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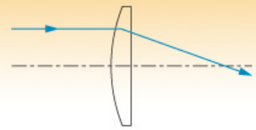
THORLABS

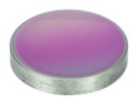
LA9792-F - September 19, 2016

Item # LA9792-F was discontinued on September 19, 2016. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

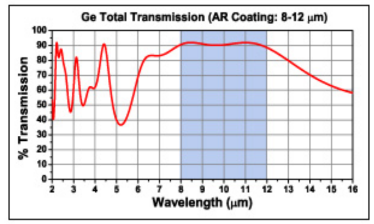
- **AR Coating Optimized for the 8 - 12 µm Range**
- **Choose from Ø1/2" or Ø1"**
- **Excellent for Security, Military, and Imaging Applications**



LA9509-F
(Ø1")



LA9410-F
(Ø1/2")



Hide Overview

OVERVIEW

Features

- Ge Substrate
- Ø1/2" and Ø1" Versions Available
- Broadband AR Coating for the 8-12 µm Range
- Focal Lengths from 15.0 - 1000.0 mm Available

Thorlabs' Ø1/2" and Ø1" Germanium (Ge) Plano-Convex Lenses are available with a broadband AR coating for the 8-12 µm spectral range deposited on both surfaces. This coating greatly reduces the high surface reflectivity of the substrate, yielding an average transmission in excess of 90% over the entire AR coating range. See the *Graphs* tab for detailed information.

Plano-Convex lenses have a positive focal length and approach best form for infinite and finite conjugate applications. These lenses focus a collimated beam to the back focus and collimate light from a point source. They are designed with minimal spherical aberration and have a focal length given by:

$$f= R/(n-1),$$

where R is the radius of curvature of the convex portion of the lens and n is the index of refraction. To minimize the introduction of spherical aberration, a collimated light source should be incident on the curved surface of the lens when being focused and a point light source should be incident on the planar surface when being collimated.

Due to its broad transmission range (2 - 16 µm) and opacity in the visible portion of the spectrum, germanium is well suited for IR laser applications. It is also inert to air, water, alkalis, and acids (except nitric acid). Germanium's transmission properties are highly temperature sensitive; in fact, the absorption becomes so large that germanium is nearly opaque at 100 °C and completely non-transmissive at 200 °C.

Specifications	
Material	Germanium
Wavelength Range	2.0 - 16.0 µm
AR Coating Range	8-12 µm
Reflectance over Coating Range (Avg.)	<1.5%
Damage Threshold[a]	0.5 J/cm^2 (10.6 µm, 100 ns, 1 Hz, Ø0.478 mm)
Diameter Tolerance	+0.00/-0.10
Thickness Tolerance	±0.2 mm
Focal Length Tolerance	±1%
Surface Quality	60-40 Scratch-Dig
Surface Flatness (Plano Side)	λ/2
Spherical Surface Power[b] (Convex Side)	3λ/2
Surface Irregularity (Peak to Valley)	λ/2
Centration	≤3 arcmin
Clear Aperture	80% of Diameter
Design Wavelength	10.6 µm

- Limited by the antireflection coating.
- Much like surface flatness for flat optics, spherical surface power is a measure of the deviation between the surface of the curved optic and a calibrated reference gauge, typically for a 633 nm source, unless otherwise stated. This specification is also commonly referred to as surface fit.

When handling optics, one should always wear gloves. This is especially true when working with germanium, as dust from the material is hazardous. For your safety, please follow all proper precautions, including wearing gloves when handling these lenses and thoroughly washing your hands afterward.

Zemax Files

Click on the red Document icon next to the item numbers below to access the Zemax file download. Our entire Zemax Catalog is also available.

