MI 8: Poster: Microanalysis and Microscopy

Chair: Enrico Langer (TU Dresden), Hartmut S. Leipner (Martin-Luther-Universität Halle-Wittenberg)

Time: Wednesday 17:00–19:30 Location: P4

MI 8.1 Wed 17:00 P4

Development of a μm-positron beam for non-destructive 3D-defect imaging — •Thomas Gigl, Markus Reiner, Christian Piochacz, and Christoph Hugenschmidt — Technische Universität München, Physik-Department E21 and FRM II, 85748 Garching

Doppler broadening spectroscopy with positrons is a well-established non-destructive tool for the investigation of lattice defects in solids. The positron as a nanoprobe is highly sensitive to open volume defects, vacancy-atom complexes and atom clusters of higher positron affinity. The chemical surrounding of the annihilation site can be studied by the coincident detection of the Doppler shifted quanta. For the current project a new high resolution Coincident Doppler Broadening (CDB) spectrometer is under development at the high intensity positron source NEPOMUC (Neutron induced Positron source MUniCh) at the research neutron source FRM II. Therefore, a brightness enhancement system consisting of a Ni(100) re-moderation foil and different magnetic and electrostatic lenses have to be designed and simulated. The aim is to reach a positron beam diameter of below a few μm at the sample position for high resolution experiments. Within this contribution the new design of the spectrometer and simulations to the brightness enhancement system will be presented. Financial support provided for the improvement of the instruments PAES and CDBS (project nos. 05KI0WOB and 05K13WO1) by the BMBF is gratefully acknowledged

MI 8.2 Wed 17:00 P4

Improved algorithm for the determination of the Fermi surface in correlated systems using positrons — •Josef Andreas Weber[1], Hubert Ceeh[1], Liviu Chioncel[3], Christoph Hugenschmidt[1,2], Michael Leitner[1], and Peter Böni[1] — [1]Technische Universität München, Physik Department, Lehrstuhl E21, James-Franck-Straße, D-85748 Garching, Germany — [2]Technische Universität München, Forschungs-Neutronenquelle Heinz Maier-Leibnitz, Lichtenbergstraße 1, D-85748 Garching, Germany — [3]University of Augsburg, Theoretical Physics III, D-86135 Augsburg, Germany

The two-dimensional measurement of the angular correlation of the positron annihilation radiation (2D-ACAR) is a powerful tool to investigate the electronic structure of materials. In order to extract the Fermi surface a reconstruction from the measured projections of the electron momentum density is necessary. We will present an improved algorithm taking into account the full symmetry of the problem and the experimental resolution. It is shown, that this procedure will facilitate the comparison between measured data and ab-initio calculations in correlated electron systems. This circumstance is demonstrated by the reconstruction of the Fermi surfaces of nickel and copper.

MI 8.3 Wed 17:00 P4

Analyse leichter Elemente mittels Kernreaktionsanalyse an der Ionenstrahlmikrosonde — •Christian Freiherr[1], Fabienne Eder[3], Silke Merchel[1], Frans Munnik[2], Christian Neelmeijer[2] und Axel D. Renno[1] — [1]Helmholtz-Institut Freiberg für Ressourcentechnologie (HIF) — [2]Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [3]TU Wien

Ein etabliertes Verfahren der chemischen Analyse mittels Ionenstrahlen ist die simultane Anwendung verschiedener Methoden wie Rutherford Backscattering Spectrometry (RBS), Particle-Induced X-Ray Emission (PIXE), Nuclear Reaction Analysis (NRA) und Particle-Induced Gamma Emission (PIGE). Am Ionenstrahlzentrum des HZDR haben wir die Möglichkeit, derartige Messungen mit einem fokussierten Ionenmikrostrahl durchzuführen, welcher eine laterale Auflösung von bis zu $3 \times 3\,\mu m^2$ liefert. Zur Zeit liegt der Schwerpunkt unserer Arbeiten auf der quantitativen Analyse von Lithium, Bor und Fluor. Die Messung derart leichter Elemente wird durch die isotopensensitiven Methoden PIGE und NRA ermöglicht. Hierbei werden durch die beschleunigten Projektilionen Kernreaktionen mit den Atomen der Probe induziert und deren Reaktionsprodukte (Photonen bzw. massive Teilchen) detektiert. Die Eignung verschiedener Kernreaktionen wird diskutiert und erste Resultate anhand untersuchter Referenzmaterialien und geologischer Proben vorgestellt. Zudem werden – dank der Zerstörungsfreiheit der Methoden – hochsensible Kunst- und Kulturgutproben untersucht.

