EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Carbon in the core: sound velocities of the Fe_7C_3 carbide at extreme conditions	**Experiment number**: ES-1253
Beamline: ID18 ID27	**Date of experiment**: from: 22.11.2022 to: 28.11.2022 from: 24.11.2022 to: 28.11.2022	**Date of report**:
Shifts: 18 12	**Local contact(s)**: Georgios Aprilis Mohamed Mezouar	*Received at ESRF:*

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Report:

The nuclear inelastic scattering (NIS) experiments were conducted using the facilities of the ID18 beamline. During the NIS experiments, we performed compression of Fe_7C_3 up to 175 GPa collecting NIS spectra about every 25 GPa. Online laser heating was conducted up to ~1900-2100 K at 40 GPa, 113 GPa, 138 GPa, and 169 GPa utilizing a portable laser-heating system for diamond anvil cells.

The high-pressure chambers for the experiment were prepared from Be gaskets and the Fe_7C_3-sample was pre-synthesized using the multi-anvil apparatus at the University of Münster. In order to check the composition and the homogeneity, the sample was characterized by the Electron Microprobe as well as XRD-analysis. Polycrystalline samples with linear dimensions of ~10x10x10 μm^3 were located in the pressure chamber between KCl, which served as a pressure transmitting medium and a thermal insulator. Special diamond anvil cells, designed for laser-heating NIS experiments were employed.

The data processing is currently in progress. As we aim to calculate sound velocities (compressional wave velocity v_p and shear wave velocity v_s) for Fe_7C_3 at conditions relevant to planetary cores, we need the Debye phonon average velocity (v_D), which consist of 90% v_s. In order to determine v_D we extract the partial phonon density of states of iron out of the nuclear inelastic scattering spectra. The selected energy dependence on nuclear inelastic scattering of Fe_7C_3 at room temperature and 1800 K is shown (Fig. 1). Detailed data processing is currently in progress.

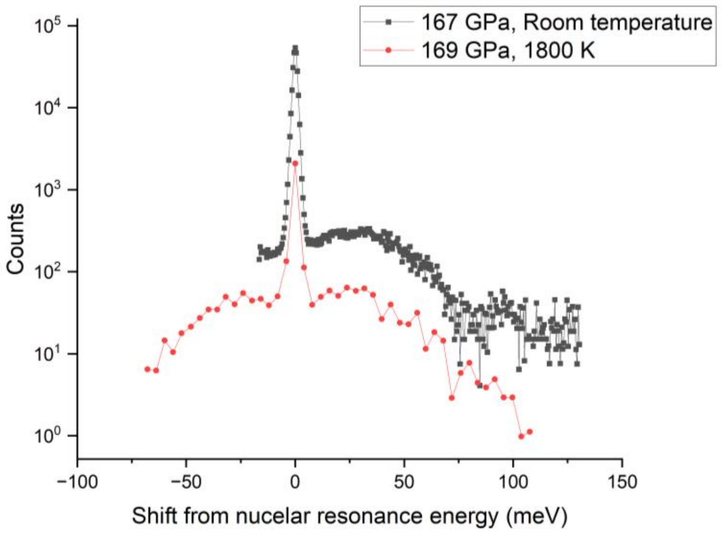

Figure 1: Energy dependence of nuclear inelastic scattering for Fe_7C_3 at 168(2) GP at room temperature (black) and at 1800 K (red).

In combination with density and bulk modulus, determined by the thermal equation of state of Fe_7C_3, it is possible to calculate shear and compressional wave velocities at high temperatures and high pressures. The thermal equation of state was measured using the facilities of the ID27 beamline up to 240 GPa at room temperature and 1800-2500 K. The preparation of the diamond anvil cell is described above. As a gasket material Re was used instead of Be and the standard membrane cells available at the ESRF were used. The P-V-T dependence can be extracted out of the measured diffraction patterns (Fig. 2) and can be fitted to retrieve the thermal equation of state parameters, in order to calculate density and bulk modulus at high pressure and temperature.

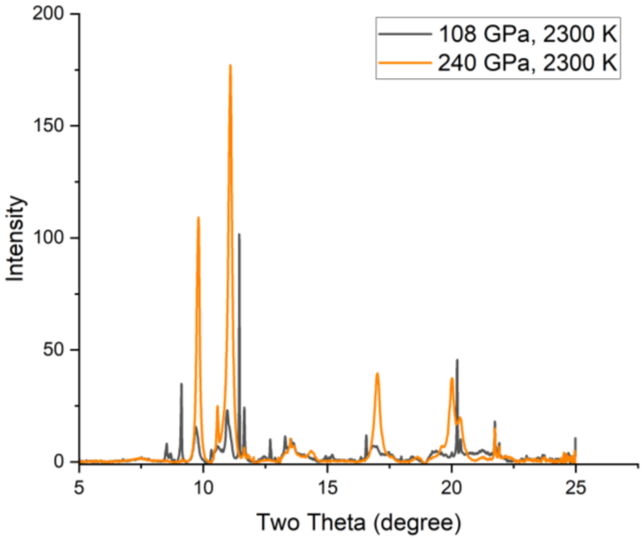

Figure 2: Comparison of XRD-pattern at 108 GPa at 2300 K (black) and at 240 GPa at 2300 K (orange).