# DS 48: Ion Interactions with Nano Scale Materials III (Focused Session – Organisers: Diesing, Facsko)

Time: Thursday 16:00–17:30 Location: GER 37

**Topical Talk** DS 48.1 Thu 16:00 GER 37

**Ion beam doping of semiconductor nanowires** — •Carsten Ronning — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

Semiconductor nanowires are of major importance within the area of nanotechnology, and are usually synthesized using the so-called vapor-liquid-solid (VLS) mechanism. Controlled doping, a necessary issue in order to realize device applications, is an unsolved problem and an extremely difficult task if using such a growth mechanism. We use an alternative route for modifying the electrical, optical and magnetic properties of semiconductor nanowires: low-energy ion implantation within the keV range. The structural impact to the nanowires was investigated, and several effects due to the fact the ion range matches the diameter of the nanostructures had to be considered. A new simulation tool was therefore developed. This together with several independent studies on optical and electrical doping of semiconductor nanowires will be presented.

DS 48.2 Thu 16:30 GER 37

**Structural investigations of ion beam doped silicon nanowires** — •Jörg Grenzer[1], Olga D. Roshchupkina[1], Reinhard Kögler[1], Pratyush Das Kanungo[2], and Peter Werner[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf , Bautzner Landstraße 400, 01328 Dresden — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle

For the development of nano-optical devices nano wires (NW) are of emerging interest. One of the most important steps in the fabrication of Si devices is doping using ion beam implantation. However, this may lead to a distortion of the NW's crystalline structure or even to an amorphization. A subsequent annealing procedure is necessary to recover the crystalline structure. The advantage of implanted Si NW's is that the electrical conductivities are significantly higher than MBE-grown in-situ doped ones [1]. NW's of about 100nm in diameter and 100..400 nm in length, nominally undoped, were MBE grown on Si(111) using Au as a growth-initiator. We followed the structural changes of the NW's caused by implantation and annealing. We used rapid thermal annealing up to a temperature of 1100°C of about 30 seconds to remove a possible damage induced by implantation. Diffraction experiments were carried out at the ID01 ESRF beamline using a microfocused X-ray beam in combination with a 2D detector to obtain 3D diffraction patterns. Our experiments have shown that defect structure and form of the investigated NW's change after implantation and annealing. [1] X.Ou, P. Das Kanungo, R. Koegler, P. Werner, U. Gosele, W. Skorupa, and X. Wang, Nano Letters 10, 171 (2010).

DS 48.3 Thu 16:45 GER 37

**Evolution of surface topography of Si(001) during ion beam erosion** — •Martin Engler[1], Sven Macko[1], Frank Frost[2], and Thomas Michely[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]Leibniz-Institut für Oberflächenmodifizierung e. V., Leipzig, Germany

We investigated the evolution of surface topography of Si(001) during 2 keV $Kr^+$ ion beam erosion with in-situ STM under UHV conditions for fluences up to $1 \times 10^{22}$ ions $m^{-2}$. At room temperature and for an ion incidence angle of $\vartheta = 75°$ with respect to the surface normal the flat surface rapidly destabilizes. The observed topography changes qualitatively with ion fluence. We have identified a sequence of distinct phases in the surface evolution: a stochastically roughened surface transforms into a ripple pattern and finally into a faceted surface. These phases are governed by different processes. At low fluences the stochastic nature of ion bombardment dominates. With increasing fluence ripples with constant wavelength are selected by an interplay of roughening and smoothening. At high fluences non-linear effects like the gradient dependence of sputtering yield and reflection of ions lead to a faceted topography which coarsens and looses homogeneity in structure size. A similar sequence was observed for impurity induced pattern formation at $\vartheta = 30°$ although the mechanisms of pattern formation are different.

DS 48.4 Thu 17:00 GER 37

**Shadowing in metal assisted ion beam patterning on Si(001)** — •Sven Macko[1], Martin Engler[1], Frank Frost[2], and Thomas Michely[1] — [1]II. Physikalisches Institut, Universität zu Köln, Germany — [2]Leibniz-Institut für Oberflächenmodifizierung e. V., Leipzig, Germany

At grazing incidence low energy ion beam erosion of Si surfaces gives rise to nanoscale surface patterning. Co-sputterdeposition of stainless steel expands the angular range of pattern formation also to non-grazing and normal directions of incidence. Here we employ co-evaporation instead of co-sputterdeposition and a 2 keV $Kr^+$ ion beam under UHV conditions. Due to the thermal energy and well defined angle of incidence of the co-evaporated species the experiments provide a more direct insight to pattern formation mechanisms. In dependence of the atom-to-ion arrival ratio we find the flat surface as well as dot and ripple patterns. Fluence dependent experiments show that the type of pattern is already selected in the early stages of pattern formation. A key parameter for pattern formation is the angle $\alpha$ between the impinging ion beam and the co-deposition flux. For $\alpha > 90°$ we observe rapid formation of a faceted and rough pattern while for small angles $\alpha \approx 30°$ pattern formation diminishes. We conclude that shadowing is of decisive importance for the formation of local impurity concentration inhomogeneities which in turn cause local sputtering yield variations and thus the destabilization of the surface.

DS 48.5 Thu 17:15 GER 37

**Nanohole Pattern Formation on Ge by Focused Ion Beam and Broad Beam** — •Monika Fritzsche, Stefan Facsko, and Kilian Lenz — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany

The morphology of surfaces strongly influences optical, electrical, and magnetic properties of thin films. Using low energy ion beam sputtering different self-organized periodic patterns can be obtained. These are ripple patterns with periodicities in the nanometre range for oblique ion incidence and hexagonal dot patterns on compound materials for normal incidence. Low energy ion beam sputtering of Ge at normal incidence using a 5 keV $Ga^+$ focused ion beam (FIB) produces periodic nanohole patterns [1]. In this work we studied the flux dependence of nanohole formation using FIB technique and compared the results with patterns produced by broad $Ga^+$ beam sputtering with a six orders of magnitude smaller ion flux. In both cases $Ga^+$ ions with an energy of 5 keV at normal incidence were used. Obtaining the same results shows that nanohole formation is independent of flux over a few orders of magnitude and that rastering of the FIB does not add extra contributions.

[1] Q. Wei, X. Zhou, B. Joshi, Y. Chen, K. Li, Q. Wei, K. Sun, and L. Wang, *Adv. Mater.* **21**, 2865 (2009).