ULTRA-NARROW BANDPASS FILTERS

Overview:

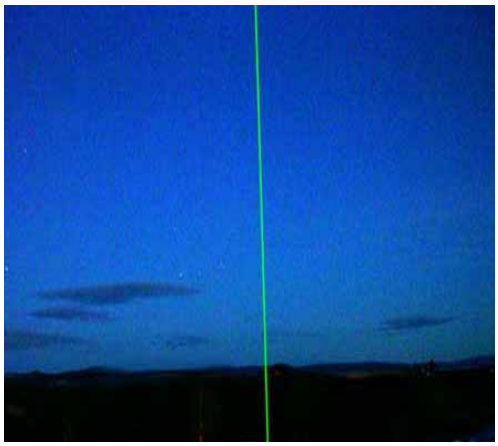
Barr offers bandpass filters with bandwidth at Full Width Half Maximum (FWHM) selectable from Wideband to Ultra-Narrowband, manufactured to customer requirements. Where the requirement is for bandpass filters with Ultra-Narrow Bandwidth, Barr can produce such filters for use in the ultraviolet, visible, and infrared spectral regions.

While there is no strict definition of just what bandwidth value constitutes “Ultra-Narrow” for a bandpass filter, a bandwidth (FWHM) of one to several angstroms in the visible spectral region, for example, might be considered as “Ultra-Narrow”. At Barr Associates, Inc., bandpass filters with this bandwidth are routinely produced, and ones can be manufactured with even narrower bandwidth (i.e. sub-angstrom). Barr Ultra-Narrow Bandpass filters can be constructed using several different coating types and are typically constructed using durable, metal-oxide optical interference coatings. This results in filters showing both thermally stable spectral properties and robust environmental durability characteristics.

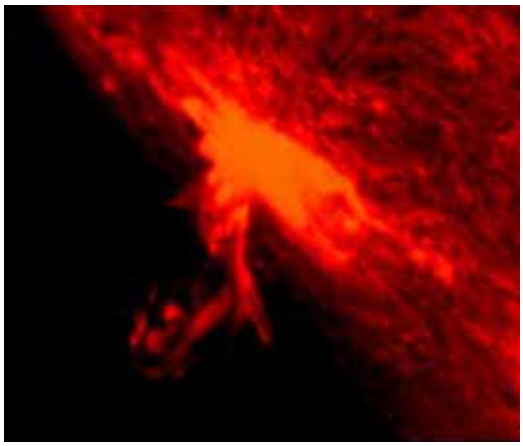
Barr designs and manufactures bandpass filters with Ultra-Narrow Bandwidth over the broad spectral range from 200nm in ultraviolet through 50 microns in the far infrared. Because Barr designs and manufactures Ultra-Narrow Bandpass filters to closely match customer specifications and optical system requirements, the filters often contribute to optimizing performance of the customer’s instrument, detector or other end-use application.

Ultra-Narrow Bandpass Filters - Representative Applications

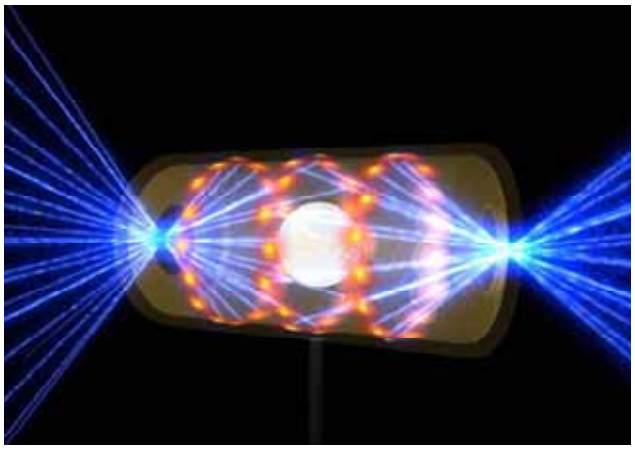
- Plasma Spectroscopy
- Nuclear Fusion Plasma Diagnostics
- Atmospheric Plasma Diagnostics
- Solar and Stellar Astronomy
- Lidar, Raman Lidar, Differential Absorption Lidar (DIAL)
- ASE Suppression
- Deep-Space Optical Telecommunications



532nm Laser - Lidar



Solar Flare- Solar Astronomy



Nuclear Fusion

Credit is given to Lawrence Livermore National Security, LLC, Lawrence Livermore National Laboratory, and the Department of Energy under whose auspices this work was performed.

