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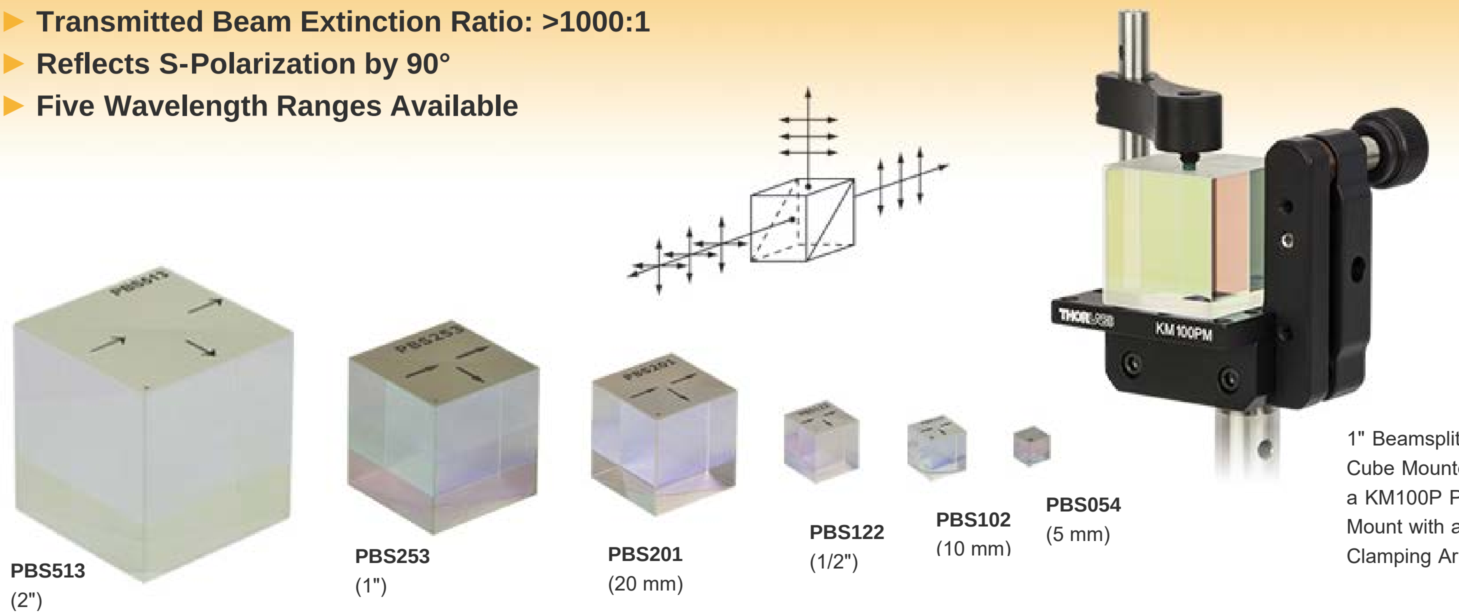
PBS511 - March 27, 2020

Item # PBS511 was discontinued on March 27, 2020. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

BROADBAND POLARIZING BEAMSPLITTER CUBES

- Transmitted Beam Extinction Ratio: >1000:1
- Reflects S-Polarization by 90°
- Five Wavelength Ranges Available



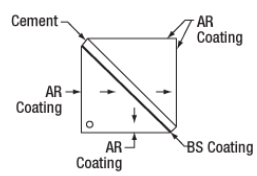
1" Beamsplitter Cube Mounted on a KM100P Platform Mount with a PM4 Clamping Arm

Hide Overview

OVERVIEW

Features

- 5 mm, 10 mm, 1/2" (12.7 mm), 20 mm, 1" (25.4 mm), and 2" (50.8 mm) Cubes
- 5 Wavelength Ranges Available:
  - 420 - 680 nm
  - 620 - 1000 nm
  - 700 - 1300 nm
  - 900 - 1300 nm
  - 1200 - 1600 nm
- Extinction Ratio
  - $T_P:T_S$ > 1000:1



Cube Beamsplitter Diagram (Coating and Cement Layer Not to Scale)

Click to Enlarge
12.7 mm Beamsplitter Cube Mounted in the CCM1-4ER Compact Cage Cube Using the BS127CAM Beamsplitter Adapter
(Refer to the *BS Cube Mounting* tab for Other Options)

Thorlabs' Polarizing Beamsplitting Cubes are offered in six sizes and with five ranges of beamsplitting coatings. These cubes separate the s- and p-polarization components by reflecting the s component with the dielectric beamsplitter coating, while allowing the p component to pass. These cubes are designed to be used with the transmitted beam, which offers an extinction ratio of $T_P:T_S$ > 1000:1. The reflected beam will only have an extinction ratio of roughly 20:1 to 100:1, depending on the beamsplitter.

