Microprobes Division
Fachverband Mikrosonden (MI)

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Overview of Invited Talks and Sessions

(Lecture Room H5; Poster B2)

Invited Talks of the Joint Session with MM

MI 1.1	Mon	10:15–10:45	H4	**The potential of valence electron energy-loss spectroscopy to probe local optical properties and band structure information in scanning transmission electron microscopy** — •Rolf Erni
MI 1.2	Mon	10:45–11:15	H4	**Application of Electron Energy-Loss Spectroscopy to Study Nanostructures and Interfaces** — •Christina Scheu
MI 2.1	Mon	11:45–12:15	H4	**Prospects for mapping spins with atomic resolution in TEM** — •Johan Verbeeck
MI 2.2	Mon	12:15–12:45	H4	**Structural Characterization of nc-Si / SiO_x based quantum superstructures for the solar cell application by aberration-corrected high resolution electron microscopy** — •Maryam Beig Mohamadi, Birger Berghoff, Joachim Mayer

Plenary Talk of the Division MI

MI 3.1	Mon	14:00–14:45	H1	**Exploring the Functionality of Advanced Materials through Scanning Transmission Electron Microscopy** — •Stephen Pennycook

Invited Talks

MI 4.1	Mon	15:15–16:00	H5	**Advanced IC failure analysis** — •Frank Altmann, Michél Simon-Najasek, Jörg Jatzkowski
MI 5.1	Tue	9:30–10:15	H5	**Quantitative Röntgenspektrometrie für die Analyse nanostrukturierter Materialien** — •Matthias Müller, Burkhard Beckhoff, Philipp Hönicke, Beatrix Pollakowski, Cornelia Streeck, Rainer Unterumsberger

Invited Talks of the Symposium "Thermoelectric and Spincaloric Transport in Nanostructures" (SYTS)

See SYTS for the full program of the symposium.

SYTS 1.1	Wed	9:30–10:00	H1	**Transport in Old and New Thermoelectric Materials** — •David Singh
SYTS 1.2	Wed	10:00–10:30	H1	**Binary oxide structures as model systems for thermoelectric transport** — •Peter J. Klar, Christian Heiliger
SYTS 1.3	Wed	10:30–11:00	H1	**Functional oxides films: from single crystals to polycrystalline substrates** — •Wilfrid Prellier
SYTS 1.4	Wed	11:00–11:30	H1	**The Planar Nernst Effect and the Search for Thermal Spin Currents in Ferromagnetic Metals** — •Barry Zink
SYTS 1.5	Wed	11:30–12:00	H1	**Tunneling magneto thermopower in magnetic tunnel junction nanopillars** — Niklas Liebing, Santiago Serrano-Guisan, Patryk Krzysteczko, Karsten Rott, Günter Reiss, Jürgen Langer, Berthold Ocker, •Hans Werner Schumacher

Invited Talks of the Symposium "Photons in Magnetism" (SYPM)

See SYPM for the full program of the symposium.

SYPM 1.1	Thu	15:00–15:30	H1	**Ultrafast emergence of nanoscale ferromagnetism far from equilibrium** — •Hermann Dürr
SYPM 1.2	Thu	15:30–16:00	H1	**Free-Electron Laser for Ultrafast Measurements in Material Science** — •Sven Reiche
SYPM 1.3	Thu	16:00–16:30	H1	**Nanomagnetism seen by Femtosecond X-rays** — •Stefan Eisebitt
SYPM 1.4	Thu	16:30–17:00	H1	**Ultrashort Radiation Pulses at Storage Rings** — •Holger Huck
SYPM 1.5	Thu	17:00–17:30	H1	**Every atom counts - Magnetic properties of supported metal atoms and small alloy clusters** — Torben Beeck, Ivan Baev, Steffen Palutke, Kai Chen, Sören Meyer, Kari Jänkälä, Michael Martins, •Wilfried Wurth

Sessions

MI 1.1–1.3	Mon	10:15–11:30	H4	**Topical Session: Using Transmission Electron Microscopy to Unravel the Mysteries of Materials I - Joint Session with MM**
MI 2.1–2.4	Mon	11:45–13:15	H4	**Topical Session: Using Transmission Electron Microscopy to Unravel the Mysteries of Materials II - Joint Session with MM**
MI 3.1–3.1	Mon	14:00–14:45	H1	**Plenary Talk Pennycook (PV II)**
MI 4.1–4.5	Mon	15:15–17:00	H5	**Analytische Elektronenmikroskopie**
MI 5.1–5.8	Tue	9:30–12:15	H5	**Quantitative Materialanalyse (mit KR)**
MI 6.1–6.5	Wed	9:30–10:45	H5	**X-ray Imaging, Holography and Tomography**
MI 7.1–7.4	Wed	11:00–12:15	H5	**Ion Beam Methods**
MI 8.1–8.3	Wed	12:30–13:30	H9	**Nanostructured Oxide Thermoelectrics - Joint Session with DF related to SYTS**
MI 9.1–9.10	Wed	15:00–17:00	Poster B2	**Poster: Microanalysis and Microscopy**
MI 10.1–10.6	Thu	9:30–11:15	H5	**Scanning Probe Microscopy**

Mitgliederversammlung des Fachverbandes Mikrosonden

Mittwoch 18:00–19:00 H5

- Bericht des Fachverbandsvorsitzenden
- Planung der DPG-Tagung 2014
- Verschiedenes

MI 1: Topical Session: Using Transmission Electron Microscopy to Unravel the Mysteries of Materials I - Joint Session with MM

Time: Monday 10:15–11:30 Location: H4

Topical Talk MI 1.1 Mon 10:15 H4

The potential of valence electron energy-loss spectroscopy to probe local optical properties and band structure information in scanning transmission electron microscopy — •Rolf Erni — Electron Microscopy Center, Empa, Swiss Federal Laboratories for Materials Science and Technology, CH-8600 Dübendorf, Switzerland

Valence electron energy-loss spectroscopy (VEELS) in scanning transmission electron microscopy (STEM) offers the possibility to measure band structure information and in particular band gap and transition energies of materials with (sub-)nanometer spatial resolution. Although the technique has been used to reliably identify dielectric information of various bulk and nanomaterials, VEEL spectra contain a wealth of spectral contributions which can complicate the extraction of the desired information. Retardation effects, such as Cerenkov losses, or the excitation of guided light modes as well as surface and finite-size effects can alter the bulk dielectric function contained in VEEL spectra. The dielectric theory describing these effects has been known for a long time, but the incorporation of these effects into routine simulations has not yet become standard. For materials of known dielectric function, it is possible to analyze the origin of individual spectral signatures. This allows for predicting possible spurious effects of unknown materials. The present contribution provides an overview of the applicability of VEELS for the study of nanomaterials, interface and surface effects, combining experiments with simulations which are adequate to address spectral signatures that are not describable by the common energy-loss function of bulk materials.

Topical Talk MI 1.2 Mon 10:45 H4

Application of Electron Energy-Loss Spectroscopy to Study Nanostructures and Interfaces — •Christina Scheu — Department of Chemistry & Center for NanoScience, Ludwig-Maximilians-University of Munich, 81377 Munich, Germany

Electron energy-loss spectroscopy (EELS) in the transmission electron microscope (TEM) provides information on the optical properties, the chemical composition and the electronic structure of materials down to the nanometer regime or even below. These informations are obtained by analyzing the spectral features occurring in the low-loss region (up to energy-losses of around 50 eV) or with the help of the element-specific ionization edges which are found in the core-loss region (above 50 eV). In this talk the different features are discussed under the impact of possible interface and nanostructure investigations. It will be shown that the band gap of individual semiconducting oxide nanosheets can be obtained by comparing experimental data acquired with a monochromated TEM to density functional theory calculations. Furthermore, electronic structure changes occurring at strained oxide-oxide interface will be presented. These changes can be investigated by analyzing the electron energy-loss near-edge structure which is associated with each element-specific ionization edge and which contains information on e.g. bonding characteristics and nominal oxidation states of the probed interfacial atoms.

MI 1.3 Mon 11:15 H4

Effect of lens aberrations on strain measurements from Convergent Beam Electron Diffraction patterns — •Christoph Mahr[1], Knut Müller[1], Andreas Rosenauer[1], Marco Schowalter[1], Daniel Erben[1], Josef Zweck[2], and Pavel Potapov[3] — [1]Universität Bremen — [2]Universität Regensburg — [3]GlobalFoundries, Dresden

This presentation deals with the effect of lens aberrations in a transmission electron microscope (TEM) on strain measurements in semiconductor heterostructures using Strain Analysis by Nano-Beam Electron Diffraction (SANBED). As this method is based on the analysis of disc positions in a series of Convergent Beam Electron Diffraction (CBED) patterns, strain measurements could be inexact e.g. due to lens aberrations of the projection system. The distortion field is detected by comparing the disc positions in an experimental CBED pattern obtained from a substrate region of the specimen with theoretical ones. Based on this field, we show how the distortions in all CBED patterns of a series can be corrected. Subsequently the effect of the correction on the strain measurements is investigated. It is found that the averaged difference between strain from uncorrected patterns and strain from corrected patterns is in the order of $10^{-3}\,\%$. This difference is one order less than the precisions of contemporary strain measurement techniques, such as SANBED, which has a precision of $(7-9)\cdot 10^{-2}\,\%$. Consequently, the effect of distortions in a diffraction pattern can be neglected at the moment. The effect could become more evident, when the precision of strain measurements is improved.

