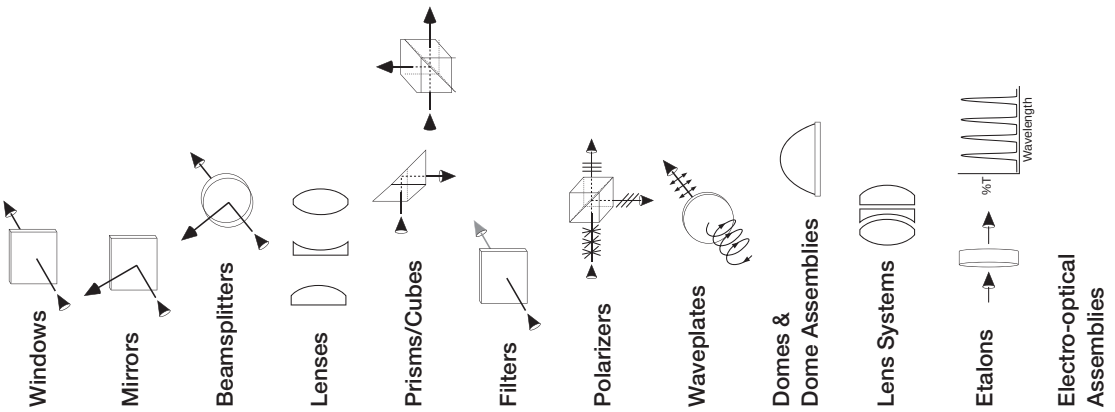
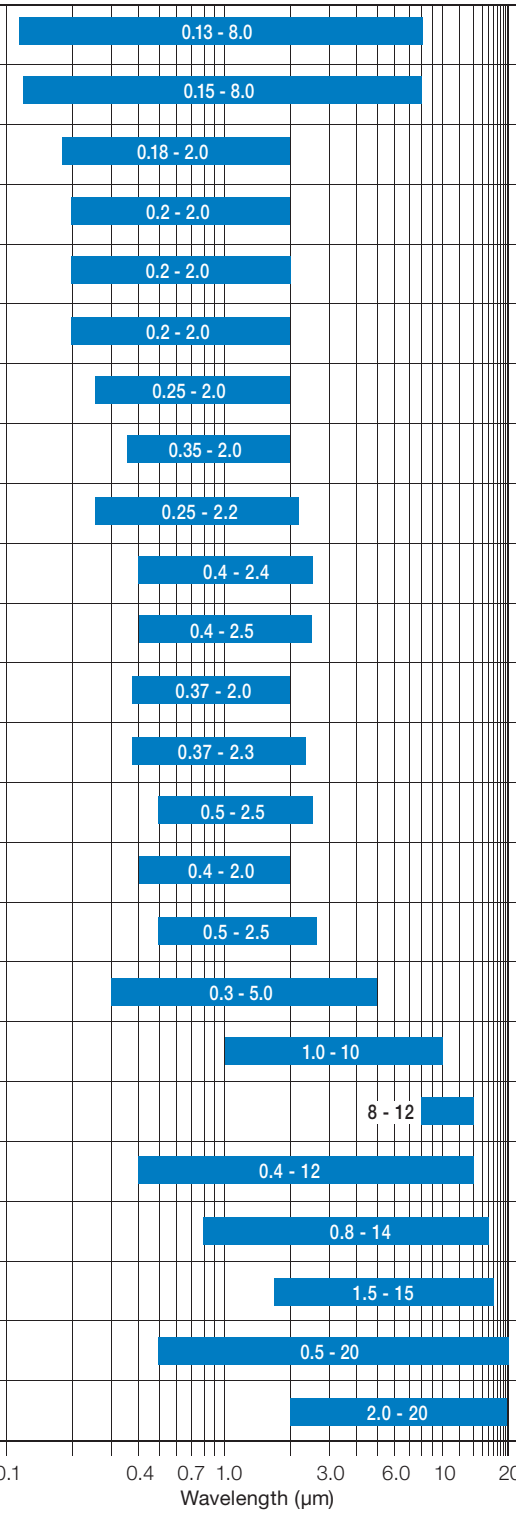
Optical Components | EXPERIENCE ACROSS THE SPECTRUM



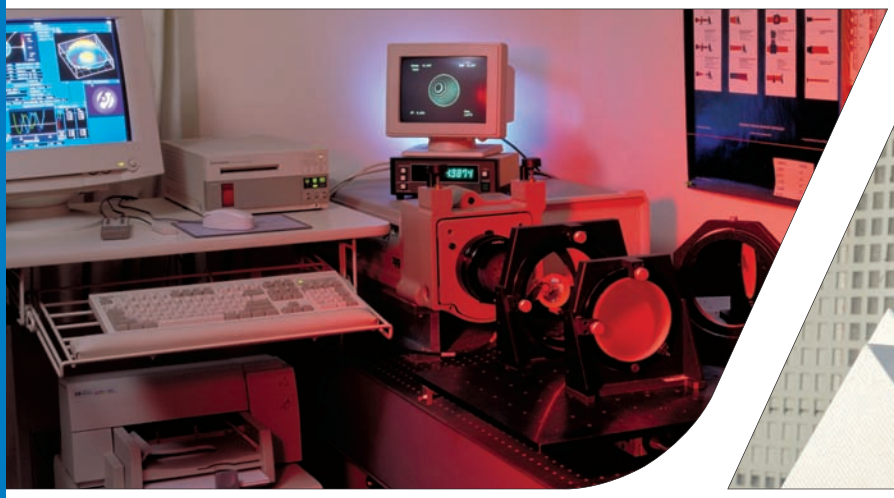
	Windows	Mirrors	Beamsplitters	Lenses	Prisms/Cubes	Filters	Polarizers	Waveplates	Domes & Dome Assemblies	Lens Systems	Etalons	Electro-optical Assemblies
MgF_2	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓
CaF_2	✓	✓	✓	✓	✓		✓		✓	✓		✓
UV Fused Silica	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
Suprasil 1	✓	✓	✓	✓	✓		✓			✓		✓
Crystal Quartz	✓			✓	✓			✓				✓
Optical Crown	✓	✓	✓	✓	✓	✓	✓			✓		✓
Infrasil 301	✓	✓	✓	✓	✓		✓			✓		✓
N-BK7	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓
N-BAK1	✓	✓	✓	✓	✓					✓		✓
N-SF10 (SF10)	✓			✓	✓					✓		✓
Calcite							✓					✓
N-LaK21				✓	✓					✓		✓
N-SF2 (SF2)	✓		✓	✓	✓		✓			✓		✓
N-SF11	✓			✓	✓		✓			✓		✓
N-F2 (F2)				✓	✓					✓		✓
Zerodur		✓									✓	✓
Sapphire	✓		✓	✓	✓				✓	✓		✓
Silicon	✓	✓	✓	✓		✓				✓		✓
ZnS	✓		✓	✓	✓				✓	✓		✓
ZnS (MS)	✓		✓	✓	✓				✓	✓		✓
AMTIR	✓			✓						✓		✓
GaAs	✓		✓	✓						✓		✓
ZnSe	✓		✓	✓	✓				✓	✓		✓
Germanium	✓		✓	✓	✓	✓			✓	✓		✓

