

- Gradient index lenses for high power laser delivery
- Aspheric performance
- Smaller focused spot size
- Single lens replacement for conventional doublets
- High performance, cost effective
- Standard designs with diameters from 5 mm to 80 mm



In high performance optical systems, spherical aberration, chromatic aberration and astigmatism induce sweat on the brows of optical designers. These aberrations can prevent optical systems from reaching their full potential.

Avoiding these factors in optical systems is often difficult without using multiple lens elements. LightPath's unique line of GRADIUM® optics makes correcting these aberrations with a single optical element a practical reality.

GRADIUM® lenses are made from LightPath's proprietary axial gradient index glass. Its unique refractive qualities can be exploited to reduce spherical aberrations – resulting in performance similar to single-term aspheres.

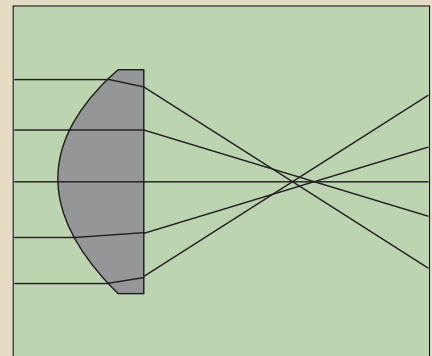
GRADIUM® lenses have been applied as simple singlets or doublets in complex multi-element systems. They have been very well received for use in high-power industrial laser systems; many of the world's largest Nd:YAG and fiber laser manufacturers now incorporate GRADIUM® optics in their laser delivery systems.

LightPath's achromatic doublets are designed for use with collimated, polychromatic light in the visible spectrum. The GRADIUM® glass element is used to reduce the spherical aberration which is a common side effect of a cemented doublet design.

General GRADIUM® Lens Specifications	
Design Wavelength	546 nm
Operating Temperature	-20°C to +200°C
Storage Temperature	-40°C to +300°C
Outer Diameter (OD) Tolerance	± 0.250 mm
Center Thickness (CT) Tolerance	± 0.100 mm
Effective Focal Length (EFL) for GPX, GBX, and GMN Series	± 1%
Working Distance (WD) for GPX, GBX, and GMN Series	± 1%
Effective Focal Length (EFL) for GAD Series	± 2%
Working Distance (WD) for GAD Series	± 2%
Surface Quality	40/20 Scratch/Dig

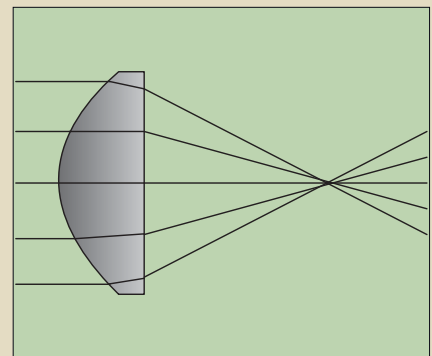
Standard Spherical Lens

Standard spherical lenses suffer from spherical aberration, which artificially limits the focused spot size.



GRADIUM® Lens

GRADIUM's® unique refractive index profile bends rays while traveling through the lens, resulting in a better focused, smaller spot.



GRADIUM® lenses provide a cost-effective solution for many high-performance applications.

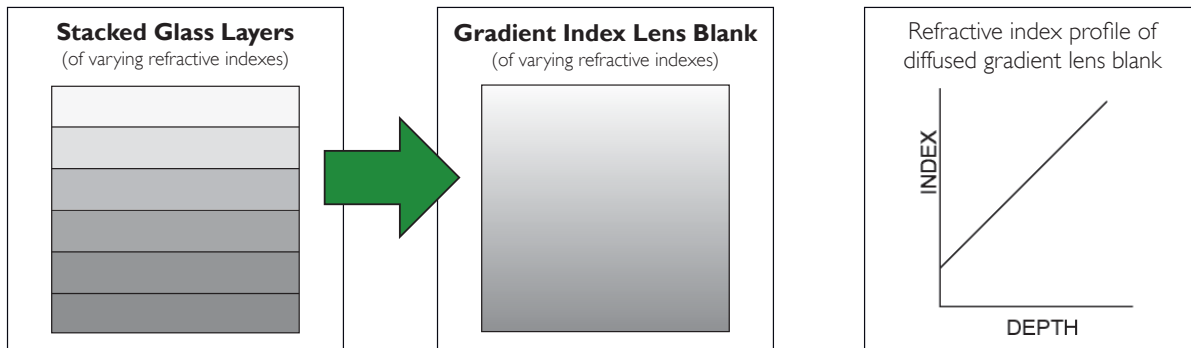
GRADIUM® lenses take advantage of recent advances in the manufacturing of axial gradient glass. Large diameter blanks are fabricated with index changes (Δn) of up to 0.15, about 100 times that available from radial GRIN (GRadient INdex) technology. The large range in Δn available provides a substantial ability to correct aberrations, especially spherical.

