DS 17 Ion beam solid interaction II

Time: Thursday 11:15–12:45 Room: GER 37

DS 17.1 Thu 11:15 GER 37

Nanobeam — •Thomas Vogel[1], J. Meijer[1], B. Burchard[1], I. Rangelow[2], L. Bischoff[3], J. Wrachtrup[4], F. Schmidt-Kaler[5], and H. Wiggers[6] — [1]Ruhr-Universität Bochum, RUBION — [2]Uni Kassel, Technische Physik — [3]Forschungszentrum Rossendorf, Ionenstrahl Physik — [4]Universität Stuttgart, 3. phys. Institut — [5]Universität Ulm, Quanten-Informationsverarbeitung — [6]Uni Duisburg-Essen, Institut für Verbrennung und Gasdynamik

A new setup for the formation of a particle beam with nanometer resolution will be presented. The main idea is to use an Atomic-Force-Microscope with a modified tip which acts as an aperture for the particle beam. Therefore a small hole with a diameter of some ten nanometer has to be drilled into the AFM-tip by focussed ion beam. The AFM can be used for orientation on the sample surface. Simultaneously particles can then be deposited on defined sites. The next step is to manufacture an electrostatic micro-lens placed on the AFM-tip to actively focus the particle beam. With this setup a spatial resolution for the particle deposition of some nanometer is achievable. Different sources can be used for the formation of the particle beam: A cluster-source that produces particles with a size of some nm, an ion gun to produce a beam of single ions or an ion trap, to reach the highest spatial resolution of below 1 nm. The presented technique can for example be used to create luminescence centres in diamond by single ion implantation. Such single photon sources can be quantum mechanically coupled if placed in near vicinity and be used for quantum computational operations.

DS 17.2 Thu 11:30 GER 37

Relaxation of slow highly charged ions penetrating a solid surface - energy deposition and reemission — •Daniel Kost and Stefan Facsko — Forschungszentrum Rossendorf, Dresden

Highly charged ions carry a large amount of potential energy, which is defined as the sum of the binding energies of all removed electrons. In the case of low velocities of the ions this energy can exceed their kinetic energy. Approaching the solid surface the ions are neutralized, relaxe to the ground state, and their potential energy is released. Thereby different mechanisms, such as surface sputtering, secondary ion emission, secondary electron emisson and X-ray emission take place [1]. The secondary particles leaving the surface carry only up to 10% of the potential energy. Using a calorimetric setup [2] we measured the amount of the potential energy which remains in the solid to 85% ± 10%. To study the detailed mechanism of the energy retention materials with different electronic structures were investigated: Cu, n-Si, p-Si, SiO_2. We can conclude, that the difference in energy depositon between these materials is below 10%. The calorimetric results are rounded off with results from energy reemission measurements using electron spectroscopy. The value of the reemitted energy increases with increasing charge state up to 10%.

[1] A. Arnau et.al.: Surf. Sci. Rep. **27**, 113 (1997).
[2] U. Kentsch et.al.: Phys. Rev. Lett. **87**, 10 (2001).

DS 17.3 Thu 11:45 GER 37

SHI Induced Phase Formation At NiO/Si-Interfaces — •Wolfgang Bolse[1], Christian Dais[1], Thunu Bolse[1], Siegfried Klaumünzer[2], Peter Schubert-Bischoff[2], and Jörg K.N. Lindner[3] — [1]Institut für Strahlenphysik, Universität Stuttgart — [2]Hahn-Meitner-Institut, Berlin — [3]Institut für Physik, Universität Augsburg

In the course of a systematic investigation of the modification of thin oxide films on Si by swift heavy ion irradiation we found that distinct phase formation and phase separation occurs at the NiO/Si-interface. The NiO was deposited onto untreated Si-wafers by means of reactive magnetron sputtering.. The irradiation was performed at 80 K with 140 - 600 MeV Kr-, Xe- and Au-ions at fluences up to $10^{16}/cm^2$. The interfaces were characterized utilizing Rutherford Backscattering Spectrometry (RBS), High Resolution Transmission Electron Microscopy, Energy Filtered Transmission Electron Microscopy (EFTEM) and Energy Dispersive X-ray spectroscopy (EDX). On top of the subtrate an undulated layer forms, which according to EDX and EFTEM contains only Si and Ni and is thus attributed to the $NiSi_2$-phase also found with RBS. This layer is sharply separated from a region containing Ni, O and Si, which according to RBS refers to $NiSiO_3$. The Silicate is followed by NiO. The undulation and the formation of the high-temperature, high-pressure phase $NiSiO_3$ clearly reflect the extreme non-equilibrium conditions in the excited ion track, which obviously govern the phase formation at the NiO/Si interface.