Thorlabs offers polarizing beamsplitter cubes in 5 mm, 10 mm, 1/2" (12.7 mm), 20 mm, 1" (25.4 mm), and 2" (50.8 mm) sizes. These cubes are made from N-SF1,
H-ZF3, or H-LaK67 glass and are offered in five different coatings to cover the following wavelength ranges: 420 - 680 nm, 620 - 1000 nm, 700 - 1300 nm, 900 - 1300 nm, and 1200 - 1600 nm. Please see the *Specs* tab for more information on each cube including its damage threshold, or see the *Graphs* tab for s- and p-polarization transmission graphs.

The dielectric beamsplitting coating is applied to the hypotenuse of one of the two prisms that make up the cube. Then, cement is used to bind the two prism halves together (refer to the diagram to the right). The engraved dot on the top of the cube indicates the prism with the beamsplitting coating. Light can be input into any of the polished faces to separate the s- and p-polarizations. Cubes larger than 5 mm also offer engraved arrows indicating one possible orientation.

Please refer to the *BS Cube Mounting* tab above for information on mounting options and compatibility. Alternatively, our 1" cubes are available pre-mounted in cage cubes. Custom beamsplitter cubes can be ordered by contacting Technical Support. For high power applications, we also offer high power polarizing beamsplitting cubes. We also offer polarizing beamsplitter cubes at laser line wavelengths, which have a higher extinction ratio of 3000:1 (T_P:T_S).

Hide Specs

S P E C S & N B S P ;

Beamsplitter Cube Size	5 mm Cube	10 mm Cube	1/2" (12.7 mm) Cube	20 mm Cube	1" (25.4 mm) Cube	2" (50.8 mm) Cube
Wavelength Ranges Available	420 - 680 nm 620 - 1000 nm 900 - 1300 nm 1200 - 1600 nm				420 - 680 nm 620 - 1000 nm 700 - 1300 nm 900 - 1300 nm 1200 - 1600 nm	420 - 680 nm 620 - 1000 nm 900 - 1300 nm 1200 - 1600 nm
Dimensional Tolerance	±0.25 mm				+0 / -0.2 mm	
Material	N-SF1					PBS511: H-LaK67 PBS512: N-SF1 PBS513: N-SF1 PBS514: N-SF1
Extinction Ratio[a]	$T_P:T_S > 1000:1$					
Transmission Efficiency	$T_P > 90\%$					
Reflection Efficiency	$R_S > 99.5\%$ [b]				-	$R_S > 97.5\%$
Transmitted Beam Deviation	<5 arcmin					
Reflected Beam Deviation	90° ± 5 arcmin					
Clear Aperture	>70% of Dimension	>80% of Dimension				>90% of Dimension
Surface Flatness	λ/4 @ 633 nm					
Transmitted Wavefront Error	<λ/4 @ 633 nm					<λ/2 @ 633 nm
Reflected Wavefront Error	N/A					<λ @ 633 nm
Surface Quality	40-20 Scratch-Dig					

a. The extinction ratio (ER) is the ratio of maximum to minimum transmission of a sufficiently linearly polarized input. When the transmission axis and input polarization are parallel, the transmission is at its maximum; rotate the polarizer by 90° for minimum transmission.
b. This reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

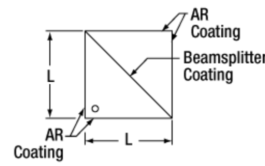
Coating Range	AR Coating Reflectance[a]	Damage Threshold[b]	
420 - 680 nm	$R_{avg} < 0.5\%$	CW[c]	350 W/cm at 532 nm, Ø1.000 mm
		Pulsed	2 J/cm^2 at 532 nm, 10 ns, 10 Hz
620 - 1000 nm		CW[c]	50 W/cm at 810 nm, Ø0.019 mm
		Pulsed	2 J/cm^2 at 810 nm, 10 ns, 10 Hz
700 - 1300 nm	$R_{avg} < 1\%$	-	
900 - 1300 nm	$R_{avg} < 0.5\%$	CW[c,d]	1000 W/cm at 1070 nm, Ø0.971 mm
		Pulsed	2 J/cm^2 at 1064 nm, 10 ns, 10 Hz
1200 - 1600 nm		CW[c,d]	1000 W/cm at 1540 nm, Ø1.030 mm
		Pulsed	5 J/cm^2 at 1542 nm, 10 ns, 10 Hz

a. Per surface at 0° AOI over wavelength range.
b. Damage thresholds apply to all cube sizes except for the PBS511. If a higher damage threshold is required, please consider our high power

polarizing beamsplitters.