The process used to produce the GRADIUM® glass turns a series of SF glass layers into a single piece of gradient material. Unlike radial GRIN lenses, this process provides large diameter optical blanks with controlled index and dispersion profiles. Proper gradient profile selection allows a simple spherical lens to act as an asphere.

GRADIUM® lenses should be used wherever small spot size, high numerical aperture (NA), increased beam energy, or excellent wavefront quality is important. A GRADIUM® singlet does not have the limited laser damage threshold of a conventional cemented doublet, so laser power can be increased, leading to increased production throughput.

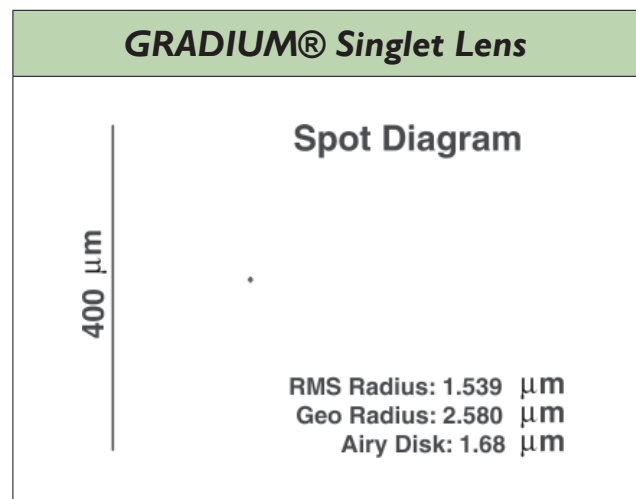
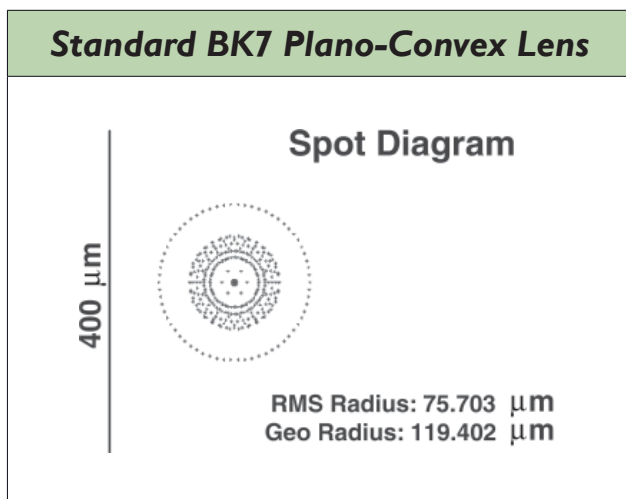
GRADIUM® glass offers the additional benefit of chromatic correction. The dispersion, as well as the optical index, varies in a controlled fashion within the lens. A finished lens can be viewed as a seamless, contiguous combination of many glass types. This continuous variation results in a transfer aberration correction not possible with homogeneous lenses.

The GRADIUM® Process

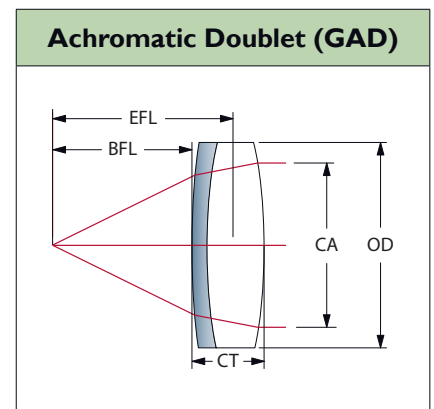
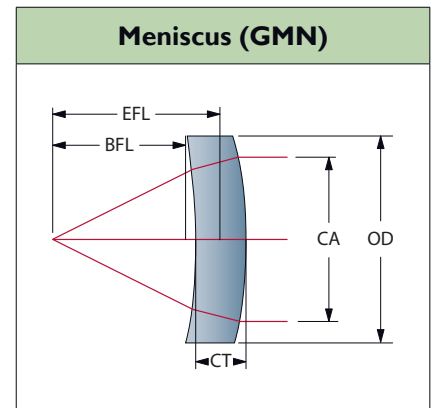
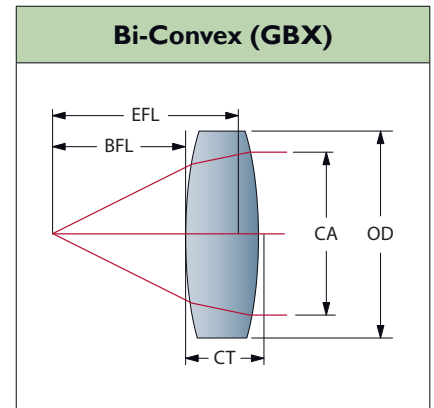
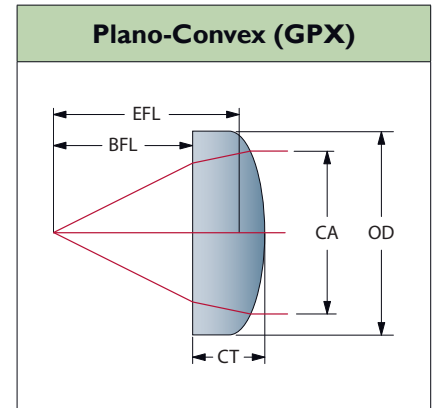


