CO2 laser processing of fused silica surfaces for high power laser applications

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Abstract

CO2 laser processing of silica is used in many scientific and industrial applications, such as micromachining to produce optical components, processing of optical fibers, polishing of micro-optical components, production of free form optics, generation of holographic structures.... The 10.6-μm irradiation by CO2 laser, is particularly adapted for fused silica because the energy is effectively absorbed within a few microns of the surface. Thermal effects subsequent to absorption induce heating of the material, temperature gradients, decrease of viscosity, viscous flow, evaporation and potentially material ablation. Such physical effects, if well controlled, can be used for micro-machining, polishing, annealing or other thermal treatments of the surface. The laser silica interaction process can however generate some detrimental effects for applications such as debris, thermo-mechanical residual stress, birefringence, reduced mechanical resistance, surface profile modifications due to viscous flow, densification... Therefore the laser material interaction has to be well controlled and understood for efficient process developments. In this communication we report on our work on the application of CO2 laser processing of fused silica optics for high power applications. Particularly, the targeted application is the improvement of the laser damage resistance to UV nanosecond pulses, in the context of the Laser MegaJoule project. Such processes include micro-shaping, surface smoothing, laser-based annealing and defect removal. In this presentation we will describe the experimental system and processing methods, as the characterization techniques that have been developed to measure the surface profile of treated fused silica optics and the residual birefringence related to thermomechanical stresses. We will also discuss about the development of a comprehensive thermo-mechanical numerical model, based on finite-element method, to simulate the laser material interaction and its effect on fused silica.

Keywords: fused silica, laser applications, optical properties, laser interaction, birefringence, thermal treatments

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