Stress testing of materials using Laser-accelerated protons

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Laser-driven proton acceleration is a growing field of interest, in particular for the manifold potential applications in different fields such as medicine, astrophysics and material science. In this letter, we provide first experimental evidence that laser-generated protons can be used in material science and in particular for testing and analyzing the response of materials in extreme conditions. Laser-driven proton bunches can produce, in a few single ns shots, the same mechanical and thermal stress than what obtained during several months of full operation for typical fusion facilities. We confirm this by analyzing changes in mechanical, optical, electrical, and morphological properties of five materials of interest that have been irradiated by laser-generated high energy protons produced with a high-intensity ($I > 4x10^{19}$ W/cm), short pulse ($\tau < 1$ ps) laser. For all the considered materials, the temperature reached during the irradiation is lower than the melting point while the erosion is in the order of a few microns for Carbon and Tungsten, and hundreds of nanometers for Titanium, Tantalum, and Molybdenum. This laser-driven testing method paves the way for performing a quicker and more efficient analysis of materials and is suitable for evaluating future materials and structures with enhanced properties.