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Amorphization of $Zr_{45}Cu_{45}Al_{10}$ alloy induced by 200 MeV Au ion irradiation

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1 Introduction

Amorphous alloys have been of great interest because of their peculiar properties which are quite different from those of crystalline alloys. Amorphous alloys have usually been produced by rapid solidification, mechanical alloying or grinding. In the present study, we have used high-energy ion irradiation as a tool for the amorphization of $Zr_{45}Cu_{45}Al_{10}$ ternary alloy[1)].

2 Experiment

We prepared $Zr_{45}Cu_{45}Al_{10}$ ternary alloy ingots by arc melting method in an argon atmosphere. After the annealing of the ingots at 873 K, they were cut into several sheets with the dimension of 10mm x10mm x1mm. The sample sheets were irradiated with 200 MeV Au ions at room temperature using a tandem accelerator at Nuclear Science Research Institute, Japan Atomic Energy Agency (JAEA-Tokai). The changes in lattice structure and local atomic arrangements around Cu atoms were investigated using the x-ray diffraction (XRD) and the extended x-ray absorption fine structure (EXAFS) measurements, respectively. The positron annihilation lifetime measurement was also performed using $^{22}NaCl$ as a positron source.

3 Results and Discussion

Fig. 1 shows the XRD spectra for the unirradiated sample and that irradiated with 200 MeV Au ions. In the spectrum for the unirradiated sample, XRD peaks corresponding to Zr_2Cu and Zr_7Cu_{10} are clearly observed. After the 200 MeV Au ion irradiation with the fluence of $1x10^{14}/cm^2$, these crystalline peaks mostly disappear,

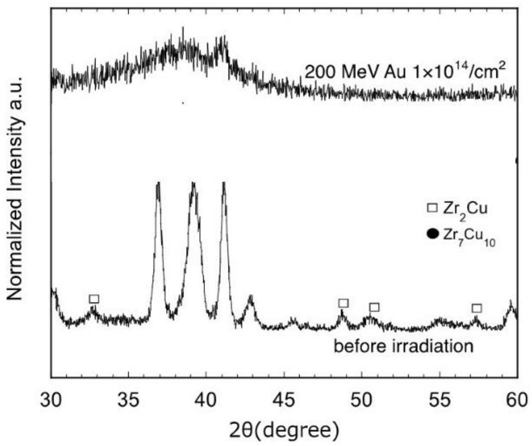

Fig. 1 XRD spectra for unirradiated and irradiated $Zr_{45}Cu_{45}Al_{10}$ alloy samples.

and a broad pattern appears around 38 degrees, implying that the sample was amorphized by the irradiation.

As can be seen in Fig. 2, the disordering of atomic arrangements around Cu atoms is observed as a decrease in the intensity of Fourier-transformed EXAFS spectra (FT-EXAFS spectra) by the irradiation.

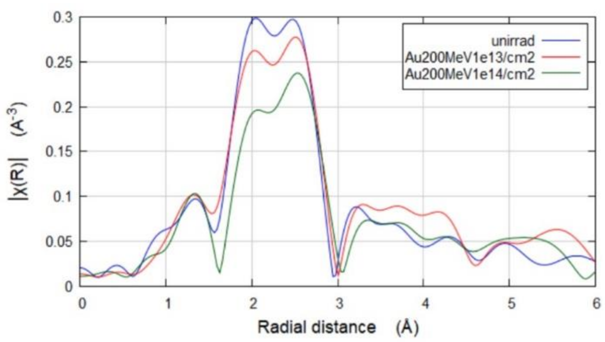

Fig. 2 FT-EXAFS spectra around Cu-K absorption edge for unirradiated and irradiated $Zr_{45}Cu_{45}Al_{10}$ samples

Fig. 3 shows that the positron annihilation lifetime tends to increase by the irradiation. It is well known that the positron lifetime for amorphous materials is longer than that for crystalline materials due to the existence of free volume. Therefore, the experimental result shown in Fig.3 is an evidence for the irradiation-induced amorphization.

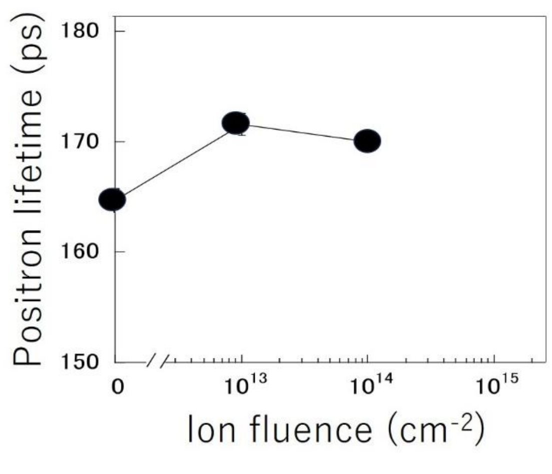

Fig. 3 Change in positron annihilation lifetime for $Zr_{45}Cu_{45}Al_{10}$ as a function of Au ion fluence.

Fig. 4 shows the change in Vickers hardness of $Zr_{45}Cu_{45}Al_{10}$ samples as a function of 200 MeV Au ion fluence. The Vickers hardness increases by the irradiation, and tends to be saturated at higher fluence.

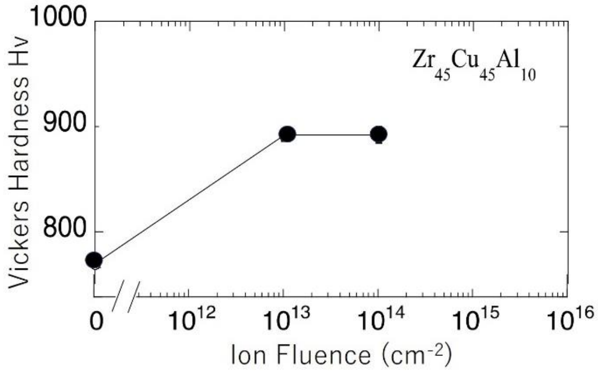

Fig. 4 Change in Vickers hardness as a function of 200 MeV Au ion fluence.

In conclusion, the amorphization of $Zr_{45}Cu_{45}Al_{10}$ crystalline alloy by 200 MeV Au ion irradiation was observed as changes in the XRD spectra, the FT-EXAFS spectra, and the positron lifetime. The Vickers hardness of the samples increased by the irradiation.

Acknowledgment

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Reference

[1] F. Hori *et al.*, *Nucl. Instrum. Methods* **B535**, 11-14 (2023).

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