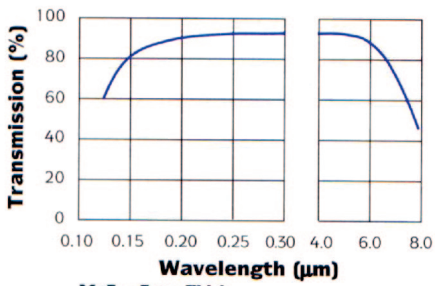
CHAPTER 4

OPTICS & MATERIASLS

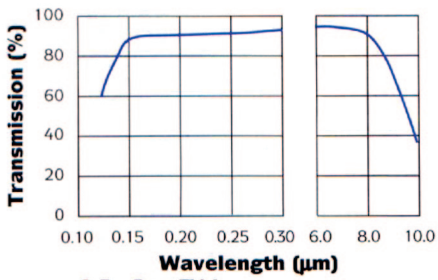
OPTICAL MATERIALS



MgF_2 - 5mm Thick

MGF2

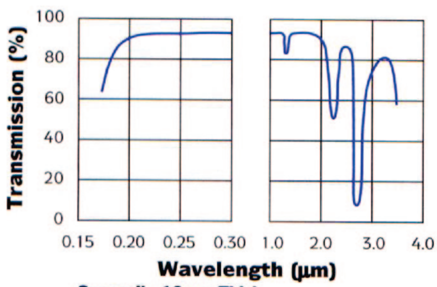
MgF2 is a tetragonal positive birefringent crystal grown using the vacuum Stockbarger technique. MgF2 is a rugged material resistant to chemical etching, mechanical, and thermal shock. High vacuum UV transmission and resistance to laser damage make MgF2 a popular choice for VUV and excimer laser windows, polarizers, and lenses.



CaF_2 - 5mm Thick

CAF2

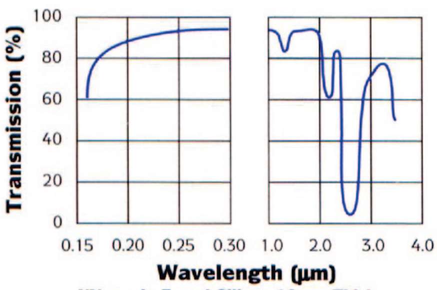
CaF2 is a cubic single crystal grown using the vacuum Stockbarger technique, Common CaF2 uses include vacuum ultraviolet components such as excimer laser windows, lenses, and prisms. Contact Onset for additional information regarding Deep UV applications.



Suprasil - 10mm Thick

SUPRASIL 1

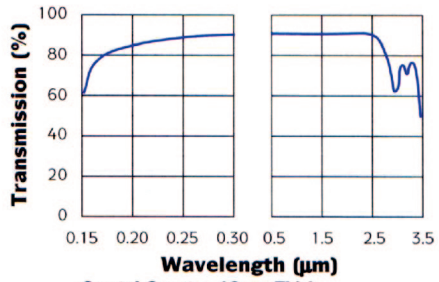
Suprasil 1 is a type of fused silica with high chemical purity and excellent homogeneity in all axes. With a metallic content less than 8 ppm, Suprasil 1 has Superior UV transmission and minimal fluorescence. Suprasil 1 is primarily used for low fluorescence UV windows, lenses, and prism where multiple axis homogeneity is required.



UV grade Fused Silica - 10mm Thick

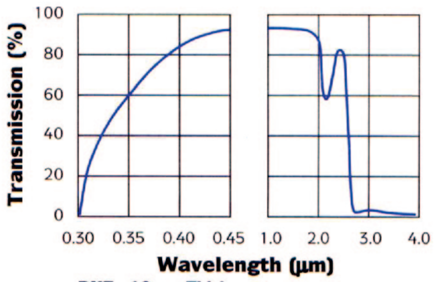
UV GRADE FUSED SILICA

UV grade Fused silica is an amorphous form of silicon dioxide made by flame hydrolysis of silicon tetrachloride. Properties include high UV transmission, low thermal expansion coefficient, and high laser damage threshold. Used for UV windows, lenses, prism, and mirror substrates.



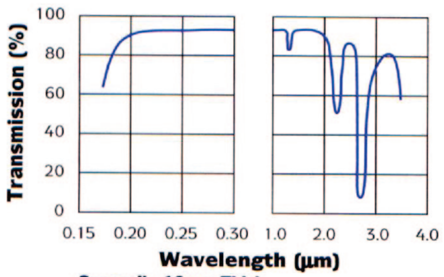
CRYSTAL QUARTZ

Crystal quartz is a positive uniaxial birefringent single crystal grown using a hydrothermal process. This crystal is selected to minimize inclusions and refractive index variation. Crystal quartz is most commonly used for high damage threshold waveplates and solarization resistant Brewster widnows for argon lasers.



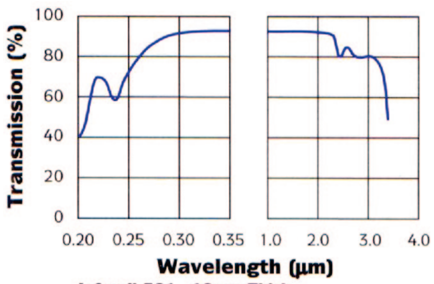
BK7

BK7 is a borosilicate crown optical glass with high homogeneity and low bubble content. BK7 is an excellent general purpose material widely used in visible and NIR windows, lenses, and prisms.



SAPPHIRE

Sapphire is a synthetic hexagonal crystal form of a aluminum oxide. Sapphire exhibits high mechanical strength, chemical resistance, and thermal stability.

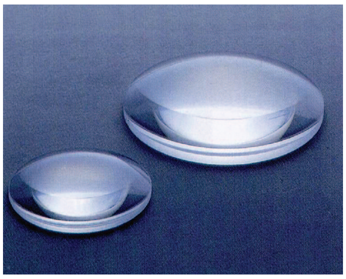


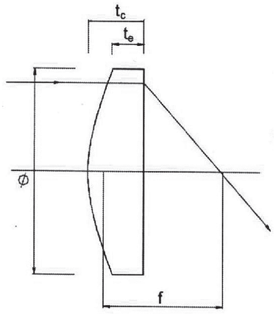
INFRASIL 301

Infrasil 301 is a low OH content fused quartz. Fused quartz is produced electrically fusing high quality quartz crystal. Infrasil 301 is used for applications where minimum OH absorption is required, including NIR high energy laser windows and Lenses.

PLANO-CONVEX SPHERICAL LENSES

Specifications	
Material	BK7
Design Index	1.5183±0.0005@632.8nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	± 0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45°





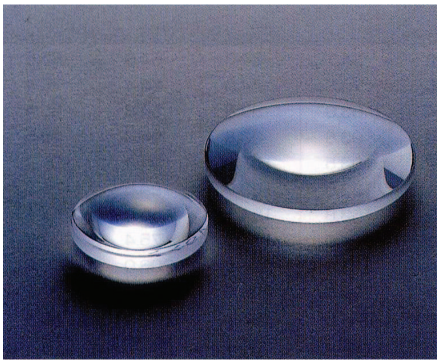
Model No	φ(mm)	f(mm)	t_c(mm)	t_e(mm)
BL100AP	25.4	25.4	11.8	2.0
BL101AP	25.4	50.0	5.3	2.0
BL102AP	25.4	75.0	4.1	2.0
BL103AP	25.4	100.0	3.6	2.0
BL104AP	25.4	125.0	3.3	2.0
BL105AP	25.4	150.0	3.0	2.0
BL106AP	25.4	175.0	2.9	2.0
BL107AP	25.4	200.0	2.8	2.0
BL108AP	25.4	250.0	2.6	2.0
BL109AP	25.4	300.0	2.5	2.0
BL112AP	25.4	500.0	2.3	2.0
BL117AP	25.4	1000.0	2.2	2.0
BL201AP	50.0	50.0	12.0	3.0
BL203AP	50.0	100.0	9.4	3.0
BL205AP	50.0	150.0	7.1	3.0
BL207AP	50.0	200.0	6.1	3.0
BL208AP	50.0	250.0	5.4	3.0
BL209AP	50.0	300.0	5.0	3.0
BL210AP	50.0	400.0	4.5	3.0
BL211AP	50.0	450.0	4.3	3.0
BL212AP	50.0	500.0	4.2	3.0
BL217AP	50.0	1000.0	3.1	2.5
BL306AP	76.2	175.0	14.0	5.6
BL309AP	76.2	300.0	10.0	5.2
BL312AP	76.2	500.0	8.0	5.2
BL314AP	76.2	700.0	7.0	5.0
BL317AP	76.2	1000.0	7.0	5.6
BL412AP	100.0	500.0	9.9	5.0
BL415AP	100.0	800.0	8.0	5.0
BL417AP	100.0	1000.0	7.4	5.0

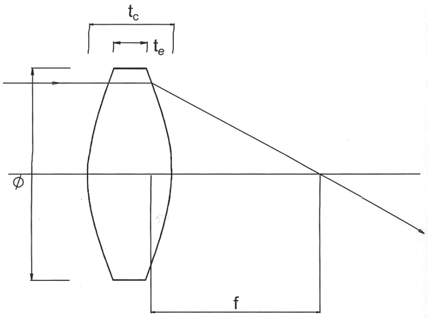
Specifications	
Material	Fused Silica
Design Index	1.46008±0.0005@546.1nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	± 0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45°

Model No	φ(mm)	f(mm)	t_c(mm)	t_e(mm)
BF101AP	25.4	50.0	5.8	2.0
BF102AP	25.4	75.0	4.4	2.0
BF103AP	25.4	100.0	3.8	2.0
BF105AP	25.4	150.0	3.2	2.0
BF106AP	25.4	175.0	3.0	2.0
BF107AP	25.4	200.0	2.9	2.0
BF108AP	25.4	250.0	2.7	2.0
BF109AP	25.4	300.0	2.6	2.0
BF112AP	25.4	500.0	2.4	2.0
BF117AP	25.4	1000.0	2.2	2.0
BF202AP	50.8	75.0	14.21	3.0
BF203AP	50.8	100.0	10.68	3.0
BF205AP	50.8	150.0	7.86	3.0
BF207AP	50.8	200.0	6.59	3.0
BF208AP	50.8	250.0	5.85	3.0
BF209AP	50.8	300.0	5.37	3.0

Onset provides VUV grade CaF_2, UV grade Fused Silica for UV and ZnSe for IR applications.

BI-CONVEX SPHERICAL LENSES





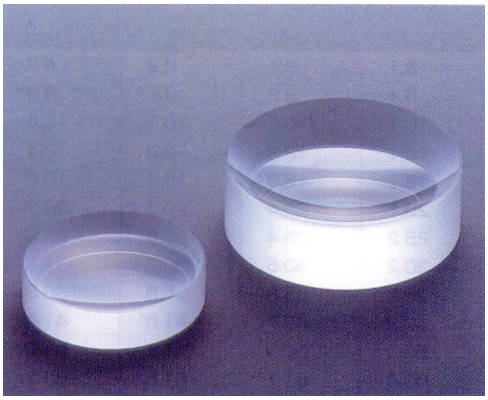
Specifications	
Material	BK7
Design Index	1.5183±0.0005@632.8nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	± 0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45°

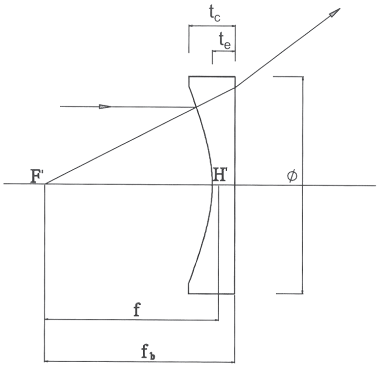
Specifications	
Material	Fused Silica
Design Index	1.46008±0.0005@546.1nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	± 0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45°

Model No	ϕ(mm)	f(mm)	t_c(mm)	t_e(mm)
BL100A	25.4	25.4	9.0	2.0
BL101A	25.4	50.0	5.2	2.0
BL102A	25.4	75.0	4.1	2.0
BL103A	25.4	100.0	3.6	2.0
BL104A	25.4	125.0	3.3	2.0
BL105A	25.4	150.0	3.0	2.0
BL106A	25.4	175.0	2.9	2.0
BL107A	25.4	200.0	2.8	2.0
BL108A	25.4	250.0	2.6	2.0
BL109A	25.4	300.0	2.5	2.0
BL112A	25.4	500.0	2.3	2.0
BL117A	25.4	1000.0	2.2	2.0
BL201A	50.0	50.0	15.5	3.0
BL203A	50.0	100.0	9.2	3.0
BL205A	50.0	150.0	7.1	3.0
BL207A	50.0	200.0	6.0	3.0
BL208A	50.0	250.0	5.4	3.0
BL210A	50.0	400.0	4.5	3.0
BL211A	50.0	450.0	4.3	3.0
BL212A	50.0	500.0	4.2	3.0
BL408A	100.0	250.0	13.7	2.5

Model No	ϕ(mm)	f(mm)	t_c(mm)	t_e(mm)
BF101A	25.4	50.0	5.7	2.0
BF102A	25.4	75.0	4.4	2.0
BF103A	25.4	100.0	3.8	2.0
BF105A	25.4	150.0	3.2	2.0
BF107A	25.4	200.0	2.9	2.0
BF108A	25.4	250.0	2.7	2.0
BF109A	25.4	300.0	2.6	2.0
BF112A	25.4	500.0	2.4	2.0
BF117A	25.4	1000.0	2.2	2.0
BF203A	50.8	100.0	10.31	3.0
BF205A	50.8	150.0	7.78	3.0
BF207A	50.8	200.0	6.56	3.0
BF208A	50.8	250.0	5.83	3.0
BF212A	50.8	300.0	4.41	3.0

PLANO-CONCAVE SPHERICAL LENSES





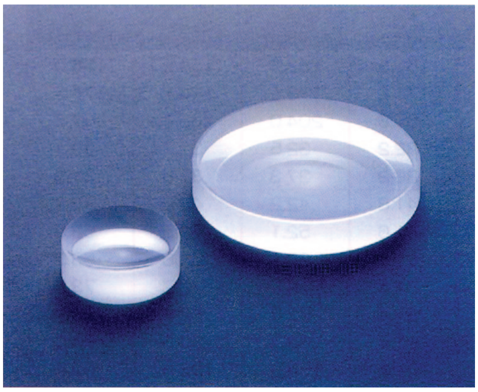
Specifications	
Material	BK7
Design Index	1.5183±0.0005@632.8nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	±0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45°

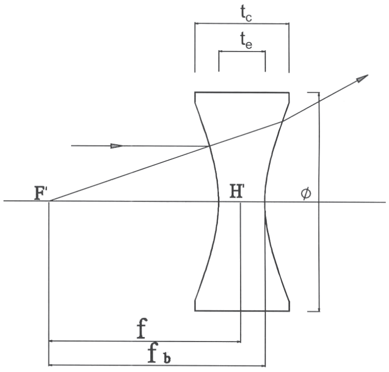
Model No	φ(mm)	f(mm)	t_c(mm)	t_e(mm)
BL101BP	25.4	-50.0	5.3	2.0
BL102BP	25.4	-75.0	4.1	2.0
BL103BP	25.4	-100.0	3.6	2.0
BL104BP	25.4	-125.0	3.3	2.0
BL105BP	25.4	-150.0	3.0	2.0
BL106BP	25.4	-175.0	2.8	2.0
BL107BP	25.4	-200.0	2.7	2.0
BL108BP	25.4	-250.0	2.6	2.0
BL109BP	25.4	-300.0	2.5	2.0
BL112BP	25.4	-500.0	2.3	2.0
BL117BP	25.4	-1000.0	2.2	2.0
BL203BP	50.0	-100.0	9.4	3.0
BL205BP	50.0	-150.0	7.1	3.0
BL207BP	50.0	-200.0	6.1	3.0
BL208BP	50.0	-250.0	5.4	3.0
BL210BP	50.0	-400.0	4.5	3.0
BL211BP	50.0	-450.0	4.3	3.0
BL212BP	50.0	-500.0	4.2	3.0

Specifications	
Material	Fused Silica
Design Index	1.46008±0.0005@546.1nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	±0.2mm
Surface Quality	60-40 scratch and dig
Bevel	0.25mm x 45o

Model No	φ(mm)	f(mm)	t_c(mm)	t_e(mm)
BF101BP	25.4	-50.0	5.8	2.0
BF102BP	25.4	-75.0	4.4	2.0
BF103BP	25.4	-100.0	3.8	2.0
BF105BP	25.4	-150.0	3.2	2.0
BF106BP	25.4	-175	3.0	2.0
BF107BP	25.4	-200.0	2.9	2.0
BF108BP	25.4	-250.0	2.7	2.0
BF109BP	25.4	-300.0	2.6	2.0
BF112BP	25.4	-500.0	2.4	2.0
BF117BP	25.4	-1000.0	2.2	2.0
BF202BP	50.8	-75.0	14.71	3.5
BF203BP	50.8	-100.0	11.18	3.5
BF205BP	50.8	-150.0	8.36	3.5
BF207BP	50.8	-200.0	7.09	3.5
BF208BP	50.8	-250.0	6.35	3.5
BF212BP	50.8	-500.0	5.41	4.0

BI-CONCAVE SPHERICAL LENSES





Specifications	
Material	BK7
Design Index	1.5183 ±0.0005@632.8nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	±0.2mm
Surface Quality	60-40 scratch and big
Bevel	0.25mm x 45o

Model No	φ(mm)	f(mm)	t_c(mm)	t_e(mm)
BL101B	25.4	-50.0	5.1	2.0
BL102B	25.4	-75.0	4.1	2.0
BL103B	25.4	-100.0	3.6	2.0
BL104B	25.4	-125.0	3.2	2.0
BL105B	25.4	-150.0	3.0	2.0
BL106B	25.4	-175.0	2.9	2.0
BL107B	25.4	-200.0	2.8	2.0
BL108B	25.4	-250.0	2.6	2.0
BL109B	25.4	-300.0	2.5	2.0
BL112B	25.4	-500.0	2.3	2.0
BL117B	25.4	-1000.0	2.2	2.0
BL203B	50.0	-100.0	9.1	3.0
BL205B	50.0	-150.0	7.0	3.0
BL207B	50.0	-200.0	6.0	3.0
BL208B	50.0	-250.0	5.4	3.0
BL210B	50.0	-400.0	4.5	3.0
BL211B	50.0	-450.0	4.3	3.0
BL212B	50.0	-500.0	4.2	3.0

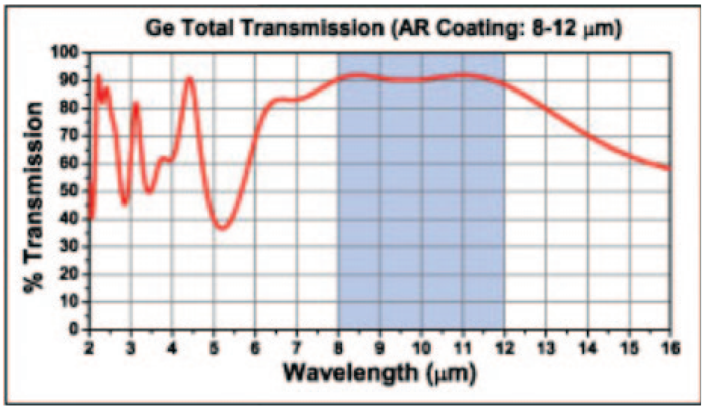
Specifications	
Material	Fused Silica
Design Index	1.46008±0.0005@546.1nm
Centration	3 arc minutes
Diameter Tolerance	+0.0, -0.15mm
Clear Aperture Diameter	>80%
Center Thickness	±0.2mm
Surface Quality	60-40 scratch and big
Bevel	0.25mm x 45o

Model No	ϕ(mm)	f(mm)	t_c(mm)	t_e(mm)
BF101B	25.4	-50.0	5.6	2.0
BF102B	25.4	-75.0	4.3	2.0
BF103B	25.4	-100.0	3.8	2.0
BF105B	25.4	-150.0	3.2	2.0
BF107B	25.4	-200.0	2.9	2.0
BF108B	25.4	-250.0	2.7	2.0
BF109B	25.4	-300.0	2.6	2.0
BF112B	25.4	-500.0	2.4	2.0
BF117B	25.4	-1000.0	2.2	2.0
BF203B	50.8	-100.0	10.63	3.5
BF205B	50.8	-150.0	8.21	3.5
BF208B	50.8	-250.0	6.32	3.5

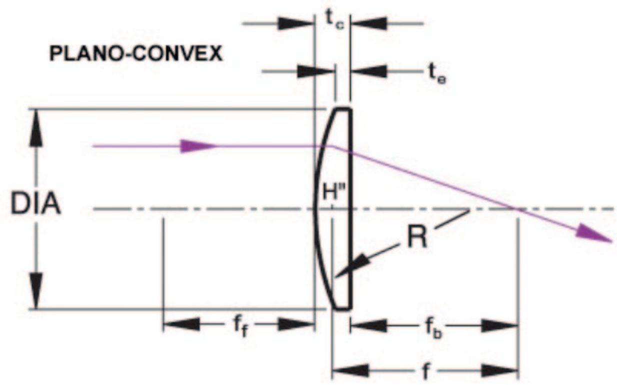
Ge SPHERICAL LENSES

- AR Coating Optimized for the 8-12 μm Range
- Choose from Ø1/2” or Ø1”
- Excellent for Security, military, and Imaging Applications

LA9509-F



Specifications	
Material	Germanium
Wavelength Range	2.0 - 16.0 μm
AR Coating Range*	8-12 μm
Reflectance over Coating Range (Avg.)	<1.5%
Diameter Tolerance	+0.00/-0.10
Thickness Tolerance	±0.2 mm
Focal Length Tolerance	±1%
Surface Quality (Scratch-Dig)	60-40
Centration	≤3 arcmin
Clear Aperture	80% of Diameter
Design Wavelength	10.6 μm

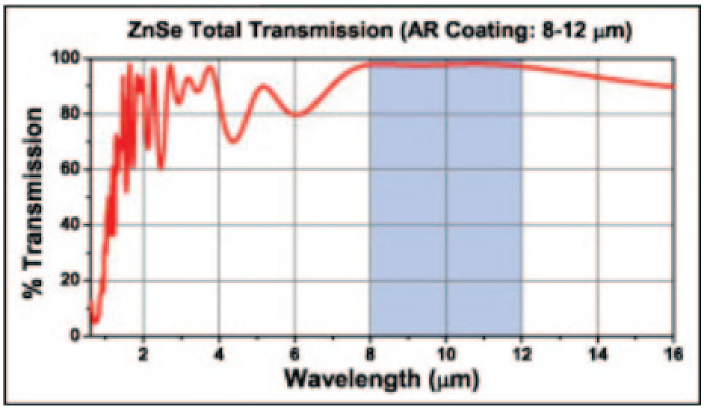


Item#	DIA	f (mm)	R (mm)	Center Thickness t_c (mm)	Edge Thickness t_e (mm)	Back Focal Length f_b (mm)	Suggested Mount
LA9410-F	1/2" (12.70 mm)	15.0	45.1	2.5	2.0	14.4	
LA9015-F	1/2" (12.70 mm)	20.0	60.1	2.3	2.0	19.4	LMR05
LA9280-F	1/2" (12.70 mm)	40.0	120.2	2.2	2.0	39.5	
LA9509-F	1" (25.40 mm)	25.4	76.3	3.1	2.0	24.6	
LA9659-F	1" (25.40 mm)	50.0	150.3	4.0	3.5	48.5	
LA9977-F	1" (25.40 mm)	75.0	225.5	4.0	3.6	73.7	
LA9928-F	1" (25.40 mm)	100.0	300.7	4.0	3.7	98.8	
LA9701-F	1" (25.40 mm)	150.0	451.0	4.0	3.8	148.8	LMR1
LA9792-F	1" (25.40 mm)	200.0	601.4	4.0	3.9	198.9	
LA9953-F	1" (25.40 mm)	500.0	1501.9	2.1	2.0	499.5	
LA9702-F	1" (25.40 mm)	750.0	2252.9	2.0	2.0	749.5	
LA9942-F	1" (25.40 mm)	1000.0	3303.9	2.0	2.0	999.5	

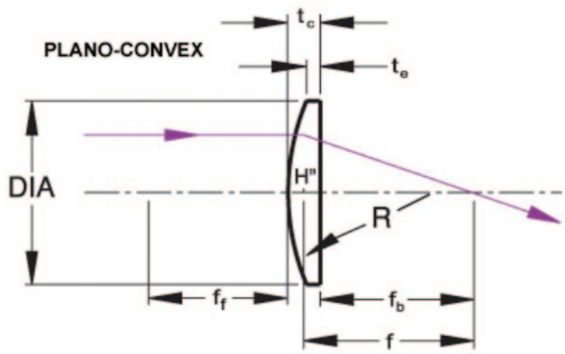
ZnSe SPHERICAL LENSES

- AR Coating Optimized for the 8-12 μm Range
- Choose from Ø1/2” or Ø1”
- Ideal for CO_2 Laser applications Due to Low Absorption Coefficient
- Excellent for IR Imaging, Biomedical, or Military Applications

LA7542-F

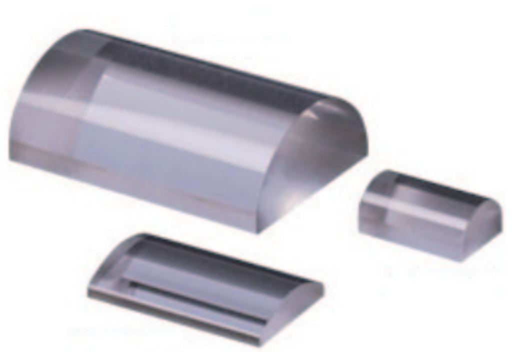


Specifications	
Material	Laser Grade Zinc Selenide
Wavelength Range	0.6 - 16.0 μm
AR Coating Range	8-12 μm
Reflectance over Coating Range (Avg.)	<1.5%
Diameter Tolerance	+0.00/-0.10
Thickness Tolerance	±0.2 mm
Focal Length Tolerance	±1%
Surface Quality	60-40 Scratch-Dig
Centration	≤3 arcmin
Clear Aperture	80% of Diameter
Design Wavelength	10.6 μm



Item#	DIA	f (mm)	R (mm)	Center Thickness tc (mm)	Edge Thickness t_e (mm)	Back Focal Length f_b (mm)	Suggested Mount
LA7477-F	1/2" (12.70 mm)	15.0	21.0	3.0	2.0	13.8	
LA7733-F	1/2" (12.70 mm)	20.0	28.0	2.7	2.0	18.9	LMR05
LA7673-F	1/2" (12.70 mm)	40.0	56.1	2.4	2.0	39.0	
LA7542-F	1" (25.40 mm)	25.4	35.6	4.3	2.0	23.6	
LA7656-F	1" (25.40 mm)	50.0	70.2	4.0	2.8	48.4	
LA7660-F	1" (25.40 mm)	75.0	105.2	4.0	3.2	73.3	
LA7261-F	1" (25.40 mm)	100.0	140.5	4.0	3.4	98.5	
LA7028-F	1" (25.40 mm)	150.0	209.0	4.0	3.6	147.3	LMR1
LA7228-F	1" (25.40 mm)	200.0	280.5	4.0	3.7	198.3	
LA7270-F	1" (25.40 mm)	500.0	701.3	2.1	2.0	499.1	
LA7234-F	1" (25.40 mm)	750.0	1052.0	2.1	2.0	749.1	
LA7753-F	1" (25.40 mm)	1000.0	1402.7	2.1	2.0	999.1	

CYLINDRICAL LENSES



- Ideal for Appilcations Requiring Magnification in One Dimension
- Provide Anamorphic Shaping of a Beam
- Collimates & Circularizes the Output of a Laser Diode

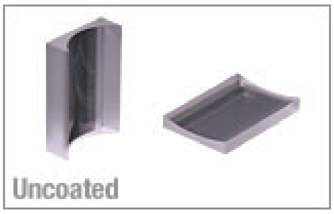
Plano-Convex, N-BK7, Uncoated

Plano-Convex, N-BK7, AR Coated: 350-700 nm

Plano-Convex, N-BK7, AR Coated: 650-1050 nm

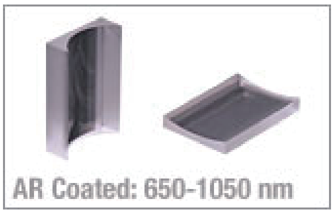
Plano-Convex, N-BK7, AR Coated: 1050-1620 nm

Plano-Concave, N-BK7, Uncoated



Plano-Concave, N-BK7, AR Coated: 350-700 nm

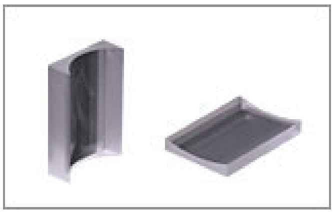
Plano-Concave, N-BK7, AR Coated: 650-1050 nm



Plano-Concave, N-BK7, AR Coated: 1050-1620 nm

Plano-Convex, UV Fused Silica

Plano-Concave, UV Fused Silica



Plano-Convex, Round, N-BK7

Plano-Concave, Round, N-BK7

Contact Onset Sales Members to Meet Your Needs

STEPS OF CHOOSING YOUR CYLINDRICAL LENSES

Step 1	Step 2	Step 3	Step 4	Step 5
Round or Square ?	PCX or PCV ?	Dimension ?	Focal Length ?	AR Coating ?

BALL LENSES

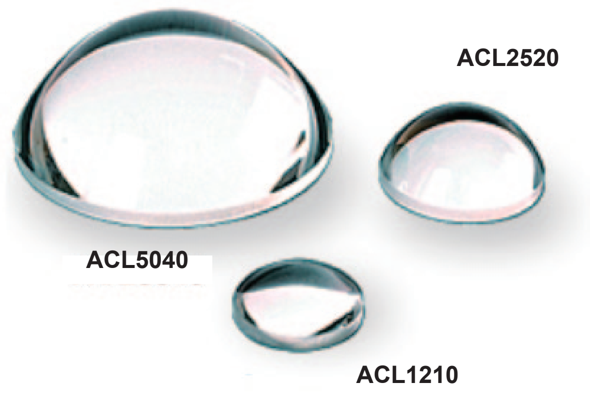
- Microspheres are mostly used for coupling optical fibers to laser diodes, another fibers or detectors optically.
- Since these ball lenses are much smaller than normal lenses and all the surfaces are polished, they must be handled carefully, but they contribute to reduction of size and weight of devices.
- AR coated and uncoated are available. AR coatings, single layer MgF2 antireflection coatings, are chosen from three bands: 400—700nm, 700—900nm, and 1300—1550nm.
- Design wavelength for the focal lengths is 587.6nm (yellow he lium line [d]).

Material	LaSFN9 or Equivalent Product
Shape	Spherical
Surface quality	40 - 20
Coating	Uncoated Single-layer MgF2 Antireflection Coating: 400 - 700nm 700 - 900nm 1300 - 1550nm

Type	D [mm]	f [mm]	fb [mm]	AR [nm]	Wavelength Range	Material	Surface Quality	Part Number
Uncoated	ø2	1.09	0.09	-	400 - 2000	LaSFN9	40-20	MS-02-1.1P
Uncoated	ø3	1.63	0.13	-	400 - 2000	LaSFN9	40-20	MS-03-1.7P
Uncoated	ø5	2.72	0.22	-	400 - 2000	LaSFN9	40-20	MS-05-2.8P
Anti-reflection coating for 632.8nm	ø2	1.09	0.09	Single Layer MgF2	400 - 700	LaSFN9	40-20	MS-02-1.1P1
Anti-reflection coating for 632.8nm	ø3	1.63	0.13	Single Layer MgF2	400 - 700	LaSFN9	40-20	MS-03-1.7P1
Anti-reflection coating for 632.8nm	ø5	2.72	0.22	Single Layer MgF2	400 - 700	LaSFN9	40-20	MS-05-2.8P1
Anti-reflection coating for 830nm	ø2	1.09	0.09	Single Layer MgF2	700 - 900	LaSFN9	40-20	MS-02-1.1P2
Anti-reflection coating for 830nm	ø3	1.63	0.13	Single Layer MgF2	700 - 900	LaSFN9	40-20	MS-03-1.7P2
Anti-reflection coating for 830nm	ø5	2.72	0.22	Single Layer MgF2	700 - 900	LaSFN9	40-20	MS-05-2.8P2
Anti-reflection coating for 1300nm	ø2	1.09	0.09	Single Layer MgF2	1300 - 1550	LaSFN9	40-20	MS-02-1.1P3
Anti-reflection coating for 1300nm	ø3	1.63	0.13	Single Layer MgF2	1300 - 1550	LaSFN9	40-20	MS-03-1.7P3
Anti-reflection coating for 1300nm	ø5	2.72	0.22	Single Layer MgF2	1300 - 1550	LaSFN9	40-20	MS-05-2.8P3

CHAPTER 4 PHOTONICS

ASPHERIC LENSES



- 10 Different Diameters Ranging from 10 to 75 mm
- Effective Focal Length Ranging from 8 to 60 mm
- Wavelength Range: 380-2100 nm
- Optimized for Condenser Applications

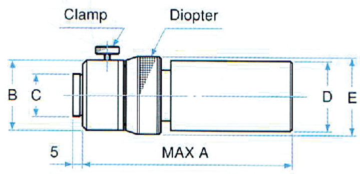
General	
Focal Length Tolerance	±5%
Wavelength Range (Uncoated Lenses)	380 - 2100 nm
Wavelength Range (A-Coated Lenses)	350 - 700 nm
Wavelength Range (B-Coated Lenses)	650 - 1050 nm
Wavelength Range (C-Coated Lenses)	1.0 - 1.6 µm
Surface Quality	80 - 50 scratch-dig
Diameter Tolerance	+0.0 mm / -0.5 mm
Center Thickness Tolerance	±0.3 mm
Edge Thickness Tolerance	±0.3 mm
Centering Tolerance (Wedge)	30 arcmin
Temperature (max.)	250 °C
Glass Type	B270 Optical Crown Glass
RoHS	Compliant

Item #	Diameter (mm)	f (mm)	f/d*	Clear Aperture (mm)	fb (mm)	Numerical Aperture	Center Thickness (mm)	Edge Thickness (mm)	Non-Aspheric Surface
ACL108	10	8	0.8	>90%	4.2	0.625	5.8	2.0	Plano
ACL1210	12	10.5	0.88	>90%	6.7	0.571	5.8	2.0	Plano
ACL1512	15	12	0.8	>90%	6.7	0.625	8.0	2.4	Plano
ACL1815	18	15	0.83	>90%	10.5	0.600	6.8	2.5	Plano
ACL2018	20	18	0.9	>90%	12.7	0.556	8.0	1.8	Plano
ACL2520	25	20	0.8	>90%	12.1	0.625	12.0	2.8	Plano
ACL3026	30	26.5	0.88	>90%	19.3	0.566	11.0	3.0	Plano
ACL4532	45	32	0.71	>90%	20.9	0.703	18.5	2.2	Spherical Convex
ACL5040	50	40	0.8	>90%	26.2	0.625	21.0	2.6	Plano
ACL7560	75	60	0.8	>90%	40.3	0.625	30.0	2.3	Plano

LASER BEAM EXPANDER

Laser Beam Expanders with Diopter Movement

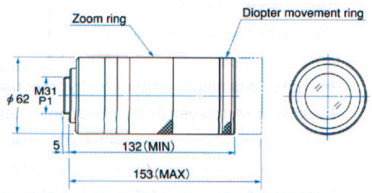
- These laser beam expander are Galilean beam expanders, and spherical aberrations are canceled. Housing design is compact and few trouble for high-power laser compared with Keplerian.
- Various models are available for various laser sources from 248 to 1064 nm with multilayer AR coatings as standard.
- Every model has a diopter movement (focus adjustment). They can be used to compensate the location of elements, and furthermore, output beams can be converged or diverged with this function. The diopter movements are lockable by a lock screw.



Design wavelenght	Expansion ratio	Entrance clear aperture(mm)	Max.input beam diameter(mm)	Max. A (mm)	Diameter B (mm)	Mounting thread C	Diameter D (mm)	Diameter E (mm)	Model No.
248nm	1.5x	Max.φ15.0	φ10.0	54	φ57	M34P=0.75	-	φ60	BE- 1.5-248
248nm	2.0x	Max.φ15.0	φ10.0	54	φ57	M34P=0.75	-	φ60	BE-2-248
248nm	3.0x	Max.φ10.0	φ 8.0	81	φ57	M34P=0.75	φ48	φ60	BE-3-248
248nm	4.0x	Max.φ 8.5	φ 6.0	90	φ57	M34P=0.75	φ48	φ60	BE-4-248
248nm	5.0x	Max.φ 7.0	φ 5.0	118	φ57	M34P=0.75	φ48	φ60	BE-5-248
248nm	7.5x	Max.φ 4.5	φ 3.5	127	φ57	M34P=0.75	φ48	φ60	BE-7.5-248
248nm	10.0x	Max.φ 3.5	φ 2.5	172	φ57	M34P=0.75	φ48	φ60	BE-10-248
400-700nm	2.0x	Maxφ 6.0	φ 3.5	46	φ36	M22P=0.75	φ26	φ40	BE-2-V
400-700nm	3.0x	Maxφ 5.0	φ 3.5	46	φ36	M22P=0.75	φ26	φ40	LBED-3
400-700nm	4.1x	Max.φ3.6	φ 2.5	66	φ36	M22P=0.75	φ26	φ40	BE-4.1-V
400-700nm	5.0x	Max.φ3.0	φ 2.0	55	φ36	M22P=0.75	φ26	φ40	LBED-5
400-700nm	6.0x	Max.φ 4.0	φ 2.0	106	φ36	M22P=0.75	φ36	φ40	BE-6-V
400-700nm	7.6x	Max.φ3.2	φ 2.0	83	φ36	M22P=0.75	φ36	φ40	BE-7.6-V
400-700nm	8.4x	Max.φ 3.0	φ 1.5	94	φ36	M22P=0.75	φ36	φ40	BE-8.4-V
400-700nm	10.0x	Max.φ2.5	φ 1.5	114	φ36	M22P=0.75	φ36	φ40	LBED-10
400-700nm	12.6x	Max.φ2.0	φ 1.2	144	φ36	M22P=0.75	φ36	φ40	BE-12.6-V
400-700nm	14.3x	Max.φ1.7	φ 1.0	165	φ36	M22P=0.75	φ36	φ40	BE-14.3-V
400-700nm	16.8x	Max.φ2.0	φ 1.0	194	φ36	M22P=0.75	φ46	φ40	BE-16.8-V
400-700nm	18.5x	Max.φ1.8	φ 1.0	215	φ36	M22P=0.75	φ46	φ40	BE-18.5-V
400-700nm	21.0x	Max.1.6	φ 1.0	245	φ36	M22P=0.75	φ46	φ40	BE-21-V
780-830nm	1.5X	Max.φ15.0	φ10.0	54	φ57	M34P=0.75	-	φ60	BE-1.5-LD
780-830nm	2.0X	Max.φ15.0	φ10.0	59	φ57	M34P=0.75	φ48	φ60	BE-2-LD
780-830nm	3.0X	Max.φ10.0	φ 8.0	70	φ57	M34P=0.75	φ48	φ60	BE-3-LD
780-830nm	4.0X	Max.φ 8.5	φ 6.0	101	φ57	M34P=0.75	φ48	φ60	BE-4-LD
780-830nm	5.0X	Max.φ 7.0	φ 5.0	131	φ57	M34P=0.75	φ48	φ60	BE-5-LD
780-830nm	7.5X	Max.φ 4.5	φ 3.5	142	φ57	M34P=0.75	φ48	φ60	BE-7.5-LD
780-830nm	10.0X	Max.φ 3.5	φ 2.5	193	φ57	M34P=0.75	φ48	φ60	BE-10-LD
1064nm	1.5X	Max.φ15.0	φ10.0	54	φ57	M34P=0.75	-	φ60	BE-1.5-1064
1064nm	2.0X	Max.φ15.0	φ10.0	54	φ57	M34P=0.75	φ48	φ60	LBED-2Y
1064nm	3.0X	Max.φ10.0	φ 8.0	70	φ57	M34P=0.75	φ48	φ60	LBED-3Y
1064nm	4.0X	Max.φ 8.0	φ 6.0	99	φ57	M34P=0.75	φ48	φ60	LBED-4Y
1064nm	5.3X	Max.φ 6.6	φ 5.0	134	φ57	M34P=0.75	φ48	φ60	BE-5.3-1064
1064nm	7.0X	Max.φ 5.0	φ 3.5	182	φ57	M34P=0.75	φ48	φ60	BE-7-1064
1064nm	10.0X	Max.φ 3.5	φ 2.5	192	φ57	M34P=0.75	φ48	φ60	BE-10-1064

Zoom Laser Beam Expander

- A Galilean beam expander for HeNe laser, which expansion ratio is variable from 2.5X to 10X continuously.
- This expander has a diopter movement (focus adjustment).Therefore it can be used to compensate the location of elements,and furthermore, output beams can be converged or diverged with this function. However it does not have locking functions for zoom and diopter movement.