MI 2: Topical Session: Using Transmission Electron Microscopy to Unravel the Mysteries of Materials II - Joint Session with MM

Time: Monday 11:45–13:15 Location: H4

Invited Talk MI 2.1 Mon 11:45 H4

Prospects for mapping spins with atomic resolution in TEM — •Johan Verbeeck — EMAT, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerp, Belgium

In this talk, the prospects for mapping spins with atomic resolution in a TEM will be outlined. The proposed method is based on the use of electron vortex STEM probes. Such probes contain a helical phase of the type $\psi(r,\phi) = f(r)e^{im\phi}$ with m the so-called topological charge. This topological charge is responsible for an orbital angular momentum of $m\hbar$ and a magnetic moment of $m\mu_B$ carried by the electron probe. The phase symmetry affects the dipole selection rules in inelastic scattering which allows us to measure the change in magnetic quantum number upon excitation. As vortex electron probes can now be made to atomic size, we also expect to get magnetic information from individual atom columns in atomic resolution STEM-EELS experiment. Indeed, simulations show that even for thicker samples where multiple scattering can become important, an atomic resolution signal remains that contains information on the spin and orbital magnetic moment of a targeted atom with atomic resolution. Preliminary experiments are shown and the different experimental obstacles will be discussed.

Invited Talk MI 2.2 Mon 12:15 H4

Structural Characterization of nc-Si / SiO_x based quantum superstructures for the solar cell application by aberration-corrected high resolution electron microscopy — •Maryam Beig Mohamadi[1], Birger Berghoff[2], and Joachim Mayer[1,3] — [1]Central Facility for Electron Microscopy, RWTH Aachen, Ahornstrasse 55, 52074 Aachen, Germany — [2]Institute of Semiconductor Electronics, RWTH Aachen University, Sommerfeldstr.24, 52074 Aachen, Germany — [3]Peter Gruenberg Institute and Ernst Ruska Center for Microscopy and Spectroscopy with Electrons, Research Centre Jülich, D-52425 Jülich, Germany

In the frame of SINOVA project, two nano-structured systems were investigated, a-Si/SiO_x and SiO_x/SiO_2 multilayer systems. After annealing the sample, Si nano-crystals formed within an amorphous SiO_2 matrix. The morphology and distribution of the nc-Si precipitates within the amorphous layer, their nucleation and growth kinetics, the thickness of conducting layers and the diffusion of O or Si through interfaces were analyzed by high resolution transmission electron microscopy, energy filtered transmission electron microscopy and electron energy loss spectroscopy. We employed aberration-corrected TEM microscopes to reveal the crystalline structure and the chemical distribution of Si on the atomic scale. It is observed that the mean size of the QDs and their distribution in the dielectric matrix changes by the initial thickness of the SiO_x layer. The kinetics of the formation of nc-Si precipitates in Si-rich layers sandwiched between barrier layers was studied as a function of stacking period and oxygen content in the system.

MI 2.3 Mon 12:45 H4

Aktuelle Ergebnisse mit den HRTEM JEOL JEM-ARM 200F — •Jürgen Heindl — JEOL (Germany) GmbH; Oskar-von-Miller-Str. 1a; 85386 Eching; Germany

Das JEOL JEM-ARM 200F ist das erste Transmissions-Elektronen-Mikroskop das von Grund auf ausschließlich für den Betrieb mit Korrektoren für die Aberration der Linsen entwickelt wurde. Es können sowohl die limitierenden Aberrationen im STEM (Scanning Transmission Electron Microscopy) Betrieb (CESCOR) als auch die des Objektivs in der hochauflösenden Transmissionselektronenmikroskopie (HREM, CETCOR) bzw. beide ausgeglichen werden. Ergänzend kann das System an Stelle der Schottky-Feldemissionskathode mit einer völlig neuartigen kalten Feldemissionsquelle (ColdFEG) mit sehr geringer Energiebreite mit hoher Intensität ausgerüstet werden. Im STEM-Betrieb zeigt die ColdFEG deutlich verbesserte Abbildungsleistungen gegenüber einer Schottky-Quelle, was bei der direkten Abbildung der H-Atome in Yttriumhydrid gezeigt wird. Im HREM-Betrieb ist die ColdFEG anderen Lösungen überlegen, weil die geringe Energiebreite der Primärelektronen unmittelbar auf die Auflösung verbessert. Der Nachteil einer polychromen Beleuchtung entfällt; die Bildergebnisse sind vollumfänglich simulierbar. Ein vollanalytisches JEM-ARM200F zeichnet sich durch den neuen JEOL Centurio-EDX- Detektor aus. Der Centurio-Detektor erreicht seine sehr hohe Empfindlichkeit durch eine aktive Fläche von 100 mm2 und einen Raumwinkel von 1 sr. Mit der neuen ColdFEG wird ein Echtzeit-EDX-Mapping an SrTi03 und GaAs gezeigt.

MI 2.4 Mon 13:00 H4

Investigation of innovative capacitors for energy storage based on 0-3 composites — •Jens Glenneberg, Gerald Wagner, Alexandra Buchsteiner, Mandy Zenkner, Thomas Grossmann, Claudia Ehrhardt, Stefan G. Ebbinghaus, Martin Diestelhorst, Sebastian Lemm, Wolfram Münchgesang, Horst Beige, and Hartmut S. Leipner — Martin-Luther-Universität, Halle-Wittenberg, 06099 Halle

Currently energy storage is an interesting and important topic. Next to accumulators, thin film capacitors with high energy densities are feasible. The aim of our work is to develop novel capacitors exhibiting several advantages like very quick charging and discharging times, long lifetimes and high robustness as well as low manufacturing costs.

For this purpose, ceramic nanoparticles with perovskite structure and high permittivities ($BaTiO_3$, $Ba(Ti,Ge)O_3$, $CaCu_3Ti_4O_{12}$) are embedded in either an organic polymer or an inorganic glass matrix. In order to achieve a uniform dispersion, the nanoparticles are coated with a specific surfactant depending on the matrix. Size and distribution of the embedded particles have a strong effect on the electrical properties of the capacitor dielectrics. Therefore, accurate knowledge of the microstructure is necessary. The single composites are imaged via environmental scanning electron microscopy (ESEM) in secondary electron (SE) and backscattered electron contrast (BSE). Additionally, transmission electron microscopy (TEM) investigations are carried out and energy-dispersive X-ray spectroscopy is conducted in order to get compositional information.

MI 3: Plenary Talk Pennycook (PV II)

Chair: Hartmut S. Leipner

Time: Monday 14:00–14:45 Location: H1

Plenary Talk MI 3.1 Mon 14:00 H1

Exploring the Functionality of Advanced Materials through Scanning Transmission Electron Microscopy — •Stephen Pennycook — Oak Ridge National Laboratory, Oak Ridge, TN, USA

The scanning transmission electron microscope can today form probes of sub-Ångstrom dimensions with sufficient current for electron energy loss spectroscopy. Not only can single atoms be imaged and identified, but their electronic structure, optical properties and even their dynamics can be studied.

In monolayer materials such as BN and graphene, stable point defect complexes consisting of substitutional Si and N atoms lead to localized surface plasmon resonances at the sub-nanometer scale. Core loss spectroscopy is able to identify the nature of their bonding, distinguishing sp3 from sp2d configurations, confirmed by density functional theory. The STEM probe can also be used to gently excite the dynamics of small clusters. A Si6 magic cluster embedded in a small hole in monolayer graphene explores a number of metastable configurations.

In complex oxide materials the ability to measure transition metal valence, to track oxygen vacancy ordering and to measure atomic positions to picometer levels has produced new insights into their functionality. Examples will be presented from multiferroics, cobaltites and ionic conductors. Future directions to directly map functionality at the nanoscale will be discussed.

Research supported by the U.S. Department of Energy, Basic Energy Sciences, Materials Sciences and Engineering Division.

MI 4: Analytische Elektronenmikroskopie

Chair: Hartmut S. Leipner

Time: Monday 15:15–17:00 Location: H5

Invited Talk MI 4.1 Mon 15:15 H5

Advanced IC failure analysis — •Frank Altmann, Michél Simon-Najasek, and Jörg Jatzkowski — Fraunhofer Center for Applied Microstructure Diagnostics (CAM), Halle, Germany

One of the major factors limiting the lifetime of integrated circuits is the occurrence of dielectric breakdowns in one of the circuit's field-effect transistors or capacitors. Process or stress related weaknesses in thin dielectrics can cause early failures in the gate or capacitor oxides. Physical analysis of failures caused by thin dielectric breakdowns can help to distinguish between process or overvoltage related root causes by analyzing the corresponding defect signature. Because of the small dimensions of dielectric breakdowns there is a high risk in modifying its original signature during localization procedure. A new approach based on Electron Beam Absorbed Current (EBAC) imaging within a Scanning Electron Microscope (SEM) will be introduced providing defect localization at extremely low dissipation power in the nW range preserving the original defect structure of thin dielectric breakdown failures. In order to optimize the performance of transistors and diodes there is a growing demand to investigate real dopant profiles to understand and correlate variations of the implant processes to the electrical performance of the devices. A new technique of advanced SEM imaging providing improved dopant contrast biasing the pn-junction combined with a reliable site specific cross section preparation based on precise mechanical grinding will be demonstrated.