MATERIAL CHARACTERISTICS | Optical Components



Material	Transmission Range	Index of Refraction	Typical Scratch/Dig	Surface Figure	Laser Damage Threshold	CTE (/°C)	Knoop Hardness
MgF_2	0.13 - 8.0	1.41 @ 0.27 µm	40-20	λ/20	High	8.04E-06/ 1.30E-05	415
CaF_2	0.15 - 8.0	1.501 @ 0.193 µm	40-20	λ/20	High	1.89E-05	158
UV Fused Silica	0.18 - 2.0	1.46 @ 0.55 µm	10-5	λ/20	High	5.50E-07	522
Suprasil 1	0.2 - 2.0	1.51 @ 0.248 µm	10-5	λ/20	High	5.50E-07	590
Crystal Quartz	0.2 - 2.0	1.55 @ 0.63 µm	10-5	λ/20	High	7.64E-06/ 1.4E-05	820
Optical Crown	0.2 - 2.0	1.52 @ 0.55 µm	20-10	λ/20	Low	5.0E-06	610
Infrasil 301	0.25 - 2.0	1.46 @ 0.63 µm	10-5	λ/20	High	5.80E-07	590
N-BK7	0.35 - 2.0	1.52 @ 0.55 µm	10-5	λ/20	Medium	7.10E-06	610
N-BAK1	0.25 - 2.2	1.57 @ 0.63 µm	10-5	λ/20	Medium	7.60E-06	530
N-SF10 (SF10)	0.4 - 2.4	1.73 @ 0.55 µm	10-5	λ/20	Medium	9.40E-06	540
Calcite	0.4 - 2.5	1.66 @ 0.55 µm	40-20	λ/20	Low	4.6E-06/ 8.3E-05	75
N-LaK21	0.37 - 2.0	1.64 @ 0.55 µm	10-5	λ/20	Medium	6.80E-06	600
N-SF2 (SF2)	0.37 - 2.3	1.65 @ 0.55 µm	10-5	λ/20	Medium	6.70E-06	539
N-SF11	0.5 - 2.5	1.79 @ 0.55 µm	10-5	λ/20	Medium	6.10E-06	450
N-F2 (F2)	0.4 - 2.0	1.62 @ 0.55 µm	10-5	λ/20	Medium	8.20E-06	420
Zerodur	0.5 - 2.5	1.55 @ 0.55 µm	10-5	λ/20	High	5.00E-09	620
Sapphire	0.3 - 5.0	1.77 @ 0.55 µm	40-20	λ/20	High	7.70E-06	1370
Silicon	1.0 - 10	3.42 @ 10.6 µm	20-10	λ/20	High	4.50E-06	1100
ZnS	8 - 12	2.20 @ 10.6 µm	20-10	λ/20	Medium	6.50E-06	1780
ZnS (MS)	0.4 - 12	2.20 @ 10.6 µm	40-20	λ/20	Medium	6.50E-06	160
AMTIR	0.8 - 14	2.50 @ 10.6 µm	40-20	λ/20	Medium	1.2E-05	170
GaAs	1.5 - 15	3.29 @ 0.55 µm	40-20	λ/20	Medium	5.40E-06	7500
ZnSe	0.5 - 20	2.40 @ 10.6 µm	40-20	λ/20	High	7.60E-06	112
Germanium	2.0 - 20	4.00 @ 10.6 µm	20-10	λ/20	Medium	5.70E-06	692

Optics | METROLOGY AND DESIGN



Extensive Metrology Capability

- White light interferometry
- Fizeau phase shift interferometers
  - Up to 12” capability
- Twyman-Green Laser phase shift interferometry with variable input wavelength
  - Allows for multi-wavelength interferometry at 20 different laser wavelengths
- Taylor Hobson® Profilometer
  - Resolution less than 1 nm
- Computer generated holograms (CGH) for cylindrical optics
- QED subaperture™ stitching
  - For production of high performance test optics
  - λ/40 for transmission and reference flats
  - λ/30 for spherical optics
- Spot size measurement
- Goniometric spectrophotometers
  - CVI Melles Griot offers analysis of reflectivity and transmission for a broad range of wavelengths
  - Direct reflection measurements from 190 nm to 1800 nm and 8.5° to 60°

Techniques

- Specialized anti-reflective coating measurement techniques
- Xsquared™ filter laser based metrology for high OD filters

Design

- Geometrical optical design software
  - Code V™
  - Zemax®
  - SYNOPSYS®
- Stray Light and Illumination
  - TracePro™
  - ProSource™
- Mechanical System Design
  - SolidWorks Simulation Professional™
  - AutoCad™
- Engineering
  - Expert, experienced team of engineers
- Thin Film Design Software
  - FilmStar
  - TFCalc
  - Essential McLeod
  - Optilayer

OPTICAL SPECIFICATIONS | Optics

Substrate material

The material from which an optic is made.

The most common materials are N-BK7, UV grade fused silica, MgF_2, and CaF_2. CVI Melles Griot has experience with a wide variety of glasses, fused silicas, and crystalline materials.

