ions/cm^2, the values of TA/TO and LA/TO increase from 0.27 to 0.37 and from 0.15 to 0.23, respectively. The FWHM of TO peak increases from 66.9 to 69.8 cm^{-1} after irradiation. These results indicate that the irradiation results in the decrease of the short-range structural order of the amorphous network in the samples[2]. The optical band-gap of a-Si : H films decreases from 1.99 to 1.72 eV as the ion fluence increases from 0 to 1.0×10^{17} ions/cm^2, as shown in Fig. 4. The reduction of optical band-gap is related with the decrease of short-range structural order, which widens the band-tails of valence and conduction bands, and then results in the decrease of optical band-gap[3].

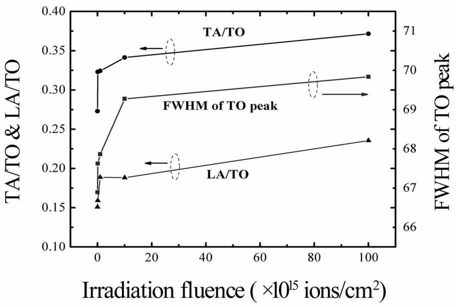

Fig. 3 The values of 3 samples as a function of ion fluence.

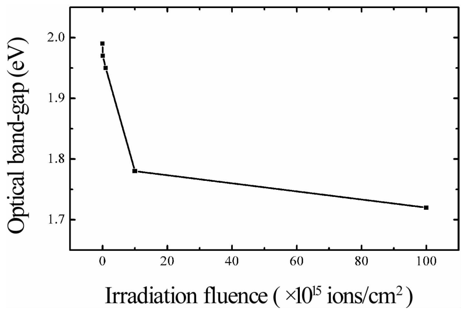

Fig. 4 The optical band-gap varying with the ion fluence.

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3 - 3 Local Crystallization induced by Swift Heavy Ion Irradiation in FeSiNbZrB Metallic Glass

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Metallic glass (also known as amorphous alloy) is a kind of new alloy materials synthesized by using modern rapid solidification metallurgical technology, owning excellent mechanical, physical and chemical properties that general metal and glass have. Its unique glassy structure leads to its high performance (such as high strength, corrosion resistance, great ductility, and having a wide supercooled liquid region, etc., just like the high-quality magnetic functional materials), generating enormous potential for development and application[1-3]. Along with the in-depth research and development of metallic glass materials, two fundamental but not yet answered scientific questions inevitably lay in front of us: what are the mechanisms of the relaxation behavior as well as the plastic deformation of the metallic glasses? The exogenous energies (force, heat, etc.) can lead to the transition between the glass localized in the shear deformation and shear zones and the liquid[3]. As is well known, conventional energetic ions lose energy in materials by inelastic and elastic collisions, and these energy losses are termed as electronic (S_e) and nuclear (S_n) stopping powers, respectively. So, ion irradiation process is a kind of special exogenous energy deposition process in materials. In order to understand the relaxation behavior and plastic deformation mechanisms of the metallic glass, in our experiment, swift heavy ion (SHI) irradiation as a kind of special non-equilibrium and exogenous energy deposition process will be applied to the study on the mechanisms of relaxation and plastic deformation of the metallic glass.

FeSiNbZrB ($Fe_{77.5}Si_{9.5}Nb_{3.0}Zr_{1.0}B_9$, at%) amorphous ribbons (2.0 mm×0.02 mm in size of cross section) were prepared by melt spinning method. And the SHI irradiation experiment was performed on the material research terminal of the 320 kV ECR platform at the Institute of Modern Physics (IMP), Lanzhou. In experiment, amorphous FeSiNbZrB alloy ribbons were irradiated at room temperature (RT) with 5.0 MeV Xe^{26+} ions of fluence ranging from 1.0×10^{12} to 1.0 10^{15} ions/cm^2.

