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Evaluation of atomic scale damages of advanced materials based on the order of atom arrangement

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Recently, mechanical properties of polycrystalline materials have been found to vary drastically depending on their micro texture. The crystallinity of grain boundaries was found to dominate both their mechanical and electrical properties and the long-term reliability. This is because various defects such as strain, vacancies, impurities, and dislocations easily concentrate around grain boundaries and thus, degrade the quality of atomic configuration in grains and grain boundaries. In this talk, a grain boundary is defined by volumetric transition area between two grains, though it has been defined as a line interface between nearby grains. The quality of grain boundaries is independent of crystallographic orientation of nearby grains The diffusion of component elements is remarkably dominated by the local quality of grain boundaries. The degradation of materials mainly starts to occur around grain boundaries with low crystallinity and atomic diffusion, such as strain-induced anisotropic diffusion and electro migration, is accelerated drastically along the poor-quality grain boundaries. The initial micro texture of various heat-resistant alloys has been found to degrade under operating conditions of advanced high efficient thermal power plants based on this strain-induced accelerated diffusion of component elements. The quality of thin-film interconnections in advanced semiconductor devices has been decreased under operation by electro-and stress-induced migration of component elements. Therefore, it is very important to evaluate the crystallinity of advanced materials quantitatively for assuring safe and reliable operation of various products. Crystallinity of grain boundaries can be evaluated quantitatively by applying electron back-scatter diffraction (EBSD) method. The order of atomic alignment in the observed area is analyzed by the sharpness of Kikuchi lines obtained from the observed area. Various materials properties vary drastically depending on the order of atomic alignment, in particular, in grain boundaries. Both fluctuation and degradation of various properties of materials such as heat-resistant alloys and thin films are investigated from the viewpoint of the crystallinity of grains and grain boundaries.

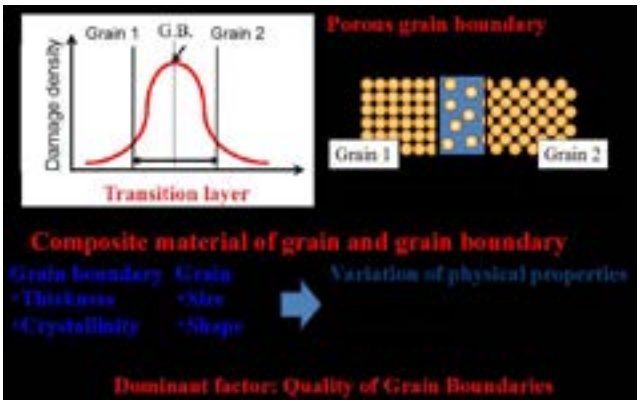

Figure1: Variation of crystallographic quality (order of atom arrangement) of a grain boundary

Biography

Prof. Hideo Miura has received his PhD from Tohoku University, Japan. He had worked for Hitachi Ltd., Japan for 20 years as a Chief Researcher of mechanical reliability of various products and moved to Tohoku University in 2003. He is the director and Professor of Fracture and Reliability Research Institute. His main research topic now is prediction and prevention of fracture of advanced functional materials and thin-film devices. He has published more than 200 technical papers in the field of mechanical reliability of various materials and thin-film devices, and obtained more than 200 patents all over the world. He also has been serving as an organizer of various international conferences.

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