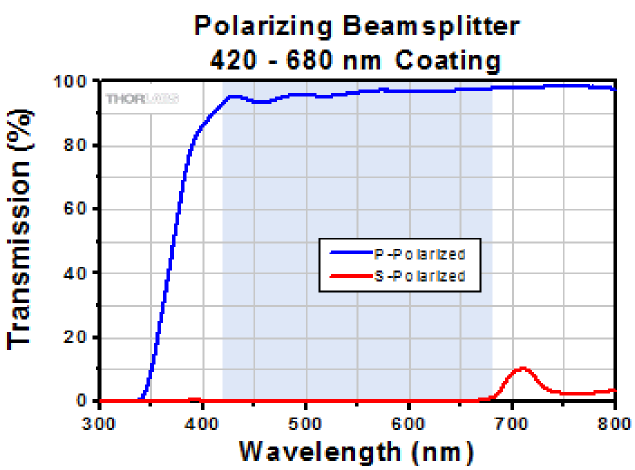
c. The power density of your beam should be calculated in terms of W/cm. For an explanation of why the linear power density provides the best metric for long pulse and CW sources, please see the *Damage Thresholds* tab.

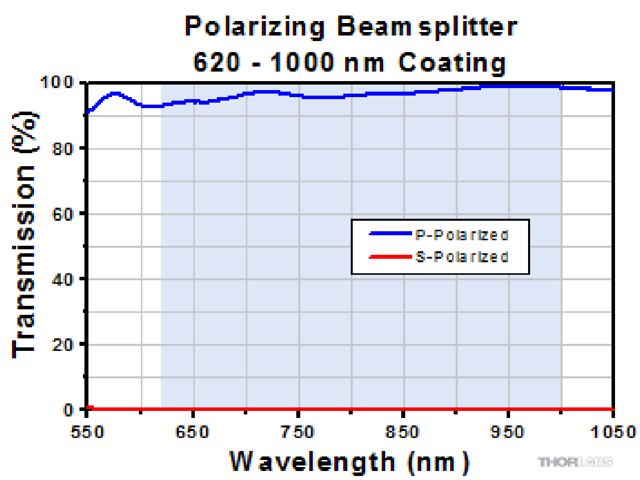
d. The stated damage threshold is a certification measurement, as opposed to a true damage threshold (i.e., the optic was able to withstand the maximum output of the laser with no damage).