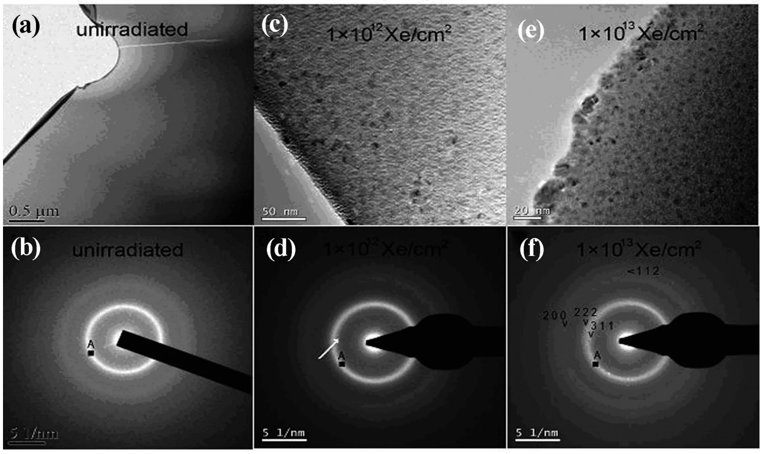

Fig. 1 The bright field TEM images of the FeSiNbZrB ribbons: (a) the pristine ribbons; (c) the ribbons irradiated up to a fluence of 1.0×10^{12} Xe/cm^2; (e) the ribbons irradiated up to a fluence of 1.0×10^{13} Xe/cm^2. (b) The corresponding ED pattern of the pristine FeSiNbZrB ribbons with the amorphous (A). (d) The ED pattern of the ribbons irradiated up to a fluence of 1.0×10^{12} Xe/cm^2 with the amorphous (A) and Debye rings indicated by a white arrow newly appeared. (f) The ED pattern of the ribbons irradiated up to a fluence of 1.0×10^{13} Xe/cm^2 with the amorphous (A) and the (3 1 1), (2 2 2), (2 0 0) and (1 1 2) rings of α-Fe(Si).

The electron diffraction pattern is composed of concentric rings, which means that our samples that contain no long-range order in the atomic lattice produce diffuse ring diffraction patterns with no discrete reflection and one diffuse ring of maximum intensity. The pristine ribbon shows typical amorphous state that is different from irradiated samples. After irradiating, amorphous ribbons become loose obviously and there are some finer precipitations with diameters of 1～2 nm on the irradiated samples. In addition, the finer precipitations have not obviously grown up with the increase of irradiation dose. The bright field selected area electron diffraction (SAED) (Fig. (b),(d) and (f)) of irradiated ribbons is very similar to the pristine samples′ indicating a similar long-range disorder, but there are some intensity diffraction spots mixed in the diffuse rings in irradiated ribbons′ pattern, which confirms that the finer precipitations have the crystallization structure. It is clear that after irradiation, not a single-phase amorphous structure but a two-phase amorphous structure is seen. A small amount of crystalline precipitate embedded in amorphous matrix is also seen in the SAED image, and the number and intensity of the Debye rings increase with increasing total dose. At high level fluence, the local crystallization phenomenon becomes obvious and the nanocrystal precipitations do not grow. The result of EDX shows that the crystalline precipitations consist mainly of Fe, Si and B elements. From above TEM and EDX results, it can be inferred that irradiation of 5.0 MeV Xe-ions with dose of 1.0×10^{12} ions/cm^2 can lead to local crystallization of amorphous FeSiNbZrB alloy ribbons and form nanocrystal precipitations with diameter of 1～2 nm. In addition, occurrence of the irradiation-induced crystallization strongly depends on the irradiation fluence ranges, and the nanoprecipitations do not grow as the Xe-ions fluence increases. But TEM and XRD results have not shown obvious consistency. In order to further verify the results of TEM and confirm the composition of nanocrystal precipitations, transmission m ssbauer spectroscopy with high velocity resolution should be done further.

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