CO2 laser ablation process for laser induced-damage mitigation of fused silica optics for LMJ optics

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Control of laser-induced surface damage of fused silica components is critical for operation of high-energy laser systems such as the Laser MégaJoule in France (LMJ). This is specifically true for the final optical stages where high energy density UV radiation is required. Surface damage on fused silica components is linked to the interaction of high-energy photons defect on optic components [1]. The initial surface damages are few micrometres in size, but they can rapidly expand under successive laser irradiation. Ideally, a technique to repair such components should eliminate the damaged site or prevent growth of it., therefore, allowing an optical component to be used several times before its final replacement.

CO_2 laser processing has proven to be an effective technique for laser-damage mitigation of large fused silica optics. Still, it is a technique very sensitive to the material thermo-mechanical properties and laser intensity variations. This leads to negative effects such as surface deformation, residual stress, debris formation, or solidification of viscous flow in the form of raised rim structures around a threated zone [2,3]. Collaboration between CEA-CESTA and Institut Fresnel has yielded CO_2 laser mitigation processes based on the micro-ablation of cone-like shapes to remove damaged sites. In this work, we present our latest results focusing on the strategy followed to reduce post-processing negative effects. Numerical simulations based on COMSOL-Multi-physics are used to have a better insight of the thermo-mechanical dynamics occurring during the laser processing of fused silica. Results are used as guidance to improve the processing parameters of the mitigation process.

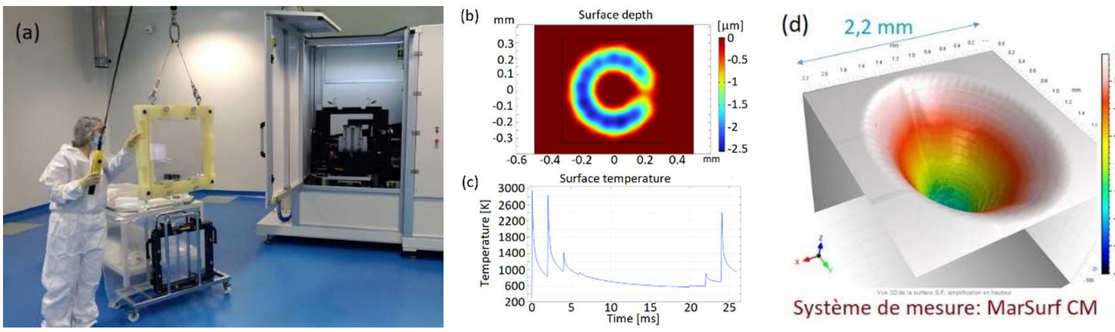

Figure 1 (a) an operator holding a damaged fused silica window (40 cm x 40 cm size) used in the LMJ, before it is mounted on the laser processing machine to get repaired. (b) Numerical simulation results of the ablated depth of a circle of 210 □m radius by a pulsed CO2 laser signal. (c) Evolution of the residual surface temperature of the axial zone where the initial pulse starts interacting with the material surface (d) confocal microscopy of the surface profile for a typical conical crater of 2,2 mm diameter ablated with a CO2 laser with a beam spot of 390 □m.

References:

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