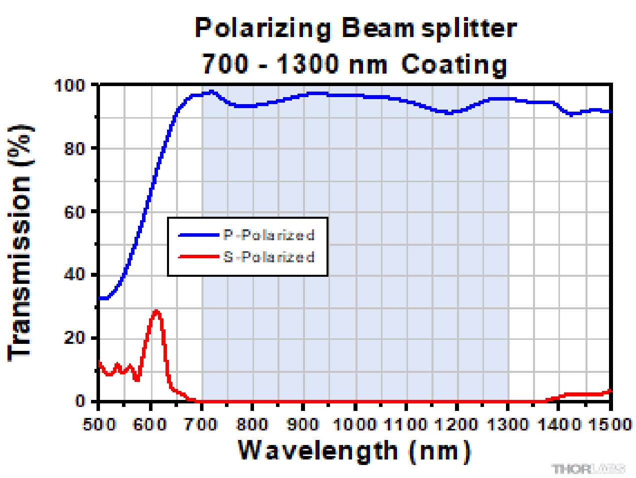


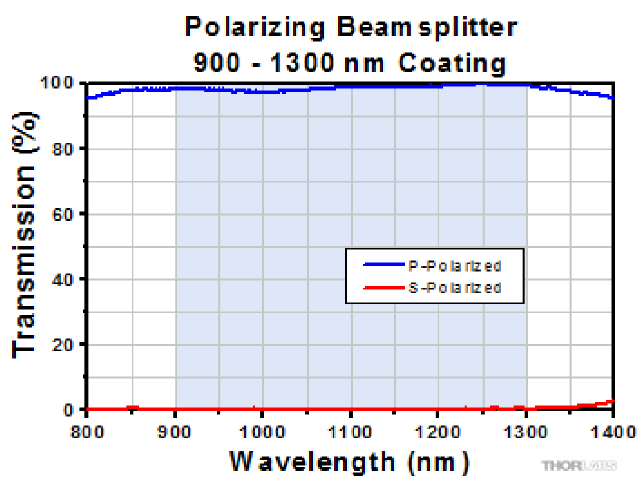
Hide Graphs

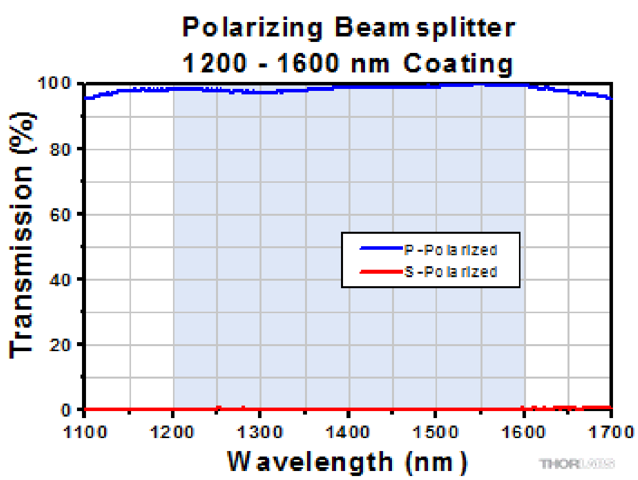
GRAPHS











DAMAGE THRESHOLDS

Damage Threshold Data for Thorlabs' Polarizing Beamsplitter Cubes

The specifications to the right are measured data for Thorlabs' polarizing beamsplitter cubes. Damage threshold specifications are constant for a given wavelength range, regardless of the size of the beamsplitter.

Coating Range	Damage Threshold[a]	
420 - 680 nm	CW[b]	350 W/cm at 532 nm, Ø1.000 mm
	Pulsed	2 J/cm^2 at 532 nm, 10 ns, 10 Hz
620 - 1000 nm	CW[b]	50 W/cm at 810 nm, Ø0.019 mm
	Pulsed	2 J/cm^2 at 810 nm, 10 ns, 10 Hz
900 - 1300 nm	CW[b,c]	1000 W/cm at 1070 nm, Ø0.971 mm
	Pulsed	2 J/cm^2 at 1064 nm, 10 ns, 10 Hz
1200 - 1600 nm	CW[b,c]	1000 W/cm at 1540 nm, Ø1.030 mm
	Pulsed	5 J/cm^2 at 1542 nm, 10 ns, 10 Hz

a. If a higher damage threshold is required, please consider our high power polarizing beamsplitters. Damage thresholds apply to all cube sizes except for the PBS511.
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 below.
c. The stated damage threshold is a certification measurement, as opposed to a true damage threshold (i.e., the optic was able to withstand the maximum output of the laser with no damage).

Laser Induced Damage Threshold Tutorial

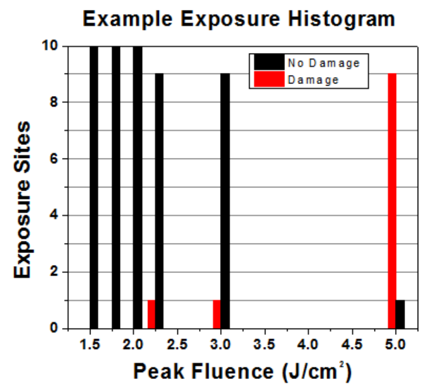
The following is a general overview of how laser induced damage thresholds are measured and how the values may be utilized in determining the appropriateness of an optic for a given application. When choosing optics, it is important to understand the Laser Induced Damage Threshold (LIDT) of the optics 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/DIS 11254 and ISO 21254 specifications.

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 30 seconds (CW) or for a 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

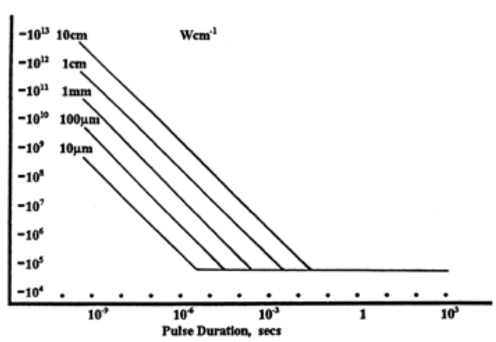
When an optic is damaged by a continuous wave (CW) laser, it is usually due to the melting of the surface as a result of absorbing the laser's energy or damage to the optical coating (antireflection) [1]. Pulsed lasers with pulse lengths longer than 1 µs can be treated as CW lasers for LIDT discussions.

