

O 19: Nanostructures at surfaces: Arrays

Time: Tuesday 10:30–12:45

Location: SCH A215

O 19.1 Tue 10:30 SCH A215

Fabrication of periodic templates on Si: from nanometer to micrometer scale — ●CHRISTIAN PFAHLER¹, FABIAN ENDERLE¹, ACHIM MANZKE¹, STEFAN WIEDEMANN¹, ALFRED PLETTL¹, PAUL ZIEMANN¹, EYK SCHREIBER², ULRICH ZIENER², and KATHARINA LANDFESTER² — ¹Institut für Festkörperphysik, Universität Ulm, D-89069 Ulm — ²Institut für Organische Chemie III, Universität Ulm, D-89069 Ulm

Colloidal polystyrene (PS) particles either pure or loaded with a metal precursor are used to generate nanomasks on Si and SiO₂. The latter ones were prepared by emulsion techniques [1,2]. Dip-coating a pre-treated substrate permits the deposition of monolayers over areas up to ten square millimeters.

Isotropic etching in oxygen plasmas reduces the diameter of the pure particles continuously down to 50 nm and the emulsion colloids to hybrid particles with 20-50 nm, respectively. Typical starting values in both cases are 300 nm. Additional annealing further reduces the Pt particles to diameters between 6-14 nm.

Using this set of particles as a mask for anisotropic reactive ion etching (RIE), arrays of pillars and pores can be fabricated with variable distance and size from 10 nm up to the classical colloidal lithography scale.

[1] A. Manzke et al., *Adv. Mater.* **19**, 1337 (2007).

[2] E. Schreiber et al., *Chem. Mater.* submitted (2008).

O 19.2 Tue 10:45 SCH A215

UTAM-synthesized large-scale regular arrays of surface patterns of 0-d and 1-d nanostructures — ●YONG LEI, STEFAN OSTENDORP, and GERHARD WILDE — Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Here we report an UTAM surface nano-patterning fabrication system in synthesizing large-scale regular arrays of 0-D (dots) and 1-D (wires and tubes) surface nanostructures. Different metallic and semiconductor nanodots were fabricated on silicon and sapphire substrates using an ultra-thin alumina membrane (UTAM) as the evaporation mask. The diameter, spacing, shape, and even the crystalline structures of the synthesized surface nano-patterns are adjustable and hence resulting in tunable physical properties of these nano-patterns. A nanoporous silicon oxide surface structure with embedded metallic oxide nano-dots can be realized by oxidizing the metallic nanodots. Using the UTAM-prepared Au nanodots as the catalysts, regular ZnO nanowire arrays were prepared using the CVD process. A unique type of rectangular cross-section ZnO nanowires with a layered structure was also obtained. These layered ZnO nanowires exhibit strong yellow photoluminescence, which is unusual compared to the green photoluminescence of the conventional CVD-prepared ZnO nanowires. The mechanism of this yellow photoluminescence is closely related to the layered structures of the nanowires. These yellow luminescent ZnO nanowires could be used as an excellent component of some optical devices such as flat displays.

O 19.3 Tue 11:00 SCH A215

Ion beam pattern formation on Si(001) with and without codeposition — ●SVEN MACKO and THOMAS MICHELY — II. Physikalisches Institut, Universität zu Köln, Germany

Si(001) is sputtered with ion fluences $> 10^{22}$ ions/m² and at angles $\vartheta = 0^\circ - 83^\circ$ with respect to the surface normal. Sputtering was performed under UHV conditions with a differentially pumped and scanning fine focus ion source. The chamber pressure rose to $\approx 9 \times 10^{-8}$ mbar during erosion and great care was exercised to sputter the Si sample only. At room temperature for $\vartheta = 0^\circ - 45^\circ$ no pattern formation was observed. To the contrary, rough starting surfaces smoothened. For flat starting surfaces the roughness remained below 3 Å. The observed absence of roughness partly agrees and partly disagrees with observations in the literature. We tested the effect of codeposition, either through physical vapor phase deposition or sputter deposition. At room temperature, with ion fluences $> 5 \times 10^{21}$ ions/m², Mo sputter codeposition leads to regular, concentration dependent patterns of dots and ripples. At elevated temperatures also other codeposited materials give rise to large surface roughness.