Typical Spot Diagram

These diagrams show the performance of a GRADIUM® lens over a comparable BK-7 plano-convex lens.



		Lens Code	Outer Diameter (mm)	Clear Aperture (mm)	F/#	Effective Focal Length (mm)	Center Thickness (mm)	Back Focal Length (mm)	
Standard GRADIUM® Lenses	Plano-Convex	GPX-5-5	5.00	4.00	1.0	5.0	2.9	3.09	
		GPX5-10	5.00	4.50	2.2	10.0	3.0	8.23	
		GPX6,3-6,19	6.30	5.67	1.0	6.19	2.6	4.65	
		GPX10-10	10.00	9.00	1.1	10.0	3.0	8.00	
		GPX10-12.5	10.00	9.00	1.4	12.5	3.0	10.68	
		GPX10-18	10.00	9.00	2.0	18.0	2.5	16.52	
		GPX10-22	10.00	9.00	2.5	22.0	2.5	20.54	
		GPX10-25	10.00	9.00	2.8	25.0	2.5	23.55	
		GPX10-30	10.00	9.00	3.3	30.0	2.5	28.53	
		GPX15-15	15.00	13.00	1.1	15.0	4.2	12.24	
		GPX15-25	15.00	13.50	1.8	24.14	3.0	22.42	
		GPX15-40	15.00	13.00	3.0	40.0	2.0	38.83	
		GPX20-60	20.00	18.00	3.3	60.0	6.0	56.49	
		GPX25-60	25.00	22.00	2.6	60.0	6.0	56.46	
		GPX25-80	25.00	22.00	3.5	80.0	4.0	77.69	
		GPX30-60	30.00	27.00	2.2	60.0	6.0	56.44	
		GPX30-70	30.00	27.00	2.6	70.0	6.0	66.47	
		GPX40-80	40.00	36.00	2.2	80.0	6.0	76.47	
	GPX50-100	50.00	45.00	2.2	100.0	8.0	94.90		
	GPX50-125	50.00	45.00	2.8	125.0	8.0	120.37		
GPX50-160	50.00	45.00	3.6	160.0	8.0	155.25			
GPX80-125	80.00	72.00	1.7	125.0	12.25	116.91			
Bi-Convex	GBX30-40	30.00	27.00	1.5	40.0	5.76	36.72		
	GBX50-80	50.00	45.00	1.8	80.0	8.0	75.46		
Available GRADIUM® Lenses*	Plano-Convex	GPX5-12.5	5.00	4.00	2.8	12.5	2.0	11.30	
		GPX6,35-12,5	6.35	5.715	2.2	12.5	2.0	11.31	
		GPX10-40	10.00	9.00	4.5	40.0	2.0	38.84	
		GPX12,5-35	12.50	11.25	3.0	33.49	3.0	31.74	
		GPX20-50	20.00	18.00	2.8	50.0	3.0	48.24	
		GPX25-40	25.00	22.50	1.8	40.08	6.0	36.55	
		GPX25-50	25.00	22.50	2.2	50.16	6.0	46.62	
		GPX25-125	25.00	22.50	5.6	125.0	6.0	121.50	
		GPX27-70	27.00	24.30	2.8	66.63	6.0	63.13	
		GPX27,82-65	27.82	25.038	2.6	63.97	6.0	60.47	
		GPX27-100	27.00	24.30	4.0	96.46	6.0	93.02	
		GPX30-80	30.00	27.00	3.0	80.0	4.0	77.68	
		GPX30-100	30.00	27.00	3.7	100.0	6.0	96.53	
		GPX40-100	40.00	36.00	2.8	100.0	6.0	96.56	
		GPX40-125	40.00	36.00	3.5	125.0	6.0	121.52	
		GPX40-150	40.00	36.00	4.2	150.0	6.0	146.49	
		GPX50-150	50.00	45.00	3.3	150.0	8.0	145.25	
		GPX50-200	50.00	45.00	4.5	200.0	8.0	195.27	
		Bi-Convex	GBX20-40	20.00	18.00	2.2	40.0	4.6	37.54
			GBX25-40	25.00	22.00	1.8	40.0	4.6	37.51
	GBX30-50		30.00	27.00	1.84	49.97	5.0	47.50	
	GBX80-255		80.00	72.00	3.38	241.37	10.0	236.83	
	ME Achromat	GAD5-15	5.00	4.00	3.3	15.0	4.0	13.07	
		GAD10-20	10.00	9.00	2.2	20.0	6.0	17.17	
		GAD25-50	25.00	22.00	2.2	50.0	11.0	44.37	
	ME	GMN30-50	30.00	27.00	1.9	50.0	5.0	46.82	