When pulse lengths are between 1 ns and 1 µs, laser-induced damage can occur either because of absorption or a dielectric breakdown (therefore, a user 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 high 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.

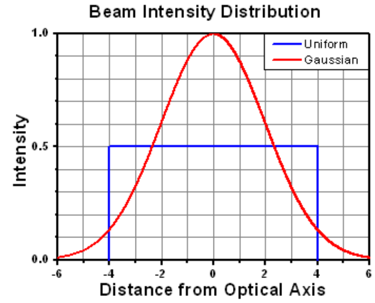
In order to use the specified CW damage threshold of an optic, it is necessary to know the following:

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



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].

Thorlabs expresses LIDT for CW lasers as a linear power density measured in W/cm. 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, as demonstrated by the graph to the right. Average linear power density can be calculated using the equation below.



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

The calculation above 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):

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

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.

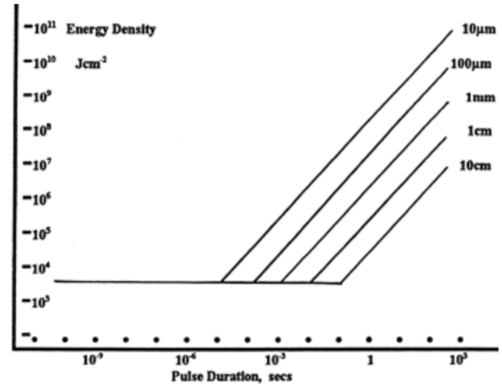
Pulses shorter than 10^{-9} s cannot be compared to our specified LIDT values with much reliability. In this ultra-short-pulse regime various mechanics, such as multiphoton-avalanche ionization, take over as the predominate damage mechanism [2]. In contrast, pulses between 10^{-7} s and 10^{-4} s may 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	No Comparison (See Above)	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



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].

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.

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.

[1] R. M. Wood, Optics and Laser Tech. **29**, 517 (1998).
[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

LIDT Calculator

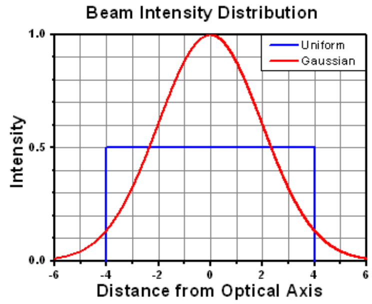
In order to illustrate the process of determining whether a given laser system will damage an optic, a number of example calculations of laser induced damage threshold are given below. For assistance with performing similar calculations, we provide a spreadsheet calculator that can be downloaded by clicking 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.

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 x 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 BS Cube Mounting

BS CUBE MOUNTING

Thorlabs offers a variety of mounting solutions for our beamsplitter cubes. The mounts below allow our cubes to be post-mounted or integrated into our 16 mm or 30 mm cage systems. Post-mountable solutions are compatible with our Ø1/2" Posts as well as Ø1" Posts with 8-32 (M4) taps.

Post-Mountable Mounts for Beamsplitter Cubes								
Click Photo to Enlarge (Cubes Not Included)								
Item #	**PCM(/M)**	**BSH10(/M) BSH05(/M) BSH20(/M) BSH1(/M) BSH2(/M)**	**FBTB(/M)**	**KM100PM(/M)**	**KM200PM(/M)**	**KM100B(/M)**	**KM200B(/M)**	**K6XS**
Required Accessories	**Base: PCMP(/M)**	-	-	**Clamp: PM3(/M) or PM4(/M)**	**Clamp: PM3(/M) or PM4(/M)**	**Clamp: PM3(/M) or PM4(/M)**	**Clamp: PM3(/M) or PM4(/M)**	**Adapter: K6A1(/M)**
Mounting Options	Ø1/2" Posts	Ø1/2" Posts[a,b]	Ø1/2" Posts	Ø1/2" Posts	Ø1/2" Posts	Ø1/2" Posts	Ø1/2" Posts	Ø1/2" Posts
Features	Compact	Compact	Glue-In Mount with Precision Tip, Tilt, and Rotation	Tip and Rotation	Tip and Rotation	Kinematic Mount	Kinematic Mount	6-Axis Mount
Compatible Beamsplitter Cube Size(s)	Up to 20 mm	10 mm, 1/2", 20 mm, 1", 2"	5 mm	Up to 20 mm[c] Up to 1" [d]	Up to 20 mm[c] Up to 1" [d] Up to 2" [e]	Up to 20 mm[c] Up to 1" [d]	Up to 20 mm[c] Up to 1" [d] Up to 2" [e]	5 mm 10 mm 1/2"

a. The BSH10(/M) requires a AP8E4E thread adapter to mount to a Ø1/2" Post.
b. The BSH1(/M) and BSH2(/M) can be mounted directly to an optical table using their two 1/4" (M6) counterbores.
c. With PM3(/M) Clamp
d. With PM4(/M) Clamp
e. With PM4(/M) and PM4SP(/M) Extension Post

