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New vacancy generation mechanism in ultrahigh-purity aluminum single crystals with a low dislocation density

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Introduction

It is well known that insufficient vacancies from the thermal equilibrium are emitted by pr-existent dislocation lines in usual metal crystals. We have reported that interstitial type dislocation loops are formed as a source for insufficient vacancies in high-purity aluminum single crystals with a low dislocation density and the loops nucleate at a impurity or their cluster with heterogeneously.[1)] However, it is not clear that the predominant vacancy source in the ultrahigh-purity aluminum crystal in which there are few impurities acting as nucleus of the loops. In ultrahigh-purity aluminum crystal with dislocations of low density, what is the predominant source for insufficient vacancies is interested.

Experimental

The specimen used in this study was a single crystal of ultrahigh-purity aluminum (99.99999 at %) with low dislocation density.[2)] The specimen was firstly heated to 300°C, kept at this temperature for 20 min., and then slowly cooled to RT. The heating and cooling rates are 1000 °C /h and 20 °C /h, respectively. During the heat treatment, about 20 topographs were taken with white beam synchrotron radiation.

Results and discussion

Figure 1(a) and (b) are topographs taken at RT (before heating) and 300°C, respectively. In Fig.1(b), many thick straight lines formed at 300°C after the temperature rise are observed instead of the interstitial dislocation loops in high-purity specimen. Figure 2 shows the magnified straight-line image. This topograph shows that the line is a row of dislocation loops aligned in the <110> direction. And these rows of dislocation loops were disappeared during the slow cooling. It is confirmed that the thermal generation process of vacancy in nearly perfect crystal with ultrahigh-pure aluminum consists of following two steps. A few interstitial loops as like as high-purity specimen are formed, and then these grow to rows of dislocation loops emitting vacancies into lattice by the formation mechanism proposed by Amelinckx *et al*.[3)]

References

1) T.Kino *et al*.: J. Phys. Soc. Jpn. **53** (1984) 3290.
2) E. Hashimoto and Y. Ueda: Mater. Trans. JIM **35** (1994) 262.
3) S.Amelinckx and W. Bontinck: Acta. Metall. **5**(1957)345.

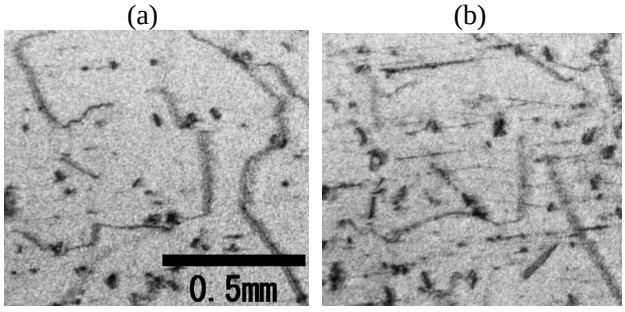

Fig.1 Topographs taken at RT (a) and 300°C(b).

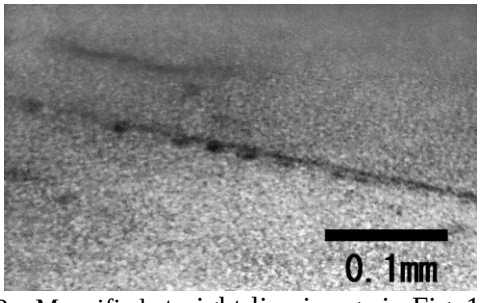

Fig.2 Magnified straight-line image in Fig. 1(b).

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