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Overview of Invited Talks and Sessions

(Lecture rooms H5 and H26; Poster E)

Invited Talks

MI 1.1	Tue	9:30–10:15	H5	**Extending the frontiers of high-resolved measurements with a Field Emission Microprobe** — Silvia Richter, •Philippe Pinard
MI 2.1	Tue	11:15–12:00	H5	**Nanocharacterisation of the structural and luminescence properties of materials in the scanning electron microscope** — •Carol Trager-Cowan, G. Naresh-Kumar, N. Allehiani, S. Kraeusel, B. Hourahine, S. Vespucci, D. Thomson, E. Pascal, R. Johnston, M. Morrison, A. Alasmari, J. Bruckbauer, G. Kusch, P. R. Edwards, R. W. Martin, A. P. Day, A. Winkelmann, A. Vilalta-Clemente, A. J. Wilkinson, P. J. Parbrook, D. Maneuski, V. O'Shea, K. P. Mingard
MI 2.2	Tue	12:00–12:45	H5	**Highly spatially resolved cathodoluminescence of III-Nitride based nanostructures directly performed in a Scanning Transmission Electron Microscope at liquid He temperatures** — •Juergen Christen, Gordon Schmidt, Frank Bertram, Marcus Mueller, Peter Veit
MI 3.1	Wed	10:00–10:45	H5	**Laboratory-based X-ray microscopy - Technique and applications** — •Ehrenfried Zschech, Jürgen Gluch, Sven Niese, Kristina Kutukova, Qiong Li

Topical Talks

MI 1.3	Tue	10:30–11:00	H5	**Quantitative Röntgenmikroanalyse von alten indischen Goldmünzen** — •Peter-Michael Wilde

Sessions

MI 1.1–1.3	Tue	9:30–11:00	H5	**Electron Probe Microanalysis**
MI 2.1–2.4	Tue	11:15–13:15	H5	**Analytical Electron Microscopy: SEM and TEM-based Material Analysis**
MI 3.1–3.7	Wed	10:00–12:30	H5	**X-ray Imaging, Holography, Ptychography and Tomography**
MI 4.1–4.3	Wed	15:00–15:45	H5	**Helium and Neon Ion Microscopy for the Analysis and Structuring on the Nanoscale**
MI 5.1–5.3	Wed	16:00–16:45	H5	**Scanning Probe Microscopy**
MI 6.1–6.1	Wed	17:00–17:30	H5	**Special Talk: Solid State Characterisation with Positrons**
MI 7.1–7.10	Wed	18:00–20:00	Poster E	**Poster: Microanalysis and Microscopy**
MI 8.1–8.4	Thu	15:40–17:00	H26	**Crystallography in Materials Science (KR, DF, MI)**

Mitgliederversammlung des Fachverbandes Mikrosonden

Donnerstag 18:00–19:00 Raum H5

- Bericht des Fachverbandsvorsitzenden
- Planung der DPG-Tagung 2017 in Dresden
- Verschiedenes

MI 1: Electron Probe Microanalysis

Chair: Enrico Langer (TU Dresden)

Time: Tuesday 9:30–11:00 Location: H5

Invited Talk MI 1.1 Tue 9:30 H5

Extending the frontiers of high-resolved measurements with a Field Emission Microprobe — Silvia Richter and •Philippe Pinard — RWTH Aachen, Germany

Field emission (FE) electron microprobes have pushed the boundaries of electron probe microanalysis (EPMA) by offering new ways to characterize smaller features. As with conventional microprobes, analytical conditions should be properly selected for an accurate and precise quantification. The challenge is to optimize these parameters to obtain the best spatial resolution. Furthermore, instrumental parameters such as the focusing capability, beam stability and stage reproducibility, influence high resolution acquisitions. Carbon contamination has to be considered as well. Higher spatial resolution can be achieved by lowering the beam energy. But this can result in quantification problems of soft x-ray lines, i.e. Lα lines of the transition elements, where the electronic structure of the atoms and chemical bonding play a significant role in the generation and absorption of x-rays. Alternative solutions would be the use of Ll lines or using a small overvoltage ratio. Using the same overvoltage ratio for all measured x-ray lines requires a good reproducibility of the beam focus and -position, if the beam energy is changed. Defocus or shift effects can be corrected by a probe tracking function. However, changing the beam energy influences brightness and contrast of the images used for probe tracking which provides new challenges. Another possibility for achieving high spatial-resolved chemical information is the use of model-based reconstruction. The concept and first results will be presented.

MI 1.2 Tue 10:15 H5

EDS; Analysis of Nanoparticles — •Meiken Falke — Bruker Nano GmbH, Berlin, Germany

Fast chemical analysis from the mm to the atomic scale can be carried out using energy dispersive X-ray spectroscopy (EDS) in the electron microscope. A wide analysis region is the condition for chemically characterizing not only nanoparticles but also their surroundings and distribution. Examples of analysis approaches for different types of nanoparticles, including core-shell and bio-generated nanoparticles will be shown and used to explain the available technology for the analysis of bulk and electron transparent specimens.

Single EDS detectors in combination with aberration corrected STEM allow the routine characterization of nm-sized core-shell nanoparticles. Even single light atoms in a carbonatious substrate were identified (R. Stroud et al., M&M 2015).

Multiple detectors and annular detector arrangements ensure large collection angles and minimize shadowing and absorption effects. In STEM a high collection angle enables speed allowing the investigation of beam sensitive samples or 3D analysis. In SEM high topography bulk specimens can be investigated fast and sometimes in a close to natural state, e.g. nano-clay particles, embedded in a porous polymer matrix.

TEM-specimens were investigated in an SEM as well. Different nanoparticle types and their distribution over large areas were statistically evaluated using the T-SEM approach (D-V. Hodoraba et al., IOP Conf. Ser. MSE, EMAS 2015, in press).

