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INVESTIGATIONS OF NONLINEAR ABSORPTANCE AND FATIGUE EFFECT IN HFO_2, ZRO_2, AND AL_2O_3 DIELECTRIC COATINGS

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The irradiation conditions in the high-power laser systems are extreme for their critical optical elements, thus, often leading to the delayed fatigue effect: a long-term degradation and catastrophic failure [1, 2]. The phenomenon behind the extreme laser light and dielectric optics interaction is typically associated with the nonlinear absorption in optical coatings [2]. The nonlinear response makes these coatings highly optically unstable, however, the knowledge about the nonlinear properties of most dielectric coatings is very limited. Furthermore, multilayer dielectric coatings are even less investigated by the means of nonlinear absorptance. To study these effects at different wavelengths single- and multi-layer HfO2, ZrO2, and Al2O3 dielectric coatings featuring different process parameters were produced. For the measurements of nonlinear absorption, we combined a high average power laser source, operating at a 1 MHz repetition rate and 10 ps pulse duration, with common-path interferometry (PCI). PCI method is a pump-probe technique [3], where the pumping beam is modulated in time, thus, also producing modulated heating of the coating. Such action subsequently creates a time-varying miniature thermal lens out of the substrate, while the probe beam interrogates the disturbed area. Pump and probe beams are overlapped and crossed at an angle on the target plane. As the probe beam is larger the than the pump beam it covers both disturbed and undisturbed regions, thus, producing a high contrast interference modulation in the far field. Such interferometric signal is then directly monitored by using a photodiode. A sample with an identical substrate material and a highly absorbing metallic coating is used to calibrate the system. The results of the nonlinear absorption measurements are then used for the interpretation of the fatigue behaviour in the same type of optical elements. S-on-1 Laser-Induced Damage Threshold (LIDT) testing was conducted in parallel on the same type of samples. An attempt is made to correlate those two types of measurements.

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