MI 4.2 Mon 16:00 H5

Strain Analysis of SiGe-based Field Effect Transistors by Nano Beam Electron Diffraction — •Daniel Erben[1], Knut Müller[1], Christoph Mahr[1], Marco Schowalter[1], Andreas Rosenauer[1], Josef Zweck[2], and Pavel Potapov[3] — [1]Institut für Festkörperphysik, Otto-Hahn-Alle 1, 28359 Bremen (Germany) — [2]Universität Regensburg — [3]Globalfoundries, Dresden

Enhancing carrier mobility in silicon-based electronic devices such as Metal Oxide Field Effect Transistors (MOSFET) has become a large field in scientific research. To this end, one approach is the introduction of stressors near source and drain to strain silicon compressively below the gate contact. In this work, we present strain and composition measurements in a MOSFET sample. In particular, Strain Analysis by

Nano Beam electron Diffraction (SANBED) at an FEI Titan facility is used to record series of CBED diffraction patterns, in which disc positions are detected accurately to measure strain according to Bragg's law. Subsequently three different algorithms can be used to calculate strain maps or profiles: edge detection, radial gradient maximisation and cross correlation with masks. In the present study, we focused on strain measurements in profiles through the MOSFET region below the gate in growth- and lateral direction, whereas first results of 2-dimensional strain mapping will be shown. By evaluating several reflections, a strain precision of $2 \cdot 10^{-3}$ is achieved. As SANBED allows for simultaneous evaluation of strain in both [001] and [110] direction, a reliable conversion to Ge-composition is possible, too.

MI 4.3 Mon 16:15 H5

Generation and propagation of dislocations and cracks in GaN single crystals — •Ingmar Ratschinski[1], Hartmut S. Leipner[1], Wolfgang Fränzel[2], Gunnar Leibiger[3], Frank Habel[3], William Mook[4], and Johann Michler[4] — [1]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle, Germany — [3]Freiberger Compound Materials GmbH, 09599 Freiberg, Germany — [4]Laboratory for Mechanics of Materials and Nanostructures, EMPA Materials Science & Technology 3602 Thun, Switzerland

(0001) GaN single crystals have been deformed at room temperature using different indenter types (Vickers, Berkovich, cube corner) in a load range from 5 mN to 4.9 N. The investigations range from the generation of dislocations at the pop-in event to the formation and propagation of radial and lateral cracks. Dislocations and cracks at the indentations were investigated by optical microscopy as well as scanning electron microscopy in secondary electron contrast and by cathodoluminescence (CL). The dislocation arrangement conforms to the symmetry of the indented surface, whereas the crack formation depends on the shape and the orientation of the indenter. Furthermore, the propagation of dislocations in the strain field of indentations was analyzed by heating and subsequent CL imaging at seven temperature levels up to 1000 °C.

MI 4.4 Mon 16:30 H5

Investigation of D3-like luminescence in mc-solar silicon — •Christoph Krause[1], Daniel Mankovics[1], Tzanimir Arguirov[1], and Kittler Martin[2] — [1]Joint Lab IHP/BTU, Brandenburgische Technische Universität, Cottbus — [2]Joint Lab IHP/BTU, IHP GmbH, Frankfurt (Oder)

In the last years we observed an increasing number of detections of a very intense luminescence in the spectral region of D3 during investigations at multicrystalline silicon. The defects which cause this luminescence even at room temperature could affect the efficiency of solar cells. Furthermore cathodoluminescence revealed a beam current of just a few pico ampere is enough to excite this kind of luminescence which could be interesting for building up some kind of light emitting diode for semiconductor based laser and also on-chip optical data transfer devices. For this reasons we tried to identify the origin with the help of photo-and cathodoluminescence as well as electron beam induced current measurements (EBIC). The temperature dependent correlation between intense luminescence and very strong EBIC-contrast could maybe point to luminescent transitions as main recombination path. We also observed a possible relation between the temperature induced shift of the center wavelength and the band gap energy.

MI 4.5 Mon 16:45 H5

Recent developments in characterization of ultrafine-grained materials by EBSD — •Florian Heidelbach — Bruker Nano GmbH, Schwarzschildstrasse 12, 12489, Berlin, Germany

Electron BackScatter Diffraction (EBSD) examines the relation between structure and properties of materials by providing quantitative microstructural information of inorganic crystalline materials such as metals, minerals, semiconductors, ceramics, etc. EBSD results can be used to assess the grain size, the grain boundary nature, grain orientation and thus texture. The EBSD technique can also be used to perform phase identification and distribution analysis especially when combined with Energy Dispersive X-Ray Spectroscopy (EDS).

We will show how an advanced combination of EBSD and EDS is a powerful tool to successfully identify the different present phases and separate those creating similar patterns. Recent developments also enable the investigation of nanostructured materials in the scanning electron microscope (SEM) by Transmission Kikuchi Diffraction (TKD). Application examples will demonstrate the high spatial resolution (<10 nm) of this technique compared to conventional EBSD.

This presentation aims to reveal the advantages brought by these new developments while presenting application examples.

MI 5: Quantitative Materialanalyse (mit KR)

Chair: Leonore Wiehl

Time: Tuesday 9:30–12:15 Location: H5

Invited Talk MI 5.1 Tue 9:30 H5

Quantitative Röntgenspektrometrie für die Analyse nanostrukturierter Materialien — •Matthias Müller, Burkhard Beckhoff, Philipp Hönicke, Beatrix Pollakowski, Cornelia Streeck und Rainer Unterumsberger — Physikalisch-Technische Bundesanstalt (PTB), Abbestr. 2-12, 10587 Berlin

Die physikalischen und chemischen Eigenschaften nanostrukturierter Materialen bestimmen maßgeblich deren Funktionalität. Für eine zielführende und effektive Materialentwicklung ist es deshalb entscheidend, dass eine zuverlässige Analytik verfügbar ist. Die quantitative Röntgenspektrometrie hat sich für die Materialcharakterisierung als leistungsfähige und zuverlässige Methode etabliert.

Die Nutzung von Röntgenstrahlung geringer Divergenz an Synchrotronstrahlungslaboren hat die Entwicklung der RFA unter streifendem Einfall ermöglicht, wodurch die tiefensensitive Charakterisierung von Nanoschichtsystemen erreicht wurde. Der Einsatz von durchstimmbarer Synchrotronstrahlung hat die Weiterentwicklung von Quantifizierungsmodellen unterstützt, welche auf der Fundamentalparametermethode basieren. Eine weitere deutliche Verbesserung lässt sich durch den Einsatz radiometrisch kalibrierter Instrumentierung erreichen, wodurch eine referenzprobenfreie Quantifizierung erreicht werden kann.

Der Vortrag gibt einen Überblick über die verschiedenen Quantifizierungsmodelle, deren Vor- und Nachteile sowie die Entwicklungsperspektiven. Anhand aktueller Arbeiten der PTB bei BESSY II werden ausgewählte Anwendungsfelder der quantitativen Röntgenspektrometrie für die Entwicklung nanostrukturierter Materialien vorgestellt.

MI 5.2 Tue 10:15 H5

Advances in Low Energy X-ray Analysis with state of the art Silicon Drift Detectors using EPMA, SEM and STEM — •T. Salge[1], R. Terborg[1], M. Falke[1], O. Tunckan[2], A. Kearsley[3], D. Pereira da Silva Dalto[4], M.J.O.C. Guimarães[4], R. Ferhati[5], I. Bjurhager[6], S. Turan[2], M.E.F. Garcia[4], and W. Bolse[5] — [1]Bruker Nano GmbH, Berlin, Germany — [2]Anadolu University, Eskisehir, Turkey — [3]Natural History Museum, London, UK — [4]UFRJ, Rio de Janeiro, Brazil — [5]University of Stuttgart, Germany — [6]Ångström Laboratory, Uppsala, Sweden

Element analysis of ever smaller structures in bulk samples requires low electron beam energy to enhance spatial resolution. To separate overlapping peaks at low energy X-ray lines (e.g. N-K/Ti-L), the line deconvolution algorithms in EDX software is important. We describe features at the submicron scale (e.g. ceramic-metal joints) using SDDs in conventional geometries. The annular four channel SDD placed between the pole piece and sample covers a large solid angle of 1.1sr. Features with high topography from experiments with wafer irradiation and hypervelocity impact craters can be analyzed as well as beam sensitive polymer composites. For cultural heritage and biological samples, carbon coating can be avoided during low vacuum acquisition. Nano- and atomic scale analysis of electron transparent samples ideally requires not only high solid angle detector design but also adjustments in pole piece and sample holder geometry as well as a high quality electron probe. This approach will be demonstrated to allow 1 sr solid angle and single atom spectroscopy even at 0.1 sr and 60 kV.