Topical Talk MI 1.3 Tue 10:30 H5

Quantitative Röntgenmikroanalyse von alten indischen Goldmünzen — •Peter-Michael Wilde — Zentralinstitut für anorganische Chemie, Berlin

Zu Zeiten der Herrschaft der Mogule in Indien des 17. Jahrhunderts wurde eine größere Anzahl von Goldmünzen geprägt. Ein besonders wertvoller Schatz ist eine Serie von zwölf Münzen mit den Motiven der bekannten Tierkreiszeichen. Die persische Schrift auf der Rückseite nennt den Namen des Moguls Jahangir, der vor 400 Jahren herrschte. Für die Bestimmung der chemischen Zusammensetzung wurden oberflächennahe Bereiche dieser Münzen mit EDX quantitativ analysiert. Es zeigte sich, dass die Goldgehalte der einzelnen Münzen unterschiedlich sind. Sie betragen zwischen 96 und 99 Masseprozent. Als zusätzliches Element wurde Silber nachgewiesen.

MI 2: Analytical Electron Microscopy: SEM and TEM-based Material Analysis

Chair: Hartmut S. Leipner (Martin-Luther-Universität Halle-Wittenberg)

Time: Tuesday 11:15–13:15 Location: H5

Invited Talk MI 2.1 Tue 11:15 H5

Nanocharacterisation of the structural and luminescence properties of materials in the scanning electron microscope — •Carol Trager-Cowan[1], G. Naresh-Kumar[1], N. Allehiani[1], S. Kraeusel[1], B. Hourahine[1], S. Vespucci[1], D. Thomson[1], E. Pascal[1], R. Johnston[1], M. Morrison[1], A. Alasmari[1], J. Bruckbauer[1], G. Kusch[1], P. R. Edwards[1], R. W. Martin[1], A. P. Day[2], A. Winkelmann[3], A. Vilalta-Clemente[4], A. J. Wilkinson[4], P. J. Parbrook[5], D. Maneuski[6], V. O'Shea[6], and K. P. Mingard[7] — [1]Dept of Physics, SUPA, University of Strathclyde, Glasgow G4 0NG, UK — [2]Aunt Daisy Scientific Ltd, Claremont House, High St, Lydney, Gloucestershire, GL15 5DX, UK — [3]Bruker Nano GmbH, Am Studio 2D, 12489 Berlin, Germany — [4]Department of Materials, University of Oxford, Oxford OX1 3PH, UK — [5]Tyndall National Institute, University College Cork, Lee Maltings, Cork, Ireland — [6]School of Physics and Astronomy, SUPA, University of Glasgow, Glasgow, G12 8QQ, UK — [7]National Physical Laboratory, Teddington, Middlesex, TW11 0LW, UK

The performance requirements for next-generation materials, with applications spanning the aerospace, automotive, oil and gas, electronics and lighting industries, demand pioneering manufacturing techniques combined with innovative characterisation tools. The structural properties of materials play a vital role in the performance of critical components and it is important to understand such properties down to the sub-micron scale. For example high temperature operation of gas turbines is affected by the crystal orientation of the nickel-based single-crystal super alloys from which they are made; the optical efficiency and lifetime of UV LEDs is strongly dependent on the type and density of structural defects such as dislocations present in AlGaN thin films.

The novel scanning electron microscopy techniques of electron backscatter diffraction (EBSD); electron channelling contrast imaging (ECCI) and hyperspectral cathodoluminescence imaging (CL) can provide complementary information on the structural and luminescence properties of materials rapidly and non-destructively with a spatial resolution of tens of nanometres. EBSD provides orientation, phase and strain analysis, whilst ECCI is used to determine the planar distribution of extended structural defects such as threading dislocations and stacking faults over a large area of a given sample. CL provides information on the influence of crystallographic defects on light emission, either specific defect-related luminescence or dark spot features where carrier recombination at defects is non-radiative. CL can also provide information on the composition of alloy thin films used in the manufacture of light emitting devices, e.g., the AlN content in AlGaN thin films.

In this talk I will describe the EBSD, ECCI and CL techniques and give some examples of their application to real material problems. In particular I will illustrate the advantages of acquiring coincident EBSD/ECCI/CL data to the understanding of nitride semiconductor structures. For example electron channelling contrast images and hyperspectral CL intensity maps of the UV emission from approximately the same region of a $Al_{0.8}Ga_{0.2}N$:Si thin film were shown. The presence of dislocations (black-white spots), revealed by ECCI, lead to a reduction in the luminescence. In particular dislocations with a screw component appear as dark spots in the CL image.

I will also describe how advances in instrumentation, e.g., digital direct electron imaging detectors, can provide exciting opportunities for new applications for these techniques.

Invited Talk MI 2.2 Tue 12:00 H5

Highly spatially resolved cathodoluminescence of III-Nitride based nanostructures directly performed in a Scanning Transmission Electron Microscope at liquid He temperatures — •Juergen Christen, Gordon Schmidt, Frank Bertram, Marcus Mueller, and Peter Veit — Otto-von-Guericke-Universität Magdeburg, Germany

For a detailed understanding of complex semiconductor heterostructures and the physics of devices based on them, a systematic determination and correlation of the structural, chemical, electronic, and optical properties on a nanometer scale is essential. Luminescence techniques belong to the most sensitive, non-destructive methods of semiconductor research. The combination of luminescence spectroscopy - in particular at liquid He temperatures - with the high spatial resolution of a scanning transmission electron microscope (STEM) (dx $<$ 1 nm at RT, dx $<$ 5 nm at 10 K), as realized by the technique of low temperature scanning transmission electron microscopy cathodoluminescence microscopy (STEM-CL), provides a unique, extremely powerful tool for the optical nano-characterization of semiconductors, their heterostructures as well as their interfaces. Typical results, which will be presented, include nm-scale correlation of the optical properties with the crystalline real structure of GaN/AlN quantum dots. In particular, we will show the preferential nucleation of GaN/AlN quantum dots at threading dislocation without inhibition of very sharp emission lines with line width below 0.5 meV.

