O 23: [DS] Focused electron beam induced processing for the fabrication of nanostructures II (focused session, jointly with O – Organizers: Huth, Marbach)

Time: Tuesday 9:30–11:30 Location: H 0111

Invited Talk O 23.1 Tue 9:30 H 0111

Free electrons for building nanodevices — •Ivo Utke — Empa, Swiss Federal Laboratories for Materials Science and Technology, Thun, Switzerland

Finely focused electron beams in scanning electron microscopes are routinely used to visualize small nanometer-sized objects. But add chemistry and they give you materials and structures for exciting physics to do at the nanometer scale! When functional gas molecules (metal-carbonyls, siloxanes, biphenyls, etc.) are injected into an electron microscope chamber held at a pressure of 1e-6 mbar or lower, they form adsorbed layers on many substrates. Focused electron beams can interact with these molecular layers, triggering surface reactions that can be used to locally etch or deposit, or to induce intermolecular reactions between the adsorbed molecules. All of these focused electron beam induced processes (FEBIP) can be performed on almost any kind of substrate [1]. This presentation will cover the fundamentals of FEBIP and give a state of the art overview on exciting nanodevices realized in the fields nanoelectronics, nanomechanics, nanophotonics, and nano(bio)sensors. Special attention will be given to FEBIP with two molecules involved, which led to the development of high performance magnetic sensors [2] having applications in bead detection.

[1] I. Utke, A. Gölzhäuser, Angew. Chem. Int. Ed. 2010, 49, 9328.
[2] L. Bernau et al., Angew. Chem. Int. Ed. 2010, 49, 8880.

Topical Talk O 23.2 Tue 10:00 H 0111

From electronic correlations to strain sensing: Nanongranular metals and their applications — •Christian Schwalb, Marcel Winhold, Fabrizio Porrati, Roland Sachser, and Michael Huth — Physikalisches Institut, Goethe-Universität, Max-von-Laue-Str.1, 60438 Frankfurt am Main

Granular metals are artificial materials that consist of a conducting phase of metallic nanoparticles embedded in a carbon-rich dielectric matrix. The charge transport in such systems is dominated by tunneling between neighboring metallic nanoparticles, a process that is strongly influenced by correlation effects, such as the Coulomb blockade in the limit of weak inter-grain coupling. Additionally the tunneling coupling in these materials has an intrinsically exponential dependence on the inter-grain distance.

In this work, we present a practical application for these fundamental processes. Using focused electron-beam-induced deposition (FEBID) we can create strain-sensing elements based on nanogranular metals. The gauge factor for these sensing elements depends on their conductivity that can be altered by electron-beam irradiation leading to a change in the sensitivity that can be attributed to a persistent change of the dielectric carbon matrix. Due to the high resolution of the FEBID process strain-sensing elements with dimensions below 20 nm are feasible, therefore enabling, e.g., the fabrication of nano-cantilevers for ultra-fast AFM applications.

Topical Talk O 23.3 Tue 10:30 H 0111

Tailored cobalt nanostructures by FEBID — •José M. de Teresa[1,2], Rosa Córdoba[2], Luis Serrano-Ramón[1,2], Amalio Fernández-Pacheco[1,2], and Ricardo Ibarra[1,2] — [1]Instituto de Ciencia de Materiales de Aragón, Universidad de Zaragoza-CSIC, Spain — [2]Laboratorio de Microscopías Avanzadas, Instituto de Nanociencia de Aragón, Universidad de Zaragoza, Spain

Focused-electron-beam-induced-deposition (FEBID) using Co2(CO)8 gas precursor allows the direct writing of cobalt-based magnetic structures [1]. We first grew high-purity cobalt structures with FEBID using high beam currents [2, 3]. The coercive field of these structures can be controlled via the shape anisotropy [4], and single-domain behavior can be observed [5]. Interestingly, the domain-wall propagation field can be lower than the domain-wall nucleation field, with potential magnetic applications [6]. The spin polarization of these cobalt deposits is large enough for its use in Spin Electronics [7]. We have recently achieved the growth of narrow high-cobalt-content nanowires (30 nm) and Hall sensors (100 nm), opening the route for the growth of cobalt structures tailored at the nanoscale [8].

