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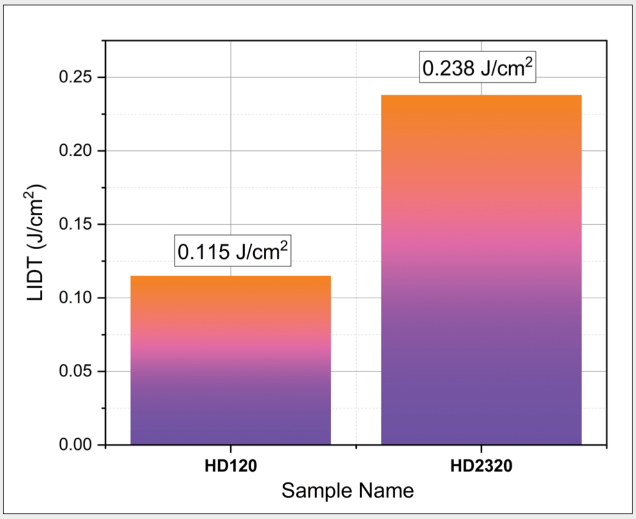
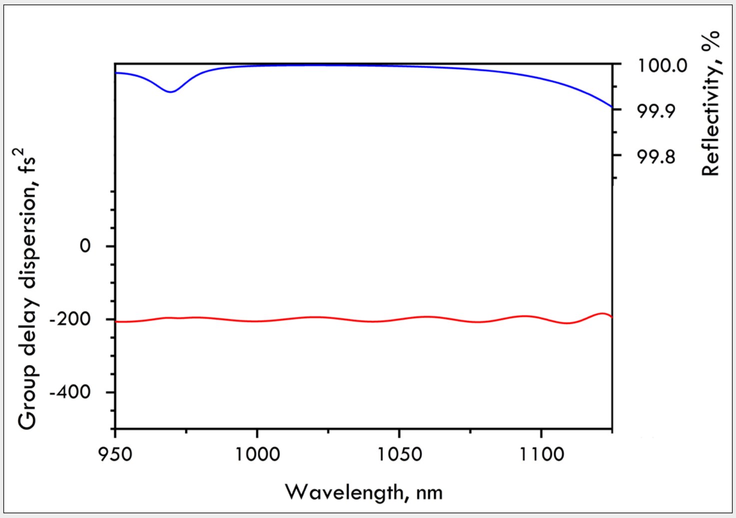
Application note:
Laser Induced Damage Threshold of ultrafast dispersive optics





Laser induced damage threshold (LIDT) of optical components, in general, and of multilayer thin film coatings, in particular, is one of the major challenges towards further advances of these technologies. Moreover, in order to avoid the appearance of nonlinear effects in air, some of these systems are placed into a vacuum environment, further aggravating LIDT issues.
UltraFast Innovations has developed a new dispersive mirror with double LIDT in vacuum compared to its predecessor model. Our standard HD120 mirror covers the 950-1120 nm range with -200 fs² of nominal group delay dispersion (GDD) and a LIDT value of 0.115 J/cm². The new mirror, HD2320, has the same specs and performance with a LIDT of 0.238 J/cm², making it perfect for those striving to achieve ever higher pulse energies and/or output power.

LIDT @1030 nm in vacuum[1]
Test conditions:

System: Mode-locked Yb:KGW, 190.0 fs (assuming Gaussian pulse shape) @ central wavelength of 1030 nm, @ repetition rate of 1 kHz. Focal spot on the sample ~ Ø 188 ± 1.6 µm @ 1/e². The tests were performed in accordance with S-on-1 (ISO 21254-2) test procedure. S = 10^3 pulses. Vacuum: $2*10^{-7}$ mbar.

[1]The LIDT tests have been performed by UAB Lidaris, Saulėtekio al. 10, 10223 Vilnius, Lithuania.

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Samples and results:

All of the sample designs were coated on fused silica substrates with Ø1" x 0.25" thk. The dielectric coatings were produced using plasma-ion assisted magnetron sputtering (MS). HD2320 utilizes HfO_2 as a high-index material instead of Ta_2O_5, consequently, the layer stack is optimized to fulfil the specification of the standard HD120.

Name	Material pair	LIDT Catastrophic (J/cm^2)
HD120	Ta_2O_5 / SiO_2	0.115 ± 0.0092
HD2320	HfO_2 / SiO_2	0.238 ± 0.019

Table 1. LIDT of various ultrafast mirrors at a central wavelength of 1030 nm in vacuum.

Material	Bandgap energy
Ta_2O_5	3.8 eV
HfO_2	5.6 eV

Table 2. Bandgap energies of the high-index materials used.

As it can be concluded from the tables: using coating materials with broader bandgap (such as HfO_2) substantially increases LIDT of the dispersive coating.
However, using materials with broader band gaps is not, unfortunately, an undebatable panacea in an endeavor of increasing the LIDT of ultrafast coatings. Materials with broader band gaps have lower refractive indices and the usage of such materials in a thin-film coating results in lower refractive index contrast and therefore in lesser achievable combination of bandwidth, reflectance and dispersion. A compromise must be sought.

UltraFast Innovations GmbH specifies LIDT of dispersive optics at a central wavelength of 1030 nm to be 0.1 J/cm^2 @ 200 fs pulse, @ 1 kHz rep. rate @ ~Ø190 μm @ $1/e^2$ beam diameter.

Key messages:

- LIDT is linearly proportional to the band gap energy of the used high index material
- Warrantied LIDT of dispersive multilayer mirrors @ central wavelength of 1030 nm is 0.1 J/cm^2 for standard optics.