International EMMI Workshop on Plasma Physics at FAIR, GSI Darmstadt, June 21 - 23, 2017

Contribution ID: **9**

Type: **not specified**

Recovery of shock-synthesized diamond and lonsdaleite from laser-driven graphite and plastic samples

Wednesday, 21 June 2017 16:00 (1h 45m)

Introduction

We are interested in the internal, chemistry-rich structure of the giant planets of our solar system and beyond. Using high energy lasers to shock compress samples of tens of micrometres, we can reach the extreme conditions that are present within those planets. Namely, more than a million times Earth's atmospheric pressure and temperatures of thousands of Kelvins, which are reached on a nanosecond timescale. When hydrocarbons are present under those extreme conditions diamond precipitation is very likely. Such a phenomena would have a significant influence on the internal structure and the heat transport mechanisms in giant planets. Apart from astrophysics there are strong scientific, technological and industrial interests regarding the generation of nanodiamonds because of their outstanding mechanical and optical properties as well as their non-toxicity [1]. Laser induced shock compression of hydrocarbons might be a good alterna-tive to current synthesis methods using explosives.

Motivation of the Experiment

Using laser-driven shocks, Kraus et al demonstrated the generation of cubic and hexagonal diamond from highly oriented pyrolytic graphite [2] as well as cubic diamond from polystyrene samples [3] using in-situ X-ray diffraction. For the upcoming experiment at GSI in November 2017 we aim to recover the nanodiamonds using target designs allowing the survival of the newly formed structures when released to ambient conditions. We expect a decent yield based on the X-ray diffraction analysis of the recent LCLS experiment [3]: about 50% of the carbon atoms in polystyrene turn into a cubic diamond structure upon shock transition. From the width of the diamond (111) Bragg peak the lower limit of the crystallite size is deduced to be 4 nm using the Scherrer formula. A successful recovery will shed light on the actual quantity of nanodiamonds and allows a sophisticated investigation with respect to their properties using various techniques such as Raman spectroscopy, Scanning Electron Microscopy (SEM) or Transmission Electron Microscopy (TEM). In addition, the existence of lonsdaleite will be clarified, which has recently been ques-tioned [4].

Experimental Details

This poster discusses the experimental set up at Z6 as well as various recovery target designs. For plas-tic samples, a double stage shock compression is necessary to reach the required pressures while keeping the temperature below the diamond melting line. This can be realised with the available pulse shaping ca-pabilities at GSI. Moreover, a VISAR system will determine the shock breakout to constrain density and pressure using simple foil targets. After that, the recovery targets will come into operation.

References

[1] V.N. Mochalin, et al. "The properties and applications of nanodiamonds." Nature nanotechnology 7.1 (2012): 11-23.

[2] D. Kraus, et al. "Nanosecond formation of diamond and lonsdaleite by shock compression of graphite." Nature communications 7 (2016).

[3] D. Kraus et al. "Formation of nanodiamonds in laser-compressed plastic at planetary interior condi-tions", submitted.

[4] P. Németh, et al. "Lonsdaleite is faulted and twinned cubic diamond and does not exist as a discrete

material." Nature communications 5 (2014).

Primary author: Ms SCHUSTER, Anja Katharina (Helmholtz-Zentrum Dresden-Rossendorf)

Co-authors: Dr GERICKE, Dirk (University of Warwick); Dr KRAUS, Dominik (HZDR); Dr PRENCIPE, Irene (Helmholtz-Zentrum Dredsen-Rossendorf); Dr VORBERGER, Jan (HZDR); Ms ROHATSCH, Katja (Helmholtz-Zentrum Dredsen-Rossendorf); Dr HARTLEY, Nicholas (Helmholtz-Zentrum Dredsen-Rossendorf)

Presenter: Ms SCHUSTER, Anja Katharina (Helmholtz-Zentrum Dresden-Rossendorf)

Session Classification: Poster Session with Coffee break