LBEZ

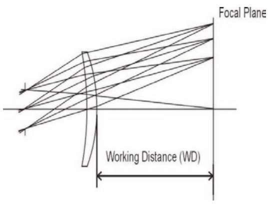
Diopter movement

Movement	Diopter	Focus distance
-2mm	-1.27	-818mm
-1mm	-0.61	-1630mm
0	0	∞
+1mm	+0.65	+1550mm
+2mm	+1.29	+775mm

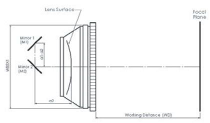
SPECIFICATIONS	
Design wavelength	632.8nm
Expansion ratio	2.5 to10x(Continuously variable)
Maximum input beam diameter	φ2mm
Lens configuration	3 groups , 5pieces
Coating	Broadband multilayer AR coating for visible(400~700nm)
Housing	Black finished aluminum
Wavelength range	632.8nm

F-THETA SCAN LENS - CO_2 LASER

F-Theta scan lens rugged single elements are designed for CO_2 laser system that employ X - Y galvo scanning mirrors. The lens are widely used in fields such as engraving and marking applications.



Single Element

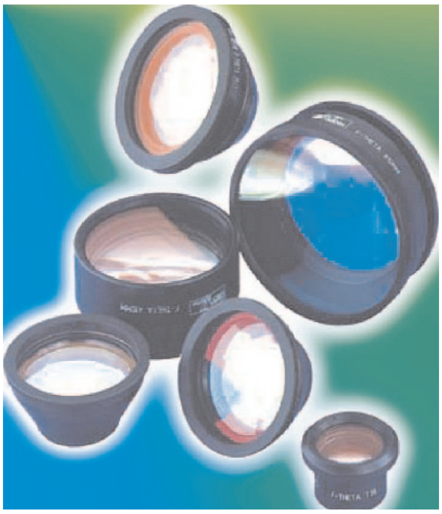


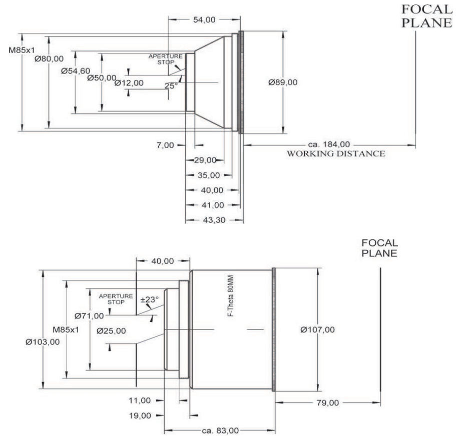
Double Element

Part No.	EFL (mm)	Scan Field (mm)	Average spot size (mm)	Beam Dia. (mm)	Mir.Sep. (mm)	2nd mir.to lens mount	Max. Input Angle (deg.)	90%CA (mm)	Working Distance (mm)
Single Element									
SL1-10.6-35-52Z	52	35x35	100	14	13	25	20	45	49
SL1-10.6-50-75Z	75	50X50	122	14	13	25	20	45	72
SL1-10.6-50-153Z	153	50x50	185	14	19	37	13	48	154
SL1-10.6-70-100Z	100	70x70	160	14	13	25	20	45	99
SL1-10.6-90-152Z	152	90x90	202	14	19	37	23	60	152
SL1-10.6-110-150Z	150	110x110	193	14	13	25	20	45	150
SL1-10.6-140-200Z	200	140X140	253	14	13	25	20	45	201
SL1-10.6-175-250Z	250	175X175	260	14	13	25	20	45	253
SL1-10.6-210-300Z	300	210X210	418	14	13	25	20	45	305
SL1-10.6-250-360Z	360	250x250	507	14	13	25	20	45	366
SL1-10.6-300-430Z	430	300x300	616	14	13	25	20	45	438
SL1-10.6-350-480Z	480	350x350	863	14	13	25	20	50	487
SL1-10.6-300-420Z	420	300X300	510	20	25	35	20	68	425
SL1-10.6-450-620Z	620	450x450	906	20	20	25	20	68	631
SL1-10.6-600-830Z	830	600x600	990	20	25	25	20	70	838
SL1-10.6-650-895Z	895	650x650	1050	25	25	26	20	75	899
SL1-10.6-800-1100Z	1100	800x800	1060	25	25	26	20	75	1116
SL1-10.6-1200-1650Z	1650	1200x1200	1321	30	25	35	20	90	1675
SL1-10.6-500-690Z	690	500x500	522	30	25	30	20	86	699
SL1-10.6-35-60G	60	35x35	100	14	20	25	20	45	58
SL1-10.6-50-80G	80	50X50	122	14	20	34	18	50	79
SL1-10.6-300-420G	420	300X300	478	20	20	30	20	68	428
SL1-10.6-30-75E	75	30x30	60	24	20	37	12	56	73
SL1-10.6-50-97E	97	50x50	98	18	23	36	20	62	96
SL1-10.6-50-105E	105	50X50	137	14	23	36	20	62	104
SL1-10.6-50-152E	152	50X50	205	14	19	37	13	47	153
SL1-10.6-90-151E	151	90x90	210	14	19	37	23	68	153
SL1-10.6-110-178E	178	110X110	190	18	23	36	25	72	178
Double Element									
SL2-10.6-35-60G	60	35X35	100	14	13	25	20	45	55
SL2-10.6-50-80G	80	50X50	118	14	13	25	20	45	76
SL2-10.6-70-122G	122	70X70	158	14	13	25	20	46	130
SL2-10.6-110-170G	170	110x110	170	14	13	25	20	54	185
SL2-10.6-140-220G	220	140X140	224	14	13	25	20	53	239
SL2-10.6-175-275G	275	175X175	239	14	13	25	20	51	305
SL2-10.6-210-300G	300	210x210	387	14	13	25	20	86	330
SL2-10.6-250-360G	360	250x250	465	14	13	25	20	86	393
SL2-10.6-300-420G	420	300x300	570	14	13	25	20	86	465
SL2-10.6-350-485G	485	350x350	822	14	13	25	20	87	528
SL2-10.6-300-420G	1 420	300X300	505	20	30	30	20	78	470
SL2-10.6-110-150Z	150	110x110	170	14	13	25	20	64	159
SL2-10.6-140-200Z	200	140X140	224	14	13	25	20	69	215
SL2-10.6-175-250Z	250	175X175	239	14	13	25	20	78	270
SL2-10.6-210-300Z	300	210x210	387	14	13	25	20	86	327
SL2-10.6-250-360Z	360	250x250	480	14	13	25	20	98	393
SL2-10.6-300-420Z	420	300x300	502	16	20	25	20	101	460
SL2-10.6-400-560Z	560	400X400	905	14	13	25	20	93	590

• Material: G-GaAs, E-Ge (only transmit 10.6um)   *• Material: Z- ZnSe (transmit both 10.6um and visible)*

F-THETA SCAN LENS- Nd:YAG LASER, GREEN & UV

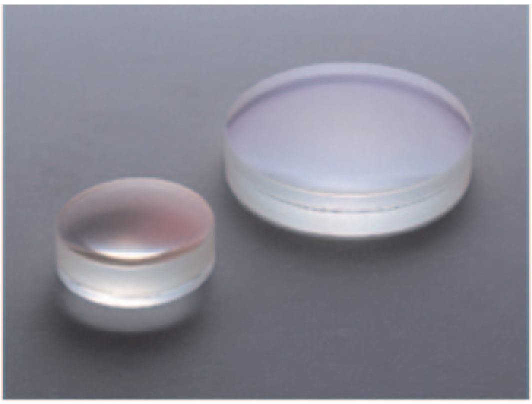




F-Theta scan lens rugged single and double elements are designed for Nd:YAG, Green, UV laser system that employ X - Y galvo scanning mirrors. The lens are widely used in fields such as engraving and marking applications.

Part No.	EFL (mm)	Scan Angle (±°)	Scan Length (mm)	Scan Field (mm)	Ent. Pupil (mm)	Average Spot Size (µm)	Length (mm)	Working Distance (mm)
Nd:YAG Laser (Wavelength= 1064nm)								
SL-1064-70-100	100.0	25°	87.0	70x70	14.0	12.0	47.0	100.0
SL-1064-105-152	152.0	25°	132.0	105x105	14.0	14.0	49.0	167.0
SL-1064-112-163	163.0	25°	142.0	112x112	14.0	16.0	49.0	184.0
SL-1064-175-254	254.0	25°	220.0	175x175	16.0	20.0	61.0	288.0
SL-1064-180-260	260.0	25°	226.0	180x180	20.0	20.0	61.0	297.0
SL-1064-100-163	163.0	25°	140.0	100x100	20.0	12.0	65.0	195.0
SL-1064-300-420	420.0	27°	380.0	300x300	20.0	30.0	70.0	495.0
SL-1064-212-300	300.0	28°	300.0	212x212	20.0	20.0	76.0	350.0
SL-1064-500-810	810.0	28°	850.0	500x500	24.0	55.0	57.0	880.0
SL-1064-120-200	200.0	25°	170.0	120x120	30.0	10.0	83.0	237.0
SL-1064-160-254	254.0	25°	220.0	160x160	30.0	12.0	75.5	287.0
SL-1064-250-420	420.0	24°	350.0	250x250	30.0	15.0	52.0	477.0
Nd:YAG Laser (Wavelength= 532nm)								
SL-532-80-163	163.0	25°	120.0	80x80	6.0	20.0	43.0	160.0
SL-532-225-410	410.0	25°	330.0	225x225	6.0	30.0	60.0	435.0
SL-532-50-100	100.0	25°	71.0	50x50	8.0	10.0	40.0	98.0
SL-532-150-254	254.0	25°	215.0	150x150	10.0	18.0	55.0	285.0
SL-532-175-300	300.0	28°	250.0	175x175	12.0	18.0	76.0	323.0
SL-532-500-810	810.0	28°	710.0	500x500	12.0	30.0	57.0	845.0
SL-532-70-100	100.0	25°	87.0	70x70	14.0	10.0	46.0	100.0
SL-532-115-165	165.0	25°	173.0	115x115	14.0	14.0	43.0	186.0
SL-532-350-508	508.0	25°	500.0	350x350	16.0	15.0	57.0	581.0
Nd:YAG Laser (Wavelength= 355nm)								
SL-355-60-100	100.0	25°	87.0	60x60	12.0	12.0	40.0	110.0
SL-355-100-163	163.0	25°	140.0	100x100	12.0	18.0	43.0	180.0
SL-355-160-254	254.0	25°	220.0	160x160	12.0	22.0	55.0	311.0
SL-355-220-350	350.0	25°	305.0	220x220	12.0	33.0	45.0	418.0
SL-355-250-410	410.0	25°	350.0	250x250	12.0	34.0	60.0	480.0
SL-355-100-163	163.0	25°	140.0	100x100	20.0	12.0	65.0	195.0
SL-355-212-300	300.0	28°	300.0	212x212	20.0	20.0	76.0	350.0
SL-355-500-810	810.0	28°	850.0	500x500	24.0	55.0	57.0	880.0
SL-355-120-200	200.0	25°	170.0	120x120	30.0	10.0	83.0	237.0
SL-355-160-254	254.0	25°	220.0	160x160	30.0	12.0	75.5	287.0
SL-355-250-420	420.0	24°	350.0	250x250	30.0	15.0	52.0	477.0
Nd:YAG Laser (Wavelength= 266nm)								
SL-266-90-254	254.0	18°	156.0	90x90	4.0	16.0	47.0	25.0
SL-266-70-100	100.0	28°	95.0	70x70	5.0	8.0	49.0	137.0
SL-266-110-160	160.0	28°	160.0	110x110	5.0	10.0	36.7	200.0

ACHROMATIC LENSES



Material	Crown Glass and Flint Glass
Design Wavelength	Blue: 486.1nm
Green: 546.1nm	
Red: 656.3nm	
Coating	Broadband Multilayer AR Coating for the Visible(BMAR)
Adhesive	Ultraviolet Hardened Adhesive
Conjugate Ratio	Infinity
Surface quality	40 - 20
Clear aperture	85% of actual aperture

D	f [mm]	tc [mm]	te [mm]	ff [mm]	fb [mm]	r1 [mm]	r2 [mm]	r3 [mm]	d1 [BK7]	d2 [SF2]	AR	Centration	Part Number
ø12.7	25.1	7.3	5.3	23.7	21.5	15.57	-11.04	-32.2	5.3	2	BMAR	≤ 1 arcmin	DLB-12.7-25PM
ø12.7	30	6.8	5.2	28.8	26.7	18.53	-13.04	-39.408	4.8	2	BMAR	≤ 1 arcmin	DLB-12.7-30PM
ø12.7	40.1	6.1	4.9	39.2	36.9	23.395	-17.6	-60.311	4.1	2	BMAR	≤ 1 arcmin	DLB-12.7-40PM
ø12.7	50.1	5.7	4.7	49.1	47.3	30.373	-21.462	-69.317	3.7	2	BMAR	≤ 1 arcmin	DLB-12.7-50PM
ø12.7	79.9	5.1	4.5	79.2	77.4	46.108	-34.5	-124.56	3.1	2	BMAR	≤ 1 arcmin	DLB-12.7-80PM
ø12.7	100.1	4.8	4.3	99.2	97.9	61.4	-42.383	-136.714	2.8	2	BMAR	≤ 1 arcmin	DLB-12.7-100PM
ø25	40.9	12.5	7.7	39	34.2	24.516	-19.33	-58.8	10	2.5	BMAR	≤ 1 arcmin	DLB-25-40PM
ø25	50.1	10.9	7.1	48	44.9	32.5	-22.245	-61.4	8.4	2.5	BMAR	≤ 1 arcmin	DLB-25-50PM
ø25	60.1	9.8	6.7	58.5	55.2	36.8	-26.659	-82.643	7.3	2.5	BMAR	≤ 1 arcmin	DLB-25-60PM
ø25	69.9	9	6.3	68.7	65.3	41.4	-31.125	-104	6.5	2.5	BMAR	≤ 1 arcmin	DLB-25-70PM
ø25	80	8.5	6.2	78.7	75.9	49.1	-34.867	-110	6	2.5	BMAR	≤ 1 arcmin	DLB-25-80PM
ø25	100.2	7.7	5.9	98.9	96.5	61.4	-43.253	-138	5.2	2.5	BMAR	≤ 1 arcmin	DLB-25-100PM
ø25	119.8	7.2	5.6	118.8	116.2	70.182	-52	-181.65	4.7	2.5	BMAR	≤ 1 arcmin	DLB-25-120PM
ø25	149.6	6.7	5.5	148.6	146.2	86.625	-65	-233.55	4.2	2.5	BMAR	≤ 1 arcmin	DLB-25-150PM
ø25	170.4	6.4	5.3	169.5	167.1	98	-73.9	-270	3.9	2.5	BMAR	≤ 1 arcmin	DLB-25-170PM
ø25	200.1	6.1	5.2	199.4	197	111.11	-88.23	-350	3.6	2.5	BMAR	≤ 1 arcmin	DLB-25-200PM
ø25	222	6	5.2	221.3	218.9	121.931	-98	-400	3.5	2.5	BMAR	≤ 1 arcmin	DLB-25-220PM
ø25	250.8	5.8	5.1	250.1	247.7	136.714	-110.4	-460	3.3	2.5	BMAR	≤ 1 arcmin	DLB-25-250PM
ø25	300	5.6	5	299.8	296.6	146.6	-146.6	-913.9	3.1	2.5	BMAR	≤ 3 arcmin	DLB-25-300PM
ø25.4	50.1	10.9	7	50.5	44.9	32.5	-22.245	-61.4	8.4	2.5	BMAR	≤ 1 arcmin	DLB-25.4-50PM
ø25.4	60.1	9.8	6.6	60.8	55.2	36.8	-26.659	-82.643	7.3	2.5	BMAR	≤ 1 arcmin	DLB-25.4-60PM
ø25.4	69.9	9	6.2	68.7	65.3	41.4	-31.125	-104	6.5	2.5	BMAR	≤ 1 arcmin	DLB-25.4-70PM
ø25.4	80	8.5	6.1	80.3	75.9	49.1	-34.867	-110	6	2.5	BMAR	≤ 1 arcmin	DLB-25.4-80PM
ø25.4	100.2	7.7	5.8	100.2	96.5	61.4	-43.253	-138	5.2	2.5	BMAR	≤ 1 arcmin	DLB-25.4-100PM
ø25.4	119.8	7.2	5.6	118.8	116.2	70.182	-52	-181.65	4.7	2.5	BMAR	≤ 1 arcmin	DLB-25.4-120PM
ø25.4	149.6	6.7	5.4	148.6	146.2	86.625	-65	-233.55	4.2	2.5	BMAR	≤ 1 arcmin	DLB-25.4-150PM
ø25.4	170.4	6.4	5.3	169.5	167.1	98	-73.9	-270	3.9	2.5	BMAR	≤ 1 arcmin	DLB-25.4-170PM
ø25.4	200.1	6.1	5.1	199.4	197	111.11	-88.23	-350	3.6	2.5	BMAR	≤ 1 arcmin	DLB-25.4-200PM
ø25.4	222	6	5.1	221.3	218.9	121.93	-98	-400	3.5	2.5	BMAR	≤ 1 arcmin	DLB-25.4-220PM
ø25.4	250.8	5.8	5	250.1	247.7	136.71	-110.4	-460	3.3	2.5	BMAR	≤ 1 arcmin	DLB-25.4-250PM
ø25.4	300	5.6	5	299.8	296.6	146.6	-146.6	-913.9	3.1	2.5	BMAR	≤ 3 arcmin	DLB-25.4-300PM
ø30	50.3	14.1	8.6	47.6	43.5	32.5	-23.395	-62.73	11.1	3	BMAR	≤ 1 arcmin	DLB-30-50PM
ø30	60.3	12.6	8.1	58.4	53.9	36.8	-27.6	-84.3	9.6	3	BMAR	≤ 1 arcmin	DLB-30-60PM
ø30	70.8	11.5	7.7	69	65	43.253	-31.498	-98	8.5	3	BMAR	≤ 1 arcmin	DLB-30-70PM
ø30	80.3	10.7	7.4	78.5	75	49.219	-35.714	-111.11	7.7	3	BMAR	≤ 1 arcmin	DLB-30-80PM
ø30	100.7	9.5	6.8	99.3	96	60.311	-44.45	-146.6	6.5	3	BMAR	≤ 1 arcmin	DLB-30-100PM
ø30	120.1	8.8	6.6	118.8	115.7	71.445	-52.461	-176.758	5.8	3	BMAR	≤ 1 arcmin	DLB-30-120PM
ø30	150	8.1	6.3	148.8	146	88.888	-65	-222.3	5.1	3	BMAR	≤ 1 arcmin	DLB-30-150PM
ø30	169.9	7.7	6.1	168.8	166	98	-74.806	-270	4.7	3	BMAR	≤ 1 arcmin	DLB-30-170PM
ø30	200.2	7.3	6	199.4	196.4	111.11	-88.23	-350	4.3	3	BMAR	≤ 1 arcmin	DLB-30-200PM
ø30	220.2	7.1	5.9	219.4	216.5	121.931	-98	-390.5	4.1	3	BMAR	≤ 1 arcmin	DLB-30-220PM
ø30	249.7	6.9	5.8	248.9	246.1	138	-110.4	-442.977	3.9	3	BMAR	≤ 1 arcmin	DLB-30-250PM
ø30	300.4	6.6	5.7	299.7	296.9	161	-135	-588.8	3.6	3	BMAR	≤ 1 arcmin	DLB-30-300PM
ø30	350	6.4	5.6	349.7	346.2	171	-171	-1067	3.4	3	BMAR	≤ 3 arcmin	DLB-30-350PM
ø30	400	6.2	5.5	399.7	396.3	195.4	-195.4	-1220	3.2	3	BMAR	≤ 3 arcmin	DLB-30-400PM
ø30	450	6.1	5.5	449.8	446.5	219.8	-219.8	-1375	3.1	3	BMAR	≤ 3 arcmin	DLB-30-450PM
ø30	500	6	5.5	499.8	496.5	244.1	-244.1	-1530	3	3	BMAR	≤ 3 arcmin	DLB-30-500PM
ø40	60.2	19.3	11	57.1	50.2	37.408	-29.084	-81.4	16.3	3	BMAR	≤ 1 arcmin	DLB-40-60PM

D	f [mm]	tc [mm]	te [mm]	ff [mm]	fb [mm]	r1 [mm]	r2 [mm]	r3 [mm]	d1 [BK7]	d2 [SF2]	AR	Centration	Part Number
ø40	70.3	17.2	10.2	67.4	61.7	44.45	-32.5	-91.75	14.2	3	BMAR	≤ 1 arcmin	DLB-40-70PM
ø40	80.2	15.8	9.7	78.1	71.8	48.022	-36.8	-117.1	12.8	3	BMAR	≤ 1 arcmin	DLB-40-80PM
ø40	99.9	13.7	8.9	97.9	92.8	60.311	-44.658	-142.95	10.7	3	BMAR	≤ 1 arcmin	DLB-40-100PM
ø40	120	12.3	8.3	118.2	113.7	72.6	-52.915	-171	9.3	3	BMAR	≤ 1 arcmin	DLB-40-120PM
ø40	150.1	10.9	7.7	148.7	144.5	88.23	-66.217	-228.36	7.9	3	BMAR	≤ 1 arcmin	DLB-40-150PM
ø40	169.7	10.3	7.5	168.3	164.5	101.2	-73.9	-249	7.3	3	BMAR	≤ 1 arcmin	DLB-40-170PM
ø40	199.7	9.6	7.2	198.3	194.8	118.3	-86.625	-296.697	6.6	3	BMAR	≤ 1 arcmin	DLB-40-200PM
ø40	220.7	9.2	7	219.4	216	128.238	-95	-340	6.2	3	BMAR	≤ 1 arcmin	DLB-40-220PM
ø40	249.1	8.8	6.9	248	244.6	142.95	-109.004	-400	5.8	3	BMAR	≤ 1 arcmin	DLB-40-250PM
ø40	300.5	8.3	6.7	299.5	296.1	167.7	-131.48	-515.883	5.3	3	BMAR	≤ 1 arcmin	DLB-40-300PM
ø40	349.9	7.9	6.5	349	345.8	195.4	-154	-603.5	4.9	3	BMAR	≤ 1 arcmin	DLB-40-350PM
ø40	399.7	7.6	6.4	398.8	395.7	219.8	-176.758	-720	4.6	3	BMAR	≤ 1 arcmin	DLB-40-400PM
ø40	450	7.4	6.3	449.8	445.5	219.8	-219.8	-1375	4.4	3	BMAR	≤ 3 arcmin	DLB-40-450PM
ø40	500	7.2	6.3	499.8	495.6	244.1	-244.1	-1530	4.2	3	BMAR	≤ 3 arcmin	DLB-40-500PM
ø50	81	22.9	13.4	77.4	69.1	50	-38.5	-111.11	18.9	4	BMAR	≤ 3 arcmin	DLB-50-80PM
ø50	100.5	19.9	12.3	97.8	90	59.892	-46	-148	15.9	4	BMAR	≤ 3 arcmin	DLB-50-100PM
ø50	120.2	17.7	11.4	117.8	111	72.2	-53.9	-173.889	13.7	4	BMAR	≤ 1 arcmin	DLB-50-120PM
ø50	150.7	15.5	10.5	148.6	142.8	90	-66.217	-219.8	11.5	4	BMAR	≤ 1 arcmin	DLB-50-150PM
ø50	169.8	14.5	10.1	167.7	162.5	102.134	-74.59	-245	10.5	4	BMAR	≤ 1 arcmin	DLB-50-170PM
ø50	200.1	13.3	9.6	198.3	193.3	117.628	-88.23	-304.585	9.3	4	BMAR	≤ 1 arcmin	DLB-50-200PM
ø50	220.7	12.7	9.3	218.7	214.5	134	-95	-310.416	8.7	4	BMAR	≤ 1 arcmin	DLB-50-220PM
ø50	249.4	12.1	9.1	247.7	243.4	148	-109.004	-371.43	8.1	4	BMAR	≤ 1 arcmin	DLB-50-250PM
ø50	299.5	11.2	8.7	298	293.7	171	-130.56	-484.627	7.2	4	BMAR	≤ 1 arcmin	DLB-50-300PM
ø50	350.2	10.7	8.6	348.9	344.5	195.4	-154	-603.5	6.7	4	BMAR	≤ 1 arcmin	DLB-50-350PM
ø50	400	10.2	8.3	398.8	394.7	222.3	-176.758	-700	6.2	4	BMAR	≤ 1 arcmin	DLB-50-400PM
ø50	451.5	9.9	8.3	450.5	446.2	245	-201.577	-849.781	5.9	4	BMAR	≤ 1 arcmin	DLB-50-450PM
ø50	500.3	9.6	8.1	499.3	495.2	273.415	-222.3	-920	5.6	4	BMAR	≤ 1 arcmin	DLB-50-500PM
ø50	599.9	9.2	8	599.6	594.4	292.9	-292.9	-1835	5.2	4	BMAR	≤ 1 arcmin	DLB-50-600PM
ø50	700	8.9	7.8	699.7	694.6	341.8	-341.8	-2140	4.9	4	BMAR	≤ 1 arcmin	DLB-50-700PM
ø50	800	8.6	7.7	799.7	794.9	390.5	-390.5	-2450	4.6	4	BMAR	≤ 3 arcmin	DLB-50-800PM
ø50	1000	8.3	7.6	999.6	995	488.2	-488.2	-3060	4.3	4	BMAR	≤ 3 arcmin	DLB-50-1000PM
ø50.8	100.5	19.9	12.1	103.5	90	59.892	-46	-148	15.9	4	BMAR	≤ 1 arcmin	DLB-50.8-100PM
ø50.8	120.2	17.7	11.2	117.8	111	72.2	-53.9	-173.889	13.7	4	BMAR	≤ 1 arcmin	DLB-50.8-120PM
ø50.8	150.7	15.5	10.4	152.2	142.8	90	-66.217	-219.8	11.5	4	BMAR	≤ 1 arcmin	DLB-50.8-150PM
ø50.8	200.1	13.3	9.5	201.1	193.3	117.628	-88.23	-304.585	9.3	4	BMAR	≤ 1 arcmin	DLB-50.8-200PM
ø50.8	249.4	12.1	9	249.9	243.4	148	-109.004	-371.43	8.1	4	BMAR	≤ 1 arcmin	DLB-50.8-250PM
ø50.8	299.5	11.2	8.6	298	293.7	171	-130.56	-484.627	7.2	4	BMAR	≤ 1 arcmin	DLB-50.8-300PM
ø50.8	400	10.2	8.3	398.8	394.7	222.3	-176.758	-700	6.2	4	BMAR	≤ 1 arcmin	DLB-50.8-400PM
ø50.8	500.3	9.6	8.1	499.3	495.2	273.415	-222.3	-920	5.6	4	BMAR	≤ 1 arcmin	DLB-50.8-500PM
ø50.8	700	8.9	7.8	699.7	694.6	341.8	-341.8	-2140	4.9	4	BMAR	≤ 3 arcmin	DLB-50.8-700PM
ø50.8	1000	8.3	7.5	999.6	995.1	488.2	-488.2	-3060	4.3	4	BMAR	≤ 3 arcmin	DLB-50.8-1000PM
ø60	170.8	17.7	11.4	168.1	161.9	105.44	-75	-233.55	13.7	4	BMAR	≤ 1 arcmin	DLB-60-170PM
ø60	200.3	16.1	10.7	198.1	192.1	120	-88.23	-292.359	12.1	4	BMAR	≤ 1 arcmin	DLB-60-200PM
ø60	250	14.3	10	247.9	242.8	150	-109.21	-363.3	10.3	4	BMAR	≤ 1 arcmin	DLB-60-250PM
ø60	499.1	10.7	8.6	497.9	493.5	276	-219.8	-883	6.7	4	BMAR	≤ 1 arcmin	DLB-60-500PM
ø60	598.6	10.1	8.3	597.4	593.2	330.322	-265	-1067	6.1	4	BMAR	≤ 1 arcmin	DLB-60-600PM
ø80	149.7	30.3	17.2	145.6	133.6	90.372	-68.287	-214	25.3	5	BMAR	≤ 1 arcmin	DLB-80-150PM
ø80	200.8	24.3	14.7	197.3	188.2	121.931	-88.23	-282.2	19.3	5	BMAR	≤ 1 arcmin	DLB-80-200PM
ø80	299.8	18.8	12.4	297.1	290.2	179.6	-130.56	-435.54	13.8	5	BMAR	≤ 1 arcmin	DLB-80-300PM
ø80	502.6	14.5	10.7	500.9	494.9	282.2	-219.8	-849.781	9.5	5	BMAR	≤ 1 arcmin	DLB-80-500PM
ø80	800.6	12.1	9.7	799.3	794.2	435.54	-358	-1500	7.1	5	BMAR	≤ 1 arcmin	DLB-80-800PM
ø100	200.6	37	31.8	195.6	181	120	-90.372	-290.929	30	7	BMAR	≤ 1 arcmin	DLB-100-200PM
ø100	297.3	28	18	293	283.2	181.65	-130.56	-415.2	21	7	BMAR	≤ 1 arcmin	DLB-100-300PM
ø100	499.6	21.1	15.2	496.8	488.8	290.929	-219.8	-778.5	14.1	7	BMAR	≤ 1 arcmin	DLB-100-500PM
ø100	799.5	17.4	13.7	797.5	790.4	442.977	-350	-1400	10.4	7	BMAR	≤ 1 arcmin	DLB-100-800PM
ø100	998.1	16.1	13.1	996.4	989.7	544.2	-441.2	-1840	9.1	7	BMAR	≤ 1 arcmin	DLB-100-1000PM

PRECISION OPTICAL FLAT MIRRORS

- UV Enhanced Aluminum Rave > 85% 250-600 nm
- Protected Aluminum Ravg > 90% 400 nm - 10 μm
- Average Reflection >95% from 800 to 10 μm

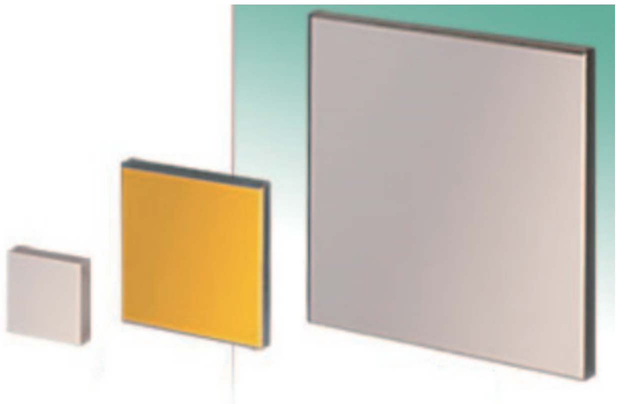
1/20 Wave Precision Mirrors					Model No.			
Diameter(in)	Diameter tolerance(in)	Thickness(in)	Thickness tolerance(in)	Material	Uncoated	Protected Aluminum	Enhanced Aluminum	Protected Gold
0.5	±0.02	0.13	±0.03	Fused silica	BFM10U	BFM10A	BFM10AE	BFM10G
0.5	±0.02	0.13	±0.03	Zerodur	BZM10U	BZM10A	BZM10AE	BZM10G
1.0	±0.04	0.50	±0.06	Fused silica	BFM11U	BFM11A	BFM11AE	BFM11G
1.0	±0.04	0.50	±0.06	Zerodur	BZM11U	BZM11A	BZM11AE	BZM11G
2.0	±0.04	0.50	±0.06	Fused silica	BFM12U	BFM12A	BFM12AE	BFM12G
2.0	±0.04	0.50	±0.06	Zerodur	BZM12U	BZM12A	BZM12AE	BZM12G

1/10 Wave Precision Mirrors					Model No.			
Diameter(in)	Diameter tolerance(in)	Thickness(in)	Thickness tolerance(in)	Material	Uncoated	Protected Aluminum	Enhanced Aluminum	Protected Gold
0.5	±0.02	0.13	±0.03	Fused silica	BFM20U	BFM20A	BFM20AE	BFM20G
0.5	±0.02	0.13	±0.03	Zerodur	BZM20U	BZM20A	BZM20AE	BZM20G
1.0	±0.04	0.50	±0.06	Fused silica	BFM21U	BFM21A	BFM21AE	BFM21G
1.0	±0.04	0.50	±0.06	Zerodur	BZM21U	BZM21A	BZM21AE	BZM21G
2.0	±0.04	0.50	±0.06	Fused silica	BFM22U	BFM22A	BFM22AE	BFM22G
2.0	±0.04	0.50	±0.06	Zerodur	BZM22U	BZM22A	BZM22AE	BZM22G
3.0	±0.04	0.75	±0.06	Fused silica	BFM23U	BFM23A	BFM23AE	BFM23G
3.0	±0.04	0.75	±0.06	Zerodur	BZM23U	BZM23A	BZM23AE	BZM23G
4.0	±0.04	0.75	±0.06	Fused silica	BFM24U	BFM24A	BFM24AE	BFM24G
4.0	±0.04	0.75	±0.06	Zerodur	BZM24U	BZM24A	BZM24AE	BZM24G
6.0	±0.04	1.00	±0.08	Fused silica	BFM26U	BFM26A	BFM26AE	BFM26G
6.0	±0.04	1.00	±0.08	Zerodur	BZM26U	BZM26A	BZM26AE	BZM26G
8.0	±0.04	1.50	±0.10	Fused silica	BFM28U	BFM28A	BFM28AE	BFM28G
8.0	±0.04	1.50	±0.10	Zerodur	BZM28U	BZM28A	BZM28AE	BZM28G

1/4 Wave Precision Mirrors					Model No.			
Diameter(in)	Diameter tolerance(in)	Thickness(in)	Thickness tolerance(in)	Material	Uncoated	Protected Aluminum	Enhanced Aluminum	Protected Gold
0.5	±0.02	0.13	±0.03	Fused silica	BFM30U	BFM30A	BFM30AE	BFM30G
0.5	±0.02	0.13	±0.03	Zerodur	BZM30U	BZM30A	BZM30AE	BZM30G
1.0	±0.04	0.50	±0.06	Fused silica	BFM31U	BFM31A	BFM31AE	BFM31G
1.0	±0.04	0.50	±0.06	Zerodur	BZM31U	BZM31A	BZM31AE	BZM31G
2.0	±0.04	0.50	±0.06	Fused silica	BFM32U	BFM32A	BFM32AE	BFM32G
2.0	±0.04	0.50	±0.06	Zerodur	BZM32U	BZM32A	BZM32AE	BZM32G
3.0	±0.04	0.75	±0.06	Fused silica	BFM33U	BFM33A	BFM33AE	BFM33G
3.0	±0.04	0.75	±0.06	Zerodur	BZM33U	BZM33A	BZM33AE	BZM33G
4.0	±0.04	0.75	±0.06	Fused silica	BFM34U	BFM34A	BFM34AE	BFM34G
4.0	±0.04	0.75	±0.06	Zerodur	BZM34U	BZM34A	BZM34AE	BZM34G
6.0	±0.04	1.00	±0.08	Fused silica	BFM36U	BFM36A	BFM36AE	BFM36G
6.0	±0.04	1.00	±0.08	Zerodur	BZM36U	BZM36A	BZM36AE	BZM36G
8.0	±0.04	1.50	±0.10	Fused silica	BFM38U	BFM38A	BFM38AE	BFM38G
8.0	±0.04	1.50	±0.10	Zerodur	BZM38U	BZM38A	BZM38AE	BZM38G

METALLIC MIRRORS

- Protected Gold: Ravg > 95 % from 800 nm - 10 µm
- Protected Silver: Ravg > 96% from 400-700 nm;
  Ravg > 97.5% from 700 nm -2.0 µm
- Protected Aluminum: Ravg > 90% from 400 nm -10 µm



Dimensions(mm)	Thickness(mm)	Model No. Enhanced Aluminum	Model No. UV Enhanced Aluminum	Model No. Protected Gold
10 Dia.	2	BPM20A	BPM20UV	BPM20G
10*10	2	BPM21A	BPM21UV	BPM21G
12.5 Dia	2	BPM22A	BPM22UV	BPM22G
15*15	2	BPM23A	BPM23UV	BPM23G
20*20	2	BPM24A	BPM24UV	BPM24G
25 Dia	3	BPM25A	BPM25UV	BPM25G
25*25	6	BPM26A	BPM26UV	BPM26G
50 Dia.	4	BPM27A	BPM27UV	BPM27G
50*50	10	BPM28A	BPM28UV	BPM28G
75*75	12	BPM29A	BPM29UV	BPM29G
100*100	15	BPM210A	BPM210UV	BPM210G

Specification	
Substrate	BK7
Dimensional Tolerance	±0.25mm
Thickness Tolerance	±0.25mm
Surface Accuracy	1/4 λ at 632.8nm
Surface Quality	60-40
Reflectivity	85% @ 400-700nm
Clear Aperture	85%