O 19.4 Tue 11:15 SCH A215

Substrate effect on supramolecular self-assembly: from semiconductors to metals — ●TAKAYUKI SUZUKI¹, THERESA LUTZ¹, DIETMAR PAYER¹, NIAN LIN^{1,2}, STEVEN TAIT^{1,3}, GIOVANNI COSTANTINI^{1,4}, and KLAUS LERN^{1,5} — ¹MPI for Solid State Res., Heisenbergstr. 1, 70569 Stuttgart — ²Dept. of Phys., The Hong Kong Univ. of Sci. Technol., Clear Water Bay, Kowloon, HK — ³Dept. of Chem., Indiana Univ., Bloomington, 47405 IN — ⁴Dept. of Chem., Univ. of Warwick, Coventry, CV4 7AL — ⁵IPN, EPFL, 1015 Lausanne

Terephthalic acid (TPA) deposited on Si(111)-7×7, Si(111)- $\sqrt{3} \times \sqrt{3}$ -Ag and Ag(111) has been studied as a model system to understand how much passivated semiconductor surfaces differ from semiconductor and metal surfaces in respect to supramolecular self-assembly. By scanning tunneling microscopy it is found that TPA molecules do not form any ordered supramolecular structure on the pristine semiconductor surface, due to a strong molecule-substrate interaction. On the contrary, TPA has a weaker interaction with Si(111)- $\sqrt{3} \times \sqrt{3}$ -Ag, leading to the formation of an ordered supramolecular layer stabilized by carboxyl hydrogen bonds. These structures are very similar to the supramolecular layer of TPA formed on Ag(111), indicating that the two substrates behave similarly in respect to the adsorption of functional organic molecules. However, the deposition of Fe on the TPA layers on Si(111)- $\sqrt{3} \times \sqrt{3}$ -Ag does not induce the formation of metal-organic frameworks which, on the contrary, readily develop on Ag(111). The origins of this difference are probably the particular electronic properties and reactivity of the two substrates.

O 19.5 Tue 11:30 SCH A215

Sub-wavelength patterning of organic monolayers via nonlinear processing with single femtosecond laser pulses — ●NILS HARTMANN¹, STEFFEN FRANZKA¹, JÜRGEN KOCH², ANDREAS OSTENDORF², and BORIS N. CHICHKOV² — ¹Fachbereich Chemie and Center for Nanointegration Duisburg-Essen (CeNIDE), Universität Duisburg-Essen (UDE), Universitätsstraße 5, 45117 Essen — ²Laser Zentrum Hannover e. V., Hollerithallee 8, 30419 Hannover

Femtosecond laser patterning of octadecylsiloxane monolayers on quartz glass at a wavelength of 800 nm, pulse lengths < 30 fs and ambient conditions has been investigated. Due to its optical band gap of 8.5 eV, quartz glass represents an ideal platform for femtosecond laser processing of silane-based monolayers via nonlinear absorption processes. Selective decomposition of the coating with single laser pulses at sub-wavelength resolution can be achieved over a wide range of fluences from 4.2 down to 3.1 J/cm². In particular, at a 1/e laser spot diameter of 1.8 microns, structures with a width of 250 nm and below were fabricated. This opens up a facile route towards laser fabrication of transparent templates with chemical structures down into the sub-100 nm regime [1]. Such templates represent promising platforms for biotechnological applications, e. g. biosensor arrays and microfluidic chips.

1. N. Hartmann, S. Franzka, J. Koch, B. N. Chichkov, A. Ostendorf, *Appl. Phys. Lett.* **92** (2008) 223111.

O 19.6 Tue 11:45 SCH A215

Electrocatalysis on Nanostructured Surfaces: Electrochemical Behaviour of Ir(210) — ●KHALED SOLIMAN, FELICE SIMEONE, LUDWIG KIBLER, and TIMO JACOB — Institut für Elektrochemie, Universität Ulm, 89069 Ulm

Recently it was found that Ir(210) transforms to a nanostructured surface morphology with three-sided nanopillars after oxygen adsorption and annealing in ultra high vacuum (UHV) [1]. Motivated by this work we envisaged to prepare such nanofaceted surfaces outside a UHV system. We could show that faceted Ir(210) can indeed be prepared by inductive heating in presence of an inert atmosphere, which contains traces of oxygen [2]. Such surfaces are of interest for electrocatalysis. In order to characterize Ir(210) cyclic voltammetry (CV) and STM measurements were carried out. In our CV-curves of faceted Ir(210) in sulfuric acid a characteristic needle-like peak appeared, which serves as indicator for the presence and quality of the nanofacets. The STM images showed a typical structure of faceted Ir(210) surface, which could be explained by theoretical calculations employing density functional theory and thermodynamic considerations [3]. Finally, we performed first studies on the electrocatalytic

behaviour of planar and nanofaceted Ir(210).

