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Ultra-fast phase transformations produced by intense fs-laser tightly focussed inside a solid

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Abstract

I present experimental and theoretical studies of phase transformations produced by a tightly focused fs-laser pulse inside different transparent solids. Confined micro-explosion proved to be an efficient and inexpensive method for achieving high energy density up to several MJ/cm^3 in the laboratory tabletop experiments. Synchrotron X-ray diffraction from the compressed sapphire revealed the presence of 18 nm crystallites of new super-dense bcc-Al, never observed before. Thus under conditions of complete confinement the spatial separation of Al and oxygen ions occurred and preserved after return to the ambient conditions. It appears that in non-equilibrium non-ideal Coulomb-dominated plasma shock wave front has a complicated structure with light and heavy ions separated in space. I also discuss the phenomena accompanying propagation of intense ionizing laser pulse through a medium such as changes in spectrum, group velocity and motion of the ionization front. We demonstrated that intense laser pulse ($\sim 5x10^{15}$ W/cm^2) with fluence up to 50 times above the ionisation threshold is effectively absorbed in the focal spot located at 10 micron deep in silica. Confined micro-explosion studies were recently extended to the opaque materials buried under transparent layer. These findings open new avenues for the studies of high-pressure material transformations and Warm Dense Matter (WDM) conditions by confined micro-explosion produced by intense fs-laser