Surface figure

The deviation from the ideal surface.

CVI Melles Griot specifies surface figure in terms of waves peak-to-valley (p-v) at 633 nm, prior to coating. The peak-to-valley specification is more stringent than an RMS or average surface specification and assures high quality parts for all applications. We manufacture flats to λ/20 and spherical surfaces to λ/10 accuracy on a routine basis. A coated surface figure may also be specified.

Cosmetic surface quality

Surface quality describes a level of defects visually detected on the surface of an optical component.

100% visual inspection is preformed on all optics. Surface quality becomes critically important in high energy laser applications or where scatter must be reduced for better signal to noise performance.

MIL-PRF-13830B
This inspection criteria was adopted in 1997. The first number denotes the size and concentration of scratches as compared to a known NIST standard. The second number defines the largest pit by its diameter in hundredths of millimeters. For example: 10 dig = ½ (Length of dig + Width of dig) = 0.1 mm diameter.

CVI Melles Griot Laser Quality
We have extensive experience in delivering high laser damage threshold optics and have developed a proprietary inspection method to consistently meet our customers' laser induced damage requirements. This proprietary inspection method utilizes significantly brighter light sources than those specified in MIL-PRF-13830B. CVI Melles Griot also utilizes magnification when required to detect scratches, digs and other imperfections.

Laser Grade
Laser grade is the highest level of inspection criteria in the optics industry. Laser grade optics are virtually defect-free. High power magnification is used to detect and measure defects.

Wedge

The angle between the two surfaces of an optical element.

This can also be expressed as the difference in edge thickness around the part, for example a 25.4 mm diameter optic with an edge thickness variation of 0.025 mm has a wedge of 3.44 minutes of arc.

Radius of curvature

The radius of the sphere coincident with the optical surface.

A flat has radius of curvature equal to infinity. The reciprocal of the radius is called the curvature of the surface. CVI Melles Griot can manufacture a wide range of curvatures using its existing tooling and test plates and has the capability to make new test plates if required. CVI Melles Griot's standard radius tolerance is ± 0.5% and ± 0.1% is available for selected radii.

Concentricity/Centration

The deviation between the optical and mechanical axes of a lens.

Concentricity error is the measured maximum edge thickness variation. CVI Melles Griot's standard concentricity is ≤ 0.05 mm edge thickness variation and the standard centration error is ≤ 3 arc minutes.

Clear aperture

The central area over which the optical specifications apply.

CVI Melles Griot specifies clear aperture in terms of the diameter or linear dimensions of this central area.

Angle and plane of incidence

The angle formed between the normal to the optical surface and the incident ray.

An incidence angle of zero degrees is referred to as normal incidence. The plane of incidence is the plane containing the incident ray and the normal.

Polarization

The orientation and phase shift of the electric field when resolved into components parallel and perpendicular to the plane of incidence.

P-polarized light has the electric field polarized parallel to the plane of incidence. S-polarized light has the electric field polarized perpendicular to the plane of incidence. UNP refers to unpolarized light, which is a random mixture of equal amounts of s- and p-polarization states. Specify the polarization state whenever ordering an optic for use at non-normal incidence angle.

Optics | LIDT & ENVIROMENTAL TESTING

Laser induced damage threshold

Typical Laser Induced Damage Threshold Data

UV data

Antireflection coatings on fused silica
193 nm > 2 J/cm^2, 20ns, 20Hz
266 nm, 355 nm > 5 J/cm^2, 10ns, 10Hz

1064nm, 20ns, 20Hz data

Antireflection coatings on fused silica >15 J/cm^2
Antireflection coatings on N-BK7 >10 J/cm^2
Antireflection coatings on N-SF11 >4 J/cm^2
Optical Cement >2 J/cm^2
High reflection coatings >20 J/cm^2

For higher damage thresholds call CVI Melles Griot to optimize the various material parameters and provide certification. CVI Melles Griot is a leader in damage resistant coatings for excimer and other high energy lasers.

Laser induced damage threshold testing

LIDT (Laser Induced Damage Threshold) is defined as any laser-induced permanent change which is observable at high magnification at the lowest power sufficient to induce damage at any test site. LIDT depends on test wavelength, pulse width, repetition rate, and inspection method.

To determine the damage threshold, CVI Melles Griot tests a number of samples at varied settings using increasing power. Visible observation is performed using a 20x microscope immediately before and after the optic is subjected to the laser. The test samples are then characterized for laser induced damage and any changes in beam scatter are documented. LIDT test procedures are subject to change, and can be changed upon the request of a customer.

The two main mechanisms that cause laser damage to an optical coating are dielectric breakdown and thermal absorption. Factors which significantly reduce the LIDT are scratches, pores, inclusions, and impurities.

Environmental testing

CVI Melles Griot is a valued supplier of critical optical components able to withstand the rigours of the most severe environments in defense and industrial applications. All tests, where applicable, are carried out per MIL specifications and on a representative witness piece coated in the same batch.

STATIC HUMIDITY TEST

A standard test typically performed over 24 hours in 98% Relative Humidity at 49ºC. This can be varied for customer specific requests. For Hard Carbon coatings and STAR coatings, this test would be performed for 7 and 10 days respectively.

CYCLING HUMIDITY TEST

This test is performed only by specific request from a customer. Typically performed at 98% Relative Humidity between 35ºC and 65ºC. This test can be performed at other temperatures and Relative Humidity by request.

WATER IMMERSION TEST

A standard test typically performed over 24 hours.

SALT SOLUTION TEST

A standard test typically performed over 24 hours. By customer request this can be extended up to 7 days.

SALT SPRAY (FOG) TEST

This test is typically performed over 24 hours at 47ºC. By customer request this can be extended up to 90 days.

TEMPERATURE TEST

A standard test which cycles between hot and cold temperatures, typically between −62ºC and +71ºC for 5 hours each. The temperature and duration can be varied to customer's specific requirements. We also have the capability to perform Thermal Shock Tests upon request.

ABRASION TEST

A standard test varying from Moderate Abrasion with cheesecloth to Severe Abrasion with an eraser at a known pressure. Other Abrasion tests that can be carried out include Sand Abrasion and Windscreen Wiper Abrasion.

