Low fluence swift heavy ion irradiation of amorphous germanium

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The high electronic energy deposition of swift heavy ion (SHI) irradiation causes interesting radiation damage effects in amorphous germanium (a-Ge) such as plastic flow and nano-porosity [1]. However, only a buried porous layer and no or at least discontinuous ion tracks can be observed in the case of SHI irradiated c-Ge [2,3].

In this study we show the onset of irradiation damage due to SHIs in a-Ge. A 1.3 μm surface layer of c-Ge was pre-amorphised by multi-energy self-ion implantation. SHI irradiations were performed at the 14UD Heavy Ion Accelerator Facility using 185MeV Au^{13+} ions with ion fluences ranging from $1\times10^{10}cm^{-2}$ to $5\times10^{11}cm^{-2}$.

Synchrotron based Small Angle X-ray Scattering (SAXS) give evidence of SHI irradiation induced ion-tracks in a-Ge. The scattering spectra of the ion-tracks can be fitted by using a model function of a cylindrical electron density distribution with an internal core shell structure. Core and shell are both of constant electron density but one being over- the other under-dense with respect to the surrounding a-Ge matrix. The dimension of core and shell add up to an over-all ion-track radius of 11.1±0.8 nm. The scattering intensity of the SAXS spectra scales with the ion-fluence up to a fluence of $1\times10^{11}cm^{-2}$ where the overlap of the ion-tracks is negligible. Scattering features in the SAXS spectra start to become blurred due to an increased ion-track overlap (40% for $3\times10^{11}cm^{-2}$) and indicates that the scattering is not coming from separated ion-tracks anymore.

Furthermore, the scattering streaks of the ion-tracks of SHI irradiated a-Ge are always accompanied by an anisotropic area of increased intensity on either side of the streaks in the SAXS images. This additional scattering feature originates from voids that are generated along the ion trajectory. TEM images and the anisotropy of the scattering features show that the voids are of non-spherical shape and well aligned with the ion-tracks. Ongoing SHI irradiation leads to a growth of the voids until an extended porous network is formed in the a-Ge layer [1]. Hence, single impacts of SHI in a-Ge generate both ion-tracks and voids along the ion trajectory and mark the onset of the SHI irradiation induced nano-porosity in a-Ge.

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