MM 50: Mechanical properties III - Evolution & deformation of microstructure

Time: Thursday 10:15–12:00 Location: IFW B

MM 50.1 Thu 10:15 IFW B

Liquid Ga penetration into ultra-fine grained Al — •Mehrnoosh Naderi, Sergiy Divinski, and Gerhard Wilde — Institute of Material physics, Münster, Germany

Under certain conditions, liquid metal can rapidly penetrate into a solid, typically along grain boundaries the phenomenon known as liquid metal embrittlement. One of the most spectacular examples of such phenomena is the gallium penetration into an aluminum grain boundary network. Most studies in this filed relate the liquid penetration process to mechanical properties of the grain boundaries. In this work the penetration behavior of liquid Ga in ultrafine grained Al produced by high pressure torsion (HPT) was investigated by dilatometry. Penetration of liquid Ga induces an unexpected, two-stage evolution of free volume in ultra-fine grained Al. The developments of the grain boundary decoration by liquid Ga and the surface evolution have been examined by scanning electron microscopy and atomic force microscopy. The abnormal length change behavior is discussed in terms of underlying mechanisms that control the Ga penetration.

MM 50.2 Thu 10:30 IFW B

Viscoplastic properties of copper with ultrafine grain structure after high-pressure torsion — •Jörn Leuthold, Matthias Wegner, Martin Peterlechner, Sergiy V. Divinski, and Gerhard Wilde — Institute of Materials Physics, University of Muenster, 48149 Muenster, Germany

Metals processed by severe plastic deformation possess a high density of stored energy in the form of vacancies, dislocations, twins, high- and low-angle grain boundaries. As a consequence of the grain refinement towards the sub-micrometer range, the structure and thermal evolution of grain boundaries as well as the interactions of the internal interfaces with defects in the grain interior become decisive factors for thermal stability, kinetic and plastic properties of the material. Even at low homologous temperatures, the viscoplastic flow can significantly contribute to the deformation mode when a mechanical stress is applied. In this study, 99.99% pure copper was processed by High Pressure Torsion (HPT) and investigated via nanoindentation. In addition to the determination of hardness maps, the viscoplastic properties were analyzed using long dwell times. Furthermore, uniaxial tensile tests were performed to determine the strain rate sensitivity in load jump tests. In combination with electron back scatter diffraction, the grain size and misorientation distribution and texture were analyzed in the as-deformed state and after additional tensile elongation at temperatures in the range from 293 K to 423 K. The results are discussed with respect to dislocation-mediated and grain boundary dominated mechanisms of plasticity.

MM 50.3 Thu 10:45 IFW B

Temperature-dependent shear behaviour of different grain boundaries in aluminium: An MD and metadynamics study — •Xueyong Pang and Rebecca Janisch — ICAMS, Bochum, Germany

We investigate the temperature-dependent mechanical shear behaviour of different tilt and twist grain boundaries in aluminium employing molecular dynamics and metadynamics simulation methods with embedded-atom method type potentials. The goal is to relate the mechanical properties of interfaces to the features of the grain boundaries gamma- respectively free energy surface, and thus to the grain boundary structure and misorientation. In the molecular dynamics simulations two different kinds of deformation modes were used to see the influence on the shear stress and the sliding mechanisms along different sliding directions, e.g. an easy-sliding and a general direction. Both molecular dynamics and metadynamics simulations were carried out at different temperatures to see the variation in energy barriers and shear strength as a function of temperature. The relation between structure and the obtained properties will be discussed in the presentation.

MM 50.4 Thu 11:00 IFW B

Room temperature grain growth in polymer-supported Cu and Au films during fatigue loading — •Oleksandr Glushko and Megan Cordill — Erich Schmid Institute, Jahnstr 12, 8700 Leoben, Austria

In this contribution a systematic investigation of microstructural changes in polymer-supported Cu and Au films under tensile fatigue loading conditions is presented. Fatigue tests were performed under total strain control and electrical resistance of the films was measured in-situ during the test. To capture the changes in the grain structure due to fatigue the EBSD and FIB ion channeling techniques were applied to the same areas of the films once before and once after cyclic mechanical test. Using this approach significant grain coarsening was observed in e-beam evaporated 500 nm thick Cu and Au films on polyimide. The grain coarsening effect is also manifested by the decrease of film resistance during first 500-1500 cycles. Under certain conditions the grain coarsening in gold films leads to total recrystallization and grain sizes are increased by 400% already after 1000 cycles. The role of grain coarsening in initiation and propagation of fatigue damage is also discussed.

