Observation of Grain Boundary Grooving Behavior of Irradiated Quasi-Nano Filamentary Composites

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1. Introduction

Grain boundary grooving behavior is important because it influences various chemical, physical and mechanical properties such as corrosion resistance and wear resistance. The grooving behavior is related to capillary-driven evolution of surface topography in the region where grain boundary emerges at the free surface of materials. Thermal grooving mechanism for the sufficiently small grooves less than submicron is well studied, in which surface self-diffusion is the mechanism responsible for the groove growth.[1]

Since the grooving morphology is related to the minimization of Gibbs free energy at plat surface, a dihedral angle at the root of grain boundary of a real system is not isotropic due to defects near surface region. This means that the materials irradiated by neutron or deformed heavily show different grooving behavior because number of defects like vacancy and void becomes increased y those processes. Although, thermo-dynamical approach about grain boundary grooving is relatively well described by Mullins and his colleagues [2, 3], the grooving behavior after irradiation is less studied. Hence, the objective of this study is to study the effect of irradiation on grain boundary grooving. Emphasis is on the observation of grain boundary grooving behavior of irradiated filamentary composites.

2. Experimental Method

Copper-silver composite were prepared by sintering at 900^{o}C with copper powders and silver filaments and heavy extrusion at 750^{o}C followed by cold drawn to 1.5 mm. The drawn wire was hot iso-statically pressed at 750^{o}C at a pressure of 100 MPa to get full density. The wire was then swaged and drawn to achieve its final size of a 2x3 mm rectangular cross section. The specimen sectioned 1 mm in thickness and was irradiated in CT hole of HANARO for 36 days at 320^{o}C with the maximum neutron fluence of 4.8×10^{20} n/cm^2 (E>1.0 MeV). Specimens were kept in hot cell for reduction of activity. The specimen was annealing at 500-700^{o}C for various time. Surface morphology and chemical analysis were carried out field emission scanning electron microscopy (JSM 6700F) and energy dispersive spectroscopy (Oxford EDX).

3. Results and Discussion

Fig. 1 is the microstructure of as-received filamentary composites. As shown in Fig. 1, polycrystalline filaments less than sub-micron well aligned along extrusion direction. Based on microstructure observation and chemical mapping by EDX, the filament and matrix are silver and copper, respectively.

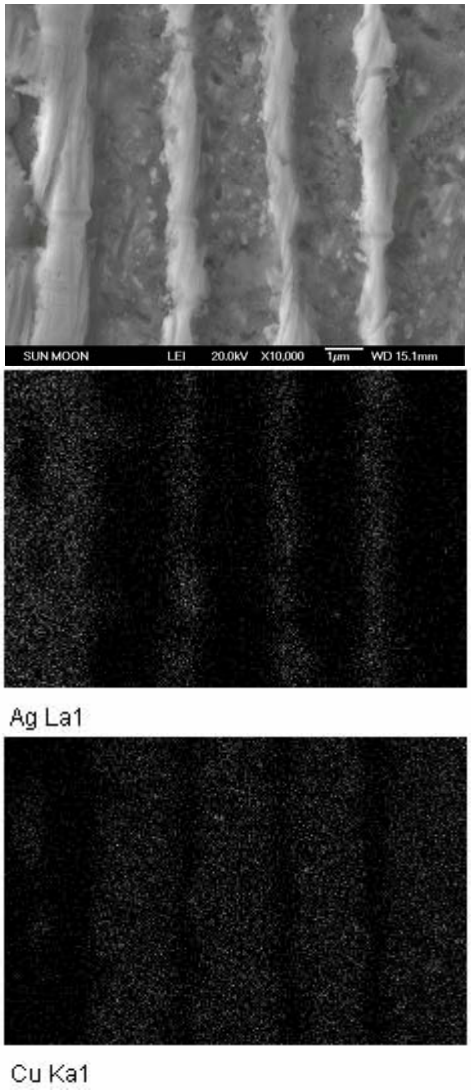

Fig. 1. FE-SEM image of as –received copper-silver quasi-nano-filamentary copper-silver composites

Fig. 2 is surface morphology annealed copper-silver composites at 600-700°C for 1-15 hours. As shown in Fig. 2, the silver filaments are broken and have a shape with facet and finally separated each other. Especially, the silver filaments are rapidly separated by annealing at 700 °C for 1 hour, which is different from thermal grooving behavior.

