TOWARDS MULTIFUNCTIONAL BULK NANOSTRUCTURES: GRAIN BOUNDARY STRUCTURE AND GRAIN BOUNDARY DIFFUSIVITY OF SEVERELY STRAINED ALLOYS

WILDE Gerhard

University of Muenster, Muenster, Germany, EU

Abstract
Bulk nanocrystalline materials offer unique and new functional properties and property combinations that render them ideally suitable for a large spectrum of applications, ranging from the biomedical area to materials for off-shore industries or the aerospace sector, to mention only a few examples. Out of the few options for producing sizeable amounts of dense nanocrystalline materials, severe plastic deformation processing offers the most versatile and also the most promising route, as shown by combinations of high strength and high ductility or high mechanical strength and high electrical conductivity. Underlying the dramatic property enhancement is a modification of the atomic structure and volume density of the grain boundaries. In fact, strain distributions around - and atomic transport along these internal interfaces determine largely the resulting property combination of the product material.

The present contribution summarizes recent experimental results based on microstructure analyses (SEM-EBSD, TEM including Cs-corrected HRTEM and local strain analyses with atomic-scale spatial resolution by Geometric Phase Analysis) together with detailed grain boundary diffusion analyses on different pure metals and binary alloys using the radiotracer method. Basic issues concerning the existence and evolution of so-called “non-equilibrium” grain boundaries, their property characteristics and their relation with the performance of SPD-processed materials are addressed. In addition to the creation of grain boundaries with specific properties, the formation of a distinct hierarchy of internal boundaries with significantly different atomic mobility along the boundary planes has been identified. Additionally, stabilization mechanisms of bulk nanocrystalline materials obtained by severe plastic deformation against coarsening are critically discussed.

Keywords: severe plastic deformation, grain boundary, diffusion, microstructure

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