Laser Damage Considerations

To avoid coating and/or window damage with laser applications, one needs to consider several parameters. The most fundamental consideration is the mode of laser operation: Pulsed vs. Continuous Wave (CW). Pulsed lasers deliver discrete energy packets, while CW beams supply continuous power.

Pulsed
The most significant parameter for pulsed lasers is Energy Density.

Energy Density
Energy density is a parameter derived from the Peak Pulse Energy and the beam or spot size as follows:

- Peak Energy: Joules or millijoules (J or mJ)
- Energy Density = Peak Pulse Energy / Beam Area (J/cm^2 or mJ/cm^2)
- Beam Area = $pi*r^2$ = $pi*d^2/4$; where r = radius and d = diameter of the beam
- Excimer lasers may be rectangular, where A = L x W, usually measured in cm^2.

Other significant factors are wavelength, pulse duration, and frequency.

Wavelength
In general, the shorter the wavelength, the lower the maximum allowable Energy Density. Whereas the Laser Damage Threshold (LDT) is typically well above 10 J/cm^2 for 1064 nm YAG lasers, the LDT for an Excimer Laser operating at the same pulse duration and 248 nm might be closer to 1 J/cm^2.

Wavelengths are expressed in microns or nanometers. 1 micron = 10^{-6} meters, 1 nm = 10^{-9} meters. 1000 nm = 1 micron.

Pulse Duration
Pulse duration generally has an even greater effect on LDT than wavelength. All other variables held constant, a pulse duration 10 times shorter reduces the LDT to roughly one-third its original value.

Pulse duration is expressed in units of time: milliseconds (10^{-3} s), microseconds (10^{-6} s), nanoseconds (10^{-9} s), picoseconds (10^{-12} s), femtoseconds (10^{-15} s). Femtosecond laser applications are the most demanding.

Frequency
Frequency is the number of pulses per time unit, typically in Hz. E.g., 50 pulses per second = 50 Hz. The total power or duty cycle for a pulsed laser may be derived from the frequency, pulse duration, peak energy, and exposure time, but this number has very little significance to LDT. Still, it is a straightforward assumption that a lower frequency would entail a longer lifetime for a coating or optic.

Continuous Wave (CW)
The most significant parameter for CW laser operation is Power Density.

Power Density
Power is the rate of energy delivery and for lasers is typically expressed in Joules/second (1 J/s = 1 Watt).

Power Density is similar to Energy Density above. The Peak CW power divided by the spot or beam size (in square cm) is the power density: Power (Watts) / Area (cm^2) = W/cm^2.

Depending on wavelength and coating material, Power Densities below 10^8 W/cm^2 are typically serviceable. Above 10^8 W/cm^2 most materials can be ablated (exploded and evaporated) by laser flux. Thus 10^8 W/cm^2 or 100 MW/cm^2 is a threshold or maximum CW value for LDT.

For specific LDT specifications, contact our engineering team.