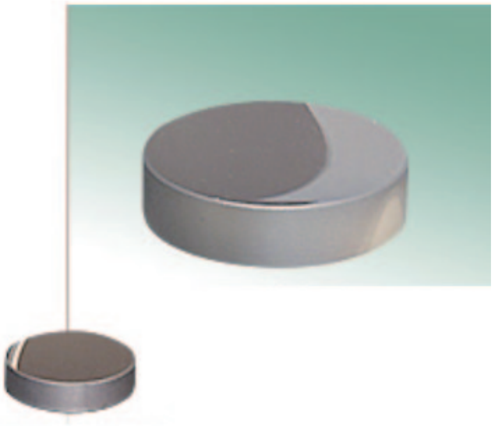
Low Cost Aluminum Mirrors

Model No.	Diameter(mm)	Thickness(mm)
BM01	25	4.0
BM02	50	10.0

CHAPTER 4 PHOTONICS

PRECISION SPHERICAL MIRRORS

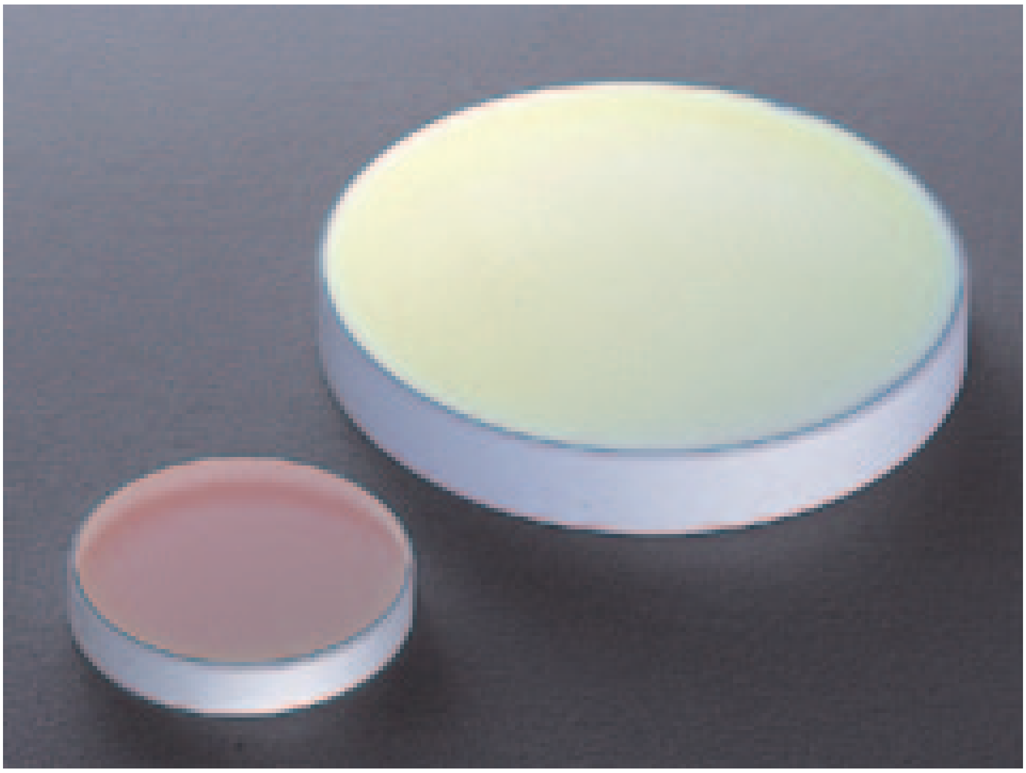
- No Chromatic Aberration Introduced
- Aluminum, Silver, or Gold Coating



PRECISION 1/4 wave SPHERICAL MIRRORS					Model No.				
Diameter(in)	Diameter tolerance(in)	Focal length(in)	f/#	Edge thickness(in)	Uncoated	Protected Aluminum	UV Enhanced Aluminum	Enhanced Aluminum	Protected Gold
1.00	+0/-0.01	1.0	1	0.25	BSM101U	BSM101A	BSM101UV	BSM101AE	BSM101G
1.00	+0/-0.01	2.0	2	0.25	BSM102U	BSM102A	BSM102UV	BSM102AE	BSM102G
1.00	+0/-0.01	3.0	3	0.25	BSM103U	BSM103A	BSM103UV	BSM103AE	BSM103G
1.00	+0/-0.01	4.0	4	0.25	BSM104U	BSM104A	BSM104UV	BSM104AE	BSM104G
2.00	+0.02/-0	2.0	1	0.50	BSM202U	BSM202A	BSM202UV	BSM202AE	BSM202G
2.00	+0.02/-0	4.0	2	0.50	BSM204U	BSM204A	BSM204UV	BSM204AE	BSM204G
2.00	+0.02/-0	12.0	6	0.50	BSM212U	BSM212A	BSM212UV	BSM212AE	BSM212G
2.00	+0.02/-0	20.0	10	0.50	BSM220U	BSM220A	BSM220UV	BSM220AE	BSM220G
2.00	+0.02/-0	40.0	20	0.50	BSM240U	BSM240A	BSM240UV	BSM240AE	BSM240G
3.00	+0.04/-0	3.0	1	0.50	BSM303U	BSM303A	BSM303UV	BSM303AE	BSM303G
3.00	+0.04/-0	6.0	2	0.50	BSM306U	BSM306A	BSM306UV	BSM306AE	BSM306G
3.00	+0.04/-0	8.0	2.7	0.50	BSM308U	BSM308A	BSM308UV	BSM308AE	BSM308G
3.00	+0.04/-0	18.0	6	0.50	BSM318U	BSM318A	BSM318UV	BSM318AE	BSM318G
3.00	+0.04/-0	30.0	10	0.50	BSM330U	BSM330A	BSM330UV	BSM330AE	BSM330G
5.00	+0.06/-0	4.0	0.8	0.90	BSM504U	BSM504A	BSM504UV	BSM504AE	BSM504G
6.00	+0.06/-0	6.0	1	1.0	BSM606U	BSM606A	BSM606UV	BSM606AE	BSM606G
6.00	+0.06/-0	12.0	2	1.0	BSM612U	BSM612A	BSM612UV	BSM612AE	BSM612G
6.00	+0.06/-0	24.0	4	1.0	BSM624U	BSM624A	BSM624UV	BSM624AE	BSM624G
6.00	+0.06/-0	36.0	6	1.0	BSM636U	BSM636A	BSM636UV	BSM636AE	BSM636G
6.00	+0.06/-0	60.0	10	1.0	BSM660U	BSM660A	BSM660UV	BSM660AE	BSM660G
8.00	+0.06/-0	24.0	3	1.37	BSM824U	BSM824A	BSM824UV	BSM824AE	BSM824G

PRECISION 1/8 wave SPHERICAL MIRRORS					Model No.				
Diameter(in)	Diameter tolerance(in)	Focal length(in)	f/#	Edge thickness(in)	Edge thickness tolerance(in)	Uncoated Aluminum	Protected Aluminum	Enhanced Gold	Protected
2.50	+0.04/-0	25	10.0	0.38	+0/-0.05	BSM25U	BSM25A	BAM25AE	BSM25G
3.00	+0.04/-0	30	10.0	0.5	+0/-0.05	BSM30U	BSM30A	BAM30AE	BSM30G
4.25	+0.02/-0	45	10.6	0.75	+0/-0.07	BSM43U	BSM43A	BAM43AE	BSM43G
6.00	+0.06/-0	60	10.0	1.00	+0/-0.10	BSM60U	BSM60A	BAM60AE	BSM60G

GAS LASER MIRROR



Laser	Wavelength
Argon-Ion	488-515nm
Argon-Ion	458-529nm
Argon-Ion	351-364nm
Argon-Ion	244-257nm
Copper Vapor	511/578nm
HeCd	442nm
HeCd	325nm
HeNe	633nm
Iodine	1315nm
Nitrogen	337nm

Diameter	Thickness
0.500”	0.375”
15.0mm	11.0mm
0.750”	0.375”
1.000”	0.250”
1.000”	8.0mm
1.000”	0.375”
1.500”	0.375”
2.000”	0.375”
3.000”	0.500”
4.000”	0.500”

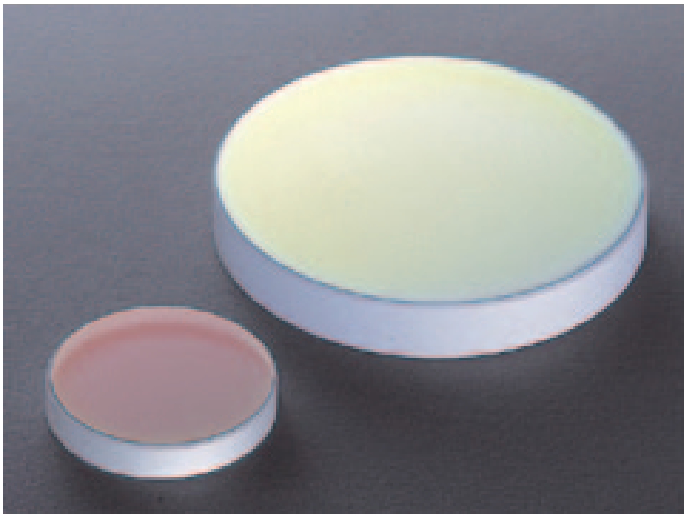
Specifications	
Substrate Material	UV grade fused silica or BK7
S1 Surface Figure	λ/10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%
Clear Aperture	Exceeds central 85% of dimension

Radius m					
0.010	0.025	0.050	0.075	0.15	0.20
0.25	0.30	0.50	0.75	1.00	1.20
1.50	2.00	3.00	4.00	5.00	6.00
7.00	8.00	9.00	10.0	15.0	20.0

Incidence Angle Degrees	
0	45

Polarization		
S	P	UNP

HIGH ENERGY TUNABLE LASER MIRROR



Specifications	
Substrate Material	UV grade fused silica or BK7 glass
S1 Surface Figure	λ/10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Bandwidth Tolerance	+0%,-10% typical
λc Tolerance	± 3%
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%

Centerr Wavelength(nm)	Bandwidth (nm) R > 99% 0°	Bandwidth (nm) R > 99% 45°S	Bandwidth (nm) R > 99% 45°P
190	10*	12*	–
210	15*	18*	–
230	18*	22*	–
250	35	43	20
300	42	50	22
350	46	59	28
400	50	64	31
450	54	70	35
500	60	75	40
550	65	82	44
600	68	90	48
650	72	96	50
700	77	102	55
750	83	108	60
800	88	110	64
900	93	116	68
950	95	119	70
1000	98	122	73
1050	100	125	76
1100	103	128	78
1150	105	131	81
1200	108	134	83
1250	110	138	85
1300	113	141	87
1350	115	144	89
1400	118	147	91
1450	120	150	92
1500	123	153	93

*R > 97%

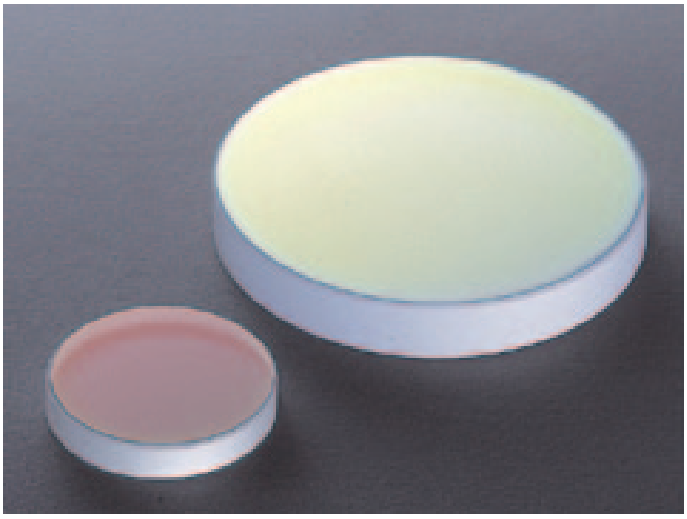
Center Wavelength nm					
190	210	230	250	300	350
400	450	500	550	600	650
700	750	800	850	900	950
1000	1050	1100	1150	1200	1250
1300	1350	1400	1500		

Incidence Angle Degrees with Polarization			
0	45P	45S	45UNP

Size Code	Diameter	Thickness
0537	0.500”	0.375”
0643	15.0mm	11.0mm
0737	0.750”	0.375”
1025	1.000”	0.250”
1032	1.000”	8.0mm
1037	1.000”	0.375”
1537	1.500”	0.375”
2037	2.000”	0.375”
3050	3.000”	0.500”
4050	4.000”	0.500”

Radius m							
0.010	0.025	0.050	0.075	0.15	0.20	0.25	0.30
0.50	0.75	1.00	1.20	1.50	2.00	3.00	4.00
5.00	6.00	7.00	8.00	9.00	10.0	15.0	20.0

BROADBAND TUNABLE LASER MIRROR



Specifications	
Substrate Material	BK7 glass
S1 Surface Figure	λ/10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Bandwidth Tolerance	+0%,-10% typical
λ c Tolerance	± 3%
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%

Center Wavelength (nm)					
450	500	550	600	650	700
750	800	850	900	950	1000
1100	1200	1300	1400	1500	

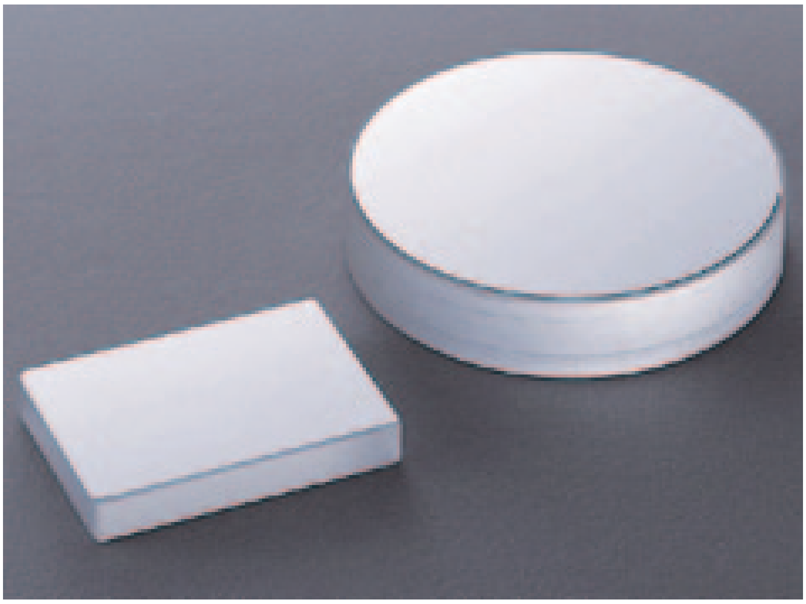
Incidence Angle Degrees with Polarization			
0	45P	45S	45UNP

Size Code	Diameter	Thickness
0316	7.75mm	4.0mm
0537	0.500”	0.375”
0643	15.0mm	11.0mm
0737	0.750”	0.375”
1025	1.000”	0.250”
1037	1.000”	0.375”
1537	1.500”	0.375”
2037	2.000”	0.375”
3050	3.000”	0.500”
4050	4.000”	0.500”

Wavelength Center (nm)	Bandwidth (nm) R > 99% 0°	Bandwidth (nm) R > 99% 45°S	Bandwidth (nm) R > 99% 45°P
450	90	113	45
500	100	125	50
550	110	138	55
600	120	150	60
650	130	163	65
700	140	175	70
750	150	188	75
800	156	197	76
850	161	204	76
900	167	212	77
950	171	219	77
1000	180	230	80
1100	193	248	83
1200	210	264	90
1300	221	280	91
1400	238	294	98
1500	255	315	105

Radius m					
0.010	0.025	0.050	0.075	0.15	0.20
0.25	0.30	0.50	0.75	1.00	1.20
1.50	2.00	3.00	4.00	5.00	6.00
7.00	8.00	9.00	10.0	15.0	20.0

EXCIMER LASER MIRROR



Laser	Wavelength
ArF	193nm
KrF	248nm
XeC	308nm
XeF	351-353nm

Size Code	Diameter	Thickness
0537	0.500"	0.375"
0643	15.0mm	11.0mm
0737	0.750"	0.375"
1025	1.000"	0.250"
1032	1.000"	8.0mm
1037	1.000"	0.375"
1537	1.500"	0.375"
2037	2.000"	0.375"
3050	3.000"	0.500"
4050	4.000"	0.500"

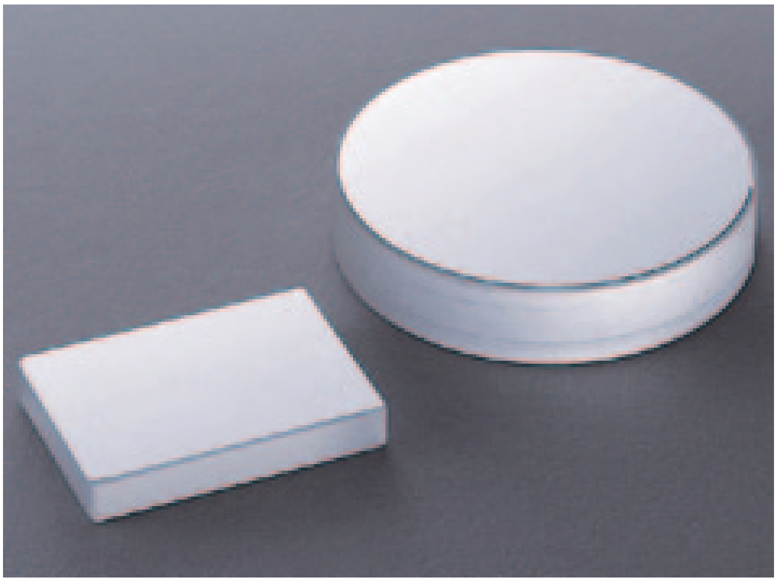
Incidence Angle Degrees with Polarization	
0	45

Polarization		
S	P	UNP

Specifications	
Substrate Material	UV grade fused silica
S1 Surface Figure	λ/10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	< 0.05mm
Radius Tolerance	±0.5%

Radius m					
0.010	0.025	0.050	0.075	0.15	0.20
0.25	0.30	0.50	0.75	1.00	1.2
1.50	2.00	3.00	4.00	5.00	6.00
7.00	8.00	9.00	10.0	15.0	20.0

VACUUM UV AND DEEP UV ALUMINUM MIRROR



- VUVA has highest 157nm Al reflectance available
- DUVA has highest 193nm Al reflectance available
- Applications include thin film ellipsometry, semicon ductor metrology, and semiconductor lithography

Boadband VUVA and DUVA mirrors provide significantly higher 157nm and 193nm reflectance and durability than standard UV protected Al mirrors

Specifications	
Substrate Material	UV grade fused silica
S1 Surface Figure	λ /10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Reflectance	VUVA:R > 80% at 157nm DUVA:R > 90-92% at 193nm, R > 85% at 400-1200nm
Clear Aperture	Exceeds central 85% of dimension

Vacuum UV Aluminum Mirror

Diameter	Thickness
10.00mm	2.00mm
0.500"	0.250"
1.000"	0.250"
30.00mm	6.0mm
1.500"	0.375"
50.00mm	0.375"
2.000"	0.375"

Deep UV Aluminum Mirror

Diameter	Thickness
10.00mm	2.00mm
0.500"	0.250"
1.000"	0.250"
30.00mm	6.0mm
1.500"	0.375"
50.00mm	0.375”
2.000"	0.375"

HIGH ENERGY PARTIALLY REFLECTING LASER MIRROR

SPECIFICATION	
Substrate Material	UV grade fused silica, BK7, or CaF2
Surface Figure	λ/10 typical at 633nm
Transmitted Wavefront	λ/10 typical at 633nm
Surface Quality	10-5 laser quality
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45otypical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%
Coating Technology	Electron beam multilayer dielectric
Adhesion and Durability	Per MIL-C-675A. Insoluble in lab solvents.

Center Wavelength nm			
193	213	244/257	248
266	308	337	355
364	488/515	527	532
589	633	670	691
755	780	800	830
850	940	1053	1047,1053
1064	1235	1319	1550
2010	2100	2940	

Reflectance %			
10±3.0	20±4.0	30±5.0	40±5.0
50±5.0	60±4.0	70±4.0	75±4.0
80±3.0	90±2.0	95±1.5	98±1.0
99±0.5			

Size code	Diameter	Thickness
0512	0.500”	0.125”
0525	0.500”	0.250”
0537	0.500”	0.375”
0643	15.0mm	11.0mm
0725	0.750”	0.250”
0737	0.750”	0.375”
1012	1.000”	0.125”
1025	1.000”	0.250”
1037	1.000”	0.375”
1525	1.500”	0.250”
1537	1.500”	0.375”
2025	2.000”	0.250”
2037	2.000”	0.375”
3050	3.000”	0.500”
4050	4.000”	0.500”

Radius m			
0.010	0.025	0.050	0.075
0.15	0.20	0.25	0.30
0.50	0.75	1.00	1.20
1.50	2.00	3.00	4.00
5.00	6.00	7.00	8.00
9.00	10.0	15.0	20.0

HIGH ENERGY Nd:YAG LASER MIRROR

Laser	Wavelength
Nd:YAG	1064nm
Nd:YAG	532nm
Nd:YAG	355nm
Nd:YAG	266nm
Nd:YAG	213nm
Nd:YAG	1319nm

diameter	Thickness
0.500”	0.375”
15.0mm	11.0mm
0.750”	0.375”
1.000”	0.250”
1.000”	8.0mm
1.000”	0.375”
1.500”	0.375”
2.000”	0.375”
3.000”	0.500”
4.000”	0.500”

Radius m					
0.010	0.025	0.050	0.075	0.15	0.20
0.25	0.30	0.50	0.75	1.00	1.2
1.50	2.00	3.00	4.00	5.00	6.00
7.00	8.00	9.00	10.0	15.0	20.0

Specifications	
Substrate Material	BK7 glass
S1 Surface Figure	λ/10 typical at 633nm
S1 Surface Quality	10-5 laser quality
S2 Surface Quality	Commercial polish
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%
Clear Aperture	Exceeds central 85% of diameter
Damage Threshold	20J/cm2, 8nsec pulse; 1MW/cm2, CW at 1064nm typical. Contact Onset for damage certification up to 40J/cm2.
Coated Surface Figure	λ/10 at 633nm over 85% of diameter available

Incidence Angle Degrees with Polarization	
0	45

Polarization		
S	P	UNP

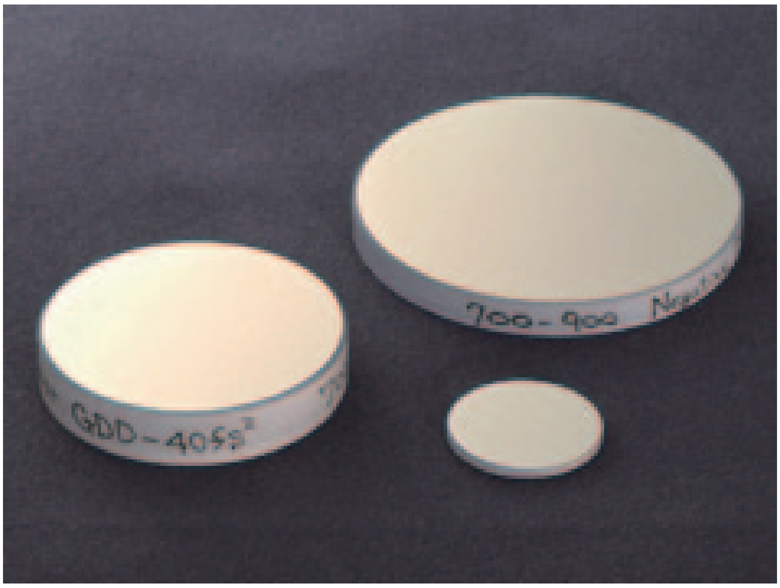
OFF-AXIS PARABOLIC MIRROR

- 30°,60°, or 90° Off-Axis Reflectors
- Aluminum Substrates

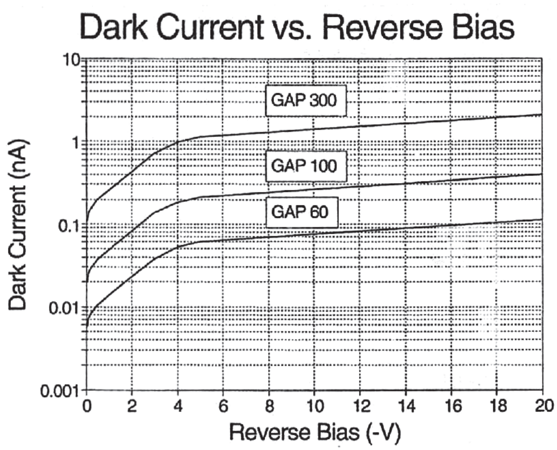
Off-axis parabolic mirrors are only a section of the parabola form. these mirrors direct and focus incident collimated light at a specific angle, allowing unrestricted access to the focal point. Typically used as collimators in Schlieren and MTF systems, our gold coated off-axis parabolic mirrors can also be used in FLIR test systems. Mirrors have three 6-32 TPI tapped holes (on 3/4" Bolt Circle for 25.4mm Dia, 1.25" Bolt Circle for 50.8mm) for easy, accurate mounting. Mounting plates sold separately.

Model No.	Type	Dia. (mm)	Parent FL (mm)	E.F.L. (mm)	Y Offset (mm)	Size A (mm)	Size B (mm)	Coating (mm)
BOP123A	30° Off-Axis	25.4	50.8	54.45	27.22	13.2	56.13	Protected Aluminum
BOP223A	30° Off-Axis	50.8	50.8	54.45	27.22	20.06	57.15	Protected Aluminum
BOP243A	30° Off-Axis	50.8	101.6	108.89	54.45	20.06	105.92	Protected Aluminum
BOP243G	30° Off-Axis	50.8	101.6	108.89	54.45	20.06	105.92	Protected Gold
BOP223G	30° Off-Axis	50.8	50.8	54.45	27.22	20.06	57.15	Protected Gold
BOP123G	30° Off-Axis	25.4	50.8	54.45	27.22	13.2	56.13	Protected Gold
BOP116A	60° Off-Axis	25.4	25.4	33.85	29.33	21.08	29.96	Protected Aluminum
BOP126A	60° Off-Axis	25.4	38.1	50.8	43.99	21.08	38.1	Protected Aluminum
BOP126G	60° Off-Axis	25.4	38.1	50.8	43.99	21.08	38.1	Protected Gold
BOP116G	60° Off-Axis	25.4	25.4	33.85	29.33	21.08	28.96	Protected Gold
BOP119A	90° Off-Axis	25.7	12.7	25.4	25.4	31.75	15.75	Protected Aluminum
BOP129A	90° Off-Axis	25.4	25.4	50.8	508	31.75	17.53	Protected Aluminum
BOP149A	90° Off-Axis	25.4	50.8	101.6	101.6	31.75	18.29	Protected Aluminum
BOP239A	90° Off-Axis	50.8	38.1	76.2	76.2	57.15	27.43	Protected Aluminum
BOP249A	90° Off-Axis	50.8	50.8	101.6	101.6	57.15	28.45	Protected Aluminum
BOP269A	90° Off-Axis	50.8	76.2	152.4	152.4	57.15	29.72	Protected Aluminum
BOP229A	90° Off-Axis	50.8	25.4	50.8	50.8	57.15	25.4	Protected Aluminum
BOP239G	90° Off-Axis	50.8	38.1	76.2	76.2	57.15	27.43	Protected Gold
BOP269G	90° Off-Axis	50.8	76.2	152.4	152.4	57.15	29.72	Protected Gold
BOP249G	90° Off-Axis	50.8	50.8	101.6	101.6	57.15	28.45	Protected Gold
BOP149G	90° Off-Axis	25.4	50.8	101.6	101.6	31.75	18.29	Protected Gold
BOP229G	90° Off-Axis	50.8	25.4	50.8	50.8	57.15	25.4	Protected Gold
BOP129G	90° Off-Axis	25.4	25.4	50.8	50.8	31.75	17.53	Protected Gold
BOP119G	90° Off-Axis	25.4	12.7	25.4	25.4	31.75	15.75	Protected Gold

NEGATIVE GROUP VELOCITY DISPERSION MIRRORS



- Low loss, prismless chirp compensation for femtosecond laser systems
- Peak correction of -100fsec^2/ bounce

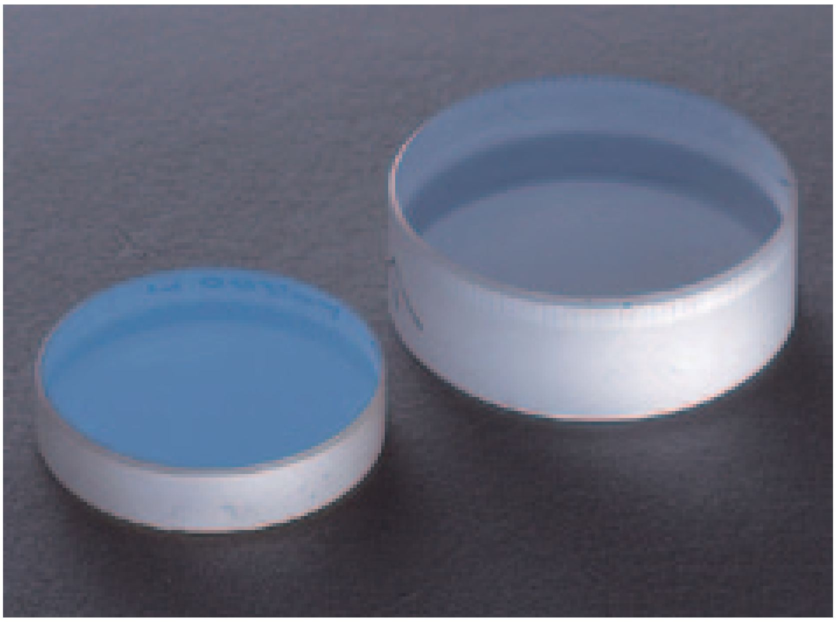


Measured group velocity dispersion of a TNM2 Series mirror.

Specifications	
Substrate Material	BK7 glass
Surface Figure	λ/10 typical at 633nm
Surface Quality	10-5 laser quality
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Concentricity	≤ 0.05mm
Radius Tolerance	± 0.5%
Clear Aperture	Exceeds central 85% of dimension
Angle of Incidence	0-20o
Damage Threshold	100J/cm2, 80 fsec pulse at 800nm typical

Wavelength Range(nm)	Reflectivity	Diameter	Thickness	Radius of Curvature
735-835	R >99.8%	0.50”	0.375"	Flat
735-835	R >99.8%	0.50”	0.375"	0.05mCC
735-835	R >99.8%	0.50”	0.375"	0.10mCC
735-835	R >99.8%	0.50”	0.375"	0.50mCC
735-835	R >99.8%	0.50”	0.375"	1.00mCC
735-835	R >99.8%	0.50”	0.375"	2.00mCC
735-835	R >99.8%	0.50”	0.375"	4.00mCC
735-835	R >99.8%	1.00”	0.375"	Flat
735-835	R >99.8%	1.00"	0.375"	0.05mCC
735-835	R >99.8%	1.00"	0.375"	0.10mCC
735-835	R >99.8%	1.00"	0.375"	0.50mCC
735-835	R >99.8%	1.00"	0.375"	1.00mCC
735-835	R >99.8%	1.00"	0.375"	2.00mCC
735-835	R >99.8%	1.00"	0.375"	4.00mCC

ETALON



Solid Etalons

Diameter(mm)	Thickness(mm)	Free Spectral Range at 600 nm (cm-1)
25.4	0.25	13.4
25.4	0.30	11.2
25.4	0.50	6.7
25.4	0.70	4.8
25.4	1.00	3.4
25.4	1.50	2.2
25.4	2.00	1.7
25.4	3.00	1.1
25.4	4.00	0.84
25.4	5.00	0.67
25.4	6.00	0.56
25.4	7.00	0.48
25.4	8.00	0.42
25.4	10.00	0.34
25.4	10.50	0.32
25.4	15.00	0.22

Specifications	
Substrate Material	UV grade fused silica
Surface Quality	10-5 laser quality
Transmitted Wavefront	λ/10 typical at 633nm
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	≤ 0.50mm T ± 25%
	> 0.50mm T ± 0.25mm
Wedge	≤ 1 second
Chamfer	0.35 mm at 45o typical
Reflectance	User specified
Center Wavelength	User specified
Clear Aperture	Exceeds central 85% of dimension
Damage Threshold	10J/cm2, 8nsec pulse; 1MW/cm2, CW at 1064nm typical

Air-Spaced Etalons

Clear Aperture Diameter	Mount Diameter mm
20	44.5
25	47.6
30	50.8

Air-Gap µm	Clear Aperture Diameter	Mount Diameter mm
25	50	100
150	250	500
1000		

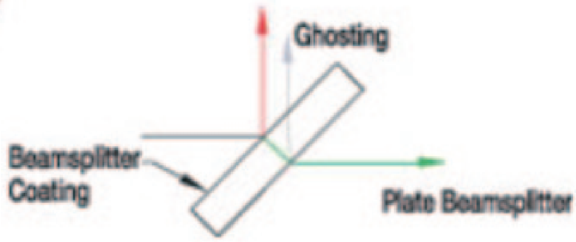
Specifications	
Substrate Material	UV grade fused silica
Surface Quality	10-5 laser quality
Spacer Thickness	25µm - 10mm
Center Wavelength	User specified from 190-2500nm
Damage Threshold	10J/cm2, 8nsec pulse; 1064nm typical

Reflectance %				
30	40	60	74	82
86	90	93	95	97

Wavelength nm		
193	248	308
488/515	1047	1064

PLATE BEAMSPLITTER

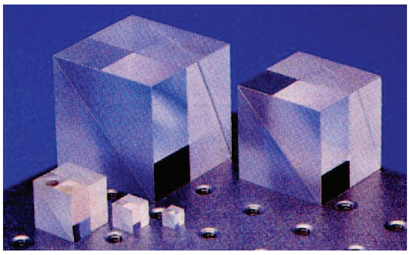
- UV Fused Silica Substrate
- Ø1/2" (12.7), Ø1" (25.4 mm), & Ø2" (50.8 mm) Size
- 250-450 nm, 400-700 nm, 700-1100 nm, or 1200-1600 nm Beamsplitter Coating for 45° Incidence



Model Dimensions	Ø1/2" (12.7 mm) thickness = 3 mm	Ø1" (25.4 mm) thickness = 5 mm	Ø2" (50.8 mm) thickness = 8 mm
		Item Number	
Wavelength Range 250-450 nm	BSW19	BSW20	BSW21
Wavelength Range 400-700 nm	BSW04	BSW10	BSW16
Wavelength Range 700-1100 nm	BSW05	BSW11	BSW17
Wavelength Range 1200-1600 nm	BSW06	BSW12	BSW18
Substrate	UV Fused Silica		
Flatness	λ /10 @ 635 nm Over the Clear Aperture		
Diameter Tolerance	+0.0 mm / -0.2 mm		
Center Thickness Tolerance	±0.4 mm		
Clear Aperture	>90% of Central Diameter		
Coating on Surface 1	Beamsplitter Coating for 45° Incidence		
Coating on Surface 2	Broadband AR Coating R<1% within Wavelength Range		
Splitter Ratio Tolerance (250-450 nm)	±10% Over Wavelength Range, |Ts-Tp|<40% and |Rs-Rp|<40%		
Splitter Ratio Tolerance (400-700 nm)	±8% Over Entire Wavelength Range, |Ts-Tp|<35% and |Rs-Rp|<35%		
Splitter Ratio Tolerance (700-1100 nm)	±5% Over Entire Wavelength Range, |Ts-Tp|<35% and |Rs-Rp|<35%		
Splitter Ratio Tolerance (1200-1600 nm)	±5% Over Entire Wavelength Range, |Ts-Tp|<15% and |Rs-Rp|<15%		
Durability	MIL-M-13508C, MIL-C-675C, MIL-C-14806		
Surface Quality	20/10 Scratch/Dig		

CUBE BEAMSPLITTERS

Standard Cube Beamsplitters



Specification	
Material	BK7
Surface Accuracy	2λ
Surface Quality	60-40
Bevel	0.3mm x 45°
Coating	
Outside Surfaces:	1/4 λ MgF_2
Hypotenuse:	multilayer dielectric coated
Transmission	50% ±5% @ 550nm
Reflection	50% ±5% @ 550nm

Cube beamsplitters are constructed by cementing two precision right angle prisms together with the appropriate interference coating on the hypotenuse surface. The absorption loss to the coating is minimal. Transmission and reflection approach 50% (average), though the output is partially polarized.

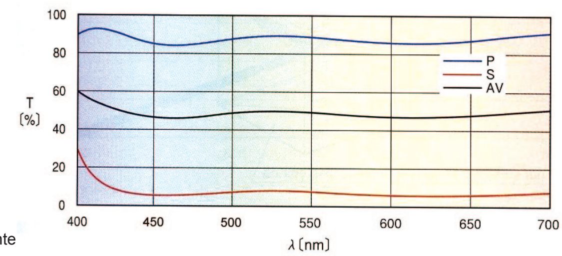
Cube Beamsplitters		
Model No	Cube size(mm)	R/T Coating
BS01D	5mm	50R/50T
BS02D	6.25mm	50R/50T
BS03D	10mm	50R/50T
BS04D	12.5mm	50R/50T
BS05D	15mm	50R/50T
BS06D	20mm	50R/50T
BS07D	25mm	50R/50T
BS08D	30mm	50R/50T
BS09D	35mm	50R/50T
BS10D	40mm	50R/50T
BS11D	45mm	50R/50T
BS12D	50mm	50R/50T

Precision Cube Beamsplitters

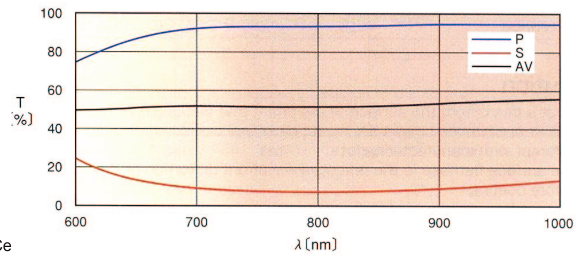
- Dielectric cube half mirrors consist of two right angle prisms. One of them is coated with dielectric multi layer partial reflection coating on the hypotenuse face.
- Half mirror divides input beam to reflectance and transmit tance in 1:1.
- The losses of input beam of these products are minimized be cause of no absorption of dielectric coating. However the rations of reflection to transmission of them depend on wavelength, po larization, and incident angel of input beam.
- Beam deviations at transmission and ghosts rarely occur.

SPECIFICATIONS	
Material	BK7
Surface flatness	λ/4
Beam deviation	≤10 arcmin
Surface quality	40-20
Coating	Dielectric multilayer partial reflection coating(R:T=1:1) Four surfaces: Multilayer Antireflection Coating
Polarization of the incident beam	Non-polarized beam or circular polarization
Wavelength range	<Visible>400~700nm <LD laser>750~850nm. 1300~1550nm
Tolerance	W ±0.2mm, L ±0.2mm, H ±0.1mm

Part Number	Wavelength range	W=L=H(mm)
CSMH-05-550	400~700nm	5
CSMH-07-550	400~700nm	7
CSMH-10-550	400~700nm	10
CSMH-15-550	400~700nm	15
CSMH-20-550	400~700nm	20
CSMH-25-550	400~700nm	25
CSMH-30-550	400~700nm	30
CSMH-50-550	400~700nm	50
CSMH-05-800	750~850nm	5
CSMH-07-800	750~850nm	7
CSMH-10-800	750~850nm	10
CSMH-15-800	750~850nm	15
CSMH-20-800	750~850nm	20
CSMH-25-800	750~850nm	25
CSMH-30-800	750~850nm	30
CSMH-10-1400	1300~1500nm	10
CSMH-20-1400	1300~1500nm	20

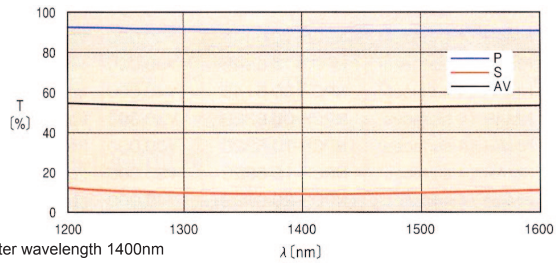


Cente



Ce

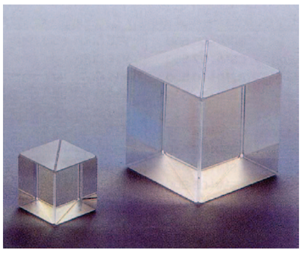
LD laser 780,830nm



Center wavelength 1400nm

LD laser 1300,1550nm

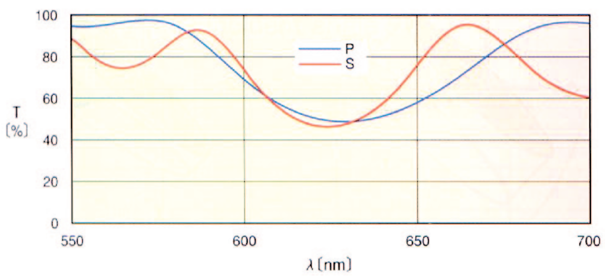
NON-POLARIZING CUBE BEAMSPLITTER



- Non-polarizing cube half mirrors consist of two right angle prisms. One of them is coated with dielectric multilayer non-polarizing coating on the hypotenuse face.
- The ratio of reflection to transmission is 1:1 regardless of the polarization condition of the input beam.
- These products are designed for a single wavelength because effective bandwidth of non-polarizing coating is narrow.