ADHESION TEST

A standard test performed using adhesive tape to a known specification.

SOLUBILITY & CLEANABILITY TEST

This test is performed only by specific request from a customer. Typical chemicals used would be Acetone, IPA or AG101.

CHEMICAL DEGRADATION TEST

This test is performed only by specific request from a customer. A coated witness sample would be subjected to chemical attack using customer specified chemicals.

SHOCK & VIBRATION TEST

This testing is used to simulate the worst case handling and shipping environments of mounted components and complex optical systems to the limits of lifetime exposure. This testing protocol assures products delivered are robust.

ASPHERIC & ASPHERIC DIFFRACTIVE LENSES | Optics

Surface Tolerances	Silicon Typical	Silicon Mfg Limit	Zinc Selenide Typical	Zinc Selenide Mfg Limit	Germanium Typical	Germanium Mfg Limit
Polished surface quality (scratch-dig)	40-20	10-5	40-20	20-10	40-20	10-5
Polished surface roughness (Å, RMS)	10	5	10	5	10	5
Polished surface power (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Polished surface irregularity (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Spherical radius accuracy (% radius)	0.10	0.02	0.10	0.02	0.10	0.02
Diamond Turned Surface roughness (Å, RMS)	50	20	60	30	40	10
Surface sag deviation from nominal aspheric shape (FR)	1.0	0.5	1.0	0.5	1.0	0.5
Dimensional Tolerances						
Diameter (mm)	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013
Center Thickness (mm)	±0.1	±0.01	±0.1	±0.01	±0.1	±0.01
Wedge (arc seconds)	30	1	30	1	30	1
Clear aperture (%)	90	98	90	98	90	98

- Color correction
- Reduced system complexity, fewer lenses
- Higher performance systems
- Deterministic manufacturing processes
- Durable BBAR coatings

Lens Types
Plano-Concave
Plano-Convex
Bi-Convex
Bi-Concave
Meniscus

Material Types
CaF_2
Si
ZnS
AMTIR
ZnSe
Ge

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size up to 250 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | SPHERICAL LENSES - UV TO NIR

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig)	40-20	10-5	5-2
Polished surface roughness (Å, RMS)	10	5	< 1
Polished spherical irregularity (waves, P-V @ 633 nm)	λ/4	λ/10	λ/100
MRF® surface irregularity (waves, P-V @ 633 nm)	λ/20	λ/40	λ/80
Spherical radius (fringes)	5	3	0.5
Flat irregularity (waves, P-V @ 633 nm)	λ/4	λ/20	λ/100

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Diameter (mm)	+0.000/-0.250	+0.000/-0.025	+0.000/-0.005
Thickness (mm)	±0.250	±0.050	±0.005
Centration (edge thickness difference, mm)	0.05	0.01	0.005
Wedge	<5 arc min	≤1 arc sec	≤0.5 arc sec
Clear aperture (%)	85	90	100

- High laser damage threshold
- Low scattering, low absorption
- Single V, Dual V, and broadband AR coatings available
- Conventional, diamond turned, and molded options available
- Ask us about FabExpress™ Rapid Prototyping in less than two weeks
- Diameters up to 600 mm
- For materials see pgs 6-7

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

SPHERICAL LENSES - INFRARED | Optics

	Silicon		Zinc Selenide		Germanium	
Surface Tolerances	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**
Surface quality (scratch-dig)	40-20	10-5	40-20	20-10	40-20	10-5
Polished Surface roughness (Å, RMS)	10	5	10	5	10	5
Surface power (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Surface irregularity (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Spherical radius accuracy (% radius)	0.10	0.02	0.10	0.02	0.10	0.02
Dimensional Tolerances						
Diameter (mm)	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013
Center Thickness (mm)	±0.1	±0.01	±0.1	±0.01	±0.1	±0.01
Wedge (arc seconds)	30	1	30	1	30	1
Clear aperture (%)	90	98	90	98	90	98

- Conventional lenses
- Durable coatings
- For aspheric and diffractive lenses see page 11

Lens Types
Plano-Concave
Plano-Convex
Bi-Convex
Bi-Concave
Meniscus

Material Types
CaF_2
Si
ZnS
AMTIR
GaAs
ZnSe
Ge

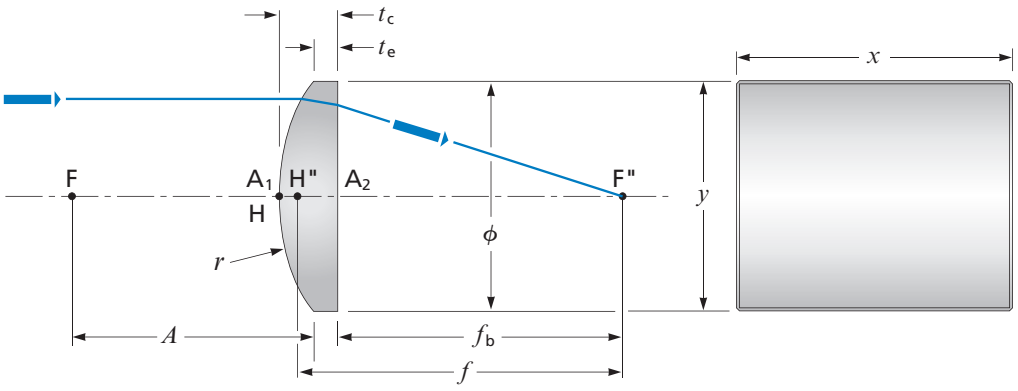
The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | CYLINDRICAL LENSES

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig)	40-20	20-10	10-5
Surface roughness (Å, RMS)	20	5	2.5
Surface irregularity (waves, P-V @ 633 nm)			
per cm along Y-axis	1λ	λ/2	λ/10
per cm along X-axis	1λ	λ/4	λ/10
Radius (fringes)	5	3	0.5
Flat irregularity (waves, P-V @ 633 nm)	λ/2	λ/10	λ/20

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Diameter (mm)	+0.000/-0.250	+0.000/-0.025	+0.000/-0.005
Length & Width (mm)	±0.050	+0.000/-0.025	+0.000/-0.010
Thickness (mm)	±0.250	±0.050	±0.005
Centration (edge thickness difference, mm)	0.05	0.01	0.005
Clear aperture (%)	85	90	95

