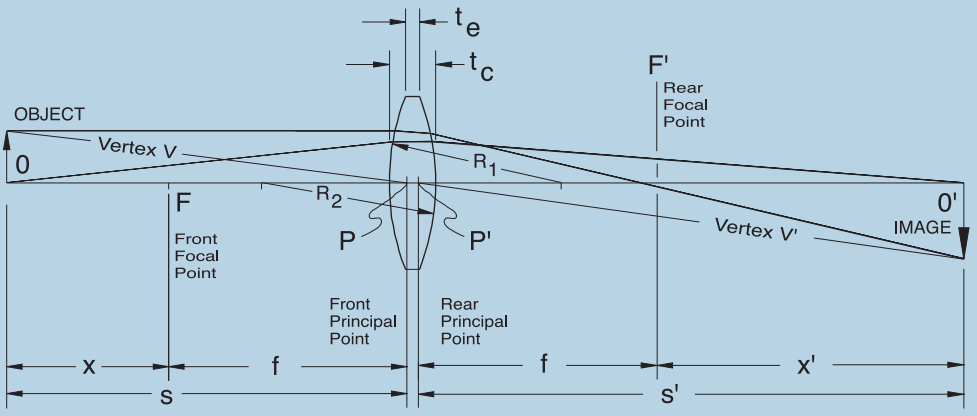
Spherical Lens Parameters



Ø = Lens Diameter

$M = \frac{S'}{S}$ Magnification or Conjugate Ratio

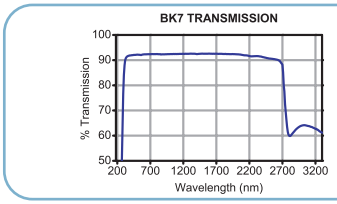
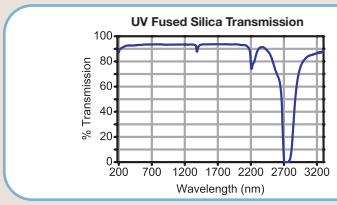
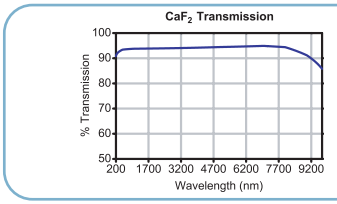
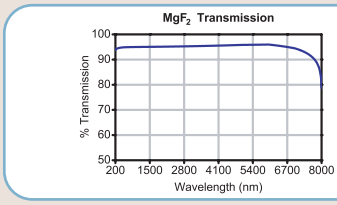
f = EFL (Effective Focal Length)

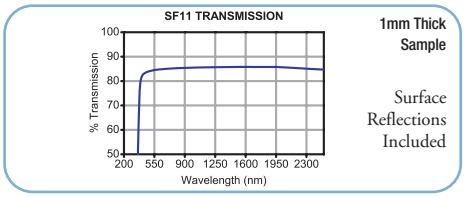
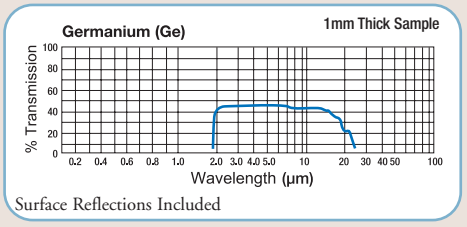
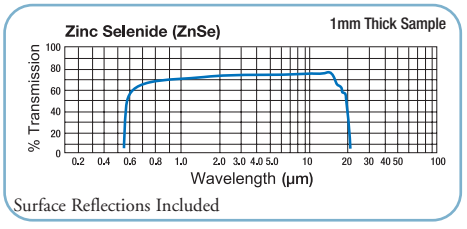
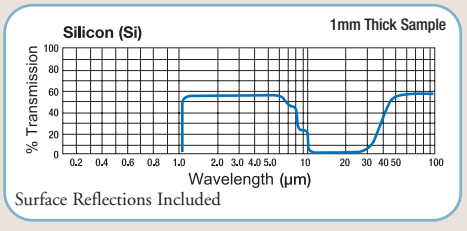
$\frac{1}{f} = \frac{1}{S} + \frac{1}{S'}$ Paraxial Lens Formula (assumes $\sin\theta \approx \theta$)

S = Object Distance, positive for objects to the left of the front principal point P.