MI 5.3 Tue 10:30 H5

Quantitative Analysis of Pyramid Textured Silicon Wafers and Size Dependence of Optical and Electronic Properties — •Jan Kegel[1,2], Heike Angermann[2], Uta Stürzebecher[3], Erhard Conrad[2], and Bert Stegemann[1] — [1]Hochschule für Technik und Wirtschaft, Berlin, Germany — [2]Helmholtz Zentrum Berlin, Berlin, Germany — [3]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik GmbH, Erfurt, Germany

Wet-chemical etching in alkaline solution is used to texture monocrystalline silicon wafers for high-efficiency solar cells. This texturing result in micron-sized random pyramids on the wafer surface which reduce reflection losses and increase the absorption probability. Successful texturing is evaluated by reflection and charge carrier lifetime measurements. Both parameters are found to be influenced by the geometric surface properties as well. Thus, elaborated image processing is applied for precise and reproducible evaluation of pyramid number and size distribution. The results show a distinct dependence of the total reflection and the minority charge carrier lifetime on the pyramid size distribution. Based on these results etching parameters can be adjusted to produce optimal surface properties with respect to highest solar cell efficiencies.

MI 5.4 Tue 10:45 H5

phase diagram of nano-hydride formation: consequences for hydrogen embrittlement — •Gerard Paul Leyson, Blazej Grabowski, Johann von Pezold, and Jörg Neugebauer — Max-Planck-Straße 1, 40237 Düsseldorf, Germany

Local hydride formation around dislocations induces stress-shielding effects and is the underlying mechanism for hydrogen-enhanced local plasticity (HELP). In this work, we present an analytic model for hydride formation around fcc Ni edge dislocations that takes input from atomistic calculations. The hydrogen-hydrogen interaction is modeled using information obtained from a semi-empirical embedded atom method (EAM) potential. Within this approach, the equilibrium concentration and the binding energies of hydrogen around the dislocation are self-consistently calculated. At 300K, local hydride formation is observed with bulk hydrogen concentrations on the order of ~500ppm, consistent previous studies [1]. The onset of nano-hydride formation and with it the activation of the HELP mechanism is predicted through a parametric study of the hydride size as a function of temperature and bulk hydrogen concentration.

[1] von Pezold J, Lymperakis L and Neugebeauer J. Acta Materialia 59 (2011), 2969-2980.

MI 5.5 Tue 11:00 H5

Diffuse scattering and stacking faults in (Bi,Na)TiO3 single crystals — •Wolfgang Donner[1], Marton Major[1], and John Daniels[2] — [1]Fachbereich Materialwissenschaft, Technische Universität Darmstadt — [2]School of Materials Science and Engineering, University of New South Wales, Sydney

In our previous work we found diffuse streaks in the x-ray diffraction from the single crystal relaxor BNT-4BT [1]. These streaks connect half-order reflections associated with octahedral tilts in the sample. The diffuse streaks and diffuse half-order peaks react upon the application of an external electric field. Similar diffuse scattering patterns had been found in electron diffraction [2] from pure BNT samples and were interpreted as arising from stacking faults in the octahedral tilt sequence. The stacking fault structure could also be viewed as a twin structure of two rhombohedral domains. Here we present results from simulations of the diffuse scattering pattern based on certain stacking faults in the R3c structure and show that the model can be applied to estimate the amount of stacking faults. The stacking fault probability in turn can be used to estimate the size of the nanopolar regions in BNT-BT giving rise to the relaxor behavior.

[1] J. Daniels, W. Jo, J. Rödel, D. Rytz and W. Donner, Appl. Phys. Lett. 98, 252904 (2011) [2] V. Dorcet, G. Trolliard, Acta Mat. 56, 1753 (2008)

15 min. break

MI 5.6 Tue 11:30 H5

Comparative Study of Ion Sputtering in XPS Depth Profiling for Thin Film Analysis. — •Andrey Lyapin[1], Stefan Reichlmaier[1], Saad Alnabulsi[2], Sankar Raman[2], John Moulder[2], Scott Bryan[2], and John Hammond[2] — [1]Physical Electronics GmbH, Fraunhoferstr. 4, D-85737, Ismaning, Germany — [2]Physical Electronics, 18725 Lake Drive East, Chanhassen, MN, 55317, USA

The objective of successful XPS sputter depth profiling is to accurately identify the layer thicknesses and chemical composition of materials within thin film structures. Cluster ion beam sputtering has been widely used in recent years with the intent to address this essential analytical goal for a broader range of materials, including organic materials. C_{60} cluster ion beam sputtering provided the first access to quantitative chemical state information below the surface for many polymers, organic and inorganic oxide materials.

The recent introduction of argon gas cluster ion beam sputtering to the XPS community has further expanded the capability of successful depth profiling with an emphasis on preserving the chemical structure of challenging polymer and organic materials that exhibit rapid radiation induced damage due to the mobility and reactivity of free radicals that are formed during the sputtering process when other ion sources are used.

The purpose of this study is to present a comparative evaluation to quantify the benefits of using either C_{60} or argon gas cluster ion beam sputtering for XPS compositional depth profiling.

MI 5.7 Tue 11:45 H5

Analysis of impurity diffusion and recrystallisation processes of Fe and FeNi polycrystals with low energy electron microscopy — •Benjamin Borkenhagen, Gerhard Lilienkamp, and Winfried Daum — Institute of Energy Research and Physical Technologies, TU Clausthal, Leibnizstraße 4, 38678 Clausthal-Zellerfeld

We use low energy electron microscopy (LEEM) and laterally resolved low energy electron diffraction (μLEED) to characterize surface properties of polycrystalline materials as well as structural and dynamic properties of grain boundaries. In this contribution, we report on our analyses of segregation and diffusion processes taking place at the surface of polycrystalline Fe and FeNi. Previously we have shown that bulk impurities, mostly sulphur, segregate from the bulk of a heated polycrystal to the surface and form two-dimensional impurity islands. At a suitable temperature we observe Ostwald ripening of these islands and, at elevated temperature, dissolution of the islands. Here we present a quantitative study of impurity diffusion processes, which yields both linear and $t^{1/2}$ time dependencies for the impurity concentrations on different grains. These different time dependencies point to different bulk impurity concentration profiles in different grains. In addition to impurity diffusion, we studied recrystallisation processes and their effects on surface topography in real time. By measuring tripel-point speeds and geometries of the grain boundaries, the rate-limiting step of the recrystallisation process – grain boundary mobility or tripel point mobility – was identified.

MI 5.8 Tue 12:00 H5

Microscopic Understanding of Ionic Thermophoresis — Mario Herzog, •Maren Reichl, Alexandra Götz, and Dieter Braun — Systems Biophysics, LMU, München, Germany

A number of microscopic models for thermophoresis has been proposed recently. Here we measured short DNA and RNA molecules over a wide parameter range (0.4-14 nm Debye length, 5-75°C base temperature, 5-50 bases, 11 different electrolytes) [1]. The measurements confirm the capacitor model of thermophoresis with the following details [2]:

1. Thermophoresis is proportional to the Debye length when the latter is smaller than the molecule radius, but saturates for Debye lengths exceeding the molecule radius. This confirms the predicted size transition between the plate and spherical limit of the capacitor model. The fitted effective charges depend on DNA length predicted by molecular dynamics simulations of Manning condensation.

2. Depending on the electrolyte, a constant additive contribution for the Seebeck effect of the electrolyte is confirmed. It can be understood from literature data without fitting parameters.

The model allows non-trivial predictions of thermophoresis. Our work confirms in detail a local equilibrium approach to thermophoresis. The finding is likely to improve biomolecule binding studies using microscale thermophoresis (Nanotemper Technologies).

[1] Herzog M and Braun D, under review

[2] Dohnt J, Wiegand S, Duhr S and Braun D, Langmuir 23, 1674-1683 (2007)

MI 6: X-ray Imaging, Holography and Tomography

Chair: Enrico Langer

Time: Wednesday 9:30–10:45 Location: H5

MI 6.1 Wed 9:30 H5

About the Potential of novel X-ray Contrast Modalities in Material Science and Non-Destructive Testing — •Friedrich Prade[1,2], Michael Chabior[1,2], and Franz Pfeiffer[1,2] — [1]Department of Physics, Technische Universität München, 85748 Garching, Germany — [2]Institute of Medical Engineering, Technische Universität München, 85748 Garching, Germany

Since its beginning X-ray imaging has attracted increasing interest in various research fields besides medicine, such as material science, non-destructive testing (NDT) and security screening. Furthermore, recent developments of new X-ray imaging techniques, such as grating interferometry, helped to improve the X-ray imaging contrast. In addition to the standard absorption contrast, differential phase-contrast imaging (DPC) yields information on the electron density, whereas dark-field contrast imaging provides further information about small angle scattering properties of the sample. While especially DPC has been extensively tested in biomedical applications, e.g. to improve soft tissue contrast, little effort has been made to adapt both DPC and dark-field imaging to material science or NDT applications. In this study we explore applications for these novel X-ray contrast modalities in material science and NDT and evaluate the additional information provided by these techniques. We primary focus on dark-field imaging to study micron sized pores and cracks as well as the micro-structure of fiber reinforced materials, since these structures show a strong scattering signal.