MI 2.3 Tue 12:45 H5

Quantifying the magnetism of individual nanomagnets: EMCD on FePt nanoparticles — •Sebastian Schneider[1,2], Darius Pohl[1], Stefan Löffler[3], Deepa Kasinathan[5], Jan Rusz[6], Peter Schattschneider[3,4], Schultz Ludwig[1,2], and Bernd Rellinghaus[1] — [1]IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany — [2]TU Dresden, Institut fur Festkörperphysik, D-01062 Dresden, Germany — [3]Vienna University of Technology, USTEM, A-1040 Vienna, Austria — [4]Vienna University of Technology, Institute of Solid State Physics, A-1040 Vienna, Austria — [5]Max-Planck Institute for Chemical Physics of Solids, D-01187 Dresden, Germany — [6]Uppsala University, S-75105 Uppsala, Sweden

Electron magnetic chiral dichroism (EMCD) is the electron wave analogue of X-ray magnetic circular dichroism (XMCD). It offers the possibility to study magnetic properties at the nanoscale in a transmission electron microscope (TEM). In a 'classical' EMCD setup, the sample is illuminated with an electron plane wave and acts as a beam splitter. Although it is meanwhile established that EMCD allows for the measurement of magnetic dichroism, only few examples are available that present quantitative results. We report on EMCD measurements on individual FePt nanoparticles with a thickness of roughly 10 nm and compare our experimental findings with simulations. From the experimental spectra, a ratio of angular to spin magnetic moment $m_l/m_s = 0.084 \pm 0.076$ is for the first time quantitatively derived for individual FePt nanoparticles.

MI 2.4 Tue 13:00 H5

Ein Experimenteller Standpunkt zur Informationstiefe von EBSD — •Wolfgang Wisniewski — Otto-Schott-Institut Jena

Bisher beruht die weit verbreitete Auffassung bezüglich der Informationstiefe von EBSD auf einer Abschätzung der Bandbreite und Simulationen bei denen nur Elektronen mit einem Energieverlust von ca. 4% oder weniger berücksichtigt wurden. Dieser Beitrag liefert eine kritische Diskussion der bestehenden Literatur, experimentelle Ansätze sowie erste Ergebnisse die darauf hin deuten, dass die Informationstiefe von EBSD mehr als doppelt so tief reicht als bisher angenommen.

MI 3: X-ray Imaging, Holography, Ptychography and Tomography

Time: Wednesday 10:00–12:30 Location: H5

Invited Talk MI 3.1 Wed 10:00 H5

Laboratory-based X-ray microscopy - Technique and applications — •Ehrenfried Zschech, Jürgen Gluch, Sven Niese, Kristina Kutukova, and Qiong Li — Fraunhofer IKTS Dresden, Germany

High-resolution nondestructive characterization of materials and structures, including kinetic processes in materials, is a highly ranked request from basic research (e. g. in materials science and nanotechnology). Due to the particular properties of X-rays, i. e. high penetration of matter and good material contrast in absorption, high resolution X-ray imaging is a versatile tool for nondestructive 3D bulk analysis of materials and for the investigation of complex 3D structures. Novel focusing lenses, so-called multilayer Laue lenses, have the potential to bring hard X-ray microscopy (high photon energy) at high efficiencies to resolutions down to the 10 nm range and below.

Examples for materials development supported by high-resolution X-ray imaging and analysis will be shown, including studies of kinetic processes in materials: Physical failure analysis in 3D-stacked microchips, kinetic reactions for energy storage and conversion processes, crack initiation and propagation in microchips and composites. Eventually, the application to biological objects (cells, pollen grains) will be demonstrated.

MI 3.2 Wed 10:45 H5

Scanning X-Ray Microscopy of Superconductor/Ferromagnet Bilayers — •Claudia Stahl[1], Stephen Ruoss[1], Markus Weigand[1], Patrick Zahn[1,2], Jonas Bayer[1,2], Gisela Schütz[1], and Joachim Albrecht[2] — [1]Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany — [2]Research Institute for Innovative Surfaces, FINO, Aalen University, Beethovenstr. 1, 73430 Aalen, Germany

The magnetic flux distribution arising from a high-T_c superconductor is detected and visualized with high spatial resolution using scanning x-ray microscopy (SXM). Therefore, we introduce a sensor layer, namely, an amorphous, soft-magnetic CoFeB cover layer [1]. The magnetic stray fields of the supercurrents lead to a local reorientation of the magnetic moments in the ferromagnet, which is visualized using the large x-ray magnetic circular dichroism (XMCD) effect of the Co and Fe L3-edge.

We show that the XMCD contrast in the sensor layer corresponds to the in-plane magnetic flux distribution of the superconductor [2] and can hence be used to image magnetic structures in superconductors with high spatial resolution [3,4]. Using the total electron yield (TEY) mode the surface structure and the magnetic domains can be imaged simultaneously and can be correlated.

The measurements are carried out at our scanning x-ray microscope MAXYMUS at Bessy II, Berlin with the new low temperature setup.

[1] C. Stahl et al., EPL 106, 27002 (2014). [2] C. Stahl et al., PRB 90, 104515 (2014). [3] S. Ruoß et al., APL 106, 022601 (2015). [4] C. Stahl et al., Journ. of Appl. Phy. 117, 17D109 (2015).