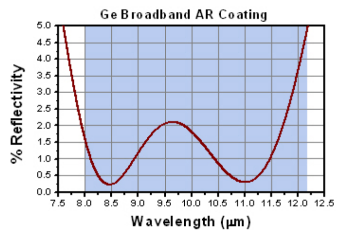
Other Spherical Singlets More [+]

Selection Guide

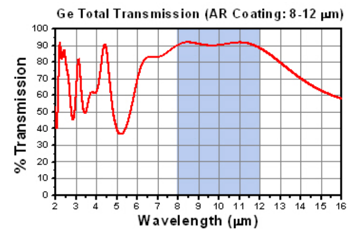
Selection Guide	
Other Ge Lenses	More [+]
Other MIR Lenses	More [+]

Hide Graphs

GRAPHS



Shown above is a theoretical graph of the percent reflectivity of the AR coating as a function of wavelength. The average reflectivity in the 8 - 12 µm range is <1.5%. The blue shading indicates the recommended usage range for these Ge plano-convex lenses.



Shown above is a graph of the theoretical transmission of the AR-coated germanium plano-convex lens. The blue shaded region denotes the 8 - 12 µm spectral range where we suggest using these Ge plano-convex lenses. For this wavelength range, the measured transmission is in excess of 88%.

Total Transmission of Optic (Ge Substrate + AR Coating)

The table below gives the approximate transmission of these optics for a few select wavelengths in the 8 - 12 µm range. To see an excel file that lists all measured transmission values for this wavelength range, please click here. Please note that the transmission values stated for wavelengths outside of the AR coating range are approximate and can vary significantly by coating lot.

Wavelength (nm)	Total Transmission	Wavelength (nm)	Total Transmission	Wavelength (nm)	Total Transmission	Wavelength (nm)	Total Transmission
8000	0.906	9000	0.910	10000	0.904	11000	0.919
8100	0.912	9100	0.908	10100	0.905	11100	0.919
8200	0.916	9200	0.906	10200	0.907	11200	0.918
8300	0.918	9300	0.904	10300	0.909	11300	0.916
8400	0.920	9400	0.902	10400	0.911	11400	0.914
8500	0.920	9500	0.901	10500	0.913	11500	0.911
8600	0.919	9600	0.901	10600	0.915	11600	0.907
8700	0.917	9700	0.901	10700	0.917	11700	0.903
8800	0.915	9800	0.902	10800	0.918	11800	0.898
8900	0.913	9900	0.902	10900	0.919	11900	0.892

Hide Index of Refraction

INDEX OF REFRACTION

Index of Refraction for the Ge Substrate

When light is incident on a boundary between two media with indices of refraction n_i and n_t, respectively, losses occur due to reflection. The fraction of light that is reflected or transmitted at the interface between two media is given by the Fresnel Equations, which were derived by considering the boundary conditions for both the electric and magnetic fields associated with the light wave (See a text such as Hecht's Optics for a full derivation). It can be shown that when the permeability of the substances involved are approximately equal to that of free space, the Fresnel Equations are given by

$$r_\perp = \frac{n_i \cos\theta_i - n_t \cos\theta_t}{n_i \cos\theta_i + n_t \cos\theta_t},$$

$$t_\perp = \frac{2n_i \cos\theta_i}{n_i \cos\theta_i + n_t \cos\theta_t},$$

$$r_\parallel = \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_i \cos\theta_t + n_t \cos\theta_i},$$

Wavelength (µm)	Refractive Index
2.06	4.10
2.15	4.09
2.44	4.07
2.58	4.06
3.00	4.05

3.42	4.03
4.36	4.02
6.24	4.01
8.66	4.00
9.72	4.00
11.04	4.00
13.02	4.00

and

$$t_{\parallel} = \frac{2n_i \cos\theta_i}{n_i \cos\theta_t + n_t \cos\theta_i}.$$