[1] I. Utke et al., J. Vac. Sci. Technol. B 26 (2008) 1197 [2] A. Fernández-Pacheco et al, J.Phys. D: Appl. Phys. 42 (2009) 055005 [3] R. Córdoba et al., Nanoscale Res. Lett. 6 (2011) 592 [4] A. Fernández-Pacheco et al, Nanotechnology 20 (2009) 475704 [5] M. Jafaar et al., Nanoscale Res. Lett. 6 (2011) 407 [6] A. Fernández-Pacheco et al, Appl. Phys. Lett. 94 (2009) 192509 [7] S. Sangiao et al., Solid State Commun. 151 (2011) 37 [8] L. Serrano-Ramón et al., ACSnano 5 (2011) 7781

O 23.4 Tue 11:00 H 0111

Structural, electrical and magnetic properties of CoPt-C alloys prepared by focused electron-beam induced deposition — •Fabrizio Porrati[1], Evgenyia Begun[1], Marcel Winhold[1], Roland Sachser[1], Achilleas Frangakis[2], and Michael Huth[1] — [1]Physikalisches Institut, Goethe Universität, Frankfurt am Main — [2]Institut für Biophysik, Goethe Universität, Frankfurt am Main

CoPt-C binary alloys have been fabricated by focused electron beam-induced deposition with the simultaneous use of the $Co_2(CO)_8$ and $(CH_3)_3CH_3C_5H_4Pt$ precursor gases. The alloys are made of CoPt nanoparticles embedded in a carbonaceous matrix. TEM investigations show that as-grown samples are in an amorphous phase. By means of a post-growth low-energy electron irradiation treatment the CoPt nanoparticles transform into face-centred tetragonal $L1_0$ CoPt nanocrystallites. In pararrel, the system undergoes a transition from a superparamagnetic to a ferromagnetic state at room temperature. By variation of the post-growth electron irradiation time the electrical- and magneto-transport properties of the alloy can be continuously tuned.

O 23.5 Tue 11:15 H 0111

Electron Beam Induced Surface Activation of Oxide Surfaces for Nanofabrication — •Florian Vollnhals[1], Tom Woolcot[2], Steffen Seiler[1], Marie-Madeleine Walz[1], Hans-Peter Steinrück[1], Geoff Thornton[2], and Hubertus Marbach[1] — [1]Lehrstuhl für Physikalische Chemie II and Interdisciplinary Center for Molecular Materials (ICMM), Friedrich-Alexander-Universität Erlangen-Nürnberg, Egerlandstr. 3, 91058 Erlangen — [2]London Centre for Nanotechnology and Department of Chemistry, University College London, 17-19 Gordon Street, London WC1H 0AH, UK

The controlled fabrication of structures on the nanoscale is a major challenge in science and engineering. Direct-write techniques like Electron Beam Induced Deposition (EBID) were shown to be suitable tools in this context. Recently, Electron Beam Induced Surface Activation (EBISA) has been introduced as a new focused electron beam technique. In EBISA, a surface, e.g. SiO_2, is irradiated by a focused electron beam, resulting in an activation of the exposed area. The activated area can then react and decompose precursor gases like iron pentacarbonyl, $Fe(CO)_5$. This leads to a primary deposit, which continues to grow autocatalytically as long as $Fe(CO)_5$ is supplied, resulting in pure (>90%at.), crystalline iron nanostructures.[1] We expand the use of this concept by exploring EBISA to produce metallic nanostructures on $TiO_2(110)$ in UHV; atomistic insight into the process is obtained via Scanning Tunneling Microscopy (STM) and chemical insight via Auger Electron Specroscopy (AES). Supported by the DFG (MA4246/1-2).

[1] M.-M. Walz et al., Angew. Chem. Int. Ed. 49 (2010), 4669