Combined Experimental and Computational Study of Damage in Silica Glass due to Laser Shock

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Abstract

Fracture initiation and propagation under laser shock is the main focus of the current study. The shock was generated by a high intensity laser using the ELFIE facility at the LULI, UMR 7605 at the French École Polytechnique. Front and rear face damages of the samples were observed and quantified by optical methods and X-ray micro-CT. They ranged from no damage at all to a completely damaged sample on both front and rear faces. Micro-CT showed that the most damaged samples also have several types of internal failure.
Peridynamic approach was used to explore the underlying mechanisms leading to damage initiation and propagation in silica samples. This method is a non-local formulation that uses integrals instead of tensors, thus removing the singularities caused by geometric discontinuities. The laser-shock experiments were simulated by using a peridynamic grid matching the size of the shocked silica samples. The loading conditions were determined by one-dimensional laser-matter simulations using the ESTHER code (developed by the CEA). They were applied to material points on the front face of the mesh corresponding to the experimental laser irradiated zone. Two specific cases were considered: High Flux (HF) and Low Flux (LF). These cases represent clear differences in both loading conditions and the observed failure modes. In the current study the HF case was used to refine the peridynamic material parameters allowing for a satisfactory description of the experimentally observed damage on both the front and rear faces. This setup was then used in LF case and damage predictions were compared to those of the recovered sample to test the accuracy of the method.
Although the comparisons between experimental measurements and peridynamic predictions are encouraging in multiple aspects, considering the lack of current data on such studies, results are also discussed in terms of qualitative or quantitative matching in order to set the limitations of the numerical approach.

Keywords: laser shock, damage, fracture, modeling, peridynamics

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