MI 3.3 Wed 11:00 H5

Efficiency simulation and measurements for MZP hard X-ray nanofocusing and imaging — •Jakob Soltau[1], Christian Eberl[2], Tim Salditt[1], Hans-Ulrich Krebs[2], and Markus Osterhoff[1] — [1]Röntgenphysik, Uni-Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen — [2]Materialphysik, Uni-Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen

Latest developments in fabrication and inspection technologies have enabled the manufacturing of multilayer zone plates (MZP) with high aspect ratio using pulsed laser deposition [1]. This allows sub-5 nm focusing of hard X-rays in two dimensions and enabling photonic imaging on a nanometer scale. To improve the efficiency of zone plates, we investigated the propagation of the electromagnetic wave field inside and behind the MZP with two different simulation methods. The results are compared with the latest measurements of a 2D-MZP with an outermost zone width of only 5 nm used at the synchrotron source at DESY. The simulation methods we used are: a multi slice propagation according to Huygens, which can handle almost any geometry with only few artefacts and a finite difference simulation which has already stated its capabilities in the waveguide development [2]. The central challenge in the development of hard X-ray nanofocusing MZPs is the fulfilling of the Bragg condition across the zone plate. To achieve this, the zones are tilted. The tilting was a central point in our investigations. It was also studied with the MZP used in our latest experiments

carried out at DESY. [1] Eberl, C. et al. Appl. Surf. Sci. 307 (2014) [2] Salditt, T. et al. Phys. Rev. Lett. 115, 203902 (2015)

MI 3.4 Wed 11:15 H5

Multi plane probe retrieval in X-ray nearfield imaging — •Johannes Hagemann and Tim Salditt — Institut für Röntgenphysik, GAU Göttingen, Deutschland

The probe, i.e. the impinging X-ray beam on the sample, is the main actor in X-ray imaging experiments when it comes to image quality. We characterized the probe of the GINIX-Setup at P10(DESY) using a multiple detection plane scheme. With that we can determine beam parameters as for example the size of the focus. We could also directly study the influence of different slit settings on the focus. We can compare the results with another approach called longitudinal nearfield ptychography.

Coffee break (15 min)

MI 3.5 Wed 11:45 H5

Holography-guided ptychography with soft X-rays — •Piet Hessing[1], Bastian Pfau[3], Erik Guehrs[2], Michael Schneider[2], Laura Shemilt[2], Jan Geilhufe[1], and Stefan Eisebitt[1] — [1]Max-Born-Institut, Berlin, Germany — [2]TU Berlin, Berlin, Germany — [3]Lund University, Lund, Sweden

We present a novel combination of two coherent imaging methods, namely holography [1,2] and ptychography [3,4] for imaging nanoscale objects using soft X-rays. Ptychography as a scanning imaging method relies on the exact knowledge (or post-experimental retrieval) of the position of the X-ray illumination on the sample during scanning. Our method combination allows to directly encode the scan positions in the diffraction pattern without the need of accurate position encoders. We demonstrate that holographically encoded positions significantly reduce the experimental and numerical requirements. Our ptychographic reconstructions cover a large field of view with diffraction-limited resolution and high sensitivity in the reconstructed phase shift and absorption of the objects.

[1] S. Eisebitt et al., Nature 432, 885 (2004). [2] B. Pfau and S. Eisebitt, X-ray holography, in: Synchrotron Light Sources and Free-Electron lasers (Springer, 2015). [3] K. Giewekemeyer et al., Opt. Express 19, 1037 (2011). [4] M. Rose et al., J. Synchrotron Rad. 22, 819 (2015).

MI 3.6 Wed 12:00 H5

Polarization contrast of nanoscale waveguides studied by coherent diffractive imaging with high-harmonic source — •Sergey Zayko, Murat Sivis, Sascha Schäfer, and Claus Ropers — 4th Physical Institute - Solids and Nanostructures, University of Göttingen, 37077 Göttingen

Recently proposed high harmonic generation (HHG) schemes offer novel means of control over the polarization state of the emitted radiation, enabling ultrafast table-top implementations of polarization-dependent spectroscopy, such as circular dichroism [1-4]. Here, we present a novel approach to analyze and control the polarization state in the case of extreme ultraviolet radiation via nanoscale waveguides. Using coherent diffractive imaging (CDI), we experimentally study the propagation of high harmonics through nanoscale slab waveguides with optically dense cladding materials and find a strong dependence of the waveguide transmission on the incident light polarization [5]. Employing such waveguides, we demonstrate a novel type of high harmonic polarizer and design a scheme to analyze the polarization state of extreme ultraviolet radiation by means of single image acquisition. Our results on polarization sensitive CDI highlight the potential of HHG sources for ultrafast magnetic imaging.

[1] O. Kfir *et al.*, Nature Photonics 9, 99-105 (2015).
[2] G. Lambert *et al.*, Nature Communications 6, 6167 (2015).
[3] A. Ferré *et al.*, Nature Photonics 9, 93-98 (2015).
[4] D. Hickstein *et al.*„ Nature Photonics 9, 743-750 (2015).
[5] S. Zayko *et al.*, Optics Express 23, 19911-19921 (2015).

MI 3.7 Wed 12:15 H5

Phase-Contrast Tomography with Anisotropic X-Ray Sources — •Malte Vassholz and Tim Salditt — Institute for X-Ray Physics, University of Göttingen, Göttingen, Germany

Nanoscale x-ray tomography is an important method for analysing hard and soft matter. However, high-resolution tomography requires high brilliance x-ray probes with small source sizes in both lateral dimensions and is therefore carried out at synchrotrons. The minimum focal spot size at laboratory x-ray sources is highly limited by insufficient photon flux, whereas anisotropic one-dimensional focusing provides significantly more flux. The central challenge is to get isotropic resolution from anisotropic x-ray probes. Towards the goal of nanoscale resolution at laboratory x-ray sources we have designed a new tomographical data-acquisition scheme with two-dimensional angular sampling and advanced reconstruction methods based on the three-dimensional Radon transform, compatible with anisotropic x-ray probes. Furthermore, we have tested the applicability of propagation-based phase contrast with the novel tomography setup.

