Compressibility and phase transition in a zirconium alloy

A.E. Shestakov, A.V. Sedov

Russian Federal Nuclear Center - Zababakhin All-Russia Research Institute of Technical Physics (RFNC-VNIITF), Snezhinsk, Russia

Keywords: zirconium alloy, high pressure, static compression, X-ray diffraction measurements, Compressibility, phase transition.

*e-mail: a.e.shestakov@vniitf.ru

This study is aimed to get experimental data on the α→ω phase transition in the zirconium alloy (Zr – Nb 1% - Sn 1.2% - Fe 0.35%, % wt) under static compression. This alloy proves to be promissing for applications mainly as fuel-element jackets. Compressibility and a possible α→ω phase transition need to be taken into account in calculations of the material behavior under high pressures and temperatures, as well as for prediction of its behavior in severe use conditions and in possible incidents.

In our work, X-ray diffraction measurements on the alloy are taken in the range from the standard pressure to 11 GPa at room temperature. The X-ray diffractometer with the Imaging Plate two-axis detector was used for measurements in the Mo-Kα radiation. Boehler-Almax Diamond Anvil Cell (DAC) was used for the uniform spherical compression of the sample. Sodium chloride (NaCl) served as the pressure propagation medium and the diffraction standard. The gasket was made of inconel metal.

Experimentally in the alloy, measurements revealed coexistanceof α- and ω-modifications of zirconium in different volumetric proportions within 6.9±0.3 to 10.9±0.3 GPa.

Pressure of the α→ω phase transition onset under the static volumetric compression is higher in the alloy compared to pure zirconium. In the case of reduction down to the standard pressure, the reverse ω→α transition is not observed to take place just like in pure zirconium.

Parameters of the ω-phase lattice under standard pressure are determined. In the case of the α→ω transition, decrease of volume per one atom was found to make 1%. Isothermal modulus of volume elasticity under normal conditions for the α-phase is approximately 10% higher in the alloy if compared to pure zirconium.