*Additional charges and longer lead time may apply for these designs.

Standard Anti-Reflective Coatings

	Coating Code	Wavelength	Reflectivity per Surface %
Broad Band	-BB1	400-700 nm	< 0.5 Average
	-BB2	650-1000 nm	< 0.5 Average
Dual Band	-DB3	1310/1550 nm	< 0.25 Maximum
	-DB5	808/940 nm	< 0.25 Maximum
VC	-VC8	1064 nm	< 0.25 Maximum

Available Anti-Reflective Coatings

	Available Coatings*	Wavelength	Reflectivity per Surface %
Broad Band	-BB3	1000-1600 nm	< 0.50 Average
	-BB4	1500-2500 nm	< 0.50 Average
Dual Band	-DB1	633/1064 nm	< 0.25 Maximum
	-DB2	532/1064 nm	< 0.25 Maximum
	-DB4	530/670 nm	< 0.25 Maximum
	-DB6	1064/1550 nm	< 0.25 Maximum
VC	-VC1	488 nm	< 0.25 Maximum
	-VC2	532 nm	< 0.25 Maximum
	-VC3	633 nm	< 0.25 Maximum
	-VC4	670 nm	< 0.25 Maximum
	-VC5	780 nm	< 0.25 Maximum
	-VC6	830 nm	< 0.25 Maximum
	-VC7	980 nm	< 0.25 Maximum
	-VC9	1300 nm	< 0.25 Maximum
	-VC10	1550 nm	< 0.25 Maximum
	-VC11	2000 nm	< 0.25 Maximum

*Additional charges and longer lead time may apply for these coatings.

Customization

LightPath would be happy to design a custom GRADIUM® lens to your individual specifications. The typical required parameters for custom GRADIUM® lenses are:

Effective Focal Length (EFL) mm

Back Focal Length (BFL) mm

Outer Diameter (OD) mm

Clear Aperture (CA) mm

Wavelengths of Interest nm

Laser Power

Anti-Reflective Coating

Wavelength Range – nm

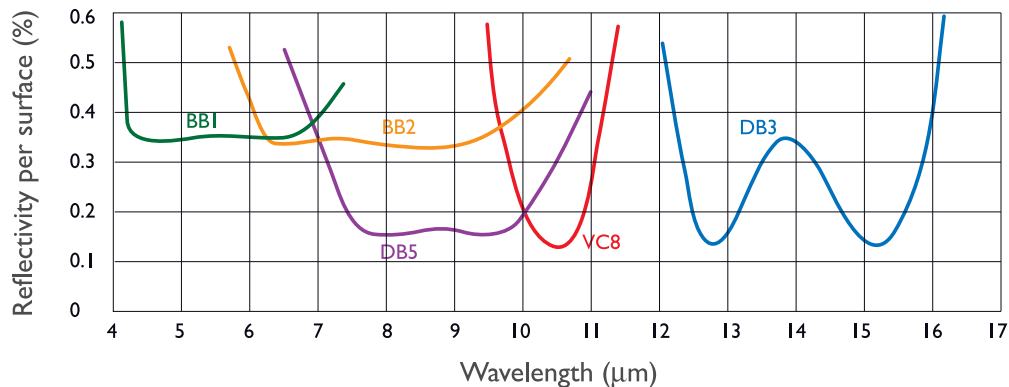
Reflectivity

Laser Beam Diameter mm

Beam Quality

For a more detailed list of parameters, please visit our website at www.lightpath.com or contact LightPath at 1-800-472-3486 to discuss your particular requirements.

Standard Coating Curves



LEGEND

- BB1
- BB2
- DB3
- DB5
- VC8