Reaction of U-Mo alloy with Al

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1. Introduction

Uranium alloys with a high uranium density have been studied for a dispersion fuel in a research reactor. U-Mo alloy has been considered as one of the research reactor fuels [1]. In spite of its good irradiation performance, these alloys react with the matrix to form an interdiffusion layer which leads to a volume expansion and a degradation of the thermal properties [2]. The reaction between the U-7wt%Mo alloy and the Al matrix should be understood well to evaluate a fuel performance.

In this study, the reaction layers in a U-7wt%Mo/Al diffusion couple were characterized by a micro X-ray diffraction system.

2. Experimental methods

A U-7wt%Mo/Al diffusion couple was prepared as reported by Park et al [3]. The couple was encapsulated in a vacuum sealed fused silica quartz tube, and then annealed at 580℃ for 5 hours. The annealed couple was cut perpendicularly to the diffusion direction, and was molded in epoxy resin. The cross section of the diffusion couple was ground and polished for an analysis.

For an analysis, a micro X-ray diffraction system developed in our laboratory was used. The details of this modified XRD system were described in a previous paper [4]. The measurement was carried out with a CuK_α line source filtered through a Ni foil and a scintillation counter (NaI) detector. The width of an exit slit and a detector slit was 0.05 mm and 0.6 mm, respectively. A spectrum was measured with a scanning step of 0.02° for 10 s per each count. The X-ray beam current was 40 mA at a 40 kV beam generation power.

3. Results

Fig. 1 shows the SEM images of the reaction zone at the U-Mo/Al interface after an annealing at 580℃ for 5 hours. The reaction layer grew to approximately 140 μm. From the images of Fig. 1, the diffusion couple can be divided by three zones, U-7wt%Mo alloy, diffusion layer, and Al metal. The XRD spectra were obtained at a position (a) in the U-7wt%Mo alloy, two positions (b, c) in the diffusion layer, and a position (d) in the Al metal (Fig. 2).

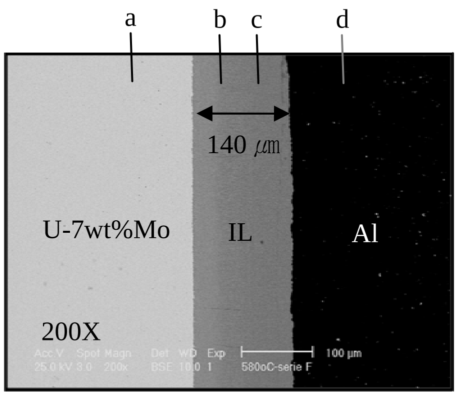

Figure 1. Scanning electron microscopy (SEM) image of U-7wt%Mo/Al diffusion couple annealed at 580℃ for 5h.

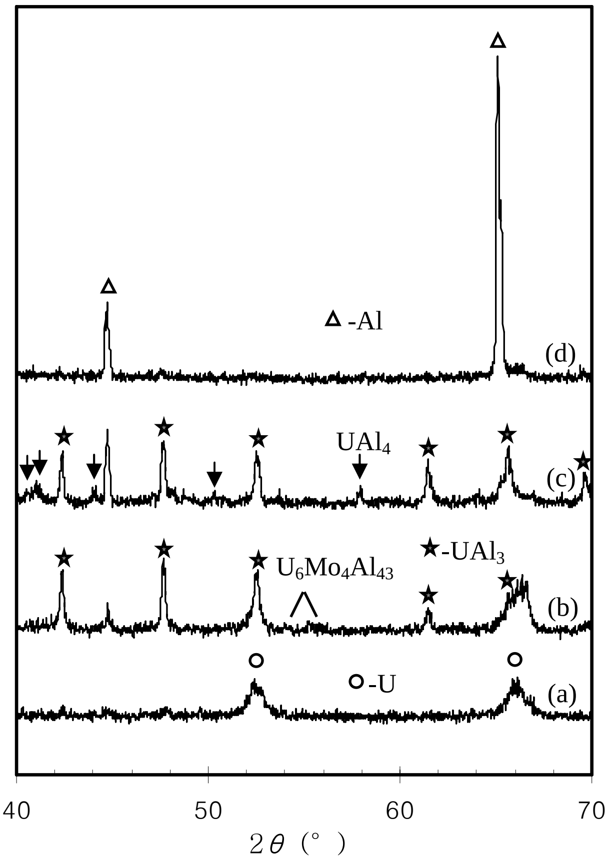

Figure 2. XRD spectra for four positions at a U-7wt%Mo alloy layer (a), diffusion layer (b, c) and a Al layer (d) in U-Mo/Al diffusion couple.

The XRD pattern of a position (a) showed a γ-phase U (cubic). It is known that γ-phase U (cubic) fuels are more resistant to a swelling during an irradiation than α-phase U (orthorhombic) fuels under a high temperature [1]. The pattern of a position (d) in the Al layer was an Al cubic phase.

In the diffusion layer, the XRD spectrum of U-7wt%Mo alloy side (b) showed phases of UAl_3 (cubic phase) and $U_6Mo_4Al_{43}$ (hexagonal phase) and that of the Al side (c) showed UAl_3 (cubic phase) and UAl_4 (orthorhombic phase). UAl_4 is known as a brittle compound.

3. Conclusions

U-Mo/Al diffusion couple was annealed at 580 ℃ and the reaction layer was measured by a micro XRD. The results were as follows. In the area of the interaction layer, UAl_3 (cubic) was formed as a major phase throughout the diffusion layer. The $U_6Mo_4Al_{43}$ (hexagonal) and UAl_4 (orthorhombic) phases were identified at the U-7wt%Mo alloy side and the Al side in the diffusion layer, respectively. The formation of the UAl_4 phase may be attributable to the brittleness of the fuel.

Acknowledgements

We acknowledge the financial support of Nuclear Development Fund from Korean Ministry of Education, Science and Technology.

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