- Metrology confirmed with computer generated holograms (CGH)
- High laser damage threshold
- Manufacturing dimensions up to 600 mm
- For materials see pgs 6-7



The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

DOMES | Optics

Specifications	Limit
Dimensional	0.1 mm
Surface Figure	2 fringes with power x 0.5 fringe irregularity over any 100 mm Ø @ 633 nm
Transmitted Wavefront Error	10.6 µm over a 230 mm diameter aperture and 152 mm diameter in the visible
Parallelism	30 arc seconds
Edge Thickness Variation (domes)	0.05 mm
Materials	Germanium, Silicon, Zinc Sulphide, Zinc Selenide, Chalcogenide Glass, Gallium Arsenide, Calcium Fluoride, Magnesium Fluoride, Optical glasses
Maximum Dimensions	Up to 430 mm diameter

- Low image distortion
- Available with AR coatings to improve transmission
- Hard coating for harsh environmental conditions
- Diameter up to 430 mm
- For materials see page 6-7

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 12.7- 430 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | PRISMS AND CUBES - UV TO NIR

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig)	20-10	10-5	5-2
Polished Surface roughness (Å, RMS)	20	5	2.5
Flat irregularity (waves, P-V @ 633 nm)	λ/4	λ/10	λ/25
MRF® surface irregularity (waves, P-V @ 633 nm)	λ/20	λ/40	λ/80

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Length & Width (mm)	±0.150	+0.000/-0.250	+0.000/-0.010
Thickness (mm)	±0.150	+0.000/-0.250	±0.005
Angular Deviation	<3 arc min	≤10 arc sec	≤0.5 arc sec
Clear aperture (%)	≥85	≥90	≥95

- High precision angular tolerance
- Optical contacting options
- High laser damage threshold
- Porro, pellin broca, penta, dove right angle, isosceles, equilateral, roof, and custom light pipes
- Manufacturing dimensions from 3 mm to 300 mm
- For materials see pgs 6-7

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

PRISMS AND CUBES - INFRARED | Optics

Surface Tolerances	CaF_2 Typical	CaF_2 Mfg Limit	Zinc Selenide Typical	Zinc Selenide Mfg Limit	Germanium Typical	Germanium Mfg Limit
Surface quality (scratch-dig)	60-40	20-10	40-20	20-10	40-20	10-5
Polished Surface roughness (Å, RMS)	40	20	10	5	10	5
Surface flatness (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Surface irregularity (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Dimensional Tolerances						
Length and Width (mm)	±0.1	±0.025	±0.1	±0.025	±0.1	±0.025
Angular deviation (arc seconds)	30	1	30	1	30	1
Clear aperture (%)	90	98	90	98	90	98

- Conventional prisms
- Cube assemblies
- Durable AR and beamsplitter coatings

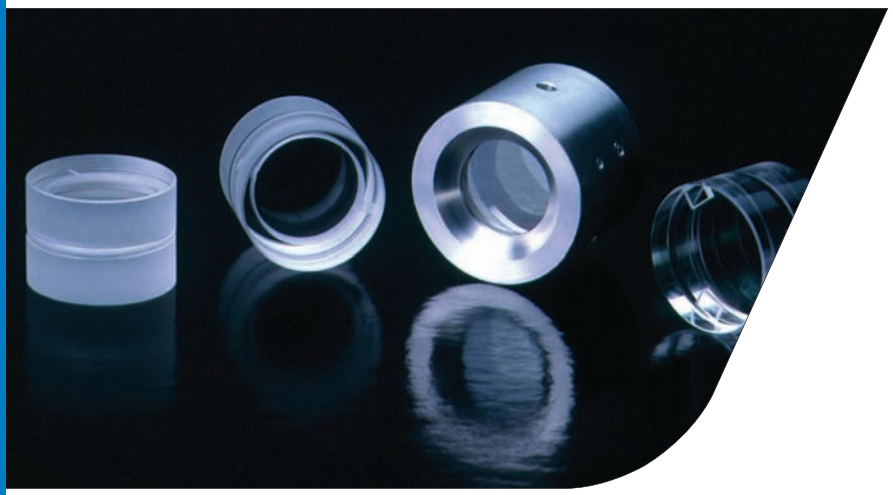
Prism Types
Right angle
Pechan
Roof
Penta
Corner cubes
Dove
Retroreflectors

Material Types
MgF_2
CaF_2
Si
ZnS & ZnS (MS)
ZnSe
Ge

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | ETALONS

Typical Optical / Surface Tolerances	Solid	Optically contacted Air-spaced	Comments
Surface Quality (scratch-dig)	10-5 Laser Grade	10-5 Laser Grade	MIL-PRF
Transmitted Wavefront Error (waves, P-V @ 633 nm)	λ/10 – <λ/100	<λ/100	Depends on diameter
Effective Finesse	>50	>100	
Wavelength Ranges (nm)	>190 nm	>190 nm	
Dimensional Limits			
Diameter (mm)	Up to 100	Up to 150	
Length & Width (mm)		Governed by diameter	
Thickness (mm)	min. 20 µm		Dependant on diameter
Wedge	≤1 arc sec		
Clear aperture (%)	90%	Depends on etalon configuration	
Spacer Thickness		20 µm - 100 mm	see #1 below
Other Parameters			
Materials	Fused Silica	Corning ULE, Schott Zerodur or Fused Silica for spacers	UV grade fused silica, water-free Fused Silica for plates.
Pressure Tuning	No	Yes	
Physical Stability	Best	Ring spaced for best performance	see #2 below
Thermal Stability		Best	Depends on CTE material
Tilt-tuning range	Yes	Yes	



- Extensive experience in design and manufacture of long-lifetime and high LDT etalons