MI 4: Helium and Neon Ion Microscopy for the Analysis and Structuring on the Nanoscale

Time: Wednesday 15:00–15:45 Location: H5

MI 4.1 Wed 15:00 H5

Nanometer scale elemental analysis in the helium ion microscope using time of flight spectrometry — •Nico Klingner[1], René Heller[1], Gregor Hlawacek[1], Johannes von Borany[1], John Notte[2], Jason Huang[2], and Stefan Fascko[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Ion Microscopy Innovation Center at Carl Zeiss Microscopy LLC, Peabody, USA

Helium ion microscopes (HIM) have become powerful imaging devices within the last decade. Their enormous lateral resolution of below 0.3 nm and the highest field of depth make them a unique tool in surface imaging. Up to now there are only limited possibilities for elemental analysis. Therefore we successfully implemented time of flight backscattering spectrometry (ToF-BS) into the HIM. Its integration introduces the ability to perform laterally resolved elemental analysis as well as elemental depth profiling on the nm scale. A lateral resolution of $\leq$ 54 nm and a time resolution of $\Delta t \leq 17$ ns ($\Delta t/t = 5.4\%$) are achieved. In addition laterally resolved time of flight secondary ion mass spectrometry (ToF-SIMS) can be performed with the same setup. Time of flight is implemented by pulsing the primary ion beam. This is achieved in a cost effective and minimal invasive way that does not influence the high resolution capabilities of the microscope when operating in standard secondary electron imaging mode. This technique can thus be easily adapted to existing devices. The particular implementation of ToF-BS and ToF-SIMS techniques are described, results are presented and advantages, challenges and limitations of this new techniques are discussed.

MI 4.2 Wed 15:15 H5

A Secondary Ion Mass Spectrometry (SIMS) add-on for Helium and Neon Ion Microscopy — David Dowsett, •Florian Vollnhals, Jean-Nicolas Audinot, and Tom Wirtz — Advanced Instrumentation for Ion Nano-Analytics (AINA), MRT Department, Luxembourg Institute of Science and Technology (LIST), 41 rue du Brill, L-4422 Belvaux, Luxembourg

Helium Ion Microscopy (HIM) was introduced a few years ago as an imaging tool with a lateral resolution below 1 nm. The addition of Neon as a working gas in the Orion NanoFab (Zeiss) has opened up new possibilities in high resolution nano-machining and FIB.

In contrast to electron microscopy, there are currently no analytical tools available on the HIM. Energy Dispersive X-Ray Spectroscopy (EDX), the most common technique in electron microscopy, is not applicable using ion radiation. In order to add analytical functionality, we combine the HIM with Secondary Ion Mass Spectrometry (SIMS). The sample is sputtered by the focused He or Ne primary ion beam while the secondary ion emission is recorded by a purpose developed spectrometer. This combination takes advantage of both the small probe size of the He/Ne beam as well as the sensitivity of SIMS analysis.

We will present our progress in instrumental and method development as well as data obtained on the prototype system [1]. He and

Ne ion beams will be shown to be viable primary species for successful SIMS, approaching the physical resolution limits of <20 nm [2].

[1] D. Dowsett et al., J. Vac. Sci. Technol. B 30 (2012), 06F602
[2] T. Wirtz et al., Nanotechnology 26 (2015), 434001

MI 4.3 Wed 15:30 H5

Writing nanoscale magnets with neon using a gas field ion source microscope — •Gregor Hlawacek[1], Anna Semisalova[1], Falk Röder[2], Sebastian Wintz[1], René Hübner[1], Lothar Bischoff[1], Hannes Lichte[2], Kay Potzger[1], Jürgen Lindner[1], Jürgen Fassbender[1], and Rantej Bali[1] — [1]Ion Beam Physics and Materials Research, Helmholz—Zentrum Dresden – Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Triebenberg Labor, Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden, Germany

Gas field ion source (GFIS) based microscopy—historically called Helium Ion Microscopy (HIM)—provides the unique ability to structure material on the nano-scale using an ion beam with a diameter of less than 5 Å. Usually high fluences of the relatively light noble gases are needed to change the shape, or induce property changes in the target structure. Here, we present a method that allows to create arbitrary shaped magnets in a $Fe_{60}Al_{40}$ alloy using fluences of only a few neon ions per square nanometer. Using neon chemical disorder can be introduced into the paramagnetic B2 phase of the alloy. The increase in Fe–Fe nearest neighbors results in a switch to ferromagnetism in the irradiated area. We will discuss the achievable minimal size (<50 nm) and the in–depth thickness of the magnets (15 nm–60 nm). X-rays, TEM and MFM have been used for characterization.

[1] G. Hlawacek et al., J. Vac. Sci. Technol. B, 32(2):020801, 2014. [2] F. Röder et al., Sci. Rep., 5:16786, 2015. [3] R. Bali et al. Nano Lett., 14(2):435, 2014.

MI 5: Scanning Probe Microscopy

Time: Wednesday 16:00–16:45 Location: H5

MI 5.1 Wed 16:00 H5

Contrast of nonlinear response in atomic force microscopy — •Daniel Forchheimer[1,2], Robert Forchheimer[3], and David Haviland[1] — [1]Royal Institute of Technology (KTH), Stockholm, Sweden — [2]Intermodulation Products AB, Segersta, Sweden — [3]Linköping University, Linköping, Sweden

A trend in Atomic Force Microscopy (AFM) is towards obtaining more information without increasing the measurement time. This can be achieved by driving the AFM cantilever at multiple frequencies simultaneously, so-called multifrequency AFM. Such drive schemes creates motion not only at the driven frequencies but also at harmonics and mixing frequencies, due to the nonlinear behavior of the force between the tip and the surface with respect to their separation. Although these nonlinear frequency components are weaker by at least an order of magnitude compared to the amplitude at the drive frequencies, we show that they provide excellent contrast when imaging heterogenous materials such as a polymer blend. Multifrequency AFM data also warrants new methods of analysis. We demonstrate how algorithms from the field of machine learning can be used to improve the contrast of images or blindly cluster data of different regions into specific groups.

Reference: D. Forchheimer, R. Forchheimer, D. B. Haviland, Nature Communications, 6, 6270 (2015).