Cage System Mounts for Beamsplitter Cubes									
Click Photo to Enlarge (Cubes Not Included)									
Item #	**Cage Cube: SC6W**	**ARV1**	**CRM1(/M) or CRM1P(/M)**	**Cage Cube: C4W or C6W [a]**		**CCM1-4ER(/M)**	**CCM1-A4ER(/M)**	**CCM1-B4ER(/M)**	**CCM1-C4ER(/M)**
Required Accessories	**Clamp: SB6C, Platform: SPM2**	**-**	**Adapter: K6A1(/M)**	**Clamp: B6C, Platform: B3C(/M) or B4C(/M)**	**Clamp: B6C, Platform: B3CR(/M) or B4CRP(/M)**	**-**	**-**	**-**	**-**
Mounting Options	16 mm Cage Systems	30 mm Cage Systems	30 mm Cage Systems or Ø1/2" Posts		30 mm Cage Systems	30 mm Cage Systems or Ø1/2" Posts			
Features	Compact	Compact	Rotation Mount	Fixed or Kinematic Platforms	Rotation Platforms	-	One Rotation Mount	Two Rotation Mounts @ 180°	Two Rotation Mounts @ 90°
Compatible Beamsplitter Cube Size(s)	10 mm	5 mm 10 mm	5 mm 10 mm 1/2"	1/2" 20 mm 1"		5 mm (with BS5CAM Adapter) 10 mm (with BS10CAM Adapter) 1/2" (with BS127CAM Adapter) 20 mm (with BS20CAM Adapter) 1" (Directly Compatible)			

a. These photos illustrate two possible combinations. Any combination of cage cube, clamp, and platform is possible.

Hide BS Selection Guide

BS SELECTION GUIDE

Thorlabs' portfolio contains many different kinds of beamsplitters, which can split beams by intensity or by polarization. We offer plate and cube beamsplitters, though other form factors exist, including pellicle and birefringent crystal. Many of our beamsplitters come in premounted or unmounted variants. Below is a complete listing of our beamsplitter offerings. To explore the available types, wavelength ranges, splitting/extinction ratios, transmission, and available sizes for each beamsplitter category, click *More [+]* in the appropriate row below.

Non-Polarizing Beamsplitters

Plate Beamsplitters	More [+]
Cube Beamsplitters	More [+]
Pellicle Beamsplitters	More [+]

- 45° AOI Unless Otherwise Noted

Polarizing Beamsplitters

Plate Beamsplitters	More [+]
Cube Beamsplitters	More [+]
Birefringent Crystal Beamsplitters	More [+]

- Mounted in a protective box, unthreaded ring, or cylinder.
- Available unmounted or mounted in a protective box or unthreaded cylinder.

Other Beamsplitters

Other Beamsplitters	More [+]

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), rutile (Near-IR to Mid-IR), and yttrium orthovanadate (YVO_4) (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	More [+]
Film Polarizers	More [+]
Beamsplitting Polarizers	More [+]
alpha-BBO Polarizers	More [+]
Calcite Polarizers	More [+]
Quartz Polarizers	More [+]
Magnesium Fluoride Polarizers	More [+]
Yttrium Orthovanadate (YVO_4) Polarizers	More [+]
Rutile Polarizers	More [+]

- 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.
- 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 Insights

INSIGHTS

Insights into Polarization Conventions

Scroll down to read about:

- Labels Used to Identify Perpendicular and Parallel Components

Click here for more insights into lab practices and equipment.

Labels Used to Identify Perpendicular and Parallel Components

When polarized light is incident on a surface, it is often described in terms of perpendicular and parallel

Figure 1: Polarized light is often described as the vector sum of two components: one whose electric field oscillates in the plane of incidence (parallel), and one whose electric field oscillates

components. These are orthogonal to each other and the direction in which the light is propagating (Figure 1).

