DS 9: Metal Layers

Time: Tuesday 9:30–10:45 Location: GER 37

DS 9.1 Tue 9:30 GER 37

Electromigration and Heat Distribution in Silver Nanowires — •Christian Wirtz, Niemma M. Buckanie, Sven Stienen, Ralf Meckenstock, Frank-Joachim Meyer zu Heringdorf, and Günter Dumpich — Universität Duisburg Essen, Experimentalphysik and Centre for Nanointegration Duisburg-Essen , Lotharstr.1 , 47048 Duisburg

We investigate the electromigration behaviour and thermal properties of single-crystalline silver nanowires subjected to high electrical current densities.

The electromigration measurements are conducted within a Scanning Electron Microscope using an experimental setup which provides SEM imaging and four-wire electrical resistance monitoring simultaneously. Current densities in excess of 10^7 A/cm^2 are applied, and the direction of electromigration mass flow is found opposite to that of the net electronic momentum.

For thermal measurements, Scanning Thermal Microscopy (SThM) is employed, revealing the heat distribution within an electrically stressed nanowire.

Further research efforts will comprise a combination of the aforementioned techniques with ferromagnetic resonance as well as resistance measurements on carbon nanotubes.

DS 9.2 Tue 9:45 GER 37

A Quantum-stabilized Mirror for Atoms — Daniel Barredo[1], Fabián Calleja[1], Pablo Nieto[1], Juan José Hinarejos[1], Guillaume Laurent[1], Amadeo Vázquez de Parga[1], •Daniel Farías[1], and Rodolfo Miranda[1,2] — [1]Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, Spain — [2]Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA-Nanociencia), Spain

Helium atom scattering is a well-established technique for investigating the structural and dynamical properties of surfaces. Because of the low energies used (100 meV), neutral He atoms probe the topmost surface layer of any material in an inert, completely nondestructive manner. This means that a Scanning Helium Atom Microscope using a focused beam of He atoms would be a unique tool for reflection or transmission microscopy, with a potential lateral resolution of ca. 50 nm. It could be used to investigate insulating glass surfaces, delicate biological materials and fragile samples which are difficult to examine by other methods. However, the practical realization of such a microscope requires the development of a mirror able to focus a beam of low energy He atoms into a small spot on the sample.

Here we show that Quantum Size Effects can be exploited to produce an ultraperfect, atomically flat film of Pb of magic thickness on a highly perfect Si(111) thin wafer. The metal film reproduces the structural perfection of the substrate, is atomically flat over micron-wide areas and stable up to 250 K. As a consequence, more than 15% of the incoming He atoms are scattered into the specular direction, which allows its use as an ultra smooth mirror for neutral atoms.

DS 9.3 Tue 10:00 GER 37

Scaling and stress effects on freestanding and substrate-attached TiNiCu thin film microbridges — •Dennis König, Michael Ehmann, Sigurd Thienhaus, and Alfred Ludwig — Ruhr-Universität, Bochum, Deutschland

TiNiCu shape memory alloys are known for their high inherent energy density and their small thermal hysteresis. Therefore, TiNiCu thin films are promising candidates for actuator materials in micro electrical mechanical systems. Due to the difference of the thermal expansion coefficients of the thin film and the substrate, after deposition and subsequent annealing, thin films are under stress. This affects the transformation temperatures. The stress-dependency of the TiNiCu phase transformation was investigated by comparing substrate-attached and freestanding thin film bridges utilizing temperature-dependent resistivity measurements. A difference of over 30 K in the transformation temperatures of freestanding and substrate-attached film was observed. Furthermore it was found that a change of the lateral dimensions of the bridges also causes a shift of the transformation temperatures. With regard to a further miniaturization of the micro-bridges to the nanometer scale, the bridges were reduced in width by focused ion beam. The phase transformation behavior was again characterized using temperature-dependent resistivity measurements. It was found that reducing the bridge width from 4 μm to 1 μm leads to a transformation temperature shift of over 30 K.

DS 9.4 Tue 10:15 GER 37

Dielectric properties of ultra-thin metal films around the percolation threshold — •Martin Hövel, Martin Alws, Bruno Gompf, and Martin Dressel — 1.Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

The dielectric properties of percolating metal films around the insulator-to-metal (IMT) transition are not well understood [1]. By combining Fouriertransform infrared spectroscopy (FITR), spectroscopic ellipsometry, and dc-conductivity measurements on ultra-thin Au films on Si/SiO_2 the effective dielectric properties around the IMT can be described Kramers-Kronig consistent over a very brought frequency range from 500 to 27 000 cm^{-1}. Above a critical thickness d_c, the so called percolation threshold, the films show for low frequencies a typical metallic-like behavior which can be fitted by a simple Drude-Model [2]. Below d_c the frequency behavior is dominated by a "Maxwell-Garnett resonance" which shifts to lower frequencies with increasing film thickness and dies out well above the IMT. A dielectric anomaly with a maximum of ϵ_1 at d_c is observed and can be described by the interplay of this resonance and the onset of the Drude-component. Additionally the temperature dependence of the films were studied. Here also a transition from an activated to a metallic like behavior at d_c was found.

[1] B. Gompf, J. Beister, T. Brandt, J. Pflaum, M. Dressel, Optics Letters 32, 1578 (2007)
[2] T. Brand, M. Hövel, B. Gompf, M. Dressel, Phys. Rev. B 78, 205409, (2008)

DS 9.5 Tue 10:30 GER 37

Surface and Surface Self-diffusion of Pt thin films on Si_3N_4/Si **and** ZrO_2 **Substrates** — •Henning Galinski, Thomas Ryll, Pierre Elser, Anja Bieberle-Hütter, Jennifer Rupp, and Ludwig Gauckler — Nonmetallic Inorganic Materials, ETH Zurich, Zurich, Switzerland

Metals and ionic bonded ceramics possess distinct diametric bonding characteristics. Thus, the stability of a metal thin film on a ceramic substrate is conditioned by the interactions between the different bonding types across the interface. In the case of weak adhesion the minimization of free surface energies gives rise to decomposition and agglomeration of thin metallic films. The morphological evolution of Pt thin films has been investigated by means of scanning electron microscopy (SEM) and atomic force microscopy (AFM). Pt thin films were deposited on Si_3N_4/Si and yttria stabilized ZrO_2 substrates and subjected to heat treatments up to 800°C for 2 hours. Three main observations have been made: i) the dominating mechanism of initial film rupture is the nucleation of holes at the triple junctions of the Pt thin film as shown by means of Minkowski measures. ii) The evolution of the film at this stage is in agreement with Brandon and Bradshaw's theory of surface energy driven diffusion. The kinetics of the hole growth were used to calculate the surface self-diffusion coefficient of Pt. iii) at high temperature, holes coalesce and Pt islands are formed that undergo an Ostwald ripening process. The evolution of the particle size distribution allowed deducing the mass transfer surface diffusion coefficient of Pt on Si_3N_4 and ZrO_2.