Effects of Heavy Ion Irradiation on AlSc Alloys

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1. Introduction

Nanostructured alloys are currently of much interest for their potential applications in extreme environments. The defects produced by ions in Al are predominantly isolated Frenkel pairs. The simpler damage structure in Al greatly facilitates comparison with theoretical models. Among Al alloys, especially, dilute Al-Sc alloys shows potential for nuclear applications due to their excellent mechanical properties [1], corrosion resistance, and low neutron absorption. Sc additions to Al alloys have shown to offer superior radiation resistance for nuclear applications [2]. To have a better knowledge on irradiation damage, this work studied Effects of Heavy Ion Irradiation on AlSc Alloys.

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2. Methods and Results

2.1 Experimental

Nanocrystalline Al alloys are grown using an AJA DC magnetron sputtering system. Al alloy was annealed at 250°C for an hour and irradiated using a High Voltage Engineering Van de Graaff accelerator up to 40 DPA.

Microstructural characterization of the specimen was conducted using TEM and STEM methods. General images were obtained using JEOL 2010 LaB6. For High Resolution Transmission Electron Microscopy (HRTEM) imaging, especially, JEOL 2010F EF-FEG was employed using high angle annular dark field (HAADF)-STEM.

2.2 Dissolution of Sc Under Irradiation

A HAADF micrograph showing the microstructure of the $AlSc_{1.1}$ alloy after thermal annealing at 250°C for 1 hour is presented in Fig. 1. Precipitates are observed by HAADF imaging after annealing, and these precipitates are located at the grain boundaries, as shown in other study [3].

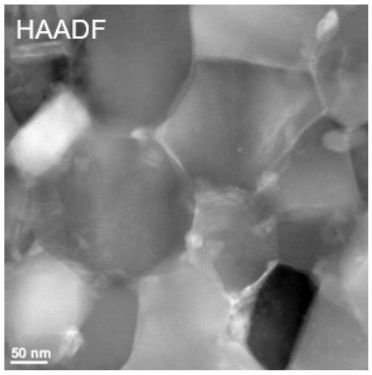

Fig. 1 $AlSc_{1.1}$ alloy after annealing at 250°C for an hour.

Figure 2(a) shows the micrograph of irradiated sample. An annealed AlSc alloy was irradiated up to 40 dpa at 75°C. After irradiation, dissolution of Sc precipitates at grain boundary is observed (Fig. 2(a)) and moreover, dislocation loops are also seen close to grain boundaries. Precipitate sizes is not reduced. The decrease in precipitation density, even without change in precipitate size is observed. According to these results, irradiation at 75 °C results in ion beam mixing that redistributes solute in the GBs [3].

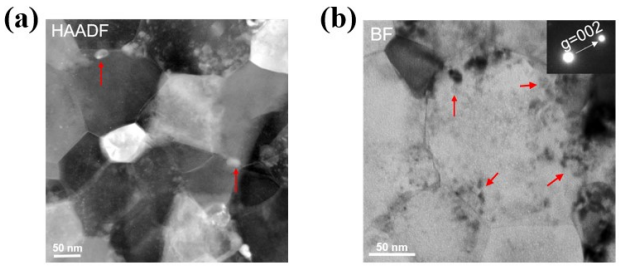

Fig. 2 TEM images after irradiation at 75 °C of $AlSc_{1.1}$ alloy (a) HAADF image, (b) bright field TEM image.

3. Conclusions

This work demonstrated effect of irradiation on pre-annealed AlSc alloy. After irradiation at 75 °C, Sc-rich precipitates near grain boundaries dissolved in to the Al matrix. The results reveal that 75 °C is ion beam mixing

dominant region and thus solutes are redistributed at 75°C.

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