S' = Image Distance, positive for images to the right of the rear rear principal point P'

Transmission of Various Materials

GLASS	DESCRIPTION	TRANSMISSION	
BK7	BK7 is a high-quality optical glass commonly used to make lenses intended for laboratory use. It has excellent mechanical and optical properties as well as good transmission in the visible and IR.	350nm to 2.0µm	 1mm Thick Sample Surface Reflections Included
UV Fused Silica	UV fused silica is an excellent material for the transmission of UV light. It is durable and has good mechanical properties $T_{external} \geq 80\%/cm$ @ 185nm $T_{internal} \geq 88\%/cm$ @ 185nm	185nm to 2.1µm	 1mm Thick Sample Surface Reflections Included
CaF_2	Calcium fluoride provides great transmission from the UV to the IR. Synthetic CaF_2 is used to improve deep UV transmission and to increase the damage threshold.	180nm to 8.0µm	 1mm Thick Sample Surface Reflections Included
MgF_2	Magnesium fluoride, an extremely rugged and durable material, is transparent over an extensive range of wavelengths from the UV to the IR.	200nm to 6.0µm	 1mm Thick Sample Surface Reflections Included

GLASS	DESCRIPTION	TRANSMISSION	
SF11	This glass provides excellent chemical resistance and has a high refractive index, which allows for the same amount of refraction with less curvature. It is useful for constructing optics that would be extremely difficult to make from BK7.	420nm to 2.3µm	
Ge	The transmission characteristics of germanium in the IR region of the spectrum make it an ideal choice for imaging 2.0 - 16µm light. Ge plano-convex lenses are particularly well suited for more biomedical and military imaging applications.	2.0µm to 16µm	
ZnSe	With a transmission range from 600nm - 16µm, zinc selenide plano-convex lenses are ideal for IR applications. Due to the low absorption coefficient, these lenses are also particularly well suited for high-power CO_2 laser applications. In contrast to Ge and Si, which also transmit in this spectral range, ZnSe transmits some visible light, thereby allowing for visual alignment of the optic.	600nm to 16µm	
Si	Silicon plano-convex lenses are an ideal choice for applications from 1.2 - 8µm and are particularly well suited for imaging, biomedical, and military applications.	1200nm to 8.0 µm	

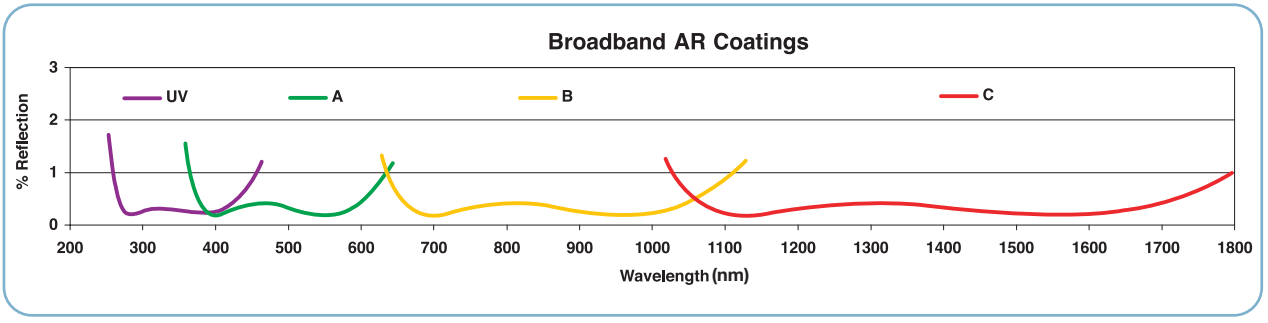
Spherical Singlet Anti-Reflection Coatings

Most of our standard optics are available with high-performance, multilayer AR coatings, which minimize surface reflections within the specified wavelength ranges. These coatings are designed for angles of incidence between 0° and 30° (0.5 NA). For optics intended to be used at large angles, consider using a custom coating optimized at a 45° of incidence; these coatings are effective from 25° to 52°. The plot shown below indicates the performance of the standard coatings in this family as a function of wavelength for a single surface. Broadband coatings have a typical absorption of 0.25% that is not shown in the reflectivity plots.