Available Features for Barr Ultra-Narrow Bandpass Filters

Barr designs and manufactures Ultra-Narrow Bandpass filters to user-specified characteristics including:

Choice of Center Wavelength (CWL) in the UV, Visible, or IR spectral regions

Barr's capabilities include ability to produce bandpass filters over the broad spectral range from 200nm in the ultraviolet through 50 microns in the far infrared.

Choice of Bandwidth

Bandwidth (FWHM) as a percentage of CWL is routinely offered from as narrow as 0.01% in the UV and visible spectral regions, to as narrow as 0.05% of CWL in the Near Infrared, 0.7% of CWL in the Mid-wave Infrared, and as narrow as 1% of CWL in the Far Infrared. Even more narrow values for bandwidth as a percentage of CWL can be achieved as part of developmental efforts. As an example, Barr has achieved bandwidth (FWHM) values on the order of 100 picometers at 1550nm (or bandwidth of 0.0065% of CWL).

User-specified Wavelength Range for Blocking

Depending upon customer requirements, out-of-band blocking can either be provided within narrow wavelength regions close to, and on either side of the passband, or over a much wider wavelength range such as where blocking would be provided to span the spectral responsivity range of an optical detector.

Deep Blocking Density (OD 6) within Blocking Wavelength Range

Out-of-band blocking density values are established to meet customer requirements with measured blocking density levels of OD 4 to ≥OD 6 routinely being provided. Filter designs with theoretical blocking levels much greater than OD 6 are possible.

Deep Blocking available Close to Passband

Where customer requirements call for effective blocking at wavelengths very close to the passband, Barr can utilize coating designs for Ultra-Narrow Bandpass filters which result in steep slopes for the passband and deep blocking close to the passband.

Available Features (continued)

Low Thermal Coefficient which results in Thermal Spectral Stability of CWL

A filter performance parameter often of importance to the filter user is the degree of wavelength shift for CWL associated with a given change in filter temperature. By proper selection of substrate materials and coating deposition materials, coupled with derivation of the proper thin film design, Barr is able to control the degree of CWL thermal shift for the filter.

Many Ultra-Narrow Bandpass filters offered by Barr are intrinsically associated with a relatively low thermal shift of CWL due to the low thermal coefficient associated with the stable metal oxide optical coating materials used to construct the filters. The temperature coefficient for a typical narrow bandpass coating is $\approx$ (4×10^{-6} /deg C). As an example, if we apply this thermal coefficient to the case of a 532nm narrow bandpass filter subjected to a change in temperature from –40 deg C to +37.8 deg C, a thermally-induced shift in center wavelength of approximately 0.17nm would be predicted. If a customer requirement calls for even smaller thermal shift Barr can utilize thin film designs and filter manufacturing processes which result in further minimizing the shift.

High in-band Transmission with Effective Out-of-Band Rejection

In many applications Barr Ultra-Narrow Bandpass filters are selected for use because they show a high signal-to-noise performance characteristic. This derives from the fact that the filters are designed to show both high in-band transmission and deep out-of-band rejection or optical isolation.

Durable Environmental Durability Characteristics

Barr can manufacture Ultra-Narrow Bandpass Filters so as to conform to environmental durability requirements associated with standard military specifications such as MIL-STD-810C, MIL-F-48616, MIL-C -48497A, MIL-C-675, and MIL-STD-13508

Image Quality available

Some applications such as astronomy require Ultra-Narrow Bandpass filters which are of image quality. Barr is able to offer image quality filters by use of low-loss, defect-free optical coatings on high purity, homogeneous optical substrate materials, by control of transmitted wavefront distortion, wedge/parallelism, surface flatness, and surface quality.