Notes

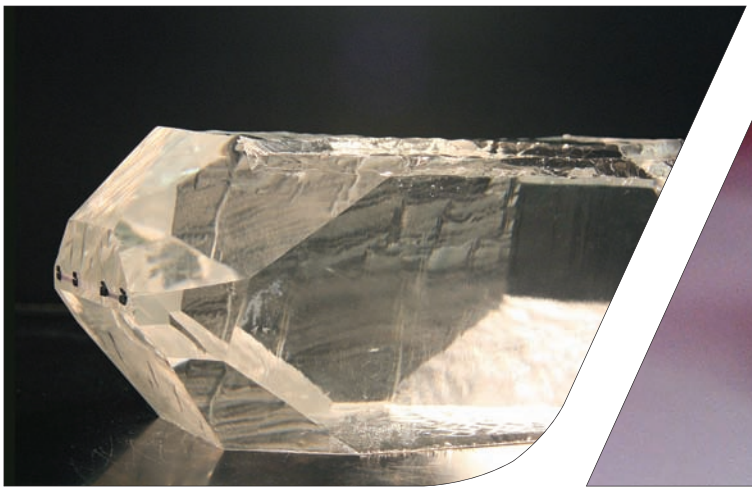
1. Larger air-gaps are possible depending on etalon configuration
2. CVI Melles Griot has extensive experience with extreme conditions. Designs have survived vibration testing up to 8 g.

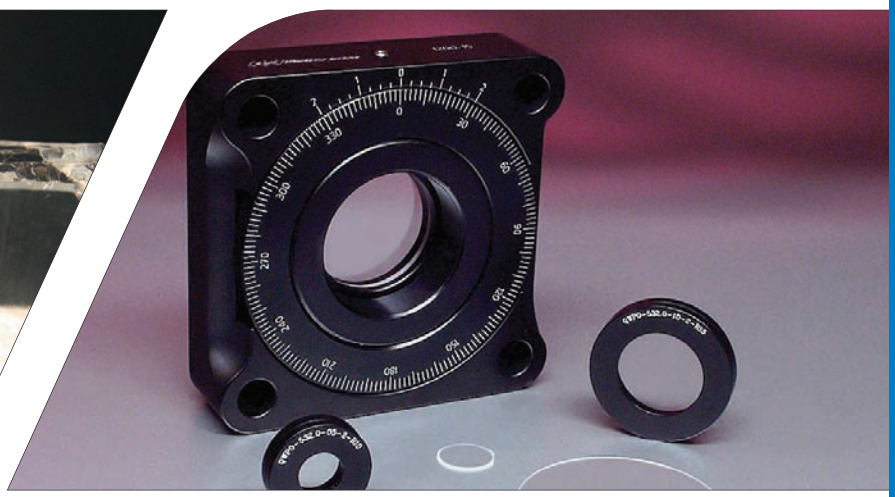
WAVEPLATES | Optics

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig) depending on material	20-10	10-5	5-2
Surface roughness (Å, RMS)	20	5	1
Transmitted Wavefront Error (waves, P-V @ 633 nm)	λ	λ/10	λ/25
Retardance Tolerance	λ/20 at 23°C	λ/200 at 23°C	λ/500 at 23°C

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Diameter (mm)	±0.250	+0.000/-0.250	+0.000/-0.010
Clear aperture (%)	≥85	≥90	≥95

- Quartz, mica, polymer, magnesium fluoride
- Wavelengths from 193 nm to 2020 nm
- High laser damage threshold
- Exceptional retardation control
- Cemented, optical contact, air spaced
- True zero-order, low order and multiple order options
- True optical measurement of retardation tolerance
- Manufacturing dimensions from 5 mm to 50.8 mm
- For materials see pgs 6-7





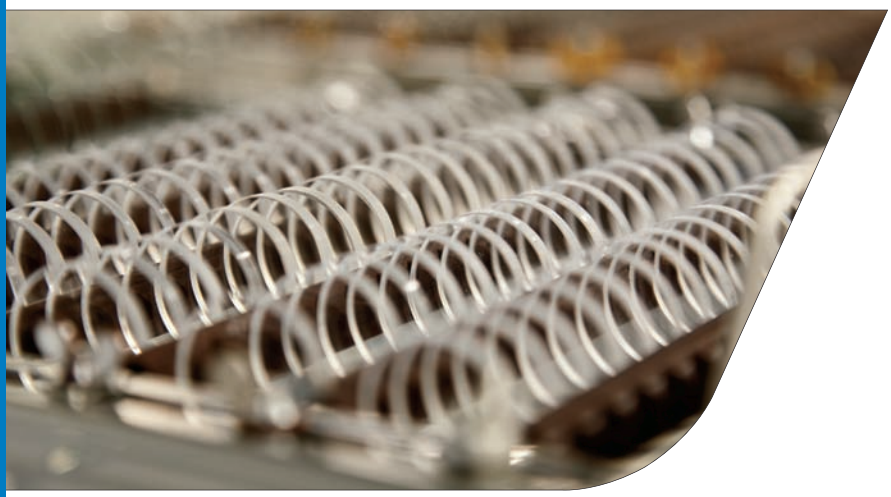
The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | WINDOWS - UV TO NIR

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig)	40-20	10-5	5-2
Surface roughness (Å, RMS)	20	5	1
Transmitted Wavefront Error (waves, P-V @ 633 nm)	λ/2	λ/10	λ/25

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Diameter (mm)	+0.000/-0.250	+0.000/-0.025	+0.000/-0.005
Length & Width (mm)	±0.050	+0.000/-0.025	+0.000/-0.010
Thickness (mm)	±0.250	±0.050	±0.005
Parallelism	≤5 arc min	≤1 arc sec	≤0.5 arc sec
Clear aperture (%)	85	90	100

- High laser damage threshold
- Low scattering, low absorption
- Single V, broadband, and dual band AR coatings available
- High volume capacity available
- Manufacturing dimensions from 3 mm to 600 mm
- For materials see pgs 6-7



The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3-100 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

WINDOWS - INFRARED | Optics

	Silicon		Zinc Selenide		Germanium	
Surface Tolerances	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**
Surface quality (scratch-dig)	40-20	10-5	40-20	20-10	40-20	10-5
Surface flatness (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Surface irregularity (waves, P-V @ 633 nm)	λ/4	λ/20	λ/4	λ/20	λ/4	λ/20
Transmitted Wavefront Error (waves, P-V @ 633 nm)	λ/2	λ/8	λ/2	λ/8	λ/2	λ/8
Dimensional Tolerances						
Diameter (mm)	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013
Center Thickness (mm)	±0.1	±0.01	±0.1	±0.01	±0.1	±0.01
Wedge (arc seconds)	30	1	30	1	30	1
Clear aperture (%)	90	98	90	98	90	98