- R < 0.5% Average Over Band at 0° Incidence
- Less Angular Sensitivity within Angular Range
- Frequently Run Coatings are Listed Below

Normal Incidence Broadband Multilayer Anti-Reflective Coating

COATING CODE	WAVELENGTH RANGE	DESIGN ANGLE OF INCIDENCE	USEFUL ANGLE OF INCIDENCE
-UV	290-370nm	0°	0 to 30°
-A	350-650nm	0°	0 to 30°
-B	650-1050nm	0°	0 to 30°
-C	1050-1620nm	0°	0 to 30°



Application Note: Using Meniscus Lenses

Poor Performance 240µm Focus

A Single f=50mm
Plano-Convex Lens

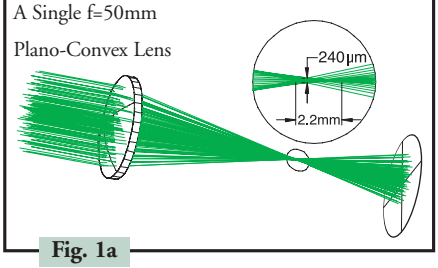


Fig. 1a

Good Performance 81µm Focus

Two f=100mm
Plano-Convex Lens

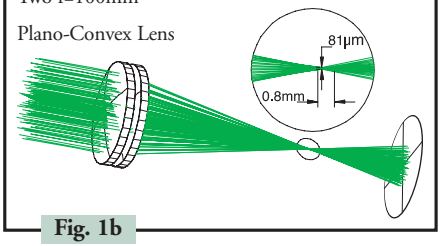


Fig. 1b

Excellent Performance 21µm Focus

One f=100mm
Plano-Convex Lens &
one f=100mm Meniscus Lens

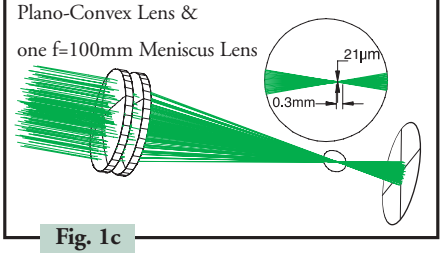


Fig. 1c

- Achieve Tighter Focusing by Combining a Meniscus Lens With Plano-Convex Lenses
- Build Multi-Element Lens Systems to Achieve Higher NA Without Significant Increases in Aberrations

These figures illustrate the performance gains that can be achieved by using multi-element imaging systems. The combination of a meniscus lens and a plano-convex lens yields a 21µm focused spot versus a 240µm spot from the single plano-convex lens.

POSITIVE MENISCUS LENSES

Positive meniscus lenses are designed to minimize spherical aberration. They have one surface convex and the other concave. When used in combination with another lens, a positive meniscus lens will shorten the focal length and increase the NA of the system. Figure 1c shows a meniscus lens being used to shorten the focal length of a 100mm focal length plano-convex lens. In addition, the transverse and lateral aberrations are greatly reduced. The convex surface of both lenses should be facing the away from the image.

NEGATIVE MENISCUS LENSES

Negative meniscus lenses are commonly used in beam expanding applications since they increase the divergence of the beam without introducing any significant spherical aberration. Combining a negative meniscus lens with another lens will increase the focal length and decrease the NA of the system.