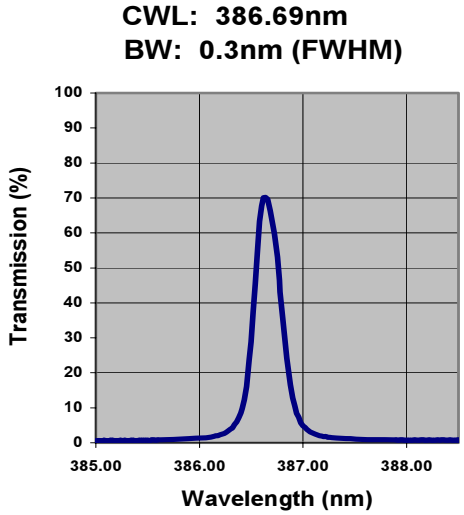
Custom Sizes

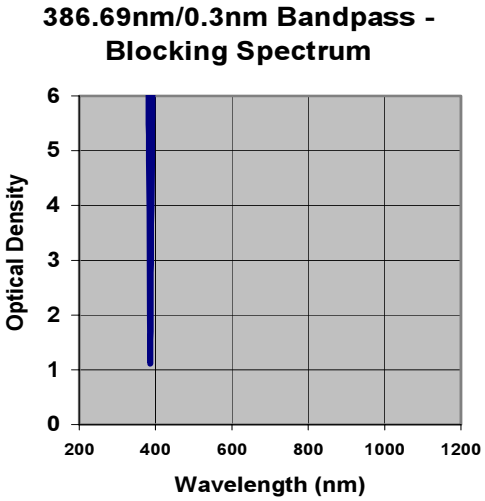
Barr can offer Ultra-Narrow Bandpass filters in different sizes and shapes, ring-mounted or unmounted, depending upon customer requirements.

Representative Measured Transmission and Blocking Spectra

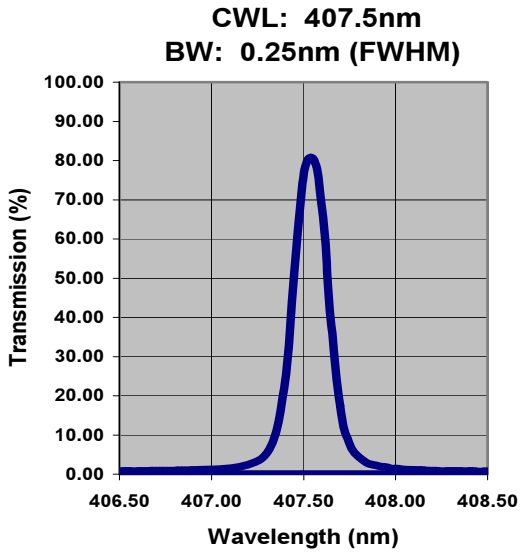
The following measured filter spectral transmission and blocking data illustrate some types of Narrow Bandpass and Ultra-Narrow Bandpass Filters Barr has produced, however, Barr's design and manufacturing capabilities are not limited to these. Since all Ultra-Narrow Bandpass filters offered by Barr are designed to individual customer requirements Barr stands ready to design filters to your specific needs.

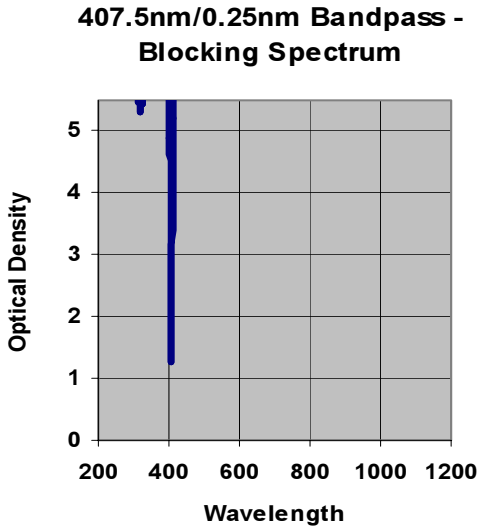
Ultra-Narrow Bandpass Filter in Ultraviolet Spectrum