The first two equations are the Fresnel Equations for light polarized perpendicular to the plane of incidence with the first one yielding the amplitude reflection coefficient and the second giving the amplitude transmission coefficient, and the latter two are for light polarized parallel to the plane of incidence where, once again, the first gives the amplitude reflection coefficient and the second is the amplitude transmission coefficient. Within these equations, n_i (n_t) is the index of refraction of the incident (transmitted) medium and θ_i (θ_t) is the angle of incidence (refraction) as measured from the normal to the surface. Since the incident and reflected waves propagate through the same medium, the reflectance *R* is simply the square of the appropriate amplitude reflection coefficient:

$$R_{\perp} = r_{\perp}^2$$

or

$$R_{\parallel} = r_{\parallel}^2.$$

Furthermore, since all the incident light is either reflected or transmitted at the boundary, it can be shown that the sum of the reflectance *R* and transmittance *T* must be unity for each polarization:

$$R_{\perp} + T_{\perp} = 1$$

and

$$R_{\parallel} + T_{\parallel} = 1$$

When light is incident normal to the surface (i.e. $\theta_i = 0$), the distinction between the parallel and perpendicular components of *R* and *T* vanishes, yielding

$$R = R_{\parallel} = R_{\perp} = \left(\frac{n_t - n_i}{n_t + n_i}\right)^2$$

and

$$T = T_{\parallel} = T_{\perp} = \frac{4n_t n_i}{(n_t + n_i)^2}$$

For example, when light is incident normal to the boundary between air (n_i = 1.0) and crown glass (n_t = 1.52), the percentage of light reflected back at the interface is approximately 4% .

Hide Damage Thresholds

DAMAGE THRESHOLDS

Damage Threshold Data for Thorlabs' F-Coated Ge Singlet Lenses

The specifications to the right are measured data for Thorlabs' F-coated germanium lenses. Damage threshold specifications are constant for all Thorlabs' F-coated, germanium lenses, regardless of the size or focal length of the lens.

Damage Threshold Specifications	
Coating Designation (Item # Suffix)	**Damage Threshold**
-F	0.5 J/cm^2 (10.6 µm, 100 ns, 1 Hz, Ø0.478 mm)

Laser Induced Damage Threshold Tutorial

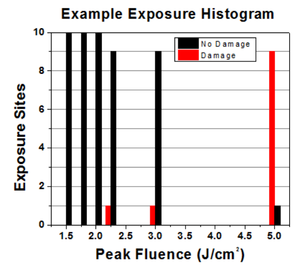
The following is a general overview of how laser induced damage thresholds are measured and how the values may be utilized in determining the appropriateness of an optic for a given application. When choosing optics, it is important to understand the Laser Induced Damage Threshold (LIDT) of the optics being used. The LIDT for an optic greatly depends on the type of laser you are using. Continuous wave (CW) lasers typically cause damage from thermal effects (absorption either in the coating or in the substrate). Pulsed lasers, on the other hand, often strip electrons from the lattice structure of an optic before causing thermal damage. Note that the guideline presented here assumes room temperature operation and optics in new condition (i.e., within scratch-dig spec, surface free of contamination, etc.). Because dust or other particles on the surface of an optic can cause damage at lower thresholds, we recommend keeping surfaces clean and free of debris. For more information on cleaning optics, please see our *Optics Cleaning* tutorial.

Testing Method

Thorlabs' LIDT testing is done in compliance with ISO/DIS11254 specifications. A standard 1-on-1 testing regime is performed to test the damage threshold.

First, a low-power/energy beam is directed to the optic under test. The optic is exposed in 10 locations to this laser beam for a set duration of time (CW) or number of pulses (pulse repetition frequency specified). After exposure, the optic is examined by a microscope (~100X magnification) for any visible damage. The number of locations that are damaged at a particular power/energy level is recorded. Next, the power/energy is either increased or decreased and the optic is exposed at 10 new locations. This process is repeated until damage is observed. The damage threshold is then assigned to be the highest power/energy that the optic can withstand without causing damage. A histogram such as that below represents the testing of one BB1-E02 mirror.

The photograph above is a protected aluminum-coated mirror after LIDT testing. In this particular test, it handled 0.43 J/cm^2 (1064 nm, 10 ns pulse, 10 Hz, Ø1.000 mm) before damage.