SPECIFICATIONS	
Material	BK7
Surface flatness	λ/4
Beam deviation	10 arcmin
T(P/S common)	50±5%
Surface quality	40-20
Coating	Dielectric multilayer partial reflection coating(R:T=1:1)
	Four surfaces:Multilayer Antireflection Coating
Wavelength range	488~1550nm
Tolerance	W ±0.2mm, L ±0.2mm, H ±0.1mm

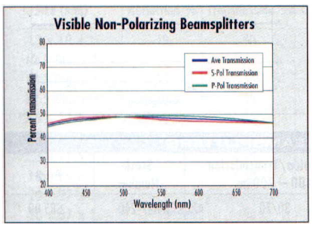
NPCH-6328[He-Ne]



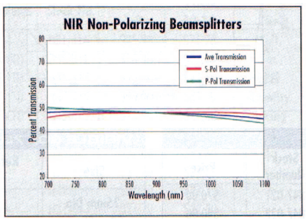
Part Number	Wavelength range	W=L=H(mm)
NPCH-10-4880	488nm	10
NPCH-15-4880	488nm	15
NPCH-20-4880	488nm	20
NPCH-10-5145	514.5nm	10
NPCH-15-5145	514.5nm	15
NPCH-20-5145	514.5nm	20
NPCH-05-6328	632.8nm	5
NPCH-10-6328	632.8nm	10
NPCH-15-6328	632.8nm	15
NPCH-20-6328	632.8nm	20
NPCH-10-6700	670nm	10
NPCH-15-6700	670nm	15
NPCH-20-6700	670nm	20
NPCH-10-7800	780nm	10
NPCH-15-7800	780nm	15
NPCH-20-7800	780nm	20
NPCH-10-8300	830nm	10
NPCH-15-8300	830nm	15
NPCH-20-8300	830nm	20
NPCH-10-13000	1.3μm	10
NPCH-15-13000	1.3μm	15
NPCH-20-13000	1.3μm	20
NPCH-10-15500	1.55μm	10
NPCH-15-15500	1.55μm	15
NPCH-20-15500	1.55μm	20

Broadband Non-Polarizing Cube Beamsplitters

- Three wavelength Ranges Available
- Precision Substrates
- Features Broadband AR Coated Faces



We offer non-polarizing beamsplitters for the visible(400-700 nm), NIR(700-1100 nm). The low polarization dependence of the metallic/dielectric hybrid coating allows the transmission and reflection for S- and P-polarization states to be within in 6% of eac other. These beamsplitters are spectrally flat across their specified wavelengthranges making them ideal for use with a variety of laser wavelength. The spectral flatness also reduces effects that are due to changes in the angle of incidence or converging/diverging beams.



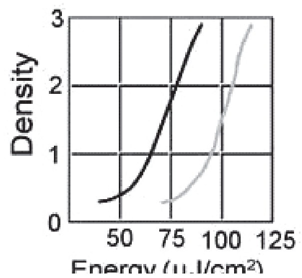
Specifications	
Material	BK7
Dimension Tolerance	±0.1mm
Surface Accuracy	λ/8
Surface Quality	40-20
Angle Toolerance	±2 arc min.
Clear Aperture	90%
Bevel	0.3mm x 45°

Coating Specifications

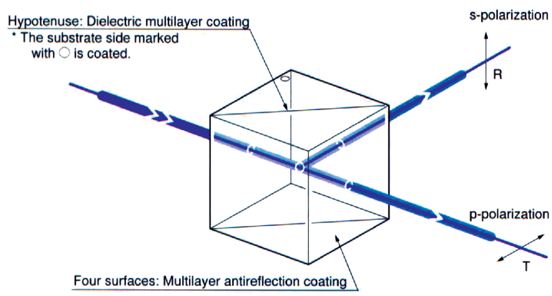
Design Wavelenght	430-670nm, Visible	720-1080nm, Near IR
Coating type	Hybrid	Hybrid
Transmittance	45%±5%	45%±5%
Absorption	<10%	<10%
Polarization	<6%	<6%
AR Coating	<0.5% 430-670nm	<0.5% 720-1080nm

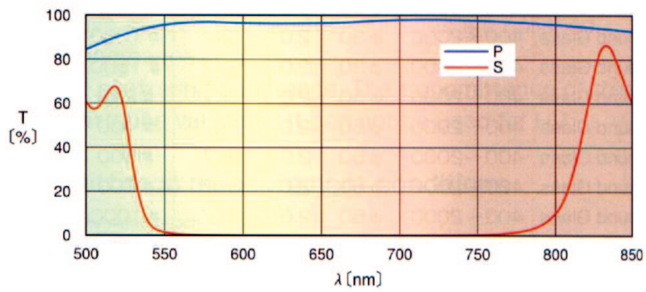
Cube Size	430~670nm	720~1080nm
5mm	BS11ND	BS21ND
10mm	BS12ND	BS22ND
15mm	BS13ND	BS23ND
20mm	BS14ND	BS24ND
25mm	BS15ND	BS25ND

POLARIZING CUBE BEAMSPLITTER



- Polarizing beamsplitters consist of two right angle prisms. One of them is coated with dielectric multilayer polarizing coating on the hypotenuse face.
- Polarizing beamsplitters split monochromatic beam entering at zero degree into p-polarization as transmitted and s-polarization as reflected.
- Four surfaces of the cube are coated with narrowband multilayer antireflection coatings.
- The losses of input beam of these products are minimized because of no absorption of dielectric coating.
- For cube beamsplitters, unlike plate beamsplitters, beam deviations of transmitted beams and ghosts rarely occur.



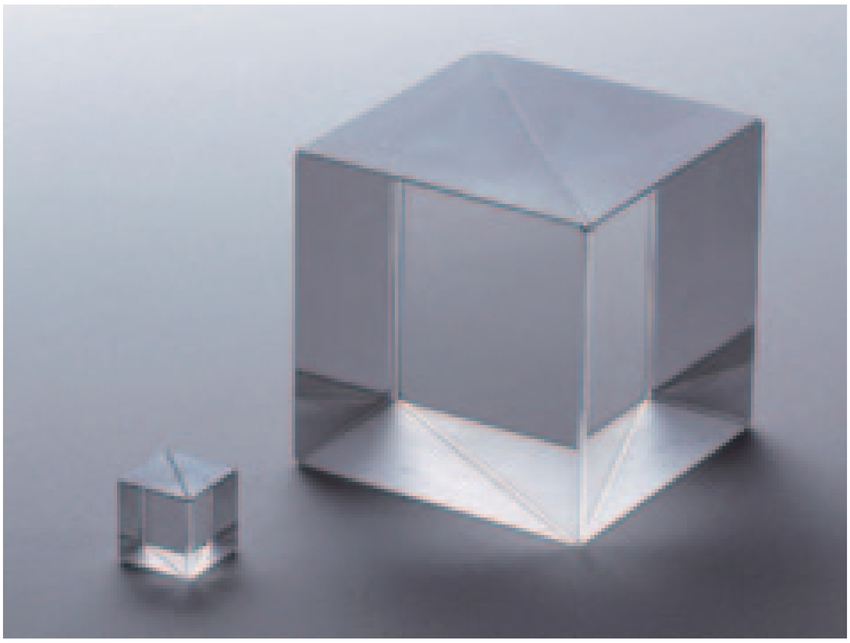


SPECIFICATIONS	
Material	BK7
Surface flatness	λ/4
Beam deviation	≤10 arcmin
Coating	Dielectric multilayer polarizing coating (effective area:80%) Four surfaces: narrowband multilayer antireflection coating
Angle of incidence	0°
Surface quality	40-20
Extinction ratio of s-polarization	Ts(Ts+Rs)=1/400
Transmittance of p-polarization	≥ 97%
Wavelength range	441.6nm~1.55μm *The wavelength range is not for each product
Tolerance	W,L ±0.2mm H ±0.1mm

Polarizing Beamsplitters

PartNumber	Wavelength range	W=L=H(mm)	PartNumber	Wavelength range	W=L=H(mm)
PBS-10 -4416	441.6nm	10.0	PBS- 5 -7800	780.0nm	5.0
PBS-15 -4416	441.6nm	15.0	PBS- 7 -7800	780.0nm	7.0
PBS-20 -4416	441.6nm	20.0	PBS-10 -7800	780.0nm	10.0
PBS-10 -4579	457.9nm	10.0	PBS-12.7 -7800	780.0nm	12.7
PBS-15 -4579	457.9nm	15.0	PBS-15 -7800	780.0nm	15.0
PBS-20 -4579	457.9nm	20.0	PBS-20 -7800	780.0nm	20.0
PBS-10 -4880	488.0nm	10.0	PBS- 5 -8300	830.0nm	5.0
PBS-12.7-4880	488.0nm	12.7	PBS- 7 -8300	830.0nm	7.0
PBS-15 -4880	488.0nm	15.0	PBS-10 -8300	830.0nm	10.0
PBS-20 -4880	488.0nm	20.0	PBS-12.7 -8300	830.0nm	12.7
PBS-10 -5145	514.5nm	10.0	PBS-15 -8300	830.0nm	15.0
PBS-12.7-5145	514.5nm	12.7	PBS-20 -8300	830.0nm	20.0
PBS-15 -5145	514.5nm	15.0	PBS- 5 -10640	1064.0nm	5.0
PBS-20 -5145	514.5nm	20.0	PBS-10 -10640	1064.0nm	10.0
PBS-10 -5320	532.0nm	10.0	PBS-12.7-10640	1064.0nm	12.7
PBS-12.7-5320	532.0nm	12.7	PBS-15 -10640	1064.0nm	15.0
PBS-15 -5320	532.0nm	15.0	PBS-20 -10640	1064.0nm	20.0
PBS-20 -5320	532.0nm	20.0	PBS- 5 -13000	1300.0nm	5.0
PBS- 5 -6328	632.8nm	5.0	PBS- 7 -13000	1300.0nm	7.0
PBS- 7 -6328	632.8nm	7.0	PBS- 10 -13000	1300.0nm	10.0
PBS-10 -6328	632.8nm	10.0	PBS-12.7-13000	1300.0nm	12.7
PBS-12.7-6330	632.8nm	12.7	PBS-15 -13000	1300.0nm	15.0
PBS-15 -6328	632.8nm	15.0	PBS-20-13000	1300.0nm	20.0
PBS-20 -6328	632.8nm	20.0	PBS- 5 -15500	1550.0nm	5.0
PBS- 5 -6700	670.0nm	5.0	PBS- 7 -15500	1550.0nm	7.0
PBS- 7 -6700	670.0nm	7.0	PBS-10 -15500	1550.0nm	10
PBS-10 -6700	670.0nm	10.0	PBS-12.7-15500	1550.0nm	12.7
PBS-12.7 -6700	670.0nm	12.7	PBS-15 -15500	1550.0nm	15.0
PBS-15 -6700	670.0nm	15.0	PBS-20 -15500	1550.0nm	20.0
PBS-20 -6700	670.0nm	20.0			

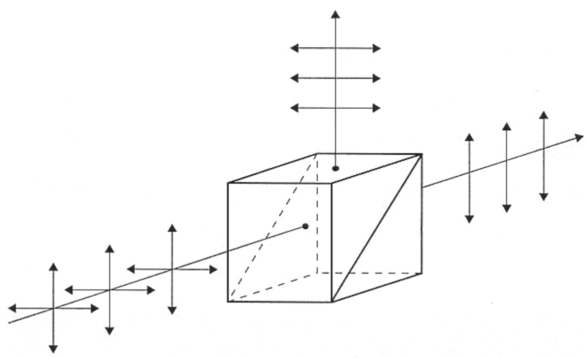
UV POLARIZING CUBES BEAMSPLITTER



SPECIFICATIONS	
Substrate Material	UV grade fused silica
Wavefront Distortion	λ/4 at 633nm
Surface Quality	10-5 laser quality
Dimensional Tolerance	± 0.50mm
Extinction Ratio	T_P / T_S > 100:1
Transmission Efficiency	T_P > 90%
Reflection Efficiency	R_S > 99%
Antireflection Coating	R ≤ 0.25%
Clear Aperture	Exceeds central 85% of dimension
Damage Threshold	10mJ/cm^2, 8nsec pulse; 10W/cm^2, CW at 266nm typical

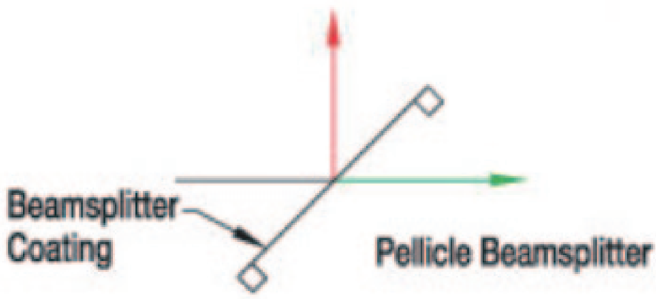
Wavelength	Dimension
248nm	0.50" or 1.00"
257nm	
266nm	
308nm	
351nm	
355nm	

- Fused silica cube polarizers for doubled argon, tripled Nd:YAG, quadrupled Nd:YAG, and UV excimer lasers
- 100:1 extinction ratio
- Transmission efficiency > 90%
- For use with fluences less than 10mJ/cm^2



PELLICLE BEAMSPLITTER

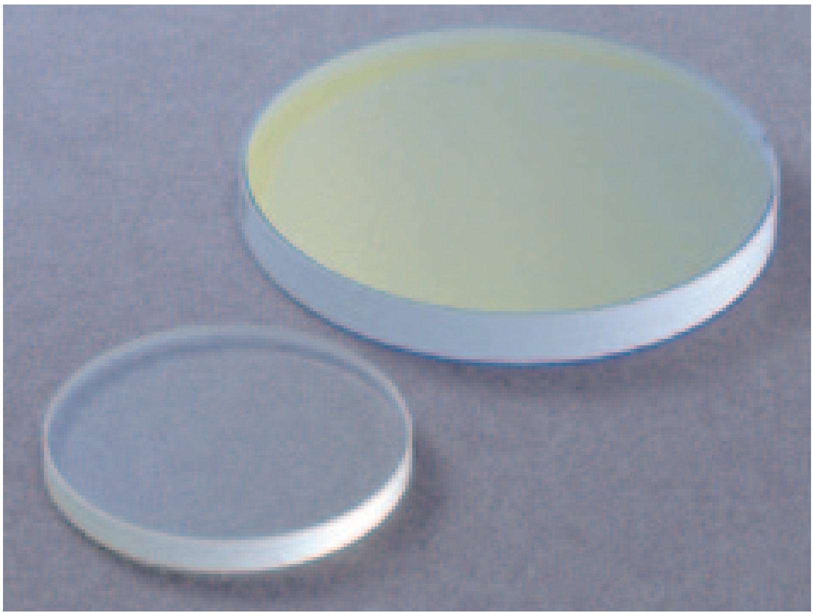
- Minimizes Dispersion, Eliminates Ghosting
- No Chromatic Aberration With Converging Beams
- Uncoated for Beam Sampling or Coated for BeamsPlitting



Specifications	
Pellicle Thickness	2 microns
Index of Refraction (nd)	1.5
Flatness	1/2 per inch
Material	Select optical-grade nitrocellulose
Thickness Uniformity	0.5 micron
Cosmetic Surface Quality	40-20
Temperature Range	-40oC to 125oC
Frame	Hard aluminum alloy, black anodized

Clear Aperture	Outer Dia.	ET	Uncoated 8R/92T	Inconel 40R/40T (400-700nm)	Dielectric 33R/67T (400-700nm)	Dielectric 50R/50T (At 632.8mm)
1”	13/8”	3/16”	BNS01P	BNS11P	BNS21P	BNS31P
2”	21/2”	1/4”	BNS02P	BNS12P	BNS22P	BNS32P
3”	31/2”	1/4”	BNS03P	BNS13P	BNS23P	BNS33P
4”	41/2”	1/4”	BNS04P	BNS14P	BNS24P	BNS34P
5”	51/2”	3/8”	BNS051P	BNS15P	BNS25P	BNS35P
6”	61/2”	3/8”	BNS06P	BNS16P	BNS26P	BNS36P

DICHROIC BEAMSPLITTER



Long Wave Pass Dichroic Beamsplitter

Specifications	
Substrate Material	UV grade fused silica or BK7 glass
Surface Figure	λ/10 at 633nm
Surface Quality	10-5 laser quality
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Average Transmission	> 85% in long wave pass
Reflectance	R ≥ 99.5% at user specifiedλ
Coating Technology	Electron beam multilayer dielectric
Adhesion and Durability	Per MIL-C-675A. Insoluble in lab solvents.
Clear Aperture	Exceeds central 85% of dimension
Antireflection Coating	R ≤ 0.25%, 45oP; R ≤ 1.3%, 45o S
Damage Threshold	10J/cm2, 8nsec pulse; 1MW/cm^2, CW at 1064nm typical

- Customer specified reflected and transmitted wavelength bands
- Large variety of substrate diameters and thicknesses
- High damage threshold, greater than 10J/cm^2

Long Wave Pass Dichroic Beamsplitters exhibit high transmission for a long wavelength band, high damage thresholds, and high reflectivity for a shorter band of wavelengths. Reflectivity bandwidth is limited by coating design, incidence angle and polarization

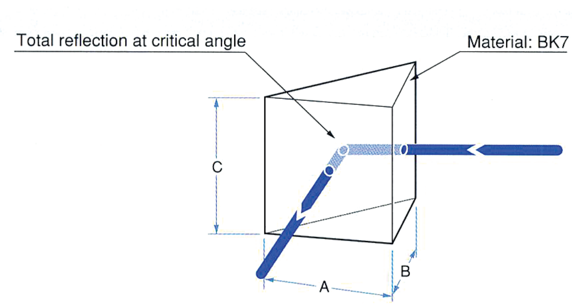
Short wave Pass Dichroic Beam splitter

Specifications	
Substrate Material	UV grade fused silica or BK7 glass
Surface Figure	λ/10 at 633nm
Surface Quality	10-5 laser quality
Diameter Tolerance	+ 0.00mm, - 0.25mm
Thickness Tolerance	± 0.25mm
Wedge	≤ 5 minutes
Chamfer	0.35mm at 45o typical
Average Transmission	> 85% in short wave pass
Reflectance	R ≥ 99.5% at user specified λ
Coating Technology	Electron beam multilayer dielectric
Adhesion and Durability	Per MIL-C-675A. Insoluble in lab solvents.
Clear Aperture	Exceeds central 85% of dimension
Antireflection Coating	R ≤ 0.25%, 45o P; R≤ 1.3%, 45o S
Damage Threshold	10J/cm2, 8nsec pulse; 1MW/cm^2, CW at 1064nm typical

- Customer specified reflected and transmitted wavelength bands
- To maximize efficiency, reflect 45o S and transmit 45o P
- High damage threshold, greater than 10J/cm2

Short Wave Pass Dichroic Beamsplitters exhibit high transmission for a short wavelength band, high damage thresholds, and high reflectivity for a longer band of wavelengths. Reflectivity bandwidth is limited by coating design, incidence angle and polarization.

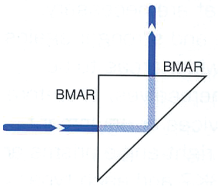
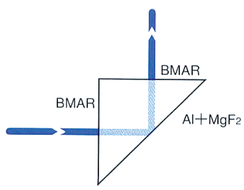
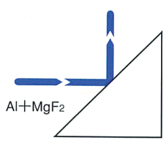
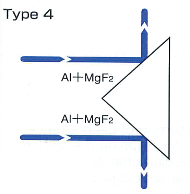
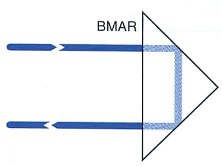
COATED RIGHT ANGLE PRISM



Right angle prisms are some of the versatile prisms available. The three polished surfaces of a prism which are coated or knife edged reflect beams internally and externally. Then it reflects input beams in 90° or 180° just as a total reflection mirror or a retro-reflector or divides beams into two directions. Right angle prisms are easier to mount, more stable and stronger against mechanical stress than mirrors because they have wider areas to be contact and have typical angle, 45° and 90°.

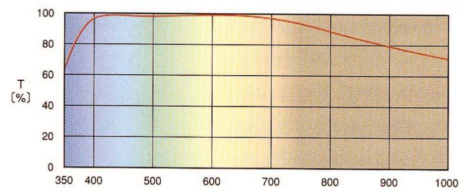
SPECIFICATION	
Material	BK7
Surface flatness	λ /4
Angular Deviation	<90°>≤±1arcmin
	<45°>≤±1arcmin
Coating	Multilayer AR coating for visible (BMAR) Protected aluminum (Al+MgF2)
Surface quality	40-20
Wavelength range	<Right angle prism> 400~700nm(λc=550nm)
	<Knife edge prism> 400nm~8μm
Tolerance	A,B +0,-0.15mm
	C +0,-0.1mm
	Chamfer <A≤15mm>Approx. 0.2C
	<A≤20mm>Approx. 0.3C

Coated Right Angle Prisms [BK7]

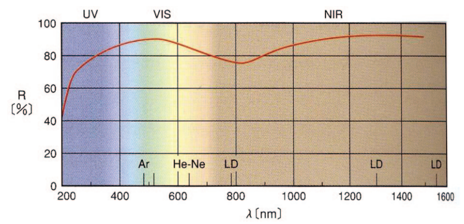
Coating	Size A=B=C(mm)	Coating 2 short side[Legs]	Coating 1 long side[Hypotenuse]	Part Number
	5	BMAR	-	RPB1- 05-550
	7	BMAR	-	RPB1- 07-550
	10	BMAR	-	RPB1- 10-550
	15	BMAR	-	RPB1- 15-550
	20	BMAR	-	RPB1- 20-550
	25	BMAR	-	RPB1- 25-550
	30	BMAR	-	RPB1- 30-550
	5	BMAR	Al+MgF_2	RPB2- 05-550
	7	BMAR	Al+MgF_2	RPB2- 07-550
	10	BMAR	Al+MgF_2	RPB2- 10-550
	15	BMAR	Al+MgF_2	RPB2- 15-550
	20	BMAR	Al+MgF_2	RPB2- 20-550
	25	BMAR	Al+MgF_2	RPB2- 25-550
	30	BMAR	Al+MgF_2	RPB2- 30-550
	5	-	Al+MgF_2	RPB3- 05-550
	7	-	Al+MgF_2	RPB3- 07-550
	10	-	Al+MgF_2	RPB3- 10-550
	15	-	Al+MgF_2	RPB3- 15-550
	20	-	Al+MgF_2	RPB3- 20-550
	25	-	Al+MgF_2	RPB3- 25-550
	30	-	Al+MgF_2	RPB3- 30-550
Type 4 	5	Al+MgF_2	-	RPB4- 05-550
	7	Al+MgF_2	-	RPB4- 07-550
	10	Al+MgF_2	-	RPB4- 10-550
	15	Al+MgF_2	-	RPB4- 15-550
	20	Al+MgF_2	-	RPB4- 20-550
	25	Al+MgF_2	-	RPB4- 25-550
	30	Al+MgF_2	-	RPB4- 30-550
Wavelength range: 400nm~8μm Knife Edge +Type 4	10	Al+MgF_2	-	KRPB4- 10-550
	15	Al+MgF_2	-	KRPB4- 15-550
	20	Al+MgF_2	-	KRPB4- 20-550
	25	Al+MgF_2	-	KRPB4- 25-550
	30	Al+MgF_2	-	KRPB4- 30-550
	5	-	BMAR	RPB5- 05-550
	7	-	BMAR	RPB5- 07-550
	10	-	BMAR	RPB5- 10-550
	15	-	BMAR	RPB5- 15-550
	20	-	BMAR	RPB5- 15-550
	25	-	BMAR	RPB5- 25-550
	30	-	BMAR	RPB5- 30-550

Coating characteristics

BMAR

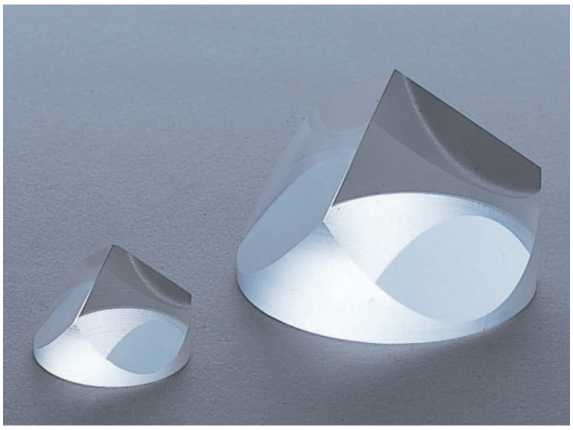


Al+MgF2



CHAPTER 4 PHOTONICS

CORNER CUBE PRISM



- Corner cube prisms (retro-reflectors) reflect input beam by 180° independently of its angle of incidence with the function of total internal reflection based on critical angle. This means that any light incident on the aperture will emerge along the same path that it came from in high reflectance.
- The accuracy of these prisms is shown with the angular deviation (parallelism) between input and output beams. It de pends on the mutual perpendicularity of the trihidron surfaces.
- We offer these prisms as coated with BMAR for visible or uncoated. The edges and the roof are chamfered (beveled) for chipping prevention.

Material	BK7
Surface flatness	λ/4
Beam Deviation	≤5 arcsec
Coating	Uncoated
	Broadband Multilayer AR Coating for Visible(BMAR)
Surface quality	40 - 20

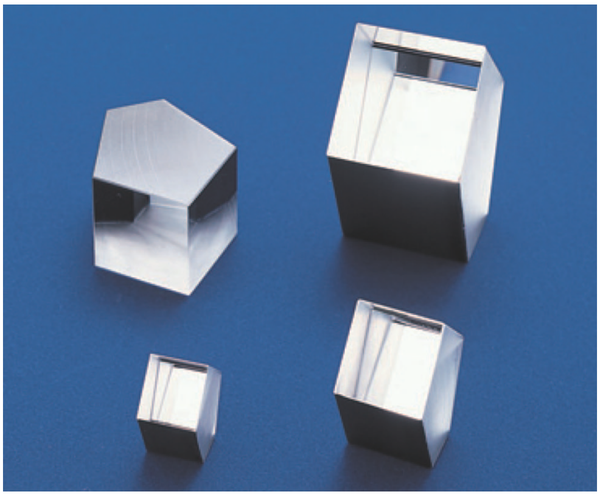
Type	D [mm]	H [mm]	Material	Surface Flatness	Beam Deviation	AR	Part Number
Uncoated	10	8.6	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-10
Uncoated	15	11.4	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-15
Uncoated	20	15.6	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-20
Uncoated	25	19	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-25
Uncoated	30	22.7	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-30
Uncoated	50	36.5	BK7	λ/4	≤ 5 arcsec	Uncoated	CCB-50
BMAR	10	8.6	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-10M
BMAR	15	11.4	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-15M
BMAR	20	15.6	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-20M
BMAR	25	19	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-25M
BMAR	30	22.7	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-30M
BMAR	50	36.5	BK7	λ/4	≤ 5 arcsec	BMAR	CCB-50M

- The product consists of the three reflection surfaces same as the corner cube, retro-reflectors (corner cube prisms) reflect input beam by 180° independently of its angle of incidence with the function of to tal internal reflection based on critical angle.
- The product can minimize an effect to polarization state and chromatic aberration by the optical path become in air and different from

Material	BK7
Coating	Aluminum
Measurement of surface flatness	Zygo Laser Interferometer System
Wavelength of surface flatness measurement	632.8nm
Clear aperture	80% of Inner Diameter øA

Material	Coating	Tolerance	Surface Quality	Housing	Case Inner Diameter [mm]	Beam Deviation of Reflection	Wavefront Distortion	Part Number
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø10	≤ 10 arcsec	1λ	RCCB-10-10NEW
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø10	≤ 30 arcsec	2λ	RCCB-10-30NEW
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø20	≤ 5 arcsec	1λ	RCCB-20-5NEW
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø20	≤ 30 arcsec	2λ	RCCB-20-30NEW
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø30	≤ 5 arcsec	1λ	RCCB-30-5NEW
BK7	Aluminum	±0.2	60-40	BA Aluminum	ø30	≤ 30 arcsec	2λ	RCCB-30-30

PENTA PRISM

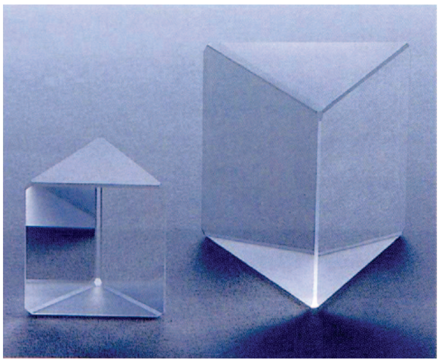


- Penta prisms are one of constant deviation (90°) prisms. There are two properties of them. The first is that they deviate an input beam by 90 degrees independently of the angle of incidence on the first surface. The second is that unlike right angle prisms, the images deviated by penta prisms are neither inverted nor re] versed. As they are used in the viewfinders of cameras, penta prisms are vests suited for image observational systems or survey ing applications.
- Penta prisms can not use the function of total internal reflection based on critical angle. Therefore a penta prism has black painted aluminum coating on its two reflective surfaces as standard. The surfaces of entrance and exit are also coated with MgF2 single-layer antireflection coating.

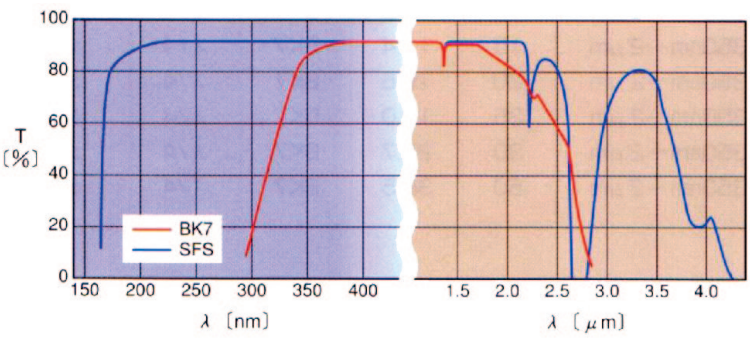
Material	BK7
Surface flatness	λ/4
Angular Deviation	≤3arcmin
Surface quality	40 - 20
Coating	MgF2 Single-layer Anti-reflection Coating(SLAR) Aluminum Coating + Black Pain

A x B x C [mm]	Material	Surface Flatness	Angular Deviation	Surface Quality	AR	RC	Part Number
10 x 10 x 10.8	BK7	λ/4	±≤ 3 arcmin	40-20	SLAR	Al Coating & Black Paint	PPB-10-4
15 x 15 x 16.0	BK7	λ/4	±≤ 3 arcmin	40-20	SLAR	Al Coating & Black Paint	PPB-15-4
20 x 20 x 23.0	BK7	λ/4	±≤ 3 arcmin	40-20	SLAR	Al Coating & Black Paint	PPB-20-4
25 x 25 x 27.1	BK7	λ/4	±≤ 3 arcmin	40-20	SLAR	Al Coating & Black Paint	PPB-25-4

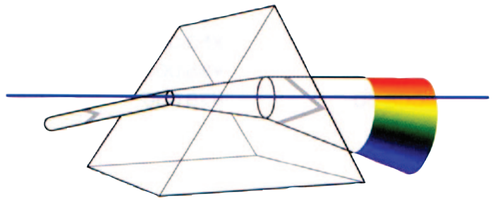
EQUILATERAL DISPERSING PRISM



Equilateral dispersing prisms disperse a light into its different colors and are used for spectrum analyzing experiments and instruments.
The roof angle of 60 degrees causes the best combination of wide dispersion and low reflection losses.
We offer both BK7 and fused silica for a selection of wavelength range from UV to near IR. Angular dispersion of BK7 is larger than that of fused silica.

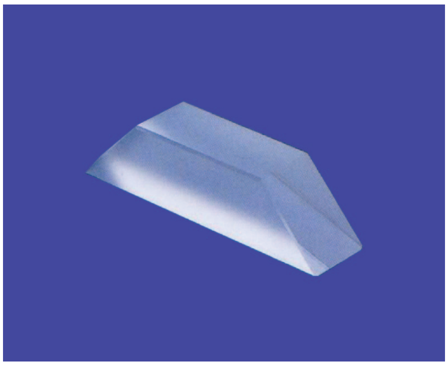


A=B=C(mm)	Surface flatness	Angular Deviation [60°]	BK7	Synthetic Fused Silica
20	λ/10	±3arcmin	DPB-20-10H	DPSQ-20-10H
25	λ/10	±3arcmin	DPB-25-10H	DPSQ-25-10H
30	λ/10	±3arcmin	DPB-30-10H	DPSQ-30-10H

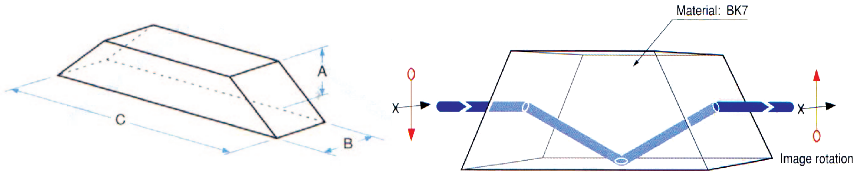


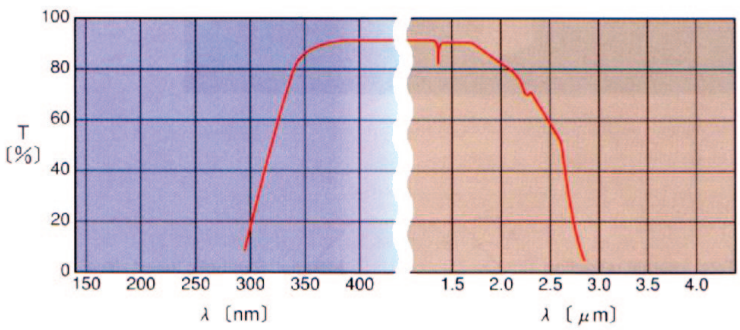
SPECIFICATION	
Material	BK7
	Synthetic fused silica (SFS)
Angular Deviation	60° ±3 arcmin
Surface flatness	λ/10
Surface quality	20-10
Wavelength ranges	(BK7)350nm~2μm
	(SFS)200nm~2μm
Tolerance	A, B ±0.2mm
	C +0, -0.15mm

DOVE PRISM



- Dove prisms are one of image rotators. A beam enter this prism is inverted its image by 180 degrees. And if the prism is rotated around the optical axis, the image will rotate at twice the rate of rotation.

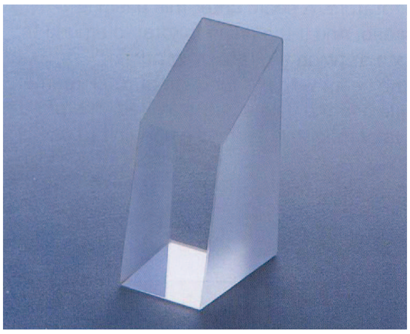




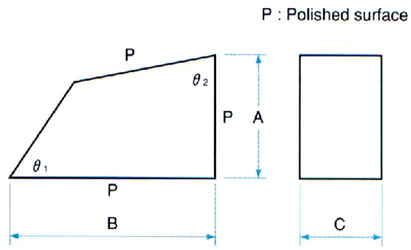
SPECIFICATION	
Material	BK7
Angular deviation	≤ 3arcmin
Surface quality	20-10
Wavelength range	350nm~2μm
Tolerance	A,B ±0.1mm
	C ±0.2mm
	Chamfer Approx. 0.2C~0.3C

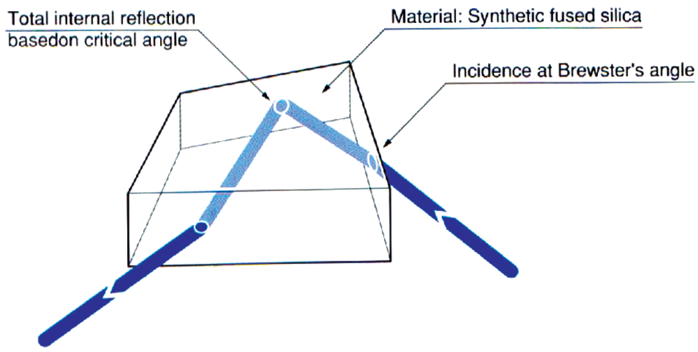
AxBxC(mm)	Material	Surface flatness	Angular deviation	Part Number
10x10x42	BK7	λ	≦ 3arcmin	DOP-10-1
15x15x63	BK7	λ	≦ 3arcmin	DOP-15-1
20x20x85	BK7	λ	≦ 3arcmin	DOP-20-1
25x25x103	BK7	λ	≦ 3arcmin	DOP-25-1
30x30x127	BK7	λ	≦ 3arcmin	DOP-30-1
10x10x42	BK7	λ/4	≦ 3arcmin	DOP-10-4
15x15x63	BK7	λ/4	≦ 3arcmin	DOP-15-4
20x20x85	BK7	λ/4	≦ 3arcmin	DOP-20-4
25x25x103	BK7	λ/4	≦ 3arcmin	DOP-25-4
30x30x127	BK7	λ/4	≦ 3arcmin	DOP-30-4

EQUILATERAL DISPERSING PRISM



- This dispersing prism is one of constant deviation(90°) prisms and also called Brewster's angle prisms because the incident angle is Brewster's angle.
- Pellin Broca prisms are used in monochrometers or in the cavities of laser to pick up a linearly polarized beam of certain wavelength.
- This prism disperses YAG fundamental and other harmonics.

