 491.0	> 93% 503.5 – 526.5	25.2 x 35.6 x 1.05	Di01-R488/543/635-25x36	$515
552 nm	543 ± 1	> 94% 541.5 – 544.5	> 93% 560.0 – 615.5			
656 nm	632.8, 635 +7/-0, 647.1	> 94% 632.8 – 647.1	> 93% 665.5 – 800.0			

SEARCHLIGHT™ — App now available for iPhone and iPad

- SearchLight App is now available for iPhone & iPad.
- Access SearchLight offline even without internet connectivity.
- Save your Sessions locally on your iPhone & iPad when offline and sync with your on-line account when you reconnect.
- Search for "Semrock" through the App Store and follow the download instructions for SearchLight.

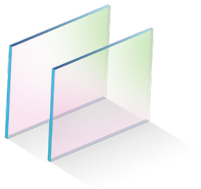




Review Semrock's article featured in *BioOptics World*

Practical Considerations for Advanced Microscopy
Our recent article in BioOptics World:Learn some of the key optics considerations that will help maximize image fidelity and quality, light transmission, and resolution.
http://www.laserfocusworld.com/articles/print/volume-52/issue-10/issue-10/optics-advanced-microscopy-practical-considerations-for-advanced-microscopy.html

StopLine® Notch Dichroic Beamsplitters



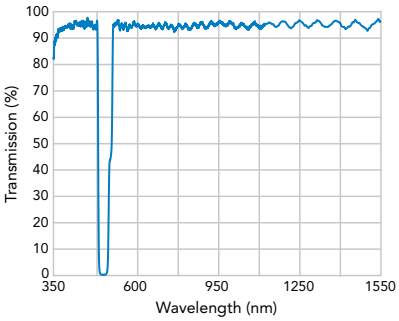
Our single-edge StopLine notch dichroics are designed for a 45° angle of incidence and will reflect just the incident laser source, while allowing wavelengths above and below the notch to transmit. These notch dichroics were designed specifically for Coherent Anti-Stokes Raman Spectroscopy (CARS) applications. The 1064 nm StopLine notch is also suitable for laser tweezing/trapping applications, reflecting just the trapping laser and allowing the fluorescence/bright-field wavelengths to transmit.

Notch Dichroic Beamsplitters

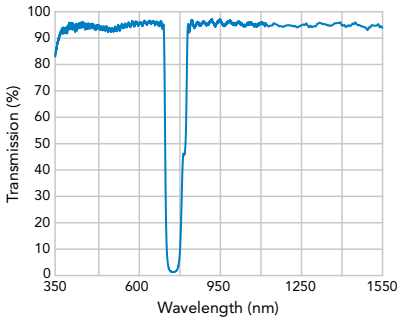
Laser Wavelength	Reflection Value & Wavelength	Avg. Transmission Bands	Size (mm) (L x W x H)	Filter Part Number	Price
405 nm	> 98% 405 nm	> 90% 350 – 386 nm & 434 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-405-25x36	$695
488 nm	> 98% 488 nm	> 90% 350 – 465 nm & 523 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-488-25x36	$695
532 nm	> 98% 532 nm	> 90% 350 – 507 nm & 570 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-532-25x36	$695
632.8 nm	> 98% 632.8 nm	> 90% 350 – 603 nm & 678 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-633-25x36	$695
785 nm	> 98% 785 nm	> 90% 350 – 749 nm & 841 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-785-25x36	$695
1040 nm 1041 nm	> 98% 1040 nm	> 90% 350 – 992 nm & 1114 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-1040-25x36	$695
1064 nm	> 98% 1064 nm	> 90% 350 – 1015 nm & 1140 – 1600 nm	25.2 x 35.6 x 1.05	NFD01-1064-25x36	$695

Actual Measured Data

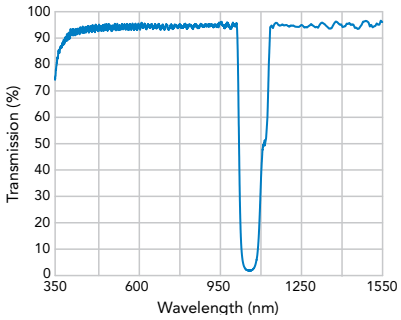
NFD01-532-25x36



NFD01-785-25x36



NFD01-1064-25x36



Notch Dichroic Beamsplitters Common Specifications

Property	Value	Comment
Reflection	> 98% (average polarization)	Absolute reflectivity over the specified laser wavelengths/bands
Transmission	> 90%	Averaged over the transmission band above
Angle of Incidence	45.0°	Range for above optical specifications Based on a collimated beam of light
Transmitted Wavefront Error	< λ / 4 RMS at λ = 633 nm	Peak-to-valley error < 5 x RMS
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 38)	
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 30.