

Mid to Long Wavelength Infrared Aspheres

- Wavelength range 1-14 μm
- Aspheric lenses reduce number of lenses in a system
- Molded optics allow low cost high volume production
- Available with diffractive elements (DOE) for enhanced performance
- Smaller focal shifts due to temperature variations
- Improved transmission at elevated temperatures
- Custom designs & catalog lenses available

LightPath is a recognized world leader in press molded aspherical optics. Traditionally, these aspheric lenses have been limited to visible and near-infrared wavelengths. Recent advances in optical materials now provide a common technology path to produce mid and long-wavelength infrared (MWIR & LWIR) aspheres by compression molding. LightPath's Black Diamond™ technology enables high performance, cost-effective IR aspheric lenses that do not rely on traditional diamond turning or lengthy polishing methods.



Utilizing aspheric optics significantly reduces the number of lenses required for typical thermal imaging systems. Traditional Germanium aspheres are manufactured by diamond turning, which is time-consuming and expensive process. Since diamond turned Germanium lenses are made one at a time, the lenses may also suffer from variations in surface figure leading to variations in performance from lens to lens. The Black Diamond™ molding process allows lenses to be manufactured in high volume with highly repeatable, consistent performance.

Diffractive features are typically added to IR aspheres to allow for sophisticated beam shaping or achromatization over a range of wavelengths. With LightPath's molding technologies, these features can be molded directly into the surfaces of the lenses.



LightPath's Black Diamond™ moldable glass has several advantages over Germanium, which is traditionally used for aspheric IR optics. The dn/dT and CTE of Black Diamond glass result in a smaller change in focal length as a function of temperature. Using Black Diamond glass enables athermalization to occur using just a single lens or with a minimum of athermalization mechanics.

Germanium also suffers from transmission loss as temperature increases, especially as the temperature reaches 100°C. Germanium's transmission decreases by 20-30% at 100°C. Black Diamond™ aspheric lenses can be used in environments up to 130°C, enabling a range of applications that were not previously possible with Germanium.

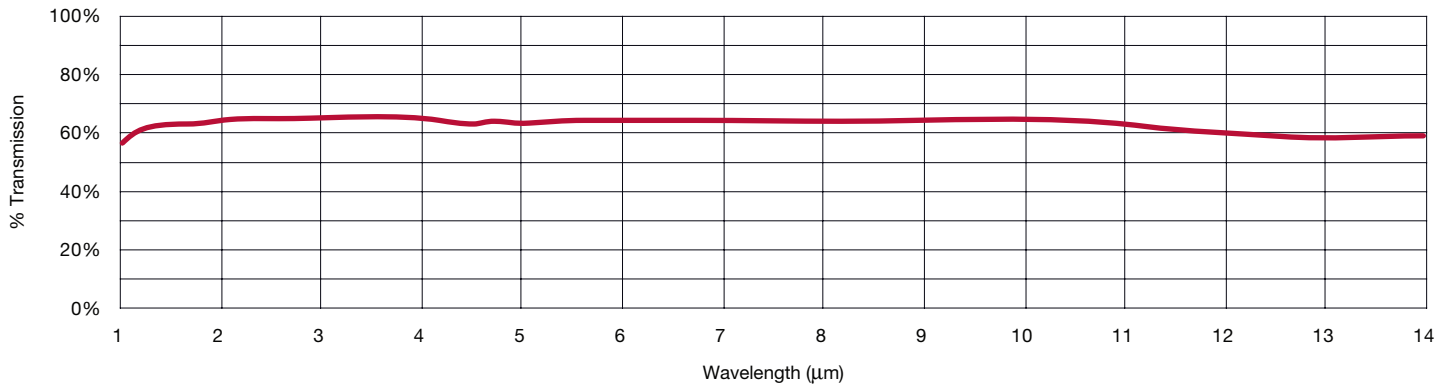
LightPath's Black Diamond™ aspheres are currently available as catalog lenses or on a custom basis. LightPath offers custom lens solutions for high volume manufacturing at prices equal to that of a standard off-the-shelf lens. If you need a custom lens to fit your particular application, we will be happy to design one for you. Our sales and engineering teams work closely together to assist you in design, prototyping, and production of custom glass aspheric lenses.

When determining specifications for custom aspheric lenses, the following parameters are typically used to specify lens performance. A LightPath product expert would be happy to discuss these parameters with you to determine the appropriate lens for your application.

Custom Black Diamond™ Infrared Lenses		
Wavelength of Application	<input type="text"/>	microns
Numerical Aperture or f/# or Laser	<input type="text"/>	
Effective Focal Length	<input type="text"/>	mm
Clear Aperture	<input type="text"/>	mm
Working Distance	<input type="text"/>	mm
Mechanical Restraints	<input type="text"/>	

LightPath specializes in producing custom lens and lens assembly designs in a short time frame.