MI 8.4 Wed 17:00 P4

Determination of trap and band states in organic field-effect transistors by scanning Kelvin probe microscopy — •Sebastian Hietzschold[1,2], Michael Scherer[2,3], Janusz Schinke[2,3], Robert Lovrincic[2,3], and Wolfgang Kowalsky[2,3] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Germany — [2]InnovationLab, Heidelberg, Germany — [3]Institut für Hochfrequenztechnik, Technische Universität Braunschweig, Germany

We determine the density of states (DOS) including gap states in organic semiconductors by means of scanning Kelvin probe microscopy (SKPM). We apply this energy resolving technique with high spatial resolution to bottom gate organic field-effect transistors (OFETs) using the small molecule organic semiconductor pentacene on either HMDS modified or unmodified silicon dioxide gate dielectric. Biasing the gate electrode leads to a filling and emptying of electronic states in the semiconductor resulting in a shift of the surface potential. Hereby we indirectly gain the density of trap as well as band states. The measurements were performed in both ambient atmosphere and ultra-high vacuum. Additionally we compare the results to transistors made of Poly[bis(4-phenyl)(2,4,6-trimethylphenyl)amine] (PTAA) which is widely used as an air stable solution processable organic p-type semiconductor. The DOS of PTAA exhibits several additional peaks compared to pentacene, probably related to impurity induced energy levels and a higher degree of structural disorder. Finally, we correlate the obtained DOS distributions to the device performances.

MI 8.5 Wed 17:00 P4

Sensitivity in SubSurface-AFM: Tip-Sample Interaction in Heterodyne Force Microscopy — •Gerard J. Verbiest[1], Tjerk H. Oosterkamp[2], and Marcel J. Rost[2] — [1]JARA- FIT and II. Institute of Physics, RWTH Aachen University, 52074 Aachen, Germany — [2]Kamerlingh Onnes Laboratory, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands

A couple of reported Heterodyne Force Microscopy (HFM) measurements demonstrate the unique possibility to nondestructively image 20 nm small nanoparticles buried 500 nm below a surface with an AFM. HFM utilizes two ultrasonic signals of slightly different frequencies that are sent through the sample and the cantilever, respectively. The sound wave through the sample contains subsurface information and access to it is possible, as the nonlinear interaction between the cantilever's tip and the sample generates a low-frequency heterodyne force that can be detected in the cantilever's motion, if one tunes this force below its fundamental resonance frequency. A quantitative analysis of the measurements and the determination of their contrast mechanism is only possible with a detailed understanding of the nonlinear dynamics.

We present an experimental and a numerical study of the cantilever motion in HFM, where the two ultrasonic frequencies and the heterodyne frequency are far from any resonance of the cantilever [1,2]. The results provide information on the sensitivity to subsurface features and deliver a recipe for the experimental settings of the frequencies.

[1] G.J. Verbiest et al., Ultramicroscopy 135, 113 (2013)
[2] G.J. Verbiest et al., Nanotechnology 24, 365701 (2013)

MI 8.6 Wed 17:00 P4

Prototyping of Cobalt MFM tips with high spatial resolution using electron beam induced deposition — •Johannes J.L. Mulders and Daniela Sudfeld — FEI Electron Optics B. V., Eindhoven, The Netherlands

The fast creation of MFM cantilevers for magnetic force microscopy studies is a challenge for many conventional lithography techniques. Electron beam induced deposition is a direct write patterning technique, using the electron beam of a scanning electron microscope (SEM) to locally dissociate injected precursor molecules adhered to a surface. The details are described elsewhere [1], but in 3 minutes a tip can be made without clean room environment. With FEI EBID technique, MFM tips in the form of Co spike tips with a lateral resolution of 10 nm were produced [2]. In addition, the magnetic spatial resolution for those MFM cantilevers is improved and measurements with those tips indicated a better signal-to-noise performance [2]. The vertical growth is controlled by the dwell time and very accurate on the nano-scale regime due to the 3 dimensional, mask-free patterning. That allows to tailor the shape of the tip to enhance the performance. The life time and stability of tips can be increased by additional carbon coating preventing natural oxidation. [1] Utke I, Moshkalev S, Russell P: Nanofabrication Using Focused Ion and Electron Beams, Chapter 10, Oxford University Press (2012; [2] L. M. Belova et al., Rev. Sci. Instrum. 83, 093711 (2012)

MI 8.7 Wed 17:00 P4

Imaging applications and fabrication process of x-ray waveguides — •Sarah Hoffmann, Henrike Neubauer, Mike Kanbach, Anna-Lena Robisch, and Tim Salditt — Institut für Röntgenphysik, Friedrich-Hund Platz 1, 37077 Göttingen