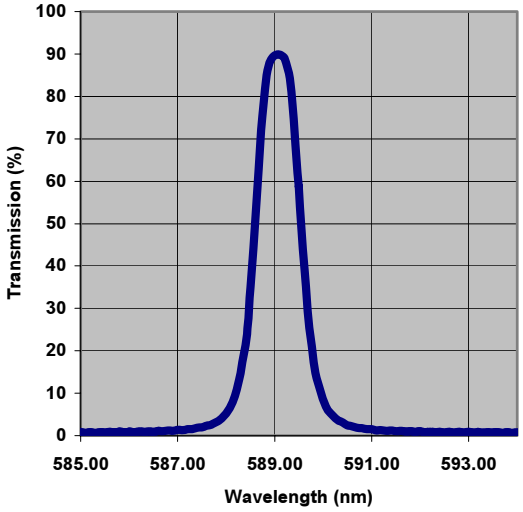
Ultra-Narrow Bandpass Filter at 407.5nm



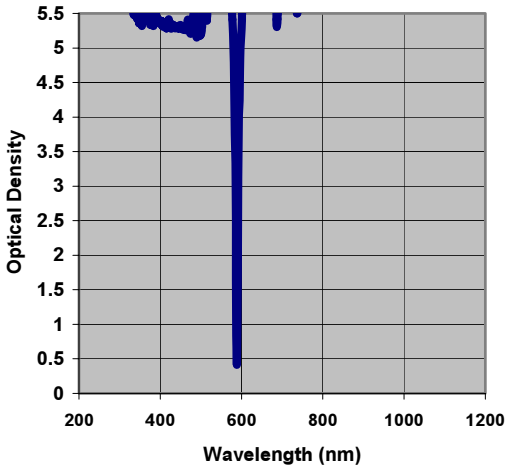


Narrow Bandpass Filter at 589nm

CWL: 589.07nm
BW: 1.0nm (FWHM)

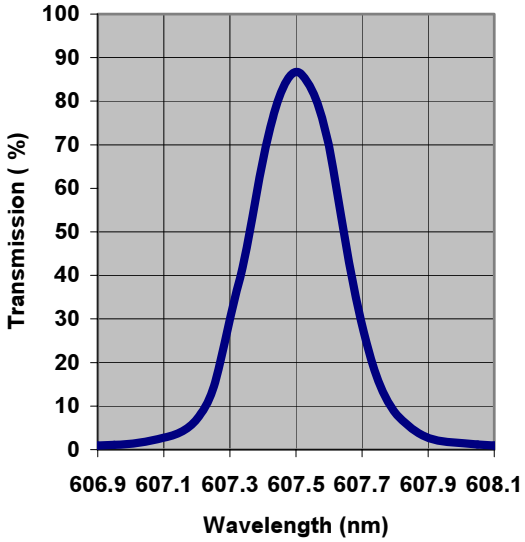


589.07nm/1.0nm Bandpass-
Blocking Spectrum

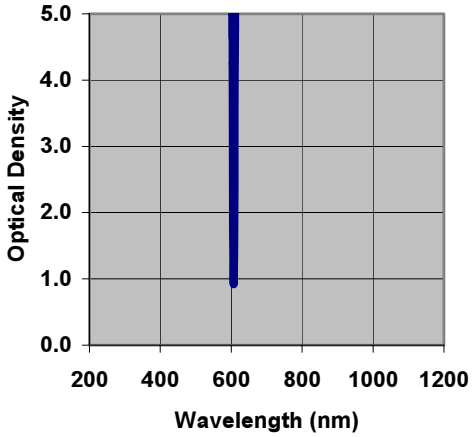


Ultra-Narrow Bandpass Filter at 607.5nm

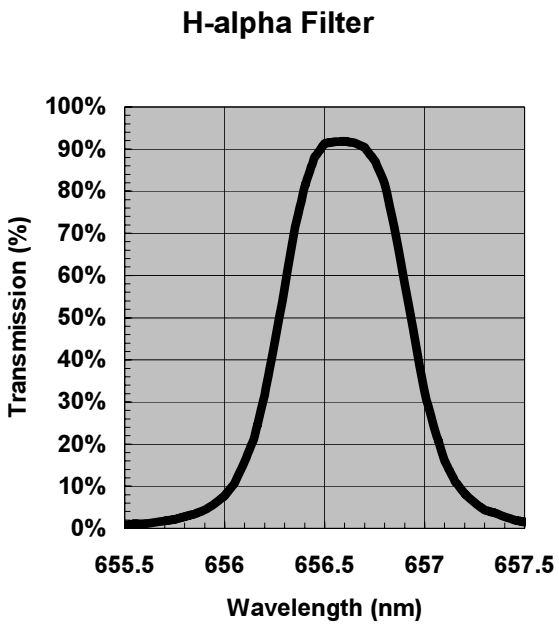
CWL: 607.50 nm
BW: 0.34nm (FWHM)

