

Microstructural Characteristics of Austenite formed via Martensitic Reversion

Kyushu University ○N. Nakada, R. Fukagawa, T. Tsuchiyama and S. Takaki
 Max-Planck-Institute für Eisenforschung D. Ponge and D. Raabe

Introduction

When maraging steel is austenitized, reversion from martensite back to austenite was reported to occur via a diffusionless shear mechanism (martensitic reversion) [1]. It is thought that austenite formed by martensitic reversion (martensitically reversed austenite) contains a high dislocation density and it contributes to the good mechanical property of this kind of steel due to an ausforming-like effect [2]. Besides these specific effects, the entire microstructural evolution occurring during martensitic reversion in such alloys remains unclear. Since austenite is an unstable phase in maraging steel at ambient temperature (R.T.), martensitically reversed austenite cannot be probed directly. In this study, for mapping martensitically reversed austenite directly, we introduce a new type of heat treatment to control austenite stability by precipitation and dissolution of carbide into 18%Ni-C steel. The microstructural characteristics of reversed austenite were then investigated

Experimental Procedure

We developed a heat treatment consisting of a three step solid-solution heat treatment sequence (STs) with the aim to modify the austenite stability of the matrix through the precipitation and dissolution of carbide, as drawn in Fig. 1. The key point in this heat treatment is the second ST that is employed to reduce the solute carbon content in the austenite matrix by a partial solution treatment in the austenite plus carbide two phase region. In order to stimulate a martensitic transformation in the entire specimen during heat treatment, the following conditions are required: (1) The austenite matrix has to be sufficiently stable at R.T. when the carbon is entirely in solid solution ($M_s < R.T.$ at 1st ST); (2) Precipitation of carbide in the austenite plus carbide two phase region increases the T_0 temperature. As a result, the martensitic transformation fully occurs during the subsequent cooling ($M_f > R.T.$ at 2nd ST). A further condition is to stabilize the martensitically reversed austenite also down to R.T.. (3) The carbide precipitated at 2nd ST immediately dissolves into the austenite matrix again after martensitic reversion in order to restore the M_s and M_f temperatures to their initial values ($M_s < R.T.$ at 3rd ST). After some thermodynamic calculations, 18%Ni-0.6%C steel was selected as optimum material used in this study. The heat treatment for the material was detailed in Fig. 1. The microstructure was observed with optical and transmission electron microscopes. The crystallographic orientation of each phase was mapped by means of the electron back scattering diffraction method using a field emission scanning electron microscope.

Results and Discussion

After microstructural analyses, it was confirmed that a full fcc→bcc→fcc reversible martensitic transformations cycle occurs through the specific heat treatment. Fig.2 shows fcc orientation imaging map of martensitically reversed austenite formed through the heat treatment. In this map, prior austenite grain boundary and annealing twin boundary are indicated by arrows A and B, respectively. The austenite is characterized by a coarse-grained structure with annealing twins, although some fine austenite grains surrounded by high-angle boundary are dispersed within the coarse microstructure. It should be noted that the fcc crystal orientation seems to be not identical but slightly distributed in the coarse austenite structure. TEM observation indicated that such mesoscale crystallographic orientation distribution comes from fine lath structure with high dislocation density that was inherited from lath martensite. Additionally, this orientation map reveals that the high-angle packet and block boundaries that originally existed in the lath martensite have disappeared in the austenite. This demonstrates that all martensite variants that were originally formed by a fcc→bcc martensitic transformation reverse into the new austenite during the bcc→fcc martensitic reversion with the same resulting orientation that the prior austenite grain had.

Reference

- [1] e.g. T. Maki et al.: *Tetsu to Hagane*, 65(1979), 1598.
- [2] e.g. T. Tasuno et al.: *ISIJ Int.*, 36(1996), 595.

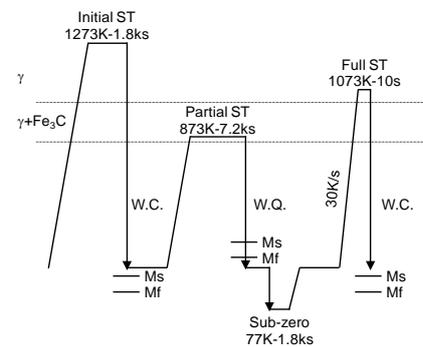


Fig. 1 Heat treatment route to control austenite stability by precipitation and dissolution of carbide.

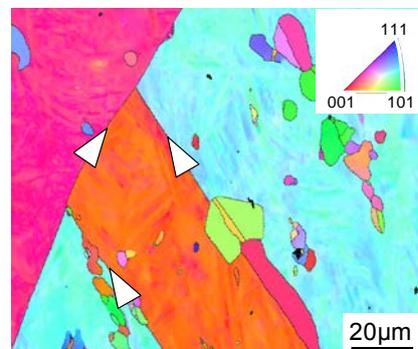


Fig. 2 Orientation imaging map of martensitically reversed austenite.