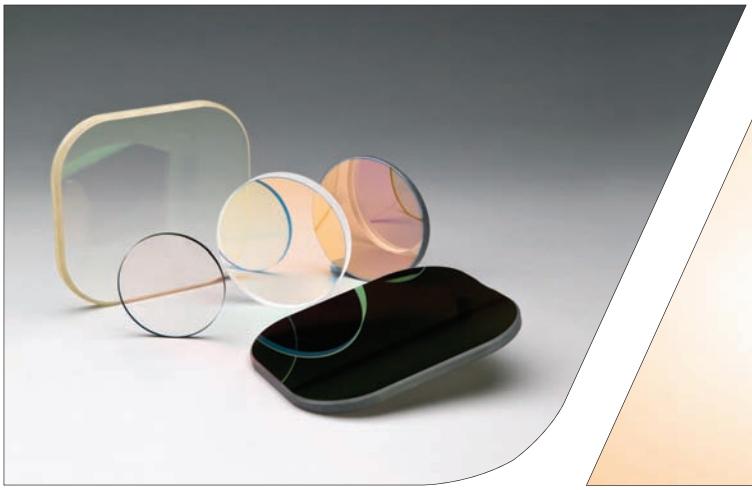
- Durable BBAR coatings
- Metalization
- Filters
- ITO

Window Types

External windows and Domes
Detector windows
Heated windows
EMI shielded windows

Material Types

MgF_2	ZnS & ZnS (MS)
CaF_2	ZnSe
Sapphire	Ge
Si	



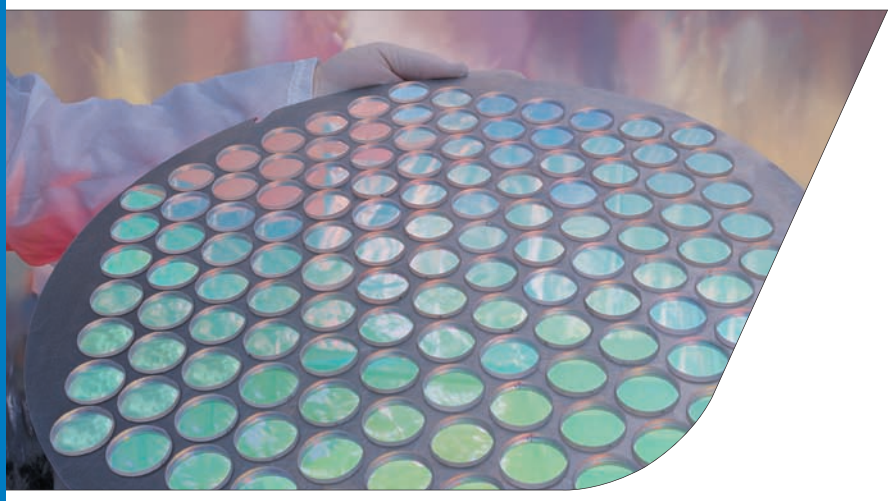
The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3- 430 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | MIRRORS, BEAMSPLITTERS AND PLATE POLARIZERS

Surface Tolerances	Precision	Laser Grade	Manufacturing Limit
Surface quality (scratch-dig)	40-20	10-5	5-2
Surface roughness (Å, RMS)	20	5	1
Flat irregularity (waves, P-V @ 633 nm)	λ/2	λ/10	λ/25

Dimensional Tolerances	Commercial	Precision	Manufacturing Limit
Diameter (mm)	+0.000/-0.250	+0.000/-0.125	+0.000/-0.010
Length & Width (mm)	±0.050	+0.000/-0.125	+0.000/-0.010
Thickness (mm)	±0.250	±0.125	±0.005
Wedge	≤5 arc min	≤1 arc sec	≤0.5 arc sec
Clear aperture (%)	85	90	95

Spherical Tolerances	Commercial	Precision	Manufacturing Limit
Spherical irregularity (waves, P-V @ 633 nm)	λ/2	λ/5	λ/100
Spherical radius (fringes)	5	3	0.5
Centration (edge thickness difference, mm)	0.05	0.01	0.005



- High laser damage threshold
- Sputtered or E-Beam options
- Low absorption options
- Flat and spherical substrates available
- Manufacturing dimensions from 3 mm to 600 mm
- For materials see pgs 6-7

The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size from 3- 600 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

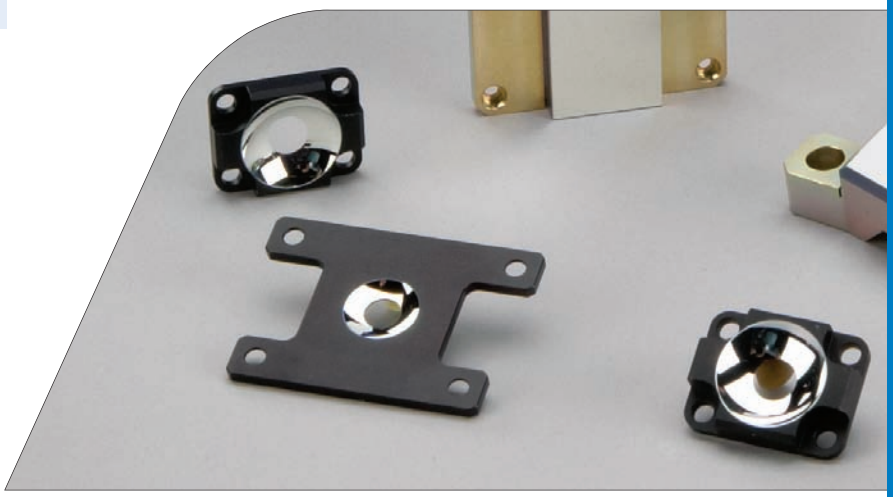
ASPHERIC MIRRORS | Optics

	Silicon		Aluminum		Nickel	
Surface Tolerances	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**	**Typical**	**Mfg Limit**
Diamond Turned Surface roughness (Å, RMS)	50	20	150	50	25	10
Spherical radius accuracy (% radius)	0.10	0.02	0.10	0.02	0.10	0.02
Surface sag deviation from nominal aspheric shape (FR)	1.0	0.5	1.0	0.5	1.0	0.5
Dimensional Tolerances						
Diameter (mm)	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013	±0.1	+0.00/-0.013
Center Thickness (mm)	±0.1	±0.01	±0.1	±0.01	±0.1	±0.01
Wedge (arc seconds)	30	1	30	1	30	1
Clear aperture (%)	90	98	90	98	90	98

