Abstract Submitted
for the DPP15 Meeting of
The American Physical Society

Melting and band gap-dynamics of shock-compressed graphite diagnosed by x-ray scattering at the LCLS[1] ULF ZASTRAU, European XFEL, HAE JA LEE, SLAC National Accelerator Laboratory — The diversity of the electronic properties of carbon makes it of key interest to the material science community; By contrast, at the high pressures typical of planetary and stellar interiors, the behavior of carbon is poorly understood with large uncertainties in the conductivity and even the material phase. Tremendous efforts have been made to measure properties of warm dense matter (WDM) in extreme conditions, e.g. temperatures in excess of 1000 K of temperature and pressures in the Mbar regime. In laboratory experiments, practical issues with gradients in the temperature and density of shock compressed matter have hindered accurate measurement and further from distinguishing theoretical models. Here, we present measurements of melting of graphite upon coalescence of two counter-propagating shocks using combinations of spatially and spectrally resolved x-ray scattering methods at the LCLS free electron laser. The MEC nanosecond lasers launch counter-propagating shock waves into graphite. At shock coalescence, pressures in excess of 1 Mbar are reached. At given time delay, we measure scattering from the sample using 5070 eV x-ray pulses. We employed curved mosaic and perfect imaging crystals for spatially resolved x-ray scattering. Compared with hydrodynamics simulations, we present data on plasmon dispersion, axial compression gradients and finally carbon melting at shock coalescence. We have indication for a widening of the band gap during compression of the solid, while the band gab fully closes in the melt.

[1]UZ was supported by the German Volkswagen Foundation.

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Date submitted: 24 Jul 2015 Electronic form version 1.4