DS 33: Progress in Micro- and Nanopatterning: Techniques and Applications II (Focused Session, jointly with O – Organisers: Graaf, Hartmann)

Time: Wednesday 11:00–13:00 Location: GER 38

DS 33.1 Wed 11:00 GER 38

Tuning the electrical conductivity of Pt-containing granular metals by postgrowth electron irradiation — •Fabrizio Porrati, Roland Sachser, Christian H. Schwalb, and Michael Huth — Physikalisches Institut, Goethe-Universität, D-60438 Frankfurt am Main, Germany

We have fabricated Pt-containing granular metals by focused electron beam induceddeposition from the $(CH_3)_3CH_3C_5H_4Pt$ precursor gas. The granular metals are made of platinum nanocrystallites embedded in a carbonaceous matrix. We have exposed the as-grown nanocomposites to low energy electron beam irradiation and we have measured the electrical conductivity as a function of the irradiation dose. Postgrowth electron beam irradiation transforms the matrix microstructure and thus the strength of the tunnel coupling between the Pt nanocrystallites. For as-grown samples (weak tunnel coupling regime) we find that the temperature dependence of the electrical conductivity follows the stretched exponential behavior characteristic of the correlated variable-range hopping transport regime. For briefly irradiated samples (strong tunnel coupling regime) the electrical conductivity is tuned across the metal-insulator transition. For long-time irradiated samples the electrical conductivity behaves like that of a metal. In order to further analyze changes of the microstructure as a function of the electron irradiation dose we have carried out atomic force microscopy (AFM) and micro-Raman measurements. These measurements reveal that by increasing the irradiation dose the matrix changes following a graphitization trajectory between amorphous carbon and nanocrystalline graphite.

DS 33.2 Wed 11:15 GER 38

Ordered triple color patterns based on two dye molecules — •Wang Wenchong, Fuchs Harald, and Chi Lifeng — Physikalisches Institut and Center for Nanotechnology (CeNTech), Universität Münster, 48149 Münster, Germany

Functional, small molecular weight organic molecules have received great scientific and technological interest due to their promising potential applications in molecular electronics and optoelectronics. Since last two decades, exciting progress has been witnessed in both materials and film preparation that applied for organic field effect transistors (OFETs),light emission diodes (OLEDs), solar cells,Memories, Sensors, and so on. However, device processing techniques yielding high performances, high levels of integration and uniformity over large area are still underdevelopment. Template directed growth of molecules has been demonstrated as a promising technique for patterning,functionalizing materials at predefined areas and improving device performance.[1-3] Here, based on liquid behavior and solid solvation of molecuoes on patterned surface, the technique can further be applied to fabricate high resolution, ordered triple color patterns with only two molecules.

[1] W. C. Wang, L. F. Chi, et al, Phys. Rev. Lett.2007, 98, 225504.
[2] W. C. Wang, L. F. Chi, et al, Adv. Mat. 2009, 21, 4721.
[3] W. C. Wang, L. F. Chi, et al, Adv. Mat. 2010, 22, 2764.

DS 33.3 Wed 11:30 GER 38

Artificial Hierarchical Gecko-mimicking Structures — •Michael Röhrig, Alexander Kolew, Fabian Pfannes, Matthias Worgull, and Hendrik Hölscher — Institute for Microstructure Technology (IMT), Karlsruhe Institute of Technology (KIT), Germany

Geckos have an impressive attachment system that makes them able to climb on nearly every surface. Like various other mechanisms developed by nature, the gecko effect is strongly connected to the structuring of surfaces. The toes of the Tokay Gecko for example are divided into several lamellae which are covered with millions of setae, delicate hairs which are about $100\,\mu m$ in height and $4\,\mu m$ in diameter. The setae branch into hundreds of tiny endings, the so called spatulae. Thus the gecko is capable of achieving intimate contact with smooth and rough surfaces which leads to a strong adhesion due to intermolecular forces, in particular van der Waals forces.

Mimicking these micro- and nanostructures leads to artificial dry attachment systems. *Hot embossing* is a well-suited molding technique to fabricate such biomimetic structures. In this talk a new variation of hot embossing, the so called *hot pulling* will be presented. Hot pulling allows the fabrication of fibrillar, gecko-mimicking surfaces. Beyond that, the method of measuring the adhesion of structures via AFM force distance curves by using spherical tips will be depicted.

DS 33.4 Wed 11:45 GER 38

Self-arranged anodic nanostructured thin films on titanium — •Robin Kirchgeorg, Steffen Berger, and Patrik Schmuki — Institute for Surface Science and Corrosion (LKO), Department Material Science and Engineering, Fridrich-Alexander-Universität Erlangen-Nürnberg, Martensstraße 7, 91052 Erlangen, Germany

Self-organized anodic oxide nanostructures, in particular highly ordered titania nanotubes offer several interesting functional properties that have been explored in a wide field of applications, such as wettability tuning of surfaces, bio medicine, electrochromic devices, and solar energy conversion. The nanotubular oxides can be tailored, for example with respect to layer thickness, tube diameter, and other morphological, electrical or chemical properties. For many applications these patterned surfaces are at prime importance. The self-organization and growth mechanism of TiO_2 nanotubes during anodization were investigated on photolithographically masked titanium thin films. The influence of potential, time and anodization conditions on the growth mechanism of TiO_2 nanotubes are evaluated. The presentation will provide an overview on the mechanisms of growth and self-ordering of TiO_2 nanotubes.

