DS 19: Synthesis of Nanostructured Films by Self-organization I (Focused Session)

Time: Wednesday 10:30–12:45 Location: H2

Topical Talk DS 19.1 Wed 10:30 H2

Glancing angle deposition: Preparation, properties, and application of micro- and nanostructured thin films — •Bernd Rauschenbach, Christian Patzig, Jens Bauer, and Chinmay Khare — Leibniz Institute of Surface Modification, 04318 Leipzig, Permoserstr. 15

Physical vapor deposition under conditions of obliquely incident flux and limited adatom diffusion results in films with a columnar microstructure. An additional substrate rotation can be used to sculpt the columns into various morphologies. This is the basis for glancing angle deposition (GLAD), which generate sculptured thin films with properties that can be designed and realized in a controllable manner. This overview examines the GLAD process and column growth, the properties observed in GLAD produced films, and the applications of this technology. The initial stages of the thin film growth focusing on concepts important to the GLAD process and the effects of ballistic shadowing and surface diffusion, as well as explaining how column morphology evolves during growth are discussed. Deposition onto prepatterned topographies and methods for controlling the column shape, predicting and modelling the column growth are examined. Because this deposition process provides precise nanoscale control over the structure, characteristics such as the mechanical, magnetic and optical properties of the sculptured films may be engineered for various applications. Depositing onto prepatterned substrates forces the columns to adopt a planar ordering, an important requirement for different applications.

DS 19.2 Wed 11:00 H2

Agglomeration kinetics and pattern formation of Pt thin films on yttria stabilized zirconia single crystals — •Henning Galinski, Thomas Ryll, Lukas Schlagenhauf, Anja Bieberle-Hütter, Jennifer M. Rupp, and Ludwig Gauckler — Nonmetallic Inorganic Materials, ETH Zurich, Zurich, Switzerland

Metals and ceramics have 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 films. Pt thin films with thicknesses up to 180nm were deposited via magnetron and ion-beam sputtering on yttria stabilized zirconia single crystals and subjected to heat treatments up to 1173K for 2 hours. In the case of ion beam sputtering the single crystal has been pre-cleaned in the ion-beam before deposition. The morphological evolution of Pt thin films has been investigated by means of scanning electron microscopy (SEM) and atomic force microscopy (AFM). Three main observations have been made: i) the pre-cleaning has an impact on the morphological evolution of the film during annealing, hence impurities on the surface can be regarded as additional sources for agglomeration. ii) The morphological evolution as function of time has been analyzed by means of Minkowski measures. For the stage of hole coalescences a deviation from the expected Gaussian behaviour is found. iii) The hole growth is in agreement with Brandon and Bradshaw's theory of surface energy driven diffusion.

DS 19.3 Wed 11:15 H2

Self-organized pattern formation on Si by low-energy ion beam erosion with simultaneous Fe incorporation — •Marina Cornejo, Bashkim Ziberi, Frank Frost, and Bernd Rauschenbach — Leibniz-Institut ür Oberflächenmodifizierung (IOM), Permoserstrasse 15, D-04318 Leipzig, Germany

A simple bottom-up approach for the generation of nanostructures on solid surfaces is the low energy ion beam erosion. Under certain sputtering conditions and despite the random nature of the ion bombardment, well ordered nanostructures, like one-dimensional ripples or regular arrays of dots, can be formed by self-organization processes. In the last years, the focus of our group has been the pattern formation by low-energy ion beam erosion, especially the correlation between the experimental parameters and the resulting topography. In this contribution the role of the substrate contamination is introduced. In particular, the incorporation of Fe and its relation with the experimental parameters and the topography evolution on Si was analyzed. For this study a Kaufman-type broad beam source was used. It is shown that with increasing divergence of the ion beam, the concentration Fe found on the Si surface increases and this strongly affects the pattern formation under near normal ion incidence conditions. The Fe originates from an enhanced sputtering of parts of the vacuum chamber. In addition, it is also demonstrated that the steady state concentration of Fe depends on the ion incidence angle. This can be explained by different angular dependence of the sputter yields of Fe and Si, respectively.

DS 19.4 Wed 11:30 H2

In-situ grazing incidence scattering investigations during magnetron sputtering deposition of FePt/Ag thin films — •Jörg Grenzer, Valentina Cantelli, Nicole M. Jeutter, and Johannes von Borany — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf e.V., P.O. Box 510119, 01314 Dresden, Germany

We report on an in-situ study on the evolution of granular magnetic $L1_0$-FePt/Ag layers deposited by magnetron sputtering on an amorphous SiO_2 substrate. Using synchrotron radiation we investigated the nanostructure growth during deposition as function of the Ag thickness by the simultaneous detection of the cluster growth and of the formation of the hard ferromagnetic $L1_0$-phase applying grazing incidence small-angle X-ray scattering (GISAXS) and X-ray diffraction, respectively.