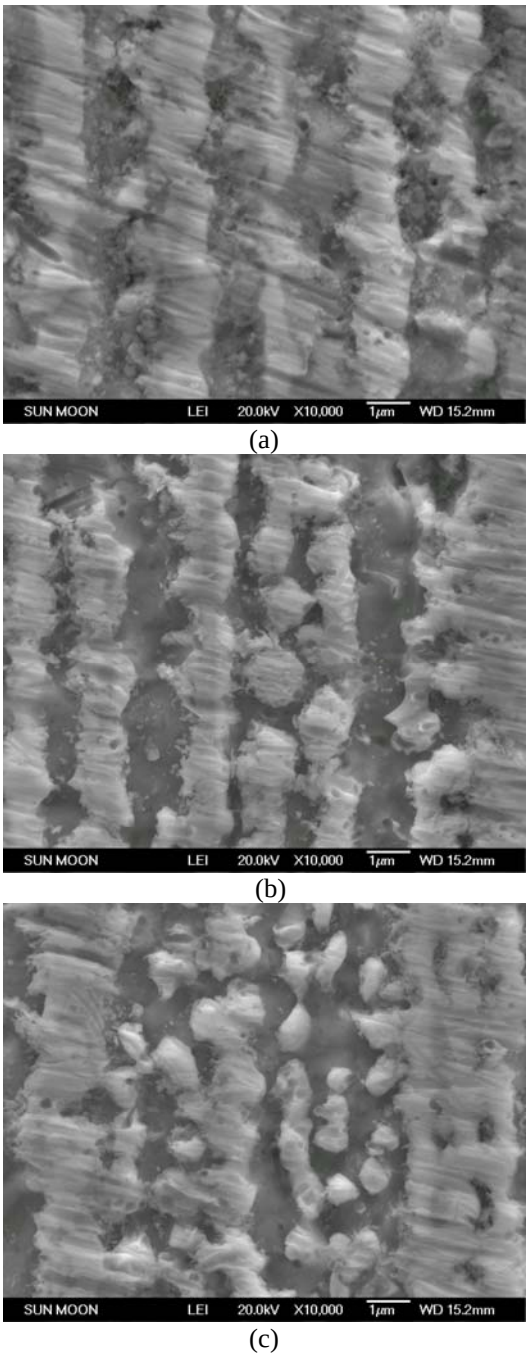

Fig. 2. FE-SEM image of annealed copper-silver quasi-nano-filamentary copper-silver composites : (a) 600°C for 10 hours (b) 700°C for 1 hour (c) 700°C for 10 hours

It is interesting to know the reasons why the grooving occurred not in copper but in silver filaments. Thermodynamics says that solute region in solid solution tends to be grooved because of chemical potential difference. However, the specimen in this study has similar amount of silver and copper. This means that the grooving of silver filaments is much more related to irradiation than thermal effects. Since the neutron absorption cross section of silver and copper are 60 and 3.6 barn, irradiation influences more silver filaments than copper matrix. Hence, it is clear that the grooving behavior of irradiated copper-silver quasi-nano filamentary composites is significantly dependent upon irradiation conditions.

4. Summary

Effect of irradiation on grooving behavior was studied by observation of morphology of quasi-nao filamentary copper-silver composites. Considering composition of the composites and neutron absorption cross section of silver and copper, the grooving behavior of irradiated composites is more related to irradiation than thermal effects.

Acknowledgements

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