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Simultaneous X-ray imaging and diffraction study of shock propagation and phase transition in silicon.[1]

ERIC GALTIER, SLAC - Natl Accelerator Lab

X-ray phase contrast imaging technique using a free electron laser have observed the propagation of laser-driven shock waves directly inside materials [1-3]. While providing images with few hundred nanometers spatial resolution, access to more quantitative information like the material density and the various shock front speeds remain challenging due to imperfections in the images limiting the convergence in the reconstruction algorithm. Alternatively, pump-probe X-ray diffraction (XRD) is a robust technique to extract atomic crystalline structure of compressed matter, providing insight into the kinetics of phase transformation and material response to stress. However, XRD by itself is not sufficient to extract the equation of state of the material under study. Here we report on the use of the LCLS free electron laser as a source of a high-resolution X-ray microscopy enabling the direct imaging of shock waves and phase transitions in optically opaque silicon. In this configuration, no algorithm is necessary to extract the material density and the position of the shock fronts. Simultaneously, we probed the crystalline structure via XRD of the various phases in laser compressed silicon. [1] A. Schropp et al. Sci. Rep. 3, 1633 (2013) [2] A. Schropp et al. Sci. Rep. 5, 11089 (2015) [3] B. Nagler et al. Rev. Sci. Instrum. 87, 103701 (2016)

[1]E. Galtier, B. Nagler, H. J. Lee, S. Brown, E. Granados, A. Hashim, E. McBride, A. Mackinnon, I. Nam, J. Zimmerman (SLAC) A. Gleason (Stanford, LANL) A. Higginbotham (University of York) A. Schropp, F. Seiboth (DESY)