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THORLABS

S15RD - April 15, 2022

Item # S15RD was discontinued on April 15, 2022. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

MOUNTED OPTICAL SLITS

- ▶ Slit Widths Available Ranging from 5 to 200 µm
- ▶ Stainless Steel Foils in Ø1/2" or Ø1" Aluminum Housings
- ▶ Blackened on Both Sides for Increased Absorbance

S5K
5 µm Slit Width,
Ø1" Housing

S200HK
200 µm Slit Width,
Ø1/2" Housing

S150K
150 µm Slit Width,
Ø1" Housing

S20HK
20 µm Slit Width,
Ø1/2" Housing

Hide Overview

OVERVIEW

Features

- Slit Widths Available: 5 - 200 µm
- Slit Length: 3 mm
- Blackened Stainless Steel Foils with Ø0.38" (Ø9.6 mm) Unmounted Diameters
- Ø1/2" or Ø1" Black-Anodized Aluminum Housings

Our optical slits are mounted in Ø1/2" or Ø1" black-anodized aluminum plates, ideal for mounting in our SM05- or SM1-series lens tubes.

If you do not see what you need in our stocked offerings below, it is possible to special order slits that are fabricated from different substrate materials, have different slit sizes, incorporate multiple slits in one foil, or provide different slit configurations. Low-power applications may benefit more from the absorbance of blackened stainless steel foils. High-power applications may need the high damage threshold and reflectance of gold-plated copper foils, the high melting point and lower reflectance of our tungsten foils, or the high melting point of our molybdenum foils paired with the low reflectance (4% @ 800 nm) of their black-coated front side. Please see the *Foil Comparison* and *Graph* tabs for more information. Customized housings are also available. Please contact Tech Support to discuss your specific needs.

Thorlabs also offers square precision pinholes in sizes from 100 µm to 1 mm for applications with a small field of view.

Apertures Selection Guide
Single Precision Pinholes
Circular in Stainless Steel Foils
Circular in Gold-Plated Copper Foils
Circular in Tungsten Foils
Circular in Molybdenum Foils
Square in Stainless Steel Foils
Pinhole Wheels
Manual
Motorized
Pinhole Spatial Filter
Slits
Annular Apertures
Alignment Tools

Hide Foil Comparison

FOIL COMPARISON

Precision Pinholes and Slits
Thorlabs offers precision pinholes with blackened stainless steel, gold-plated copper, tungsten, or molybdenum foils. Our pinholes with stainless steel foils are blackened on both sides for increased absorbance and are available from stock in circles from Ø1 µm to Ø2 mm and squares from 100 µm x 100 µm to 1 mm x 1 mm. Our pinholes with gold-plated copper foils, plated with gold on one side and black-oxide coated on the reverse, are available with pinhole diameters from 5 µm to 2 mm. Our pinholes with tungsten foils are uncoated and available with pinhole diameters from 5 µm to 2 mm. Lastly, our pinholes with molybdenum foils have an absorptive polymer coating on the front sides and are available with pinhole diameters from 5 µm to 2 mm. We also offer slits in blackened stainless steel foils from stock with slit widths from 5 to 200 µm.

Precision Pinhole and Optical Slit Selection Guide	
Material	**Product**
Blackened Stainless Steel	Circular Precision Pinholes
	Square Precision Pinholes
	Optical Slits
Gold-Plated Copper Foil (Rear) and PVD Black Coating (Front)	Circular Precision Pinholes
Tungsten Foil	Circular Precision Pinholes
Molybdenum Foil (Rear) and Absorptive Polymer Coating (Front)	Circular Precision Pinholes

If you do not see what you need among our stock pinhole and slit offerings, it is also possible to special order pinholes and slits that are made with different foil materials, have different hole sizes and shapes, incorporate multiple holes in one foil, or provide different hole configurations. Please contact Tech Support to discuss your specific needs. For more information on the properties of the bulk materials from which the pinholes are fabricated, see the table below.

Material Properties

Depending on the application, it can be important to consider the material properties of the pinhole or slit. The material used to construct the aperture can have varying levels of melting point, density, and thermal conductivity, as detailed in the table below.