Labels and symbols applied to the perpendicular and parallel components can make it difficult to determine which is which. The table identifies, for a variety of different sets, which label refers to the perpendicular component and which to the parallel.

perpendicular to the plane of incidence. Note that the oscillations of the electric field are also orthogonal to the beam's propagation direction.

Labels		Notes
Perpendicular	Parallel	
s	p	Senkrecht (s) is 'perpendicular' in German. Parallel begins with 'p.'
TE	TM	TE: Transverse electric field. TM: Transverse magnetic field. The transverse field is perpendicular to the plane of incidence. Note that electric and magnetic fields are orthogonal.
	//	and // are symbols for perpendicular and parallel, respectively.
σ	π	The Greek letters corresponding to s and p are σ and π, respectively.
Sagittal	Tangential	A sagittal plane is a longitudinal plane that divides a body.

The perpendicular and parallel directions are referenced to the plane of incidence, which is illustrated in Figure 1 for a beam reflecting from a surface. Together, the incident ray and the surface normal define the plane of incidence, and the incident and reflected rays are both contained in this plane. The perpendicular direction is normal to the plane of incidence, and the parallel direction is in the plane of incidence.

The electric fields of the perpendicular and parallel components oscillate in planes that are orthogonal to one another. The electric field of the perpendicular component oscillates in a plane perpendicular to the plane of incidence, while the electric field of the parallel component oscillated in the plane of incidence. The polarization of the light beam is the vector sum of the perpendicular and parallel components.

Normally Incident Light
Since a plane of incidence cannot be defined for normally incident light, this approach cannot be used to unambiguously define perpendicular and parallel components of light. There is limited need to make the distinction, since under conditions of normal incidence the reflectivity is the same for all components of light.

Date of Last Edit: Mar. 5, 2020

Hide 5 mm Polarizing Beamsplitter Cubes

5 mm Polarizing Beamsplitter Cubes

PBS054

Item #	PBS051	PBS052	PBS053	PBS054
Cube Size	5 mm x 5 mm x 5 mm			
Wavelength Range	420 - 680 nm	620 - 1000 nm	900 - 1300 nm	1200 - 1600 nm
Material	N-SF1			
Transmission	$T_P > 90\%$			
Reflection[a]	$R_S > 99.5\%$			

Surface Quality	40-20 Scratch-Dig

a. Reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

Part Number	Description	Price	Availability
PBS051	5 mm Polarizing Beamsplitter Cube, 420 - 680 nm	$189.38	5-8 Days
PBS052	5 mm Polarizing Beamsplitter Cube, 620 - 1000 nm	$189.38	Today
PBS053	5 mm Polarizing Beamsplitter Cube, 900 - 1300 nm	$189.38	Today
PBS054	5 mm Polarizing Beamsplitter Cube, 1200 - 1600 nm	$189.38	Today

Hide 10 mm Polarizing Beamsplitter Cubes

10 mm Polarizing Beamsplitter Cubes

Item #	PBS101	PBS102	PBS103	PBS104
Cube Size	10 mm x 10 mm x 10 mm			
Wavelength Range	420 - 680 nm	620 - 1000 nm	900 - 1300 nm	1200 - 1600 nm
Material	N-SF1			
Transmission	$T_P > 90\%$			
Reflection[a]	$R_S > 99.5\%$			
Surface Quality	40-20 Scratch-Dig			

a. Reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

Part Number	Description	Price	Availability
PBS101	10 mm Polarizing Beamsplitter Cube, 420 - 680 nm	$202.35	Today
PBS102	10 mm Polarizing Beamsplitter Cube, 620 - 1000 nm	$202.35	Today
PBS103	10 mm Polarizing Beamsplitter Cube, 900 - 1300 nm	$202.35	Today
PBS104	10 mm Polarizing Beamsplitter Cube, 1200 - 1600 nm	$202.35	5-8 Days