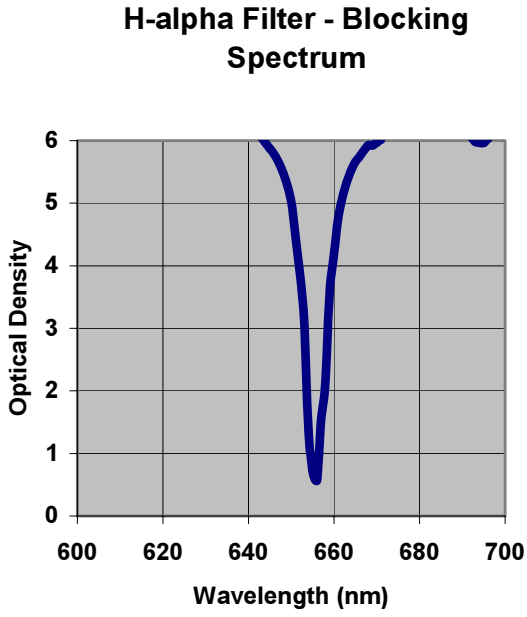


607.5/0.30 nm Bandpass -
Blocking Spectrum



H-alpha Narrow Bandpass Filter for Astronomy





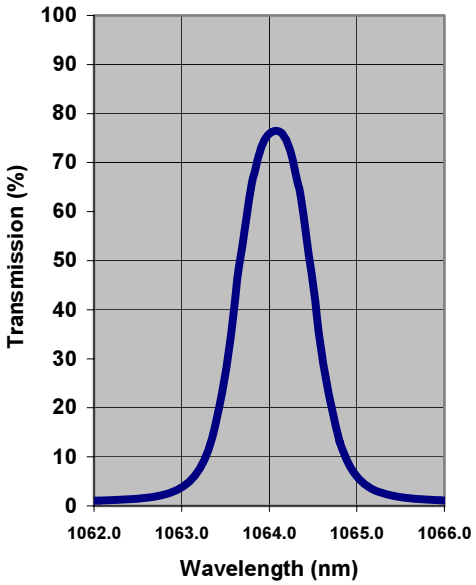
Bandwidth Units

Micron	Nanometer	Angstrom	Picometer
1.0 micron	1000nm	10,000 angstrom	1,000,000 pm
0.001 micron	**1.0 nm**	10 angstrom	1000 pm
0.0001 micron	0.1 nm	**1 angstrom**	100 pm
1.0 E-6 micron	0.001 nm	0.01 angstrom	**1.0 pm**

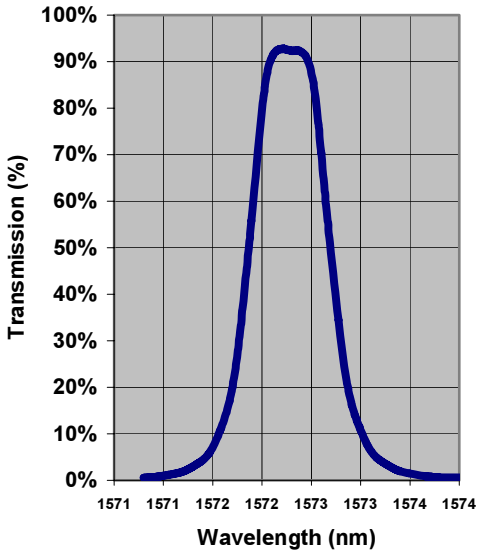
1 micron = 1×10^{-6} m
1 nanometer = 1×10^{-9} m
1 angstrom = 1×10^{-10} m
1 picometer = 1×10^{-12} m

Ultra-Narrow Bandpass Filters in Near Infrared

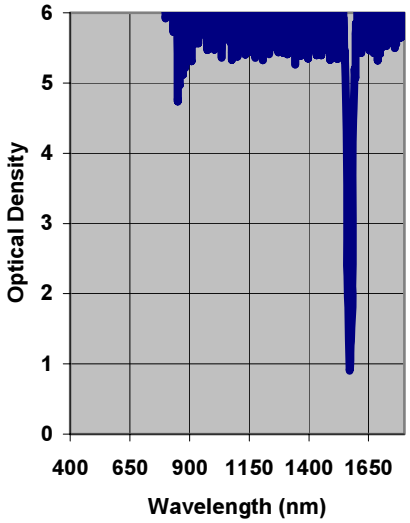
CWL: 1064.05nm,
BW: 0.96nm (FWHM)



