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Simultaneous SAXS and WAXS ion track recovery studies on metallic glasses and consequences on their magnetization properties

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Amorphous metals, also called metallic glasses, are metallic alloys with a disordered non-crystalline atomic structure. There is a high level of interest in metallic glasses as consequence of their particular structure, lacking of medium and long range order leading to interesting physical properties such as high mechanical strength, great wear and corrosion resistance, and high elasticity [1]. Furthermore, such interesting mechanical properties combined with permanent magnetization (as in Fe- and Co-based alloys) have motivated an important emerging field through the recent development of nanocrystalline materials from metallic glasses for magnetic applications. Nanocrystalline Fe based alloys exhibit outstanding magnetic properties characterized by a very low coercivity and very high saturation magnetization.

Ions at energies of some MeV per nucleon lose their energy predominantly to the electronic system when passing through matter. In this process, energy transfer from the electronic system to the atoms due to electron-phonon coupling may finally lead to the formation of long columnar defects along the ion trajectories, so called ion tracks [2,3].

Simultaneous synchrotron based small and wide angle X-ray scattering (SAXS and WAXS) study is presented on swift heavy ion irradiated amorphous Fe –B based metallic glasses. Melt-spun ribbons with cylindrical ion tracks produced by irradiation with 2 GeV U and 2.2 GeV Au ions were annealed in situ with temperatures of up to 440℃. Ion track recovery followed by crystallization of the alloy is observed. While the ion track radius remained approximately constant during annealing, the SAXS scattering intensities of individual monodisperse ion tracks decreased until vanishing before the onset of crystallization. Subsequently SAXS/WAXS indicates the nucleation of α-Fe and Fe_3B nanocrystals. The time evolution of the particle size distribution revealed a nucleation dominated crystallisation process. Through magnetic measurements of the metallic glasses irradiated to different doses, ion tracks induced microstructural changes in the material were found to reduce the magnetic coercivity of the nanocrystalline material.

[1] A. Inoue and A. Takeuchi, Acta Materialia (2011), doi:10.1016/j.actamat.2010.11.027
[2] P. Kluth et al., Phys. Rev. Lett. 101 (2008) 175503
[3] M. D. Rodriguez et al., J. of Non-Cryst. Solids 358 (2012) 571

Speakers Gender

Male

Travel Funding

No

Level of Expertise

Experienced Researcher

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No

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