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Simultaneous Imaging and Diffraction from Shock Compressed Matter at the LCLS

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Despite being the subject of numerous shock compression studies, the behavior of silicon under dynamic loading is vigorously debated [1-3]. The few studies that combine shock compression and X-ray diffraction have exclusively focused on "normal" X-ray geometry whereby X-rays are collected along the shock propagation direction, consequently sampling numerous strain states at once, greatly complicating both phase identification and studies of phase transition kinetics. Here, we present a novel setup performing in situ X-ray diffraction studies perpendicular to the shock propagation direction at the Matter at Extreme Conditions end station at LCLS. Combining the extremely bright microfocussed X-ray beam with a nanosecond drive laser, we unambiguously determine the character of each wave for the first time.

As a further development, we present the simultaneous combination of phase contrast imaging (PCI) techniques with in situ X-ray diffraction perpendicular to the shock compression direction to investigate multiple-wave features in laser-driven germanium. PCI allows one to take femtosecond snapshots of magnified real-space images of shock waves as they progress though matter. X-ray diffraction perpendicular to the shock propagation direction provides the opportunity to isolate and identify different waves and determine the crystal structure unambiguously. We combine these two powerful techniques simultaneously, by using the same Be lens setup to focus the fundamental beam at 8.2 keV to a size of 1.5 mm on target for PCI and the 3rd harmonic at 24.6 keV to a spot size of 2 um on target for diffraction

References

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[3] W. H. Gust & E. B. Royce, "Axial Yield Strengths and Two Successive Phase Transition Stresses for Crystalline Silicon"JAP, 42, 1897 (1971)

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