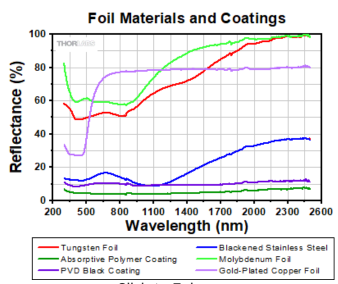
Material Properties				
Material	300 Series Stainless Steel[a]	Copper[b]	Tungsten	Molybdenum[c]
Melting Point	1390 - 1450 °C	1085 °C	3422 °C	2623 °C
Density	8.03 g/cm^3	8.96 g/cm^3	19.25 g/cm^3	10.28 g/cm^3
Brinell Hardness	170 MPa	878 MPa	2570 MPa	1500 MPa
Damage Threshold[d] (10 ns Pulse, 1 kHz @ 355 nm)	1.54 MW/mm^2	4.82 MW/mm^2	9.39 MW/mm^2	6.34 MW/mm^2
Thermal Expansion Coefficient	16.2 (µm/m)/°C	16.7 (µm/m)/°C	4.5 (µm/m)/°C	5.0 (µm/m)/°C
Specific Heat @ 20 °C	485 J/(K*kg)	385 J/(K*kg)	134 J/(K*kg)	250 J/(K*kg)
Thermal Conductivity	16.2 W/(m*K)	401 W/(m*K)	173 W/(m*K)	138 W/(m*K)
Thermal Diffusivity @ 300 K	3.1 mm^2/s	111 mm^2/s	80 mm^2/s	54.3 mm^2/s

a. Stainless steel pinholes and slits are blackened on both sides to increase absorbance. The material properties will be predominantly that of bulk stainless steel.
b. Gold-plated copper pinholes have a thin coating of gold on one side of the bulk copper foil. With a beam incident on this side, reflectance will be dominated by the properties of the thin gold coating (77% @ 800 nm), while thermal properties will be predominantly copper-based.
c. Molybdenum pinholes have an absorptive coating on the front side. The material properties will be predominantly that of bulk molybdenum.
d. Damage threshold data refers to the bulk materials listed here only.

Reflectance

The reflectance of the foil material or coating affects performance in a variety of applications. Below is presented a reflectance graph for all the materials and coatings that are offered with our circular and square precision pinholes, as well as our mounted optical slits. The raw reflectance data can be found here.

It is important to note that the front of the gold-plated copper foil circular precision pinholes have a low-reflectance PVD black coating. The rear of these pinholes leaves the gold-plated copper foil bare. This also occurs on the molybdenum foil circular precision pinholes, which have a low-reflectance absorptive polymer coating on the front and the molybdenum foil is left bare on the back.



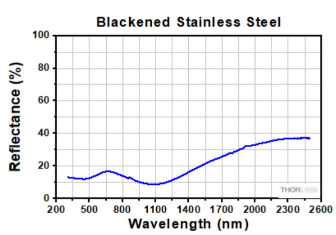
Click to Enlarge

Hide Graph

GRAPH

Reflectance Graph

Below is presented a reflectance graph for the blackened stainless steel on the mounted optical slits. The raw reflectance data can be found here.



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Hide LIDT Calculations

LIDT CALCULATIONS

LIDT Calculator

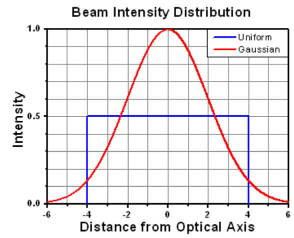
In order to illustrate the process of determining whether a given laser system will damage an optic, a number of example calculations of laser induced damage threshold are given below. For assistance with performing similar calculations, we provide a spreadsheet calculator that can be downloaded by clicking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

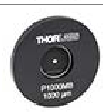
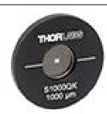
Pulsed Microsecond Laser Example

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 1.2×10^{-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 Apertures Selection Guide

