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MICROSTRUCTURAL PECULIARITIES IN 316L-TYPE STEEL SUBJECTED TO PRIMARY RECRYSTALLIZATION FOLLOWING SMALL DEFORMATION

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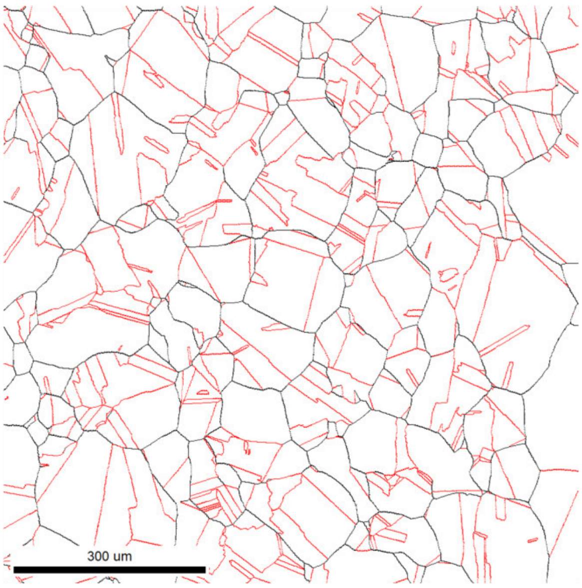
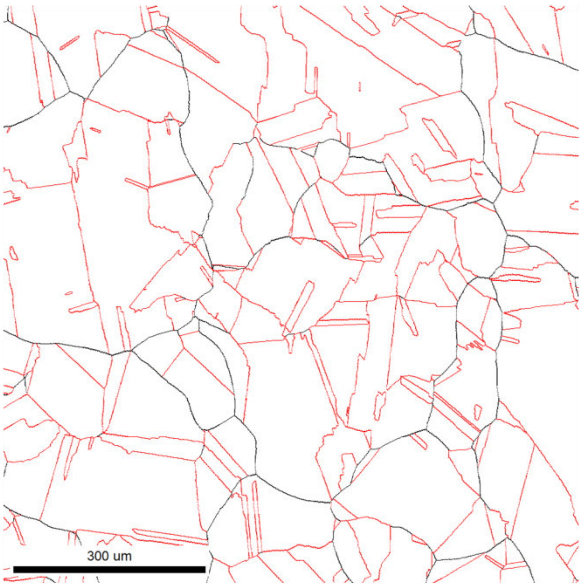
The grain boundary engineering is a promising approach to improve the intergranular corrosion resistance in austenitic stainless steels [1]. This approach involves the optimization of grain boundary character distribution in order to increase the fraction of so-called special boundaries with high density of coincident site lattice (CSL), e.g., Σ3 CSL twin boundaries in face centered cubic lattice. Such Σ3 CSL boundaries are expected to interrupt the connectivity of ordinary grain boundary network and, hence, slow down intergranular corrosion. The development of Σ3 CSL boundaries in austenitic stainless steels with low stacking fault energy is associated with annealing twins appearing during recrystallization [2]. The fraction of Σ3 CSL boundaries and their density after annealing of ultrafine grained austenitic stainless steels have been expressed by a ratio of the annealed grain size to initial one [3, 4]. The obtained relationships predict rapid increase in the fraction of Σ3 CSL boundaries at early stage of recrystallization and grain growth followed by slow down the rate of increase in the fraction of Σ3 CSL boundaries upon further grain growth, whereas the density of Σ3 CSL boundaries increases to its maximum at recrystallization beginning followed by a gradual decrease during subsequent grain growth. Therefore, a large fraction of Σ3 CSL boundaries in austenitic stainless steels could be expected after rapid grain nucleation and growth owing to primary recrystallization. The aim of the present study is to clarify the recrystallization time/temperature effect on the grain boundary character distribution in a cold worked 316L-type stainless steel.

Several samples of a 316L-type steel with an average grain size of 24 μm were subjected to 5% rolling reduction at ambient temperature followed by annealing at 1000 or 1100 °C for 5 to 60 min. The microstructural characterizations were performed using a Quanta 600 scanning electron microscope (SEM) equipped with an electron back-scattered diffraction (EBSD) detector incorporation orientation imaging microscopy (OIM) with TSL OIM Analysis 6 software. The OIM micrographs were obtained with a step size of 1 μm. The grain size was measured by a linear intercept method, omitting Σ3 CSL boundaries.