Hide 1/2" (12.7 mm) Polarizing Beamsplitter Cubes

1/2" (12.7 mm) Polarizing Beamsplitter Cubes

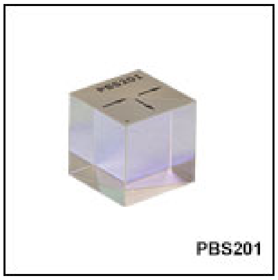
Item #	PBS121	PBS122	PBS123	PBS124
Cube Size	1/2" x 1/2" x 1/2" (12.7 mm x 12.7 mm x 12.7 mm)			
Wavelength Range	420 - 680 nm	620 - 1000 nm	900 - 1300 nm	1200 - 1600 nm
Material	N-SF1			
Transmission	$T_P > 90\%$			
Reflection[a]	$R_S > 99.5\%$			
Surface Quality	40-20 Scratch-Dig			

a. Reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

Part Number	Description	Price	Availability
PBS121	Customer Inspired! 1/2" Polarizing Beamsplitter Cube, 420 - 680 nm	$206.68	Today
PBS122	Customer Inspired! 1/2" Polarizing Beamsplitter Cube, 620 - 1000 nm	$206.68	Today
PBS123	Customer Inspired! 1/2" Polarizing Beamsplitter Cube, 900 - 1300 nm	$206.68	Today
PBS124	Customer Inspired! 1/2" Polarizing Beamsplitter Cube, 1200 - 1600 nm	$206.68	Today

Hide 20 mm Polarizing Beamsplitter Cubes

20 mm Polarizing Beamsplitter Cubes



Item #	PBS201	PBS202	PBS203	PBS204
Cube Size	20 mm x 20 mm x 20 mm			
Wavelength Range	420 - 680 nm	620 - 1000 nm	900 - 1300 nm	1200 - 1600 nm
Material	N-SF1			
Transmission	T_P > 90%			
Reflection[a]	R_S > 99.5%			
Surface Quality	40-20 Scratch-Dig			

a. Reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

Part Number	Description	Price	Availability
PBS201	20 mm Polarizing Beamsplitter Cube, 420 - 680 nm	$218.59	Today
PBS202	20 mm Polarizing Beamsplitter Cube, 620 - 1000 nm	$218.59	5-8 Days
PBS203	20 mm Polarizing Beamsplitter Cube, 900 - 1300 nm	$218.59	Today
PBS204	20 mm Polarizing Beamsplitter Cube, 1200 - 1600 nm	$218.59	5-8 Days

Hide 1" (25.4 mm) Polarizing Beamsplitter Cubes

1" (25.4 mm) Polarizing Beamsplitter Cubes

Item #	PBS251	PBS252	PBS255	PBS253	PBS254
Cube Size	1" x 1" x 1" (25.4 mm x 25.4 mm x 25.4 mm)				
Wavelength Range	420 - 680 nm	620 - 1000 nm	700 - 1300 nm	900 - 1300 nm	1200 - 1600 nm
Material	N-SF1		H-ZF3	N-SF1	
Transmission	T_P > 90%				
Reflection[a]	R_S > 99.5%		-	R_S > 99.5%	
Surface Quality	40-20 Scratch-Dig				

a. Reflection data is based on that of the beamsplitter coating and does not account for the BBAR surface coating.

Part Number	Description	Price	Availability
PBS251	1" Polarizing Beamsplitter Cube, 420 - 680 nm	$235.90	Today
PBS252	1" Polarizing Beamsplitter Cube, 620 - 1000 nm	$235.90	Today
PBS255	Customer Inspired! 1" Polarizing Beamsplitter Cube, 700 - 1300 nm	$235.90	Today
PBS253	1" Polarizing Beamsplitter Cube, 900 - 1300 nm	$235.90	Today
PBS254	1" Polarizing Beamsplitter Cube, 1200 - 1600 nm	$235.90	5-8 Days

Hide 2" (50.8 mm) Polarizing Beamsplitter Cubes

2" (50.8 mm) Polarizing Beamsplitter Cubes

Item #	PBS511	PBS512	PBS513	PBS514
Cube Size	2" x 2" x 2" (50.8 mm x 50.8 mm x 50.8 mm)			
Wavelength Range	420 - 680 nm	620 - 1000 nm	900 - 1300 nm	1200 - 1600 nm
Material	H-LaK67	N-SF1		
Transmission	T_P > 90%			
Reflection	R_S > 97.5%			
Surface Quality	40-20 Scratch-Dig			

Part Number	Description	Price	Availability
PBS511	Customer Inspired! 2" Polarizing Beamsplitter Cube, 420 - 680 nm	$839.73	Lead Time
PBS512	Customer Inspired! 2" Polarizing Beamsplitter Cube, 620 - 1000 nm	$839.73	Today
PBS513	Customer Inspired! 2" Polarizing Beamsplitter Cube, 900 - 1300 nm	$839.73	Today
PBS514	Customer Inspired! 2" Polarizing Beamsplitter Cube, 1200 - 1600 nm	$839.73	Today

Visit the *Broadband Polarizing Beamsplitter Cubes* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=739