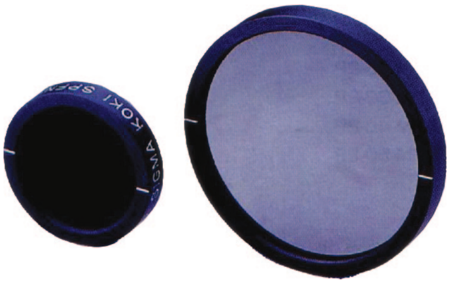




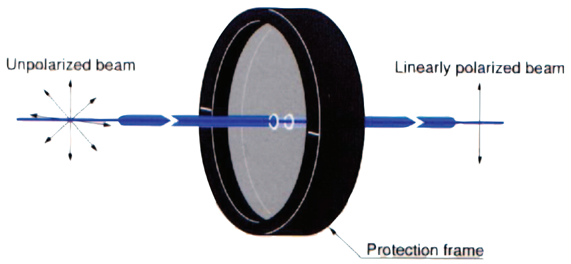
SPECIFICATION	
Material	Synthetic fused silica (SFS)
Surface flatness	λ/10
Surface quality	20-10
Coating	Uncoated
Wavelength ranges	YAG laser (fundamental /other harmonics separation)
Tolerance	A ,B ±0.2mm C +0, -0.1mm

A X B X C(mm)	θ_1	θ_2	Material	Surface flatness	Part Number
30 X 50 X 20	56.13°	78.87°	SFS	λ/10	PBP-30-20

LINEAR GLASS POLARIZER

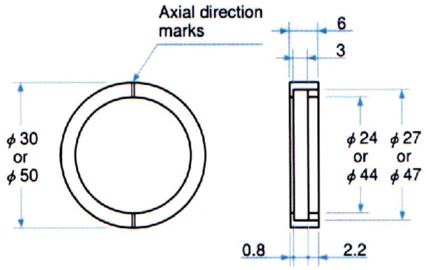


- These sheet polarizers are filters that have polarizing high-polymer films sand wiched between pairs of glass disks and mounted in aluminum frame.
- Not only be used to transmit linearly polarized beam against unpolarized input beam but also be used as beam attenuators against linearly polarized input beam
- Optical preciseness, mechanical strength and chemical resistance are much improved than plastic sheet polarizers by using glass protection.

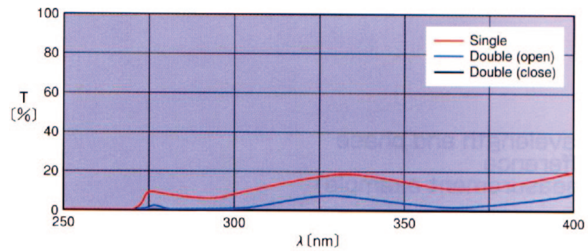


SPECIFICATIONS

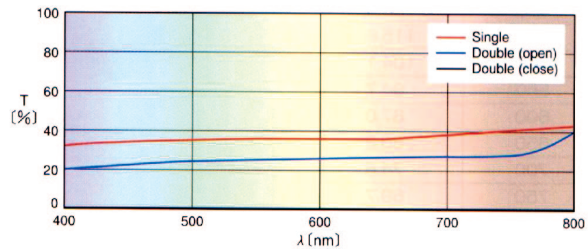
Material	SPFU(UV)	Polarizing high-polymer film laminated between quarts glasses
	SPF(Visible)	Polarizing high-polymer film laminated between optical glasses
	SPFN(Near-IR)	Polarizing high-polymer film laminated between optical glasses
Frame	Black anodized aluminum with engraved marks of perpendicular to the polarization direction of output beam	
Coating (on both surface)	SPFU(UV) Single-layer antireflection coatings	
	SPF(Visible) Multilayer antireflection coatings	
	SPFN(Near-IR) Single-layer antireflection coatings	
Wavelength range	SPFU(UV)	280~400nm
	SPF(Visible)	400~700nm
	SPFN(Near-IR)	760~2000nm
Tolerance	Frame	Diameter +0~-0.1mm
		Thickness +0~-0.1mm



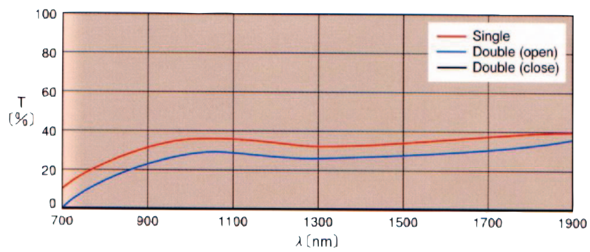
●SPFU (UV)



●SPF (Visible)

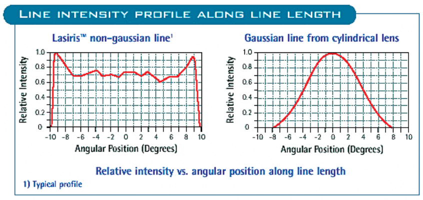


●SPFN (Near-IR)

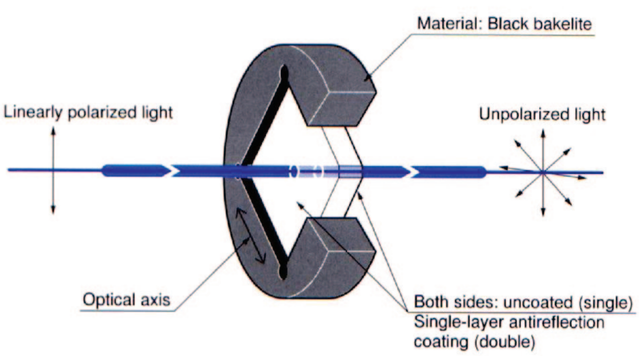


Wavelength range	Frame Dxt (mm)	Element (mm) Diameter	Element (mm) Diameter	Clear Aperture(mm)	Antireflection coating	Part Number
320~400nm	φ30x6	φ27	φ27	φ24	SLAR(Both surfaces)	NSPFU-30C
400~700nm	φ30x6	φ27	φ27	φ24	BMAR(Both surfaces)	SPF -30C-32
400~700nm	φ50x6	φ47	φ47	φ44	BMAR(Both surfaces)	SPF -50C-32
760~2000nm	φ30x6	φ27	φ27	φ24	SLAR(Both surfaces)	SPFN-30C-26

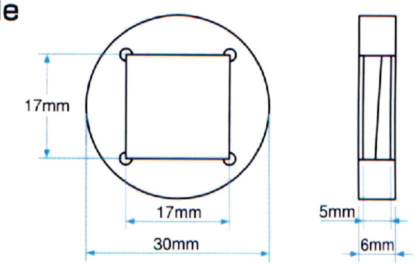
DEPOLARIZER



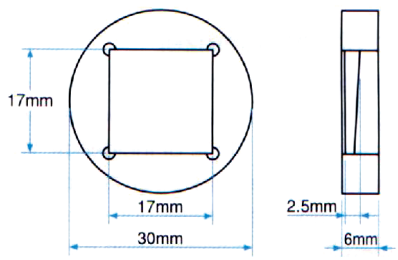
- Quartz depolarizers convert linearly polarized input beams to unpolarized beams and are used in front of and the behind of measurement equipment that must avoid polarization. There are two types, single and double type.
- The single type is made of single optical quartz plate. It has a wider transmission range, but has a larger beam deviation due to the 2 degrees wedge shape.
- The double type consists of cemented plates of optical quartz and synthetic fused silica. It does not have beam deviation, but the transmission range is not wide as the single type.
- Usually linearly polarized beams are input to the depolarizers in a leaning of 45 degrees against its optic axis.



● Double



● Single

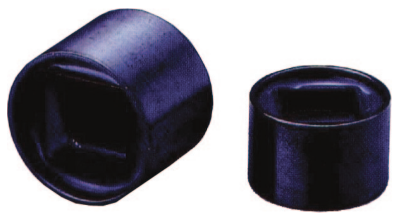


SPECIFICATION	
Material	Optical grade crystalline quartz Synthetic fused silica (SFS)
Surface quality	10-5
Coating	Single-type Uncoated Double-type Single-layer antireflection coating
Wavelength range	Single-type 180nm~3.5μm Double-type 350nm~2.5μm
Tolerance frame	Diameter +0~-0.2mm Thickness ±0.2mm

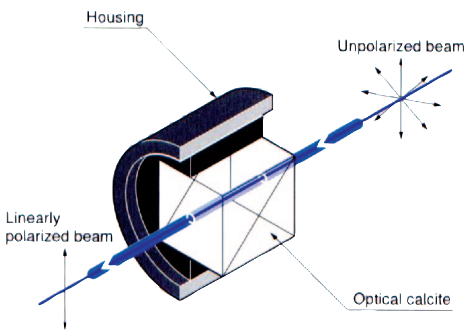
Quartz Depolarizers

Model No.	Type	AR coating	Wavelength range	Material	Dimensions of quartz (mm)	Size of Frame (mm)
DEQ-1N	Single	-	180nm~3500nm	Quartz	17x17x2.5t	φ30x6t
DEQ-2S	Double	SLAR	350nm~2000nm	Quartz, SFS	17x17x5t	φ30x6t

GLAN-TAYLOR PRISM



- Air - spaced
- Cutting angle close to Brewster's Angle
- The extraordinary ray passes though with little deviation
- Sealed mount without escape windows is suitable for low to medium power application where the rejected beam is not required.

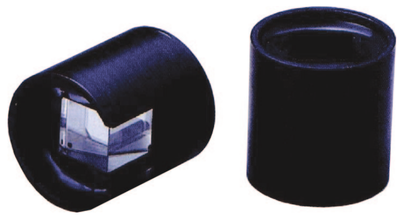


Specifications	
Wavelength Range	190-3500nm(α-BBO)
	350-2300nm(Calicte)
Surface Quality	20-10 scratch and dig
Dimension Tolerance	± 0.1mm
Beam Deviation	<3 arc minutes
Coating	Single Layer MgF_2 on Input and Output Surface
Mounting	Black Anodized Aluminum

Model NO.	Material	Wavelength Range(nm)	Extinction Ratio	Angle Field	Cleat Aperture (mm)	Mounting Tubes ϕ x L(mm)
BCZ01G	α-BBO	200-270	$< x 10^{-6}$	6.0^0	8	25.4 x 17.0
BCZ02G	α-BBO	200-270	$< x 10^{-6}$	6.0^0	10	25.4 x 18.5
BCZ03G	α-BBO	200-270	$< x 10^{-6}$	6.0^0	15	30.0 x 23.0
BCZ04G	α-BBO	200-270	$< x 10^{-6}$	6.0^0	20	38.0 x 27.0
BCZ11G	α-BBO	400-700	$< x 10^{-6}$	6.0^0	8	25.4 x 17.0
BCZ12G	α-BBO	400-700	$< x 10^{-6}$	6.0^0	10	25.4 x 18.5
BCZ13G	α-BBO	400-700	$< x 10^{-6}$	6.0^0	15	30.0 x 23.0
BCZ14G	α-BBO	400-700	$< x 10^{-6}$	6.0^0	20	38.0 x 27.0
BCZ21G	α-BBO	700-3000	$< x 10^{-6}$	6.0^0	8	25.4 x 17.0
BCZ22G	α-BBO	700-3000	$< x 10^{-6}$	6.0^0	10	25.4 x 18.5
BCZ23G	α-BBO	700-3000	$< x 10^{-6}$	6.0^0	15	30.0 x 23.0
BCZ24G	α-BBO	700-3000	$< x 10^{-6}$	6.0^0	20	38.0 x 27.0
BCZ31G	Calcite	350-2000	$<5 x 10^{-5}$	7.7^0	8	25.4 x 17.0
BCZ32G	Calcite	350-2000	$<5 x 10^{-5}$	7.7^0	10	25.4 x 18.5
BCZ33G	Calcite	350-2000	$<5 x 10^{-5}$	7.7^0	15	30.0 x 23.0

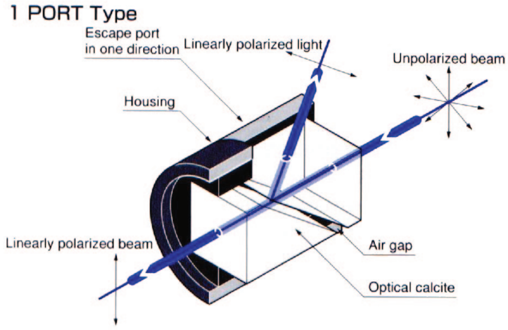
GLAN-LASER PRISM

- Cutting angle close to Brewster's angleMounted with escape windows.
- Therefore, it is suitable for high power applications.

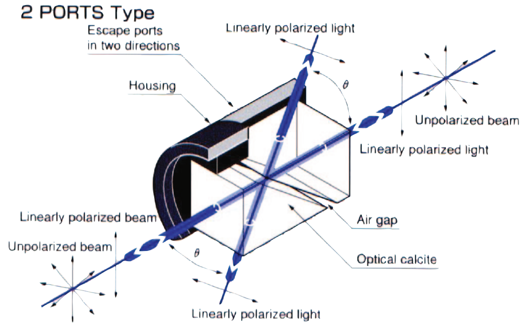


Specifications	
Surface Quality	190-3500nm(α-BBO) 350-2300nm(Calcite)
Wavelength Range	20-10 Scratch and Dig
Dimension Tolerance	±0.1mm
Beam Deviation	<3 are minutes
Transmission Wavefront	< λ/4@632.8nm for α-BBO
Distortion	< λ/2@632.8nm for Calcite
Escape Window	Double
Coating	Single Layer MgF_2 on Input and Output Surface
Damage Threshold	>1GW/cm^2 at 1064 nm
Housing	Black Anodized Aluminum

1 PORT Type

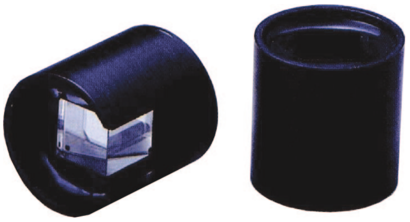


2 PORTS Type

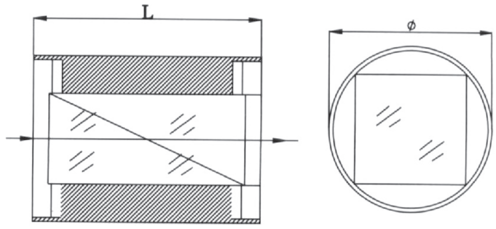


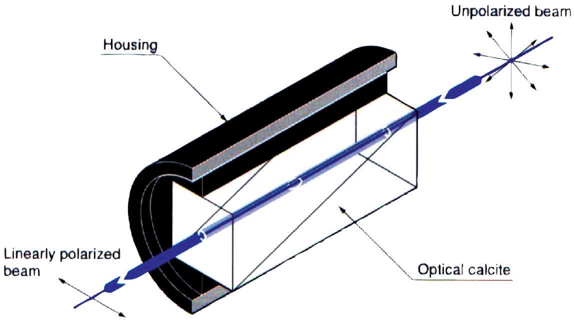
Model No.	Material	Wavelength Range(nm)	Extinction Ratio	Angle Field	Cleat Aperture (mm)	Mounting Tubes ϕ x L(mm)
BCZ01L	α-BBO	200-270	< x 10^{-6}	6.0^0	8	25.4 x 30.6
BCZ02L	α-BBO	200-270	< x 10^{-6}	6.0^0	10	25.4 x 31.0
BCZ03L	α-BBO	200-270	< x 10^{-6}	6.0^0	15	30.0 x 38.6
BCZ04L	α-BBO	200-270	< x 10^{-6}	6.0^0	20	38.0 x 48.9
BCZ11L	α-BBO	400-700	< x 10^{-6}	6.0^0	8	25.4 x 25.0
BCZ12L	α-BBO	400-700	< x 10^{-6}	6.0^0	10	25.4 x 26.0
BCZ13L	α-BBO	400-700	< x 10^{-6}	6.0^0	15	30.0 x 33.4
BCZ14L	α-BBO	400-700	< x 10^{-6}	6.0^0	20	38.0 x 41.7
BCZ21L	α-BBO	700-3000	< x 10^{-6}	6.0^0	8	25.4 x 24.7
BCZ22L	α-BBO	700-3000	< x 10^{-6}	6.0^0	10	25.4 x 25.9
BCZ23L	α-BBO	700-3000	< x 10^{-6}	6.0^0	15	30.0 x 33.0
BCZ24L	α-BBO	700-3000	< x 10^{-6}	6.0^0	20	38.0 x 43.6
BCZ31L	Calcite	350-2000	<5 x 10^{-5}	7.7^0	8	25.4 x 24.5
BCZ32L	Calcite	350-2000	<5 x 10^{-5}	7.7^0	10	25.4 x 26.2
BCZ33L	Calcite	350-2000	<5 x 10^{-5}	7.7^0	15	30.0 x 33.3

GLAN-THOMPSON PRISM



- Cemented
- Suitable for low power applications
- Special design for the ratio of L/A (length/aperturs) guarantees the wide acceptance angle.



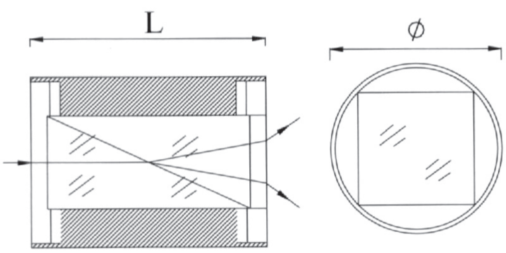


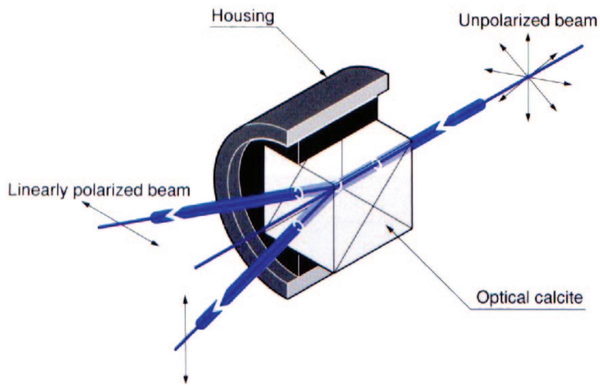
Specifications	
Material	Calcite Crystal
Wavelength Range	350-2300nm
Surface Quality	60-40 scratch and dig
Dimension Tolerance	± 0.1mm
Beam Deviation	<3 arc minutes
Mounting	Black Anodized Aluminum

Model No.	Clear Aperture ϕ(mm)	L/A	Extinction Ratio	Angle Field	Mounting Tube ϕx L (mm)
BCZ01T	10.0	2.5	$5X\ 10^{-5}$	14^0-16^0	25.4 X 30.0
BCZ02T	15.0	2.5	$5X\ 10^{-5}$	14^0-16^0	30.0 X 45.5
BCZ11T	10.0	3	$5X\ 10^{-5}$	25^0-28^0	25.4 X 38.0
BCZ12T	15.0	3	$5X\ 10^{-5}$	25^0-28^0	30.0 X 53.0

WOLLASTON PRISM

- Cemented
- Both ordinary and extraordinary beams are deviated.
- Suitable for low power applications and where the large deviation is required.





Specifications	
Material	Calcite Crystal
Wavelength Range	350-2300nm
Surface Quality	60-40 scratch and dig
Dimension Tolerance	± 0.1mm
Mounting	Black Anodized Aluminum

Model No.	Clear Aperture ϕ(mm)	Extinction Ratio	Angle Field	Mounting Tube ϕx L (mm)
BCZ01W	10.0	5X 10^{-5}	15^{0}- 20^{0}	25.4 X 18.5
BCZ02W	15.0	5X 10^{-5}	15^{0}-20^{0}	30.0 X 23.0

GLAN-THOMPSON PRISM

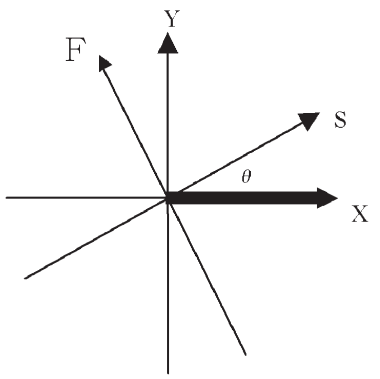
Waveplates operate by imparting unequal phase shifts to orthogonally polarized field compontss of an incident wave. This causes the conversion of one polarization state into another.

Suppose a waveplate made from a uniaxial material has light propagating perpendicular to the optics axis. This makes the field component parallel to the optic axis an extraordinary wave and the component perpendicular to the optics axis an ordinary wave. If the crystal is positive uniaxial, $n_e > n_o$, then the optic axis is called the slow axis, which is the case for crystal quartz.

With linear birefringence, the index of refraction and hence phase shift differs for two orthogonally polarized linear polarizations. Then the phase delay to the slow axis:

$\phi = \phi_s - \phi_f = 2\pi\Delta n(\lambda)t/\lambda$,

$\Delta n(\lambda)$ is the birefringence $n_s(\lambda) - n_f(\lambda)$.



Orientation of the slow and fast axis of waveplate with respect to an X-polarized input field.

When the waveplate is placed between parallel and perpendicular polarizers the transmissions are given by:

$$T_{\Pi} \propto |E_{2x}|^2 = 1 - \sin^2 2\theta \sin^2 \phi/2$$

$$T_{\perp} \propto |E_{2y}|^2 = 1 - \sin^2 2\theta \sin^2 \phi/2$$

Note that θc is only a function of the waveplate orientation , and ϕ , the birefringence, is a function of wavelength and the plate thickness.

For a half waveplate:

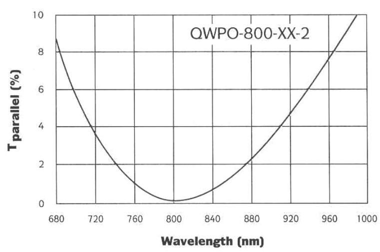
$\phi = (2m+1)\pi.$

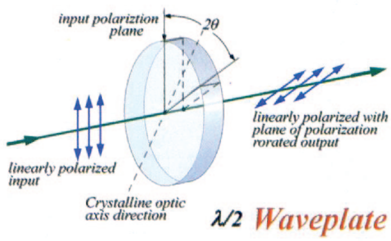
This transmission result is the same as if an initial linearly polarized wave were rotated through an angle 2θ. Thus a half waveplate finds use as a polarization rotator.

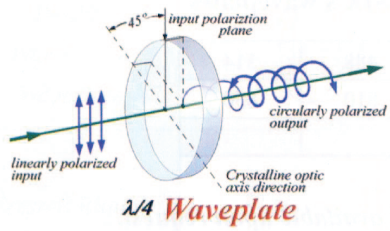
For a quarter waveplate:

$\phi = (2m+1)\pi$; ie. An odd multiple of $\pi/2$.

To obtain circularly polarized light, lin early polarized light is aligned midway between the slow and fast axes.







Broadband waveplate

At 500 nm, a crystal quartz zero order half waveplate has a retardation tolerance of λ/50 over a band width of about 50nm. this increase to about 100nm at a center wavelength of 800nm. However, there is a waveplate design that can give an even larger bandwidth.

If two different materials are used to create or low order waveplate, cancellation can occur between the dispersions of the two materials. Then, the net birefrigent phase shift can be held constant over a much wider range than in waveplates made fron one material. The ACWP series crystal quartz and MgF_2 Achromatic Waveplates are used in high power, air-spaced designs.

The curves on page 3-55 demonstrate the high degree of achromatization achievable by the dual material design. In addition, out use of thin plates of low dispersion material assure low group velocity dispersion in ultrashort pulse applications.

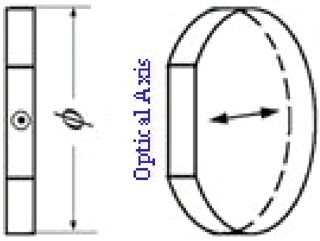
Rotating the polarization of one wavelength by 90 degrees, and leaving the other unchanged. In nonlinear doubking or tripling laser source.

SOLEIL-BABINET COMPENSATOR

- Precision Retardation Measurements
- Uniform Retardance over Full Aperture
- Two Wavelength Ranges (VIS & IR)
- Continuously Variable Retardance
- Graduated Rotation Ring
- 45° Index Stops

Item Number	SBC-VIS	SBC-IR
Wavelength Range	365 - 800 nm	740 - 1650 nm
Retardance Adjustment	0 to 2π (full wave)	
Clear Aperture	Ø10 mm	
Beam Deviation	<1 arcmin	
Transmitted Wavefront Error	<λ/4	
Surface Quality	40-20 Scratch-Dig	
Digital Readout Resolution	0.001 mm	
Repeatability Values*	@405 nm: 0.0016 waves @633 nm: 0.001 waves @800 nm: 0.0008 waves	@1064 nm: 0.0012 waves @1550 nm: 0.0008 waves
Rotation	360o continuous	
Rotation Division Scale	1° increment	
Detent Index Stops	Every 45°	
Software	N/A	

LOW-ORDER WAVEPLATE



See p.3-52, the the order of cave plates is given by integer m. for m>0, the waveplate is termed a multiple order waveplate.
Multiple order waveplates are inexpensive, high damage threshold retarders. How quickly the retardence changes with wavelength. Because of this, multiple order waveplates are generally useful only at their design wavelength.
Multiple order waveplates are not useful with tunable or broad bandwidth sources. A zero order waveplate can greatly improve the useful bandwifth in a compact, high damage threshold device.

- Thickness: 0.2-0.4mm
- High Damage Threshold
- Better Temperature Bandwidth
- Low cost

Specifications	
Material	Crystal quartz
Dimension Tolerance	+0.0, -0.2mm
Wavelength Distortion	λ/8@632.8nm
Retardation Tolerance	<λ/500
Wavelength Range	240-2100nm
Paralleelism	<1 arc second
Surface Quailty	20-10 scratch and dig
AR. AR Coating	R<0.2% at central wavelength

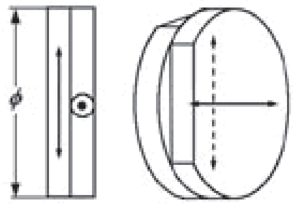
φ(mm)	Uncoated Part No.	AR/AR coated Part No.
10.0	WPL1110	WPL1210
12.7	WPL1112	WPL1212
15.0	WPL1115	WPL1215
20.0	WPL1120	WPL1220
25.4	WPL1125	WPL1225

The standard wavelength(nm) of Onset's waveplate							
248	266	355	400	488	514	532	632.8
780	800	810	850	1064	1310	1480	1550

Other wavelengths within the range of 200-2300nm are also available upon request.

Order Information: Part NO. - Retardation - Wavelength
For example: WPL1115 -λ/4 - 670

ZERO-ORDER WAVEPLATE



Cemented & Optically Contracted Zero-Order Waveplate

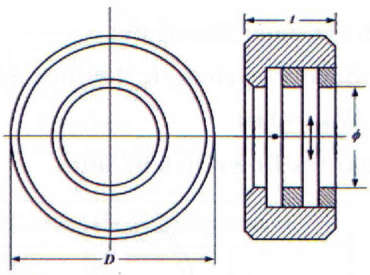
- Double Plates
- Broad Spectral Bandwidth
- Wide Temperature Bandwidth
- AR Coated

Zene-order waveplates teature bardwidte. If made from a single plate of crystal quartz, the waveplate would be about 45μm thick, which is too thin for easy fabrication and handling. The solution is to take two crystal quartz plates differing in thickness by 45μm and align them with the slow axis of one against the fast axis of the other. The net phase shft of this zero order waveplate is π. The two plates may be either air-space or optically contacted.

Specifications	
Material	Crystal quartz
Dimension Tolerance	+0.0, -0.2mm
Wavelength Distortion	λ/8@632.8nm
Retardation Tolerance	< λ/500
Wavelength Range	400-2100nm
Paralleelism	<1 arc second
Surface Quailty	20-10 scratch and dig
AR Coating	R<0.2% at central wavelength

Cemented Zero-Order		Optically Contracted Zero-Order	
Part No.	φ(mm)	Part No.	φ(mm)
WPZ1210	10.0	WPZ1410	10.0
WPZ1212	12.7	WPZ1415	15.0
WPZ1215	15.0	WPZ1425	25.4
WPZ1220	20.0	/	
WPZ1225	25.4	/	

Air spaced Zero-Order Waveplate



- Double Retardation plates
- Broad Spectral Bandwidth
- AR Coated and Mounted
- Wide Wavelength bandwindth
- High Damage Threshold

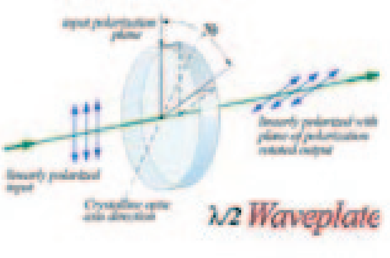
Specifications	
Material	Crystal quartz
Dimension Tolerance	+0.0, -0.2mm
Wavelength Distortion	λ/8@632.8nm
Retardation Tolerance	< λ/500
Wavelength Range	400-2100nm
Parallelism	<1 arc second
Surface Quailty	20-10 scratch and dig
AR Coating	R<0.2% at central wavelength

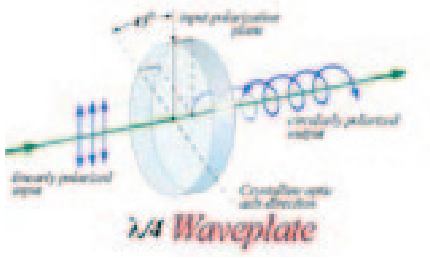
Part No.	OutsideDiameter D(mm)	Aperture φ(mm)	Thickness t(mm)
WPZ1310	25.4	10.0	8.0
WPZ1312	25.4	12.7	8.0
WPZ1315	25.4	15.0	8.0
WPZ1320	30.0	20.0	8.0
WPZ1325	30.0	25.4	8.0

Materials | Singlet Lenses | Multiple Lenses | Mirrors | Etalons | Beam splitters | Prisms | Polarizing Optics | Filters | Gratings | Microscope Objectives | Crystals | Photonic Crystal Fibers

CHAPTER 4 PHOTONICS

ACHROMATIC WAVEPLATES





- High energy air-spaced design
- Achromatic over extremely broad ranges
- Quarter and half wave retardances available
- Application examples: OPOs, spectopho tometry, femtosecond pulses, and continuum generation Low group velocity dispersion

Specifications	
Substrate Material	Crystal quartz and MgF2
Transmitted Wavefront	λ/4 at 633nm
Surface Quality	20-10 laser quality
Retardation Tolerance	λ/100 at 500nm
Transmission	T > 98%
Damage Threshold	2J/cm2, 8nsec pulse; 500kW/cm2, CW at 1064nm typical

Crystal quartz and MgF_2 Achromatic Waveplates are used in high power, air-spaced designs. Retardation tolerance is better than λ/100 over the entire wavelength range of Achromatic Waveplates.

Wavelength Range(nm)	Retardation	Housing Diameter OD	Housing Thickness T	Clear Aperture CA
400-700	λ/4	1.500"	0.500"	22.0mm
700-1000	λ/4	1.500"	0.500"	22.0mm
1000-1600	λ/4	1.500"	0.500"	22.0mm
400-700	λ/2	1.500"	0.500"	22.0mm
700-1100	λ/2	1.500"	0.500"	22.0mm
1000-1600	λ/2	1.500"	0.500"	22.0mm

DUAL WAVELENGTH WAVEPLATE

- Precise polarization control for dual wavelength sources
- Multiple order waveplates for narrow bandwidth applications
- Standard 1.5" OD ring mount prevents breakage and fits easily into 1.5" lens or mirror mount
- Other wavelength and retardation combinations available

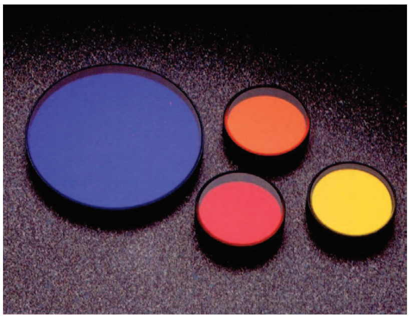
Specifications	
Substrate Material	Crystal quartz
Transmitted Wavefront	λ/10 at 633nm
Surface Quality	10-5 laser quality
Outside Dia.	1.50”
Diameter Tolerance	+ 0.00mm, - 0.25mm
Parallelism	≤0.5 seconds
Retardation Tolerance	λ/100 at 20ºC typical
Antireflection Coating	R ≤0.50%
Damage Threshold	2J/cm^2, 8nsec pulse; 500kW/cm^2, CW at 1064nm typical

Dual Wavelength Waveplates

Wavelength 1 (nm)	Wavelength 1 Retardation	Wavelength 2 (nm)	Wavelength2 Retardation	Clear Aperturer
1064	λ/2	532	λ	0.850"
355	λ/2	532	λ	0.850"
355	λ/2	1064	λ	0.850"
532	λ/2	266	λ	0.850"
532	λ/2	355	λ	0.850"
532	λ/2	1064	λ	0.850"
1064	λ/2	355	λ	0.850"

CHAPTER 4 PHOTONICS

STANDARD BANDPASS FILTER

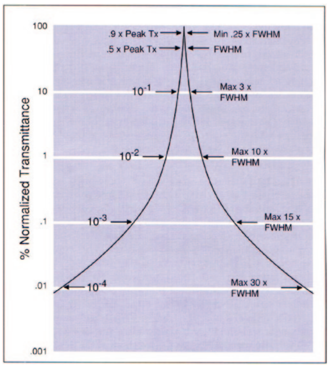


GENERAL SPECIFICATIONS

Diameter tolerance	+0/-.25mm	
Usable aperture	Size	Aperture
	12.5mm φ	9.0mm φ
	25.0mm φ	21.0mm φ
	50.0mm φ	45.0mm φ
Surface quality	80-50 (Per MIL-O-13830)	
Out-of-band blocking	1 x 10-4 from X-ray to FIR	
Maximum survival	CW/L 214 to 380nm	
temperature range	-50oC to +50oC	
	CW/L 380.1 to 1550nm	
	-50oC to +70oC	

All of our bandpass filter are stabilized to prevent drift of peak wavelength with age and are hermetically sealed for maximum humidity protection. Each filter is mounted in a black anodized aluminum ring which affords increased protection against damage resulting from rough handling and moisture penetration. However, even with this construction, it is advisable to avoid prolonged exposure to environments in which high humidity and large temperature variations are concurrent. The effects of temperature, optical path geometry and environmental conditions must be considered when selecting or specifying bandpass filters. All of our filters are designed to operate at 23°C in normal incidence collimated beams.

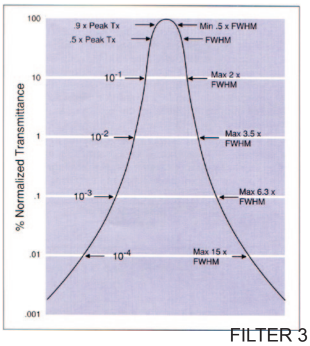
FILTER 1



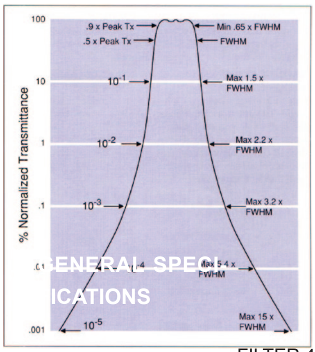
Onset offers one of the most extensive listing of standard "OFF THE SHELF" interference filter in this industry. Wavelengths range from the ultraviolet through the near infrared and include many of the primary laser, mercury, biomedical and analytical spectral lines. Standard size include 12.5mmϕ, 25mmϕ and 50.0mmϕ.

All filter are mounted in back anodized metal rings which provide an added measure of protection against chipping, scratching and high humidity conditions. All filters have their part number permanently engraved on their edge and each filter is supplied with a calibrated spectral bandpass data curve at no-charge.