MI 6.2 Wed 9:45 H5

OMNY- An Instrument for Ptychographic Nano-Tomography — Mirko Holler, •Jörg Raabe, Ana Diaz, Manuel Guizar-Sicairos, Christoph Quitmann, Andreas Menzel, and Oliver Bunk — Swiss Light Source, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

OMNY (tOMography Nano crYo stage) is an instrumention project under way at the SLS aiming for 3D nanometric imaging. It uses ptychographic reconstruction of coherent diffraction patterns and tomography to acquire images in 3D. In the final implementation it will be used to image biomaterial, materials science and physics samples. A test-setup is installed at the cSAXS beamline to verify the performance of key components in air and at room temperature. It has produced 2D and 3D-data sets with < 50 nm resolution (2D). A laser interferometer stabilizes the position of the sample with respect to the beam (z) along the x- and y-axis. The position feedback provides a stability < 10 nm and compensates any long term drifts.

We present results on 2D lithographic test patterns to specify resolution, drift etc. and on integrated circuits to demonstrate the potential of the instrument.

MI 6.3 Wed 10:00 H5

Advanced image processing algorithms for coherent X-ray nanoCT — •Benedikt Daurer, Björn Enders, Andreas Fehringer, Marco Stockmar, Martin Dierolf, Irene Zanette, Franz Pfeiffer, and Pierre Thibault — Departement of Physics (E17), Technische Universität München, Germany

A recently developed coherent diffractive imaging technique named ptychography [1] provides the possibility to reconstruct tomographic volumes of nano-structured samples using hard X-ray beams [2].

Today's algorithms used for ptychography retrieve the accumulated complex-valued index of refraction behind an object for all tomographic angles individually. The total acquisition time for a full tomographic scan using ptychography is typically between 6 and 24 hours and thus the different projections are individually shifted due to limited mechanical accuracy and thermal drifts. This requires the use of advanced alignment procedures without fiducial markers [3], which is particularly challenging in the case of local tomography or limited-angle tomography. We will present a quantitative analysis of the different algorithms available and will describe newly developed strategies.

[1] Rodenburg, J. et al. (2007). Hard-X-Ray Lensless Imaging of Extended Objects. Physical Review Letters, 98(3), 034801.

[2] Dierolf, M. et al. (2010). Ptychographic X-ray computed tomography at the nanoscale. Nature, 467(7314), 436-439.

[3] Guizar-Sicairos, M. et al. (2011). Phase tomography from x-ray coherent diffractive imaging projections. Optics Express, 19(22), 21345.

MI 6.4 Wed 10:15 H5

3D validation of X-Ray Diffraction Contrast Tomography reconstructions of polycristalline materials by means of serial sectioning and EBSD analysis — •Barbara Lödermann[1], Andreas Graff[2], Andreas Trenkle[1], Melanie Syha[1], Mathias Reichardt[1], Michael Selzer[1], Daniel Weygand[1], Wolfgang Ludwig[3], and Peter Gumbsch[1] — [1]KIT, IAM ZBS, Karlsruhe, Germany — [2]Fraunhofer IWM, Halle, Germany — [3]ESRF, Grenoble, France

A cylindric strontium titanate specimen which has been subjected to repetitive X-Ray Diffraction Contrast Tomography (DCT) scans is investigated by means of Electron Backscatter Diffraction Analysis (EBSD). Therefor, 8 cross-sections of the sample in 3-10 microns distance have been prepared manually. Corresponding cross-sections of the reconstructed microstructures as obtained by DCT are identified and compared to EBSD characterizations. Moreover, a 3D reconstruction generated by a Voronoi segmentation algorithm of the destructive characterization is presented and aligned to the structure as obtained by DCT alongside with a direct comparison of the crystallographic orientation obtained for the individual crystallites. Focussing on the position and curvature of the grain boundaries, the results are discussed in the context of the spatial resolution and optimization potential of the diffraction data.

MI 6.5 Wed 10:30 H5

The Potential of Scatter-Free Pinholes for X-ray Analytical Equipment — •Andreas Kleine, Frank Hertlein, and Carsten Michaelsen — Incoatec GmbH, Max-Planck-Str. 2, 21502 Geesthacht, Germany

Parasitic scattering caused by apertures is a well-known problem in X-ray analytics, which forces users and manufactures to adapt their experimental setup to this unwanted phenomenon. Increased measurement times due to lower photon fluxes, a lower resolution caused by an enlarged beam stop, a larger beam defining pinhole-to-sample distance due to the integration of an antiscatter guard and generally a lower signal-to-noise ratio leads to a loss in data quality.

In this presentation we will show how the lately developed scatter-free pinholes overcome the aforementioned problems. We will show measurements performed at home-lab small angle X-ray scattering (SAXS) systems and at synchrotron beamlines which compare conventional pinholes, scatterless Germanium slit systems and scatter-free SCATEX pinholes.

We will further present the latest developments regarding the novel liquid metal jet X-ray source, a technology which has already shown intensities superior to the best rotating anode. The latest results of this new source technology in combination with scatter-free pinholes will be presented.

MI 7: Ion Beam Methods

Chair: Enrico Langer

Time: Wednesday 11:00–12:15 Location: H5

MI 7.1 Wed 11:00 H5

The He Ion Microscope: Extending the frontiers of nanoscale research — •Peter Gnauck — Carl Zeiss Microscopy, Oberkochen, Germany

The need for more precise image information of samples coming from fields such as materials analysis, semiconductor processing, and life sciences have pushed the boundaries of charged particle microscopy. A new microscope has been developed that uses a beam of helium ions which is focused and scanned across the sample. In principle, and in its applications, it is similar to a traditional scanning electron microscope (SEM). However, the source technology, the sample interaction, and the contrast mechanisms are distinctly different. The helium ion source offers high brightness and a small energy spread, and hence allows the beam to be focused into very small probe sizes. As the helium ion microscope uses heavier Helium ions instead of electrons the helium ion microscope overcomes the diffraction effect that limits the resolution of a classical SEM. As the beam interacts with the sample, the beam penetrates relatively deeply before it diverges and hence there is a narrow sample interaction region near the surface. This results in an unmatched surface sensitive imaging capability. The helium beam generates secondary electrons, scattered helium atoms (ions and neutrals), and other detectable particles from which images can be generated or analysis can be performed. Due to the different beam * sample interaction of the He ions compared to electrons the HIM provides unmatched surface sensitivity even at high voltages.

MI 7.2 Wed 11:30 H5

Broadening of a helium beam in hydrogen silsesquioxane — •Paul Alkemade[1], Anja van Langen-Suurling[1], Emile van Veldhoven[2], and Diederik Maas[2] — [1]Kavli Institute of Nanoscience, Delft University of Technology, Delft, The Netherlands — [2]TNO Nano-instrumentation, TNO, Delft, The Netherlands

The realization of a practical helium gas field-ionization source made helium ion microscopy possible as an imaging and nanofabrication technique with high spatial resolution. Three key elements enable the high resolution: 1) the sub-nanometer probe size; 2) the fact that the emission of secondary electrons and backscattered ions is highly localized; and 3) the weak scattering of helium ions in matter.

With help of experiments and simulations we investigate how scattering of the penetrating ions causes broadening of the beam and thus loss of resolution. The helium beam energy is 30 keV and the material used is hydrogen silsesquioxane, a radiation sensitive material.

The results suggest that the most common simulation model (SRIM) underestimates the broadening of the penetrating helium beam. We will discuss causes of the observed discrepancy.

MI 7.3 Wed 11:45 H5

Ultra-high 2D and 3D imaging SIMS with cluster ions - approaching the physical limits — •Sven Kayser, Felix Kollmer, Wolfgang Paul, Martin Krehl, and Ewald Niehuis — ION-TOF GmbH, Münster, Germany

Time-of-flight secondary ion mass spectrometry (TOF-SIMS) is a very sensitive surface analytical technique. It provides detailed elemental and molecular information about surfaces, thin layers, interfaces, and full three-dimensional analysis of the sample. One major improvement especially for the analysis of organic materials on a small scale was the introduction of cluster ion beams to the field. During the last years bismuth clusters have become the standard primary ion species for all imaging applications providing a lateral resolution of down to 80 nm. Recent developments of the emitter technology and the ion optics allow pushing the performance further towards the physical limits of the technique reaching a lateral resolution of down to 20 nm.

At the same time new sputter ion sources were developed using large argon clusters for dual beam depth profiling of organic materials. With the new sources the preservation of molecular information under high-dose sputtering conditions has become possible. This has enabled TOF-SIMS to do depth profiling and 3D analysis of organic materials.

In this contribution we will present the latest results in high-resolution TOF-SIMS imaging with bismuth primary ion clusters. We will also discuss examples from the field of organic electronics using the combination of bismuth and large argon clusters for analysis.