MI 5.2 Wed 16:15 H5

Liquid helium free scanning probe microscope working at below 10 K — •Byoung Choi — RHK Technology, Troy Michigan, USA

We developed a closed cycle cryostat base low temperature scanning probe microscope (LT-SPM) that works below 10 K without consuming any liquid cryogen. The basic performance of the microscope was validated in various conditions such as noisy environment and modulated temperature in a sub-atomic scale. The state-of-the-art technique allows the extended time elapsed measurements such as week-long investigation of surface dynamics at low temperature without interrupting the critical moment of the tip while refilling the conventional cryogen tanks. The compact, rigid design of the microscope also allows the study in a variable temperature without the hassle of liquid cryogen consumption. We will presents the time evolution of the surface states at various temperatures between 10 K and 350 K on the 2D electron substrates such as Bi_2Se_3, Bi_2Te_3 and $TiSe_2$. In the end, we will discuss how the cryogen free LT-SPM can open the new capabilities to surface scientists and researchers in nanotechnology in terms of the economical and practical reason.

MI 5.3 Wed 16:30 H5

Fast-scanning and quantitative-imaging atomic force microscopy (AFM) combined with advanced optical techniques — •Elmar Hartmann, Dimitar R. Stamov, and Torsten Jähnke — JPK Instruments AG, Berlin, Germany

AFM is well known as a multi-purpose and meanwhile indispensable tool for high-resolution studies under natural conditions. Recent tip-scanning AFM developments deliver now insight into the dynamics of macromolecular systems, while simultaneously offering a seamless integration capability with advanced optical techniques.

Collagen type I attracted a lot of attention, due to its large interactome, hierarchical structural and mechanical stability. This study is devoted to non-invasively monitor the kinetics of collagen fibrillogenesis by modifying environmental conditions. We show that fast AFM imaging can successfully be applied to understand the real-time kinetics of collagen I and the fibrillar nanomatrix formation with high spatial and temporal resolution [1].

The newly gained capability of higher imaging velocity has also been used to directly study living fibroblast cells. Here, the dynamics of individual membrane structures of a single cell is investigated with AFM, while simultaneously observing the same cell in the optical phase contrast image and DirectOverlay^{TM} technique. Super-resolution (dSTORM and STED) have been combined with AFM when operated in the Quantitative Imaging (QI^{TM}) mode that is based on fast force-distance curves to demonstrate close relationship of cellular structures and nano-mechanical properties.

[1] Stamov et al., Ultramicroscopy, 149, 86 (2015).

MI 6: Special Talk: Solid State Characterisation with Positrons

Die Positronenannihilation hat sich als Methode zur Untersuchung der Realstruktur von kristallinen Festkörpern bewährt. Positronen, die in Strukturdefekten eingefangen werden (Leerstellen, Leerstellencluster, Versetzungen, Ausscheidungen und Korngrenzen) ändern ihre Annihilationsparameter, so dass Aussagen zur Art, Dichte sowie Morphologie der Defekte getroffen werden können.

Time: Wednesday 17:00–17:30 Location: H5

MI 6.1 Wed 17:00 H5

Micro Structural Changes in Welded AlCuLi-Alloys by Positron Annihilation Spectroscopy, SAXS and DSC — Danny Petschke, Waldemar Klauser, and •Torsten E.M. Staab — Universität Würzburg, Fakultät Chemie, LCTM, Röntgenring 11, D-97070 Würzburg

When welding sheets of aluminium alloys, size and density of hardening precipitates are influenced by the heat input created during the process. This can result in total dissolution of the alloying elements

and formation of new precipitates. Further, it can have significant effects on the strength of welded sheet at the weld line and in the heat affected zone. We investigate changes in the micro structure at different distances from the weld nugget occurring due to the created heat by different methods: Small Angle X-ray Scattering (SAXS), giving information on size and density of precipitates, Differential Scanning Calorimetry (DSC), giving information on formed precipitates by their dissolution signal, and positron annihilation spectroscopy, being sensitive to vacancies and dislocations but also to the morphology of precipitates. We start by characterizing the base material as a reference and proceed via the heat affected zone to the weld nugget for laser welded and friction-stir welded AlCuLi-alloys (AA2198). By the use of complementary methods we obtain information on structure, kind and distribution of precipitates and correlated this with hardness measurements.

MI 7: Poster: Microanalysis and Microscopy

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

Time: Wednesday 18:00–20:00 Location: Poster E

MI 7.1 Wed 18:00 Poster E

Micro-XRF studies on the colour brilliance in ancient wool carpets — •Andreas Späth[1], Markus Meyer[1], Camelia Borca[2], Karl Messlinger[3], Manfred Bieber[4], and Rainer H. Fink[1] — [1]FAU Erlangen-Nürnberg, Physical Chemistry II & Interdisciplinary Center for Molecular Materials (ICMM), Erlangen, Germany — [2]Swiss Light Source (SLS), Paul Scherrer Institute, Villigen, Switzerland — [3]FAU Erlangen-Nürnberg, Physiology and Pathophysiology, Erlangen, Germany — [4]Ex Oriente, Waldbrunn, Germany

Chemical colouring of natural fibers is one of the oldest crafts in mankind and still a highly relevant market. Experimental archaeologists revived an ancient Anatolian dyeing method based on previous fermentation of the wool fibers resulting in remarkable colour brilliance and persistence. Mordants used during the bating process are typically potassium alum or iron(II)sulfate. Electron microscopic studies show morphological changes of the fibers due to fermentation, suggesting an easier and deeper penetration of mordants into the hair fiber. We present micro-XRF studies on cross-sections of such prepared recent wool fibers and regional carpet fibers from the 18th century showing the distribution of mordant metals. A comparison with undyed fibers proves a significantly increased metal content also in the central region of the recently fermented and ancient wool fibers. These findings provide a conclusive explanation for persistent colour brilliance and prove the suggested crafting of the ancient specimen. Further studies focus on the oxidation state of the Fe mordant to clarify the typically strong modification of dye colour that is not apparent for redox-inactive Al.