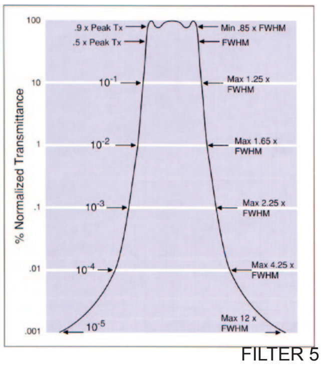
FILTER 2



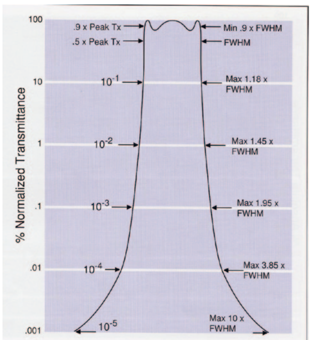
FILTER 3



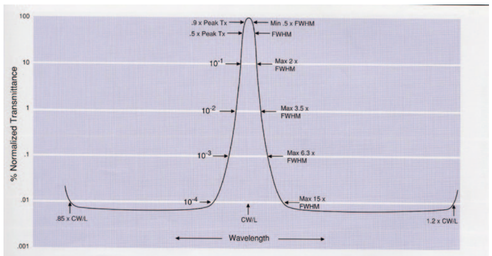
FILTER 4



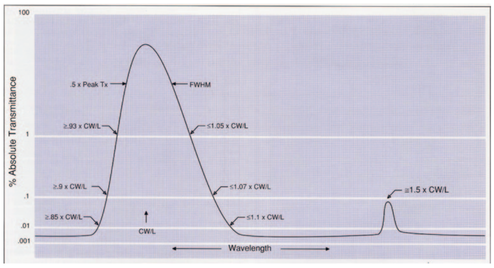
FILTER 5



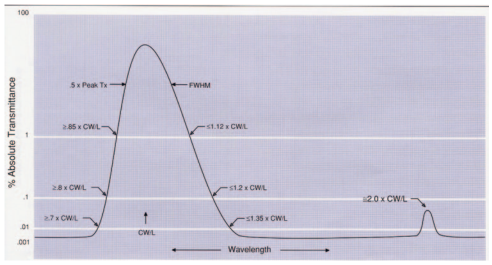
FILTER 6



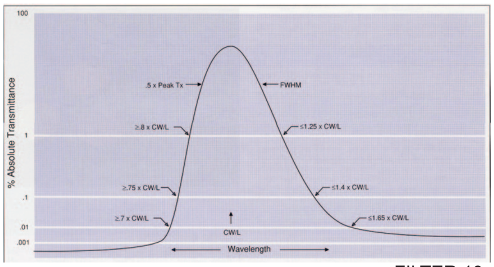
FILTER 7



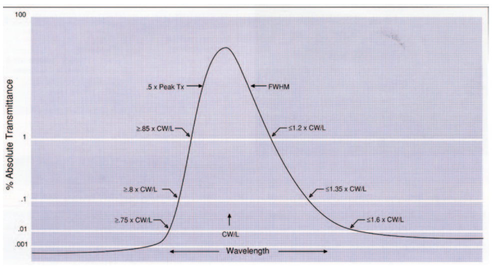
FILTER 8



FILTER 9



FILTER 10



Type	CW/L(nm)	FWHM(nm)	# of Cav	Filter Type	MinT(%)	n*	Thick (mm)	12.5mm φ	25mmφ	50mm φ
Zn	214.0+3/-0	10±2	-	7	12	---	4.0	214FS10-12.5	214FS10-25	214FS10-50
Zn	214.0±3	22±4	-	8	20	---	4.0	214FS22-12.5	214FS22-25	214FS22-50
-	220.0+3-0	10±2	-	7	12	---	4.0	220FS10-12.5	220FS10-25	220FS10-50
Cd	228.0+3-0	10±2	-	7	15	---	4.0	228FS10-12.5	228FS10-25	228FS10-50
Cd	228.0±3	25±5	-	8	20	---	4.0	228FS25-12.5	228FS25-25	228FS25-50
Ni	232.0+3/-0	10±2	-	7	15	---	4.0	232FS10-12.5	232FS10-25	232FS10-50
Co	239.0+3-0	10±2	-	7	15	---	4.0	-	239FS10-25	239FS10-50
Co	239.0±3	25±5	-	8	20	---	4.0	239FS25-12.5	239FS25-25	239FS25-50
HeCd	248.0+3-0	10±2	-	7	12	---	4.0	248FS10-12.5	248FS10-25	248FS10-50
-	250.0+3-0	10±2	-	7	12	---	4.0	250FS10-12.5	250FS10-25	250FS10-50
Hg	253.7+3-0	10±2	-	7	12	---	4.0	254FS10-12.5	254FS10-25	254FS10-50
Hg	253.7±3	25±5	-	8	20	---	4.0	254FS25-12.5	254FS25-25	254FS25-50
Hg	253.7+10-0	40±8	-	8	20	---	4.0	254FS40-12.5	254FS40-25	254FS40-50
-	260.0+3/-0	10±2	-	7	12	---	4.0	260FS10-12.5	260FS10-25	260FS10-50
Hg	265.0+3/-0	10±2	-	7	12	---	4.0	265FS10-12.5	265FS10-25	265FS10-50
Hg	265.0±3	25±5	-	8	20	---	4.0	265FS25-12.5	265FS25-25	265FS25-50
-	270.0+3/-0	10±2	-	7	12	---	4.0	-	270FS10-25	270FS10-50
Hg	280.0+3/-0	10±2	-	7	12	---	4.0	280FS10-12.5	280FS10-25	280FS10-50
Hg	280.0±3	25±5	-	8	20	---	4.0	280FS25-12.5	280FS25-25	280FS25-50
Hg	289.0+3-0	10±2	-	7	15	---	4.0	289FS10-12.5	289FS10-25	289FS10-50
Hg	296.7+3/-0	10±2	-	7	15	---	4.0	297FS10-12.5	297FS10-25	297FS10-50
-	300.0+3/-0	10±2	-	7	15	---	4.0	300FS10-12.5	300FS10-25	300FS10-50
-	300.0±3	25±5	-	8	20	---	4.0	300FS25-12.5	300FS25-25	300FS25-50
-	300.0+10/-0	40±8	-	8	20	---	4.0	300FS40-12.5	300FS40-25	300FS40-50
Zn	307.1+3/-0	10±2	-	7	15	---	4.0	307FS10-12.5	307FS10-25	307FS10-50
Zn	307.1±3	25±5	-	8	20	---	4.0	307FS25-12.5	307FS25-25	307FS25-50
-	310.0+3-0	10±2	-	7	15	---	4.0	310FS10-12.5	310FS10-25	310FS10-50
Hg	313.0+3/-0	10±2	-	7	15	---	4.0	313FS10-12.5	313FS10-25	313FS10-50
Hg	313.0±3	25±5	-	8	20	---	4.0	313FS25-12.5	313FS25-25	313FS25-50
-	320.0+3/-0	10±2	3	3	25	1.45	8.0	320FS10-12.5	320FS10-25	320FS10-50
Cd	326.1+.5/-0	3±.5	2	2	15	1.45	8.0	326FS03-12.5	326FS03-25	326FS03-50
Cd	326.1+2/-0	10±2	3	3	25	1.45	8.0	326FS10-12.5	326FS10-25	326FS10-50
Cd	326.1±3	25±5	3	3	25	1.45	8.0	326FS25-12.5	326FS25-25	326FS25-50
-	330.0+3/-0	10±2	3	3	25	1.45	8.0	-	330FS10-25	330FS10-50
Hg	334.0+2/-0	10±2	3	3	25	1.45	8.0	334FS10-12.5	334FS10-25	334FS10-50
N laser	337.1+.5/-0	3±.5	2	2	20	1.45	7.0	337FS03-12.5	337FS03-25	337FS03-50
N laser	337.1+2/-0	10±2	3	3	25	1.45	7.0	337FS10-12.5	337FS10-25	337FS10-50
Biomedical	340.0+2/-0	8±2	3	3	*35	1.45	7.0	340FS08-12.5	340FS08-25	340FS08-50
Biomedical	340.0+3/-0	10±2	3	3	25	1.45	7.0	340FS10-12.5	340FS10-25	340FS10-50
Biomedical	340.0±3	25±5	3	3	25	1.45	7.0	340FS25-12.5	340FS25-25	340FS25-50
-	350.0+3/-0	10±2	3	3	25	1.45	7.0	350FS10-12.5	350FS10-25	350FS10-50
-	350.0±3	25±5	3	3	25	1.45	7.0	350FS25-12.5	350FS25-25	350FS25-50
-	350.0+10/-0	40±8	3	3	25	1.45	7.0	350FS40-12.5	350FS40-25	350FS40-50
Nd/YAG/laser	355.0+2/-0	10±2	3	3	25	1.45	7.0	355FS10-12.5	355FS10-25	355FS10-50
-	360.0 +3/-0	10±2	3	3	25	1.45	7.0	360FS10-12.5	360FS10-25	360FS10-50
Hg	365.0+1/-0	5±1	2	2	20	1.45	7.0	365FS05-12.5	365FS05-25	365FS05-50
Hg	365.0+2/-0	10±2	3	3	25	1.45	7.0	365FS10-12.5	365FS10-25	365FS10-50
Hg	365.0±3	25±5	3	3	25	1.45	7.0	365FS25-12.5	365FS25-25	365FS25-50
-	370.0+3/-0	10±2	3	3	25	1.45	7.0	-	370FS10-25	370FS10-50
-	380.0+3/-0	10±2	3	3	25	1.45	7.0	380FS10-12.5	380FS10-25	380FS10-50
-	390.0+3/-0	10±2	3	3	40	1.45	7.0	-	390FS10-25	390FS10-50
	400.0+3/-0	10 ±2	3	3	45	1.45	7.0	400FS10-12.5	400FS10-25	400FS10-50
-	400.0 ±2	20 ±4	3	3	45	1.45	7.0	400FS20-12.5	400FS20-25	400FS20-50
-	400.0+10/-0	40 ±8	3	3	45	1.45	7.0	400FS40-12.5	400FS40-25	400FS40-50
-	400.0+25/-0	70 ±16	-	10	60	---	7.0	400FS70-12.5	400FS70-25	400FS70-50
Hg	404.7+1/-0	5 ±1	2	2	35	1.45	7.0	405FS05-12.5	405FS05-25	405FS05-50
Hg	404.7+2/-0	10 ±2	3	3	45	1.45	7.0	405FS10-12.5	405FS10-25	405FS10-50
-	410.0+3/-0	10 ±2	3	3	45	1.45	7.0	-	410FS10-25	410FS10-50
-	415.0+2/-0	10 ±2	3	3	45	1.45	7.0	415FS10-12.5	415FS10-25	415FS10-50
-	420.0+3/-0	10 ±2	3	3	45	1.45	7.0	-	420FS10-25	420FS10-50
-	430.0+3/-0	10 ±2	3	3	45	1.45	7.0	-	430FS10-25	430FS10-50
Hg	435.8+1/-0	5 ±1	2	2	45	1.45	7.0	436FS05-12.5	436FS05-25	436FS05-50
Hg	435.8+2/-0	10 ±2	3	3	45	1.45	7.0	436FS10-12.5	436FS10-25	436FS10-50
-	440.0+3/-0	10 ±2	3	3	45	1.45	7.0	-	440FS10-25	440FS10-50
He/Cd laser	441.6+.2/-0	1 ±.2	2	2	35	1.45	8.5	442FS02-12.5	442FS02-25	442FS02-50
He/Cd laser	441.6+.5/-0	3 ±.5	2	2	40	1.45	8.5	442FS03-12.5	442FS03-25	442FS03-50
He/Cd laser	441.6+2/-0	10 ±2	3	3	45	1.45	7.0	442FS10-12.5	442FS10-25	442FS10-50
-	450.0+3/-0	10 ±2	3	3	45	1.45	7.0	450FS10-12.5	450FS10-25	450FS10-50
-	450.0 ±2	20 ±4	3	3	55	1.45	7.0	450FS20-12.5	450FS20-25	450FS20-50
-	450.0+10/-0	40 ±8	3	3	55	1.45	7.0	450FS40-12.5	450FS40-25	450FS40-50
-	450.0+25/-0	80 ±16	-	9	65	---	7.0	450FS80-12.5	450FS80-25	450FS80-50
Cs	455.5+2/-0	10 ±2	3	3	50	1.45	7.0	456FS10-12.5	456FS10-25	456FS10-50
Ar/Ion laser	457.9+.2/-0	1 ±.2	2	2	40	1.45	8.5	458FS02-12.5	458FS02-25	458FS02-50
Ar/Ion laser	457.9+.5/-0	3 ±.5	2	2	45	1.45	8.5	458FS03-12.5	458FS03-25	458FS03-50
Ar/Ion laser	457.9+2/-0	10 ±2	3	3	50	1.45	7.0	458FS10-12.5	458FS10-25	458FS10-50

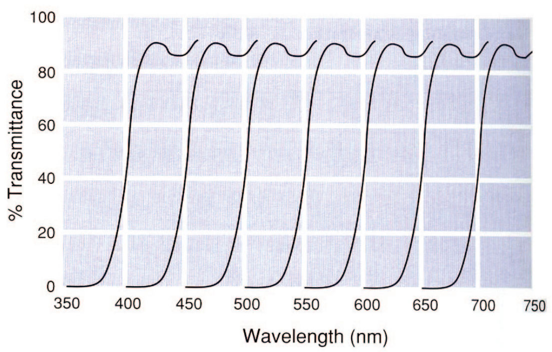
Type	CW/L(nm)	FWHM(nm)	# of Cav	Filter Type	MinT(%)	n*	Thick (mm)	12.5mm φ	25mm φ	50mm φ
-	460.0+3/-0	10 ±2	3	3	50	1.45	7.0	-	460FS10-25	460FS10-50
-	470.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	470FS10-25	470FS10-50
-	480.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	480FS10-25	480FS10-50
H	486.1+2/-0	10 ±2	3	3	50	2.05	7.0	486FS10-12.5	486FS10-25	486FS10-50
Ar/Ion laser	488.0+.2/-0	1 ±.2	2	2	45	2.05	8.5	488FS02-12.5	488FS02-25	488FS02-50
Ar/Ion laser	488.0+.5/-0	3 ±.5	2	2	50	2.05	8.5	488FS03-12.5	488FS03-25	488FS03-50
Ar/Ion laser	488.0+2/-0	10 ±2	3	3	55	2.05	7.0	488FS10-12.5	488FS10-25	488FS10-50
-	490.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	490FS10-25	490FS10-5
	500.0+3/-0	10 ±2	3	3	55	2.05	7.0	500FS10-12.5	500FS10-25	500FS10-50
-	500.0 ±2	20 ±4	3	3	55	2.05	7.0	500FS20-12.5	500FS20-25	500FS20-50
-	500.0+10/-0	40 ±8	3	3	55	2.05	7.0	500FS40-12.5	500FS40-25	500FS40-50
-	500.0+25/-0	80 ±16	-	9	70	---	7.0	500FS80-12.5	500FS80-25	500FS80-50
Cd	508.5+2/-0	10 ±2	3	3	55	2.05	7.0	508FS10-12.5	508FS10-25	508FS10-50
-	510.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	510FS10-25	510FS10-50
Ar/Ion laser	514.5+.2/-0	1 ±.2	2	2	45	2.05	8.5	515FS02-12.5	515FS02-25	515FS02-50
Ar/Ion laser	514.5+.5/-0	3 ±.5	2	2	50	2.05	8.5	515FS03-12.5	515FS03-25	515FS03-50
Ar/Ion laser	514.5+2/-0	10 ±2	3	3	55	2.05	7.0	515FS10-12.5	515FS10-25	515FS10-50
-	520.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	520FS10-25	520FS10-50
-	523.0+2/-0	10 ±2	3	3	55	2.05	7.0	523FS10-12.5	523FS10-25	523FS10-50
-	530.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	530FS10-25	530FS10-50
Nd/YAG laser	532.0+.2/-0	1 ±.2	2	2	45	2.05	8.5	532FS02-12.5	532FS02-25	532FS02-50
Nd/YAG laser	532.0+.5/-0	3 ±.5	2	2	50	2.05	8.5	532FS03-12.5	532FS03-25	532FS03-50
Nd/YAG laser	532.0+2/-0	10 ±2	3	3	55	2.05	7.0	532FS10-12.5	532FS10-25	532FS10-50
Ti	535.0+2/-0	10 ±2	3	3	55	2.05	7.0	535FS10-12.5	535FS10-25	535FS10-50
-	540.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	540FS10-25	540FS10-50
-	543.5+2/-0	10 ±2	3	3	55	2.05	7.0	544FS10-12.5	544FS10-25	544FS10-50
Hg	546.1+1/-0	5 ±1	2	2	50	1.45	7.0	546FS05-12.5	546FS05-25	546FS05-50
Hg	546.1+2/-0	10 ±2	3	3	55	2.05	7.0	546FS10-12.5	546FS10-25	546FS10-50
-	550.0+3/-0	10 ±2	3	3	55	2.05	7.0	550FS10-12.5	550FS10-25	550FS10-50
-	550.0 ±2	20 ±4	3	3	55	1.45	7.0	550FS20-12.5	550FS20-25	550FS20-50
-	550.0+10/-0	40 ±8	3	3	55	2.05	7.0	550FS40-12.5	550FS40-25	550FS40-50
-	550.0+25/-0	80 ±16	-	9	70	---	7.0	550FS80-12.5	550FS80-25	550FS80-50
-	560.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	560FS10-25	560FS10-50
-	570.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	570FS10-25	570FS10-50
Hg	577.0+1/-0	5 ±1	2	2	50	1.45	7.0	577FS05-12.5	577FS05-25	577FS05-50
Hg	577.0+2/-0	10 ±2	3	3	55	2.05	7.0	577FS10-12.5	577FS10-25	577FS10-50
-	580.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	580FS10-25	580FS10-50
Na	589.3+2/-0	10 ±2	3	3	55	2.05	7.0	589FS10-12.5	589FS10-25	589FS10-50
-	590.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	590FS10-25	590FS10-50
	600.0+3/-0	10 ±2	3	3	55	2.05	7.0	600FS10-12.5	600FS10-25	600FS10-50
-	600.0±2	20 ±4	3	3	55	1.45	7.0	600FS20-12.5	600FS20-25	600FS20-50
-	600.0+10/-0	40 ±8	3	3	55	2.05	7.0	600FS40-12.5	600FS40-25	600FS40-50
-	600.0+25/-0	80 ±16	-	9	70	---	7.0	600FS80-12.5	600FS80-25	600FS80-50
-	610.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	610FS10-25	610FS10-50
-	620.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	620FS10-25	620FS10-50
-	630.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	630FS10-25	630FS10-50
HeNe laser	632.8+.2/-0	1 ±.2	2	2	50	2.05	8.5	633FS02-12.5	633FS02-25	633FS02-50
HeNe laser	632.8+.5/-0	3 ±.5	2	2	50	2.05	8.5	633FS03-12.5	633FS03-25	633FS03-50
HeNe laser	632.8+2/-0	10 ±2	3	3	55	2.05	7.0	633FS10-12.5	633FS10-25	633FS10-50
Zn	636.2+2/-0	10 ±2	3	3	60	2.05	7.0	636FS10-12.5	636FS10-25	636FS10-50
-	640.0+3/-0	10 ±2	3	3	60	2.05	7.0	-	640FS10-25	640FS10-50
Kr laser	647.1+.2/-0	1 ±.2	2	2	50	2.05	8.5	647FS02-12.5	647FS02-25	647FS02-50
Kr laser	647.1+.5/-0	3 ±.5	2	2	50	2.05	8.5	647FS03-12.5	647FS03-25	647FS03-50
Kr laser	647.1+2/-0	10 ±2	3	3	60	2.05	7.0	647FS10-12.5	647FS10-25	647FS10-50
-	650.0+3/-0	10 ±2	3	3	55	2.05	7.0	650FS10-12.5	650FS10-25	650FS10-50
-	650.0±2	20 ±4	3	3	55	2.05	7.0	650FS20-12.5	650FS20-25	650FS20-50
-	650.0+10/-0	40 ±8	3	3	50	2.05	7.0	650FS40-12.5	650FS40-25	650FS40-50
-	650.0+25/-0	80 ±16	-	9	70	---	7.0	650FS80-12.5	650FS80-25	650FS80-50
H-alpha	656.3+.2/-0	1 ±.2	2	2	45	2.05	8.5	656FS02-12.5	656FS02-25	656FS02-50
H-alpha	656.3+.5/-0	3 ±.5	2	2	50	2.05	8.5	656FS03-12.5	656FS03-25	656FS03-50
H-alpha	656.3+2/-0	10 ±2	3	3	55	2.05	7.0	656FS10-12.5	656FS10-25	656FS10-50
-	660.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	660FS10-25	660FS10-50
	670.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	670FS10-25	670FS10-50
Li	670.8+2/-0	10 ±2	3	3	55	2.05	7.0	671FS10-12.5	671FS10-25	671FS10-50
Laser Diode	675.0 ±2	20 ±4	3	3	55	2.05	7.0	675FS20-12.5	675FS20-25	-
-	680.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	680FS10-25	680FS10-50
-	690.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	690FS10-25	690FS10-50
Ruby laser	694.3+.2/-0	1 ±.2	2	2	45	2.05	8.5	694FS02-12.5	694FS02-25	694FS02-50
Ruby laser	694.3+.5/-0	3 ±.5	2	2	50	2.05	8.5	694FS03-12.5	694FS03-25	694FS03-50
Ruby laser	694.3+2/-0	10 ±2	3	3	55	2.05	7.0	694FS10-12.5	694FS10-25	694FS10-50
	700.0+3/-0	10 ±2	3	3	55	2.05	7.0	700FS10-12.5	700FS10-25	700FS10-50
-	700.0 ±2	20 ±4	3	3	55	2.05	7.0	700FS20-12.5	700FS20-25	700FS20-50
-	700.0+10/-0	40 ±8	3	3	50	2.05	7.0	700FS40-12.5	700FS40-25	700FS40-50
-	700.0+25/-0	80 ±16	-	9	55	ÑÑÑ	7.0	700FS80-12.5	700FS80-25	700FS80-50
-	710.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	710FS10-25	710FS10-50

Type	CW/L(nm)	FWHM(nm)	# of Cav	Filter Type	MinT(%)	n*	Thick (mm)	12.5mm φ	25mm φ	50mm φ
	720.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	720FS10-25	720FS10-50
-	730.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	730FS10-25	730FS10-50
-	740.0+3/-0	10 ±2	3	3	55	2.05	7.0	-	740FS10-25	740FS10-50
-	750.0+3/-0	10±2	3	3	50	2.05	7.0	750FS10-12.5	750FS10-25	750FS10-50
-	750.0±2	20±4	3	3	50	2.05	7.0	750FS20-12.5	750FS20-25	750FS20-50
-	750.0±5	40±5	3	3	40	2.05	7.0	750FS40-12.5	750FS40-25	750FS40-50
-	750.0+25/-0	100±20	-	9	65	ÑÑ	7.0	750FS00-12.5	750FS00-25	750FS00-50
-	760.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	760FS10-25	760FS10-50
K	766.5+2/-0	10 ±2	3	3	50	2.05	7.0	766FS10-12.5	766FS10-25	766FS10-50
-	770.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	770FS10-25	770FS10-50
Rb	780.0+3/-0	10 ±2	3	3	50	2.05	7.0	780FS10-12.5	780FS10-25	780FS10-50
Laser Diode	780.0 ±2	20 ±4	3	3	50	2.05	7.0	780FS20-12.5	780FS20-25	-
-	790.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	790FS10-25	790FS10-50
Rb	794.7+2/-0	10 ±2	3	3	50	2.05	7.0	795FS10-12.5	795FS10-25	795FS10-50
	800.0+3/-0	10 ±2	3	3	50	2.05	7.0	800FS10-12.5	800FS10-25	800FS10-50
-	800.0±2	20 ±4	3	3	50	2.05	7.0	800FS20-12.5	800FS20-25	800FS20-50
-	800.0+10/-0	40 ±8	3	3	50	2.05	7.0	800FS40-12.5	800FS40-25	800FS40-50
-	800.0+25/-0	100 ±20	-	9	65	---	7.0	800FS00-12.5	800FS00-25	800FS00-50
Laser Diode	810.0+3/-0	10 ±2	3	3	50	2.05	7.0	810FS10-12.5	810FS10-25	810FS10-50
Laser Diode	810.0 ±2	20 ±4	3	3	50	2.05	7.0	810FS20-12.5	810FS20-25	-
-	820.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	820FS10-25	820FS10-50
GaAlAs laser	830.0+3/-0	10 ±2	3	3	50	2.05	7.0	830FS10-12.5	830FS10-25	830FS10-50
Laser Diode	830.0 ±2	20 ±4	3	3	50	2.05	7.0	830FS20-12.5	830FS20-25	-
-	840.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	840FS10-25	840FS10-50
-	850.0+3/-0	10 ±2	3	3	50	2.05	7.0	850FS10-12.5	850FS10-25	850FS10-50
-	850.0 ±2	20 ±4	3	3	50	2.05	7.0	850FS20-12.5	850FS20-25	850FS20-50
-	850.0+10/-0	40 ±8	3	3	50	2.05	7.0	850FS40-12.5	850FS40-25	850FS40-50
-	850.0+25/-0	100 ±20	-	9	65	---	7.0	850FS00-12.5	850FS00-25	850FS00-50
-	860.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	860FS10-25	860FS10-50
-	870.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	870FS10-25	870FS10-50
-	880.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	880FS10-25	880FS10-50
-	890.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	890FS10-25	890FS10-50
	900.0+3/-0	10 ±2	3	3	50	2.05	7.0	900FS10-12.5	900FS10-25	900FS10-50
-	900.0 ±2	20 ±4	3	3	50	2.05	7.0	900FS20-12.5	900FS20-25	900FS20-50
-	900.0+10/-0	40 ±8	3	3	50	2.05	7.0	900FS40-12.5	900FS40-25	900FS40-50
-	900.0+25/-0	100 ±20	-	9	60	---	7.0	900FS00-12.5	900FS00-25	900FS00-50
GaAs	905.0+.2/-0	1 ±.2	2	2	45	2.05	8.5	905FS02-12.5	905FS02-25	905FS02-50
GaAs	905.0+.5/-0	3 ±.5	2	2	45	2.05	8.5	905FS03-12.5	905FS03-25	905FS03-50
GaAs	905.0+2/-0	10 ±.2	3	3	50	2.05	7.0	905FS10-12.5	905FS10-25	905FS10-50
-	910.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	910FS10-25	910FS10-50
-	920.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	920FS10-25	920FS10-50
-	930.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	930FS10-25	930FS10-50
-	940.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	940FS10-25	940FS10-50
-	950.0+3/-0	10 ±2	3	3	50	2.05	7.0	950FS10-12.5	950FS10-25	950FS10-50
-	950.0±2	20 ±4	3	3	50	2.05	7.0	950FS20-12.5	950FS20-25	950FS20-50
-	950.0+10/-0	40 ±8	3	3	50	1.45	7.0	950FS40-12.5	950FS40-25	950FS40-50
-	950.0+25/-0	100 ±20	-	9	60	---	7.0	950FS00-12.5	950FS00-25	950FS00-50
-	960.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	960FS10-25	960FS10-50
-	970.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	970FS10-25	970FS10-50
-	980.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	980FS10-25	980FS10-50
-	990.0+3/-0	10 ±2	3	3	50	2.05	7.0	-	990FS10-25	990FS10-50
	1000.0+3/-0	10 ±2	3	3	45	2.05	8.5	100FS10-12.5	100FS10-25	100FS10-50
-	1000.0 ±2	20 ±4	3	3	45	2.05	8.5	100FS20-12.5	100FS20-25	100FS20-50
-	1000.0+10/-0	40 ±8	3	3	45	1.45	8.5	100FS40-12.5	100FS40-25	100FS40-50
-	1000.0+25/-0	100 ±20	-	9	60	---	8.5	100FS00-12.5	100FS00-25	100FS00-50
Hg	1014.0+2/-0	10 ±2	3	3	45	2.05	8.5	-	014FS10-25	014FS10-50
-	1046.0+2/-0	10 ±2	3	3	45	2.05	8.5	046FS10-12.5	046FS10-25	046FS10-50
-	1050.0+3/-0	9 ±2	3	3	45	2.05	8.5	-	050FS10-25	050FS10-50
Nd/YAG	1064.0+.2/-.0	1 ±.2	2	2	40	2.05	8.5	064FS02-12.5	064FS02-25	064FS02-50
Nd/YAG	1064.0+.5/-.0	3 ±.5	2	2	45	2.05	8.5	064FS03-12.5	064FS03-25	064FS03-50
Nd/YAG	1064.0 +2/-0	10 ±2	3	3	40	2.05	8.5	064FS10-12.5	064FS10-25	064FS10-50
-	1100.0+3/-0	10 ±2	3	3	40	2.05	8.5	-	110FS10-25	110FS10-50
-	1150.0+3/-0	10 ±2	3	3	40	2.05	8.5	-	115FS10-25	115FS10-50
-	1200.0+3/-0	10 ±2	2	2	35	2.05	8.5	-	120FS10-25	120FS10-50
-	1250.0+3/-0	10 ±2	2	2	35	2.05	8.5	-	125FS10-25	125FS10-50
Laser Diode	1300.0+3/-0	10 ±2	2	2	35	2.05	8.5	130FS10-12.5	130FS10-25	130FS10-50
Laser Diode	1300.0 ±3	20 ±5	3	3	35	2.05	8.5	130FS20-12.5	130FS20-25	130FS20-50
Laser Diode	1350.0+3/-0	10 ±2	2	2	35	2.05	8.5	135FS10-12.5	135FS10-25	135FS10-50
Laser Diode	1400.0+3/-0	10 ±2	2	2	30	2.05	8.5	140FS10-12.5	140FS10-25	140FS10-50
Laser Diode	1500.0+3/-0	10 ±2	2	2	30	2.05	8.5	150FS10-12.5	150FS10-25	150FS10-50
Laser Diode	1500.0 ±3	20 ±5	3	3	30	2.05	8.5	150FS20-12.5	150FS20-25	150FS20-50
Laser Diode	1550.0+3/-0	10 ±2	2	2	30	2.05	8.5	155FS10-12.5	155FS10-25	155FS10-50
Laser Diode	1550.0 ±3	20 ±5	3	3	30	2.05	8.5	155FS20-12.5	155FS20-25	155FS20-50

EDGE FILTERS(LONG WAVE/SHORT WAVE)

Often referred to as long wave pass (LWP) and short wave pass (SWP) filters, these sharp-cut edge filters are distinguished by their high rate of transition between their region of reflection and transmission. This high rate of transition makes them an excellent choice as emission filters in fluorescence applications, and as order sorting filters in photometry. They are also very useful as stray light or trim filters, to eliminate any unwanted near band radiation. All LWP/SWP filters are constructed of hard, durable first-surface dielectric coatings, and will withstand the normal cleaning and handling associated with any high-quality optical component. Their film construction is essentially a modified quarter-wave stack, using interference effects rather than absorption to isolate their spectral bands. Unlike filter glass, which is not sensitive to wavelength shift with angle, these filters will shift shorter in wavelength with an increase in their angle of incidence. This feature can be useful in applications where it may be desirable to fine tune the 50% cut-on, or cut-off wavelength. All standard edge filters are available in 50nm increments from 400nm to 1000nm. Custom edge filters are available and will be quoted upon request.

VISIBLE LONG PASS FILTERS



Specifications	
Size Tolerance	+0.0mm/-0.5mm
Thickness	4.0mm max.
Minimum Clear Aperture	95% of O.D.
Substrate Material	Glass
Flatness	3 to 5 wave per 25mm
Parallelism	3 Arc minutes or better
Surface Quality	80/50 Per MIL-O-13830B
Coating Quality	40/20 Per MIL-O-13830B
Humidity and Abrasion	Per MIL-C-675A
Operating Temperature	-50°C to +100°C
Cut-on and cut-off slopes	6% Maximum
Cut-on and cut-off tolerance	±10nm
Mechanical	Not mounted in metal holders
Transmission	
Long Wave Pass	85% average from the 50% cut-on point to 2000nm
Short Wave Pass	85% average from the 50% cut-off point to 0.6 x the 5% cut-off-point *With the exception of the 400nm filter, all others will drop off in transmission at wavelengths less than 425nm.
Rejection	
Long Wave Pass	99% or greater from 0.9 x the 50% point to the ultraviolet
Short Wave Pass	99% or greater from 1.07 x the 50% point to 1.25 x the 50% point
Effective Index of Refraction (n*)	1.7 (approximately)

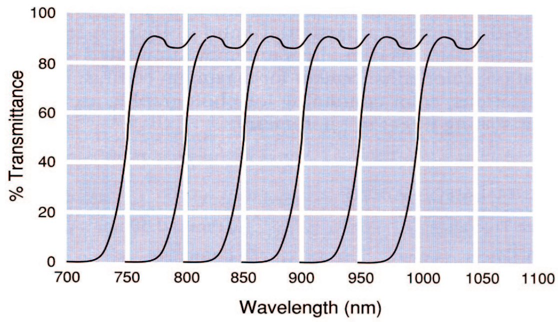
Visible Long Wave Pass Filters

	Part Numbers		
50% Point	25mmϕ	50mmϕ	50mm sq
400nm	400FH90-25	400FH90-50	400FH90-50S
450nm	450FH90-25	450FH90-50	450FH90-50S
500nm	500FH90-25	500FH90-50	500FH90-50S
550nm	550FH90-25	550FH90-50	550FH90-50S
600nm	600FH90-25	600FH90-50	600FH90-50S
650nm	650FH90-25	650FH90-50	650FH90-50S
700nm	700FH90-25	700FH90-50	700FH90-50S

Near Infrared Long Wave Pass Edge Filters

50% Point	Part Numbers		
	25mmφ	50mmφ	50mm sq.
750nm	750FH90-25	750FH90-50	750FH90-50S
800nm	800FH90-25	800FH90-50	800FH90-50S
850nm	850FH90-25	850FH90-50	850FH90-50S
900nm	900FH90-25	900FH90-50	900FH90-50S
950nm	950FH90-25	950FH90-50	950FH90-50S
1000nm	100FH90-25	100FH90-50	100FH90-50S

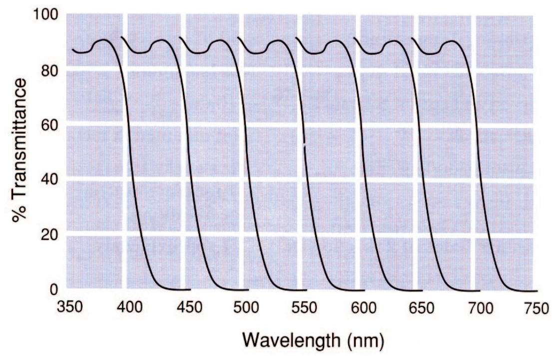
NEAR INFRARED LONG PASS FILTERS



Visible Short Wave Pass Filters

50% Point	Part Numbers		
	25mmφ	50mmφ	50mm sq.
400nm	400FL07-25	400FL07-50	400FL07-50S
450nm	450FL07-25	450FL07-50	450FL07-50S
500nm	500FL07-25	500FL07-50	500FL07-50S
550nm	550FL07-25	550FL07-50	550FL07-50S
600nm	600FL07-25	600FL07-50	600FL07-50S
650nm	650FL07-25	650FL07-50	650FL07-50S
700nm	700FL07-25	700FL07-50	700FL07-50S

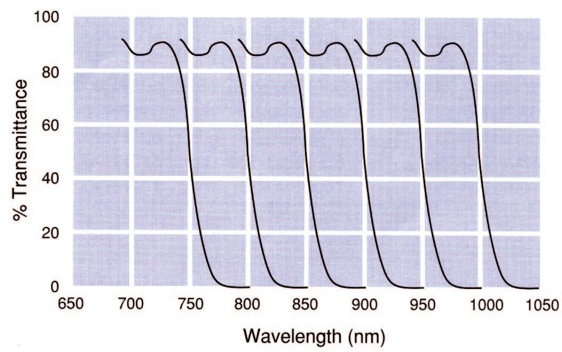
VISIBLE SHORT PASS FILTERS



Near Infrared Short Wave Pass Filters

50% Point	Part Numbers		
	25mmφ	50mmφ	50mm sq.
750nm	750FL07-25	750FL07-50	750FL07-50S
800nm	800FL07-25	800FL07-50	800FL07-50S
850nm	850FL07-25	850FL07-50	850FL07-50S
900nm	900FL07-25	900FL07-50	900FL07-50S
950nm	950FL07-25	950FL07-50	950FL07-50S
1000nm	100FL07-25	100FL07-50	100FL07-50S

NEAR INFRARED SHORT PASS FILTERS



HEAT CONTROL FILTERS

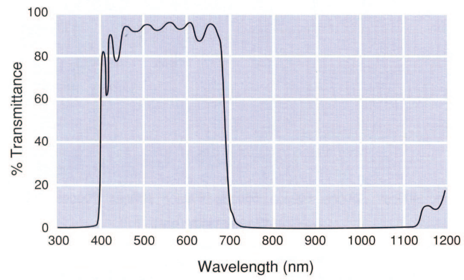
Heat Control filters are mainly used to remove the heat from high-power illumination system.

The optical system should be configured so that the first mirror in the system is a cold mirror mounted at 45° to the incident radiation. This configuration will transmit a major portion of the systems heat while reflecting the visible light. The second component in the optical path should be a hot mirror mounted perpendicular to the light beam. This mirror will reflect the remaining heat while still transmitting 90% of the visible light.

Speciations	
Size Tolerance	+0.0mm/-0.5mm
Thickness	3.0mm ±0.5mm
Minimum Clear Aperture	95% of O.D.
Substrate Material	Borosilicate Glass
Flatness	5 to 10 waves per 25mm
Parallelism	3 Arc Minutes Or Better
Surface Quality	80/50 Per MIL-O-13830
Coating Quality	40/20 Per MIL-O-13830
Max Operating Temperature	+200°C

HOT MIRROR

Hot Mirror reflect the heat (HOT) and transmit the visible light. All of the coatings are classified as hard, first surface dielectric and will meet or exceed the specified humidity and abrasion specifications. To prevent cracking or crazing from high heat applications, all coatings are deposited onto a low expansion material such as borosilicate glass.

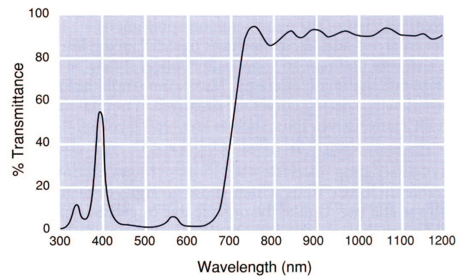


Average Transmittance	450nm to 675nm ≥ 85%
Average Reflection	750nm to 1200nm ≥90%

Ordering Information: 775FW82-25 (25:φ25mm, 50: φ50mm, 50s:50mmsq)

COLD MORRIR

A Cold Mirror it reflects the visible (COLD) and transmits the infrared. Their coating are all first surface variety and like the hot mirrors, are also deposited onto low expansion material such as borosilicate glass. These mirrors are usually used at a 45° angle of incidence in randomly polarized light.

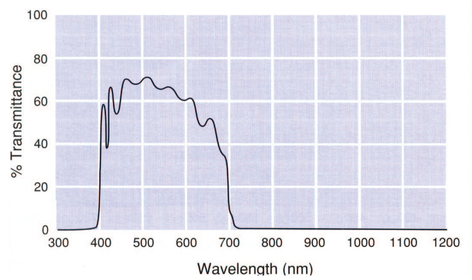


Average Transmittance	800nm to 1200nm ≥ 85%
Average Reflection	450nm to 650nm ≥ 90%

Ordering Information: 645FK84-25 (25:φ25mm, 50:φ50mm, 50s:50mmsq)

INFRARED SUPPRESSION FILTERS

These filter are very similar to the Hot Mirror with the exception of their longer IR blocking range. This extened blocking range is achieved by a combination of reflection from the dielectric stack and absorption from an IR absorbing filter glass. Due to this absorption factor, these filters are only useful in low power applications where the maximum filter temperature does not exceed 100°C.

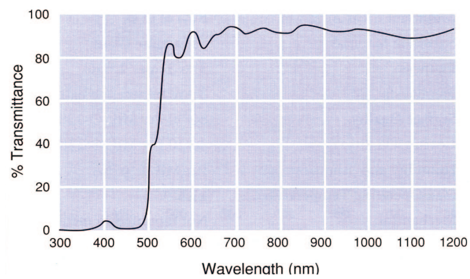


Average Transmittance	400nm to 600nm ≥ 65%
Average Reflection	700nm to 2000nm ≥ 10%

Ordering Information: 800FB72-25 (25:φ25mm, 50: φ50mm, 50s:50mmsq)

Ultraviolet Cold Mirrors

Ultraviolet Cold Mirrors efficiently reflect the ultraviolet and transmit the visible and infrared. They are normally used at an angle of 45° and are excellent for applications where one wants to separate the ultraviolet from the visible and near infrared.



Average Transmittance	600nm to 1200nm ≥ 85%
Average Reflection	325nm to 475nm ≥ 90%

Ordering Information: 375FV86-25(25:φ25mm, 50: φ50mm, 50s:50mmsq)

NOTCH FILTERS

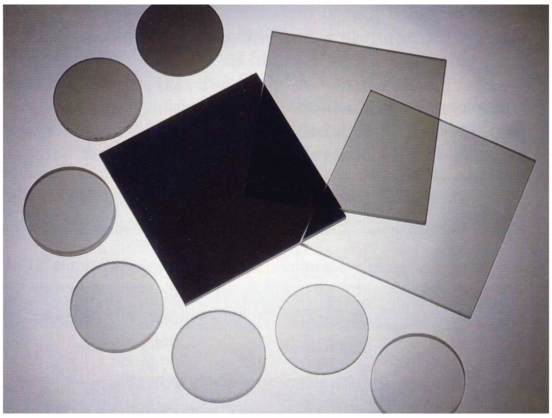
- Narrow Band Rejection by Reflection
- Low Ripple, No Harmonics
- Will Not Autofluoresce
- Designed for 0° Angle of Incidence

Rugate notch filters are interference filters that have a deep, narrow rejection band while also providing high, flat transmission for the rest of the spectrum. Typical applications include laser-based fluorescence and ophthalmic devices. Rugate notch filters feature superior performance over standard notch filters due to the novel manufacturing process that yields a continuously varying index of refraction throughout the oxide film layers. Because of this process, Rugate notch filters feature low ripple and no harmonic reflections compared to standard notch filters, which are made with discrete layers of materials with different indices of refraction. Rugate Notch Filters exhibit a high degree of environmental durability and extremely low wavelength shift at high temperatures. The center wavelength will shift to lower wavelengths when incident light is not collimated or at 0° AOI.

