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THORLABS

LPIRE050-C - November 19, 2015

Item # LPIRE050-C was discontinued on November 19, 2015. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

ECONOMY LAMINATED FILM POLARIZERS

- **AR-Coated, N-BK7 Protective Glass**
- **Three Sizes: Ø1/2", Ø1", and Ø2"**
- **High Polarizing Efficiency: >99%**
- **High UV Absorption**

LPNIRE200-B
(Ø2")

LPIRE100-C
(Ø1")

LPVISE050-A
(Ø1/2")

Application Idea

LPVISE050-A Ø1/2" Polarizer in a PRM05 Optic Mount

Hide Overview

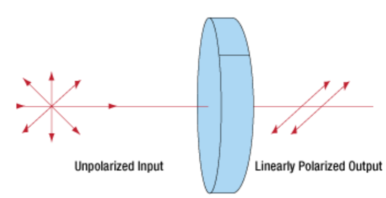
OVERVIEW

Features

- AR-Coated, Protective N-BK7 Windows
- Three Operating Wavelength Ranges Available:
  - 400 - 700 nm (-A Designation)
  - 600 - 1100 nm (-B Designation)
  - 1100 - 1700 nm (-C Designation)
- High Polarization Efficiency: >99% (See Below for Extinction Ratio Data)
- Dichroic Polarizing Film Between Two N-BK7 Windows

Click to Enlarge
One Ø2" Polarizer and One Ø2" Polymer Zero-Order Wave Plate Each Mounted in an LCRM2 Cage Rotation Mount

Common Specifications	
Polarizing Material	Dichroic Film
Window Material	N-BK7
Clear Aperture	>90% of Diameter
Diameter Tolerance	±0.2 mm
Thickness Tolerance	±0.2 mm
Surface Quality	60-40 Scratch-Dig
Wavefront Distortion	1.5λ Over Clear Aperture
Acceptance Angle	±30°



The line on the polarizer marks the direction of output polarization.

These glass polarizers, which provide high absorption of the orthogonal polarization and polarization efficiency in excess of 99%, are ideal for low-power applications. They are available in Ø1/2", Ø1", and Ø2" sizes and consist of a dichroic polarizing film sheet with a protective N-BK7 window epoxied onto each side of the film. Each window has one of three AR coatings deposited on the glass-to-air interface: 400 - 700 nm (-A), 650 - 1050 nm (-B), or 1050 - 1700 nm (-C). Please note that the operation wavelength range of the polarizer is not the same as the AR coating range for the windows. We also offer 2" x 2" sheets of the visible dichroic polarizer without protective windows that are ideal for cutting custom sizes and are optimized for performance in the 400 - 700 nm range.

The dichroic polarizing material is designed and optimized for use within the AR coating range; performance falls off rapidly for wavelengths longer than the upper bound of the range. We would not recommend using this product outside of the specified operation range, which is shaded in blue in the plots below. The output polarization direction is marked with a line on the side of each polarizer (see schematic to the right).

These polarizers are sensitive to stress when mounting. Overtightening the retaining ring can cause stress-induced birefringence in both the glass and the assembly as well as reduce the extinction ratio of the optic. To ensure that the polarizer is not loose in the housing, we recommend the use of the SM1LTRR Stress-Free Retaining Ring. While the polarizer's surfaces can be cleaned with normal solvents, take care to avoid the polarizer's edge.

Hide Damage Thresholds

DAMAGE THRESHOLDS

Damage Threshold Data for Thorlabs' Laminated Film Polarizers

The specifications to the right are measured data for Thorlabs' laminated thin film polarizers. Damage threshold specifications are constant for all of the polarizers with a given coating designation, regardless of the size of the optic.

Damage Threshold Specifications	
Coating Designation (Item # Suffix)	**Damage Threshold**
-A	1 W/cm (532 nm, CW, Ø0.471 mm)[a] 0.4 J/cm^2 (532 nm, 10 ns, 10 Hz, Ø0.750 mm)
-B	1 W/cm (810 nm, CW, Ø0.004 mm)[a] 0.3 J/cm^2 (810 nm, 10 ns, 10 Hz, Ø0.08 mm)
-C	1 W/cm (1542 nm, CW, Ø0.161 mm)[a] 2 J/cm^2 (1540 nm, 10 ns, 10 Hz, Ø0.242 mm)

- The power density of your beam should be calculated in terms of W/cm. For an explanation of why the linear power density provides the best metric for long pulse and CW sources, please see the "Continuous Wave and Long-Pulse Lasers" section below.

