MM 34: Nanomaterials I

Time: Thursday 11:00–13:00 Location: IFW B

MM 34.1 Thu 11:00 IFW B

Random structural inhomogeneities in the axial direction in high pressure torsion processed samples — •David Geist, Hans-Peter Karnthaler, and Christian Rentenberger — University of Vienna, Physics of Nanostructured Materials, Boltzmanngasse 5, 1090 Wien, Austria

High pressure torsion (HPT) is a widely used method of severe plastic deformation to produce bulk nanostructured materials. In this study, it is shown for the intermetallic compound Zr3Al by TEM and SEM methods that grain refinement happens in a random manner. This contradicts the commonly accepted HPT formula which predicts that grain refinement, prior to saturation, should have a radial dependence only. Unlike earlier findings of violations of the HPT formula, that showed systematic inhomogeneities along the axial direction due to material flow during the early stages of HPT deformation, this work presents a mostly random refinement behavior along both the radial and the axial direction. In this inhomogeneous structure, refined regions carry most of the deformation while coarse grained regions hardly get deformed. Local hardness measurements are able to explain this deformation behavior by revealing the refined structure being softer. To study in detail the interface regions between these structurally distinct sample volumes, some samples were surface treated prior to deformation, leading to a systematic localization of the refined regions at the sample surfaces. High resolution TEM of the interface region reveals twinned structures and high dislocation densities, that could arise by the large strain gradient present at the interfaces.

MM 34.2 Thu 11:15 IFW B

***In Situ* Probing of fast Defect Annealing in Cu and Ni with a High-Intensity Positron Beam** — •Bernd Oberdorfer[1], Eva-Maria Steyskal[1], Wolfgang Sprengel[1], Werner Puff[1], Philip Pikart[2], Christoph Hugenschmidt[2], Michael Zehetbauer[3], Reinhard Pippan[4], and Roland Würschum[1] — [1]Inst. f. Materialphysik, TU Graz (A) — [2]Physik Dept. E21 u. FRM II, TU München (D) — [3]Physik Nanostr. Mater., Fak. Physik, Univ.Wien (A) — [4]Erich Schmid Inst. Mater. Sci, Univ. Leoben (A)

The thermally activated annealing characteristics of atomic defects in ultrafine-grained, high purity Ni and Cu after severe plastic deformation (SPD) have been analyzed by means of positron annihilation techniques and dilatometry. This was realized using the high-intensity monoenergetic positron beam at the NEPOMUC positron source of FRM II which allows for fast, *in situ* temperature dependent positron-electron annihilation spectroscopy on a time scale of minutes. Furthermore, high-precision length change measurements with a difference dilatometer provided information about the amount of excess free volume in these SPD materials associated with defects such as vacancies, vacancy agglomerates, dislocations and grain boundaries. The combination of these two *in situ* methods, atomistic positron annihilation and macroscopic dilatometry allows for an identification of the structural defects in solids by means of a detailed analysis of their annealing kinetics upon linear heating [1]. Financial support by the Austrian Science Fund (FWF) is appreciated (project P21009-N20).

[1] B. Oberdorfer et al., Phys. Rev. Lett. **105**, 146101 (2010).

MM 34.3 Thu 11:30 IFW B

Grain boundary excess volume in metals determined by dilatometry — •Eva-Maria Steyskal[1], Bernd Oberdorfer[1], Wolfgang Sprengel[1], Michael Zehetbauer[2], Reinhard Pippan[3], and Roland Würschum[1] — [1]Inst. f. Materialphys., TU Graz, 8010 Graz, Austria — [2]Phys. Nanostrukt. Mater., Fakultät f. Phys., Uni. Wien, Austria — [3]Erich Schmid Institute of Mater. Sci., Leoben, Austria