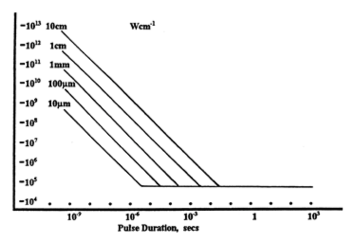
Example Test Data			
Fluence	# of Tested Locations	Locations with Damage	Locations Without Damage
1.50 J/cm^2	10	0	10
1.75 J/cm^2	10	0	10
2.00 J/cm^2	10	0	10
2.25 J/cm^2	10	1	9
3.00 J/cm^2	10	1	9
5.00 J/cm^2	10	9	1

According to the test, the damage threshold of the mirror was 2.00 J/cm^2 (532 nm, 10 ns pulse, 10 Hz, Ø0.803 mm). Please keep in mind that these tests are performed on clean optics, as dirt and contamination can significantly lower the damage threshold of a component. While the test results are only representative of one coating run, Thorlabs specifies damage threshold values that account for coating variances.

Continuous Wave and Long-Pulse Lasers

When an optic is damaged by a continuous wave (CW) laser, it is usually due to the melting of the surface as a result of absorbing the laser's energy or damage to the optical coating (antireflection) [1]. Pulsed lasers with pulse lengths longer than 1 µs can be treated as CW lasers for LIDT discussions. Additionally, when pulse lengths are between 1 ns and 1 µs, LIDT can occur either because of absorption or a dielectric breakdown (must check both CW and pulsed LIDT). Absorption is either due to an intrinsic property of the optic or due to surface irregularities; thus LIDT values are only valid for optics meeting or exceeding the surface quality specifications given by a manufacturer. While many optics can handle high power CW lasers, cemented (e.g., achromatic doublets) or highly absorptive (e.g., ND filters) optics tend to have lower CW damage thresholds. These lower thresholds are due to absorption or scattering in the cement or metal coating.

Pulsed lasers with high pulse repetition frequencies (PRF) may behave similarly to CW beams. Unfortunately, this is highly dependent on factors such as absorption and thermal diffusivity, so there is no reliable method for determining when a high PRF laser will damage an optic due to thermal effects. For beams with a large PRF both the average and peak powers must be compared to the equivalent CW power. Additionally, for highly transparent materials, there is little to no drop in the LIDT with increasing PRF.

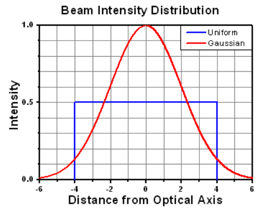


LIDT in linear power density vs. pulse length and spot size. For long pulses to CW, linear power density becomes a constant with spot size. This graph was obtained from [1].

In order to use the specified CW damage threshold of an optic, it is necessary to know the following:

1. Wavelength of your laser
2. Linear power density of your beam (total power divided by 1/e^2 beam diameter)
3. Beam diameter of your beam (1/e^2)
4. Approximate intensity profile of your beam (e.g., Gaussian)

The power density of your beam should be calculated in terms of W/cm. The graph to the right shows why expressing the LIDT as a linear power density provides the best metric for long pulse and CW sources. In this regime, the LIDT given as a linear power density can be applied to any beam diameter; one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now consider hotspots in the beam or other non-uniform intensity profiles and roughly calculate a maximum power density. For reference, a Gaussian beam typically has a maximum power density that is twice that of the uniform beam (see lower right).



Now compare the maximum power density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately. A good rule of thumb is that the damage threshold has a linear relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 10 W/cm at 1310 nm scales to 5 W/cm at 655 nm):

$$Adjusted\ LIDT = LIDT\ Power\left(\frac{Your\ Wavelength}{LIDT\ Wavelength}\right)$$

While this rule of thumb provides a general trend, it is not a quantitative analysis of LIDT vs wavelength. In CW applications, for instance, damage scales more strongly with absorption in the coating and substrate, which does not necessarily scale well with wavelength. While the above procedure provides a good rule of thumb for LIDT values, please contact Tech Support if your wavelength is different from the specified LIDT wavelength. If your power density is less than the adjusted LIDT of the optic, then the optic should work for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. The damage analysis will be carried out on a similar optic (customer's optic will not be damaged). Testing may result in additional costs or lead times. Contact Tech Support for more information.

