

High Resolution Synchrotron X-Ray Diffraction of Swift Heavy Ion Irradiated Graphite

C. Hubert^{1,2#}, M. Tomut^{1,3##}, K. Kupka^{1,2}, A. Romanenko^{1,2}, B. Schuster^{1,2}, H-P.Liermann⁴ and C. Trautmann^{1,2}

¹GSI, Darmstadt, Germany; ²TU Darmstadt, Germany; ³NIMP Bucharest, Romania; ⁴DESY Petra III Beam line P02, Hamburg, Germany

The use of graphite as material for the Super-FRS target and beam catchers at FAIR requires a proper understanding of ion-beam induced structural changes and defect formation.

The irradiation of high-density isotropic graphite was performed at the UNILAC with a flux of 1×10^9 ions/cm²s. The samples were exposed to 3.6-MeV/u Au ions of fluences up to 1×10^{14} ions/cm².

For structural analysis, synchrotron XRD measurements were performed at the P02 beam-line of Petra III (DESY, Hamburg) using a wavelength of 0.29135Å. The facility provides x-ray beams of very high brilliance, allowing transmission experiments with high resolution in real and reciprocal space [1]. The micro-focused beam spot and the high precision sample positioning made it possible to perform spatially resolved X-ray diffraction along the ion trajectories of the irradiated samples.

Diffractograms of graphite exposed to different fluences are shown in Fig. 1. In contrast to the 100 and 101 peaks significant broadening and intensity reduction are observed for the 002 and 004 diffraction peaks. This process is ascribed to a distribution of increased inter-planar distances along the c-axis of the graphite crystal due to interstitial clusters formation. With increasing fluence, the interstitial clusters coalesce to new crystalline planes, leading to turbostratic graphite formation.

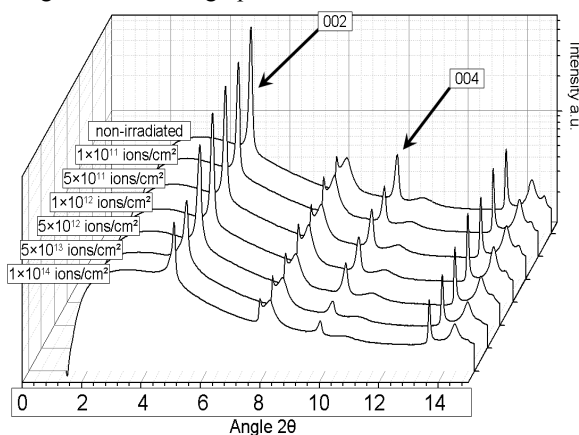


Figure 1: Synchrotron XRD patterns of isotropic graphite samples irradiated with 3.6-MeV/u Au ions and increasing fluences (x-rays collinear with ion tracks)

* Work supported by GSI-TUD cooperation contract and HGS-HIRE.

c.hubert@gsi.de, ## m.tomut@gsi.de

The second type of measurements focused on monitoring structural changes along the ion trajectory. The x-ray beam thus scanned through the cross-section of the sample (x-rays normal to ion tracks). The X-ray beam spot has a size of $2 \mu\text{m} \times 2 \mu\text{m}$. As presented in Fig. 2, a maximum of structural disordering occurs at a sample depth of around $45 \mu\text{m}$, as evident by the decreased intensity and broadening of the 002 diffraction peak. According to the SRIM code, this depth position correlates well with the energy deposition due to the elastic collision cascade.

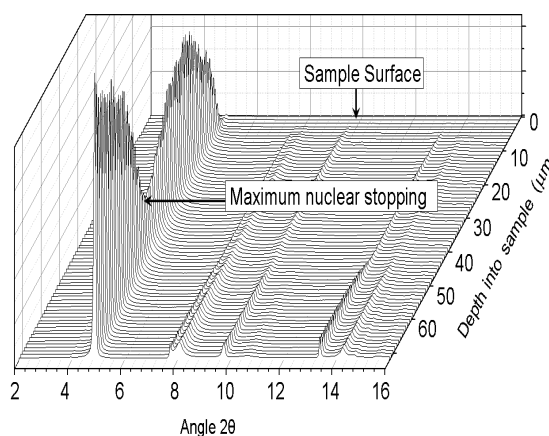


Figure 2: XRD-spectra of isotropic graphite recorded in cross-sectional geometry (x-rays perpendicular to ion tracks). The irradiation was performed with 3.6-MeV/u Au ions of 5×10^{13} ions/cm²

The analysis shows that the irradiation of graphite with 3.6-MeV/u Au ions mainly induces disordering due to defect cluster formation. Increasing ion fluence enhances the disordering. At the stopping end of the ions, elastic collisions are more effective than electronic excitation in inducing structural disorder. A perfect alignment of the sample and beam was difficult. The gradual intensity increase of the 002 peak at the surface is due to the finite X-ray beam-spot size and sample positioning. The broadening of the disorder effect at a range of $45 \mu\text{m}$ is due to irradiation-induced bending of the sample.

[1] H.-P. Liermann et al., The Extreme Conditions Beam-line at PETRA III, DESY: Possibilities to conduct time resolved monochromatic diffraction experiments in dynamic and laser heated DAC. J. Phys., Conf. Ser. 215 (2010) 012029.