MI 7.4 Wed 12:00 H5

A position sensitive germanium detector for the measurement of angular deviation of positron-electron annihilation radiation — •Benjamin Löwe[1], Markus Reiner[2], Werner Egger[1], Christoph Hugenschmidt[2], and Günther Dollinger[1] — [1]Universität der Bundeswehr, LRT2, Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany — [2]FRM II, Technische Universität München, Lichtenbergstraße 1, 85747 Garching, Germany

To improve electron momentum sensitivity in Coincidence Doppler Broadening Spectroscopy (CDBS) measurements it is envisaged to measure the angular correlation of annihilation radiation along with the energy of both annihilation photons. For this purpose two position sensitive 36-fold pixelated, planar germanium detectors will be utilized. The position sensitivity of one of those detectors has been tested with a collimated gamma source. A data acquisition system consisting of 37 sampling analogue-to-digital converters with PC based on-line/off-line processing has been installed. A position sensitivity of 1.6 mm has been be achieved.

MI 8: Nanostructured Oxide Thermoelectrics - Joint Session with DF related to SYTS

Time: Wednesday 12:30–13:30 Location: H9

MI 8.1 Wed 12:30 H9

Thermoelectric properties of p-type $Bi_2Sr_2Co_2O_9$ glass-ceramics — •Matthias Jost[1,3], Julian Lingner[1,2], Martin Letz[2], and Gerhard Jakob[1] — [1]Johannes-Gutenberg Univeristät, Institut für Physik, Staudinger Weg 7, Mainz D-55128 — [2]Schott AG, Hattenbergstraße 10, Mainz D-55122 — [3]Technische Universität Darmstadt, Institut für Mikrowellentechnik und Photonik, Merckstraße 25, Darmstadt D-64283

In the oxide system of Bi-Sr-Co glass melts were prepared by adding a small amount of glass formers. A crystallization leads to crystalline phases of $Bi_8Sr_8Co_4O_25$, $BiSrCo_2O_x$ and $Bi_2Sr_2Co_2O_9$ (BC-222) densely embedded into a residual glass phase. We show that it is possible via such glass-ceramic approach to obtain microstructured bulk material with low thermal conductivity and relatively high electrical conductivity. We further show that these materials are stable under thermal cycling for temperatures up to 700°C. A characterization of the thermoelectric properties leads to values of ZT between 0.008 and 0.018.

MI 8.2 Wed 12:50 H9

Glass-ceramics as a new material class for high temperature oxide thermoelectrics — •Julian Lingner[1,2], Gerhard Jakob[1], and Martin Letz[2] — [1]Universität Mainz — [2]Schott AG Mainz

The research on thermoelectric materials has progressed enormously over the last years and is still growing because of the global demand for eco-sensitive energy conversion. Innovative approaches like bulk-nanostructuring helped to increase the efficiency of the investigated materials. Materials which withstand high temperatures above 500°C are especially in great demand because the thermoelectric efficiency is proportional to the temperature and the possible fields of application broaden. It is of great importance to find materials which are able to operate under these circumstances while at the same time being naturally abundant and non-toxic. This presentation focuses on glass-ceramics as a new material class for high temperatures in thermoelectrics. Starting from a base glass via a controlled thermal treatment, a certain crystal structure is embedded in the glass-matrix leading to many new properties of the material. Especially the possibility to induce small crystallites, the pore-free surface combined with the high-temperature durability of this material class support this approach. Measurements of different systems of glass-ceramic thermoelectric materials are presented.

MI 8.3 Wed 13:10 H9

Indium-oxide-based Seebeck gas sensors — •Markus Mischo[1], Volker Cimalla[2], Oliver Ambacher[1,2], and Friedemann Völklein[3] — [1]Laboratory for Compound Semiconductor Microsystems, Department of Microsystems Engineering - IMTEK, University of Freiburg, Germany — [2]Fraunhofer Institute for Applied Solid State Physics Freiburg, Germany — [3]RheinMain University, Institute of Microtechnologies

The intention of this research is to develop a highly sensitive long-lasting ozone sensor based on the thermoelectric effect. The thermoelectric, or Seebeck effect is the direct conversion of temperature differences into electricity. Direct thermoelectric gas sensors are based on the dependency of the Seebeck coefficient on the surrounding gas concentration. Beside the Seebeck coefficient there are several other important parameters which have an influence on the thermoelectric power. Generally, the thermoelectric power is characterized by the figure of merit ZT: $ZT = (S^2\sigma/\kappa)T$ where S, σ, κ and T are the major influencing parameters, namely the Seebeck coefficient, the specific electronic and thermal conductivity, respectively, and the temperature. Compounds such as InN, InAs, and InOx have good thermoelectric properties. In addition, the Fermi level and the surface band bending can be modified by specific gas adsorption, while thermal conductivity is decreased by reducing the grain size in the material. These effects are used for a highly-sensitive Seebeck gas sensor. The sensors are able to compete with conventional resistive gas sensors regarding accuracy, reproducibility and response time.

MI 9: Poster: Microanalysis and Microscopy

Chair: Hartmut S. Leipner, Enrico Langer

Time: Wednesday 15:00–17:00 Location: Poster B2

MI 9.1 Wed 15:00 Poster B2

A new soft X-ray microscopy endstation for time-resolved experiments at PETRA III — •Philipp Wessels[1], Moritz Schlie[1], Marek Wieland[1], Johannes Ewald[2], Gennaro Abbati[2], Stefan Baumbach[2], Johannes Overbuschmann[2], Thomas Nisius[2], Jens Viefhaus[3], Thomas Wilhein[2], and Markus Drescher[1] — [1]Institute for Experimental Physics, University of Hamburg, Germany — [2]Institute for X-Optics, RheinAhrCampus Remagen, Germany — [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

We present first results of a new full-field transmission microscope for the soft X-ray beamline P04 at the high brilliance synchrotron radiation source PETRA III. A flat-top illumination field of 20 μm diameter is generated by a grating condenser and the sample plane is imaged by a micro zone plate with outermost zone width of 50 nm. The microscope is built into a mobile endstation vacuum system with in-house developed encoded three-axis piezo motorized stages for high accuracy positioning of all microscopy-components inside the chambers. In the first images a resolution of 70 nm was achieved.

For future applications, the microscope can be equipped with a mobile synchronized femtosecond laser system to perform time-resolved pump-probe experiments for example on magnetic nanostructures via X-ray magnetic circular dichroism (XMCD) spectro-microscopy with a time-resolution limited only by the PETRA III pulse duration of 44 ps root mean square.

MI 9.2 Wed 15:00 Poster B2

Ring Laser Gyroscope with Varying Arm Lengths — •Kathrin Schaller and Lothar Kador — University of Bayreuth, Institute of Physics and Bayreuther Institut für Makromolekülforschung (BIMF), Bayreuth, Germany

Variations of the lock-in threshold of a ring laser gyroscope upon slight changes of its arm lengths have been investigated. The setup features a HeNe discharge tube and a rectangular ring cavity encompassing about 0.2 square-meters and is built on a precision rotating stage. Two of the cavity mirrors are mounted on piezo translators, so that their positions can be changed in the range of a few micrometers with or without varying the total cavity length. The influence of variations of the arm lengths on the lock-in threshold was studied in the regime of single-mode and dual-mode operation of the laser and for different rotation rates.

MI 9.3 Wed 15:00 Poster B2

Beam characteristics of the new positron source NEPOMUC *upgrade* — •Thomas Gigl, Christian Piochacz, Florian Lippert, Samantha Zimnik, Markus Reiner, Philip Pikart, Hubert Ceeh, Josef-Andreas Weber, Sebastian Vohburger, and Christoph Hugenschmidt — Technische Universität München, Physik-Department E21 und FRM II, 85748 Garching

The neutron-induced positron source NEPOMUC at the FRM II provides a mono-energetic positron beam of high intensity for a variety of experiments in the field of solid state and surface physics. In order to increase the beam brightness the first version of NEPOMUC was improved and now replaced by NEPOMUC *upgrade*[1]. At the end of 2012 we succeeded to extract a slow positron beam (0,2-1 keV) with enhanced brightness. Detailed measurements of the beam characteristics such as intensity and beam shape will be presented. Furthermore an overview of recent and planed positron beam experiments for fundamental research and application in solid state physics is given.

References:

[1] C. Hugenschmidt, C. Piochacz, M. Reiner, K. Schreckenbach, The NEPOMUC *upgrade* and advanced positron beam experiments, New Journal of Physics 14, 2012

MI 9.4 Wed 15:00 Poster B2

Novel techniques and applications in (C)DB-spectroscopy at the NEPOMUC positron beam — •Markus Reiner[1], Benjamin Löwe[2], Philip Pikart[1], and Christoph Hugenschmidt[1] — [1]Technische Universität München, Physik-Department E21 und FRM II, 85748 Garching — [2]Universität der Bundeswehr München, Institut für Angewandte Physik und Messtechnik LRT2, 85577 Neubiberg

In (Coincident) Doppler Broadening Spectroscopy ((C)DBS) the positron is used as a nanoprobe, which is highly sensitive to open volume defects, vacancy-atom complexes and atom clusters of higher positron affinity. The coincident detection of the Doppler shifted annihilation quanta enables the characterization of the chemical vicinity of the annihilation site. The high intensity positron beam NEPOMUC at the FRM II has been successfully used for depth dependent and in-situ investigations at high temperatures. Due to the short measurement times, CDBS at NEPOMUC enables novel applications like studies on thin film annealing and alloying. Currently, a new sample heating device is installed in order to allow in-situ measurements at temperatures up to 1300 K. Furthermore, a new detector system of two pixelated HPGe detectors is set up and will be used for the 3D detection of electron momenta. Within this contribution, recent measurements as well as new developments at the CDB-spectrometer will be presented. Financial support within the project no. 05KI0WOB by the BMBF is gratefully acknowledged.

