MECHANICS OF MATERIALS

Optimization of laser damage detection and growth monitoring capabilities : application to the Laser MegaJoule facility

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Auteurs : Guillaume Hallo

The 176 beams of the Laser MegaJoule (LMJ) facility are designed to deliver each one 7.5 kJ of laser energy at a wavelength of 351 nm over a pulse duration of few nanoseconds. Under these conditions, fused silica optics are particularly susceptible to laser damage. The 176 vacuum windows, critical fused silica components of the LMJ, with a thickness of 34 mm and a side length of 40 cm, ensure the vacuum tightness of the experiment chamber while allowing the laser beams to reach the target. An imaging system is used to acquire daily in-situ images of vacuum windows. However, the spatial resolution of the images is greater than the diameter of damage sites whose growth must be monitored. The aim of this thesis is to optimize the in-situ detection and monitoring capabilities of damage growth on the LMJ final optics. This optimization is organized in 3 parts. First, a method to estimate the diameter of damage sites from the gray levels of the images is introduced. Second, an image correction algorithm based on digital image correlation principles has been developed to correct for image disturbances and thus to in-situ monitor damage growth. Third, we demonstrate that the analysis of the gray levels and the diameter of a damage site allows an additional information to be extracted, namely, damage growth in depth, usually accessible by more complex methods.