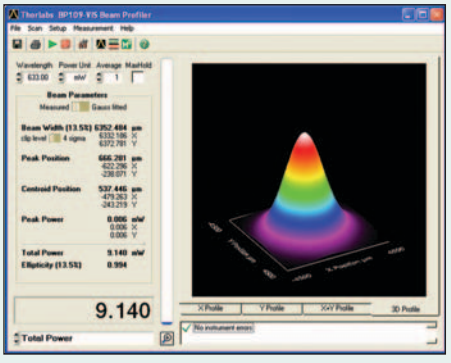
Buying More Than 10 Pieces of an Optic?
Call for a Discount!

Laser Beam Profiler

TOOLS OF THE TRADE

- High Precision Analysis of Beam Quality and Spatial Power Distribution
- Powerful Graphical Interface
- USB 2.0

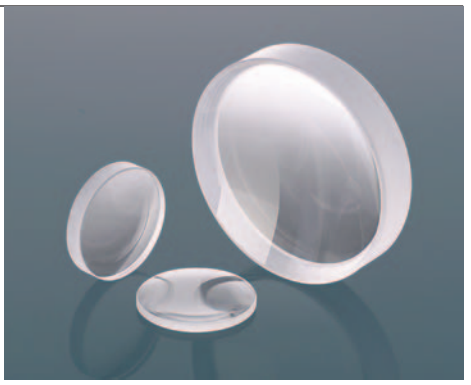
User software showing pseudo 3D beam profile



BP100 SERIES
(Base & Post Not Included)

See Page 966

UV Grade Fused Silica: Meniscus Lenses



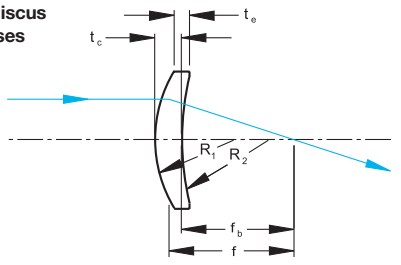
When used to form a positive lens assembly, the Positive Meniscus lens can increase the NA of the system while decreasing the total spherical aberration.

The Negative Meniscus lens is used to increase the focal length of another lens while maintaining the angular resolution of the optical assembly. This lens shape is best used when one conjugate is relatively far from the lens.

Specifications

- **Material:** UV Grade Fused Silica
- **Wavelength Range:** 185nm-2.1µm Uncoated
- **Design Wavelength:** 588nm, n = 1.460
- **Dia. Tolerance:** +0.00/-0.10mm
- **Focal Length Tolerance:** ±1%
- **Scratch-Dig:** 40-20
- **Centration:** ≤3arcmin
- **Clear Aperture:** >90%
- **Transmission:** $T_{internal} \geq 88\%/cm$ @ 185nm

Meniscus Lenses



Positive Meniscus Lenses: UV Grade Fused Silica

Item #	DIA (mm)	f (mm)	PRICE $	PRICE £	PRICE €	PRICE RMB	R_1 (mm)	R_2 (mm)	t_c (mm)	t_e[1] (mm)	f_b (mm)	SUGGESTED MOUNT[2]
LE4173	25.4	100.0	$ 83.40	£ 52.50	€ 77,60	¥ 796.50	31.0	91.2	4.0	2.2	95.9	
LE4197	25.4	150.0	$ 82.50	£ 52.00	€ 76,70	¥ 787.90	47.6	149.8	3.2	2.0	146.8	
LE4467	25.4	200.0	$ 82.00	£ 51.70	€ 76,30	¥ 783.10	64.2	209.8	2.9	2.0	197.2	LMR1
LE4329	25.4	300.0	$ 82.00	£ 51.70	€ 76,30	¥ 783.10	97.6	330.6	2.6	2.0	297.5	
LE4484	25.4	500.0	$ 80.00	£ 50.40	€ 74,40	¥ 764.00	166.8	603.4	2.4	2.0	497.8	
LE4950	25.4	1000.0	$ 79.60	£ 50.10	€ 74,00	¥ 760.20	348.0	1425.7	2.2	2.0	998.0	
LE4412	50.8	100.0	$ 324.50	£ 204.40	€ 301,80	¥ 3,099.00	30.6	80.9	10.7	1.2	89.0	
LE4125	50.8	150.0	$ 291.50	£ 183.60	€ 271,10	¥ 2,783.80	46.5	135.3	7.8	2.7	142.0	
LE4560	50.8	200.0	$ 280.50	£ 176.70	€ 260,90	¥ 2,678.80	63.0	193.4	6.6	2.9	193.4	LMR2
LE4984	50.8	300.0	$ 269.50	£ 169.80	€ 250,60	¥ 2,573.70	97.6	327.6	5.4	3.0	294.8	
LE4150	50.8	500.0	$ 269.50	£ 169.80	€ 250,60	¥ 2,573.70	165.4	582.2	5.0	3.6	495.2	
LE4822	50.8	1000.0	$ 262.90	£ 165.60	€ 244,50	¥ 2,510.70	356.7	1580.2	5.0	4.3	995.6	