FePt/Ag nanoparticle were prepared using a dual magnetron deposition chamber, equipped with two Be windows to allow X-ray penetration, that was mounted on the six-circle goniometer of the Rossendorf beam line (ROBL BM20) at the ESRF (European Synchrotron Radiation Facility). The possibility to tune X-ray beam energy, to reduce air scattering and absorption, together with the high brilliance of the synchrotron source had made it possible to obtain a reliable GISAXS signal and to control the cluster morphology during growth even at the initial stage [1].

[1] V. Cantelli, J. von Borany, N.M. Jeutter, J. Grenzer, Adv. Eng. Mat. 11, 478 (2009).

DS 19.5 Wed 11:45 H2

Factors influencing metal impurity induced ion beam patterning of Si(001) — •Sven Macko[1], Frank Frost[2], Bashkim Ziberi[2], Daniel Förster[1], and Thomas Michely[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]Leibniz-Institut für Oberflächenmodifizierung e. V., Leipzig, Germany

On Si(001) ion beam pattern formation at angles $\vartheta < 45°$ with respect to the surface normal takes only place in the presence of metal impurities. Here we report experiments addressing the factors influencing impurity induced pattern formation using well controlled UHV experiments. Ion erosion is performed through fluences $> 5 \times 10^{21}$ ions/m^2 of 2 keV Kr^+ with a differentially pumped fine focus ion source. Co-deposition of metal impurities is performed through co-sputtering and co-evaporation of Fe. With increasing Fe concentration under otherwise identical conditions a smooth unpatterned surface, a dot pattern and finally for the highest Fe concentrations a ripple pattern is observed. Co-sputtering measurements at temperatures below and above room temperature lead to identical pattern sequences. Thus thermal diffusion is irrelevant for ion beam pattern formation on Si(001) at room temperature. Finally, the orientation of ripple patterns appears to be associated with the direction of impinging Fe atoms.

DS 19.6 Wed 12:00 H2

Dependence of wavelength of Xe ion-induced rippled structures on the fluence in the medium ion energy range — •Antje Hanisch[1], Andreas Biermanns[2], Jörg Grenzer[1], and Ullrich Pietsch[2] — [1]Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]Institute of Physics, University of Siegen, Walter Flex 3, 57078 Siegen, Germany

Ion-beam eroded self-organized nanostructures on semiconductors offer new ways for the fabrication of high density memory and optoelectronic devices. It is known that wavelength and amplitude of noble gas ion-induced rippled structures tune with the ion energy and the fluence depending on the energy range, ion type and substrate. The linear theory by Makeev [1] predicts a linear dependence of the ion energy on the wavelength for low temperatures. For Ar^+ and O_2^+ it was observed by different groups [2] that the wavelength grows with increasing fluence after being constant up to an onset fluence and before saturation. In this coarsening regime power-law or exponential behavior of the wavelength with the fluence was monitored. So far, investigations for Xe ions on silicon surfaces mainly concentrated on energies below 1keV. We found a linear dependence of both the ion energy and the fluence on the wavelength and amplitude of rippled structures over a wide range of the Xe^+ ion energy between 5 and 70keV. Moreover, we estimated the ratio of wavelength to amplitude to be constant meaning a shape stability when a threshold fluence of $2x10^{17}cm^{-2}$ was exceeded.

[1] Makeev et al., NIM B 197, 185-227 (2002) [2] Karmakar et al., APL, 103102 (2008), Datta et al., PRB 76, 075323 (2007)

Topical Talk DS 19.7 Wed 12:15 H2

Synthesis of Nanostructured Films by Self-organization — •Hans Hofsäss — II. Physikalisches Institut, Universität Göttingen, Göttingen, Germany

Two approaches to achieve self-organized formation of nanostructured thin films will be discussed. In the first approach, nanocomoposite films are prepared by simultaneous deposition of two desired constitutents, e.g. the formation of metal-carbon nanocomposites by simultaneous metal and carbon ion deposition [1]. Depending on the phase diagram one would expect a homogeneous alloy or nanocomposite system. Instead, one often observes multilayered films with alternating metal and carbon layers. The formation of such layered films is explained by self-organization caused by surface segregation, clustering, sputtering and ion induced diffusion. A growth model taking into account these processes allows to predict the transition between self-organized multilayer formation and formation of homogeneous nanocomposites as function of ion energy and ion flux ratio. The second approach is surfactant sputtering [2], i.e. sputter erosion of a substrate, simultaneously exposed to a weak flux of surfactant atoms. Depending on the surfactant-substrate combination self-organized nanostructured ultrathin films are formed as a steady-state. This leads to the generation of novel surface patterns and surface nanostructures. Selected examples of will be discussed. [1] H. Hofsäss and K. Zhang, Appl. Phys. A: Mat. Sci. Proc. 92 (2008) 517 [2] I. Gerhards, H. Stillrich, C. Ronning, H. Hofsäss and M. Seibt, Phys. Rev. B70 (2004) 245418