EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Lonsdaleite Properties from High-pressure Investigation of Impact Diamonds with Planar Defects	**Experiment number**: ES-472
Beamline: ID15B	**Date of experiment**: from:01.02.2017 to:06.02.2017	**Date of report**: 08.03.2017
Shifts: 15	**Local contact(s)**: Micheal Hanfland	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists, + indicates proposers):

*/+ Dr. Sergey Gromilov (1, 2); * PhD candidate Aleksandr Sukhikh (1, 2);

(1) Nikolaev Institute of Inorganic Chemistry / Novosibirk, Russia; (2) Novosibirsk State University / Novosibirsk, Russia;

*/+ Dr. Kirill Yusenko (3) Swansea University / Swansea, UK

The aim of the project was an investigation of pressure response of a number impact diamond up to 25 GPa. We investigated 5 crystals of 30-50 μm collected and preliminary characterized using *in house* single crystal diffractometer at ambient conditions equipped with a microfocus Cu X-ray tube. All particles have plate-shape and were loaded in DAC using He as a pressure-transmitting medium. Pressure response of lonsdaleite phase has been theoretically predicted using *ab initio* calculations. The main target was to prove bulk moduli for impact nanodiamonds as well as lonsdaleite intergrowths. We collected compressibility curves up to 20-25 GPa at room temperature and one sample was later laser-heated up to 2000-2500°C. At ambient pressure, lonsdaleite-rich diamonds undergo transformation into graphite above 1900°C. Under compression, lonsdaleite-rich samples do not show any phase transitions.

Nanostructured diamonds usually show lower bulk moduli (300-350 GPa) in comparison with pure bulk mono-crystalline diamonds. Nevertheless, bulk modulus for lonsdaleite hexagonal phase should be similar to bulk cubic diamond according to recent theoretical predictions. We experimentally prove high bulk moduli for both, cubic diamond nanostructured matrix and lonsdaleite intergrowths. Both phases show isotropic compression with identic slopes (Figure 1), which proves low compressibility of lonsdaleite.

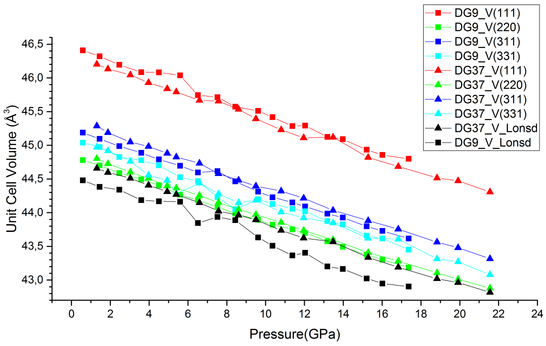


Figure 1. Selected compressibility curves for cubic diamond matrix and lonsdaleite intergrowths.

We also performed two compressibility experiments with multicomponent alloys asa part of our on-going research in the area of high-entropy alloys. Our refractory *hcp*-HEAs represents the first family of truly single-phase *hcp* alloys with unique HT—HP stability as single phase up to their melting temperature (*ca.* 2000-2500 °C) and 50 GPa (Figure 2). Similar experiments were performed with *hcp*-$Ir_{0.70}Re_{0.30}$ alloy up to 45 GPa with following off-line laser-heating. *hcp*-$Ir_{0.70}Re_{0.30}$ alloy show lower thermal expansion coefficients and smaller compressibility in comparison with individual metals.

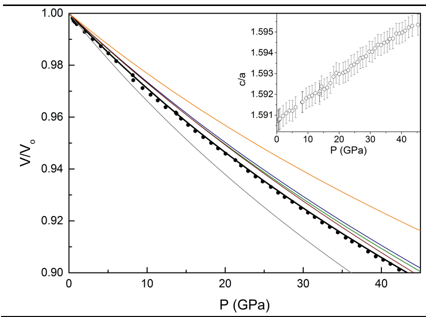
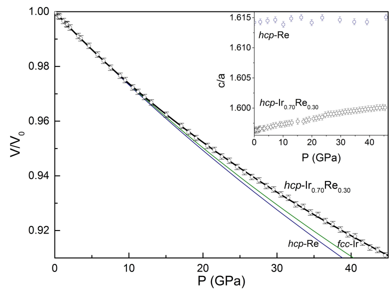


Figure 2. Room temperature compressibility of *hcp*–HEA *versus* pure components; insert shows *c*/*a* pressure dependence (*Left*). Pressure dependence of atomic volume for *hcp*-$Ir_{0.70}Re_{0.30}$, pure Ir and Re (*Right*). Insert shows pressure dependence of *c*/*a* ratio.



Two papers were already submitted following the experiment:

KV Yusenko, E Bykova, S Riva, M Bykov, TI Dyachkova, WA Crichton, A Sukhikh, S Arnaboldi, M Hanfland, LS Dubrovinsky, SA Gromilov (2017): Ir—Re binary alloys under high-pressure high-temperature conditions, *Acta Materialia*, *submitted*.

KV Yusenko, S Riva, PA Carvalho, S Arnaboldi, A Sukhikh, M Hanfland, SA Gromilov (2017): First hexagonal close packed high-entropy alloy with outstanding stability under extreme conditions and high electrocatalytic activity in methanol oxidation, *Chemistry – A European Journal, submitted.*