Higher-order Gradient Crystal Plasticity Analysis of Microscale Material Test Involving Grain Boundary Effect

Yuichi Tadano*

* Department of Mechanical Engineering
Saga University
1 Honjo-machi, Saga 840-8502, Japan
e-mail: tadano@me.saga-u.ac.jp

ABSTRACT

A scale dependency of plastic deformation, i.e., a smaller crystal grain provides a higher flow stress, is an important characteristic of metallic materials. From both the theoretical and experimental viewpoints, it is known that dislocation structures at crystalline scale play an important role in the scale effect. For example, Imrich et al. conducted an experimental study on a micropillar compression of bicrystalline copper [1] and revealed that the misorientation angle of grain boundary strongly affects the mechanical behavior of a bicrystalline material. Specifically, a coherent twin boundary provides almost no elaboration in the flow stress, while a general large angle grain boundary increases the flow stress. This result suggests the grain boundary effect may be strongly affected by the misorientation angle.

Incorporating a higher-order gradient effect is an efficient way to introduce a scale effect into a crystal plasticity framework. One of the features of the higher-order crystal plasticity is that a boundary condition corresponding to the higher-order effect is naturally introduced. This boundary condition is interpreted as a representation of dislocation mobility on a boundary. However, dislocation behaviors on grain boundary are still less well understood. To clarify the mechanism of the scale effect of metallic materials, a detailed investigation of grain boundary effect is essential. In this study, a numerical analysis of a micropillar is demonstrated using the higher-order crystal plasticity model [2], and the grain boundary effect on the dislocation motion is discussed.

REFERENCES

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