MM 50.5 Thu 11:15 IFW B

Mechanical alloying of Cu50Ta50 produced by high pressure torsion — •Nazar Ibrahim, Martin Peterlechner, Sergiy Divinski, and Gerhard Wilde — Institute of Materials Physics, Westfälische Wilhelms-University Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

Mechanical alloying (MA) is generally considered as a solid-state powder processing technique, which involves repeated cold welding, fracturing and re-welding of powder particles in a high-energy ball mill. Recently, high pressure torsion (HPT) has been considered as a new MA method and was used for the fabrication of advanced materials with unique properties. In this work, HPT-induced mechanical alloying has been studied in the case of the immiscible Cu-Ta system. Cu and Ta foils with a thickness of 0.025 mm and a diameter of 10 mm were assembled alternatingly and subjected to HPT processing under an applied pressure of 4 GPa for 10, 30, 50, 100 and 150 turns at a rotational speed of 1.5 rpm. The phase constitution and microstructures were examined by X-ray diffraction, transmission and scanning electron microscopy. Additionally, the samples were characterized via microhardness measurements. It was shown that the HPT processing for 150 turns allows to completely mix Cu and Ta.

MM 50.6 Thu 11:30 IFW B

High-strength titanium-based materials processed by selective laser melting — •Hooyar Attar[1,2], Mariana Calin[2], LaiChang Zhang[1], and Jürgen Eckert[2,3] — [1]Edith Cowan University, Perth, WA 6027, Australia — [2]IFW Dresden, Institute for Complex Materials, P.O. Box 270116, D-01171 Dresden, Germany — [3]TU Dresden, Institute of Materials Science, D-01062 Dresden, Germany

Titanium and its alloys are widely used in biomedical industries. Improvement of their mechanical properties plays an important role in enhancing the biomechanical compatibility of Ti-based implants, leading to increase their longevity in the human system. The traditional processing technologies utilized for manufacturing medical devices are usually highly time and material consuming processing steps. Selective laser melting (SLM)is providing the ideal platform for producing components with almost no geometric constraints and is economically feasible down to a batch size of one. In the present work, optimal manipulation of SLM parameters were used to produce high strength commercially pure titanium (CP-Ti) and Ti-TiB composites with superior properties than those of conventionally processed. Results showed that mechanical properties of SLM-processed CP-Ti have been significantly increased compared to those of traditionally manufactured. The noticeable improvement of mechanical properties of SLM-processed CP-Ti is result of ultrafine martensitic grains formed during the SLM process. Moreover, micro-hardness and compressive strengths of the CP-Ti were increased greatly when it was reinforced with TiB particles.

MM 50.7 Thu 11:45 IFW B

Influence of pressure during high pressure torsion of NiAl — •Christine Tränkner[1], Robert Chulist[2], Werner Skrotzki[1], Benoît Beausir[3], Thomas Lippmann[4], Jelena Horky[5], and Michael Zehetbauer[5] — [1]Institut für Strukturphysik, Technische Universität Dresden, Dresden, Germany — [2]Instytut Metalurgii i Inzynierii Materiałowej, Polskiej Akademii Nauk, Kraków, Poland — [3]Laboratoire d'Etude des Microstructures et de Mécanique des

Matériaux, Université de Lorraine, Metz, France — [4]Institut für Werkstoffforschung, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany — [5]Fakultät für Physik, Universität Wien, Wien, Austria

NiAl is an intermetallic compound with a brittle-to-ductile-transition temperature at about 300°C and ambient pressure. As shown in [1], fracture stress and fracture strain are increased under high pressure. Therefore, deformation at low temperatures is only possible at high pressures, as for instance used in high pressure torsion (HPT). In order to study the influence of pressure on texture evolution and microstructure formation, small discs of polycrystalline NiAl were deformed by HPT at temperatures ranging from room temperature to 500°C and pressures from 2 to 8 GPa. For low temperatures higher pressures lead to less cracking and slipping. Regarding texture, pressure mainly influences the intensities of the texture components. Grain size also changes with pressure. For deformation at 500°C, the grains in the 2 GPa sample are twice as large as in the material deformed at 8 GPa. The results will be discussed with regard to dynamic recrystallization.

[1] R. Margevicius et al., Met. Mater. Trans. A 25, 1994, 1457-1470.