Impact of Swift Heavy Ion Irradiation on Bismuth Nanowires and its Phase Transitions

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The irradiation of solids with heavy ions induces defects and structural changes and enables us to selectively influence characteristic material properties [1]. The combination of ion irradiation and high static pressures has shown that relative phase stabilities at high pressures may be modified and that new thermodynamic pathways may become accessible [2]. So far, these effects have only been observed in a few materials.

In the present study, we plan to compress bismuth nanowires to high static pressures and subsequently expose them to heavy ions of GeV energies at the GSI heavy ion accelerator facility. The aim is to investigate the impact of structural changes induced by ion irradiation on pressure-induced phase transitions in nano-materials.

As a model system, bismuth was selected due to its well characterized pressure-induced phase transitions, which occur at room temperature at 2.5, 2.8, and 7.7 GPa for the phase transitions Bi-I to Bi-II, Bi-II to Bi-III, and Bi-III to Bi-V, respectively. The same applies to temperature-dependent phase transformations, which can occur from 460 K upwards [3]. In contrast to metals, bismuth is known to be sensitive under swift heavy ion irradiation [4]. In a first step of the project, the effects of pressure and ion irradiation are investigated separately.

Here we present the fabrication of bismuth nanowires with tailored diameter and crystallinity by means of ion-track technology combined with template based electrodeposition. Ion-induced morphological and structural changes obtained by irradiation at ambient conditions and a comparative study of the equation of states of non-irradiated bismuth nanowires using diamond anvil cells (DACs) will be discussed.

This project makes use of a newly installed setup at the ion synchrotron of GSI, which accelerates ion beams to sufficiently high kinetic energies (up to 50 GeV) in order to reach the nanowires pressurized inside the DAC. The setup is equipped with on-line Raman spectroscopy to characterize the compressed samples during irradiation.

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