3D characterization of precipitates in N-added austenitic stainless steel using FIB-SEM tomography

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The corrosion resistance and the mechanical properties are influenced by alloying elements, and in particular, nitrogen is commonly added to austenitic stainless steels because it improves mechanical properties and corrosion resistance, and stabilization of austenite1). Addition of nitrogen is very effective method for improving normal and high temperature strength, due to solid-solution strengthening2), I-S effect3), and particle dispersion strengthening4). These proposed mechanisms have not been confirmed yet, so that it is still necessary to investigate the nitrogen-added samples at nanoscale to determine the role of nitrogen, and to improve the physical properties of austenitic stainless steel. In this study, both FIB-SEM serial-sectioning method and (S)TEM characterization were applied on the nitrogen-added austenitic stainless steel (SUSXM15J1), to characterize the intra- and intergranular precipitates, in detail.

The grip part of tensile sample was observed by FIB-SEM tomography for three-dimensional reconstruction of precipitates. Structural and compositional identification of precipitates were carried out using JEM-ARM200F by electron diffraction patterns and EDS analyses, respectively.

The most representative SEM image and three-dimensionally reconstructed volume are shown in Fig. 1(a) and 1(b), respectively. It can easily be seen that a large number of precipitates are present at the grain boundaries and grain interiors. Almost homogeneously dispersed intragranular precipitates are color-coded to differentiate plate-type (red), rod-type (yellow) and granular-type (green) precipitates, as shown in Fig.2. These precipitates are determined as Cr2N by electron diffraction and EDS analyses and distinctive crystallographic orientation relationship was observed between the each precipitates and the matrix. According to the contrast of SEM images of different grain boundaries, two-types of intergranular precipitates with different contrast were present in the volume, ones with dark-gray, and another ones with light-gray. These precipitates are determined as Cr2N and Cr3Ni2Si by electron diffraction and EDS analyses. Intergranular precipitates maintained orientation relationship with matrix, which might have determined the morphology of them.

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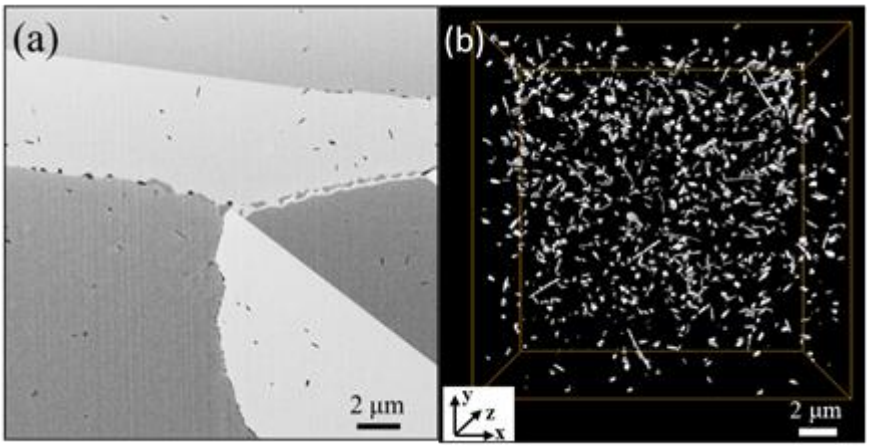

Fig. 1. (a) SEM image of grain boundaries and (b) Three-dimensional reconstructed image.

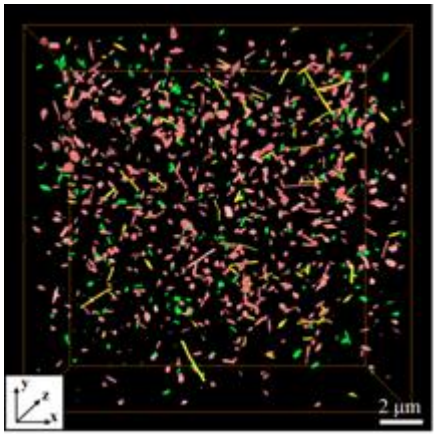

Fig.2. A color-codded three-dimensional reconstructed image of precipitates by their morphologies.