MM 2: Topical Session: Nanomechanics of nanostructured materials and systems I - Grain size effects

Time: Monday 10:15–11:30 Location: BAR 205

Topical Talk MM 2.1 Mon 10:15 BAR 205

Effects of grain size, alloying and temperature on the mechanical behavior of nanocrystalline metals — •Ruth Schwaiger — Karlsruhe Institute of Technology (KIT), Institute for Applied Materials (IAM-WBM)

Characterization, control and optimization of mechanical properties are key issues in materials engineering. While nanocrystalline metals are very attractive candidates for applications requiring high strength, size-dependent deformation, deformation mechanisms and microstructural stability are still under debate. Experimentally, the transition from bulk to interface-dominated deformation mechanisms in nanocrystalline metals is reflected by increased strain rate sensitivity at low temperatures and smaller activation volumes compared to coarse-grained materials. Introducing miscible solutes can be expected to lead to modified mechanical properties compared to the pure metals. Furthermore, alloying of nanocrystalline metals may stabilize the microstructure if the solute segregates to the boundaries facilitating mechanical testing at elevated temperatures. Our investigations of PdAu and PdAg alloys showed a hardness increase with increasing alloying content. The grain size was observed to increase with increasing plastic strain at room temperature while the grain size was stable at annealing temperatures up to 95°C. In this presentation, mechanical behavior and size effects will be discussed for different metallic alloying systems and grain sizes.

MM 2.2 Mon 10:45 BAR 205

Nanoindentation of sputter-deposited Al and Al-Li thin films — •Diana Courty, Alla S. Sologubenko, and Ralph Spolenak — Laboratory for Nanometallurgy (LNM), ETH Zurich, Wolfgang-Pauli-Strasse 10, CH-8093 Zurich, Switzerland

Bulk, heavily-deformed fine-grained Al-Li-based alloys are known for their superplastic behavior at elevated temperatures. In these materials, grain-rotation is considered to be the major mechanism responsible for large plastic strains (up to 700%). An intrinsic feature of a thin metallic film, the nano-grained morphology, is very advantageous for the activation of this deformation mode, provided the inherent columnarity of the film morphology can be overcome.

Al-x at.%Li (x=0, 2, 5, and 10) thin film alloys have been sputter-deposited on Si wafers by different sputtering modes enabling the control of the grain morphology, breaking the columnar grain growth and tuning the sublayer thickness. These thin film alloys have been tested by nanoindentation at room temperature, 100°C and 150°C, showing a decrease in hardness for higher indentation temperatures. An effect of film thickness, composition and microstructure on the mechanical behavior of the thin film alloys was studied. Our particular interest is directed to the comparison of films of same thickness and composition but with different grain sizes, were smaller grain sizes showed an increase in hardness - smaller than expected by the Hall-Petch-effect.

MM 2.3 Mon 11:00 BAR 205

Small scale deformation of Chromium - Influence of Microstructure & Temperature — •Verena Maier, Megan J. Cordill, and Daniel Kiener — Department Materials Physics, Montanuniversität Leoben, Jahnstr.12, A-8700 Leoben

Time-dependent mechanical behavior, expressed by a materials strain-rate sensitivity, is an important indication for thermally activated processes during deformation. The ongoing miniaturization of components and material phases requires studying these effects on the local scale. In this work, the influence of microstructure and temperature on the strain-rate sensitivity of body-centered cubic Cr was studied by nanoindentation strain-rate jump tests at ambient and elevated temperatures. It was observed that Cr in the single crystal condition exhibits a more pronounced strain-rate sensitivity than ultrafine-grained Cr. This is due to the effects of the high lattice friction of bcc-metals at low temperatures, where the motion of the screw dislocations are dominating the deformation behavior, causing there an enhanced strain-rate sensitivity. Increasing the temperature over a material-dependent critical temperature Tc, it is demonstrated that the deformation behavior clearly changes. The thermally activated strength contribution diminishes and thus the strain-rate sensitivity is significantly reduced. However, for the ufg-state an increase of the strain-rate sensitivity with increasing temperature can be observed. This might be correlated to thermally activated motion and annihilation of dislocations at grain boundaries, as previously seen in ultrafine grained face centered cubic materials such as Al and Cu.

MM 2.4 Mon 11:15 BAR 205

Stress induced martensitic phase transformation during nanoindentation in NiTi shape memory alloys — •Guillaume Laplanche, Gunther Eggeler, and Janine Pfetzing-Micklich — Institut für Werkstoffe, Ruhr-Universität Bochum, D-44780 Bochum, Germany

NiTi shape memory alloys (SMA) exhibit remarkable functional properties which rely on a stress and/or temperature induced martensitic phase transformation. Our study is motivated by the need to mechanically characterize small NiTi components, such as micromechanical systems like stents and microactuators. In this study, we use a NiTi alloy with specific phase transformation temperatures. In our NiTi alloy, stress induced martensite is stable at room temperature and this allows its post-mortem characterization. We use EBSD to select grains with specific crystallographic surface normals. In those grains, we perform nanoindentation with spherical indenter tips, in order to avoid symmetries others than those of the crystal structure. The topography of the remnant indents were characterized using atomic force microscopy (AFM). The stress induced formation of martensite shows a crystallographic anisotropy which manifests itself in orientation dependent surface patterns. These patterns reflect the well-known symmetries of the cubic crystal lattice and vanish upon heating, when the martensite transforms back to austenite. AFM investigations of the topography of the regions surrounding the remnant indents directly after nanoindentation, reveal that the stress induced formation of martensite results in the formation of crystallographic sink-in regions surrounding the contact.