LASER INDUCED DAMAGE THRESHOLD CHANGE IN TIME IN NANOSTRUCTURED GLAD ALL-SILICA HIGHLY REFLECTIVE OPTICAL MIRRORS

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Optical components are critical elements in laser systems, where they control and direct laser radiation. As the demand for high-power laser systems grows so does the need for highly resistive and durable optical mirrors. Nanostructured thin film mirrors deposited using the GLancing Angle Deposition (GLAD) technique [1] have emerged as a promising alternative to conventional mirrors, offering higher potential Laser Induced Damage Threshold (LIDT). Although GLAD coatings have issues, that may be solved only with more research and development.

The aim of this study is to investigate the change of LIDT in time of all-silica nanostructured high-reflectivity (HR) mirrors fabricated using the GLAD method. By applying GLAD method at 70°, self-shadowing effect is induced to form nanostructured layers which have lower effective refractive index. Combining porous layers with dense layers formed at 0° allows us to make Bragg mirrors from only SiO_2[1]. Conventional mirrors have a dielectric of a lower bandgap, which has a higher refractive index, thus limiting the maximum potential LIDT. In this case all-silica mirrors have an advantage. Although GLAD mirrors exhibit high potential, they are known to absorb water or other harmful particles from environment and reduce resistance to repeated laser exposure. This can be avoided with optimizations of manufacturing and storage processes.

In this work, six HR mirrors designed for operation at a wavelength of 355 nm (reflectance >95%) were investigated. The all-silica mirrors were fabricated using the GLAD technique. After deposition, all samples were stored in argon-filled PET-G boxes and sealed with Kapton tape, to suppress degradation [2]. LIDT 1-on-1 measurements were performed monthly by sequentially unsealing selected samples, allowing the degradation rate to be evaluated as a function of storage time, and to see if unsealing the mirror accelerates degradation. Another factor that will be experimented on, is whether the LIDT of conditioned [2] all-silica mirror will change over time.

The results show great LIDT (at 355nm laser wavelength) 1-on-1 results, the mirror survived 163.57 J/cm^2 laser shots, but damage occurred from 67 J/cm^2. After a month these values didn't change much, the maximum energy survived – 162.1 J/cm^2, and first damage – 56 J/cm^2. When compared to other 355nm wavelength mirrors, this degradation is quite slow, and unlike other mirrors, all-silica mirrors can be rejuvenated with laser conditioning [2].

Further investigation is required for solutions and insights into the nanoscale physical mechanisms responsible for coating degradation under sealed storage conditions and to optimize GLAD mirror designs and production sequences for long-term use in high-power and ultrafast laser systems.

[1] Tolenis T. et al., Scientific Reports, 7:10898 (2017)
[2] Ramalis L. et al., Science Direct, Optics 14 100616 (2024)