

Experimental Observation for New Polymorphs of Silicon Formed through Ultrafast-Laser-Induced Microexplosion

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Intense ultrafast laser pulses tightly focused in the bulk of transparent material produce plasma in the extreme conditions similar to those in the cores of planets. The plasma generates strong shock waves in such confined geometry, thus inducing a laser-ignited microexplosion. This new method of compression of matter by ultra-short laser induced micro-explosion generates pressures in excess of Terapascals, leaving all the pressure/temperature-affected material confined inside the bulk of pristine crystal for the further investigations [1,2]. In contrast to dynamic (shock wave) and static (diamond-anvil cell) methods, the initial materials in a microexplosion are transformed into the high entropy state of extreme dense plasma where the memory of the initial state is completely lost. This state is similar to “a primeval soup” at the early stages of the Universe evolution. The randomised material swiftly cools down isochorically to ambient in a short, nanosecond-scale time. For example, it was demonstrated that a sapphire crystal converted by a fs-

laser pulse to plasma returns to the ambient state as a mixture of nano-crystallites of the previously unobserved form of bcc-aluminium [3].

In this presentation the new experimental results evidencing the formation of novel structures in laser-induced confined micro-explosion in silicon will be highlighted. Electron diffraction pattern of the shock wave isochorically affected areas reveals the presence of a mixture of silicon phases with a number of previously unidentified diffraction spots. Indexation of the diffraction patterns from various microexplosion sites demonstrate close correlation between the numerically predicted phases and the observed diffracted spots.

The observation of a new Si phase is a confirmation that ultrafast laser-induced microexplosion in confine geometry is a unique method for dynamic generation of transient states of matter by fast quenching from the laser-induced plasma where the new phases are reserved for further studies.

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