JOURNAL OF MATERIALS SCIENCE **40** (2005) 817

Preface to the special issue on grain boundary engineering

T. WATANABE, S. TSUREKAWA
Laboratory of Materials Design and Interface Engineering, Department of Nanomechanics, Graduate School of Engineering, Tohoku University, Sendai, 980-8579, Japan

Grain boundaries (including interphase boundaries in multiphase materials) are important elements of the microstructure in polycrystalline materials which have been widely used as engineering materials, whether they are metallic, intermetallic, ceramic and semiconductor materials. Grain boundaries can play important roles as preferential sites in most metallurgical phenomena because they are two-dimensional defects and can generally exist in any kind of material. The encounter of neighbouring grains can produce some interaction between them and also generate an additional or even a new function and property which individual grains (crystallites) can never obtain without interaction with others. Moreover, the way and the magnitude of the interaction between grains have a large variety because of different crystallographic orientations of individual grains and the numerous relative orientation relationships between them. This provides a polycrystal system with the versatility and possibility of production of high performance and a new function which cannot be achieved in single crystalline material. Therefore, we can say that the interaction of grains across a grain boundary can be the source of excellent and desirable bulk properties which conventional polycrystalline materials do not have, if grain boundaries would be properly designed and controlled. As a consequence of numerous basic studies of the structure and properties of grain boundaries [1–3] since 1960's, it has been well established that physical, chemical and mechanical properties of grain boundaries strongly depend on the type and structure of the boundary. Now we know very well that bulk properties of polycrystalline materials are not only controlled by the grain size, as understood in the past, but by the grain boundary character distribution (GBCD), the grain boundary connectivity and geometrical configurations of grain boundaries [4] which the modern Orientation Imaging Microscopy (OIM) can quantitatively determine without much difficulty [5]. It is self-evident that an increase of the density of grain boundaries should affect more strongly bulk properties of a polycrystalline material with decreasing grain size, down to nanocrystalline materials as the extreme case [6]. So nanostructured materials produced by different processing methods [7, 8] may be endowed with novel properties which cannot be expected for conventional and presently existing polycrystalline materials. The time has come when grain boundary and interface engineering should be seriously considered and attempted in order to produce high performance structural and functional materials in the 21st century. This special issue was planned and published to demonstrate and confirm how much grain boundaries and interface boundaries have the structural and property versatilities that we can utilize through engineering of these boundaries. The materials world can provide us with unlimited and unexpected benefit and fortune, if we human beings would properly understand the importance and usefulness of the interaction with individual tiny crystallites (grains) and to intentionally foster and use the product of the interaction.

References

1. G. A. CHADWICK and D. A. SMITH (ed.), "Grain Boundary Structure and Properties" (Academic Press, London, 1976).
2. R. W. BALLUFFI (ed.), "Grain Boundary Structure and Kinetics" (ASM, 1980).
3. D. WOLF and S. YIP (ed.), "Materials Interfaces" (Chapman & Hall, 1992).
4. T. WATANABE, *Res Mechanica* **11** (1984) 47.
5. B. L. ADAMS, S. I. WRIGHT and K. KUNZE, *Met. Trans.* **24A** (4) (1993) 813.
6. H. GLEITER, in Proc. the 4th JIM Intern.Symp.on Grain Boundary Structure and Related Phenomena," edited by Y. Ishida, *Trans. JIM.* **27** (Suppl.) (1986) 43.
7. G. THOMAS (ed.), *Acta Mater.* **47** (15/16) (1999).
8. H. GLEITER, *Mater. Trans.* **44**(6) (2003) 1057–1067.

0022–2461