Pulsed Lasers

As previously stated, pulsed lasers typically induce a different type of damage to the optic than CW lasers. Pulsed lasers often do not heat the optic enough to damage it; instead, pulsed lasers produce strong electric fields capable of inducing dielectric breakdown in the material. Unfortunately, it can be very difficult to compare the LIDT specification of an optic to your laser. There are multiple regimes in which a pulsed laser can damage an optic and this is based on the laser's pulse length. The highlighted columns in the table below outline the relevant pulse lengths for our specified LIDT values.

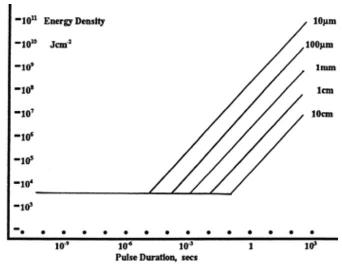
Pulses shorter than 10^{-9} s cannot be compared to our specified LIDT values with much reliability. In this ultra-short-pulse regime various mechanics, such as multiphoton-avalanche ionization, take over as the predominate damage mechanism [2]. In contrast, pulses between 10^{-7} s and 10^{-4} s may cause damage to an optic either because of dielectric breakdown or thermal effects. This means that both CW and pulsed damage thresholds must be compared to the laser beam to determine whether the optic is suitable for your application.

Pulse Duration	$t < 10^{-9}$ s	$10^{-9} < t < 10^{-7}$ s	$10^{-7} < t < 10^{-4}$ s	$t > 10^{-4}$ s
Damage Mechanism	Avalanche Ionization	Dielectric Breakdown	Dielectric Breakdown or Thermal	Thermal
Relevant Damage Specification	N/A	Pulsed	Pulsed and CW	CW

When comparing an LIDT specified for a pulsed laser to your laser, it is essential to know the following:

1. Wavelength of your laser
2. Energy density of your beam (total energy divided by $1/e^2$ area)
3. Pulse length of your laser
4. Pulse repetition frequency (prf) of your laser
5. Beam diameter of your laser ($1/e^2$)
6. Approximate intensity profile of your beam (e.g., Gaussian)

The energy density of your beam should be calculated in terms of J/cm^2. The graph to the right shows why expressing the LIDT as an energy density provides the best metric for short pulse sources. In this regime, the LIDT given as an energy density can be applied to any beam diameter; one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now adjust this energy density to account for hotspots or other nonuniform intensity profiles and roughly calculate a maximum energy density. For reference a Gaussian beam typically has a maximum energy density that is twice that of the $1/e^2$ beam.



LIDT in energy density vs. pulse length and spot size. For short pulses, energy density becomes a constant with spot size. This graph was obtained from [1].

Now compare the maximum energy density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately [3]. A good rule of thumb is that the damage threshold has an inverse square root relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 1 J/cm^2 at 1064 nm scales to 0.7 J/cm^2 at 532 nm):

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Wavelength}{LIDT\ Wavelength}}$$

You now have a wavelength-adjusted energy density, which you will use in the following step.

Beam diameter is also important to know when comparing damage thresholds. While the LIDT, when expressed in units of J/cm², scales independently of spot size; large beam sizes are more likely to illuminate a larger number of defects which can lead to greater variances in the LIDT [4]. For data presented here, a <1 mm beam size was used to measure the LIDT. For beams sizes greater than 5 mm, the LIDT (J/cm2) will not scale independently of beam diameter due to the larger size beam exposing more defects.

