Grain boundary diffusion and segregation: a radiotracer study

Sergiy V. Divinski

Institute of Materials Physics, University of Münster,
Wilhelm-Klemm-Str. 10, 49149 Münster, Germany

An overview of recent advances in grain boundary diffusion and segregation in bi-crystalline, tri-crystalline, and poly-crystalline metals is presented with an emphasis on the relationship between the structure and kinetic properties. Grain boundary diffusion is strongly affected by the structural state of interfaces and segregation of residual impurities. Temperature-induced transitions in the grain boundary structure are revealed by radiotracer diffusion measurements for specific low sigma interfaces [1, 2]. The results are compared with the data obtained previously on high-purity copper [3]. The segregation of Ag at Cu Sigma 5 and Sigma 17 grain boundaries is found to be significantly stronger as compared to that at general high-angle grain boundaries as they are present in annealed polycrystalline copper. An existence of critic temperatures, which corresponds simultaneously to specific "kinks" in the temperature dependences of the grain boundary diffusivity and the disappearance of the grain boundary diffusion anisotropy, is discovered and they are related to temperature-induced phase transitions as shown in [4].

The so-called “high-energy” state of grain boundaries is introduced by severe plastic deformation of metals using different routes. These interfaces are characterized by an increased free volume, larger excess free energy and, as a result, enhanced diffusivities. The kinetic and structure properties of the “high-energy” grain boundaries are investigated for several pure metals (Cu, Ni, Ti, Ag) and Cu-based alloys severely deformed via equal channel angular pressing or high-pressure torsion. The relaxation behavior of interfaces in ultra-fine grained metals is investigated by the radiotracer diffusion measurements and differential scanning calorimetry [5-8].

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