[1] I. Ermanoski, C. Kim, S. P. Kelty, T. E. Madey, *Surf. Sci.*, **596**, 89 (2005). [2] K. A. Soliman, F. C. Simeone and L. A. Kibler, *Electrochem. Comm.*, **11**, 31 (2008). [3] P. Kaghazchi, F. C. Simeone, K. A. Soliman, L. A. Kibler, T. Jacob, *Faraday Discuss.*, **140**, 69 (2008).

O 19.7 Tue 12:00 SCH A215

Photoluminescence quenching of PS and its use as template to confine R6G — ●PUSHPENDRA KUMAR¹, MANASH GHOSH¹, PETER LEMMENS¹, FRANK LUDWIG², and MEINHARD SCHILLING² — ¹IPKM, TU Braunschweig, Germany — ²EMG, TU Braunschweig, Germany

The different chemical treatment including Ag nanoparticle deposition was carried out on the electrochemically formed mesoporous silicon (PS) to investigate the PL quenching of PS and its further use as a porous template to confine the rhodamine 6G (R6G). For all states of preparation of PS sample, PL and UV/VIS transmission spectroscopy was measured. In the final state the complete quenching of PL was observed. From our transmission measurements we concluded that the quenching of PL is attributed to a fundamental disruption of the luminescence mechanism. R6G is then confined to PL quenched PS sample. The blue shift in the R6G PL peak is observed compare to bulk R6G. The shift in R6G peak is attributed to a confining effect.

O 19.8 Tue 12:15 SCH A215

Towards covalently bonded supramolecular networks - substrate induced polymerisation in 2D — ●HERMANN WALCH, RICO GUTZLER, GEORG EDER, WOLFGANG M. HECKL, and MARKUS LACKINGER — Center for NanoScience (CeNS) und Sekt. Kristallographie, LMU München, Theresienstr. 41, 80333 München

Hydrogen-bonds as stabilizing intermolecular links for supramolecular self-assembly and the influence of the substrate have extensively been investigated. Compared to hydrogen bonded structures, metal-coordination networks were found to be more stable due to increased interaction strength. However, in terms of network stability it is desired to introduce covalent intermolecular bonds. The main challenge is to still maintain ordered growth despite the irreversibility of the bonds. While 3D covalent organic frameworks (COFs) are widely investigated, little is known about surface supported 2D COFs. So far, the prepara-

tion of covalently bonded molecular aggregates on surfaces is limited to a few molecules and close-packed structures. Here, we report on the formation of 2D COFs from a halogen substituted polyaromatic compound on Ag(110) and Cu(111) surfaces. Interestingly, on HOPG(001) the same compound forms non-covalently bonded networks which are stabilized by halogen-hydrogen bonds, whereas on metal surfaces the formation of covalent networks is observed. This illustrates that for this compound the substrate is not only an epitaxial template but can also act as a catalyst for the formation of covalent bonds. Experiments were carried out with a Scanning Tunnelling Microscope (STM) at room temperature under ultrahigh vacuum conditions.

O 19.9 Tue 12:30 SCH A215

Temperature-induced phase transition in self-assembled supramolecular monolayers — ●RICO GUTZLER¹, THOMAS SIRTLL¹, MICHAEL SCHMITTEL², WOLFGANG M. HECKL^{1,3}, and MARKUS LACKINGER¹ — ¹Center for NanoScience (CeNS) and Ludwig-Maximilians-University — ²University Siegen — ³Deutsches Museum

We present self-assembled molecular monolayers at the liquid-solid interface, whose morphology can be switched reversibly between two crystallographically different structures by heating above a temperature threshold. At room temperature, STM experiments reveal a non-densely packed six-fold honeycomb pattern at the interface between solution and graphite. The solute molecule with C3 symmetry and carboxyl-terminated lobes adsorbs in a planar manner when dissolved in nonanoic acid. In this adsorption geometry, all of the three carboxylic groups are involved in two-fold intermolecular hydrogen bonds. Raising the temperature of the sample induces a phase transition which is accompanied by a substantial change in the monolayer morphology. The rearrangement results in a row structure comprised of densely packed, nearly upright standing molecules. The reversibility is demonstrated by subsequent cooling to room temperature which yields the original hexagonal monolayer. This unambiguously proves that the room temperature structure is not only a kinetically trapped metastable state which is just converted to the thermodynamically equilibrium structure by supplying thermal energy. Since in the row structure one carboxylic group per molecule points off the surface, the phase transition is accompanied by a change in surface affinity.