BD-2 Uncoated Transmission Curve (5 mm thickness)



Refractive Indices and Absorption Coefficient

Index	λ (μm)	Absorption (cm^{-1})
2.6266	3	0.01
2.6210	4	0.01
2.6173	5	0.01
2.6142	6	0.01
2.6117	7	0.01
2.6088	8	0.01
2.6055	9	0.01
2.6023	10	0.01
2.5983	11	0.03
2.5942	12	0.13
2.5892	13	0.20
2.5843	14	0.20

Mechanical Properties

Density	4.67 g/cm ³
Hardness	150 knoop
Young's Modulus	22.1 GPa

Thermal Properties

T _g	278 °C
CTE	14 × 10 ⁻⁶ / °C
dn/dT	91 × 10 ⁻⁶ / °C

Composition

Component	Percentage
Germanium (Ge)	28%
Antimony (Sb)	12%
Selenium (Se)	60%

Equivalent Glasses

Manufacturer	Glass
Amorphous Materials	AMTIR-3
Schott/Vitron	IG5

LightPath lenses that have a 390xxx prefix use the BD-2 IR glass.



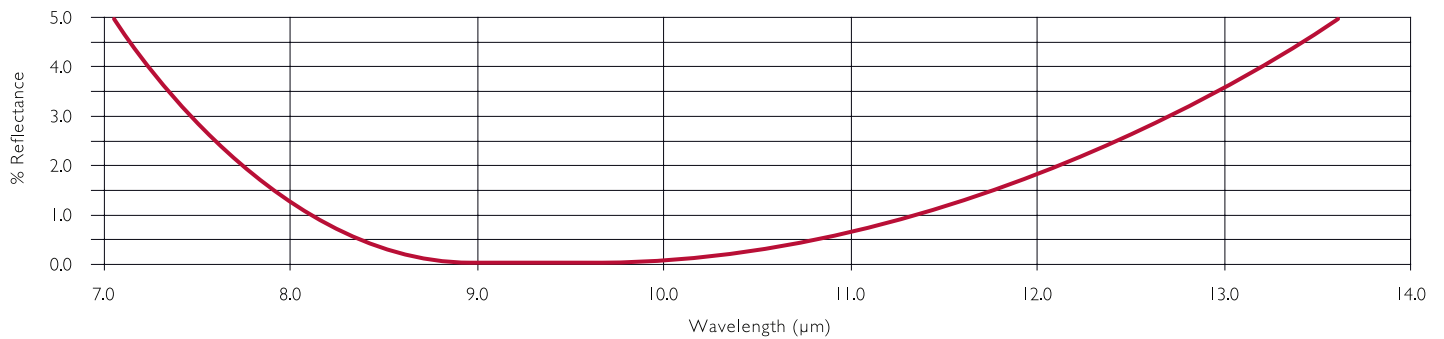
Available Coatings

Coating	λ Range (μm)	R_{AVG}
IR-1	7 - 14	< 1.0% per side
IR-3	2 - 6	< 0.6% per side
IR-4	1.75 - 3	< 1.0% per side



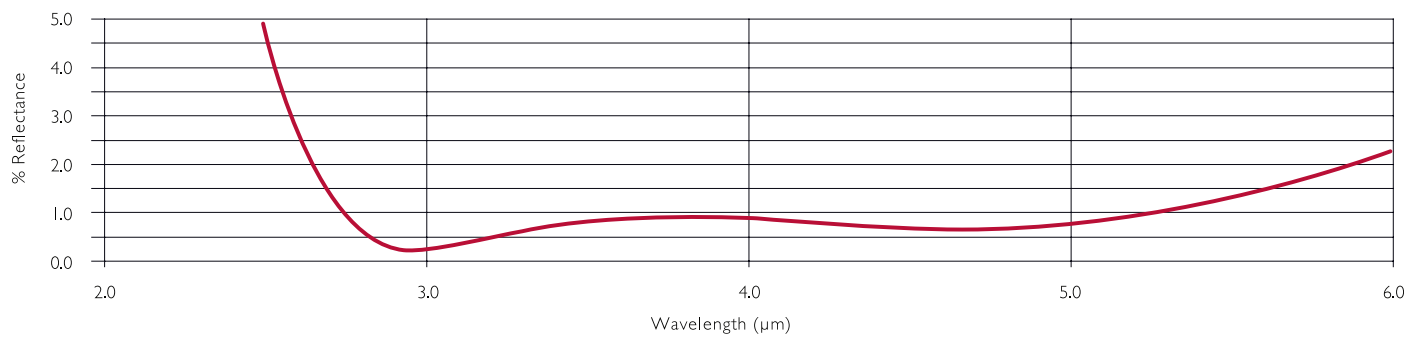
IR-1

Typical Reflectance Curve (spec: 7-14 μm)



