DS 23 Nanowires, nanoparticles and nanostructures

Time: Thursday 15:30–17:30 Room: GER 38

Invited Talk

DS 23.1 Thu 15:30 GER 38

Laser-induced diffusion processes on metal nanoparticles — •Andreas Heilmann — Fraunhofer Institute for Mechanics of Materials Halle (Saale)

Although metal nanoparticles embedded in an insulating matrix show sufficient long-term stability, diffusion processes of metal atoms occur at temperatures far below the melting point of the metals. The material transport is driven by the free surface energy of the nanoparticles and associated with lattice defects and grain boundaries. These diffusion processes result in changes of the size and shape distribution of the embedded particles. Therefore, the optical and electrical properties of the nanoparticles change dramatically.

The simplest way to accelerate and to study such diffusion processes is thermal treatment, but also Laser irradiation or electron beam irradiation can cause nanostructural changes inside the beam spot without material ablation. By irradiating nanoparticle assemblies with linearly polarized, ultrashort laser pulses in far field arrangement, parallel arranged line structures of embedded gold or silver nanoparticles were achieved inside the laser spot. These structures are result of diffusion processes induced by the irradiation energy and directed by linear polarization of the laser pulses. The anisotropic structure modification results in anisotropic optical and electrical properties of the nanoparticle assemblies.

DS 23.2 Thu 16:15 GER 38

Electromigration in single- and polycrystalline silver nanowires — •M. Hartmann and G. Dumpich — Experimentalphysik, Universität Duisburg-Essen (Standort Duisburg), Lotharstr. 1, 47048 Duisburg

Electromigration measurements are conducted for polycrystalline silver nanowires prepared by electron beam lithography (EBL) as well as for singlecrystalline nanowires grown by self organization of Ag onto vicinal Si substrates. The observed resistance changes as a function of time can be directly correlated to structural changes in the nanowire, such as void and hillock formation, by *in situ* observation in a scanning electron microscope (SEM). A direct comparison between single- and polycrystalline wires in a parallel connection shows that the ratio between the two governing forces, the windforce and the direct force, differs greatly for these wire types.
While polycrystalline wires exhibit the electrical breakdown at the cathode, the atomic mass flux in singlecrystalline wires is just the other way around. This indicates a higher absolute value of the direct force in singlecrystalline nanowires - as compared to the wind force - which is found in nearly no other system. However, by increasing the current density in these singlecrystalline wires the direction of the diffusion is found to change its sign at a certain critical value of j_c. This effect is discussed in terms of current induced defect formation. This work is supported within SFB 616.

DS 23.3 Thu 16:30 GER 38

Reversible electromigration behavior of gold nanowires — •Burkhard Stahlmecke and Günter Dumpich — Experimental Physics, Department of Physics, University Duisburg-Essen (Duisburg Campus), Lotharstraße 1, 47057 Duisburg, Germany

We perform *in-situ* scanning electron microscopy (SEM) observations of electromigration in gold nanowires. The wires are prepared by means of electron beam lithography and have typical dimension of length l = 10 μm, width w = 200 $nm - 1$ μm and thickness t = 40 nm. Electrical currents with a current density of approximately $1 * 10^8 A/cm^2$ are applied to the wires using either a constant voltage or a constant current mode. During the measurements the polarity of the current is reversed, which leads to a partly reversed electromigration behavior in the nanowires. Additionally we investigate the influence of contaminations due to the *in-situ* SEM observations on the electromigration behavior of the nanowires.

This work was supported by the DFG within the special research area (SFB) 616: Energy dissipation at surfaces.