CW: 1572.3nm
BW: 0.8nm (FWHM)

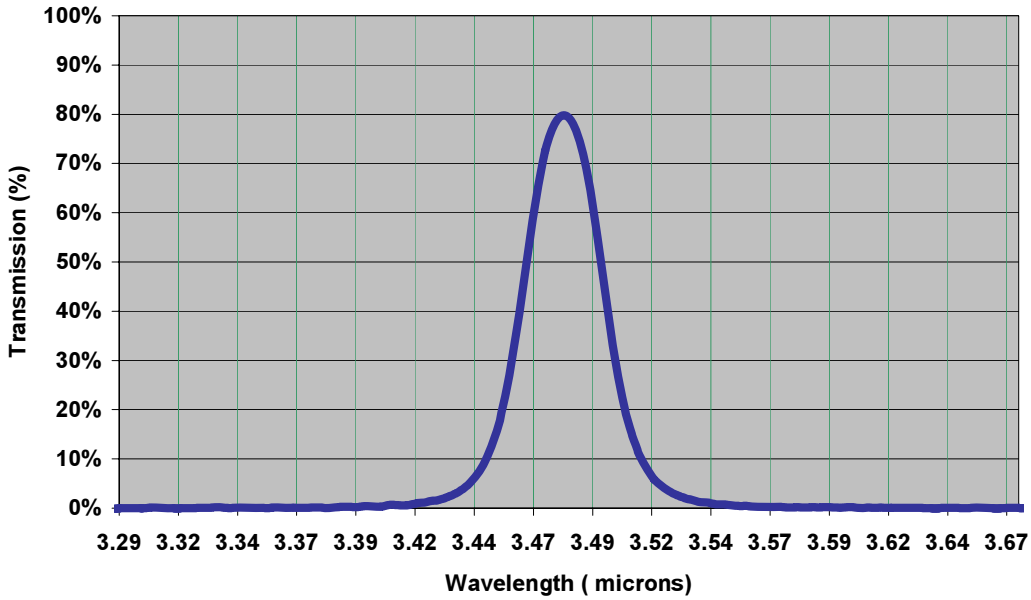


1572.3/0.8nm Bandpass Filter - Blocking Spectrum

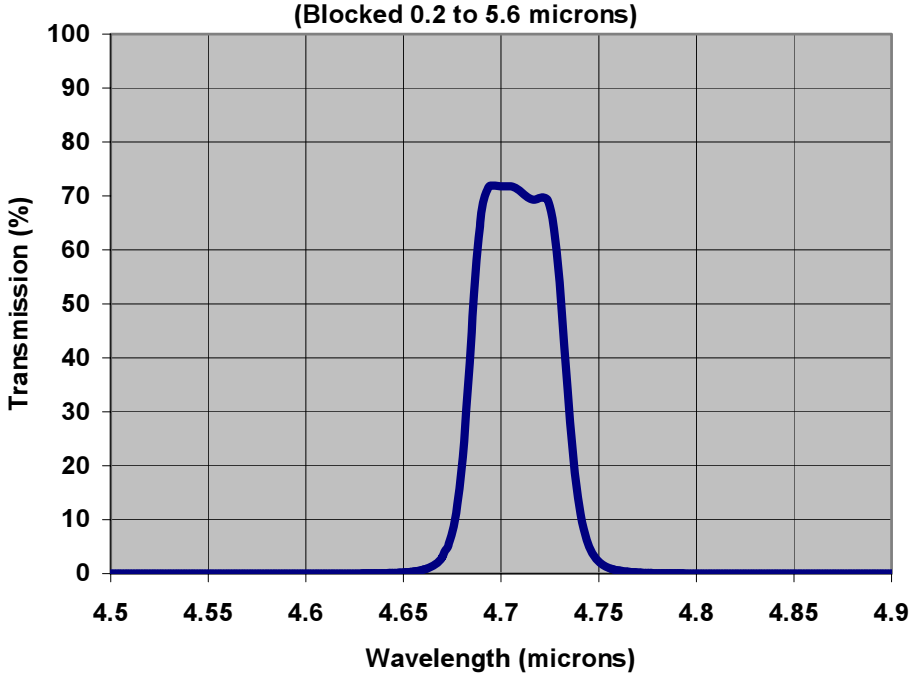


Ultra-Narrow Bandpass Filters with ≤ 1.1% bandwidth in Mid-Wave Infrared

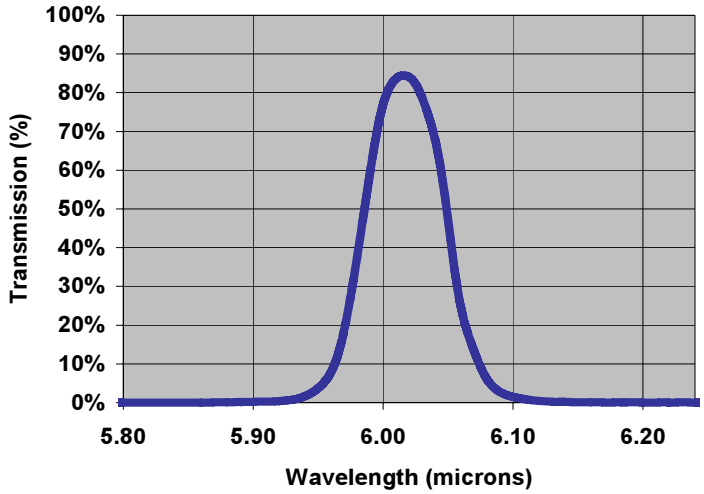
CWL: 3.4776 microns