Specification Table	
Diameter	25.4mm, +0.0/-0.25mm
Thickness	2.54mm, +0.0/-0.127mm
Clear Aperture	21.6mm minimum
Surface Quality	60-40
Central Wavelength (CWL) Tolerance	± 1% of CWL
Full Width Half Maximum (FWHM)	5% of CWL
FWHM Tolerance	± 0.5% of CWL
Transmission	90% average
Ripple	5% max
Blocking at CWL	3.0 minimum Optical Density
Reflectivity at CWL	99.5% minimum
Transmitted Wavefront Distortion	λ /inch
Construction	Rugate interference coating on UV-grade Fused Silica substrate mounted in aluminum ring

CWL (nm)	FWHM (nm)
1064.000	53.200
488.000	24.400
532.000	26.600
632.800	31.600

ABSORPTION NEUTRAL DENSITY FILTERS



Absorption type neural filters are attain their density by absorbing light within the substrate, whereas the metallic type attain their density by both reflection and absorption. These filters reflect very little light. The absorption type neutral density filter is preferred over the metallic type since the reflections are very low. To further eliminate the possibility of any unwanted reflected light are coated. Both surfaces of all absorbing neutral density filters with a visible broadband anti-reflection coating. This coating reduces the surface reflection to approximately 0.5% per surface.

Since the glass absorbs the light within the substrate, the optical density is very dependent upon the thickness of the substrate.

Optical density (D) is defined as the logarithm to the base 10 of the reciprocal of the transmitted radiant power(T)

$$D=\log_{10}1/T \quad \text{or} \quad T=10^{-D}$$

Specifications	
Thickness	5.0mm (maximum)
Dimensional Tolerances	±0.5mm
Clear Aperture	90% of diameter
Surface Quality	60/40 Per MIL-0-13830B
Max. Operating temperature	+100°C
Substrate Material	Schott® absorption glass
Optical Quality	Flatness of 3 to 5 waves per inch and parallelism of 3 arc minutes or better
Anti-Reflection Coatings	< or = 0.5% avg. per surface from 400nm to 700nm

Optical Density	Density Tolerance @550nm	Transmission %	Spectral Range	Thickness	25mmϕ	50mm x 50mm
0.10	±10%	79.43	400nm-700nm	4.95mm	010ABND-25	010ABND-50S
0.20	±10%	63.10	400nm-700nm	1.91mm	020ABND-25	020ABND-50S
0.30	±10%	50.12	400nm-700nm	2.84mm	030ABND-25	030ABND-50S
0.40	±10%	39.81	400nm-700nm	3.78mm	040ABND-25	040ABND-50S
0.50	±10%	31.62	400nm-700nm	2.11mm	050ABND-25	050ABND-50S
0.60	±10%	25.12	400nm-700nm	2.54mm	060ABND-25	060ABND-50S
0.70	±10%	19.95	400nm-700nm	2.95mm	070ABND-25	070ABND-50S
0.80	±10%	15.85	400nm-700nm	3.38mm	080ABND-25	080ABND-50S
0.90	±10%	12.59	400nm-700nm	1.75mm	090ABND-25	090ABND-50S
1.00	±10%	10.00	400nm-700nm	1.96mm	100ABND-25	100ABND-50S
1.50	±10%	03.16	400nm-700nm	2.90mm	150ABND-25	150ABND-50S
2.00	±10%	01.00	400nm-700nm	1.96mm	200ABND-25	200ABND-50S
3.00	±10%	00.10	400nm-700nm	2.92mm	300ABND-25	300ABND-50S
4.00	±10%	00.01	400nm-700nm	2.82mm	400ABND-25	400ABND-50S

METALLIC NEUTRAL DENSITY FILTERS

Neutral density filters are very useful in a number of applications such as attenuators for broadband spectral sources, partial reflectors for light balancing applications and for use as neutral beamsplitters. Metallic type neutral density filters obtain their optical density by depositing a metal alloy coating onto a specific type of substrate which is determined by the wavelength region of interest, the substrate is either optical grade glass or fused silica.
Since these films are partially reflecting and absorbing, they will withstand more incident energy than the totally absorbing type: however, their maximum power density is still limited by the fact that are partially absorbing.

Optical density (D) is defined as the logarithm to the base 10 of the reciprocal of the transmitted radiant power(T)

$$D=\log_{10}1/T \quad \text{or} \quad T=10^{-D}$$

Specifications	
Thickness	1.5mm for glass 1.5mm for fused silica
Dimensional Tolerances	±0.5mm
Clear Aperture	85% of O.D.
Surface Quality	60/40 Per MIL-0-13830B
Coating Quality	40/20 Per MIL-0-13830B
Max. operating temperature	+100°C
Substrate Material	Fused silica for the spectral region from 250nm to 2000nm or glass for the spectral region from 350nm to 2000nm
Optical Quality	Flatness of 3 to 5 per inch and parallelism of 3 arc minutes or better

Visible/Near Infrared Region 350nm to 2000nm

Optical Density O.D.	Nominal Transmittance (%)	Part Numbers			
		12.5mmφ	25mmφ	50mmφ	50mm x 50mm
0.10	79.43	010FN52-12.5	010FN52-25	010FN52-50	010FN52-50S
0.15	70.79	015FN52-12.5	015FN52-25	015FN52-50	015FN52-50S
0.20	63.1	020FN52-12.5	020FN52-25	020FN52-50	020FN52-50S
0.30	50.12	030FN52-12.5	030FN52-25	030FN52-50	030FN52-50S
0.40	39.81	040FN52-12.5	040FN52-25	040FN52-50	040FN52-50S
0.50	31.62	050FN52-12.5	050FN52-25	050FN52-50	050FN52-50S
0.60	25.12	060FN52-12.5	060FN52-25	060FN52-50	060FN52-50S
0.70	19.95	070FN52-12.5	070FN52-25	070FN52-50	070FN52-50S
0.80	15.85	080FN52-12.5	080FN52-25	080FN52-50	080FN52-50S
0.90	12.59	090FN52-12.5	090FN52-25	090FN52-50	090FN52-50S
1.00	10.00	100FN52-12.5	100FN52-25	100FN52-50	100FN52-50S
1.30	5.010	130FN52-12.5	130FN52-25	130FN52-50	130FN52-50S
1.50	3.160	150FN52-12.5	150FN52-25	150FN52-50	150FN52-50S
2.00	1.000	200FN52-12.5	200FN52-25	200FN52-50	200FN52-50S
2.50	0.320	250FN52-12.5	250FN52-25	250FN52-50	250FN52-50S
3.00	0.100	300FN52-12.5	300FN52-25	300FN52-50	300FN52-50S
4.00	0.010	400FN52-12.5	400FN52-25	400FN52-50	400FN52-50S

Optical Density O.D.	Nominal Transmittance (%)	Part Numbers			
		12.5mmφ	25mmφ	50mmφ	50mm x 50mm
0.10	79.43	010FN46-12.5	010FN46-25	010FN46-50	010FN46-50S
0.15	70.79	015FN46-12.5	015FN46-25	015FN46-50	015FN46-50S
0.20	63.10	020FN46-12.5	020FN46-25	020FN46-50	020FN46-50S
0.30	50.12	030FN46-12.5	030FN46-25	030FN46-50	030FN46-50S
0.40	39.81	040FN46-12.5	040FN46-25	040FN46-50	040FN46-50S
0.50	31.62	050FN46-12.5	050FN46-25	050FN46-50	050FN46-50S
0.60	25.12	060FN46-12.5	060FN46-25	060FN46-50	060FN46-50S
0.70	19.95	070FN46-12.5	070FN46-25	070FN46-50	070FN46-50S
0.80	15.85	080FN46-12.5	080FN46-25	080FN46-50	080FN46-50S
0.90	12.59	090FN46-12.5	090FN46-25	090FN46-50	090FN46-50S
1.00	10.00	100FN46-12.5	100FN46-25	100FN46-50	100FN46-50S
1.30	05.01	130FN46-12.5	130FN46-25	130FN46-50	130FN46-50S
1.50	03.16	150FN46-12.5	150FN46-25	150FN46-50	150FN46-50S
2.00	01.00	200FN46-12.5	200FN46-25	200FN46-50	200FN46-50S
2.50	00.32	250FN46-12.5	250FN46-25	250FN46-50	250FN46-50S
3.00	00.10	300FN46-12.5	300FN46-25	300FN46-50	300FN46-50S
4.00	0.010	400FN46-12.5	400FN46-25	400FN46-50	400FN46-50S

CIRCULAR VARIABLE DENSITY FILTERS

- Linear, Adjustable Attenuation by Rotation
- Optical Density Range: 0- 2.0, 0 - 4.0
- UV Fused Silica Substrate
- Spectral Range: 380-1200 nm

NDC-25C-2

NDC-25C-2M

Substrate	UV Fused Silica
Diameter Tolerance	
A & B	Outer Diameter: +0.00/-0.25 mm
	Internal Diameter:+0.25/- 0.00 mm
Thickness Tolerance	±0.25 mm
C & D	
Coating Radial Angle E	±1o
Spectral Range	240-1200 nm
Coating1	Front ND, Back Uncoated
Irregularity (per cm2)	<λ
Surface Quality	60-40 Scratch-Dig
Wedge	<3 arcmin
Optical Density Tolerance	±5% (At Both Extremes)
Linearity of Density	±5%
Chamfer	0.2 mm x 0.2 mm

tem #	Optical Density1	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)
NDC-25C-2	0 - 2.0	25	7.5	8	23	270o
NDC-25C-4	0 - 4.0	25	7.5	8	23	270o
NDC-50C-2	0 - 2.0	50	7.5	8	48	270o
NDC-50C-4	0 - 4.0	50	7.5	8	48	270o
NDC-100C-2	0 - 2.0	100	7.5	8	98	270o
NDC-100C-4	0 - 4.0	100	7.5	8	98	270o

Item #	Optical Density1	Outer Diameter	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)
NDC-25C-2M	0 - 2.0	1.25”	25	7.5	8	23	270o
NDC-25C-4M	0 - 4.0	1.25”	25	7.5	8	23	270o
NDC-50C-2M	0 - 2.0	2.5”	50	7.5	8	48	270o
NDC-50C-4M	0 - 4.0	2.5”	50	7.5	8	48	270o
NDC-100C-2M	0 - 2.0	4.5”	100	7.5	8	98	270o
NDC-100C-4M	0 - 4.0	4.5”	100	7.5	8	98	270o

STEPPED DENSITY FILTERS

- Coated for Various Optical Density Step Size: 0.04 - 1.0 and 0.04 -3.0
- UV Fused Silica Substrate
- Spectral Range: 380 -120 nm
- Mounted and unmounted Versions

NDC-50S-1

NDC-50S-3M

Substrate	UV Fused Silica
Diameter Tolerance A & B	Outer Diameter: +0.00/-0.25 mm Internal Diameter:+0.25/- 0.00 mm
Thickness Tolerance C & D	±0.25 mm
Coating Radial Angle E	±1o
Spectral Range	240-1200 nm
Coating1	Front ND, Back Uncoated
Irregularity (per cm2)	<λ
Surface Quality	60-40 Scratch-Dig
Wedge	<3 arcmin
Optical Density Tolerance	±5% (At Both Extremes)
Chamfer	0.2 mm x 0.2 mm

Item #	Optical Density1	A (mm)	B (mm)	C (mm)	D (mm)	E	F (mm)
NDC-50S-1	0.04 (uncoated), 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 1.0	50	7.5	8	48	45o	2
NDC-50S-3	0.04 (uncoated), 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 3.0	50	7.5	8	48	45o	2
NDC-100S-4	0.04 (uncoated), 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 1.0, 2.0, 3.0	100	7.5	8	98	36o	2

Item #	Optical Density1	Outer Diameter	A (mm)	B (mm)	C (mm)	D (mm)	E	F (mm)
NDC-50S-1M	0.04 (uncoated), 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 1.0	2.5”	50	7.5	8	48	45o	2
NDC-50S-3M	0.04 (uncoated), 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 3.0	2.5”	50	7.5	8	48	45o	2
NDC-100S-4M	0.04 (uncoated), 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 3.0	4.5”	100	7.5	8	98	36o	2

BIOPTICS FLUORESCENCE FILTERS

THE 11 (OR BASIC) SERIES

The most fundamental of Chroma's filter sets. These sets were designed primarily for viewing the fluorescence of single fluorochrome. All of these sets contain longpass emission filters. Longpass emission filters cannot exclude the fluorescence of a second fluorochrome which may also be excited. For instance, blue light, which is the primary excitation color for FITC, will also excite, albeit slightly less efficiently, than TRITC. A longpass emission filter will be unable to exclude the fluorescence of TRITC. Most of the barrier filters of our Basic sets are made from absorptive glass.

THE 31 (OR STANDARD) SERIES

By replacing the longpass emission filter of the 11/Basic Series with bandpass emission filters Chroma's Standard series prevents bleed-through of undesired long wavelength fluorescence: for example, preventing red fluorescence from appearing in the green image. These filters also tend to decrease the problems associated with autofluorescence.

THE 41 (OR HQ) SERIES

This filter series was designed to increase brightness without a corresponding increase in noise. By increasing the number of interference cavities in both the excitation and emission filters, we have created filters with steeper passbands. This allowed wider excitation and emission filters which were spectrally closer together than the Standard series. Wider and steeper filters provide more excitation and capture more fluorescence, resulting in greater signal to noise. This unique design also allows for the excitation/dichroic/emissions to be placed closer together for those dyes with a very short Stoke's shift.

SPEICHER FILTER SETS FOR MULTI-COLOR FISH

The first group of filter sets for Multi-color FISH were designed for Dr. Michael Speicher, University of Munich. Each of the components of these filter sets (except for the SP100 set) are even steeper than the 41 series. This allows for color discrimination when using up to seven different fluorochromes. To increase brightness, each of the components is anti-reflected. Again, the SP100 is the exception.

M-F Filter Sets

The second group of M-FISH filter sets were specified by Perceptive Scientific for use with Vysis fluorochromes. Please contact Vysis for the official Vysis M-FISH filter sets.

THE 51 (OR DUAL BAND) SERIES

The dual band filter sets were designed for simultaneous viewing of two fluorochromes. Each excitation filter contains two passbands for simultaneous excitation. Concurrently each emission filter contains two passbands for simultaneous viewing. The polychroic beamsplitters contain complementary reflection and transmission bands specific to the excitation and emission filters. These sets were originally designed for FISH (fluorescence in situ hybridization). During their history their performance has been relied upon in many other applications.

THE 61 (OR TRIPLE BAND) SERIES

The triple band filter sets were designed for simultaneous viewing of three fluorochromes. Each excitation filter contains three passbands for simultaneous excitation. Concurrently each emission filter contains three passbands for simultaneous viewing. The polychroic beamsplitters contain complementary reflection and transmission bands specific to the excitation and emission filters. Like the dual band series, these sets were originally designed for FISH (fluorescence in situ hybridization). Also like the dual band sets these filter sets have shown great practicality for other applications.

SBX FILTER SETS

The acronym SBX stands single-band excitation filters. Each of our dual and triple-band filter sets is offer for sale eity single-bnad excitation filters instead of the dual or triple-bnad exciter that is usually contained. This single-band excitation filter usually housed in excitation filter wheels or excitation filter sliders. Placing a stationary multi-band beamsplitter and a multi-band emission filter within the body of microscope substantially reduces the probability of a shfted image, which often occurs by using single-band filter sets.

For example, should you wish a 51006 set with both the dual exciter and the single-band excitation filters, you would order the complete 51006 filter set plus #51490 FITC excitaionfilter and #51570 Texas Red excitation filter.

Please note that there is a choice of single-band filters for exciting DAPI. Some of these exciters are centered around 400nm. Others at 360nm excitation filters will excite a brighter DAPI signal. Each has its use. The application will detect which exciter to order.

Please call our sales department should you be interested in other set. In addition to the single-band excitation filters, we offer single-band emission filters for the various multi-band filter sets. Please contact out sales group for those listings.

THE 70 (OR RATIOMETRIC) SERIES

This series of filters was designed to allow either multiple excitation or multiple emission of a fluorochrome. By using filters mounted in either a wheel or slider, this design allows for radiometry ultilizing rather two excitation wavelengths or two emission wavelengths. This capability requires specialized hardware on the part of the investigator.

THE 80 SERIES

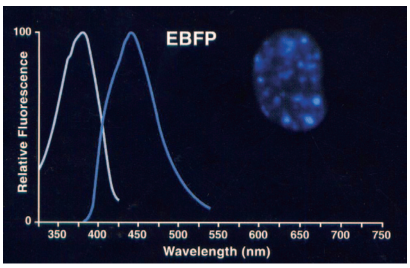
The first filter sets in this series were designed for Comparative Genomic Hybridization. The original set, #81000, was designed for Dr. Dan Pinkel and his colleagues at the university of California in San Francisco. That set and others that emerged later use a multi-band beamsplitter and emission filter which remain stationary within the body of the microscope while single-band and multi-band excitation filters are moved into light path in filter wheels or filter sliders. The use a stationary beamsplitter and emission filter guarantees registered of sequential images.

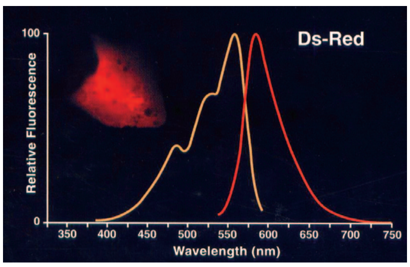
The next development was filter sets that employ a stationary multi-beamsplitter with both single-band excitation and emission filters. Both types of filter sets are listed in this section, although all of the filter sets that employ both single-band excitation and emission filters begin with the number 86.

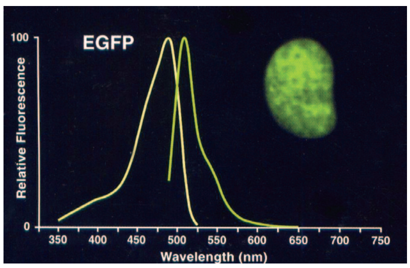
91 SERIES

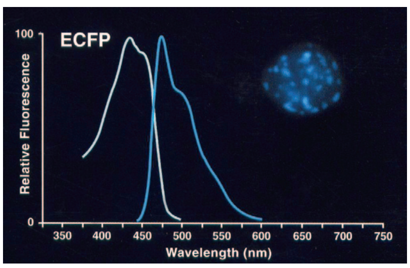
Chroma Technology Corp 91 series includes filter holders (sometimes referred to as cubes or sliders). We either manufacture locally or purchase from the microscope manufacturer cubes that are designed for most of the currently used fluorescence microscopes.

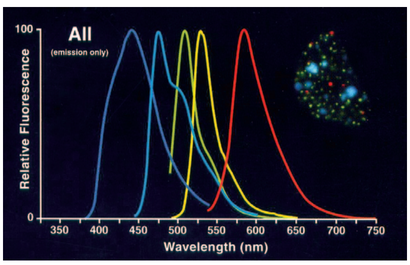
Chroma Technology Corp produces many of our current filter sets and a few custom designs for Leica Microsystems. Both Carl Zeiss and Nikon Corp. offer extensive selections of our filter sets for their new microscope models. Olympus dealers and distributors have access to our products through Olympus America and directly from us. We encourage you to work with your local dealer or representative when purchasing filter sets manufactured by us.

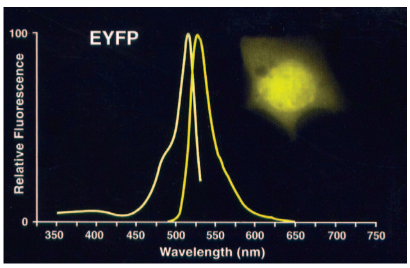












CHAPTER 4 PHOTONICS

GRATINGS: BASICS

DIFFRACTION GRATING

A grating consists of a series of equally spaced parallel grooves formed in a reflective coating deposited on a suitable substrate. The distance between adjacent grooves and the angle the grooves form with respect to the substrate influence both the dispersion and efficiency of a grating.
The way in which the grooves are formed separates gratings into two basic types, holographic and rules. Physically forming grooves into a reflective surface with a diamond mounted on a "ruling engine" produces ruled gratings. Gratings produced from laser constructed interference patterns and a photolithographic process are know as interference or holographic gratings.

The general grating equation is usually written as: $n\lambda=d(\sin i \pm \sin i')$,
where n is order of diffraction, λ is the diffracted wavelength, d is the grating constant (the distance between successive grooves), i is the angle of incidence measured from the normal and i' is the angle of diffraction measured from the normal.
For a specific diffracted order (n) and angle of incidence (i), different wavelengths (λ) will have different diffraction angles(i'), separating polychromatic radiation impinging on the grating into its constituent wavelengths.

CHOOSING A GRATING

EFFICIENCY: In general, ruled gratings have a higher efficiency than holographic gratings. Applications such as fluorescence excitation and other radiation induced reactions may require a ruled grating.

BLAZE WAVELENGTH: Ruled gratings, due to their "sawtooth" groove profiles, have a relatively sharp peak around their blaze wavelength while some holographic gratings have a flatter spectral response. Applications centered around a narrow wavelength range could benefit from a ruled grating blazed at that wavelength.

WAVELENGTH RANGE: The spectral range covered by a grating is dependent on groove spacing and is the same for ruled and holographic gratings with the same grating constant.

STRAY LIGHT: Signal-to-noise is critical, stray light of a holographic is an advantage.

RESOLVING POWER: There is no difference in resolving power for holographic and ruled gratings with identical groove spacing. Holographic gratings are, however, available with up to 3600 grooves per mm while Optometrics does not normally rule gratings with more than 1200 grooves per mm.

BLAZE ANGLE AND WAVELENGTGH

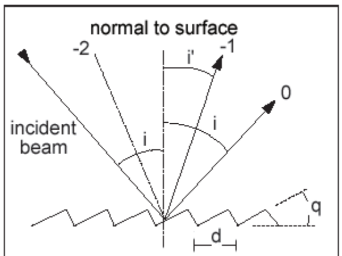
The blaze angle concentrates diffracted radiation to a specific region of the spectrum, increasing the efficiency of the grating in that region. when the spacing to wavelength ratio is near one, a sinusoidal grating has virtually the same efficiency as a ruled grating.

Diffracted orders

Order overlap can be compensated for by the judicious use of sources, detectors and filters and is not a major problem in gratings used in low orders.

Ghost andstray light

Ghost are define periodic error in groove spacing. Stray light originates from random errors and irregularities of the reflecting surfaces.



Grating angles and terms

CHAPTER 4 PHOTONICS

TYPES OF GRATINGS

STANDARD RULED AND HOOGRAPHIC REPLICATED GRATINGS

Standard replicated grating are produced from ruled and holographic originals and are intended for use in moderate resolution spectrophotometers, spectrometers and monochromators where low cost, high efficiency and low stray light are of primary concern.

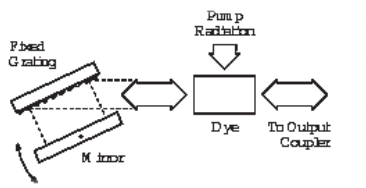
HIGH RESOLUTION FIRST ORDER GRATINGS

Replicating master grating on Pyrex", flat to$\lambda/4$, produces gratings with flatness,$\lambda/4$ or better, good thermal stability, and resolution equal to 80-90% of the master.

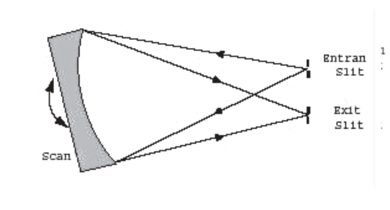
TF AND UTF SERIES GRATINGS AND ECHELLES FOR DYE LASERS

Withstand high incident energies. Damage thresholds as high as 250 watt/cm^2 for CW sources are available.

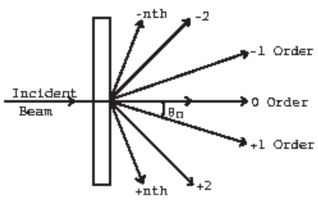
GRAZING INCIDENCE GRATINGS



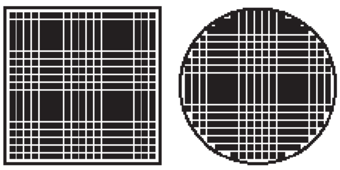
CONCAVE HOLOGRAPHIC GRATINGS

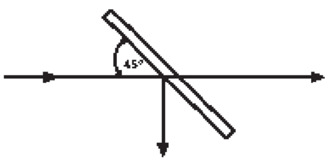


TRANSMISSION GRATING BEAMSPLITTERS

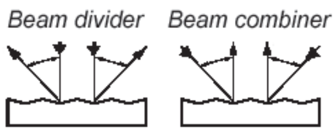


50/50 ÓPOLKA DOTÓ BEAMSPLITTER





REFLECTING BEAM DIVIDERS OR COMBINERS



HIGH RESOLUTIONECHELLES

Special low period gratings designed for use in the high orders. Generally used with a second grating or prism to seperate overlapping diffracted orders. Supplied on precision glass substrates, Echelleshave a resolution of 80-90% of theoretical.

TRANSMISSION GRATINGS

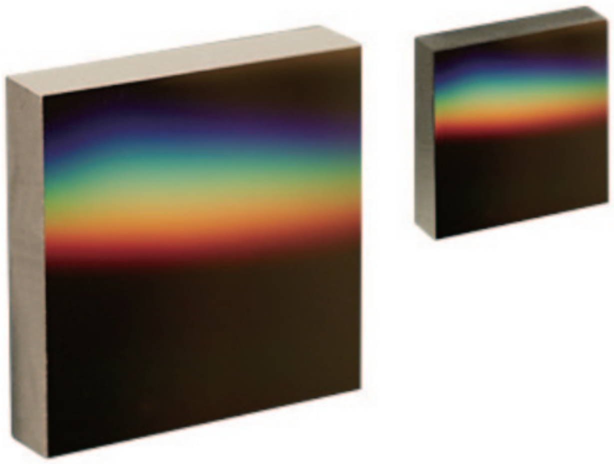
The incident light is dispersed on the opposite side of the grating at a fixed angle. Transmission grating are also very forgiving for some type of grating alignment errors.

TELECOM GRATINGS

A new 600 line/mm reflection grating, specifically designed for use in telecommunications applications,this grating is engineered to offer both high efficiency and low polarization dependance between 1500 and 1600nm. Available on float glass, Pyrex or Zerodur.

RULED DIFFRACTION GRATINGS

- 300 nm to 1.6 μm Blaze Wavelengths
- Higher Efficiencies than Holographic Gratings
- 1/2”, 1”, and 2” Squares Available



12.7 x 12.7 x 6 mm

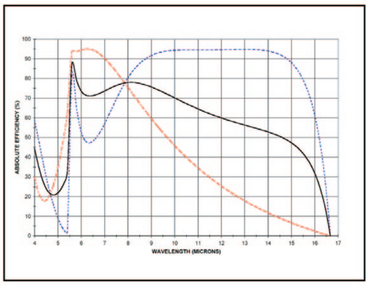
Item #	Grooves (lines/mm)	Blaze λ (nm)	Blaze Angle	Dispersion (nm/mrad)
GR13-0303	300	300	2° 34’	3.33
GR13-0305	300	500	4° 18’	3.32
GR13-0310	300	1000	8° 36’	3.30
GR13-0605	600	500	8° 37’	1.65
GR13-0608	600	750	13° 0’	1.62
GR13-0610	600	1000	17° 27’	1.59
GR13-0616	600	1600	28° 41’	1.46
GR13-1203	1200	300	10° 22’	0.82
GR13-1205	1200	500	17° 27’	0.80
GR13-1208	1200	750	26° 44’	0.74
GR13-1210	1200	1000	36° 52’	0.67
GR13-1850	1800	500	26° 44’	0.50

25 x 25 x 6 mm

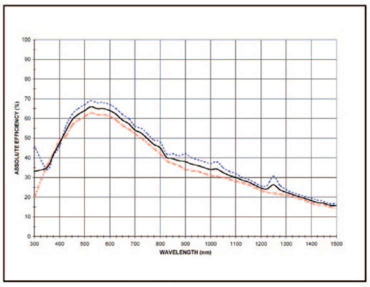
Item #	Grooves (lines/mm)	Blaze λ (nm)	Blaze Angle	Dispersion (nm/mrad)
GR25-0303	300	300	2° 34’	3.33
GR25-0305	300	500	4° 18’	3.32
GR25-0310	300	1000	8° 36’	3.30
GR25-0605	600	500	8° 37’	1.65
GR25-0608	600	750	13° 0’	1.62
GR25-0610	600	1000	17° 27’	1.59
GR25-0613	600	1250	22° 1’	1.55
GR25-0616	600	1600	28° 41’	1.46
GR25-1204	1200	400	13° 53’	0.81
GR25-1205	1200	500	17° 27’	0.80
GR25-1208	1200	750	26° 44’	0.74
GR25-1210	1200	1000	36° 52’	0.67
GR25-1850	1800	500	26° 44’	0.50

GRATING EFFICIENCY CURVES

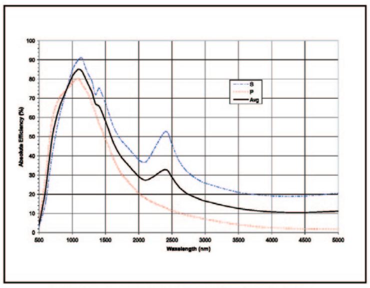
RULED GRATINGS



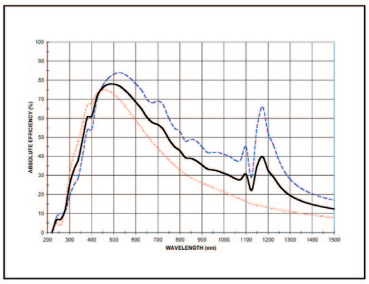
120 grooves/mm BLAZED AT 12.0 µ



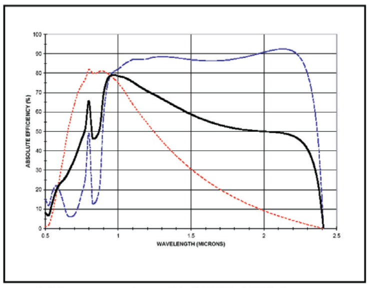
150 grooves/mm BLAZED AT 500 nm



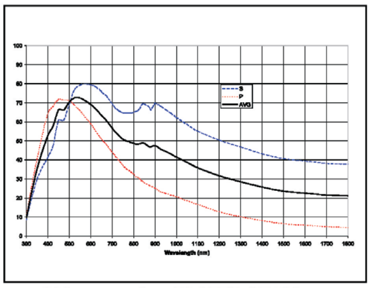
300 grooves/mm BLAZED AT 1.0 µ



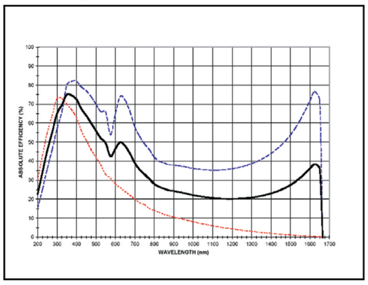
600 grooves/mm BLAZED AT 500 nm



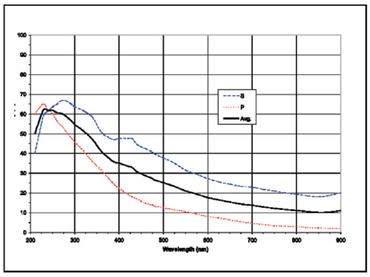
830 grooves/mm BLAZED AT 1.2 µ



900 grooves/mm BLAZED AT 500 nm

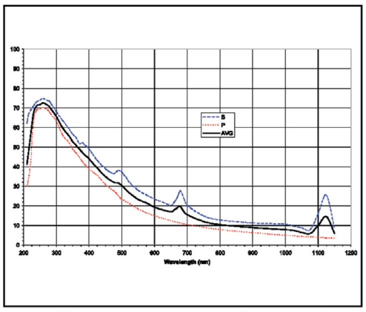


1200 grooves/mm BLAZED AT 400 nm

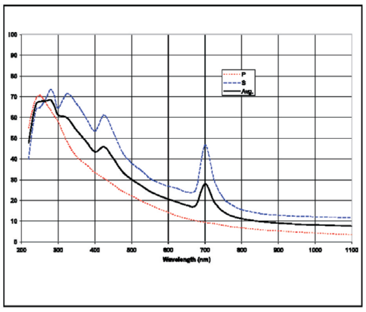


1800 grooves/mm BLAZED AT 240 nm

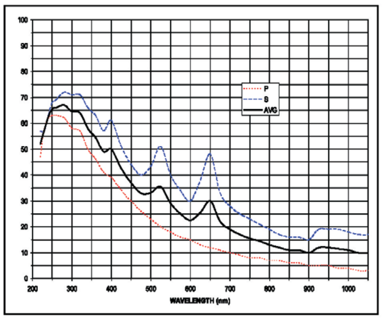
HOLOGRAPHIC GRATINGS



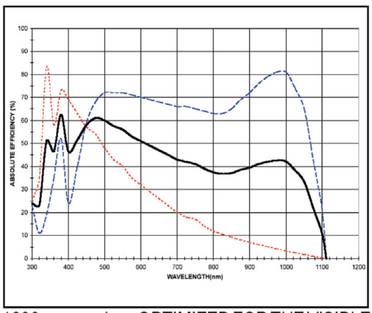
600 grooves/mm BLAZED FOR THE UV



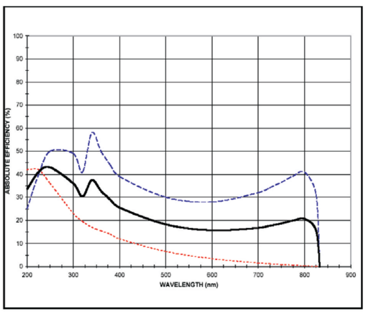
1000 grooves/mm BLAZED FOR THE UV



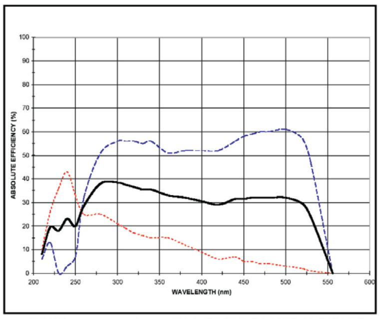
1200 grooves/mm OPTIMIZED FOR THE UV



1800 grooves/mm OPTIMIZED FOR THE VISIBLE



2400 grooves/mm OPTIMIZED FOR THE UV



3600 grooves/mm OPTIMIZED FOR THE UV

CONCAVE BLAZED HOLOGRAPHIC GRATINGS

GH25-06U

GH13-06U

- Free from Random Spacing Errors
- Optimized for the UV and Visible Spectrum
- 45% to 65% Efficiencies

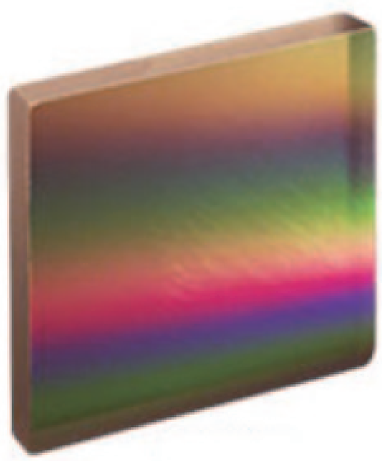
UV Optimized

Item #	Grooves (lines/mm)	Dispersion (nm/mrad)	Size
GH13-06U	600	1.67 @ 250 nm	12.7 x 12.7 x 6 mm
GH25-06U	600	1.67 @ 250 nm	25 x 25 x 6 mm
GH13-12U	1200	0.82 @ 250 nm	12.7 x 12.7 x 6 mm
GH25-12U	1200	0.82 @ 250 nm	25 x 25 x 6 mm
GH13-18U	1800	0.54 @ 250 nm	12.7 x 12.7 x 6 mm
GH25-18U	1800	0.54 @ 250 nm	25 x 25 x 6 mm
GH13-24U	2400	0.40 @ 250 nm	12.7 x 12.7 x 6 mm
GH25-24U	2400	0.40 @ 250 nm	25 x 25 x 6 mm
GH13-36U	3600	0.25 @ 250 nm	12.7 x 12.7 x 6 mm
GH25-36U	3600	0.25 @ 250 nm	25 x 25 x 6 mm

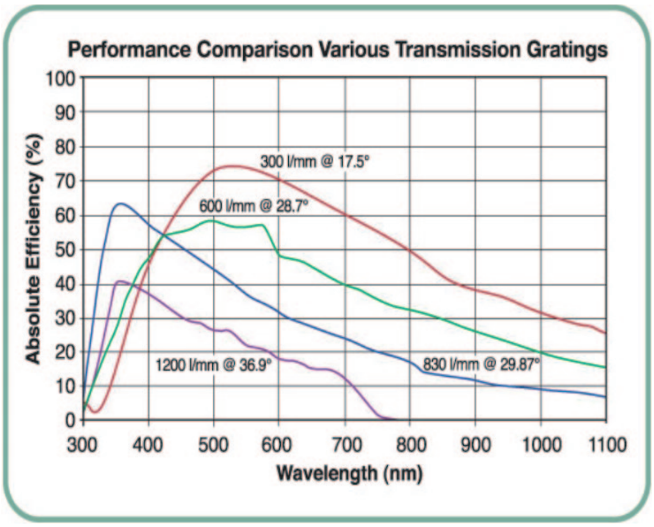
Visible Optimized

Item #	Grooves (lines/mm)	Dispersion (nm/mrad)	Size
GH13-12V	1200	0.79 @ 500 nm	12.7 x 12.7 x 6 mm
GH25-12V	1200	0.79 @ 500 nm	25 x 25 x 6 mm
GH50-12V	1200	0.79 @ 500 nm	50 x 50 x 9.5 mm
GH13-18V	1800	0.50 @ 500 nm	12.7 x 12.7 x 6 mm
GH25-18V	1800	0.50 @ 500 nm	25 x 25 x 6 mm
GH50-18V	1800	0.50 @ 500 nm	50 x 50 x 9.5 mm
GH13-24V	2400	0.33 @ 500 nm	12.7 x 12.7 x 6 mm
GH25-24V	2400	0.33 @ 500 nm	25 x 25 x 6 mm
GH50-24V	2400	0.33 @ 500 nm	50 x 50 x 9.5 mm

VISIBLE TRANSMISSION GRATINGS



- Four Groove Densities Available
- Ideal for Fixed Grating Applications
- Custom Sizes Available



Common Specifications	
Substrate Material	Schott B270
Thickness	3 mm Nominal
Dimensional Tolerance	± 0.5 mm
Thickness Tolerance	± 0.5 mm

300 GROOVES/MM

GT13-03	Vis Trans Grating	17.5° Blaze Angle	12.7 ×12.7 mm
GT25-03	Vis Trans Grating	17.5° Blaze Angle	25 × 25 mm
GT50-03	Vis Trans Grating	17.5° Blaze Angle	50 × 50 mm

600 GROOVES/MM

GT13-06V	Vis Trans Grating	28.7° Blaze Angle	12.7 ×12.7 mm
GT25-06V	Vis Trans Grating	28.7° Blaze Angle	25 × 25 mm
GT50-06V	Vis Trans Grating	28.7° Blaze Angle	50 × 50 mm

830 GROOVES/MM

GT13-08	Vis Trans Grating	29.87° Blaze Angle	12.7 ×12.7 mm
GT25-08	Vis Trans Grating	29.87° Blaze Angle	25 × 25 mm
GT50-08	Vis Trans Grating	29.87° Blaze Angle	50 × 50 mm

1200 GROOVES/MM

GT13-12	Vis Trans Grating	36.9° Blaze Angle	12.7 ×12.7 mm
GT25-12	Vis Trans Grating	36.9° Blaze Angle	25 × 25 mm
GT50-12	Vis Trans Grating	36.9° Blaze Angle	50 × 50 mm

