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RELATIONSHIP BETWEEN DISLOCATION MULTIPLICATION BEHAVIOR AND YIELD DROP PHENOMENA DURING TENSILE DEFORMATION IN 1200 ALUMINUM SHEETS

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INTRODUCTION

It has been reported that the elongation of the as-rolled 1200 sheet is higher than that of 1200 sheet subsequently annealed at 250°C 50 min. This is because the local deformation progressed immediately afterwards yield drop generation and there is hardly uniform deformation during tensile deformation in the annealed sheet. It is also reported that the yield drop phenomena generated in ultra-fine grained aluminum fabricated by severe plastic deformation methods and it is considered that these causes are same. Though, the cause of generation is not clarified. In this study, by using In-situ XRD technique at SPring-8 synchrotron facility, dislocation density change during tensile deformation were measured in high time resolution and the reason why the yield drop phenomenon appeared in aluminum was examined.

EXPERIMENTAL PROCEDURES

99% purity aluminum (1200 aluminum) samples were homogenized at 823K for 6 h and quenched to water. Then warm-rolling and cold-rolling were conducted to the sheets of 0.4 mm thickness. The specimens were subjected to annealing at 523K for 50 min. In addition, temper-rolling of 5% reduction was conducted to the annealing sample. They were cold rolled to a thickness of 1mm, and tensile test specimens were prepared by electric discharge machine. The change of dislocation density in Al alloys were measured during tensile deformation by the *in-situ* XRD technique in beam line BL19B2 at SPring-8 synchrotron facility (Proposal No.2015B1640). The initial strain rate was $8.3\times10^{-4}\ s^{-1}$. The energy of incident X-ray was 25 keV, the beam size was 0.15×3 mm and the time resolution was 2 s. The inhomogeneous strains were obtained by using Williamson-Hall equation from diffraction peaks.

RESULTS AND DISCUSSION

The grain sizes of as-rolled and annealed temper-rolled samples are 1.28 and 0.83 μm, respectively. By temper-rolling, the grain size hardly changed. The total elongation in as-rolled, annealed and temper-rolled samples were 17.8, 9.6 and 14.7%, respectively. Only in the annealed sample, the yield drop occurred and the local deformation started just after yield drop. As the result of In-situ XRD, the changes in dislocation density proceed in four stages in all samples. The first stage was a region of elastic deformation with little change in dislocation density. The second stage was a region of elastic-plastic deformation with rapid increase of dislocation density. In third stage, deformation progressed almost only by plastic deformation with moderate dislocation density change and dislocation density decreased by the fracture in the fourth stage. In this study, σ_{I} and σ_{II} were considered. σ_{I} is the stress when dislocation multiplication starts and σ_{II} is the stress when deformation began to progress almost only by plastic deformation. In these samples, $\sigma_{0.2}$ is very close to σ_{II} rather than σ_{I} and yield drop was generated in the stress near $\sigma_{0.2}$ and σ_{II}. This result means that the dislocation density rapidly increased from the strain which was considerably lower than the strain in which the yield drop was generated and dislocation multiplication rate became gentle near the strain in which the yield drop was generated. It obviously indicated that the rapid increase of mobile dislocation density was not the reason of the yield drop phenomenon generation in 1200 aluminum.

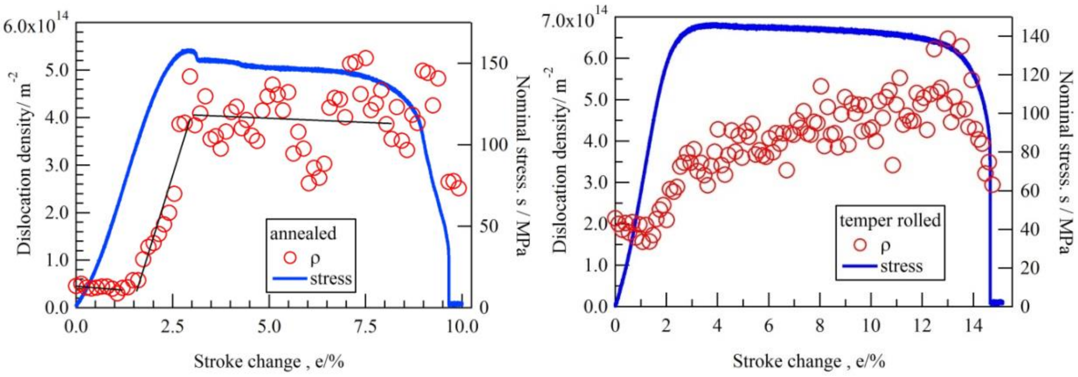

Figure 1. Dislocation density changes in annealed and temper-rolled samples, respectively.

CONCLUSIONS

In the temper-rolled sample, yield drop did not generate though the grain size is similar to the annealed sample. In temper-rolled sample, because initial dislocation density is high, the amount of plastic deformation is large and in a second stage, the amount of elastic deformation becomes small relative to that in annealed sample. As a result, it is considered that the stress overshoot was hardly generated in a second stage and stress drop did not occur when it shifts to a third stage (plastic deformation region).

REFERENCES

Adachi. H. (2015). Evaluation of dislocation density for 1100 aluminum with different grain size during tensile deformation by using *in-situ* X-ray diffraction technique. *Materials Transactions*, *56*(5), 671–678.

KEYWORDS

Pure aluminum, Yield drop, Dislocation density, In-situ XRD