The amount of excess volume in grain boundaries (GB) represents a physical key parameter which for instance determines the GB energy and GB diffusion. The direct method of time-differential dilatometry is applied in order to study the specific excess volume associated with grain boundaries by measuring the irreversible length change in submicrocrystalline (smc) Ni upon annealing-induced crystallite growth. In smc-Ni prepared by high-pressure torsion two annealing regimes occur of which the distinct stage at ca. 200°C is due crystal growth after structural relaxation. From the measured length decrease in this stage and the concomitant increase of the crystallite size as determined by scanning electron microscopy, an excess volume per unit area $\epsilon = (0.034 \pm 0.004)$ nm of relaxed grain boundaries is deduced. Taking into account the anisotropic grain structure, this value is independent of the measuring direction of the length change. The results will be compared with available literature data obtained from molecular dynamic simulations, high-resolution transmission electron microscopy, or indirect experimental techniques. Financial support by the FWF Austrian Science Fund is appreciated (project P21009-N20).

MM 34.4 Thu 11:45 IFW B

Grain boundary segregation of carbon and formation of nanocrystalline iron-carbon alloys by ball milling — •Yuzeng Chen, Andreas Herz, and Reiner Kirchheim — Institut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen, Deutschland

Based on a novel defactants (defect acting agents) concept (R. Kirchheim, IJMR (Z. Metallkde) 100 (2009) 483 and Acta Materialia 55 (2007) 5129 and 5139), a novel method of understanding and synthesizing NC material was proposed by introducing defactants into materials to enhance the formation ability of nanocrystalline (NC) structures. Iron-carbon system was chosen as a model system where carbon acts as the so-called defactant. NC iron-carbon alloys with different carbon concentrations (C_0) were prepared by ball milling. Afterwards, the as-milled powder with relatively low carbon concentration was annealed at a certain temperature to achieve saturation of GBs by carbon. Mean grain sizes of the powders (D) were investigated by TEM and XRD. The results indicated that once the saturation of GBs is achieved, D will be strongly dependent on C_0 and will follow a mass balance of carbon in a closed system, i.e. $D = 3\Gamma_{gb}V_m/(C_0 - C_g)$ with C_g the carbon concentration in grains, Γ_{gb} the grain boundary excess, and V_m the molar volume. Based on the experimental results, the formation of NC iron-carbon alloys was treated within the framework of the defactant concept.

MM 34.5 Thu 12:00 IFW B

Laser radiation welding of transparent polymer foils by using noble metal nanoparticles as absorption layer — •Matthias Neuber, Thomas Hanke, Jörg Lucas, and Andreas Heilmann — Fraunhofer Institute for Mechanics of Materials IWM, Walter-Hülse-Straße 1, Halle (Saale), Germany

Laser radiation welding of transparent polymer foils requires an additional absorption layer. Due to their optical plasmon resonance, metal nanoparticles can act as such an absorber. The spectral position, intensity and half width of the absorption peak are determined by the size and shape distribution of the particles as well as by the surrounding media. During carefully performed laser irradiation, the optical absorption behaviour of a thin nanoparticle layer is sufficient to join two much thicker transparent polymer foils and the particles change their size and shape basically by diffusion processes and melting processes of the polymer during this radiation process.

The metallic nanoparticles were deposited on the surface of ethylene tetrafluoroethylene foils by evaporation processes or magnetron sputtering. Laser irradiation was performed by a defocused continuous wave diode laser at a wavelength of 808 nm and a spot diameter of about 3 mm. During this radiation, the foils were welded and finally a nearly transparent welding seam was achieved. The nanostructures and the optical properties of the nanoparticle layers before and after laser irradiation were determined and compared. Mechanical tensile tests of the laser welding seams have demonstrated that their tensile strength is comparable to conventional thermal welding seams.