Laser Induced Damage Threshold Tutorial

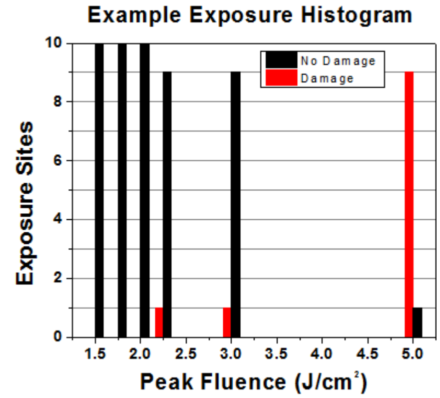
The following is a general overview of how laser induced damage thresholds are measured and how the values may be utilized in determining the appropriateness of an optic for a given application. When choosing optics, it is important to understand the Laser Induced Damage Threshold (LIDT) of the optics 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.



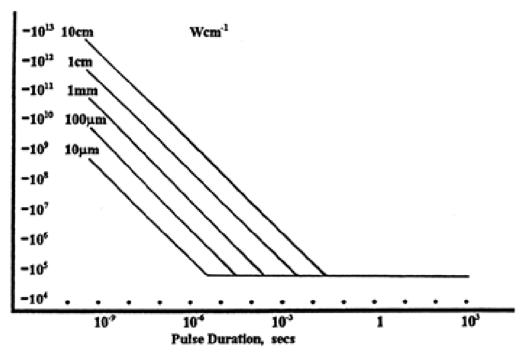
Example Test Data			
Fluence	# of Tested Locations	Locations with Damage	Locations Without Damage
1.50 J/cm^2	10	0	10
1.75 J/cm^2	10	0	10
2.00 J/cm^2	10	0	10
2.25 J/cm^2	10	1	9
3.00 J/cm^2	10	1	9
5.00 J/cm^2	10	9	1

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.

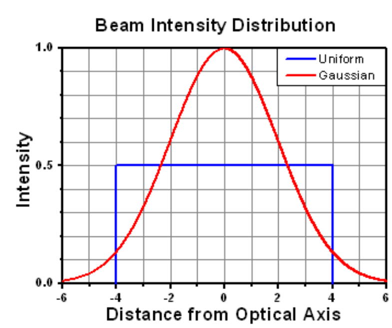


LIDT in linear power density vs. pulse length and spot size. For long pulses to CW, linear power density becomes a constant with spot size. This graph was obtained from [1].

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 spot size)
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 the linear power density provides the best metric for long pulse and CW sources. Under these conditions, linear power density scales independently of spot size; 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 nonuniform 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.

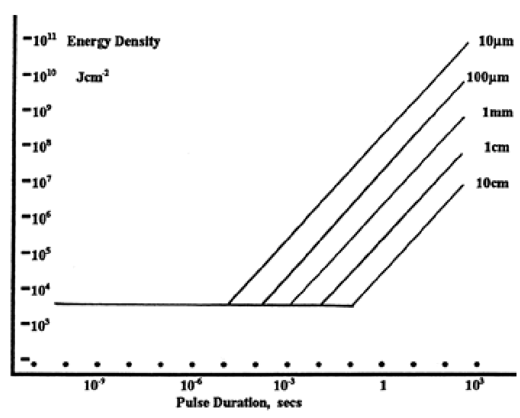
Pulses shorter than 10^{-9} s cannot be compared to our specified LIDT values with much reliability. In this ultra-short-pulse regime various mechanics, such as multiphoton-avalanche ionization, take over as the predominate damage mechanism [2]. In contrast, pulses between 10^{-7} s and 10^{-4} s may 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 the energy density provides the best metric for short pulse sources. Under these conditions, energy density scales independently of spot size, 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 Polarizer Guide

POLARIZER GUIDE

Polarizer Selection Guide

Thorlabs offers a diverse range of polarizers, including wire grid, film, calcite, alpha-BBO, rutile, and beamsplitting polarizers. Collectively, our line of wire grid polarizers offers coverage from the visible range to the beginning of the Far-IR range. Our nanoparticle linear film polarizers provide extinction ratios as high as 100,000:1. Alternatively, our other film polarizers offer an affordable solution for polarizing light from the visible to the Near-IR. Next, our beamsplitting polarizers allow for use of the reflected beam, as well as the more completely polarized transmitted beam. Finally, our Alpha-BBO (UV), calcite (visible to Near-IR), and rutile (Near-IR to Mid-IR) polarizers each offer an exceptional extinction ratio of 100,000:1 within their respective wavelength ranges.

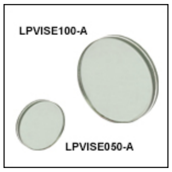
To explore the available types, wavelength ranges, extinction ratios, transmission, and available sizes for each polarizer category, click *More [+]* in the appropriate row below.

