DS 45: Ion Interactions with Nano Scale Materials I (Focused Session – Organisers: Diesing, Facsko)

Time: Thursday 11:00–13:00 Location: GER 37

DS 45.1 Thu 11:00 GER 37

Electron emission in the interaction of slow ions and electrons with nanostructured surfaces — Pierfrancesco Riccardi, Michele Pisarra, and •Antonio Sindona — Università della Calabria and INFN, Cosenza, Italy

We will discuss some case studies showing that secondary electron spectroscopy of nanomaterials reveals important electronic properties of the targets. Early studies [1] showed that a submonolayer Sodium film grown on Metal substrates can be converted into two-dimensional patches by ion bombardment. Spectroscopy of electrons, emitted by autoionization of projectiles excited in collisions with target atoms, reveals the coexistence of surface regions with very different work functions which are relatively adsorbate rich and adsorbate depleted. More recently, studies of of ion- and electron-induced electron emission have been carried out on carbon based nanomaterials [2]. Here, we will report on the energy distributions of electrons ejected by the impact keV He ions and electrons on graphene adsorbed on a Ni surface [3]. We use secondary electron spectroscopy to probe the excited states of graphene adsorbed on a Ni surface. A fine structure directly related to the empty bands above the vacuum level of the sample is resolved in the spectra excited by electrons. Ion-induced spectra reveal a high energy feature that is consistent with electron promotion from valence to conduction band states. References [1] P. Riccardi et al. Thin Solid Film 289 (1996) 177 [2] M. Commisso et al. Surface Science 601 (2007) 2832 [3] P. Riccardi et al. Applied Physics Letters 97 (2010) at press

Topical Talk DS 45.2 Thu 11:15 GER 37

Energy dissipation in the scattering of N_2 from W(110) — •J. Inaki Juaristi — Departamento de Física de Materiales, Facultad de Químicas, UPV/EHU, San Sebastián, Spain — Centro de Física de Materiales (CSIC-UPV/EHU), San Sebastián, Spain

Motivated by the measurements reported in [1], we study the scattering of N_2 from W(110) with classical dynamics calculations on a multi-dimensional potential energy surface (PES). In this talk, I will show the results of our simulations for the rotational state distributions and discuss the possible mechanisms involved in the energy dissipation measured in the experiments. The potential energy surface is obtained by the interpolation of an extended ab-initio data set calculated within density functional theory over a broad six-dimensional configuration space. Regarding the energy dissipation mechanisms we analyze the relative importance of electron-hole and phonon excitations. The former are incorporated through a friction force with the aid of a model developed in our group. Briefly, the friction coefficient is calculated within a local density approach, for an ion embedded in an electron gas [6]. Phonon excitations are included via a Generalized Langevin Oscillator model [7].

[1] Hanisco T F, Kummel A C, J. Vac. Sci. Technol. A, 11, 1907 (1993)

[6] Juaristi J I, Alducin M, Díez Muiño R, Busnengo H F, and Salin A, Phys. Rev. Lett., 100, 116102 (2008)

[7] Busnengo H F, Dong W, and Salin A, Phys. Rev. Lett., 93, 236103 (2004)

DS 45.3 Thu 11:45 GER 37

Internal Electron Emission detected in Metal-Insulator-Metal Thin Film Tunnel Devices bombarded with keV Cluster Projectiles — •Mario Marpe[1], Christian Heuser[1], Detlef Diesing[2], and Andreas Wucher[1] — [1]Fakultät für Physik , Universität Duisburg-Essen, D-47048 Duisburg, Germany — [2]Fakultät für Chemie, Universität Duisburg-Essen, D-45117 Essen, Germany

The electronic excitation of a solid surface bombarded by energetic ions manifests in the production of hot electrons, which can be either emitted from the surface (”kinetic electron emission”) or remain within the solid. We use Metal-Insulator-Metal (MIM) tunneling junctions to detect and investigate hot charge carriers (electrons and holes) produced during bombardment of a metal surface with keV rare gas (Ar+) ions. The sample consists of a top metal film of about 20 nm thickness (the actual bombarded target surface), an underlying thin (2-3 nm) oxide film deposited and another metal electrode underneath. With such a device, excitations below the vacuum level can be detected as an internal electron emission current between the two metal electrodes. By combining the information obtained from external and internal emission, it is possible to gain information regarding the depth distribution of the generated excitation as well as the transport mechanism distributing the excitation away from its initial point of generation. We demonstrate this by varying the impact angle of the projectile ion beam. It is found that external and internal emission currents vary exactly in opposite direction when going from normal to oblique incidence.

