DS 6: Focus Session: Ion Beam Induced Surface Patterns II

Time: Monday 14:45–16:00 Location: H8

DS 6.1 Mon 14:45 H8

Surface instability due to ion induced atomic mass transport - the CV model revisited — •Hans Hofsäss — II. Physikalisches Institut, Universität Göttingen

In this work the deterministic defining equations for the height evolution dh(x,y,t)/dt of a surface, originating from atomic mass redistribution parallel to the surface caused by ballistic displacements, are derived. The calculations follow the description of Carter and Vishnyakov [1] and Davidovitch et al. [2] but take into account important additional contributions to the height evolution not considered so far. Moreover, Monte Carlo simulations using SDTrimSP V5.05 [3] are used to derive ion incidence angle dependent quantities, like the recoil depth distribution and the lateral mean distance of atomic mass transport, from the calculated 3-dimensional recoil distributions. In this way simplified approximations of an angle dependence using a sine or cosine behaviour can be avoided. It will be shown that the transition from stability to instability in x-direction (parallel to the projected beam direction) is no longer fixed at 45°. Moreover, it will be shown, that in contrast to the conclusion in [2], ion-induced mass redistribution gives no contribution to stability or instability in y-direction.

[1] G. Carter, V. Vishnyakov, Phys. Rev. B 54, 17647 (1996).
[2] B. Davidovitch, MK. J. Aziz, M.P. Brenner, Phys. Rev. B 76, 205420 (2007).
[3] W. Eckstein, R. Dohmen, A. Mutzke, R. Schneider, MPI for Plasma Physics, IPP Report 12/3 (2007).

DS 6.2 Mon 15:00 H8

Ion beam induced surface patterns due to mass redistribution and curvature dependent sputtering — •Omar Bobes, Kun Zhang, and Hans Hofsäss — II. Physikalisches Institut, Universität Göttingen, Germany

We investigate the pattern formation on amorphous carbon films irradiated with 200 eV to 10 keV Xe ions. Sputter yield and number of displacements within the collision cascade vary strongly as function of ion energy and allow to investigate the contributions of curvature dependent erosion according to the Bradley-Harper model [1] and mass redistribution according to the Carter-Vishnyakov model [2]. We find parallel ripple orientations for 60° ion incidence angle and all energies. A transition to perpendicular patterns or a flat surface occurs around 80°. Our results are compared with calculations based on both models with parameters determined from simulations with program SDTrimSP [3]. The curvature coefficients S_x and S_y show that mass redistribution is dominant for parallel pattern formation. The angle where the parallel pattern orientation disappear is related to curvature dependent sputtering.

[1] R. M. Bradley and J. M. E. Harper, J. Vac. Sci. Technol. A6, 2390 (1988).
[2] G. Carter, V. Vishnyakov, Phys. Rev. B54, 17647 (1996).
[3] W. Eckstein, R. Dohmen, A. Mutzke, R. Schneider, MPI for Plasma Physics, IPP Report 12/3 (2007).

DS 6.3 Mon 15:15 H8

The role of phase separation for self-organized surface pattern formation by ion beam erosion and metal atom co-deposition — •Kun Zhang, André Pape, Omar Bobes, Marc Brötzmann, and Hans Hofsäss — II. Physikalisches Institut, Universität Göttingen, Germany

We investigate ripple pattern formation on Si during normal incidence ion beam erosion under simultaneous co-deposition of metallic surfactant atoms. In previous work on ion erosion of Si during co-deposition of Fe we proposed that chemical interactions between Fe and Si of the steady-state mixed Fe_xSi surface layer is a dominant contribution to self-organized pattern formation [1,2]. To generalize phase separation effects on the pattern formation we irradiated Si with normal incidence 5 keV Xe ions under simultaneous co-deposition of metal atoms. The metals in the two groups (Fe, Ni, Cu) and (W, Pt, Au) are similar regarding their collision cascade behaviour, but differ strongly regarding their tendency to silicide formation. We find pronounced pattern formation only for those metals which are prone to formation of mono- and disilicides. In contrast, for Cu and Au surfactants the surface remains very flat. Phase separation is seen as the relevant process for the pattern formation on Si during metal co-deposition.

[1] K. Zhang, M. Brötzmann, H. Hofsäss, New. J. Phys. 13, 013033 (2011).
[2] H. Hofsäss, M. Brötzmann, K. Zhang, AIP Advances 2, 032123 (2012).

DS 6.4 Mon 15:30 H8

Depth-resolved X-ray photoelectron and X-ray absorption spectroscopic study of Fe-implanted Si (100) — •behnam khanbabaee[1], stefan facsko[2], and ullrich pietsch[1] — [1]Universität Siegen, Festkörperphysik, 57072 Siegen, Germany — [2]Helholtz-zentrum Dresden-Rossendorf, 01314 Dresden, Germany

The bombardment of solid surfaces with energetic ions such as Ar+, Kr+ can be used for the fabrication of self-organized structures on surfaces. It was shown that different types of patterns on the nanoscale, i.e. dots, ripples and relief pattern can be generated by varying the experimental parameters. A number of experimental studies have shown that the simultaneously co-deposition of metal atoms like Fe during ion beam erosion has tremendous influence on pattern formation. Many aspects of the influence of co-deposited metal atoms are not fully understood. However, the formation of Fe-silicide is considered important for pattern formation on Si surfaces. In this work, we report on the formation of Fe-silicide in various phases after a direct, off-normal, ion implantation of 5 keV Fe+ ions on Si (100). A combination of X-ray photoelectron spectroscopy (XPS) and grazing incidence X-ray absorption spectroscopy (XAS) using synchrotron radiation were applied to clarify surface chemical states of Fe implanted Si. We found the formation of Fe-rich silicide (Fe3Si) in the near surface region, but the dominance of Si-rich silicide (FeSi2) in larger depth.

DS 6.5 Mon 15:45 H8

Tuning the uniaxial magnetic anisotropy of Fe thin films by using nano-rippled Si (100) substrates — •Sarathlal Koyiloth Vayalil[1], Ajay Gupta[2], and Stephan V. Roth[1] — [1]HASYLAB at DESY, Notkestr. 85, D-22603, Hamburg, Germany. — [2]UGC-DAE Consortium for Scientific Research, University Campus, Khandwa Road, Indore, India.

In this work, an alternative and effective way of tuning and tailoring the magnetic properties of Fe thin film by using nano-rippled Si(100) substrates prepared by low energy ion beam sputtering have been studied. The average wavelength and modulation depth of nano-rippled Si (100) substrate is in the order of 32 nm and 1.2 nm. Evolution of the magnetic properties of ultra thin Fe film on nano-rippled Si (100) substrate has been studied using in-situ MOKE measurements. Fe film on nanorippled Si surface exhibits a magnetic dead layer of 0.9 nm because of possible intermixing of Fe with Si to form non-magnetic silicide. It exhibits a strong uniaxial magnetic anisotropy with its easy axis along a direction normal to the ripple wave vector. The magnetic anisotropy is found to be decreasing with increasing film thickness. From the in-situ resistivity measurements done simultaneously along and normal to the ripple wave vector shows, a clear anisotropy in the growth behavior along and normal to the ripple wave vector. Atomic force microscopy and GISAXS measurements on Fe thin films with different thicknesses shows that, initially the film conforms the morphology of the rippled substrate and later it vanishes.