Successive Austenite Formation in Fe-18 Ni (mass%) Alloy During Intercritical Annealing

Microstructure change at a temperature near to the upper boundary of two phase (α+γ) region was studied. At the early stage, a fine lamellar structure consists of precipitated austenite and initial martensite is formed. By further holding, new austenite grains nucleated and grew at the expense of the lamellar aggregate.

Reverse transformation of the Fe-18 Ni alloy was studied during isothermal holding in upper phase boundary of the two phase region.

It was found that a lamellar aggregate consisting of precipitated austenite laths and initial martensite is formed at the early stage. By further holding new austenite grains nucleate independently and grow at the expense of lamellar aggregate. An EPMA of the specimen annealed at 863 K for 240 min is shown in Fig. 1 which demonstrates the distribution of Ni atom in the lamellar aggregate and large white area. In lamellar region, enrichment of reversely formed austenite by Ni is pointed out which clearly indicates that the austenite laths are formed by a diffusional transformation mechanism. Neighboring tempered martensite has been depleted of Ni atoms conversely. However, the large white area shows a uniform distribution of Ni concentration.

EBSD analysis of a specimen isothermally reverted at 873 K and 863 K reveal that the lamellar area shows a near KS pattern while when the large white area is incorporated to the analysis, the orientations deviate from the KS orientation relationship.

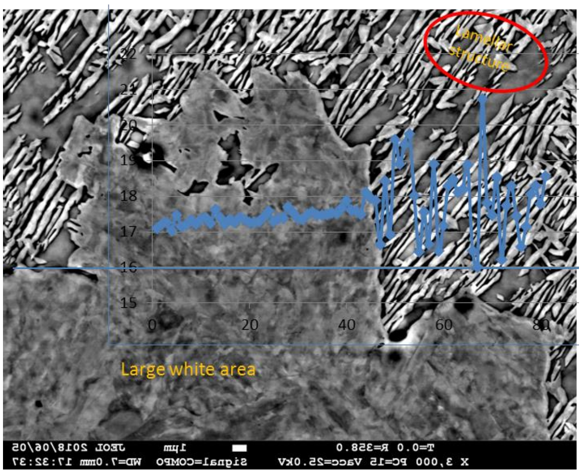

Fig. 1 EPMA analysis of Ni distribution after reverse transformation at 863 K and holding for 240 min.

Austenite in large white area has some similar characteristics of massive transformation such as partitionless without any specific orientation relationship [1, 2, and 3]. However, the transformation involves essentially a diffusion mechanism leading to the uniform distribution of Ni atoms unlike the massive transformation which is defined by interface-controlled diffusional phase transformation. Therefore, a discontinuous dissolution mechanism of transformation could be assumed for the formation of new austenite grains in which accelerated interfacial diffusion plays the main role.

According to the binary Fe-Ni phase diagram, the equilibrium state of the Fe-18 Ni alloy at 873 K and 863 K consist of ferrite and austenite. The relative amount of reverted

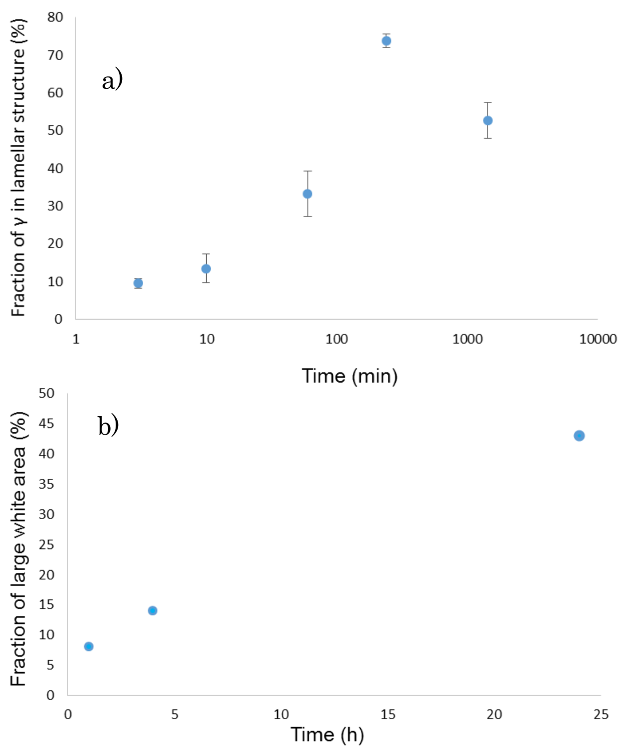

Fig. 2 Fraction of austenite during holding at 873 K for various time; a) austenite in lamellar area b) austenite in large white area

austenite at 873 K was calculated about 98 %. At the earlier stages of reversion treatment, relative amount of ferrite is higher than the equilibrium state and, therefore, the relative amount of ferrite decreases during isothermal holding which is practically accompanied by increasing of the relative amount of reversed austenite. The kinetics of this phase change should be controlled by the partitioning of Ni atoms which is expected to be rather slow due to the partial coherency of KS related martensite/austenite interfaces. Fig. 2 shows the fraction of precipitated austenite in lamellar area and new single phase as denoted by large white area in Fig. 1. Fraction of precipitated austenite increased by holding time and then decreased after 1440 min of holding. This can be related to the expense of lamellar aggregate by formation of new austenite grains at large white area.

A single phase austenite is formed in the large white region despite the fact that present treatment condition is located in the two phase region. Thermodynamics assessment is applied to interpret the peculiar features of this transformation which is demonstrated in Fig. 3, where G^{γ} and $G^{(\alpha+\gamma)}$ are the molar Gibbs free energy of large white area and the lamellar aggregate respectively. It is found out that the difference between free energy of lamellar and single phase austenite ($G^{(\alpha+\gamma)}$-G^{γ}) is very low for the present condition. However, remarkable interfacial energy is elaborated due to the formation of lamellar aggregate which acts as a driving force of transformation. This phenomena can be important for experimentally calculation of coherent interfacial energy as the transformation is assisted by interfacial energy.

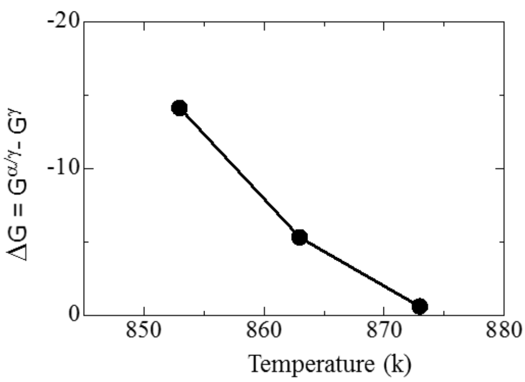

Fig. 3 Thermodynamic assessment of free energy change during reverse transformation of Fe-18 Ni alloy.

References

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