Femtosecond laser three-dimensional exposure of silica substrate in the non-ablative regime : from laser-induced modifications to applications

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Abstract

Thanks to non-linear absorption processes, non-ablative femtosecond laser pulses applied to fused silica induce bulk morphological transformations in the material associated with a variety of local changes of physical properties. These structural changes includes locally densified glass matrices, self-organized nanostructures as well as the formation of polymorphic phases. As a direct consequence, the material experiences localized volume variation resulting in either tensile or compressive stress, which intensity and direction are both controlled by the pulse energy and the laser polarization, respectively. Here, we will discuss these laser modifications, both from the viewpoint of stress-states and structural changes induced in the material. In particular, we will show how these controlled states along with this ability to tune material properties can be used for novel applications in optomechanics, such as tunable Duffing oscillators, embedded optical wave plates, but also, as a means to investigate mechanical properties at the small scales and for the packaging of complex optical devices. Finally, we will conclude by showing the existence of intermittent behavior observed while writing in material and illustrates how this apparent erratic behavior bearing randomness provides useful information related to fracture mechanics at small scales.

Keywords: Femtosecond lasers, fused silica, high pressure polymorphic phases, glass micro, mechanics.

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