In situ annealing studies of ion tracks in amorphous Fe-B alloys

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Ion tracks in amorphous materials are characterized only by subtle differences in structure and density between track and matrix material [1, 2]. This lack of contrast leaves the complex structure of ion tracks inaccessible with most experimental techniques. As a consequence, there is currently little information about ion tracks in metallic glasses while still in the amorphous phase.

We investigated the morphology of ion tracks produced in Fe-B based (amorphous) metallic glasses and their influence on the recrystallisation behaviour upon *ex situ* annealing [3] using synchrotron based small angle x-ray scattering (SAXS). The tracks are cylindrical and show a density difference to the matrix material of less than 0.1 % [2]. The ion tracks were generated with various heavy ion beams with energies ranging from 500 MeV to 2.2 GeV. The fluence varied between 1×10^{10} and 3×10^{11} ions/cm^2 which is sufficiently low to form individual ion tracks with negligible overlap. The annealing kinetics of the ion tracks were studied with simultaneous SAXS and wide angle x-ray scattering (WAXS) in combination with *ex situ* isochronal annealing experiments. The *ex situ* annealing of the samples showed a clear change of the track radii due to the relaxation of the ion track boundaries. Such track recovery occurs while the material still is amorphous and gradually becomes brittle [3].

SAXS/WAXS *in situ* annealing measurements were performed at the Australian Synchrotron, in Melbourne, to further investigate the recovery of the ion tracks. Series of regular isothermal annealing steps of 15 to 25 min, comprised of 15 s exposure time measurements, were collected between room temperature and 550°C.

Figure 1 shows the SAXS intensity profiles of annealed tracks of $Fe_{80}B_{20}$. The positions for the minima in the track intensity profiles determine the track radius. The intensity data were fitted assuming cylindrical track geometry of constant radial density difference with respect to the matrix material. The radii extracted from the fits show a nearly constant value (Fig. 2), which is in contrast to the earlier *ex situ* annealing experiments. However, the maximum intensities from the track signals (at $q \approx 0.001$ Å^{-1})) decrease with increasing annealing time (not shown here) and temperature (see Figure 2). These results suggest that the track radius remains approximately constant during the annealing process. Whereas the intensity decrease is an indication of different scenarios: the number of ion tracks in the material decreases (unlikely), the density difference between the matrix and tracks decreases and/or the ion tracks gradually reduce their length. Further studies are in progress to clarify the differences found between *ex situ* and *in situ* annealing processes.

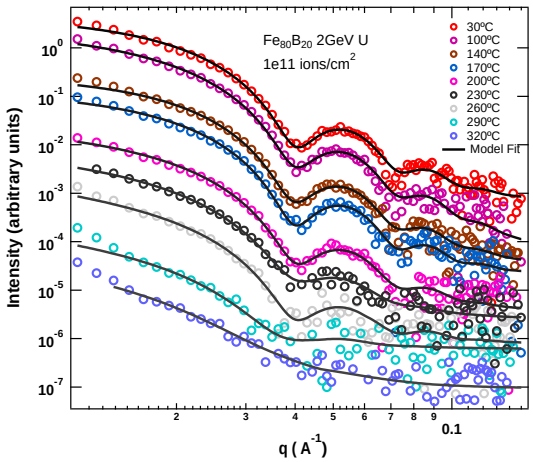

Figure 1: SAXS intensities as a function of scattering vector q (symbols) and corresponding fits (lines) with the hard cylinder model for different annealing temperatures. Vertical shifts of are applied for better visualization.

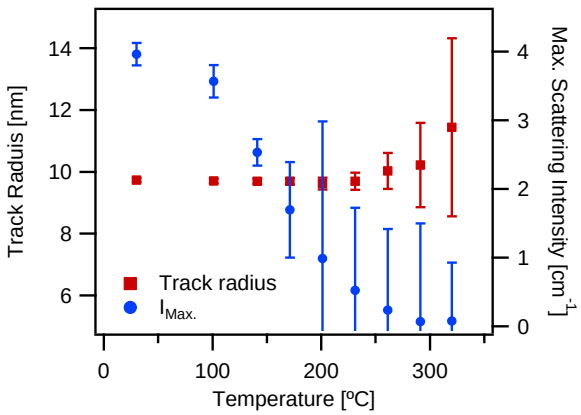

Figure 2: Track radii extracted from fits to SAXS data and experimental maximum SAXS scattering intensity (at q≈0.001Å^{-1}) versus annealing temperature for 15 min isothermal steps.

References

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