BULK DAMAGE AND ABSORPTION IN FUSED SILICA DUE TO HIGH-POWER LASER APPLICATION

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Laser fusion projects are heading for IR optics with high broadband transmission, high shock and temperature resistance, long laser durability, and best purity. For this application, fused silica is an excellent choice. The energy density threshold on IR laser optics is mainly influenced by the purity and homogeneity of the fused silica. Heraeus Quarzglas developed the material grades Suprasil 3002/3001/300 especially for the infrared spectrum where performance must be optimized.

The absorption behavior regarding the hydroxyl content was studied for various synthetic fused silica grades. The main absorption influenced by OH vibrational excitation leads to different IR attenuations for OH-rich and low-OH fused silica [1]. The attenuation depends on the wavelength. Three wavelengths 946 nm, 1064 nm and 1319 nm were analyzed, which are typically used for laser diodes, pumping, material processing, Nd-doped lasers and medical purposes.

Industrial laser systems aim for the maximum energy extraction possible. Heraeus developed an Yb-doped fused silica fiber to support this growing market [2]. But the performance of laser welding and cutting systems is fundamentally limited by beam quality and stability of focus. Since absorption in the optical components of optical system has a detrimental effect on the laser focus shift, the beam energy loss and the resulting heating has to be minimized both in the bulk materials and at the coated surfaces. In collaboration with a laser research institute, an optical finisher and end users, photothermal absorption measurements on coated samples of different fused silica grades were performed to investigate the influence of basic material properties on the absorption level [3].

High purity, synthetic fused silica is as well the material of choice for optical components designed for DUV applications (wavelength range 160 nm - 260 nm). With the advent of the DUV microlithography stepper generation, the importance of fused silica as optical material has increased still further.

For higher light intensities, e.g. provided by excimer lasers, UV photons may generate defect centers that effect the optical properties during usage, resulting in an aging of the optical components (UV radiation damage). Powerful excimer lasers require optical materials that can withstand photon energy close to the bandgap and the high intensity of the short pulse length. We concentrate on the induced absorption effect in fused silica caused by ArF and KrF laser radiation (193 nm and 248 nm). This absorption is restricted to the DUV wavelength range below 300 nm and consists of three different absorption bands centered at 165 nm (peroxy radicals), 215 nm (E'-center), and 265 nm (non-bridging oxygen hole center (NBOH)), which change the transmission behavior of material [4].

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