BP: 0.0374 microns



CWL: 4.708 microns,
BW: 0.050 microns
(Blocked 0.2 to 5.6 microns)

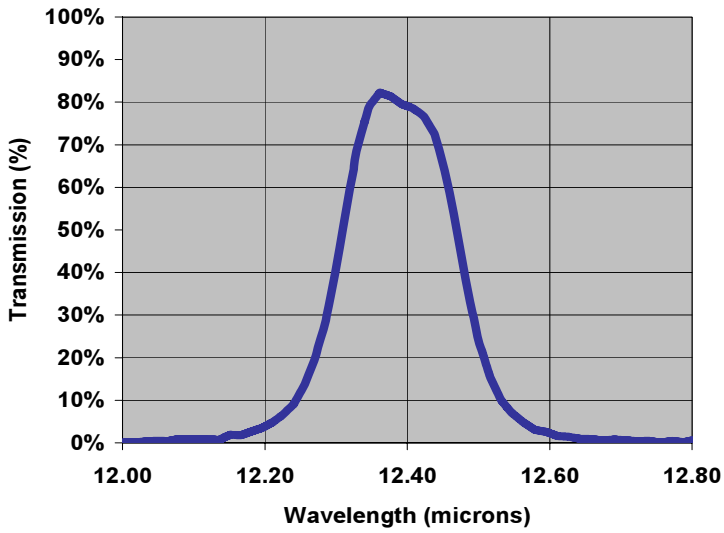


CWL: 6.017 microns,
BW: 0.0697 microns (FWHM)



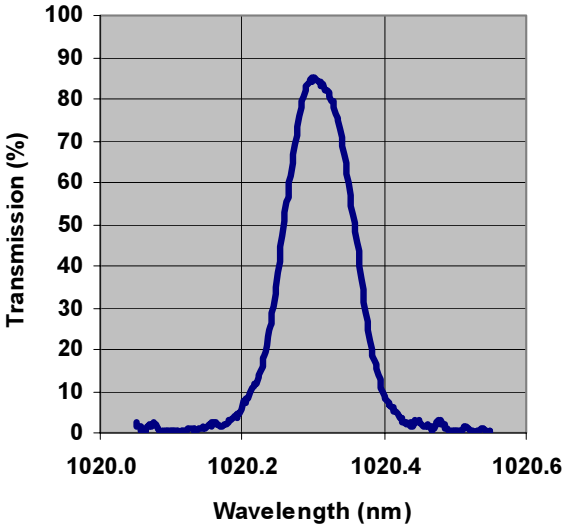
Ultra-Narrow Bandpass Filter with 1.4 % bandwidth in Long-Wave Infrared