MI 7.2 Wed 18:00 Poster E

The estimation of thickness and composition of thin films using EDX — •Steffen Schulze[1], Sandra Hahn[2], Wolfgang Baumann[3], and Hans-Jörg Hunger[3] — [1]TU Chemnitz, Physik, Analytik an Festkörperoberflächen — [2]TU Chemnitz, Maschinenbau, Werkstoffwissenschaft — [3]TU Karl-Marx-Stadt, Physik/EB

EDX is capable of estimating thickness and composition of thin films on substrates in the 10 nm range. The intensity ratio of X-rays from the coating to that of the substrate depends sensitively on film thickness. For taking into account the alterations of X-ray generation by substrate backscattering and of the absorption in the coating the depth distribution function of X-ray production as given by Packwood and Brown [1] has been slightly modified to take account of the thin film situation. Examples are given demonstrating successfull quantification and thickness determination by use of the according correction procedures.

[1] Packwood, Brown: X-ray spectroscopy, Vol. 10, 3 (1981).

MI 7.3 Wed 18:00 Poster E

Generation of electron vortex beams and OAM selection using aberration-corrected probes for local EMCD measurements — Darius Pohl[1], •Sebastian Schneider[1,2], Pascal Gerhards[1,2], Jan Rusz[3], Jakob Spiegelberg[3], Peter Tiemeijer[4], and Bernd Rellinghaus[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]TU Dresden, Institute for Solid State Physics, D-01062 Dresden, Germany — [3]Uppsala University, Department of Physics and Astronomy, SE-752 37 Uppsala, Sweden — [4]FEI Company, PO Box 8066, 5600 KA Eindhoven, The Netherlands

Electron vortex beams (EVBs) carry a discrete orbital angular momentum (OAM), L, and are predicted to reveal magnetic dichroic in electron energy loss spectra upon interacting with magnetic samples. Since electron beams can be easily focused down to sub-nanometer diameters, this novel technique provides the possibility to quantitatively determine local magnetic properties with unrivalled lateral resolution. The generation of EVBs in the double aberration-corrected FEI Titan^3 80-300 transmission electron microscope (TEM) is achieved by the implementation of spiral and dislocation-type apertures into the condenser lens system. The setup allows for scanning TEM investigations (STEM) with EVBs, whose OAM is selected by means of an additional discriminator aperture. New FIB cutting strategies facilitate the production for 50 μm wide and 1 μm thick high quality vortex apertures. The status quo of both experiments and simulations of the interaction of the EVB with $L1_0$-FePt nanomagnets will be presented.

MI 7.4 Wed 18:00 Poster E

Nanostructures from electron beam assisted decomposition of gold nitrates — •Daniel Zink, Torsten Henning, and Peter J. Klar — Justus-Liebig-Universität Gießen, I. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen

To produce elemental gold in defined structures on substrates is of interest for a wide range of applications. It may be useful for optical and electrical devices, plasmonic structures or gold nanoparticles. The electron beam assisted decomposition of $(NO_2)[Au(NO_3)_4]$ and $(NO)[Au(NO_3)_4]$ has advantages compared with common methods for depositing gold nanostructures (including MOCVD or organic resists as PMMA) such as avoiding carbon contamination. The decomposition of gold precursor takes place by interaction with the electron beam. As in conventional e-beam lithography proximity effects need to be controlled in order to optimize the lateral resolution. We will present some first experiments using this novel method.

MI 7.5 Wed 18:00 Poster E

First results of ptychographic imaging at MAXYMUS X-ray microscope — •Iuliia Bykova, Markus Weigand, Michael Bechtel, Joachim Gräfe, Eberhard Goering, and Gisela Schütz — Max-Planck-Institut für Intelligente Systeme, Heisenbergstraße 3, 70569 Stuttgart, Germany

Ptychography is a recently established and actively developing technique for producing highly resolved images. This method is a combination of x-ray diffraction imaging with scanning microscopy which aids to visualize objects with spatial resolution not limited by the properties of the used optics. MAXYMUS is an Ultra-High Vacuum Scanning Transmission X-ray Microscope (STXM) operated by the MPI for Intelligent Systems at the Bessy II synchrotron (Berlin, Germany). The feasibility of high brightness and selectable polarization measurements make it a unique tool for studying magnetic materials in an element specific manner. To allow high resolution ptychographic imaging MAXYMUS was upgraded with a new fast in-vacuum CCD camera with high readout speed up to 450 Hz, quantum efficiency >70% (for E>300 eV) and RMS noise per pixel less than 3e-. We will present the results of commissioning of the new in-vacuum CCD camera and the implementation of ptychographic imaging at MAXYMUS. We will show the first ptychographic reconstructions made at MAXYMUS which have significant advantage in resolution over images done using conventional STXM methods.

MI 7.6 Wed 18:00 Poster E

Ultra-narrow germanium-slits for laboratory and synchrotron x-ray applications — •F. Döring, S. Hoffmann, M. Kanbach, and Tim Salditt — Institute for X-Ray Physics, University of Göttingen

Modern nano-beam x-ray diffraction and imaging applications rely on

precise optical elements for beam focusing and shaping. We have recently developed x-ray waveguide optics to deliver coherence and wavefront filtered beams confined down to below 20 nm. While these optics are well suited for coherent imaging applications with synchrotron radiation, the transmission is too low for laboratory applications. Here we investigate the transition from a x-ray waveguide to a nanoscale slit suitable for laboratory and synchrotron applications in a setting of low and medium brilliance. Therefore, we aim at a larger angular acceptance of the beam, requiring a smaller optical thickness so that the mode structure is not yet fully developed, while the absorption must be sufficiently high. So, we replace silicon by germanium and adapt the processes of silicon based waveguide fabrication to germanium slit production. We use a lithographic manufacturing process at 400 nm in combination with reactive ion etching (RIE) and germanium wafer bonding. Along the vertical direction, the slit size shall be varied from 100 nm up to 1 μm as controlled by RIE parameters, while the horizontal size is controlled by UV exposure and varied in the range between 1 μm and 1.5 mm. The slit length is selected according to the required photon energy, ranging from 200 μm to 1 mm, for 8-20 keV photon energy, respectively. The fabrication is guided by finite differences simulation.

