DS 22: Synthesis of Nanostructured Films by Self-organization II (Focused Session)

Time: Wednesday 16:00–17:45 Location: H2

Topical Talk DS 22.1 Wed 16:00 H2

Self-organization during the growth of phase-separated nanostructured thin films — •Gintautas Abrasonis — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, PF-510119, 01314 Dresden, Germany — School of Physics, University of Sydney, New South Wales 2006, Australia

Control over the morphology and spatial correlations at the nanoscale is one of the major challenge of the nowadays nanoscience and nanotechnology. Bottom-up approaches to nanostructured material synthesis are based on self-organization processes to precisely define ordered nanostructures on a large scale. Self-organization occurs via the interplay between two factors - an external constraint acting on internal system processes. During the thin film growth this is translated into the interplay between thermodynamic driving forces and kinetic constraints. In this talk I will summarize the recent research activities of our group on the phase separation during the growth of carbon-transition metal thin films. Different processes can be 'switched off/on' by external control of the experimental parameters such as temperature, substrate type, matrix/dispersed phase chemical affinity or incoming particle energy. This results in a large variety of lateral or vertical composition modulations, such as encapsulated nanoparticles, high aspect ratio nanocolumns or self-organized layered 3D nanoparticle arrays. Such self-organization process is versatile as different carbon-transition metal systems show this effect. The observed tendencies will be discussed on the basis of the interplay of thermal and energetic ion induced phenomena.

DS 22.2 Wed 16:30 H2

Biaxial optical anisotropy of self aligned silver nanoparticles and nanowires — •Mukesh Ranjan, Stefan Facsko, and Wolfhard Möller — Forschungszentrum Dresden-Rossendorf, Dresden, Germany

In the present study ion beam sputtering has been used for prestructuring of a silicon substrate followed deposition of metal by e-beam evaporation. First a low energy ion beam (Ar^+, 500 eV) is incident on the substrate surface at an angle of 67° to the surface normal to produce well ordered (20-50 nm)ripple patterns. Then physically vaporized Ag atoms are deposited at grazing angle of 70° to the surface normal and normal to the ripples direction. Varying deposition parameters, i.e. ripple periodicity, substrate temperature and atomic flux, we were able to produce well ordered nanoparticles and nanowires. Self-aligned Ag nanoparticles and nanowires deposited on pre-patterned ripple surfaces exhibit strong optical anisotropy. Generalised ellipsometry measurements show that off diagonal Jones matrix elements (Ψ_{ps}, Δ_{ps}, Ψ_{sp}, Δ_{sp}) are non zero and vary with Eulers angle φ. This indicates that such a medium is biaxial in nature. A biaxial layer model approach is used to calculate dielectric functions for such a system. Tauc-Lorentz oscillators are used along x and y direction independently and Drude model along z-direction for nanoparticles. This approach provides a very good fitting with the measured Jones matrix element Ψ_{pp}, Δ_{pp}, Ψ_{ps}, Δ_{ps}, Ψ_{sp}, Δ_{sp}. Different cases for ordered nanoparticles and wires will be presented.

DS 22.3 Wed 16:45 H2

Growth of quantum dot crystals in amorphous matrix on rippled substrates — •Maja Buljan[1,2], Jörg Grenzer[3], Adrian Keller[3], Nikola Radić[2], Thomas Cornelius[4], Till Harmut Metzger[4], and Vaclav Holý[1] — [1]Faculty of Mathematics and Physics, Charles University in Prague, 12116 Prague, Czech Republic — [2]Ruder Bošković Institute, Bijenička c. 54, 10000 Zagreb, Croatia — [3]Forschungszentrum Dresden-Rossendorf, e.V. P.O. Box 10119, 01314 Dresden, Germany — [4]European Synchrotron Radiation Facility (ESRF), BP 220, F-38043, Grenoble, France

The formation of quantum dot crystals by multilayer deposition has been reported and explained satisfactorily only in crystalline materials, so far. Here we demonstrate a method for the growth of quantum dot crystals in amorphous matrices. The ordering of the positions of quantum dots is induced by the deposition of a multilayer on a periodically rippled substrate at an elevated substrate temperature. During the deposition, the quantum dots self-arrange following the morphology of the substrate. The result is a formation of well ordered lattice of Ge quantum dots in amorphous silica matrix. We have investigated the ordering of the dots by grazing-incidence small-angle X-ray scattering and we found that the distance of the dots in the multilayer interfaces close to the rippled surface indeed equals the ripple period. However, in more distant interfaces the dot-dot distance approaches the value for non-rippled substrate and the dot ordering is slightly less pronounced. This finding confirms the beneficial influence of the rippled substrate on the ordering of quantum dots in an amorphous matrix.

DS 22.4 Wed 17:00 H2

Kinetic Monte Carlo simulation of a three-dimensional Si/Ge quantum-dot crystal growth — •Martin Mixa and Václav Holý — Department of Condensed Matter Physics, Charles University, Ke Karlovu 5, 121 16 Prague, Czech Republic

A very regular three-dimensional (3D) arrangement of quantum dots can be achieved by a self-organized growth taking place on a prepatterned substrate. This growth technique has been successfully used at fabrication of 3D quantum-dot crystal of Ge dots in a Si matrix grown on a prepatterned Si(001) surface [1,2].

In our theoretical study we use the kinetic Monte Carlo method for simulation of such a Ge/Si(001) superlattice growth. We developed an efficient and simple kinetic Monte Carlo model [3] describing the surface diffusion and coalescence of deposited adatoms, whereas the shape of the growing dots is not atomistically simulated (it is taken ad hoc from the experiment). The self-organization effect is incorporated in the model via an influence of the strain field induced by buried dots on the hopping probabilities of migrating adatoms.

[1] D. Grützmacher et al., Nano Lett. 7, 3150 (2007). [2] V. Holý et al., Phys. Rev. B 79, 035324 (2009). [3] M. Mixa et al., Phys. Rev. B 80, 045325 (2009).

Topical Talk DS 22.5 Wed 17:15 H2

Self-organization and molecular diffusion processes in organic thin film growth — •Christian Teichert — Institute of Physics, University of Leoben, A-8700 Leoben, Austria

Crystalline films of conjugated organic semiconductors offer attractive potential for optoelectronic and electronic applications on flexible substrates. Due to the complexity and anisotropy of the molecular building blocks, novel growth mechanisms can occur as is demonstrated for the growth of the rod-like oligophenylene molecule parasexiphenyl (6P) on mica surfaces. On clean mica(001), the self-organization of crystallites into one-dimensional chains is observed on a wetting layer where the 6P molecules lie on the surface [1]. However, if the mica surface is amorphized by gentle bombardment with 500 eV Ar^+ ions, the formation of terraced mounds composed by almost upright standing molecules is found by atomic force microscopy. Quantitative analysis of the morphology together with transition state theory calculations revealed the existence of level dependent step edge barriers [2]. A lower barrier due to less molecular tilt in the first layer results in the completion of one monolayer before mound formation starts.

[1] C. Teichert, et al., Appl. Phys. A 82 (2006) 665. [2] G. Hlawacek, P. Puschnig, P. Frank, A. Winkler, C. Ambrosch-Draxl, C. Teichert, Science 321 (2008) 108.

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