CWL: 12.390 microns
BW: 0.179 microns (FWHM)

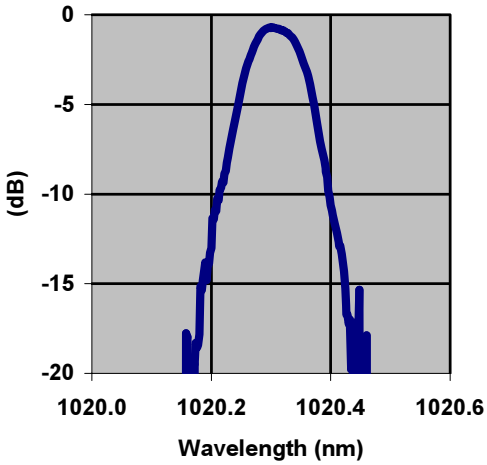


Representative Filters with Angstrom and Sub-angstrom Bandwidth resulting from Developmental efforts at Barr

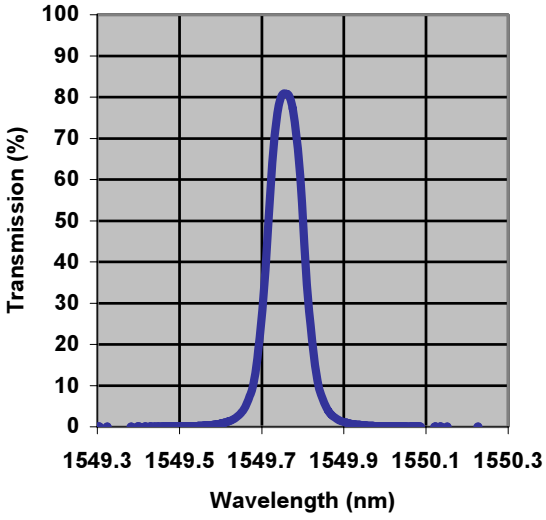
CWL: 1020.31nm,
BW: 105 picometers (FWHM)



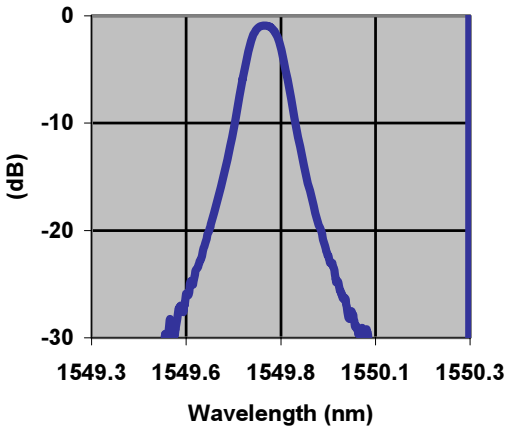
Out-of-Band Isolation for 1020nm BP with 105 picometer bandwidth



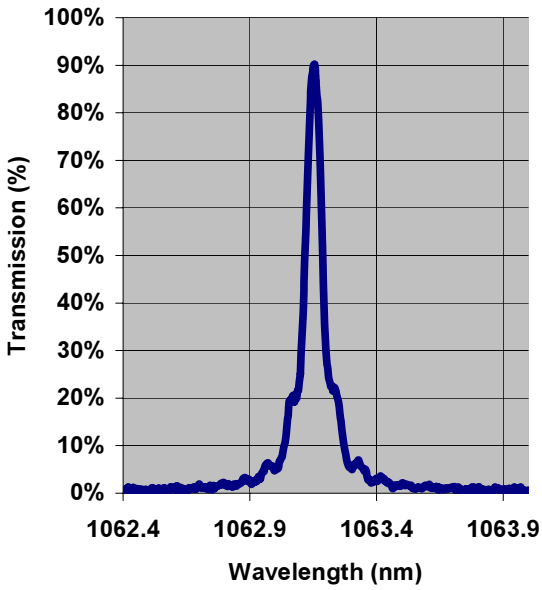
CWL: 1549.758nm,
BW: 99 picometer (FWHM)



Out-of-Band Isolation for 1550nm BP with 99 picometer Bandwidth (FWHM)



CWL: 1063.15nm,
BW: 78 picometers (FWHM)



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