DS 45.4 Thu 12:00 GER 37

Time resolved transport of alkali ions through ultra-thin films — •Susanne Schulze and Karl-Michael Weitzel — Philipps-Universität Marburg, Fachbereich Chemie, 35032 Marburg

In this study, we report on the transport of K^+ through poly(*para*-xylylene) films of 200 to 3000 nm thickness. The experiments are performed in an ultra-high vacuum chamber where an ion beam is generated by thermionic emission of K^+ from aluminosilicates [1]. In one experiment the film is bombarded by a c.w. K^+ ion beam. Individual ions transmitted through the film are detected by two microchannel plates. The analysis of the pulse-pair correlation function of successive ion detection events reveals a sharp drop in the width of the probability distribution between impact energies of 1300 and 1400 V. This variation is interpreted as an indication of a change in the underlying transport mechanism connected to an electrical breakdown induced by space charge zones as a consequence of the ion bombardment [2]. In a second experiment the film is bombarded by a pulsed ion beam. Ions passing through the film are analysed in a time of flight (TOF) spectrometer. The TOF is measured through the film as a function of the impact energy and is compared to the one in the absence of the film. For low impact energies the ions are delayed by the film, which is not the case for high impact energies. These results will be discussed in terms of the transition from diffusive to space-charge driven transport. [1] T. Kolling, A. Schlemmer, C. Pietzonka, B. Harbrecht, J. Appl. Phys., 107, 014105, (2010). [2] K. Schröck, S. Schulze, A. Schlemmer, K.-M. Weitzel, J. Phys. D Appl. Phys., 43, 025501, (2010).

DS 45.5 Thu 12:15 GER 37

Monitoring particle and photo induced electronic excitations by metal–insulator–semiconductor devices — •Kevin Stella[1], Domocos A. Kovacs[1], Wolfgang Brezna[2], Jürgen Smoliner[1], and Detlef Diesing[1] — [1]Fakultät für Chemie, Universität Duisburg-Essen, D-45117 Essen, Germany — [2]Institut für Festkörperelektronik, TU Wien, A-1040 Wien, Austria

Excited charge carriers in and on thin metal-insulator-semiconductor devices (MIS) are released either by internal photoemission or by exposing the device surface with argon ions. Photons (visible and near infrared) penetrate all three layers of the MIS device and excite carriers in the semiconductor as well as in the metal. Excited carriers by low energy argon ions ($E_{kin} = 200\,\mathrm{eV}$) are released only in the first atomic layers of the top metal film. Photon induced carrier transport shows a strong bias dependence with saturation values of up to 0.1 for the photoyield in reverse bias. The voltage necessary for reaching the saturation value is a clear function of the interstitial oxide layers thickness. With forward bias the photoyield decreases to 10^{-4}. Ion induced carrier transport exhibits an opposed bias dependence with a suppression of the signal in reverse biasing.

DS 45.6 Thu 12:30 GER 37

Ion Beam Irradiation of Nanostructures - A 3D Monte Carlo Simulation Code — •Christian Borschel and Carsten Ronning — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena

We have developed a computer program for the simulation of ion beam irradiation of nanostructures. The code uses a Monte Carlo algorithm to simulate the transport of energetic ions through matter, similar to the often used SRIM code. When irradiating nanostructures, which are of the same size as the ion range or the dimension of the damage cascade, new effects occur as compared to bulk. Our code can account for these effects by allowing almost arbitrary 3-dimensional target structures as opposed to the layered target structures used in SRIM. Thus, more accurate 3D distributions of implanted ions and implantation damage for nanostructures can be obtained. The functionality of the code is demonstrated by comparing simulations with experimental results from ion beam implantation into nanowires.

DS 45.7 Thu 12:45 GER 37

Production and design of quantum dot lattices by ion beam irradiation — •Maja Buljan[1], Iva Bogdanović-Radović[1], Nikola Radić[1], Marko Karlušić[1], Goran Dražić[2], Sigrid Bernstorff[3], and Holy Vaclav[4] — [1]Rudjer Bošković Institute, 10000 zagreb, Croatia — [2]Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia — [3]Sinchrotrone Trieste, 34102 Basovizza, Italy — [4]Faculty of Mathematics and Physics, Charles University in Prague, 12116 Prague, Czech Republic

Quantum dot (QD) based materials are widely investigated nowadays due to their interesting properties and numerous possible applications. Especially interesting are semiconductor quantum dots embedded in amorphous wide-bandgap matrices due to strong confinement effects. However, the production of such materials with controllable size, composition and arrangement properties remains a challenge. Here we demonstrate a method for the production of a well-ordered three-dimensional array of semiconductor quantum dots in amorphous silica matrix. The ordering is achieved by ion beam irradiation and annealing of a multilayer film. Structural analysis shows that the quantum dots nucleate along the direction of the ion beam, while the mutual distance of the dots is determined by the diffusion properties of the multilayer material rather than by the distances between the traces of the irradiating ions. In addition, we present the effects of a post-irradiation annealing on the internal structure of the quantum dots.

[1] M. Buljan, et al. Appl. Phys. Lett. 95, 063104 (2009). [2] M. Buljan, et al. Phys. Rev. B 81 085321 (2010).