Nanoscale x-ray sources as provided by x-ray channel waveguides enable a multitude of novel applications such as diffraction, high resolution spectroscopy, microscopy and holography [1,2].We report on imaging experiments and the fabrication process of these hard x-ray waveguides deployed at the synchrotron source DESY, PETRA III/P10. Among other techniques e-beam lithography, reactive ion etching and Silicon wafer bonding are involved within the fabrication of two-dimensional, sub-100 nm sized waveguide channels. Both waveguide geometry and material can be adapted to meet the requirements of a specific experiment, such as the photon energy (7.9-17.5 keV), the desired source size, or the application of a reference beam in a holography setup. As the tunability of the optical properties provided by the waveguides, such as the coherence of the beam, its divergence or the waveguide transmission, depends sensitively on the precise control over the (several) process steps, an iterative process of diagnostics and optimization is essential.

[1] A. Jarre et al., Phys. Rev. Lett. 94, 074801 (2005)
[2] C. Krywka et al., J. Appl. Cryst. 45, 85-92 (2012)
[3] A. Kohlstedt et al., Appl. Phys. A 91, 6-12 (2008)
[4] H. Neubauer et al., in preparation

MI 8.8 Wed 17:00 P4

Diffractive Optics Research at Max Planck Institute for Intelligent Systems in Stuttgart — •Kahraman Keskinbora, Umut Tunca Sanli, Marcel Mayer, Corinne Grévent, and Gisela Schütz — Max Planck Institute for Intelligent Systems, 70569, Stuttgart, Germany

We develop new nano-fabrication methods for advanced focusing optics called Fresnel zone plates (FZP). One of these methods, implies a combination of the atomic layer deposition (ALD) and the focused ion beam (FIB), and allows to fabricate FZPs having outermost zone widths as small as 10 nm with extremely high aspect ratios compared to the FZPs fabricated by e-beam lithography (EBL). Moreover, we have demonstrated that these zone plates can actually work efficiently over a wide energy range from soft to hard X-rays. Our current research covers the improvement and optimization of the material selection of the ALD deposition process and FIB slicing/polishing. In another fabrication method, we utilize the direct writing capabilities of the FIBs for ultra-rapid fabrication of FZPs with features as small as 30 nm. It was possible to resolve features down to 21 nm. The fabrication lasts less than 9 minutes and the resolution is close to those of standard EBL-FZPs, which is remarkable. We are working towards improving resolutions and diffraction efficiencies of IBL-FZPs by pattern design and process optimizations as well as material improvements

MI 8.9 Wed 17:00 P4

Status and upgrades of the MAXYMUS X-ray microscope — •Iuliia Bykova, Markus Weigand, Michael Bechtel, Claudia Stahl, Eberhard Goering, and Gisela Schütz — Max-Plank-Institute for Intelligent Systems, Stuttgart, Germany

MAXYMUS is an Ultra-High Vacuum (UHV) Scanning Transmission X-ray Microscope (STXM) operated by the MPI for Intelligent Systems at a dedicated soft X-ray undulator beamline at the Bessy II synchrotron (Berlin, Germany) with the feasibility of high brightness and selectable polarization measurements. MAXYMUS is a fully UHV compatible and sensitive for surface current measurements at pressures below $5 \cdot 10^{-9}$ mBar. Also, it is custom-built photon counting and synchronization setup that allows efficient time resolved experiments with the resolution of < 100 ps. These characteristics make MAXYMUS one of the world leading devices in magnetic imaging. We will show results which were obtained due to mentioned features as well as additional options like adjustable magnetic field setups, goniometric and cryostat sample holders, enabling sample temperatures of 80 to 500 K. Currently, MAXYMUS is undergoing an extensive upgrade, which includes the introduction of a new control software and interferometer feedback system as well as a fast in-vacuum CCD camera. The capability of energy-sensitive single photon detection at rates up to 1000 fps will allow drastic increase in resolution and throughput by the use of ptychography and soft X-ray fluorescent microscopy.

MI 8.10 Wed 17:00 P4

Study of core-shell nanowires by kinematic scattering theory — •Thilo Krause and Michael Hanke — Paul Drude Institut für Festkörperelektronik, Hausvogteiplatz 5-7, D-10117 Berlin, Germany

We investigate GaAs/InGaAs/GaAs core-shell nanowires with respect to strain and morphology. We vary parameters such as Indium concentration and shell thickness which can also be controlled during the nanowire growth. For different models we perform kinematic scattering simulations based on the finite element method (FEM). From this we are able to analyze the total elastic strain. The kinematic scattering simulations shall be compared to experiments performed at a synchrotron nano-probe beamline with a spot size of about 100 nm in diameter. Such highly focused beams enable X-ray diffraction experiments on single nanowires and small ensembles.