DS 52: Ion and Electron Beam Induced Processes

Time: Thursday 17:00–18:15 Location: H11

DS 52.1 Thu 17:00 H11

High Current LMIS for Ion Implanters and Single-ended Accelerators — •Philipp Laufer[1], Daniel Bock[1], Wolfgang Pilz[1], Lothar Bischoff[2], and Martin Tajmar[1] — [1]Technische Universität Dresden, 01062 Dresden — [2]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden

An ion source module based on high current Liquid Metal Ion Sources (LMIS) will be presented for optional use of mon - or polyatomic ion currents of metallic or semiconducting elements [1, 2, 3]. Total emitted ion currents in the order of 100 μA can be reached which are formed to a nearly parallel ion beam of 2 mm diameter using an asymmetric ion-optical Einzel lens. Cluster ion fractions are in the range of per mil up to a few percent dependent on the emitted elements. A mass separation system (Wien filter) selects the desired ions while a quadrupole is used for beam adjustment. Few-atomic cluster ions are of interest to be implanted for an effective surface modification [4]. High cluster ion currents enable the formation of different nanostructures or even smooth surfaces over an area in cm^2-range. The LMIS preparation and the performance of the ion beam module at certain experiments will be presented and discussed.

[1] M. Tajmar, et al., Ultramicroscopy 111 (2010) 1
[2] D. Bock, et. al., DPG Conference Dresden (2014) DS 17.6
[3] P. Laufer, et al., DPG Conference Berlin (2015) DS 19.9
[4] L. Bischoff, et al., Nucl. Instr. and Meth. B 272 (2012) 198

DS 52.2 Thu 17:15 H11

Milling and imaging techniques at the helium ion microscope for sub 2 nm nanopore fabrication — •Daniel Emmrich[1], Emanuel Marschewski[1], Jani Kotakoski[2], Achim Nadzeyka[3], Frank Nouvertné[3], Jannik Meyer[2], André Beyer[1], and Armin Gölzhäuser[1] — [1]Physics of Supramolecular Systems, Bielefeld University, Germany — [2]Physics of Nanostructured Materials, University of Vienna, Austria — [3]Raith GmbH, Dortmund, Germany

The helium ion microscope (HIM) is a charged particle microscope employing helium ions for probing the sample. In the low dose regime, the HIM operates as microscope, high doses enable material modification and sputtering. Compared to conventional focussed ion beams (FIB) using metal ions like gallium, the HIM offers a very small focal spot size down to 0.35 nm and a strongly localized sputter interaction with the material. We employ the HIM for both milling nanopores in free standing membranes as well as for the inspection of pores. The helium ion beam with its unique properties overcomes the resolution limit of conventional FIB tools as we show in a comparison with a high resolution gallium FIB. We investigated three different materials: 30 nm thick silicon nitride, graphene and 1 nm thick carbon nanomembranes (CNM) made from aromatic self-assembled monolayers by electron-induced cross-linking. By HIM milling and imaging we can detect smallest nanopores at 3 nm diameter in all membranes. Further studies on CNM with an atomic resolution STEM revealed even nanopores with diameters of less than 2 nm made by ion beam exposure.

DS 52.3 Thu 17:30 H11

Tuning pattern symmetry by choosing the substrate in reverse epitaxy — •Martin Engler[1], Xin Ou[2], and Stefan Facsko[1] — [1]Institute for Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai, China

Ion beam erosion of solid surfaces is long known to yield regular surface morphologies, like periodic ripples or hexagonal dot patterns. At room temperature, semiconductors are amorphized by the ion beam. Pattern formation under these conditions has been studied extensively in the last decades.

Ion beam erosion above a material dependent dynamic recrystallization temperature allows the formation of crystalline nano scale patterns on semiconductor surfaces. At these elevated temperature pattern formation is driven by diffusion of vacancies created by sputtering of atoms. Anisotropic diffusion on the surface and diffusion barriers across step edges lead to the formation of pattern reflecting the symmetry of the irradiated surface. We will discuss how the surface symmetry determines the pattern symmetry.

DS 52.4 Thu 17:45 H11

Energy loss and charge exchange of slow highly charged ions in graphene — •Richard Wilhelm[1], Elisabeth Gruber[2], Valerie Smejkal[2], Janine Schwestka[2], Roland Kozubek[3], Anke Hierzenberger[3], Marika Schleberger[3], Stefan Facsko[1], and Friedrich Aumayr[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]TU Wien, Institut für Angewandte Physik, Wien, Österreich — [3]Universität Duisburg-Essen, FB Physik, Duisburg, Deutschland

Slow highly charged ions (e.g. Xe^{q+} with $q = 10 - 40$) enable studies of ion-solid interaction far from equilibrium. These ions neutralize quickly in a solid, i.e. typically within the first nm of the solid. The neutralization is associated with the deposition of the ion's potential energy in a small volume (nm^3) during a short time (fs). To study the neutralization dynamics in more detail and also to study charge state enhanced kinetic energy loss we used graphene as the thinnest target material there is for ion transmission experiments. We observe even in freestanding single layer graphene strong charge exchange and extracted a surprisingly short neutralization time of around 2-3 fs. Additionally we see a strong enhancement of the energy loss (stopping) with charge state and with charge exchange.

DS 52.5 Thu 18:00 H11

Properties of TiO2 films grown by reactive ion beam sputter deposition — •Thomas Lautenschläger, Eric Thelander, Daniel Spemann, and Carsten Bundesmann — Leibniz-Institut für Oberflächenmodifizierung, Permoserstr. 15, 04318 Leipzig

Ion beam sputter deposition is a versatile technique for tailoring thin film properties as it provides several ways of varying the properties of the film-forming, secondary particles. TiO2 films were deposited by reactive ion beam sputter deposition under systematic variation of ion beam and geometrical parameters. The films were characterized concerning thickness, growth rate, structural properties, mass density, composition and optical properties. Film thickness and growth rate show an over-cosine angular distribution that is tilted in forward direction. The growth rate was found to increase with increasing ion energy and ion incidence angle, which can be explained by the known dependence of the sputter yield. The TiO2 films are amorphous and show systematic variations in the mass density and index of refraction. Mass density and index of refraction reveal a strong correlation. The systematic variations in mass density and index of refraction are assigned to the properties of the backscattered primary particles. Furthermore, a considerable amount of primary particles was found in the films. The atomic fraction of inert gas particles depends on the scattering geometry, i.e. it increases with increasing sum of ion incidence angle and polar emission angle, but seems to be unaffected by the ion energy.