The pulse length must now be compensated for. The longer the pulse duration, the more energy the optic can handle. For pulse widths between 1 - 100 ns, an approximation is as follows:

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Pulse\ Length}{LIDT\ Pulse\ Length}}$$

Use this formula to calculate the Adjusted LIDT for an optic based on your pulse length. If your maximum energy density is less than this adjusted LIDT maximum energy density, then the optic should be suitable for your application. Keep in mind that this calculation is only used for pulses between 10^{-9} s and 10^{-7} s. For pulses between 10^{-7} s and 10^{-4} s, the CW LIDT must also be checked before deeming the optic appropriate for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. Contact Tech Support for more information.

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[1] R. M. Wood, Optics and Laser Tech. **29**, 517 (1997).
[2] Roger M. Wood, *Laser-Induced Damage of Optical Materials* (Institute of Physics Publishing, Philadelphia, PA, 2003).
[3] C. W. Carr *et al.*, Phys. Rev. Lett. **91**, 127402 (2003).
[4] N. Bloembergen, Appl. Opt. **12**, 661 (1973).

Hide LIDT Calculations

LIDT CALCULATIONS

In order to illustrate the process of determining whether a given laser system will damage an optic, a number of example calculations of laser induced damage threshold are given below. For assistance with performing similar calculations, we provide a spreadsheet calculator that can be downloaded by clicking the button to the right. To use the calculator, enter the specified LIDT value of the optic under consideration and the relevant parameters of your laser system in the green boxes. The spreadsheet will then calculate a linear power density for CW and pulsed systems, as well as an energy density value for pulsed systems. These values are used to calculate adjusted, scaled LIDT values for the optics based on accepted scaling laws. This calculator assumes a Gaussian beam profile, so a correction factor must be introduced for other beam shapes (uniform, etc.). The LIDT scaling laws are determined from empirical relationships; their accuracy is not guaranteed. Remember that absorption by optics or coatings can significantly reduce LIDT in some spectral regions. These LIDT values are not valid for ultrashort pulses less than one nanosecond in duration.

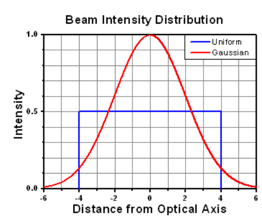
LIDT Calculator

CW Laser Example

Suppose that a CW laser system at 1319 nm produces a 0.5 W Gaussian beam that has a $1/e^2$ diameter of 10 mm. A naive calculation of the average linear power density of this beam would yield a value of 0.5 W/cm, given by the total power divided by the beam diameter:

$$Linear\ Power\ Density = \frac{Power}{Beam\ Diameter}$$

However, the maximum power density of a Gaussian beam is about twice the maximum power density of a uniform beam, as shown in the graph to the right. Therefore, a more accurate determination of the maximum linear power density of the system is 1 W/cm.



A Gaussian beam profile has about twice the maximum intensity of a uniform beam profile.

An AC127-030-C achromatic doublet lens has a specified CW LIDT of 350 W/cm, as tested at 1550 nm. CW damage threshold values typically scale directly with the wavelength of the laser source, so this yields an adjusted LIDT value:

$$Adjusted\ LIDT = LIDT\ Power\left(\frac{Your\ Wavelength}{LIDT\ Wavelength}\right)$$

The adjusted LIDT value of 350 W/cm x (1319 nm / 1550 nm) = 298 W/cm is significantly higher than the calculated maximum linear power density of the laser system, so it would be safe to use this doublet lens for this application.

Pulsed Nanosecond Laser Example: Scaling for Different Pulse Durations

Suppose that a pulsed Nd:YAG laser system is frequency tripled to produce a 10 Hz output, consisting of 2 ns output pulses at 355 nm, each with 1 J of energy, in a Gaussian beam with a 1.9 cm beam diameter ($1/e^2$). The average energy density of each pulse is found by dividing the pulse energy by the beam area:

$$Energy\ Density = \frac{Pulse\ Energy}{Beam\ Area}$$

As described above, the maximum energy density of a Gaussian beam is about twice the average energy density. So, the maximum energy density of this beam is ~0.7 J/cm^2.

