【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Breakthrough toward "second-generation" grain boundary engineering

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Research Project Number : 16H06366 Researcher Number : 40227484
Research Area : Materials Science and Engineering
Keyword : Microstructural control, grain boundary, dislocation

【Purpose and Background of the Research】

Bulk properties of polycrystalline materials are significantly affected by grain boundaries. Tadao Watanabe has proposed the concept of grain boundary engineering for providing desirable properties of polycrystalline materials" in 1983 / 1984 on the basis of the structure-dependent grain boundary properties, which is nowadays known to be useful for achieving enhanced bulk properties like creep resistance and corrosion resistance (Fig. 1). As mentioned above, "first generation" grain boundary engineering achieved certain results. However, there still remain some issues to be settled for further establishment of grain boundary engineering: *e.g.*, grain boundary engineering is not commonly applied to the materials with a high stacking fault energy.

Motivation of this project is to achieve a breakthrough toward "second generation" grain boundary engineering. We will deal with two major issues as follows:

Issue 1: Comprehensive understanding of grain boundary phenomena to strengthen fundamental base of grain boundary engineering

- Local mechanical properties near the grain boundary – Understanding Hall-Petch relation on the basis of the interaction between grain boundary and dislocations.
- Structure and properties of non-equilibrium grain boundaries

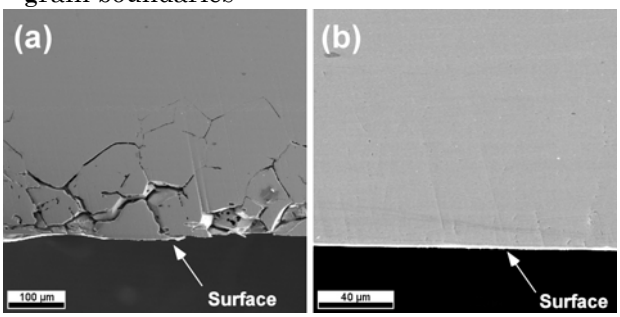

Fig.1 Effect of grain boundary control on corrosion in austenitic stainless steel (SUS304): (a) Conventionally processed, (b) grain boundary engineered. (S.Tsurekawa *et al.*, Acta Mater., 54,3617, (2006).)

Issue 2: Guiding principle for grain boundary control of materials with high stacking fault energy

【Research Methods】

(1) Orientation controlled bicrystals are used for nanoindentation tests to study the local mechanical properties near the grain boundaries, and for *in-situ* deformation / observation in TEM to examine the relation between the dislocation motion and mechanical response.
(2) Quantitative evaluation of grain boundary microstructure using the fractal and percolation theory.

【Expected Research Achievements and Scientific Significance】

The achievements of this study make it possible to apply the grain boundary engineering to a wide-rang of materials, and would promote an innovation for development of new advanced materials based on grain boundary functions. In addition, we propose a new elements strategy because grain boundary engineering can achieve enhanced properties even for conventional materials without using further allying elements.

【Publications Relevant to the Project】

- T. Watanabe, S. Tsurekawa, The Control of Brittleness and Development of Desirable Mechanical Properties in Polycrystalline Systems by Grain Boundary Engineering, Acta Mater., 47, 4171–4185, 1999.
- S. Tsurekawa, Y. Chihara, K. Tashima, P. Lejček, Local plastic deformation in the vicinity of grain boundaries in Fe-3 mass% Si alloy bicrystals and tricrystal, J. Mater. Sci., 49, 4698 – 4704, 2014.

【Term of Project】 FY2016-2020

【Budget Allocation】 137,900 Thousand Yen

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