APERTURES SELECTION GUIDE

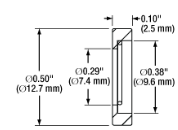
Apertures Selection Guide			
Aperture Type	**Representative Image (Click to Enlarge)**	**Description**	**Aperture Sizes Available from Stock[a]**
Single Precision Pinholes[a]		Circular Pinholes in Stainless Steel Foils	Ø1 µm to Ø2 mm
		Circular Pinholes in Gold-Plated Copper Foils	Ø5 µm to Ø2 mm
		Circular Pinholes in Tungsten Foils	Ø5 µm to Ø2 mm
		Circular Pinholes in Molybdenum Foils	Ø5 µm to Ø2 mm
		Square Pinholes in Stainless Steel Foils	100 to 1000 µm Square
Slits[a]		3 mm Long Slits in Stainless Steel Foils	Slit Widths: 5 to 200 µm
Annular Apertures		Annular Aperture Obstruction Targets on Quartz Substrates with Chrome Masks	Ø300 µm or Ø2 mm Pinholes with ε Ratiosb of 0.85, Ø1 mm Pinholes with ε Ratiosb of 0.05 0.1, or 0.85
Pinhole Wheels		Manual, Mounted, Chrome-Plated Fused Silica Disks with Lithographically Etched Pinholes	Each Disk has 16 Pinholes from Ø25 µm to Ø2 mm and Four Annular Apertures (Ø100 µm Hole, 50 µm Obstruction)
		Motorized Pinhole Wheels with Chrome-Plated Glass Disks with Lithographically Etched Pinholes	Each Disk has 16 Pinholes from Ø25 µm to Ø2 mm and Four Annular Apertures (Ø100 µm Hole, 50 µm Obstruction)

a. Single precision pinholes and slits can be special ordered with different aperture sizes, foil materials, shapes, and hole distributions than those offered from stock. Please contact Tech Support with inquiries.
b. Ratio of the Obstruction Diameter to the Pinhole Diameter

Hide Ø1/2" Mounted Optical Slits

Ø1/2" Mounted Optical Slits

- Optical Slits with Widths from 5 to 200 µm
- Stainless Steel Foils have a Black-Oxide Conversion Coating on Both Sides for Increased Absorbance
- Slits with Widths ≤40 µm Include a Recessed Counterbore to Minimize Laser Power Loss
- Black-Anodized Aluminum Housing:
  - 1/2" Outer Diameter, 0.10" Thick
  - Includes Engraved Horizontal Lines on the Front Face to Facilitate Slit Alignment



Click to Enlarge
Dimensions for Mounted Stainless Steel Slits in Ø1/2" Housings

These mounted optical slits are available with slit widths from 5 to 200 µm. These slits are fabricated from stainless steel foils that have a black-oxide conversion coating on both sides. The foils are mounted in Ø1/2", 0.10" (2.5 mm) thick aluminum housings that are black-anodized. The front face of the housings are engraved with the slit item #, slit width, and horizontal lines to aid with slit alignment.

Our Ø1/2" mounted optical slits with widths of ≤40 µm have a recessed counterbore in order to thin down material around the slit. This makes the edges sharper, thus minimizing laser power loss.

The slits can be taken out of their housings by removing the retaining ring or spring using small tweezers or pliers; use care as the foil is very thin (50 µm).

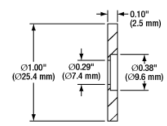
Item #	Slit Width	Tolerance	Slit Length	Foil Thickness	Foil Material	Housing Material
S5HK	5 µm	±1 µm	3 mm	50 µm	300 Series Stainless Steel, Black-Oxide Conversion Coating	6061-T6 Aluminum
S10HK	10 µm	±1 µm				
S15HK	15 µm	±1.5 µm				
S20HK	20 µm	±2 µm				
S30HK	30 µm	±2 µm				
S40HK	40 µm	±3 µm				
S50HK	50 µm	±3 µm				
S100HK	100 µm	±4 µm				
S150HK	150 µm	±4 µm				
S200HK	200 µm	±4 µm				