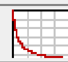
Wire Grid Polarizers
Film Polarizers
Beamsplitting Polarizers
alpha-BBO Polarizers
Calcite Polarizers
Quartz Polarizers
Rutile Polarizers

- Click on the graph icons in this column to view a transmission curve for the corresponding polarizer. Each curve represents one substrate sample or coating run and is not guaranteed.
- Mounted in a protective box, unthreaded ring, or cylinder that indicates the polarization axis.
- Available unmounted or in an SM05-threaded (0.535"-40) mount that indicates the polarization axis.
- Available unmounted or in an SM1-threaded (1.035"-40) mount that indicates the polarization axis.
- Available unmounted or mounted in cubes for cage system compatibility.
- Calcite's transmittance of light near 350 nm is typically around 75% (see *Transmission* column).
- Available unmounted or in an unthreaded Ø1/2" housing.
- The transmission curves for calcite are valid for linearly polarized light with a polarization axis aligned with the mark on the polarizer's housing.
- The 1064 nm V coating corresponds to a -C26 suffix in the item number.
- Available unmounted or mounted in a protective box or unthreaded cylinder that indicates the polarization axis.

Hide Economy Laminated Film Polarizers, 400 - 700 nm

Economy Laminated Film Polarizers, 400 - 700 nm

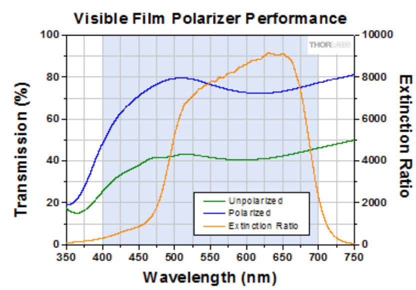


Item #	LPVISE050-A	LPVISE100-A	LPVISE200-A
Operating Wavelength Range	400 - 700 nm		
AR Coating Range	400 - 700 nm		
Reflectance over Coating Range (Avg.)	<0.5% at 0° AOI		
AR Coating Curve			
Extinction Ratio[a]	>100:1 (400 - 500 nm) >1000:1 (500 - 700 nm) >5000:1 (530 - 690 nm)		
Size	Ø1/2"	Ø1"	Ø2"
Thickness	2.4 mm	3.6 mm	6.8 mm
Damage Threshold	1 W/cm (532 nm, CW, Ø0.471 mm)[b] 0.4 J/cm^2 (532 nm, 10 ns, 10 Hz, Ø0.750 mm)		

a. The direction of the output polarization is marked with a line on the edge of each polarizer. The extinction ratio (ER) is the ratio of the maximum transmission of a linearly polarized signal when the polarizer's axis is aligned with the signal to the minimum transmission when the polarizer is rotated by 90°.

b. The power density of your beam should be calculated in terms of W/cm. For an explanation of why the linear power density provides the best metric for long pulse and CW sources, please see the *Damage Thresholds* tab.

These thin film polarizers, which are optimized for use in the 400 - 700 nm range, have an AR coating for the 400 - 700 nm range deposited on the air-to-glass interface of each window. They offer an average transmission of 38% over their operating wavelength range.



Click to Enlarge

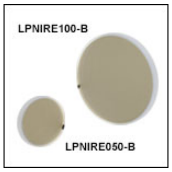
Click to Download Transmission and Extinction Ratio Data

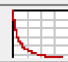
The graph above shows the transmission of unpolarized light as well as that of polarized light aligned with the polarization axis of the optic. The shaded region represents the specified operating wavelength range of the polarizer.

Part Number	Description	Price	Availability
LPVISE050-A	Customer Inspired!Ø1/2" Linear Polarizer with N-BK7 Protective Windows, 400-700 nm	$75.00	Today
LPVISE100-A	Customer Inspired!Ø1" Linear Polarizer with N-BK7 Protective Windows, 400-700 nm	$89.00	Today
LPVISE200-A	Customer Inspired!Ø2" Linear Polarizer with N-BK7 Protective Windows, 400-700 nm	$150.00	Today

Hide Economy Laminated Film Polarizers, 600 - 1100 nm

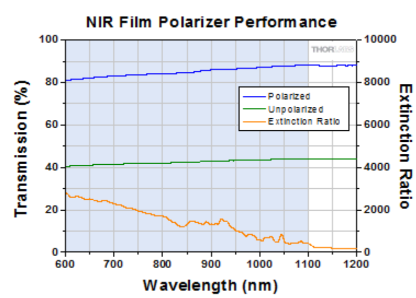
Economy Laminated Film Polarizers, 600 - 1100 nm



