CONTROL OF GRAIN COARSENING IN A SUBMICRON GRAINED Al-Sc ALLOY

Nanang Burhan and Michael Ferry

School of Materials Science and Engineering
University of New South Wales

ARC Centre of Excellence
Design in Light Metals

Overview, Aims & Materials

- Particle-free Al alloys exhibiting a submicron grain (SMG) size are generally unstable at moderate temperatures [1-2]. It is generally found that annealing at 300-400 °C is sufficient for the fine-grained structure to be replaced by a very coarse grain size by either rapid continuous coarsening or discontinuous processes such as recrystallization and abnormal grain growth
- The aim is to investigate, by electron backscatter diffraction (EBSD), the thermal stability of the microstructure of an ECAP-deformed Al-Sc alloy with particular focus on the recrystallization behaviour at high temperatures.
- A supersaturated Al-0.3 wt.% Sc alloy was cold deformed by ECAP to a von Mises strain of 9.2 then pre-aged at 350 °C to generate a fine-grained alloy of average grain size 1 µm containing a uniform dispersion of nanosized Al_3Sc particles. The alloy was annealed for various time at temperatures of 400 to 550 °C

Grain Coarsening

- The microstructure was highly resistant to grain coarsening at temperatures up to 500 °C with discontinuous coarsening (recrystallization) occurring at higher temperatures (Fig. 1).

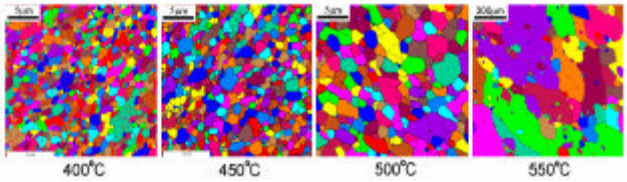
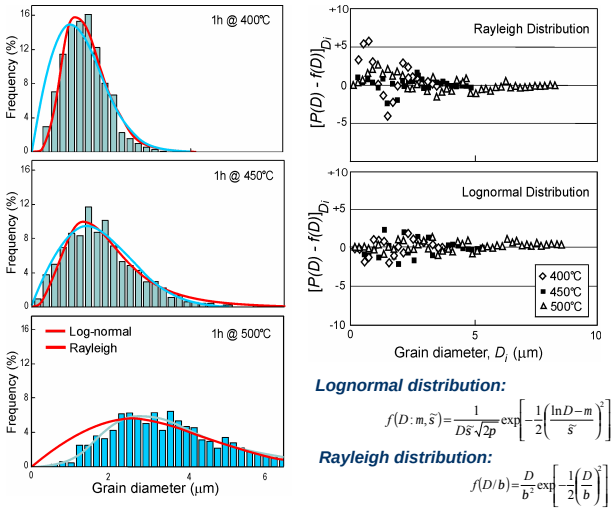


Figure 1. EBSD micrographs after annealing for 1h at various temperatures.

Grain Size Distributions

- A detailed statistical analysis showed that the initial grain size distribution was very close to lognormal and remained lognormal throughout annealing (Figs 2 and 3) but with a moderate broadening of the size distribution.



Lognormal distribution:

$$f(D:m,\tilde{s}) = \frac{1}{D\tilde{s}\sqrt{2p}} \exp\left[-\frac{1}{2}\left(\frac{\ln D - m}{\tilde{s}}\right)^2\right]$$

Rayleigh distribution:

$$f(D/b) = \frac{D}{b^2}\exp\left[-\frac{1}{2}\left(\frac{D}{b}\right)^2\right]$$

Figure 2. (a) Grain size distributions during annealing at various temperatures showing a closest fit with the lognormal probability distribution. (b) Comparison between computed and actual grain size distribution over the entire grain size range.

Comparison with Theoretical Distributions

- Figure 3 shows, for all annealing conditions, the relationship between the experimental and computed values of the mean and standard deviation, respectively. The computed statistical parameters correspond closely with the measured values, as indicated by the correlation coefficients.

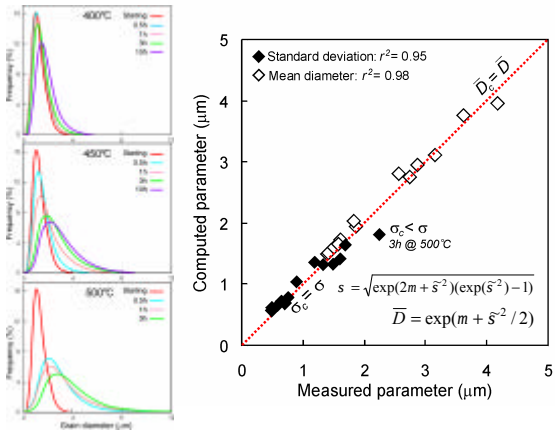


Figure 3. Fitted grain size distributions and comparison between measured mean grain size and standard deviation, for a given annealing condition, with those calculated from the theoretical lognormal distribution.

Discontinuous Grain coarsening

- Figure 4 shows the high resistance to recrystallization of the present alloy with the stability related to the particle dispersion parameter, *f/d* where *f* and *d* is the volume fraction and mean diameter of Al_3Sc particles, respectively. For *f/d* < 0.4 /µm, the initial fine-grained microstructure recrystallized to a coarse grain size, as predicted from recent theoretical analysis [1].

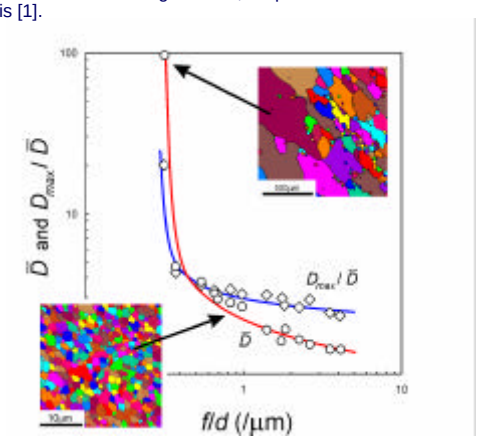


Figure 4. Mean grain diameter and the ratio of maximum to mean grain diameter as a function of the computed particle dispersion parameter (*f/d*).

References

1. F.J. Humphreys and M. Hatherly. **Recrystallization and related annealing phenomena**, Elsevier Science (2004)
2. M. Ferry, N.E. Hamilton and F.J. Humphreys *Continuous and discontinuous grain coarsening in a fine grained particle-containing Al-Sc alloy* **Acta Materialia**, vol. 53, pp. 1097-1109 (2005)

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