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Amorphization Process of Two-Phase $Ni_{30}Zr_{70}$ Alloy by High-Energy Heavy Ion Irradiation

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1 Introduction

Amorphous alloys have peculiar properties such as high mechanical hardness, toughness, and corrosion resistance. They are generally produced by quenching crystalline alloys from their liquid state. The amorphization of crystalline alloys is also possible through high-energy particle irradiation. In our previous papers, we have reported the ion irradiation-induced amorphization of one-phase intermetallic compounds such as Ni_3Nb [1,2], Ni_3Ta [1,2], and NiTi [3]. Although a lot of industrially used alloys are multi-phase alloys, there have never been many studies on irradiation-induced amorphization for multi-phase alloys. In the present report, we will show the amorphization process of the two-phase NiZr alloy by the high-energy heavy ion irradiation [4].

2 Experiment

Samples for the present study were sheets of $Ni_{30}Zr_{70}$ two-phase alloy with a dimension of 4x4x0.5 mm^3. They were irradiated with 100 MeV Au ions at room temperature using a tandem accelerator at Nuclear Science Research Institute of Japan Atomic Energy Agency (JAEA). The ion fluences were$1x10^{13}$, $5x10^{13}$, $1x10^{14}$ and $5x10^{14}/cm^2$.

X-ray diffraction (XRD) measurements were performed to observe the change in crystal structures of the samples due to the irradiation. In addition, to obtain some information about the atomic arrangements around Zr and Ni atoms in the unirradiated and irradiated samples, the extended x-ray absorption fine structure (EXAFS) measurements were carried out near the Ni-K absorption edge (8.3 keV) and the Zr-K absorption edge (18 keV).

3 Results and Discussion

Fig. 1 shows the surface image of the optical microscope for the unirradiated $Ni_{30}Zr_{70}$ sample. The surface image surely shows that the sample consists of two phases.

Fig. 2 shows the XRD spectra of the unirradiated sample and those irradiated with 100 MeV Au ions. The XRD spectrum for the unirradiated sample confirms that the sample consists of pure Zr phase and $NiZr_2$ phase. By the ion irradiation, XRD peaks for the $NiZr_2$ phase tend to disappear, and a broad peak gradually grows, but the peaks corresponding to the pure Zr phase are little changed. The irradiation-induced change in the XRD spectrum implies that the $NiZr_2$ phase is amorphized by the irradiation, but that the lattice structure of the pure Zr phase remains the original structure even after the ion irradiation.

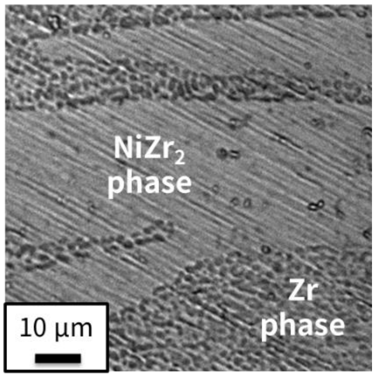

Fig. 1: Surface image of unirradiated $Ni_{30}Zr_{70}$ sample

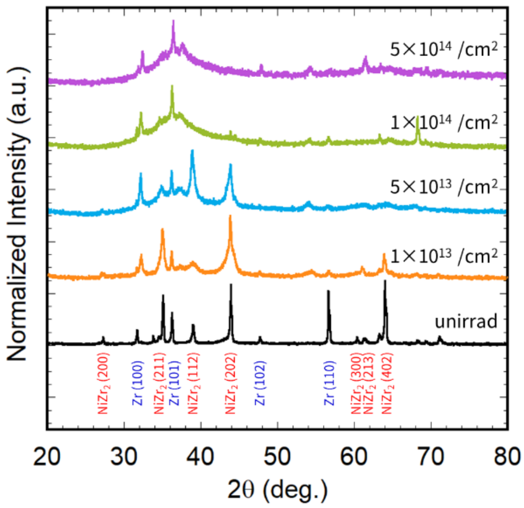

Fig. 2: XRD spectra for unirradiated and 100 MeV Au ion irradiated $Ni_{30}Zr_{70}$ samples.

Fig. 3 shows the FT-EXAFS spectra near Ni-K and Zr-K absorption edges. In Fig. 3a, the intensity of the main peaks around 2.7 Å, which correspond to the bonding of Ni atoms with their nearest neighbor atoms (Ni and/or Zr atoms), decreases with increasing ion-fluence. The result indicates that the atomic arrangement around Ni atoms is disordered by the irradiation. On the other hand, in Fig. 3b, the intensity of the main peaks around 2.8 Å and other peaks is almost unchanged even by the irradiation. This result implies that the atomic arrangement around Zr atoms in the pure Zr phase and/or the $NiZr_2$ phase is little changed even after the irradiation.

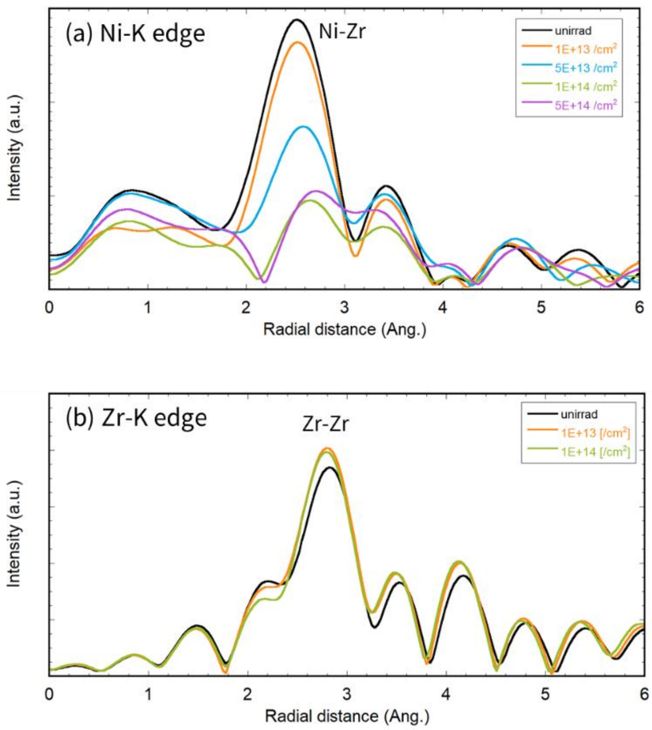

Fig. 3: Effects of 100 MeV Au ion irradiation on FT-EXAFS spectra (a) near Ni-K edge and (b) near Zr-K edge.

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