Item #	LPNIRE050-B	LPNIRE100-B	LPNIRE200-B
Operating Wavelength Range	600 - 1100 nm		
AR Coating Range	650 - 1050 nm		
Reflectance over Coating Range (Avg.)	<0.5% at 0° AOI		
AR Coating Curve			
Extinction Ratio[a]	>1,000:1 (600 - 950 nm) >400:1 (600 - 1100 nm)		
Size	Ø1/2"	Ø1"	Ø2"
Thickness	2.2 mm	3.4 mm	6.6 mm
Damage Threshold	1 W/cm (810 nm, CW, Ø0.004 mm)[b] 0.3 J/cm^2 (810 nm, 10 ns, 10 Hz, Ø0.08 mm)		

a. The direction of the output polarization is marked with a line on the edge of each polarizer. The extinction ratio (ER) is the ratio of the maximum transmission of a linearly polarized signal when the polarizer's axis is aligned with the signal to the minimum transmission when the polarizer is rotated by 90°.
b. The power density of your beam should be calculated in terms of W/cm. For an explanation of why the linear power density provides the best metric for long pulse and CW sources, please see the *Damage Thresholds* tab.

These thin film polarizers, which are optimized for use in the 600 - 1100 nm range, have an AR coating for the 650 - 1050 nm range deposited on the air-to-glass interface of each window. They offer an average transmission of 43% over their operating wavelength range. Unlike some polarizers, the NIR polarizers sold here do not completely absorb the rejected polarization. On average, they reflect 25% of the rejected light.

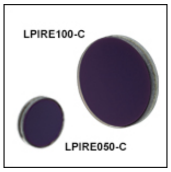


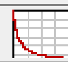
Click to Enlarge
Click to Download Transmission and Extinction Ratio Data
The graph above shows the transmission of unpolarized light as well as that of polarized light aligned with the polarization axis of the optic. The shaded region represents the specified operating wavelength range of the polarizer.

Part Number	Description	Price	Availability
LPNIRE050-B	Ø1/2" Linear Polarizer with N-BK7 Protective Windows, 600-1100 nm	$81.00	Today
LPNIRE100-B	Ø1" Linear Polarizer with N-BK7 Protective Windows, 600-1100 nm	$107.00	Today
LPNIRE200-B	Ø2" Linear Polarizer with N-BK7 Protective Windows, 600-1100 nm	$132.00	Today

Hide Economy Laminated Film Polarizers, 1100 - 1630 nm

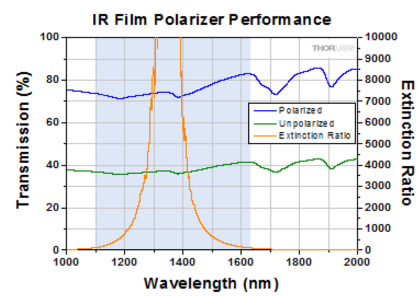
Economy Laminated Film Polarizers, 1100 - 1630 nm



Item #	LPIRE050-C	LPIRE100-C	LPIRE200-C
Operating Wavelength Range	1100 - 1630 nm		
AR Coating Range	1050 - 1700 nm		
Reflectance over Coating Range (Avg.)	<0.5% at 0° AOI		
AR Coating Curve			
Extinction Ratio[a]	>5,000:1 (1300 - 1400 nm) >1,000:1 (1260 - 1480 nm) >100:1 (1100 - 1630 nm)		
Size	Ø1/2"	Ø1"	Ø2"
Thickness	2.4 mm	3.6 mm	6.8 mm
Damage Threshold	1 W/cm (1542 nm, CW, Ø0.161 mm)[b] 2 J/cm^2 (1540 nm, 10 ns, 10 Hz, Ø0.242 mm)		

a. The direction of the output polarization is marked with a line on the edge of each polarizer. The extinction ratio (ER) is the ratio of the maximum transmission of a linearly polarized signal when the polarizer's axis is aligned with the signal to the minimum transmission when the polarizer is rotated by 90°.
b. The power density of your beam should be calculated in terms of W/cm. For an explanation of why the linear power density provides the best metric for long pulse and CW sources, please see the *Damage Thresholds* tab.

These thin film polarizers, which are optimized for use in the 1100 - 1630 nm range, have an AR coating for the 1050 - 1700 nm range deposited on the air-to-glass interface of each window. They offer an average transmission of 38% over their operating wavelength range.



Click to Enlarge
Click to Download Transmission and Extinction Ratio Data
The graph above shows the transmission of unpolarized light as well as that of polarized light aligned with the polarization axis of the optic. The shaded region represents the specified operating wavelength range of the polarizer.

Part Number	Description	Price	Availability
LPIRE050-C	Ø1/2" Linear Polarizer with N-BK7 Protective Windows, 1100-1630 nm	$100.00	Lead Time
LPIRE100-C	Ø1" Linear Polarizer with N-BK7 Protective Windows, 1100-1630 nm	$168.00	Lead Time
LPIRE200-C	Ø2" Linear Polarizer with N-BK7 Protective Windows, 1100-1630 nm	$350.00	Lead Time

Visit the *Economy Laminated Film Polarizers* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=4984