DS 33.5 Wed 12:00 GER 38

Flexible, free-standing and electrically active TiO_2 nanotubular membranes via lithographic approaches — •Sergiu P. Albu, Steffen Berger, Himendra Jha, and Patrik Schmuki — Department of Materials Science, WW4-LKO, University of Erlangen-Nuremberg, Martensstrasse 7, D-91058 Erlangen, Germany

In the presentation we show the fabrication of a new generation of TiO_2 nanotube membranes. The anodic oxide nanotube growth can be performed through a patterned Ti foil into an underlying Al metal layer [1]. After the selective dissolution of the Al/alumina layer, a very well defined both side open suspended TiO_2 nanotube layer can be obtained. Using lithographic patterning of the anodization area allows to achieve large scale, flexible and well electrically connected nanotubular flow-through membranes with fast electrical switching features over the entire membrane. The removal of the top-initiation layer is based on carrying out anodization through a slowly soluble photoresist coating [2]. These approaches facilitate a better quality and new features of the TiO_2 nanotubular structures.

[1] S. P. Albu, A. Ghicov, S. Berger, H. Jha, P. Schmuki, Electrochem. Commun. 2010, 12, 1352.
[2] S. P. Albu, P. Schmuki, Phys. Status Solidi RRL 2010, 4, 151.

DS 33.6 Wed 12:15 GER 38

ALD Growth of Highly Ordered ZnO Nanotube Arrays with Tunable Structures and Their Device Applications — •Hui Sun, Kin-Mun Wong, Stefan Bartels, Gerhard Wilde, and Yong Lei — Institute of Materials Physics and Center for Nanotechnology, University of Münster, Münster 48149, Germany

Because of the highly ordered feature, anodic alumina membranes have been widely used as nano-templates for growing one-dimensional (1D) nanostructures of various materials. The structural parameters of the template-prepared 1D nanostructures are adjustable including the size, spacing, and aspect ratio of the nanostructures. Recently, we successfully fabricated large-scale ordered arrays of ZnO nanotubes using a synthesizing route combining the template technique and atomic layer deposition (ALD) process. The advantages of the template technique together with the natures of the ALD process (e.g., precisely controllable atomic-scale growing process) results in attractive features of the obtained ZnO nanotube arrays, including tunable tube diameter, wall thickness, length and array density. These nanostructures are of extremely high and variable surface-to-volume ratio, which means that the change of surface status would affect the state of the material significantly. We believe that those constructions will largely enhance the utility of surface electronics devices, such as chemical sensors, biosensors etc., and the structure meets the requirement for conductometric semiconductor gas sensors of high sensitivity. Potential applications, such as photonic detector of super high resolution and band edge mode surface emitting laser are discussed.

DS 33.7 Wed 12:30 GER 38

Surface Patterning using Nano-Templates For Realizing Highly Ordered Nanostructure Arrays with Controllable Properties — •Huaping Zhao, Shikuan Yang, Fabian Grote, Feng Xu, and Yong Lei — Institute of Materials Physics and Center for Nanotechnology, University of Muenster, Muenster 48149, Germany

Here we present the research progress of template-based surface nanopatterning techniques [1-5] in our group. Two kinds of templates were used in the surface patterning process: ultra-thin alumina membranes and monolayer polystyrene spheres. Using the templates, surface patterns of different materials with diverse shapes were synthesized. The structural parameters of the template-prepared surface patterns largely depend on those of the templates. The feature size of the building blocks of the patterns can be adjusted from the quantum size to nanoscale and microscale range [1]. The cost-effective and time-saving fabrication processes of template-based surface patterning approaches are highly desirable for industrial applications in fabricating different nano-devices, giving rise to broad applications of template-prepared surface nanostructures.

References:

1.Lei Y, Yang SH, Wu MH, et al., Chem. Soc. Rev., in press, 2010 (DOI:10.1039/ B924854B).

2. Wu MH, Wen LY, Lei Y, et al., Small, 6 (5), 695, 2010.

3. Lei Y, Cai WP, Wilde G, Prog. Mater. Sci., 52, 465, 2007.

DS 33.8 Wed 12:45 GER 38

Dynamics of step bunches on vicinal surfaces: Sublimation, electromigration and transparent steps — •Marian Ivanov[1], Vladislav Popkov[2], and Joachim Krug[1] — [1]Institut für Theoretische Physik, Universität zu Köln, Köln — [2]Dipartimento di Fisica Teorica, Università degli Studi di Salerno, Salerno, Italy

Using morphological instabilities one can produce templates for nanoscale technology. One example of such an instability is step bunching, which splits a regular vicinal surface into regions of low and high density of monoatomic steps. We consider a one-dimensional step train evolving in the presence of sublimation, step-step interactions, fast kinetics and an Ehrlich-Schwoebel effect. We show that the interplay of sublimation and step-step interactions removes the conservation law for the crystal volume in the co-moving frame, which has been assumed in previous work [1,2]. As a consequence large step bunches are found to break up into smaller bunches of a characteristic size, and the monotonic coarsening dynamics of the volume-conserving model is replaced by a complex quasiperiodic pattern [3]. This interesting behavior is preserved by adding the corresponding terms due to the effect of electromigration. In the case of fast diffusion we consider a recently introduced model for transparent steps [4] and present simulation results for the evolution of the bunch geometry.

[1] V. Popkov, J. Krug, Europhys. Lett. 72, 1025 (2005) [2] V. Popkov, J. Krug, Phys. Rev. B 73, 235430 (2006) [3] M. Ivanov, V. Popkov, J. Krug, Phys. Rev. E 82, 011606 (2010) [4] B. Ranguelov, S. Stoyanov, Surf. Sci. 603, 2907 (2009)