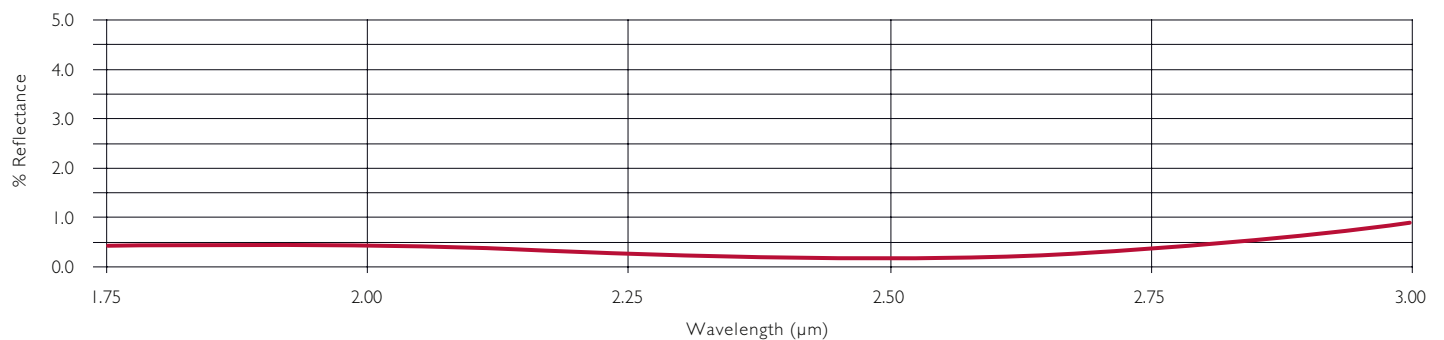
IR-3

Typical Reflectance Curve (spec: 2-6 μm)



IR-4

Typical Reflectance Curve (spec: 1.75-3 μm)



MWIR & LWIR Collimating Lenses

- High numerical aperture for max collection efficiency
- Compact, single lens design
- Diffraction limited performance
- RoHS Compliant



MWIR/LWIR collimating lenses have a high numerical aperture for maximum light collection for collimating light from MWIR and LWIR lasers, including quantum cascade lasers (QCL). The aspheric design enables a single lens to replace complex multiple component optical system.

Lens Code 390036

Optical Glass Material	BD-2
Design Wavelength	2.5 μm
Numerical Aperture (NA)	0.56
Clear Aperture (CA)	5.00 mm
Effective Focal Length (EFL)	4.0 mm \pm 1%
Magnification	Infinite
RMS WFE	< Diffraction Limited
Outer Diameter (OD)	6.50 mm
Working Distance (WD)	3.05 mm
Center Thickness (CT)	2.5 mm

Lens Code 390037

Optical Glass Material	BD-2
Design Wavelength	7 μm
Numerical Aperture (NA)	0.85
Clear Aperture (CA)	4.00 mm
Effective Focal Length (EFL)	1.873 mm \pm 1%
Magnification	Infinite
RMS WFE	< Diffraction Limited
Outer Diameter (OD)	5.50 mm
Working Distance (WD)	0.723 mm
Center Thickness (CT)	3.0 mm

Mounted MWIR/LWIR

390036XX-MT	390037XX-MT	General Specifications and Tolerances	
		Holder Material	Stainless Steel 304
		Holder Outer Diameter	\pm 0.025 mm
		Holder Inner Diameter	\pm 0.100 mm
		Holder Length	\pm 0.100 mm
		Length of Threaded Section	\pm 0.100 mm

Infrared Lens Assemblies

- Molded lenses using Black Diamond™ chalcogenide glass
- Wavelength range 8 μm – 14 μm
- Passive athermalization for -40°C to +85°C
- High volume, cost effective manufacturing
- Designed for uncooled IR sensors

LightPath's Infrared Lens Assemblies are specifically designed to be a lower cost replacement for standard IR optical assemblies. These lens assemblies integrate our Black Diamond molded lenses into a complete ready-to-use package. Molded IR lenses are a lower cost substitute for traditional high volume diamond-turned optics.



Part Number 7100109: Athermalized Black Diamond™ Lens Assembly

Drawing	Optical Properties	
	Focal Length	19 mm (nominal)
	f/#	1.1
	Back Focal Distance	14.1 mm
	Diagonal FOV	30° (maximum)
	Diagonal Image Size	10 mm (maximum)
	Transmission	~ 90% (average)
	Glass Material	BD-2
	Focus	Fixed Focus, Manually Adjusted
	Focus Range	0.5 m to Infinity
	Athermalized	✓
	Mechanical Properties	
	Weight	25 g
	Lens Mount	M25 x 0.5
	Environmental Properties	
Operating Temperature	-40°C to +85°C	

Custom Lens Assembly Specifications

Wavelength of Application <input type="text"/> microns	Detector # of Pixels <input type="text"/> × <input type="text"/>
f/# <input type="text"/>	Detector Pixel Size <input type="text"/> microns
Field of View (FOV) <input type="text"/> degrees	Working Distance <input type="text"/> mm
Effective Focal Length <input type="text"/> mm	Mechanical Interface <input type="text"/>
MTF <input type="text"/> % @ <input type="text"/> lp/mm	Environmental Constraints <input type="text"/>
Detector Type <input type="text"/>	