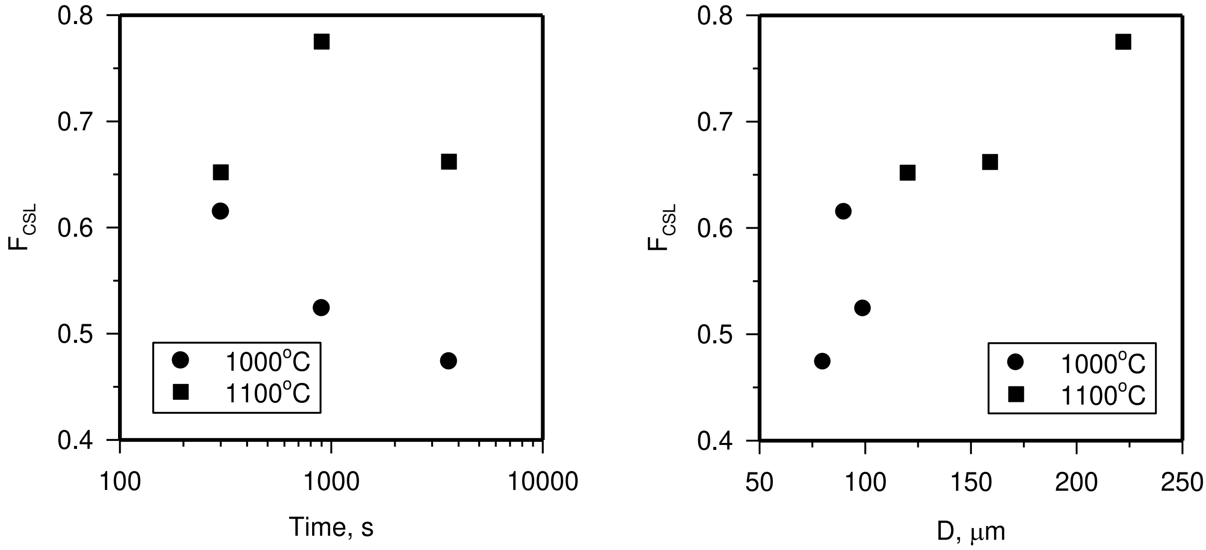
a



b

Fig. 1. OIM microstructures of a 316L steel annealed at 1000°C for 5 min (a) and 1100°C for 15 min (b). Ordinary grain boundaries and $\Sigma3^n$ CSL boundaries are indicated by the black and red lines, respectively

Typical annealed microstructures are shown in Fig. 1. Increasing both temperature and time for primary recrystallization results in an increase in the recrystallized grain size. The density of annealing twins also decreases as the grain size increases during recrystallization. However, the fraction of the twin boundaries increases with increasing the recrystallized grain size. Moreover, an increase in the grain size during recrystallization is accompanied by the disruption of the grain boundary network. Frequent interruption of the grain boundary network continuity is clearly seen in Fig. 1b as terminated black lines.



a b

Fig. 2. Effect of recrystallization temperature and time on the fraction of Σ3 SCL boundaries, F_{CSL}, (a) and the relationship between F_{CSL} and the recrystallized grain size (b)

The fraction of Σ3 SCL boundaries rapidly increases well above 0.5 at early stage of primary recrystallization (Fig. 2a). It should be noted that an increase in annealing temperature promotes the annealing twins. On the other hand, an increase in annealing time does not lead to remarkable change in the fraction of Σ3 CSL boundaries. This suggests the twin formation mainly during the recrystallization beginning, whereas subsequent grain growth is accompanied by a partial twin consumption by the growing grains. Nevertheless, the fraction of Σ3 CSL boundaries tends to increase with an increase in the recrystallized grain size (Fig. 2b) much similar to previous studies on the grain boundary distribution in austenitic stainless steels subjected to severe deformation followed by recrystallization annealing [3, 4].

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