- Hot mirrors
- Cold mirrors
- Durable reflective coatings

Mirror Types
Flats
Cylinders
Toroids
Freeform

Material Types
Aluminum
Copper
Nickel
Silicon



The general tolerance specifications above provide a guideline regarding manufacturing capabilities for uncoated optics ranging in size up to 250 mm. The manufacturing limits are not absolute and may vary depending on material; tighter tolerances may be possible. Part specific tolerances may vary. All specifications do not need to be from single column.

Optics | FILTERS - UV TO NIR

	ULTRA-NARROW			STANDARD			MULTIPLE NOTCH		
Notch	Standard	Precision	Mfg limit	Standard	Precision	Mfg limit	Standard	Precision	Mfg limit
Transmission	>90%	>90%	>95%	>90%	>95%	>98%	>80%	>85%	>90%
#Blocking bands	1	1	1	1	1	1	2	3	4
Bandwidth	<4%	<3%	<2%	<6%	<5%	<2%	<6%	<4%	<3%
Blocking	5 OD	6 OD	7 OD	5 OD	6 OD	8 OD	4 OD	5 OD	6 OD
Bandpass									
Transmission	>90%	>90%	>95%	>90%	>95%	>98%	>90%	>95%	>98%
CWL tolerance	0.3%	0.2%	<0.1%	0.5%	0.2%	<0.1%	1.0%	0.5%	<0.1%
Bandwidth	<1%	<0.5%	<0.1%	NA	NA	NA	NA	NA	NA
Blocking	5 OD	6 OD	8 OD	5 OD	6 OD	8 OD	5 OD	6 OD	8 OD
Slope*	NA	NA	NA	3%	2%	<1%	3%	1.5%	<0.5%
Shape factor**	20%	25%	40%	20%	30%	50%	20%	40%	70%
	*slope =(0.3 OD point - 6 OD)/CWL			**shape factor =3 dB BW/ 6 OD BW					
Edge									
Transmission	>90%	>90%	>95%	>90%	>90%	>95%	>90%	>90%	>95%
Trans ripple*	10%	5%	2%	5%	2%	1%	10%	5%	2%
Slope**	5%	3%	1%	5%	1%	0.5%	5%	3%	1%
Blocking	4 OD	5 OD	6 OD	4 OD	6 OD	7 OD	2 OD	3 OD	4 OD

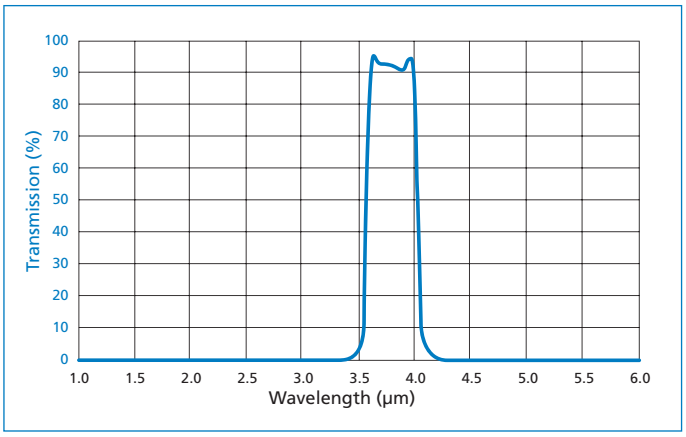
*ripple is measured as standard deviation over the passband
**slope is measured from 0.3 OD to blocking band

- High volume capacity
- High laser damage threshold
- High OD
- Ask us about our far IR capabilities
- Manufacturing dimensions from 3 mm to 50.8 mm
- For materials see pgs 6-7

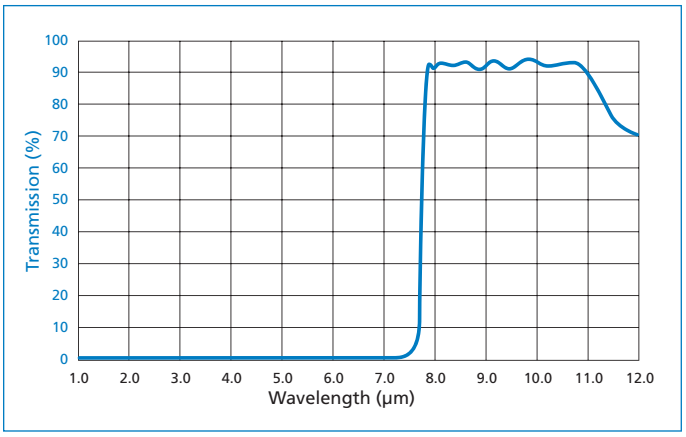
FILTERS - INFRARED | Optics

Wide Bandpass Long Wavepass Short Wavepass	2 - 6 µm		6 - 12 µm	
	Standard	Precision	Standard	Precision
Transmission*	90%	90%	90%	90%
Edge Slope	< 3%	< 2.5%	< 5%	< 3%
Edge Position	± 2%	± 1%	± 5%	± 2.5%
Blocking	OD 3	OD 3	OD 3	OD 3

* Transmission measurements can be made down to 77°K



Infrared Bandpass Filter



Infrared Long Wavepass Filter

IR Filter Applications

- IR Illuminators and Imagers
- Night Vision Sights
- Contrast enhancement
- Infrared Detectors
- Gas detection and analysis
- Manufacturing dimensions: 25.4 mm typical diameter
- For materials see pgs 6-7