MI 9.5 Wed 15:00 Poster B2

Investigations of Co-Ni-Al ferromagnetic shape memory alloys by means of X-ray Kossel diffraction and the EBSD method — Enrico Langer[1], Siegfried Däbritz[1], •Mateus Melo[1,2], Leonid Potapov[1,3], and Jaromir Kopeček[4] — [1]Technische Universität Dresden, Institut für Festkörperphysik, Helmholtzstraße 10, 01062 Dresden, Germany — [2]Universidade Presbiteriana Mackenzie, Departamento de Engenharia de Materiais, Rua da Consolação, 930, CEP: 01302907, Consolação - São Paulo - SP, Brazil — [3]St. Benno-Gymnasium Dresden, Pillnitzer Straße 39, 01069 Dresden, Germany — [4]Academy of Sciences of the Czech Republic, Institute of Physics, Na Slovance 2, 18221 Prague, Czech Republic

Current research activities are focussing on a complete understanding of the structure and the behavior of ferromagnetic shape memory alloys (FSMA). The Co-Ni-Al system attracts special attention in the area of FSMA due to certain features such as good oxidation resistance, low density and appreciable ductility at room temperature.

The present work studied austenitic single crystals with nominal composition $Co_{38}Ni_{33}Al_{29}$ (matrix B2-β-phase with precipitates of A1-γ-phase) by means of X-ray Kossel diffraction and EBSD within a scanning electron microscope. The samples were prepared by the Bridgman method and grown in [100] direction. Overlaps of Kossel reflections of two different crystal phases were observed which allowed to determine precisely the orientation relationship as Kurdjumow-Sachs: $(111)_{A1} \parallel (110)_{B2}$, $[\bar{1}10]_{A1} \parallel [\bar{1}1\bar{1}]_{B2}$. Moreover, remarkable dark regions (lower backscatter coefficient η) between the B2 matrix and the γ-phase were seen using backscattered electrons. On the basis of the Kossel investigations it may be concluded that this structure along the boundary is connected to the measured exact plane orientation relationship (misorientation within a few tenths of a degree) and therefore reveals areas of excellent crystal quality with very low dislocation density.

MI 9.6 Wed 15:00 Poster B2

Characterization of Mechanical Properties of qPlus Sensors — •Jan Berger, Martin Švec, Martin Müller, Martin Ledinský, Antonín Fejfar, Pavel Jelínek, and Zsolt Majzik — 1Institute of Physics of the Czech Academy of Science, Prague, 162 00, Czech republic

Tuning fork based sensors (qPlus) became frequently used in non-contact atomic force microscopy (nc-AFM) last years. However, precise characterization of mechanical properties of each sensor is crucial for proper estimation of measured quantities such as forces or the dissipation energy. If a prong of the tuning fork is shortened to achieve higher electrical sensitivities (i.e. to produce more charge per oscillation) the mechanical parameters must be calibrated again.

In this poster we present a comparison of three different methods that can be used for estimating the stiffness of qPlus sensors. The first method is based on continuum theory of elasticity. The second (Cleveland's method) uses change in the eigenfrequency, which is induced by loading of small masses. Finally, the stiffness is obtained by analyses of the thermal noise spectrum. We show that all three methods give similar results. Surprisingly, neither the gold wire nor the gluing rise to significant changes of the stiffness.

We describe a fast and cost-effective way to perform the Cleveland's method, based on gluing small pieces of a tungsten wire. The mass is obtained from the volume of the wire, which is measured by optical microscope. For detection of oscillation eigenfrequencies under ambient conditions, we designed and built a device for testing qPlus sensors.

MI 9.7 Wed 15:00 Poster B2

Detecting the Water Bridge Formation in Atomic Force Microscopy Using Dynamic Force Spectroscopy: Numerical Simulations and Experiments — •Mahfujur Rahaman[1], Raul D. Rodriguez[1], Lilibeth Leal[1], Alexander Villabona[1], Emmanuelle Lacaze[2], Jacques Jupille[2], and Dietrich R.T. Zahn[1] — [1]Semiconductor Physics, Chemnitz University of Technology, Chemnitz, Germany — [2]Institut des Nano-Sciences de Paris (INSP), Paris, France

Experimental analysis of force spectroscopy is a challenging issue due to the high non-linearity of the tip-sample interaction forces. In this work, numerical simulations are used in order to support experimental results in dynamic mode force spectroscopy obtained on hydrophilic-hydrophilic and hydrophilic-hydrophobic systems. Several tip-sample interaction forces such as long-range van der Waals force, short-range adhesive and repulsive forces are taken into account for simulating amplitude and phase vs. distance curves (APD). In addition to these forces, it is found that capillarity plays an important role in the AFM dynamics. The capillary force arises from the formation of water meniscus due to the liquid condensation between tip and sample under ambient conditions. In this contribution we propose that the attractive/repulsive transition in APD curves are affected by this capillary force. Numerical simulations are performed taking into account capillarity with exact simulated solutions for a meniscus at different relative humidity and tip-sample distances. A good agreement between our numerical model and the experimental results has been observed.

MI 9.8 Wed 15:00 Poster B2

Optimization of the differential conductance contrast in spin-polarized room-temperature scanning tunneling microscopy of e-fct Mn on Co/Cu(001) — •Jiaming Song, Chii-Bin Wu, and Wolfgang Kuch — Freie Universität Berlin, Fachbereich Physik, Institut für Experimentalphysik, Arnimallee 14, 14195 Berlin, Germany

Spin-polarized scanning tunneling microscopy is an effective technique to study the magnetic structure of magnetic surfaces at the nanoscale. We have used a ferromagnetic Fe-ring probe with in-plane spin sensitivity to record differential conductance maps from ultra-thin epitaxial antiferromagnetic Mn layers on Co/Cu(001) at room temperature. We observe a clear contrast between areas of different Mn thicknesses, which reverses as a function of bias voltage. To compare to dI/dV-V curves of the respective areas obtained at a certain bias voltage and constant tip height, one needs to take into account the effect of different bias voltages on the tip height in areas with different spectroscopic contrast. Correcting the dI/dV-V curves correspondingly using a simultaneously recorded I-V curve leads to a good agreement with the bias dependence of the contrast that is observed in constant-current scans of differential conductance maps. This can be used to quickly estimate the bias voltages at which a contrast reversal occurs, and to identify the conditions for maximum spectroscopic spin contrast. We demonstrate this for 4.6 monolayers (ML) antiferromagnetic e-fct Mn on 4.8 ML Co/Cu(001).

MI 9.9 Wed 15:00 Poster B2

Coupling Kelvin Probe Force Microscopy and Raman Spectroscopy — •Susanne Müller, Raul D. Rodriguez, Evgeniya Sheremet, Alexander Villabona, and Dietrich R.T. Zahn — Semiconductor Physics Group, Chemnitz University of Technology, 09126 Chemnitz, Germany

The Atomic Force Microscope (AFM) is currently one of the most used tools to investigate the topography of samples with nanometer resolution in three dimensions. However, the AFM lacks chemical sensitivity. Therefore, in order to simultaneously achieve chemical information, the AFM needs to be equipped with electrical or optical capabilities. The most prominent techniques in these fields are Kelvin probe force microscopy (KPFM) and tip-enhanced Raman spectroscopy (TERS). In this work we aim at combining these methods, with the goal of achieving high-resolution Raman, while scanning a surface in KPFM. We are able to fulfill this goal by investigating a test sample consisting of a thin organic film of manganese phthalocyanine deposited on a two dimensional array of silver coated polystyrene spheres. We found that strong interactions between the two methods take place and should be further investigated when KPFM and TERS are being used at the same time.

MI 9.10 Wed 15:00 Poster B2

Three-dimensional Scanning Near-field Optical Microscopy with Single Color Centers — •Thomas Oeckinghaus, Julia Tisler, Rainer Stöhr, Roman Kolesov, Rolf Reuter, Friedemann Reinhard, and Jörg Wrachtrup — 3. physikalisches Institut, Universität Stuttgart

We are using single color centers as a light source for apertureless scanning near-field optical microscopy. Specifically, we use a nanodiamond of a size below 20 nm, containing only a single nitrogen-vacancy color center (NV), which we attach to the tip of an AFM.

This technique offers the opportunity to investigate near-field effects between the NV and another object that only occur at a range below a few nanometers. For example, we were able to map the fluorescence quenching of the NV caused by a graphene monolayer in all three dimensions.