DS 17.4 Thu 12:00 GER 37

Ion beam enhanced etching of $LiNbO_3$ — •Thomas Gischkat[1], Frank Schrempel[1], Holger Hartung[2], Ernst-Bernhard Kley[2], and Werner Wesch[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany — [2]Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany

Single crystals of z-cut and x-cut $LiNbO_3$ were irradiated at room temperature and 15 K using 350 keV Ar^+-ions with ion fluences between 5×10^{12} and 1×10^{15} cm^{-2}. The damage formation investigated with RBS channeling analysis depends on the crystal cut as well as the irradiation temperature. Irradiation of z-cut material at 300 K provokes complete amorphisation at 0.4 dpa (displacements per target atom). In contrast 0.27 dpa are sufficient to amorphise the x-cut $LiNbO_3$. Irradiation at 15 K reduces the number of displacements per atom necessary for amorphisation to 0.18 dpa. To study the etching behavior 400 nm thick amorphous layers were generated via multiple irradiation with Ar^+-ions of different energies and fluences. Etching was performed in a 3.6% HF-solution at 40 °C. Whereas the etching rate of the perfect crystal is negligible, that of amorphised regions amounts to 80 nm min^{-1}. The influence of the ion fluence, the irradiation temperature and subsequent thermal treatment on damage and etching of $LiNbO_3$ is discussed.

In conlusion, negligible etching of the perfect crystal, high etching rates and high contrast of Ion Beam Enhanced Etching (IBEE) allow the realisation of high aspect ratio microstructures in $LiNbO_3$.

DS 17.5 Thu 12:15 GER 37

Dewetting of thin metal-oxide films on silicon under swift heavy ion bombardment — •Thunu Bolse[1], Klara Lyutovich[2], Hartmut Paulus[1], Bouchaib Bouhachi[1], Siegfried Klaumünzer[3], and Wolfgang Bolse[1] — [1]Institut für Strahlenphysik, Universität Stuttgart — [2]Institut für Halbleitertechnik, Universität Stuttgart — [3]Hahn-Meitner Institut Berlin

Dewetting, occuring when a thin film on a non-wettable substrate is transferred to its molten state, has gained strong interest during the last decade, since it results in nano-scale, large-area-covering patterns. Recently we found that swift heavy ion irradiation of thin NiO-, Fe_2O_3- and TiO_2-films on Si at 80 K results in amazingly similar dewetting pattern, although in this case the coating has never reached its melting point. SEM analysis clearly reveals that similar dewetting mechanisms as for liquid films were active. AFM shows that the circular holes formed in the early stages of the dewetting process exhibit the same rim-structure as in the case of thermally driven dewetting. RBS was used to measure the open surface of the film as a function of the fluence. The substrate coverage decreases with increasing fluence and reaches a saturation value after the holes coalesce. The different dewetting stages exhibit different kinetics, from which conclusions concerning the involved processes can be drawn. The observed dewetting pattern and kinetics will be discussed in close comparison with the models developed for dewetting of liquid films with special attention to the fact, that here mass transport can occur only step-by-step in a highly localised nano-scale region during the excited stage of the ion track.

DS 17.6 Thu 12:30 GER 37

Ion-beam induced nano-sized metal clusters in glass — •Heinz-Eberhard Mahnke[1], Beate Schattat[1], Ivo Zizak[1], Peter Schubert-Bischoff[2], Nikola Novakovic[1,3], and Vasil Koteski[3] — [1]Ionenstrahllabor ISL, HMI Berlin — [2]HMI Berlin — [3]VINČA Institute, Belgrade

We have studied the formation of Ag-metal clusters in soda lime glass with x-ray absorption spectroscopy (XAS), with transmission electron microscopy (TEM), and with small angle x-ray scattering (SAXS). Silver was introduced by ion exchange into 0.1-mm thick glass platelets. While annealing under a reducing atmosphere of Ar with a few % H_2 already leads to the formation of metal clusters, such clusters are not very uniform in size and are randomly distributed over the Ag-containing glass volume. Irradiating these Ag-containing glass platelets with 600-MeV

Au ions with fluences around 10^{12} ions/cm^2 at ISL followed by annealing, the distribution of the size of the metal clusters becomes more uniform and the clusters are arranged in chains parallel to the direction of the ion beam. While the metallic form of Ag in the glass is proven by determining the local structure (co-ordination and inter-atomic distances) with EXAFS, measured at HASYLAB, the arrangement of the clusters in chains and their size is made visible by TEM. In a first SAXS experiment on the newly commissioned 7T-MPW beamline at BESSY an arrangement of the clusters approaching a columnar shape with a diameter around 7 nm could be proven. An extension to Cu-metal clusters is under way.