DS 23.4 Thu 16:45 GER 38

Electronic properties of nanometer-sized ion tracks embedded in tetrahedral amorphous carbon — •Anne-Katrin Nix[1], Daniel Schwen[1], Hans Krauser[2], Christina Trautmann[3], and Hans Hofsäss[1] — [1]II. Physikalisches Institut, Universität Göttingen, Germany — [2]Hochschule Harz, Wernigerode, Germany — [3]Gesellschaft für Schwerionenforschung, Darmstadt, Germany

We investigated the formation of quasi one-dimensional conducting filaments in diamondlike carbon (DLC) films by swift heavy ion irradiation. Various DLC films with thicknesses of several 100 nm were grown using mass separated ion beam deposition on highly conducting Si and Fe substrates. After deposition the films were irradiated with 1 GeV ^{238}U ions with fluences between 10^9 and 10^{11} ions/cm^2. Due to their high electronic energy loss of about 30 keV/nm the swift heavy ions graphitize the predominantly (80%) sp^3-bound carbon film along their trajectories yielding conductig nanowires embedded in an insulating matrix. Using atomic force microscopy (AFM) with conducting cantilevers and applied bias voltage the presence of conducting tracks was confirmed and their conductivities were determined to be several orders of magnitude higher than of the host matrix. Temperature dependent electrical measurements were performed on the irradiated samples at 300 K - 10 K with fields up to 5 V/μm. We will discuss the results with respect to contact resistances and possible one-dimensional conduction mechanisms within the tracks.

DS 23.5 Thu 17:00 GER 38

Electrical investigations of tungsten oxide nano-particles using Impedance Spectroscopy — •Tim Patrick Hülser[1,2], Hartmut Wiggers[2], and Axel Lorke[1] — [1]Institute of physics, University Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg — [2]Institute of combustion and gas dynamics, University Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg

We report on the electrical properties of tungsten oxide nanoparticles, which are analyzed using Impedance Spectroscopy. The particles are synthesized in a low pressure premixed flame reactor using WF_6 as precursor material. The parameters can be adjusted to synthesize WO_X particles with $2.6 < x < 3$. Thin films of particles in the size range from 5 nm to 9 nm deposited on interdigital capacitors as well as small discs of this material are investigated by AC-methods.

Impedance Spectroscopy on the as-prepared WO_X thin films have been carried out under air in the range from 313 K to 503 K. Two contributions to the overall impedance are detected and analyzed by fitting the data using equivalent circuits. Two contributions can be identified, one from the grain-boundary contacts (GB), the other from the electrode-particle (EC) contacts. The resistance of both decreases with increasing temperatures as expected for semi-conducting materials. Activation energies of -1.93 eV for the GB and -201 meV for the EC contacts have been found.

The conductivity of compacted, understoichiometric WO_X is higher than that of stoichiometric WO_3. Furthermore, compacted material also shows GB and EC contributions in agreement with the results from the interdigitated capacitors.

DS 23.6 Thu 17:15 GER 38

Large-scale fabrication of Au nanostructures in the process of amalgam formation followed by Au-Hg alloy thermal decomposition — •Tomasz Kobiela — University of Bonn, Institute of Physical and Theoretical Chemistry, Wegelerstrasse 12, D-53115 Bonn, Germany — Institute of Physics, Polish Academy of Sciences, Al. Lotnikow 32/46, 02-668 Warsaw, Poland

Formation of gold nanostructures onto surfaces is fundamental process for fabricating various micro/nano devices and systems. These nanostructures exhibit not only the novel physical properties, but are commercially used in the electronic devices, catalysts and efficient biomolecular sensors. In this work, Au films deposited under ultra-high vacuum conditions on air-cleaved mica substrates were exposed "in situ"to Hg vapor (residual gas pressure 1x10^{-7} Pa, with Hg vapor pressure 0.24 Pa). This led to transformation of continuous gold film into isolated amalgam islands of nanometer scale. The changes of Au thin film surface topography caused by amalgamation carried out within 40 h was studied by the atomic force microscopy method, while the phase transition in the bulk of Hg-dosed Au films was monitored by means of X-ray diffraction. The

islands' morphology varies from irregular, ramified structures on terraces to compact shapes along the steps on the mica substrate. After thermal decomposition of the amalgam, thin gold films consisting of isolated Au nanostructures on mica can be obtained. The experimental data are compared with theoretical calculations of the kinetic processes occurring at the thin Au film surface.