Beside these result, I will present our implementation of a technique to acquire three-dimensional fluorescence images from a single tapping-mode AFM scan. [Mangum et al., Nano Letters, 2009, 9]

MI 10: Scanning Probe Microscopy

Time: Thursday 9:30–11:15 Location: H5

MI 10.1 Thu 9:30 H5

Interaction Imaging with Amplitude-dependence Force Spectroscopy — •Daniel Platz[1], Daniel Forchheimer[1], Erik Tholén[2], and David Haviland[1] — [1]Royal Institute of Technology (KTH), Nanostructure Physics, Albanova University Center, SE-106 91 Stockholm, Sweden — [2]Intermodulation Products AB, Vasavägen 29, SE-169 58 Solna, Sweden

The ultimate goal in atomic force microscopy (AFM) is the combination of imaging with accurate force measurement. Dynamic AFM offers only qualitative information about the tip-surface interaction while imaging, because the sharp cantilever resonance efficiently filters out the high frequency components of the tip-surface. Traditional force measurements are based on slow, point-wise surface approaches and are incompatible with imaging. Here, we present a method called amplitude-dependence force spectroscopy (ADFS) that enables quantitative dynamic force reconstruction at every point of an AFM image, while scanning at normal speeds [1]. ADFS breaks with the paradigm of constant tip oscillation amplitude, as the oscillation amplitude is rapidly modulated at every image point. The measured response gives the amplitude-dependence of the Fourier component of the force at the resonant frequency, which allows for a model-free reconstruction of the tip-surface. We have made rigorous tests of ADS using numerical simulations and have used it for a detailed study of the mechanical properties of polymer surfaces.

[1] Platz et al., accepted for publication in Nature Communications

MI 10.2 Thu 9:45 H5

Adapting the Principle of Atomic Force Microscopy for Highly Resolved Measurements of Atmospheric Turbulence with the 2D-Atmospheric Laser Cantilever Anemometer — •Ingrid Neunaber, Jaroslaw Puczylowski, Joachim Peinke, and Michael Hölling — ForWind - Center for Wind Energy Research, Institute of Physics, University of Oldenburg, Germany

Using the principle of atomic force microscopy, we developed a sensor for characterization of atmospheric turbulent flow. As there are various applications in wind energy research and fundamental research, the demand for high resolving and reliable sensors is very high. With the 2D-Atmospheric Laser Cantilever Anemometer (2D-ALCA) we provide a sensor, which satisfies these requirements: The 2D-ALCA is capable of collecting data with sampling rates in the kHz-range, which allows for a spatial resolution in the millimeter range according to Taylor's hypothesis for typical atmospheric wind velocities of 10 m/s. Therefore the detection of very small turbulent structures is possible. The 2D-ALCA is a redesigned version of the successfully proofed 2D-LCA, an anemometer designed for laboratory use only. It is adapted to match the hostile operating environment off-shore. The 2D-ALCA is a drag force based sensor; the sensing element is a tiny microstructured cantilever made of stainless steel. When exposed to airflow it experiences a drag force and deflects. This deflection is detected by means of the laser pointer principle. Depending on the inflow direction the cantilever experiences two deformation modes (bending and twisting), thus enabling simultaneous measurements of 2 velocity components.

MI 10.3 Thu 10:00 H5

Chemical Resolution with nc-AFM in InSn Mixed Atomic Chains on Si(100) — Martin Setvín[1,2], Pingo Mutombo[1], •Martin Ondráček[1], Zsolt Majzik[1], Vladimír Cháb[1], Ivan Oštádal[2], Pavel Sobotík[2], and Pavel Jelínek[1] — [1]Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic — [2]Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic

Although scanning tunneling microscopy (STM) and atomic force microscopy (AFM) are very successful in probing atomic and electronic structure of surfaces, achieving chemical sensitivity at the atomic level is still a challenge. Sugimoto *et al.* [Nature **466**, 64 (2007)] demonstrated a method of single-atom chemical identification on a surface alloy of IV-group elements on Si(111) using a frequency modulation atomic force microscope (FM-AFM). In our present study, we combine room-temperature (RT) FM-AFM measurements with DFT simulations to explore atomic and chemical structure of heterogeneous atomic chains composed of III and IV-group atoms (In and Sn) grown on the Si(100) surface. These chains consist of dimers of either the same or different atomic species. We demonstrate that in contrast to STM, the FM-AFM technique is able to resolve individual atoms in such structures even at RT. We also show that chemical identification of single atoms is possible when the force-site spectroscopy is combined with DFT simulations. The unambiguous chemical identification could be achieved even though the force measured on top of a particular atom could strongly depend on the neighboring atoms in the chain.

15 min. break

MI 10.4 Thu 10:30 H5

Kelvin Probe Force Microscopy in Liquids — Anna Domanski, Esha Sengupta, Karin Bley, Stefan Weber, Maria Untch, Clemens Weiss, Katharina Landfester, Hans-Jürgen Butt, and •Rüdiger Berger — Max-Planck-Institut für Polymerforschung, Mainz, Ackermannweg 10, Germany

Thin organic films on metal surfaces lead to a significant shift in the electronic work function Φ of the metals. Typically ultraviolet photoelectron spectroscopy (UPS) is used to determine work functions of materials. UPS measurements require areas > 1 mm^2 and thus, variations on a nanometer scale cannot be investigated directly. Kelvin Probe Force Microscopy (KPFM) is a powerful tool to investigate local surface potential changes with high spatial resolution. Often ultrahigh vacuum conditions are required to keep surfaces clean. Here, we will discuss KPFM measurements in unipolar liquids and present an in-situ study of the self-assembly process of hexadecanethiols on gold in decane (1). As test structures, we prepared nanostructured Au surfaces by colloid monolayer lithography. Our study revealed a work function shift for hexadecanethiols on Au by -1.5 eV which is in excellent agreement with UPS data. The lowering of the work function is induced by the formation of an interfacial dipole layer which is directed towards the metal surface, i.e. the negative charges are positioned at the metal/sulfur interface and the positive charges to the decane interface. Our study shows that electrical methods such as KPFM benefit largely by performing measurements in liquids.

(1) A.L. Domanski et al., Langmuir 28 13892-13899 (2012)

MI 10.5 Thu 10:45 H5

k-space Imaging of the Eigenmodes on a Sharp Gold Taper for Near-field Scanning Optical Microscopy — •M. Esmann, B. B. da Cunha, S. F. Becker, J. H. Brauer, P. Gross, and C. Lienau — Carl von Ossietzky Universität, 26111 Oldenburg, Germany

Adiabatic nanofocusing of surface plasmon polaritons on tapered metallic waveguides bears great potential as a novel method for apertureless near-field scanning optical microscopy (NSOM) [1,2]. Plasmon polariton wavepackets are launched on a grating-coupler and ideally come to a complete halt at the taper apex where a single point-dipole like light source is formed. This however only holds for the lowest rotationally symmetric eigenmode of the taper [3]. Higher modes that are also excited on the coupler may disturb the imaging process as they radiate into the far field before reaching the taper end. Thus, they only contribute to background signals.

We have therefore developed and implemented a k-space imaging technique to analyze the different eigenmodes emitted from tapered metallic nanowaveguides. Higher order eigenmodes in the emission of adiabatically nanofocused plasmon polariton modes on ultrasharp gold tapers are identified and filtered. Our approch allows us to use the spatial symmetry of the re-radiated light as an indicator for the tip-sample coupling and presents a step forward towards background-free NSOM imaging with ultrahigh resolution.

[1] M. I. Stockman, Phys. Rev. Lett. **93**, 137404 (2004)
[2] S. Schmidt et al., ACS Nano **6**, 6040 (2012)
[3] J. C. Ashley et al., Surf. Science **41**, 615 (1974)

MI 10.6 Thu 11:00 H5

Confocal Raman Microscopy: True Surface and 3D Raman Imaging — Ute Schmidt, •Max Stadler, Thomas Dieing, and Olaf Hollricher — WITec GmbH, 89081 Ulm, Germany

Confocal microscopy has been used to reconstruct three-dimensional images of micro-objects by using a spatial pinhole to eliminate out-of focus light in specimens thicker than the focal plane. Raman spectroscopy on the other hand is used to unequivocally determine the chemical composition of a material. Confocal Raman microscopy combines the chemically sensitive Raman spectroscopy with high resolution confocal microscopy leading to chemical images with diffraction limited resolution. The discrimination of out of focus information used in confocal microscopy is particularly beneficial for confocal Raman imaging since it reduces the volume from which the Raman spectrum is collected. This leads to a diffraction limited resolution in chemical imaging of samples. However, the high confocality always results in high focus sensitivity. Therefore, Confocal Raman imaging of rough opaque samples was so far very challenging due to the inability to keep the samples in focus. The true surface confocal Raman imaging method combines confocal Raman imaging and optical profilometry. An integrated profilometer is used to acquire topographic scans of several square millimeters, similar to very large AFM topographic images. The coordinates of this large topographic image are used to trace the surface contours while acquiring the confocal Raman image. Therefore, topographic and diffraction limited Raman images of heavily inclined and rough samples can be obtained in one instrument.