MM 34.6 Thu 12:15 IFW B

Ultrasound-driven design of new mesoporous metal catalysts — •Jana Schäferhans[1], Ekaterina Skorb[2], Nicolas Pazos Perez[1], and Daria Andreeva[1] — [1]Physikalische Chemie II, Uni Bayreuth, Deutschland — [2]Max-Planck-Institut für Kolloid- und Grenzflächenforschung, Golm, Deutschland

Mesoporous metal nanocomposites were formed by a “green chemistry” method with ultrasound irradiation. The sonication technique combines the fabrication of a mesoporous support consisting of metallic particles (Al, Mg) several tens of micrometers in size and the subsequent incorporation of metal (Ag, Au, Pt etc.) nanoparticles into its pores. Next to filling the mesoporous support with particles we are also able to form mesoporous alloys e.g. AlNi or CoAlFe. The resulting material is analyzed by transmission electron microscopy, powder X-ray diffraction, small-angle neutron scattering and the Brunauer-Emmett-Teller and the Barrett-Joyner-Halenda method. Surface areas up to 200 m^2/g with a narrow pore size distribution around 3 nm can be achieved. The mesoporous structures are analyzed by confocal light microscopy after coloring the particles with dye. We explain the formation of the mesoporous inner structures by the following mechanism: Thermal etching and recrystallization of metals by ultrasound-stimulated high-speed jets of liquid form the porous structure that is stabilized by surface oxidation through free radicals generated during cavitation. We expect this approach to be universal and opening perspectives for a whole new class of catalytic materials that can be prepared in a fairly easy and cost effective way.

MM 34.7 Thu 12:30 IFW B

Correlation of structure and electron transport in Fe filled carbon nanotubes — •Vadim Migunov, Marina Spasova, and Michael Farle — Fakultät für Physik, and CeNIDE University Duisburg-Essen, 47048 Duisburg, Germany

Carbon nanotubes (CNT) are potentially the interesting building blocks for different types of future electronic and mechanical devices. The filling of CNT with magnetic materials opens new multifunctional possibilities for novel applications.

The Fe filled CNT (FeCNT) were synthesized by chemical vapor deposition [1]. Transport studies were conducted inside a Philips CM-12 transmission electron microscope (TEM) using Nanofactory scanning probe microscopy (SPM) holder for TEM. A gold SPM tip was brought in contact with a single FeCNT, and two-point resistance measurements were carried out.

We have found that high current densities ($>10^{10}$ A/m^2) lead to evaporation of Fe in FeCNT. After the evaporation the total resistance of the system decreases by up to a factor of three as confirmed by steps in the I-V curves.

The work has been supported by SFB 445. The FeCNT were prepared by the CVD group of the IFW Dresden.

[1] A. Leonhardt, M. Ritschel, R. Kozhuharova, A. Graff, T. Muhl, R. Huhle, I. Monch, D. Elefant, C. M. Schneider, Diamond and Relat. Mater. 12, 790 (2003)

MM 34.8 Thu 12:45 IFW B

Electrical properties of an Al-NWFET fabricated under different gate oxide layers — •Dawit Gedamu[1], Torge Behrendt[1], Hermann Kohlstedt[2], Ondrej Vavra[2], Adrian Petraru[2], and Rainer Adelung[1] — [1]Functional Nanomaterials, Institute of Materials Science, Faculty of Engineering, University of Kiel, Kaiser Strasse 2, 24143 Kiel, Germany — [2]Nanoelektronik, Technische Fakultät Kiel, Christian-Albrechts-Universität Kiel, 24143 Kiel , Germany

Recently 1 D nanostructures such as nanowires (NWs) becoming gradually more important as components for micro- and nanoelectronic devices because of their high surface to volume ratio [MRS Bulletin 32, 99 (2007), Acc. Chem. Res. 32, 435 (1999)]. Nonetheless, the development of 1D NWs with desired thicknesses on preferred substrates or between two metal contacts as well as their understanding their physical properties, are the still challenging. Several methods have been utilized so far to grow 1D NWs but according to industrial demand, we have used thin film fracture [Nat. Mater. 3, 375 (2004)] as NW templates and electron beam lithography techniques to fabricate Al NW field effect transistors (NWFETs). The fabrication of Aluminum NWFETs with dimensions in the sub-100 nm regime and the electrical characteristics of bottom gate FETs will be presented. An 100 nm thick silicon dioxide on 380 micron thick <100> oriented p-doped silicon was used gate oxide. In another approach, Alumina film synthesized through electrochemical oxidation on silicate glass substrate was used to as gate dielectric. A close analysis of the NWFETs reveals a slight drop down of the conductance with increasing gate voltage.