1 Edge Thickness given before 0.2mm @ 45° typ. Chamfer.
2) See the Lens Mount Section, Starting on Page 153.

Negative Meniscus Lenses: UV Grade Fused Silica

Item #	DIA (mm)	f (mm)	PRICE $	PRICE £	PRICE €	PRICE RMB	R_1 (mm)	R_2 (mm)	t_c (mm)	t_e[1] (mm)	f_b (mm)	SUGGESTED MOUNT[2]
LF4938	25.4	-100.0	$ 83.50	£ 52.60	€ 77,70	¥ 797.40	150.0	35.0	3.0	4.9	-99.4	
LF4370	25.4	-150.0	$ 82.50	£ 52.00	€ 76,70	¥ 787.90	150.0	47.0	3.0	4.2	-149.1	
LF4624	25.4	-200.0	$ 82.00	£ 51.70	€ 76,30	¥ 783.10	150.0	56.6	3.5	4.4	-198.5	LMR1
LF4348	25.4	-300.0	$ 82.00	£ 51.70	€ 76,30	¥ 783.10	150.0	71.4	3.5	4.1	-297.8	
LF4706	25.4	-500.0	$ 80.00	£ 50.40	€ 74,40	¥ 764.00	200.0	106.4	3.5	3.9	-497.2	
LF4986	25.4	-1000.0	$ 79.60	£ 50.10	€ 74,00	¥ 760.20	300.0	180.8	4.0	4.2	-995.8	
LF4315	50.8	-100.0	$ 324.50	£ 204.40	€ 301,80	¥ 3,099.00	200.0	37.1	5.0	13.4	-99.3	
LF4101	50.8	-150.0	$ 291.50	£ 183.60	€ 271,10	¥ 2,783.80	200.0	50.2	5.0	10.2	-148.8	
LF4328	50.8	-200.0	$ 280.50	£ 176.70	€ 260,90	¥ 2,678.80	200.0	62.5	5.0	8.8	-198.4	LMR2
LF4929	50.8	-300.0	$ 269.50	£ 169.80	€ 250,60	¥ 2,573.70	250.0	88.4	5.0	7.4	-298.1	
LF4329	50.8	-500.0	$ 269.50	£ 169.80	€ 250,60	¥ 2,573.70	300.0	129.5	5.0	6.0	-497.4	
LF4246	50.8	-1000.0	$ 269.50	£ 169.80	€ 250,60	¥ 2,573.70	300.0	180.6	5.0	5.7	-994.7	

1 Edge Thickness given before 0.2mm @ 45° typ. Chamfer.
2) See the Lens Mount Section, Starting on Page 153.

Metallic ND Filter Kits

ITEM #	$	£	€	RMB
NDK01	$ 489.00	£ 308.10	€ 454,80	¥ 4,670.00

Complete Set of 10 ND Filters, Mounted, and Boxed

See Page 875

THz Lenses - Teflon

Thorlabs now offers Teflon lenses made for transmission in the THz region.

See Page 706