The energy density of the beam can be compared to the LIDT values of 1 J/cm^2 and 3.5 J/cm^2 for a BB1-E01 broadband dielectric mirror and an NB1-K08 Nd:YAG laser line mirror, respectively. Both of these LIDT values, while measured at 355 nm, were determined with a 10 ns pulsed laser at 10 Hz. Therefore, an adjustment must be applied for the shorter pulse duration of the system under consideration. As described on the previous tab, LIDT values in the nanosecond pulse regime scale with the square root of the laser pulse duration:

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Pulse\ Length}{LIDT\ Pulse\ Length}}$$

This adjustment factor results in LIDT values of 0.45 J/cm^2 for the BB1-E01 broadband mirror and 1.6 J/cm^2 for the Nd:YAG laser line mirror, which are to be compared with the 0.7 J/cm^2 maximum energy density of the beam. While the broadband mirror would likely be damaged by the laser, the more specialized laser line mirror is appropriate for use with this system.

Pulsed Nanosecond Laser Example: Scaling for Different Wavelengths

Suppose that a pulsed laser system emits 10 ns pulses at 2.5 Hz, each with 100 mJ of energy at 1064 nm in a 16 mm diameter beam ($1/e^2$) that must be attenuated with a neutral density filter. For a Gaussian output, these specifications result in a maximum energy density of 0.1 J/cm^2. The damage threshold of an NDUV10A Ø25 mm, OD 1.0, reflective neutral density filter is 0.05 J/cm^2 for 10 ns pulses at 355 nm, while the damage threshold of the similar NE10A absorptive filter is 10 J/cm^2 for 10 ns pulses at 532 nm. As described on the previous tab, the LIDT value of an optic scales with the square root of the wavelength in the nanosecond pulse regime:

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Wavelength}{LIDT\ Wavelength}}$$

This scaling gives adjusted LIDT values of 0.08 J/cm^2 for the reflective filter and 14 J/cm^2 for the absorptive filter. In this case, the absorptive filter is the best choice in order to avoid optical damage.

Pulsed Microsecond Laser Example

Consider a laser system that produces 1 µs pulses, each containing 150 µJ of energy at a repetition rate of 50 kHz, resulting in a relatively high duty cycle of 5%. This system falls somewhere between the regimes of CW and pulsed laser induced damage, and could potentially damage an optic by mechanisms associated with either regime. As a result, both CW and pulsed LIDT values must be compared to the properties of the laser system to ensure safe operation.

If this relatively long-pulse laser emits a Gaussian 12.7 mm diameter beam ($1/e^2$) at 980 nm, then the resulting output has a linear power density of 5.9 W/cm and an energy density of 1.2×10^{-4} J/cm^2 per pulse. This can be compared to the LIDT values for a WPQ10E-980 polymer zero-order quarter-wave plate, which are 5 W/cm for CW radiation at 810 nm and 5 J/cm^2 for a 10 ns pulse at 810 nm. As before, the CW LIDT of the optic scales linearly with the laser wavelength, resulting in an adjusted CW value of 6 W/cm at 980 nm. On the other hand, the pulsed LIDT scales with the square root of the laser wavelength and the square root of the pulse duration, resulting in an adjusted value of 55 J/cm^2 for a 1 µs pulse at 980 nm. The pulsed LIDT of the optic is significantly greater than the energy density of the laser pulse, so individual pulses will not damage the wave plate. However, the large average linear power density of the laser system may cause thermal damage to the optic, much like a high-power CW beam.

