MM 32: Transport II - Microstructure/Grain boundaries

Time: Tuesday 15:45–16:45 Location: IFW B

MM 32.1 Tue 15:45 IFW B

Wetting and pre-melting phase transitions in Cu(Bi) alloys studied by tracer diffusion — •Henning Edelhoff[1], Boris Straumal[2], Sergiy Divinski[1], and Gerhard Wilde[1] — [1]Institute of Materials Physics, University of Münster, Münster, Germany — [2]Institute of Solid State Physics, Chernogolovka, Russia

It is well known that segregation of impurity elements to grain boundaries (GB) can cause a severe change of the material properties. In some systems, e.g. for the Cu-Bi one, the solute (Bi) excess at Cu GBs leads to grain boundary embrittlement (GBE). Due to increasing amounts of GBs in ultrafine grained and nanocrystalline materials and the potential enrichment of Bi in copper-based materials for microelectronic applications, evoked by the usage of Pb-free solders like Sn-Bi or Sn-Ag-Bi in the chip technology, the understanding of the GBE phenomenon in general and in the Cu(Bi) system particularly is of great importance.

Previously, GB diffusion of Cu and Bi in Cu(Bi) alloys has been investigated and kinetic enhancement corresponding to a pre-wetting phase transition was reported [1]. The question arises how the atomic transport of other solutes is influenced by the phenomenon of GBE in the Cu(Bi) system. In this work the GB diffusion of Ag, as one of the main elements in Pb-free solder alloys, in Cu(Bi) alloys is investigated by the radiotracer technique. The effect of segregation, grain size and GB wetting transition on the kinetics of Ag GB diffusion is discussed.

[1] S.V. Divinski, M. Lohmann, Chr. Herzig, B. Straumal, B. Baretzky, W. Gust, Phys. Rev. B., 71, 104 (2005)

MM 32.2 Tue 16:00 IFW B

Transport and structural properties of grain boundaries in ultrafine grained Cu — •Matthias Wegner[1], Jörn Leuthold[1], Martin Peterlechner[1], Daria Setman[2], Michael Zehetbauer[2], Sergiy V. Divinski[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Universität Münster, Wilhelm-Klemm-Straße 10, D-41849, Germany — [2]Physics of Nanostructured Materials, Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Wien, Austria

According to existing models of grain refinement by severe plastic deformation, the abundance of lattice dislocations created during the severe straining serves to modify the grain boundary structure of general high angle grain boundaries (GHAGB) towards a state with an enhanced excess free energy density. The hereby modified microstructure of 4N Cu, processed by High Pressure Torsion (HPT), tends to recrystallize already at low homologous temperatures of about 0.26 revealing a significant decrease in the recrystallization temperature. Diffusion in these structures features "ultra fast" in addition to "conventional" rates of grain boundary diffusion along GHAGB (as present in annealed coarse-grained polycrystals). The results indicate a special microstructural state of at least a fraction of interfaces (suitable for percolation) which relax, but are still observable at 320 K. Diffusion experiments above 320 K involve a complete recrystallization of the initial structure. Fast diffusion rates are still measurable featuring the presence of "High Energy Grain Boundaries" (HEGB) in recrystallized HPT Cu. At temperatures higher than 443 K, microstructural relaxation induces a further transformation of HEGB into GHAGB.

MM 32.3 Tue 16:15 IFW B

Diffusion and microstructure in ultrafine grained nickel — •Simon Trubel, Sergiy Divinski, Martin Peterlechner, Gerrit Reglitz, Matthias Wegner, Christian Simon, and Gerhard Wilde — Institut für Materialphysik der Westfälischen Wilhelms-Universität

Ultrafine grained and nanocrystalline materials produced by methods of severe plastic deformation (SPD) have roused a growing interest in science and technology. Previous experiments on Nickel of 99.6% purity show ultra-fast diffusion rates in severely deformed materials created by equal channel angular pressing (ECAP) [1]. Further investigations on pre-annealed ECAP-Nickel were conducted to analyse the nature of its recovery on a microscopic scale. In order to analyse the impact of the strain path and particularly of the hydrostatic component of the applied stress, the material of the same starting ingot has also been applied to high pressure torsion (5 turns, 2 GPa applied pressure). Grain boundary self-diffusion has been analysed by applying the 63Ni radioisotope in combination with high-precision parallel grinding. The results of the diffusion measurements and of measurements by electron backscattered diffraction (EBSD) and transmission electron microscopy (TEM) are discussed with respect to modifications of grain boundary structures and characteristics by SPD.

MM 32.4 Tue 16:30 IFW B

Lattice degradation in bi-crystalline Ag wires during reversible electromigration — •Simon P. Sindermann, Michael Horn-von Hoegen, Günter Dumpich, and Frank-J. Meyer zu Heringdorf — Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE) University of Duisburg-Essen, D-47057 Duisburg, Germany

Electromigration is known as the reversible mass transport occuring at high electric current densities. We use well controlled bi-crystalline Ag test structures [1] to study the interaction of electromigration driven voids with the crystal lattice by *in-situ* scanning electron microscopy (SEM).

Previously we have shown that the void shape is strongly influenced by the lattice symmetry [2], and we observed an increased number of additional voids in the motion path of voids [3].

Here, we present our observation of void motion at the reversal of the electric current direction. We find that a void exactly retraces its previous path. The test structure remembers where a void has passed through it. Electron backscatter diffraction (EBSD) shows that this kind of memory effect is caused by a permanent lattice degradation. Electromigration is thus not reversible with respect to the microstructure.

[1] S. Sindermann et al. RSI **82**, 123907 (2011)
[2] A. Latz et al. PRB **85**, 035449 (2012)
[3] S. P. Sindermann et al. JAP **113**, 134505 (2013)