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Degradation of crystallinity and properties of advanced functional materials caused by anisotropic local diffusion of component atoms under severe operating conditions

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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 study, 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 electromigration, is accelerated drastically along the poor-quality grain boundaries. 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.

Biography

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 of Fracture and Reliability Research Institute. His main research topic now is prediction and prevention of fracture of advanced functional materials and devices. He has published more than 200 technical papers in the field of mechanical reliability of various materials and thin-film devices, and has been serving as an organizer of international conferences.

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