MICROSCOPE OBJECTIVES

Standard

Model	Magnification	N.A.	Focal Length	Objective Length
BMO04	4X	0.10	28.5mm	25.0mm
BMO10	10X	0.25	15.8mm	34.0mm
BMO20	20X	0.40	8.5mm	38.9mm
BMO40	40X	0.65	4.7mm	39.6mm
BMO60	60X	0.85	2.9mm	40.8mm

LONG WORKING DISTANCE

- High quality plan apochromat design
- Good color reproducibility
- Long working distance for bright field inspection

	BMO02A	BMO05A	BMO10A	BMO20A	BMO50A	BMO100A
Numerical Aperture, NA	0.055	0.14	0.28	0.42	0.55	0.70
Working Dist, W.D.(mm)	34.0	34.0	33.5	20.0	13.0	6.0
Focal Length(mm)	100	40	20.0	10	4	2
Resolution Power(μm)	5.0	2.0	10	0.7	0.5	0.4
Depth of Focus(μm)	91	14.0	0.7	1.6	0.9	0.6
Field of View-Dia(mm)						
Eyepiece, 24 Dia. Field	12	4.8	1.2	1.2	0.48	0.24
Eyepiece, 18 Dia. Field	9	3.6	0.9	0.9	0.36	0.18
Field of View L x W (mm)						
2/3 CCD Camera	3.3x4.4	1.32x1.8	0.66x0.88	0.33x0.44	0.13x0.18	0.07x0.09
1/2 CCD Camera	2.4x3.2	0.96x1.28	0.48x0.64	0.24x0.32	0.10x0.13	0.05x0.06

UV OBJECTIVES

- Air Spaced Doublet or Triplet design for maximum UV transmission
- Infinite conjugate ratio design
- Perfect for micromachining, laser scribing, and microlithography

Specifications	
Substrate Material	UV grade fused silica
Wavefront Distortion	λ/4 at 633nm typical
Antireflection Coating	User specified, Ravg 0.5%
Damage Threshold	1 J/cm2, 8 nsec pulse at 248nm typical
Housing	Black anodized barrel or mounted into a microscope objective style stainless steel housing

f/#	NA	Magnification (170mm/fl)	BFD (mm)	WD (mm)	CA (mm)	Wavelength Range (nm)
F/5.3	.09	42.5	2.01	1.63	0.75	193-248
F/3.2	.15	16.5	6.3	5.85	3.2	193-248
F/4.7	0.11	12.1	7.8	6.5	3	193-248
F/2.1	.23	7.96	14.8	13	10	193-248
F/5.3	.09	42.5	2	1.63	0.75	248-355
F/3.2	.15	16.5	6.3	5.9	3.2	248-355
F/4.7	0.11	12.1	7.8	6.5	3	248-355
F/2.1	.23	7.96	14.8	13	10	248-355
F/5.3	.09	42.5	2	1.63	0.75	355-532
F/3.2	.15	16.5	6.3	5.85	3.2	355-532
F/4.7	0.11	12.1	7.8	6.5	3	355-532
F/2.1	.23	7.96	14.8	13	10	355-532

INFINITY CORRECTED LONG WORKING DISTANCE OBJECTIVES

Infinity-Corrected Long Working Distance Objectives

- Super-Long Working Distance, 6mm for 100X
- Bright Filed Inspection
- High Quality Plan Apochromat Design
- Good Color Reproducibility
- Flat Image Surface over Entire Field of View

	Dimensions(mm)			
Magnification	A	B	C	D
2X	61.0	1.6	27.5	24.5
5X	61.0	1.6	25.0	22.0
10X	61.5	3.4	25.0	24.0
20X	75.0	4.4	25.2	23.8
50X	82.0	4.6	25.2	23.2
100X	89.0	6.7	25.2	17.0

	BMO02A	BMO05A	BMO10A	BMO20A	BMO50A	BMO100A
Numerical Aperture, NA	0.055	0.14	0.28	0.42	0.55	0.70
Working Dist., W.D.(mm)	34.0	34.0	33.5	20.0	13.0	6.0
Focal Length(mm)	100	40	20.0	10	4	2
Resolving Power(µm)	5.0	2.0	10	0.7	0.5	0.4
Depth of Focus(µm)	91	14.0	0.7	1.6	0.9	0.6
Field of View-Dia(mm)						
Eyepiece, 24 Dia. Field	12	4.8	1.2	1.2	0.48	0.24
Eyepiece, 18 Dia. Field	9	3.6	0.9	0.9	0.36	0.18
Field of View L x W (mm)						
2/3 CCD Camera	3.3x4.4	1.32x1.8	0.66x0.88	0.33x0.44	0.13x0.18	0.07x0.09
1/2 CCD Camera	2.4x3.2	0.96x1.28	0.48x0.64	0.24x0.32	0.10x0.13	0.05x0.06

OPTEM® M PLAN APO, LONG-WORKING DISTANCE OBJECTIVES

CAT. NO.	OBJECTIVE DESCRIPTION	NUMERICAL APERTURE	WORKING DISTANCE	BACK FOCAL	EFL (mm)	RESOLUTION	DOF (µm)	REAL FOV (mm) (Ø24 eyepiece)	REAL FOV (VxH, mm) (1/2" CCD camera)	MASS (g)
28-21-02-000	LWD 2X	0.055	34mm	0	100	6.1	181.8	ø12	2.4x0.3.2	330
28-21-05-000	LWD 5X	0.14	34mm	0	40	2.4	28.1	ø4.8	0.96x0.1.28	280
28-21-10-000	LWD 10X	0.30	34mm	-6.4mm	20	1.1	6.1	ø2.4	0.48x0.64	240
28-21-11-000	LWD 20X	0.42	20mm	-11.2mm	10	0.8	3.1	ø1.2	0.24X0.32	280
28-21-50-000	LWD 50X	0.55	13mm	-8.3mm	4	0.61	1.8	ø0.48	0.10x0.13	N/A

OPTEM® HIGH-RESOLUTION, LONG-WORKING DISTANCE OBJECTIVES

CAT. NO.	OBJECTIVE DESCRIPTION	NUMERICAL APERTURE	WORKING DISTANCE	BACK FOCAL	EFL (mm)	RESOLUTION	DOF (µm)	REAL FOV (mm) (Ø24 eyepiece)	REAL FOV (VxH, mm) (1/2" CCD camera)	MASS (g)
28-20-44-000	High-Res 5X	0.225	34mm	-0.6mm	40	1.5	10.9	Not Applic*	Not Applic	210
28-20-45-000	High-Res 10X	0.45	19mm	-31.0mm	20	0.74	2.7	Not Applic*	Not Applic	190
28-20-46-000	High-Res 20X	0.60	13mm	-14.7mm	10	0.56	1.5	Not Applic*	Not Applic	290

*Optem High-Resolution Objectives are specifically designed for use with Optem Lens Systems. Not intended for use with conventional microscope optics.

Infinity-Corrected super long Working Distance Objectives

- Super-Long Working Distance for Bright Field Inspection
- 13mm Working Distance for 100X
- High Quality Plan Apochromat Design
- Flat Image Surface over Entire Field of View
- Good Color Reproducibility

Specification Table

	BMO20AS	BMO50AS	BMO80AS	BMO100AS	BMO200AS
Numerical Aperture	0.28	0.42	0.5	0.55	0.62
Working Distance	30.5	20.5	15.0	13.0	13.0
Focal Length (mm)	10	4	2.5	2	1
Resolution Power (µm)	1.0	0.7	0.6	0.5	0.4
Depth of Focus (µm)	3.5	1.6	1.1	0.9	0.7
Field of View (mm)					
Eyepiece, 24 Dia. Field	1.2	0.48	0.30	0.24	0.12
Eyepiece, 18 Dia. Field	0.9	0.36	0.22	0.18	0.09
2/3" CCD Camera (H x V)	0.44 x 0.33	0.18 x 0.13	0.11 x 0.08	0.09 x 0.07	0.040 x 0.034
1/2" CCD Camera (H x V)	0.32 x 0.24	0.13 x 0.10	0.08 x 0.06	0.06 x 0.05	0.030 x 0.025
Weight (g)	240	275	280	290	490

LONG WORKING DISTANCE OBJECTIVES-VISIBLE TO NEAR INFRARED

NIR SERIES

- Infrared Radiation Range Correction
- For Visible to Near Infrared Applications
- Long Working Distance for Bright Field Inspection
- Designed to be Color Corrected from 480nm to 1800nm & Focused Within Focal Depth
- Ideal for use in Laser Marking & Cutting Semiconductor Circuits

	BNIR 5X	BNIR 10X	BNIR 20X	BNIR 50X	BNIR 100X
Numerical Aperture	0.14	0.26	0.40	0.42	0.50
Working Distance	37.5	30.5	20.0	17.0	12.0
Focal Length (mm)	40.0	20.0	10.0	4.0	2.0
Resolution Power (μm)	2.0	1.1	0.7	0.7	0.6
Depth of Focus (μm)	14.0	4.1	1.7	1.6	1.1
Field of View (mm)					
Eyepiece, 24 Dia. Field	4.8	2.4	1.2	0.48	0.24
Eyepiece, 18 Dia. Field	3.6	1.8	0.9	0.36	0.18
2/3" CCD Camera (H x V)	1.8 x 1.32	0.88 x 0.66	0.44 x 0.33	0.18 x 0.13	0.09 x 0.07
1/2" CCD Camera (H x V)	1.28 x 0.96	0.64 x 0.48	0.32 x 0.24	0.13 x 0.10	0.06 x 0.05
Weight (g)	220	250	300	315	335

Long Working Distance Objectives- Near UV to visible

NUV SERIES

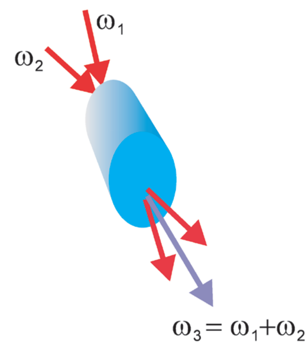
- Near-Ultra Violet Radiation Correction
- For Near UV to Visible Applications
- Long Working Distance for Bright Field Inspection
- Designed to be Color Corrected from 355nm to 620nm & Focused Within Focal Depth

	BNUV 20X	BNUV 50X	BNUV 100X
Numerical Aperture	0.40	0.42	0.50
Working Distance	17.0	15.0	11.0
Focal Length (mm)	10	4	2
Resolution Power (μm)	0.7	0.7	0.6
Depth of Focus (μm)	1.7	1.6	1.1
Field of View (mm)			
Eyepiece, 24 Dia. Field	1.2	0.48	0.24
Eyepiece, 18 Dia. Field	0.9	0.36	0.18
2/3" CCD Camera (H x V)	0.44 x 0.33	0.18 x 0.13	0.09 x 0.07
1/2" CCD Camera (H x V)	0.32 x 0.24	0.13 x 0.10	0.06 x 0.05
Weight (g)	340	350	380

NONLINEAR OPTICS APPLICATIONS

FREQUENCY CONVERSION

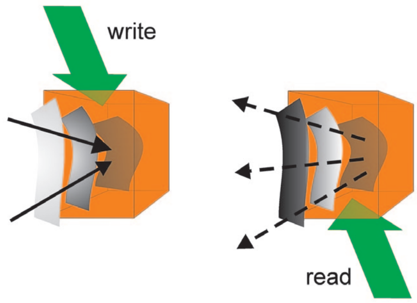
- 2nd, 3rd, 4th, and 5th harmonic generation
- Parametric generation, oscillation, and amplification



LBO
BBO
KTP
KD*P
LiO_3
$LiNbO_3$
ADP
UREA, etc.

PHOTOREFRACTIVE CRYSTAL

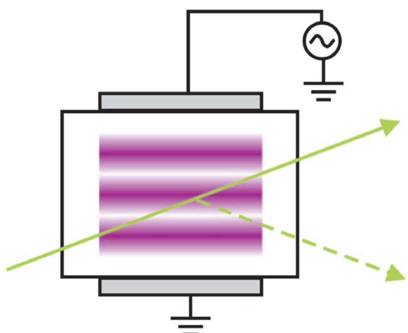
- Phase conjugation
- Holographic recording
- Data storage



BSO
BGO
$Ce:BaTiO_3$
$Fe:LiNbO_3$
$Fe:Mn:LiNbO_3$
$Ba_{1-x}Sr_xTiO_3$
$BaTiO_3$
$Rh:BaTiO_3$, etc.

ACOUSTO/ELECTRO-OPTICAL MODULATION

- Amplitude modulation
- Phase modulation
- Q-switch and optical switch
- Diffraction grating



$LiNbO_3$
$LiTaO_3$
$PdMoO_4$
TeO_2

FREQUENCY CONVERSION

Typical optical frequency conversion is a 3-wave nonlinear process in which the electromagnetic radiation from one frequency is converted to two other frequencies or vice versa. The 3-wave process includes second-harmonic generation, sum-frequency generation, difference-frequency generation, and optical parametric generation. The frequency conversion can occur when an intensive light beam passes through a nonlinear medium, in most cases, the crystals, such as BBO or KDP. To achieve high conversion efficiency, the wave vectors of input beams and generated beams must be matched, the process called phase matching. For conversion with crystals, the phase-matching condition can be obtained by properly aligning the light beams along specific directions. Theoretically, for perfectly matched cases, the conversion efficiency is proportional to the input power, the square of effective nonlinear coefficient and crystal length. In general, the input power has to be lower than the damage threshold of the crystal and the nonlinear coefficient is determined by crystal itself.
In order to meet your various demands, Onset offers several crystals for frequency conversion from visible to infrared. Please specify the following parameters to custom your crystals:

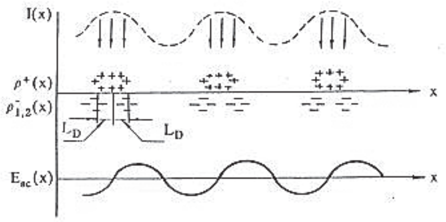
- Crystal material
- Crystal size: aperture and length
- Crystal orientation(crystal cut)
- End face: Brewster or perpendicular
- Coating
- Laser: wavelength, power, and beam size

CHAPTER 4 PHOTONICS

INFORMATION RECORDING IN PHOTOREFRACTIVE CRYSTALS

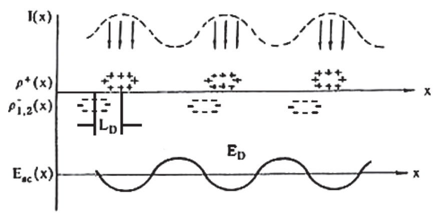
Photorefractive effect

Photorefractive effect originates from the formation of a nonuniform space charge and electric field under the irradiation of light. There exist two basic recording mechanisms, namely, diffusion and drift. In the diffusion model, the electrons excited by light migrate from the illuminated region, where their concentration is higher, toward the nonilluminated regions, where the carrier concentration is lower. There they become trapped. The redistribution of the photoexcited electrons gives rise to three charge gratings.



Formation of charge and electric-field gratings through diffusion.

In the drift model, the photoexcited electrons move in one direction and pass, on the average, a certain typical distance Lo before being trapped. Incident light allows charge to migrate within the illuminated area. Thus sets up a space charge field that modifies the refractive index through the electro-optic effect.



Formation of charge and electric-field gratings through drift.

HOLOGRAPHIC RECORDING IN PHOTOREFRACTIVE CRYSTAL

PR crystals feature excellent resolution, readout efficiency, reversibility, storage capacity, and sensitivity. They are highly flexible, being useful in both read/write and read-only systems.

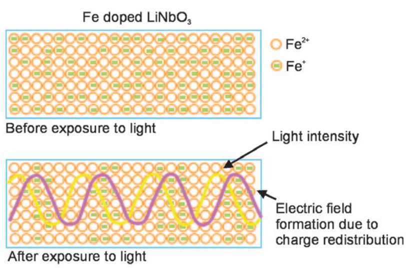
The advantages include the improvement of techniques for hologram fixing, the storage of many thick holograms at different angles within the same volume of a crystal, and electronic means for storage and readout enhancement.

Holograms in PR materials consist of bulk space charge patterns. They are formed when an interference pattern of light generates a pattern of electronic charge carriers that are free to move. Migration of the carriers toward areas of low optical illumination, and subsequent capture in localized sites called traps, produces patterns of net space charge. This sets up a corresponding electric field pattern. Since PR crystals have strong electro-optic properties, the result is a pattern of variations in the refractive index, a phase hologram.

Consider the special case of Fe-doped $LiNbO_3$. The essential features of hologram storage in Fe doped material are shown below. The crystal contains a single species of photosensitive electron traps (introduced by Fe doping) and storage comes about from the spatial redistribution of electrons in these traps. The electron transport produces space charge, positive where the electrons came from, negative where they accumulate. The result is an electric field pattern that produces the desired variations in refractive index.

APPLICATIONS

- Dynamic information recording
- Optical computing
- Optical shutter/switch



INTRODUCTION TO ELECTRO-OPTIC (E-O) EFFECT

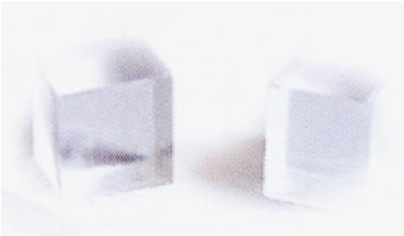
The electro-optic effect consists of a change of the refractive index of the crystal and a change of the orientation of its optical axes on application of an external electric field. In terms of crystal optics, the electro-optic effect rests on the dependence of components of the dielectric impermeability tensor on the electric field E.

A plane light wave with an arbitrary linear polarization direction in the crystal can be represented as a superposition of two so-called eigenmodes. One of the eigenmodes is the wave with the polarization normal to the optical axis and the direction of propagation. This wave is referred to as the ordinary wave, and the ordinary refractive index n_o corresponds to it. Second mode is determined unambiguously and is called the extraordinary wave, with the corresponding extraordinary refractive index n_e. Crystals in which n_o is not equal to n_e are called birefringent crystals.

When light wave propagates in a birefringent crystal, because of different propagation velocities, the two modes have different phase delays, the phase difference $\phi_{oe}=2\pi d(n_0-n_e)/\lambda$,where d is the crystal length and £fis is wavelength. Application of the electric field can cause variation in n_o and n_e, and a change of ϕ_{oe}, i.e., $\Delta\phi_{oe}$ arises. Variation in phase retardation induced by the applied field can be used to manipulate the polarization state of light beam. A specific characteristic of the magnitude of the electro-optic effect is the so-called half-wave voltage $V_{\lambda/2}$. It is defined as the value of the applied voltage V at which $\Delta\phi_{oe}$ becomes equal toπ. In this case, the polarization of the resultant wave changes by 90^0 at the crystal exit. Then the crystal is equivalent to the so-called half-wave plate. With a polarization analyzer after, the phase modulation, resulting from different phase delays caused by application of an external E-field, can be converted into the light intensity variation, the amplitude modulation.

NONLINEAR CRYSTAL: BBO, LBO

BBO, Beta-Barium Borate (BBO)



- Broad phase-match range for SHG form 0.4 to 3.5μm
- High damage threshold of 10 GW/cm2 for 0.1ns pulse @ 1.064μm
- Good mechanical and physical properties

FEATURES

- wide transmission region from 190nm to 3500nm
- Large effective second-harmonic-generation(SHG) coefficient
- wide temperature-bandwidth of about 55^{0}C. (for type I SHG 1064nm)
- Ultra-thin BBO crystals available down to 0.01mm thickness.

REFRACTIVE INDICES:

Therm-Optic Coefficients:

$dn_0/dT=-9.3 \times 10^{-6}/^0C$

$dn_e/dT=-16.6 \times 10^{-6}/^0C$

Linear Absorption Coeffcients:

a <0.001cm^{-1}(λ=1064nm)

a <0.01cm^{-1}(λ=532nm)

a <0.5cm^{-1}(λ=2550nm)

NonLinear Optical Properties	
Phase-Matchable Output Range	189-1750nm
NLO coefcients	d11=5.8 x d36(KDP) d31=0.05 x d11 , d22<0.05 x d11
Electro-Optic Coefficients	g11=2.7pm/V;dg22, g31<0.1g11
Half-Wave Voltage	48KV(at 1064nm)
Damage Threshold	
at 1.064μm	5GW/cm2(10ns);10 GW/cm2(1.3ns);
at 0.532μm	1GW/cm2(10ns); 7GW/cm2(250ps);
at 0.266μm	120MW/cm2(8ns)

LBO, Lithium triborate (LiB_3O_5)

- SHG phase-match range from 0.55 to 2.6μm
- high damage threshold of 19GW/cm^2 for 1 ns pulse @1.064μm
- Wide acceptance angle and small walk-off.
- Non-hygroscopic

FEATURES

- broad transparency range from 160nm to 2.6μm
- type I and type II non-critical phase-matching(NCPM)
- relatively large effective SHG coefficient

REFRACTIVE INDICES:

Therm-Optic Coefficients:

dnx/dT=-9.3 x 10-6/ 0C

dnv/dT=-16.6 x 10-6/ 0C

dnz/dT=(-6.3+2.1l) x 10-6/ 0C

Absorption Coeffcients:

<0.1%cm-1at 1064nm

<0.3%cm-1at 532nm

The non-vanished NLO susceptibilities are:

d31=1.05±0.09pm/V; d32=-0.98±0.09pm/V; d33=0.05±0.006pm/V

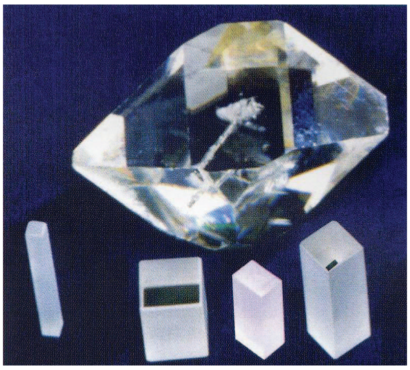
The temperature acceptance of LBO for SHG is:

SHG: 1064+1064->532nm T=5.80C/cm damage threshold

Damage threshold

Crystal	Energy Density (J/cm2)	Power Density (GW/cm2)	Ratio
KTP	6.0	4.6	1.00
KDP	10.9	8.4	1.83
BBO	12.9	9.9	2.15
LBO	24.6	18.9(1.3ms@1053)	4.10

KTP, Potassium Titanyl Phosphate ($KTiOPO_4$)



- Wide Angular Bandwidth and Small Walk-off Angle
- Broad Temperature and Spectral Bandwidth
- High Electro-Optic(E-O) Coefficient and Low Dielectric Constant
- Large Figure of Merit for an Optical Waveguide Modulator
- Nonhygroscopic, Good Chemical and Mechanical Properies

TRANSPARENCY RANGE :350-4500 NM, REFRACTIVE INDICES:

Wavelength	n_x	n_y	n_z
1064nm	1.7377	1.7453	1.8297
532nm	1.7780	1.7886	1.8887

THERM-OPTIC COEFFICIENTS:

dnx/dT=1.1 x 10-5/0C

dnv/dT=1.3 x 10-5/0C

dnz/dT=1.6x 10-5/0C

Linear Absorption Coefficients: a<0.001cm-1 @ λ=1064nm or 532nm

NonLinear Optical Properties:

Phase-Matchable Output Range: 492-1700nm

NLO Coefficients:

d31=2.54 pm/V, d32=4.35 pm/V, d33=16.9 pm/V

d24=3.64 pm/V, d15=1.91 pm/V at 1064nm

Electro-Optic Coefficients	Low Frequency (pm/V)	High Frequency (pm/V)
g_{13}	9.5	8.8
g_{23}	15.7	13.8
g_{33}	36.3	35.0
g_{51}	7.3	6.9
g_{42}	9.3	8.8

$AgGaS_2$, $AgGaSe_2$

Sliver Gallium Sulfide ($AgGaS_2$), Sliver Gallium Selenite ($AgGaSe_2$) are used in middle and deep infrared (IR) with large nonlinear optical(NLO) coefficients and high transmission in the IR region. $AgGaS_2$ allow 3-wave interactions in the mid and near IR. $AgGaSe_2$ has been used as an efficient NLO crystal for 3-10μm IR output, particularly.

Linear Optical Properties

Crystal	AgGaS2		AgGaSe2	
Transparency Range(nm)	0.50-13.2		0.78-18.0	
Refractive Indices	n0	ne	n0	ne
@1.064μm	2.4521	2.3990	2.7010	2.6792
@5.300μm	2.3945	2.3408	2.6134	2.5808
@10.60μm	2.3472	2.2934	2.5912	2.5579
Wavelength @				
n0=ne(μm)	0.4974		0.811	
Thermo-Optic Coefficients				
dn0/dt(10-5/0C)	15.4		~15	
dne/dt(10-5/0C)	15.5		~15	
Absorption Coefficients(cm-1)				
@1.064μm	0.01		<0.05	
@10.6μm	0.6		<0.02	

Nonlinear Optical Properties

Crystal	AgGaS2	AgGaSe2
Phase-Matching SHG output		
range(μm)	1.8-11.2	3.1-12.8
NLO Susceptibilities d36(pm/V)		
SHG @ 10.64 mm	18	58
Linear Electro-Optic Coefficients		
g41T	4.0±0.2	3.0±0.1
g63T	4.5@1.15μm	3.9@1.15μm
Damage Threshold(MW/cm2)		
@~10ns,1.064μm	25, surface	20-30, surface
@~10ns,10.6 μm	>500 bulk	

$LiNbO_3$, Lithium Niobate

- Large acousto-optic and electro-optic coefficients.
- Capable of quasi phase matching
- Broad IR transparent range from 0.42 to 5.2μm.

Commonly used material for Pockel Cells, Q-switch and phase modulators, wave-guide substrate, and surface acoustic wave (SAW) wafers.
Absorption Coefficient ~0.1%/cm^{-1} @1064nm
Transparency Range 420-5200nm
Refractive Indices
n_e=2.146, n_0=2.220 @1300nm
n_e=2.156, n_0=2.232 @1064nm

Nonlinear Optical Properties	
NLO Coefficient	d33=34.4pm/V d31=d15=5.95pm/V d22=3.07pm/V

Effective NLO Coefficients	deff=5.7pm/V or ~14.6 x d36(KDP) for frequency doubling 1300nm;
	deff=5.3pm/V or ~13.6 x d36(KDP) for OPO pumped at 1064nm;
	deff=17.6pm/V or ~45 x d36(KDP) for quasi-phase-matched structure.

Electro-Optic Coefficients	gT33=32pm/v, gS33=31pm/V gT31=10pm/v, gS31=8.6pm/V gT22=6.8pm/v, gS22=3.4pm/V
Half-Wave Voltage, DC	
Electrical files @z, light @z	3.03KV
Electrical files @x or y, light @z	4.02KV
Damage Threshold	100MW/cm2(10ns, 1064nm)

MGO: $LINBO_3$

Magnesium Oxide Doped Lithium Niobate Crystals (MgO:$LiNbO_3$)

MgO:$LiNbO_3$ crystal exhibits its particular advantages for NCPM frequency doubling (SHG) of Nd:Lasers, mixing (SFG) and optical parametric oscillators(OPOSs). MgO:$LiNbO_3$ is also a good crystal for optical parametric oscillators (OPOs) and amplifiers (OPAs), quasi-phase-matched doublers and integrated waveguide.
MgO: $LiNbO_3$ has similar effective nonlinear coefficients to pure $LiNbO_3$

ZnO: $LiNbO_3$ crystal has advantages of high damage threshold, non-critical phase-matching and good physical and chemical properties like MgO:$LiNbO_3$.
It has better optical quality and lower absorption loss than MgO:$LiNbO_3$

Iron Doped Lithium Niobate Crystal (Fe:$LiNbO_3$)

Fe:$LiNbO_3$ Crystal is a kind of common used photorefractive material with large electro-optic(EO) coefficients, high photorefractive sensitivity and high diffraction efficiency.
Fe:$LiNbO_3$ crystal has a wide range applications: Holography Storage; Bragg Grating, Dynamic Holography; Optical Memories; Optical Phase Conjugation and Neutral Networks.

LASER CRYSTAL

Onset provides several laser crystals for generating laser radiations, especially in diode-pump solid-state lasers

- Diode-pump solid-state lasers
- Ultrashort pulse lasers
- Laser Amplifiers

Nd:YVO_4, Neodymium Doped Yttrium Vanadate

- Low lasing threshold and high slope efficiency
- High absorption over a wide range of pumping wavelength
- High diode pumped optical to optical efficiency

Nd:YVO4 is one of the most efficient laser host crystal currently existing for diode laser-pumped solid-state lasers. Its large stimulated emission cross-section at lasing wavelength, high absorption coefficient and wide absorption bandwidth at pump wavelength, high laser induced damage threshold as well as good physical, optical and mechanical properties make Nd:YVO4 an excellent crystal for high power, stable and cost-effective diode pumped solid-state lasers.

THERMAL EXPANSION COEFFICIENT: AA=4.43X10-6/K ,AC=11.37X10-6/K
THERMAL CONDUCTIVITY COEFFICIENT: C :5.23W/M/K; C:5.10W/M/K

Optical Properties (typically for 1.1 atm% Nd:YVO_4, a-cut crystals)	
Lasing Wavelengths	914nm , 1064nm , 1342nm
Crystal Class	n_0=1.9573, n_e=2.1652, @1064nm
Thermal Optical Coefficient	$dn_0/dT=8.5x10^{-6}/k, dn_e/dT=3.0x10^{-6}/K$
Stimulated Emission Cross-Section	$25.0x10^{-19}cm^{-2}$,@1064nm
Fluorescent Lifetime	90ms(about 50μs for 2 atm % Nd doped)
Absorption Coefficient	$31.4cm^{-1}$ @808nm
Absorption Length	0.32mm @808nm
Intrinsic Loss	Less 0.1%cm^{-1}, @1064nm
Gain Bandwidth	0.96nm(257GHz) @1064nm
Polarized Laser Emission	π polarization; parallel to optic axis(c-axis)
Diode Pumped Optical to Optical Efficiency	>60%

Nd:YAG, Neodymium Doped Yttrium Aluminum Garnet

- Most used material of solid-state lasers

Neodymium Doped Yttrium Aluminum Garnet (Nd:YAG) Crystal	
Thermal Expansion Coefficient	7.8×10^{-6}/K [111], 0-250°C
Thermal Conductivity	14W/m/K @20°C, 10.5W/m/K@100°C
Lasing Wavelength	1064nm
Stimulated Emission Cross Section	$2.8 \times 10^{-19} cm^{-2}$
Relaxation Time of Terminal Lasing Level	30ns
Radiative Lifetime	550μs
Spontaneous Fluorescence	230μs
Loss Coefficient	$0.003 cm^{-1}$ @1064nm
Effective Emission Cross Section	$2.8 \times 10^{-19} cm^{-2}$
Pump Wavelength	807.5nm
Absorption band at pump wavelength	1nm
Linewidth	0.6nm
Polarized Emission	Unpolarized
Thermal Birefringence	High

Yb:YAG, Ytterbium Doped Yttrium Aluminum Garnet

FEATURES

- High thermal conductivity and strength
- Broad absorption band, ~10nm@940nm
- Long upper-state lifetime, no excited-state absorption or up-conversion
- High diode pumped optical to optical efficiency

Yb:YAG crystal is one of the most promising laser-active materials and more suitable for diode-pumping than the traditional Nd-doped systems. It can be pumped at 0.94μm and generates 1.03μm laser output. Yb:YAG crystal has a much larger absorption bandwidth of reduces thermal management requirements for diode lasers, a longer upper-state lifetime, three to four times lower themal loading per unit pump power.

Basic Properties	
Thermal Expansion Coefficient	7.8×10^{-6}/K [111], 0-250°C
Thermal Conductivity	14W/m/K @20°C
Loss Coefficient	$0.003 cm^{-1}$
Index of Refraction	1.82
Lasing Wavelength	1030nm
Pump Wavelength	940nm
Absorption band about pump wavelength	10nm

Chromium Doped Yttrium Aluminum Garnet (Cr:YAG) Crystal

Chemically stable, durable, UV resistant, good thermal conductivity, and high damage threshold(>500MW/cm^2)

Damage Threshold	>500MW/cm^2
Refractive Index	1.82@1064nm

Cr:YAG is also a laser crystal with tunable output from 1.35μm to 1.6μm. It can generate ultrashort pulse laser (to fs pulsed) when pumped by Nd:YAG laser at 1.064μm.

Cr: Forsterite, Chromium Doped Forsterite ($Cr:Mg_2SIO_4$)

- Tuning range from 1167 to 1345nm, covering minimal dispersion band in optical fibers.

The Cr:Forsterite laser eventually explores its niche applications for semiconductor characterization, eye-safe ranging medical, industrial and scientific research.

Physical, Thermal and Optical Properties	
Thermal Expansion Coefficient	$9.5x10^{-6}/^{0}C$
Thermal Conductivity	8/W/m/K(300K)
Stimulated Emission Cross Section	$1.44x10^{-19}cm^{-2}$
Relaxation Time of Terminal Lasing Level	<10ps
Radiative Lifetime	25μs
Spontaneous Fluorescence	2.7μs
Loss Coefficient	$0.02cm^{-1}$
Refractive Index	1.635

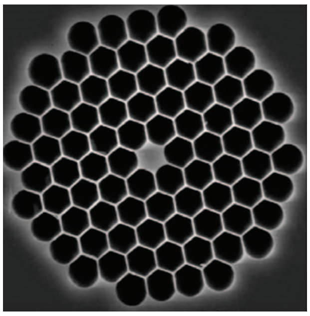
Spectroscopic and Laser Properties	
Lasing Wavelength(center)	1235nm(pulsed), 1244nm(CW)
Spectral Bandwidth	30nm(pulsed), 12nm(CW)
Typical Slope Efficiency	23%(pulsed), 38%(CW)
Tuning range	1167-1345nm

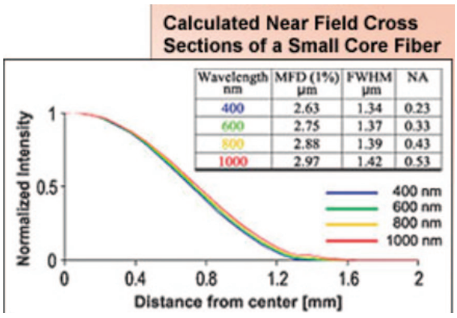
Ti:Sapphire, Titanium Doped Sapphire ($Ti:Al_2O_3$)

Ti:Sapphire crystal is the most widely used laser material for ultrashort pulsed and widely tunable laser with high gain and high power output. It can be lased over the entire broad band from 660nm to 1050nm which makes it an excellent replacement for common dye laser materials.

Thermal Conductivity	25W/m/K
Fluorescence Lifetime	3.2μs(T=300K)
Tuning Range	660-1050nm, peak @795nm
Absorption Range	400-600nm, peak @488nm

NONLINEAR PHOTONIC CRYSTAL FIBERS





- Zero Dispersion Wavelengths from 670-1040 nm
- PM Version with Zero Dispersion at 850 nm Wavelength
- core Diameter from 1.5-5.0 µm

Optical Properties

Item #	λ_0	Dispersion Slope[a]	Attenuation	MFD[a,b]	NA[a,c]	Effective Nonlinear Area	Nonlinear Coefficient[a]
NL-1.5-670-02	670 ± 5 nm	1.4 ps/(nm^{2}km)	λ_0 < 90 dB/km 1550 nm < 25 dB/km 1380 nm < 300 dB/km 1000 nm < 60 dB/km 600 nm < 110 dB/km	1.1 ± 0.1 µm	0.5/0.55	1.23 µm^2	190 (W·km^{-1}
NL-1.7-700-02	700 ± 5 nm	1.0 ps/(nm^{2}km)	λ_0 < 50 dB/km 1550 nm < 20 dB/km 1380 nm < 300 dB/km 1000 nm < 40 dB/km 600 nm < 60 dB/km	1.2 ± 0.1 µm	0.45/0.52	1.51 µm^2	148 (W·km)$^{-1}$
NL-1.8-730-02	730 ± 5 nm	0.79 ps/(nm^{2}km)	λ_0 < 50 dB/km 1550 nm < 20 dB/km 1380 nm < 300 dB/km 1000 nm < 30 dB/km 600 nm < 50 dB/km	1.3 ± 0.1 µm	0.45/0.50	1.76 µm^2	122 (W·km)$^{-1}$
NL-2.0-745-02	745 ± 5 nm	0.85 ps/(nm^{2}km)	λ_0 < 30 dB/km 1550 nm < 20 dB/km 1380 nm < 200 dB/km 1000 nm < 20 dB/km 600 nm < 40 dB/km	1.4 ± 0.1 µm	0.42/0.47	2.03 µm^2	103.8 (W·km)$^{-1}$
NL-2.3-790-02	790 ± 5 nm	0.64 ps/(nm^{2}km)	λ_0 < 25 dB/km 1550 nm < 15 dB/km 1380 nm < 100 dB/km 1000 nm < 17 dB/km 600 nm < 40 dB/km	1.5 ± 0.1 µm	0.41/0.44	2.66 µm^2	75 (W·km)$^{-1}$
NL-2.4-800	800 ± 5 nm	0.55 ps/(nm^{2}km)	λ_0 < 80 dB/km 1550 nm < 50 dB/km 1380 nm < 420 dB/km 1000 nm < 60 dB/km 600 nm < 100 dB/km	1.5 ± 0.1 µm	0.19	2.8 µm^2	70 (W·km)$^{)-1}$
NL-2.8-850-02	850 ± 5 nm	0.48 ps/(nm^{2}km)	λ_0 < 10 dB/km 1550 nm < 6 dB/km 1380 nm < 40 dB/km 1000 nm < 10 dB/km 600 nm < 17 dB/km	2.0 ± 0.1 µm	0.38/0.39	3.97 µm^2	46.6 (W·km)$^{-1}$
NL-3.3-890-02	890 ± 5 nm	0.33 ps/(nm^{2}km)	λ_0 < 10 dB/km 1550 nm < 5 dB/km 1380 nm < 40 dB/km 1000 nm < 10 dB/km 600 nm < 20 dB/km	2.1 ± 0.1 µm	0.36/0.37	4.76 µm^2	37.52 (W·km)$^{-1}$
SC-5.0-1040	1040 ± 10 nm	-	λ_0 < 2 dB/km 1550 nm < 1.5 dB/km 600 nm < 15 dB/km	4.0 ± 0.2 µm	0.20±0.05	-	11 (W·km)$^{-1}$

Physical Properties

Item #	Core Diameter	Pitch	Air Fill in Holey Region	Diameter of Holey Region	Diameter of Outer Silica Cladding	Fiber O.D.
NL-1.5-670-02	1.5 µm	1.9 µm	>90%	20 µm	106 µm	220 µm
NL-1.7-700-02	1.7 µm	1.8 µm	>85%	18.5 µm	116 µm	220 µm
NL-1.8-730-02	1.8 µm	2.0 µm	>88%	21 µm	127 µm	220 µm
NL-2.0-745-02	2.0 µm	2.0 µm	>90%	28 µm	127 µm	220 µm
NL-2.3-790-02	2.3 µm	1.6 µm	>94%	35 µm	147 µm	220 µm
NL-2.4-800	2.4 µm	2.9 µm	>90%	27 µm	105 µm	230 µm
NL-2.8-850-02	2.8 µm	2.7 µm	>88%	28 µm	136 µm	220 µm
NL-3.3-890-02	3.2 µm	3.1 µm	>88%	32 µm	154 µm	220 µm
SC-5.0-1040	4.8 µm	3.25 µm	-	-	125 µm	244 µm

a) Measured at λ0
b) Mode Field Diameter
c) Numerical Aperture