Hide Ø1/2" Germanium Plano-Convex Lenses

Ø1/2" Germanium Plano-Convex Lenses

Item #	Diameter	Focal Length	Diopter[a]	Radius of Curvature	Center Thickness	Edge Thickness[b]	Back Focal Length[c]	Reference Drawing
LA9410-F	1/2"	15.0 mm	+66.6	45.1 mm	2.5 mm	2.0 mm	14.4 mm	
LA9015-F	1/2"	20.0 mm	+50.0	60.1 mm	2.3 mm	2.0 mm	19.4 mm	
LA9280-F	1/2"	40.0 mm	+25.0	120.2 mm	2.2 mm	2.0 mm	39.5 mm	

Suggested Fixed Lens Mount: LMR05

- Reciprocal of the Focal Length in Meters
- Edge Thickness Given Before 0.2 mm at 45° Typical Chamfer
- Measured at the Design Wavelength, 10.6 µm

Part Number	Description	Price	Availability
LA9410-F	Ø1/2" Ge Plano-Convex Lens, f = 15.0 mm, AR-Coated: 8-12 µm	$134.00	Today
LA9015-F	Ø1/2" Ge Plano-Convex Lens, f = 20.0 mm, AR-Coated: 8-12 µm	$134.00	Today
LA9280-F	Ø1/2" Ge Plano-Convex Lens, f = 40.0 mm, AR-Coated: 8-12 µm	$134.00	Today

Hide Ø1" Germanium Plano-Convex Lenses

Ø1" Germanium Plano-Convex Lenses

Item #	Diameter	Focal Length	Diopter[a]	Radius of Curvature	Center Thickness	Edge Thickness[b]	Back Focal Length[c]	Reference Drawing
LA9509-F	1"	25.4 mm	+39.4	76.3 mm	3.1 mm	2.0 mm	24.6 mm	
LA9659-F	1"	50.0 mm	+20.0	150.3 mm	4.0 mm	3.5 mm	49.0 mm	
LA9977-F	1"	75.0 mm	+13.3	225.5 mm	4.0 mm	3.6 mm	74.1 mm	
LA9928-F	1"	100.0 mm	+10.0	300.7 mm	1.8 mm	1.5 mm	99.6 mm	
LA9701-F	1"	150.0 mm	+6.7	451.0 mm	4.0 mm	3.8 mm	149.1 mm	
LA9792-F	1"	200.0 mm	+5.0	601.4 mm	4.0 mm	3.9 mm	199.2 mm	
LA9953-F	1"	500.0 mm	+2.0	1501.9 mm	2.1 mm	2.0 mm	499.5 mm	
LA9702-F	1"	750.0 mm	+1.3	2252.9 mm	2.0 mm	2.0 mm	749.5 mm	
LA9942-F	1"	1000.0 mm	+1.0	3303.9 mm	2.0 mm	2.0 mm	999.5 mm	

Suggested Fixed Lens Mount: LMR1

- Reciprocal of the Focal Length in Meters
- Edge Thickness Given Before 0.2 mm at 45° Typical Chamfer
- Measured at the Design Wavelength, 10.6 µm

Part Number	Description	Price	Availability
LA9509-F	Ø1" Ge Plano-Convex Lens, f = 25.4 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9659-F	Ø1" Ge Plano-Convex Lens, f = 50.0 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9977-F	Ø1" Ge Plano-Convex Lens, f = 75.0 mm, AR-Coated: 8-12 µm	$232.00	Lead Time
LA9928-F	Ø1" Ge Plano-Convex Lens, f = 100.0 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9701-F	Ø1" Ge Plano-Convex Lens, f = 150.0 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9792-F	Ø1" Ge Plano-Convex Lens, f = 200.0 mm, AR-Coated: 8-12 µm	$232.00	Lead Time
LA9953-F	Ø1" Ge Plano-Convex Lens, f = 500.0 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9702-F	Ø1" Ge Plano-Convex Lens, f = 750.0 mm, AR-Coated: 8-12 µm	$232.00	Today
LA9942-F	Ø1" Ge Plano-Convex Lens, f = 1000.0 mm, AR-Coated: 8-12 µm	$232.00	Today

Visit the *Germanium Plano-Convex Lenses* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=1780