Observation of Misoriantation Behavior in SUS304 and SUS316L with Harmonic Structure by Synchrotron DCT under Tensile and Cyclic loading

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A bimodal harmonic structure is a structure in which fine grain structures (shell) are arranged around coarse grains structure (core). Metallic materials with a bimodal harmonic structure have both high ductility and high strength. However, the role of these each two structures in tensile deformation and fatigue on strength and ductility is not clear. In this study, X-ray diffraction contrast tomography (DCT) was used to investigate the role of the two structures under tensile and fatigue tests.

DCT is a 3D particle mapping technique for polycrystalline materials using ultra-bright synchrotron X-rays. When the sample is irradiated with X-rays, diffraction occurs at the grains that satisfy the Bragg condition. Diffraction spots appear in the direction of the diffraction angle, and dark extinction spots appear behind the sample. The diffraction spot appears in the grain over the rotation range $\Delta\omega_{diff}$ that satisfies the Bragg condition. Since this corresponds to the misorientation in the grains, the misorientation β is calculated by $\Delta\omega_{diff}$, diffraction angle θ, and Debye–Scherrer ring angle ψ. Furthermore, the excess dislocation density ρ was calculated from the grain size *D* which measured from result of DCT and Burger's vector *b*.

DCT imaging was performed using the BL46XU beamline of the synchrotron radiation facility of Super Photon ring 8(SPring-8). Grains as small as 10 μm or less cannot be reconstructed by DCT. A sample in which the grain size was increased while maintaining the grain size ratio of the shell and core was prepared. The average grain size of core is 77μm and that of shell is 15μm. Fig. 2 shows the results of tensile test for the specimens with the harmonic and normal homogeneous structure. It was found that the tensile strength and elongation of harmonic structure specimen are higher than those of the homogeneous structure specimen. The prepared samples with coarsened grains also had the characteristics of the harmonic structure.

DCT measurements were performed during the tensile tests. The reconstructed grains were classified by size, and the misorientation and dislocation density of each grain were investigated. Fig. 3 shows the change in the excess dislocation density. The change in dislocation density ρ is small for grains with a size of 20-80μm, on the other hand, it is large for grains with a size of less than 20μm and more than 80μm. It was found that the change in dislocation density differs between the core and shell structures.

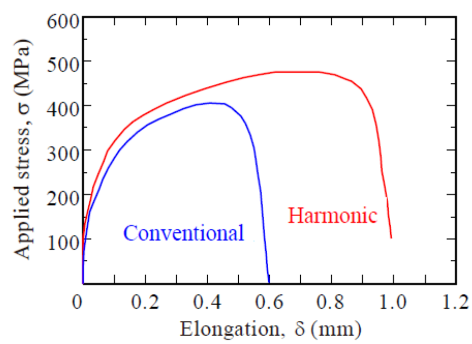

Fig. 1 Stress-elongation relationships

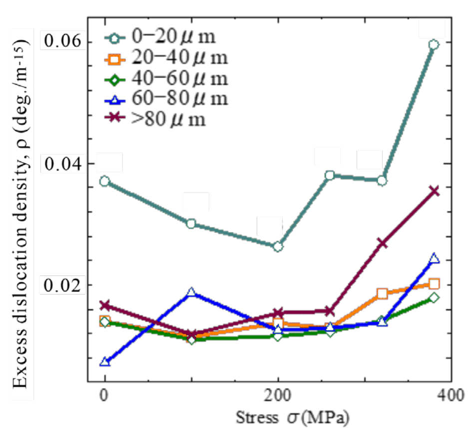

Fig. 2 Change of excess dislocation density in tensile test.