Part Number	Description	Price	Availability
S5HK	Ø1/2" Mounted Slit, 5 ± 1 µm Wide, 3 mm Long	$126.14	Today
S10HK	Ø1/2" Mounted Slit, 10 ± 1 µm Wide, 3 mm Long	$119.62	Today
S15HK	Ø1/2" Mounted Slit, 15 ± 1.5 µm Wide, 3 mm Long	$119.62	Today
S20HK	Ø1/2" Mounted Slit, 20 ± 2 µm Wide, 3 mm Long	$119.62	7-10 Days
S30HK	Ø1/2" Mounted Slit, 30 ± 2 µm Wide, 3 mm Long	$109.83	Today
S40HK	Ø1/2" Mounted Slit, 40 ± 3 µm Wide, 3 mm Long	$104.12	Today
S50HK	Ø1/2" Mounted Slit, 50 ± 3 µm Wide, 3 mm Long	$104.12	Today
S100HK	Ø1/2" Mounted Slit, 100 ± 4 µm Wide, 3 mm Long	$104.12	Today
S150HK	Ø1/2" Mounted Slit, 150 ± 4 µm Wide, 3 mm Long	$104.12	Today
S200HK	Ø1/2" Mounted Slit, 200 ± 4 µm Wide, 3 mm Long	$104.12	Today

Hide Ø1" Mounted Optical Slits

Ø1" Mounted Optical Slits

- Optical Slits with Widths from 5 to 200 µm
- Stainless Steel Foils have a Black-Oxide Conversion Coating on Both Sides for Increased Absorbance
- Black-Anodized Aluminum Housing:
  - 1" Outer Diameter, 0.10" Thick



Click to Enlarge
Dimensions for Mounted Stainless Steel Slits in Ø1" Housings

These mounted optical slits are available with slit widths from 5 to 200 µm. These slits are fabricated from stainless steel foils that have a black-oxide conversion coating on both sides. The foils are mounted in Ø1", 0.10" (2.5 mm) thick aluminum housings that are black-anodized. The front face of the housings are engraved with the slit item # and the slit width.

The slits can be taken out of their housings by removing the retaining ring or spring using small tweezers or pliers; use care as the foil is very thin (50 µm).

Item #	Slit Width	Tolerance	Slit Length	Foil Thickness	Foil Material	Housing Material
S5K	5 µm	±1 µm	3 mm	50 µm	300 Series Stainless Steel, Black-Oxide Conversion Coating	6061-T6 Aluminum
S10K	10 µm					
S15RD	15 µm	±1.5 µm				
S20K	20 µm	±2 µm				
S30K	30 µm					
S40K	40 µm	±3 µm				
S50K	50 µm	±3 µm				
S100K	100 µm	±4 µm				
S150K	150 µm	±4 µm				
S200K	200 µm	±4 µm				

Part Number	Description	Price	Availability
S5K	Ø1" Mounted Slit, 5 ± 1 µm Wide, 3 mm Long	$126.14	Today
S10K	Ø1" Mounted Slit, 10 ± 1 µm Wide, 3 mm Long	$119.62	Today
S15RD	Ø1" Mounted Slit, 15 ± 1.5 µm Wide, 3 mm Long	$119.62	Lead Time
S20K	Ø1" Mounted Slit, 20 ± 2 µm Wide, 3 mm Long	$119.62	Today
S30K	Ø1" Mounted Slit, 30 ± 2 µm Wide, 3 mm Long	$109.83	Today
S40K	Ø1" Mounted Slit, 40 ± 3 µm Wide, 3 mm Long	$104.12	Today
S50K	Ø1" Mounted Slit, 50 ± 3 µm Wide, 3 mm Long	$104.12	Today
S100K	Ø1" Mounted Slit, 100 ± 4 µm Wide, 3 mm Long	$104.12	Today
S150K	Ø1" Mounted Slit, 150 ± 4 µm Wide, 3 mm Long	$104.12	Today
S200K	Ø1" Mounted Slit, 200 ± 4 µm Wide, 3 mm Long	$104.12	Today