Laser Induced Damage Threshold

Overview:

Developments in laser technology continue to increase output powers year-on-year, with commercially available CW power as high as 100kW (in 2023). Pulsed lasers have seen a corresponding rise in pulse energy, peak pulse power and average output power across fs-ns-µs pulsed lasers. All optical components used in conjunction with these high power CW and pulsed lasers need to have a high laser induced damage threshold (LIDT).

The LIDT of an optical component is determined by (i) the choice of glass; (ii) its purity; (iii) how it is processed from its blank or substrate state; (iv) residual surface roughness; and (v) optical coatings.

PowerPhotonic optics and assemblies use the highest grades of fused silica, have the smoothest freeform surfaces available, and are coated with specially selected coatings all to ensure the best in class LIDT performance.

The PowerPhotonic Effect:

>100kW/cm

AR coated optic, CW LIDT

>0.5J/cm²

AR coated optic, picosecond LIDT

>5J/cm²

AR coated optic nanosecond LIDT

Pulsed Laser Damage:

Pulsed laser damage occurs due to electric field (spatial) gradient of the laser pulse inducing dielectric breakdown of the substrate or coating.

Pulsed Laser Induced Damage Thresholds are specified in terms of the maximum power or energy density incident on the surface, J/cm² or MW/cm². MW/cm² is the more useful definition as it gives the peak power density whereas the J/cm² unit requires a pulse length to be stated as well.

CW Laser Damage:

CW laser damage occurs due to thermal degradation, driven predominantly by the absorption in the bulk material and/or optical coating of the component.

Continuous Wave LIDT and measurement is defined in the International Organization for Standards (ISO) document number ISO 21254-1:2011. According to these standards, CW damage varies linnearly with the spot diameter rather than the area and so is specifed in W/cm instead of an irradiance W/cm².

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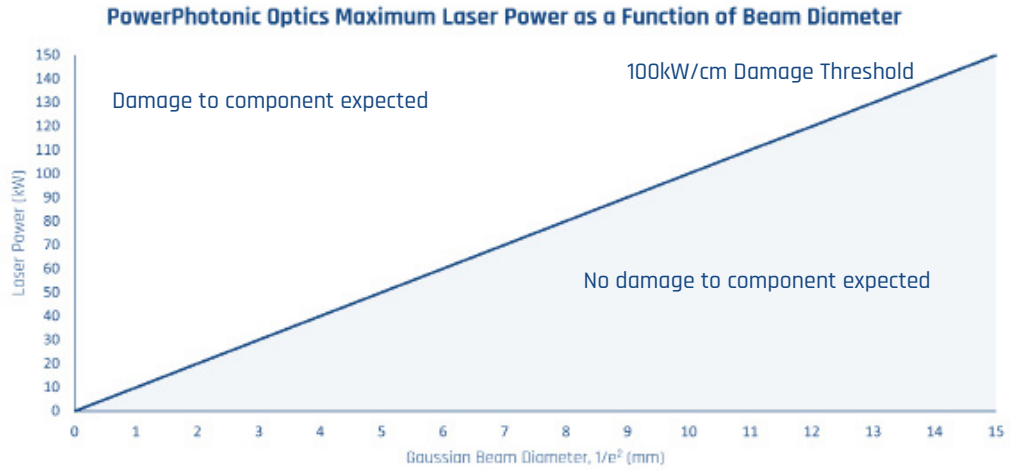
Pulsed Thresholds:

Pulse Length	Wavelength (nm)	Pulse Energy (J)	Peak Power Density
Femtosecond (fs)	532	25	>2PW/cm^2
Picosecond (ps)	1064	1.57	>5GW/cm^2
Nanosecond (ns)	1064	0.85	>100MW/cm^2

Based off customer performance. Individual LIDT is dependant on source characteristics and optic type.

CW Threshold:



LIDT Scaling Laws:

Both CW and Pulsed LIDT results can be scaled in wavelength and pulse length to apply to different laser beam characteristics. These scaling laws are estimates, and only apply for small changes in parameters (<10% CW wavelength and ±5% pulsed wavelength or ± a factor of 3 of pulse duration), but can be a handy tool for estimating LIDT of an optical component.

CW Scaling Laws:

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

Pulsed Scaling Laws:

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

or

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

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