MI 7.7 Wed 18:00 Poster E

Acto-myosin in cardiac muscle cells by scanning x-ray nanodiffraction — •Jan-David Nicolas, Marten Bernhard, and Tim Salditt — Institut für Röntgenphysik, Göttingen, Deutschland

Owing to the highly oriented molecular structure of the actin-myosin cortex in muscle cells, diffraction techniques are well-suited to study the geometry of this filament assembly down to nanometer resolution. In particular, classical x-ray diffraction studies on muscular tissue were the first to unravel the detailed structure of the sarcomere. In these experiments, however, structural information is averaged over macroscopically large volumes of the tissue, with diffraction volumes containing a vast ensemble of muscle cells. Contrarily, recent progress in x-ray optics has enabled diffraction experiments with spot sizes in the sub-micron range, well-suited to illuminate only selected organelles of a single cell.

We report on recent experiments analyzing the micro-structure of acto-myosin complexes in individual cardiomyocytes which make up the striated muscular tissue of the heart. We performed experiments on (initially) alive, chemically fixed as well as freeze-dried cell preparations. Scanning the sample through the nano-focused beam, SAXS data were recorded and analyzed to generate mappings of different structural parameters. Scanning SAXS mappings are complemented by holographic reconstructions, extending the covered frequency range by two orders of magnitude. By means of x-ray holography, samples could also be immediately checked for radiation damage.

MI 7.8 Wed 18:00 Poster E

SIMS based in-situ correlative microscopy: HIM-, TEM- and SPM-SIMS — David Dowsett, Santhana Eswara, •Florian Vollnhals, and Tom Wirtz — Advanced Instrumentation for Ion Nano-Analytics (AINA), MRT Department, Luxembourg Institute of Science and Technology (LIST), 41 rue du Brill, L-4422 Belvaux, Luxembourg

While Secondary Ion Mass Spectrometry (SIMS) is among the most sensitive surface analysis techniques, like all techniques, it has its limitations. For example, the lateral resolution in commercial instruments is limited to several tens of nanometers with a fundamental limit of around 10-20 nanometers.

Fortunately, some of the limitations of SIMS can be overcome by combining it with complementary techniques in a correlative approach. Combining SIMS data with high resolution microscopy techniques such as Transmission Electron Microscopy (TEM) or Helium Ion Microscopy (HIM), we can take advantage of high spatial resolution and high chemical sensitivity. Correlation with other analysis techniques, like Energy Dispersive X-ray Spectroscopy (EDS), facilitates quantification. Additionally, SIMS combined with Atomic Force Microscopy (AFM) provides a path to artifact free 3D reconstruction even for complex samples with widely varying sputter yields.

In order to apply these techniques for in-situ correlative microscopy, we developed integrated instruments and methods, which will be presented in this contribution [1].

[1] T. Wirtz et al., Nanotechnology 26, 434001 (2015).

MI 7.9 Wed 18:00 Poster E

Stress Analysis in Semiconductor Devices by Kelvin Probe Force Microscopy — •Evgeniya Sheremet[1], Florian Fuchs[1,3], Soumya D. Paul[1], Sven Haas[1], Dietmar Vogel[2], Raul D. Rodriguez[1], Andreas Zienert[1], Jörg Schuster[2], Danny Reuter[1], Thomas Gessner[1], Dietrich R.T. Zahn[1], and Michael Hietschold[1] — [1]Technische Universität Chemnitz, Chemnitz, Germany — [2]ENAS Fraunhofer, Chemnitz, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf and Center for Advancing Electronics Dresden (cfaed), Dresden, Germany

The determination of built-in strain in semiconductor devices with nanometer spatial resolution and high sensitivity is needed for the characterization of nanoscale electronic devices. Kelvin probe force microscopy (KPFM) is an atomic force microscopy-based method that provides the spatially resolved surface potential at the sample surface, fulfilling the requirements on resolution and sensitivity. The contrast observed in KPFM imaging is often attributed to stress, but there are only a few reports on the application of KPFM for quantitative stress analysis [1]. In this contribution we focus on the application of KPFM for analysis of stress in silicon devices, such as copper through silicon vias and silicon membranes. The experimental results are compared with density functional theory calculations of strained silicon. This work provides critical insights into the quantitative determination of stress at the nanoscale that so far has gone largely unnoticed in the scanning probe microscopy community.

[1] W. Li, D.Y. Li, J. Appl. Phys. 99, 073502 (2006).

MI 7.10 Wed 18:00 Poster E

Characterization of a UHV evaporator for the coating of W-tips for room-temperature SP-STM — •Kai Besocke, Hendrik Bettermann, and Mathias Getzlaff — Institute of Applied Physics, University Düsseldorf

Our research involves supported nanoparticles of 3d-metal alloys. Magnetic and electronic properties and temperature dependent behavior are interesting for fundamental research and possible technological applications. These properties depend strongly on the nanoparticles' size.

A possible approach to measure the magnetic properties and their magnetic interaction on different substrates with spatial resolution is spin-polarized scanning tunneling microscopy (SP-STM).

We focus on the in-situ coating of non-magnetic W-tips with a layer of Fe since this system is known to have an intrinsic in-plane magnetization and hence doesn't need external magnetic fields.

Self-etched and commercially available tips are used. Effects of heating on the Fe-layer that was prepared by rod and/or crucible evaporation were investigated. The MircoSPM by Omicron is operating at room temperature at a base pressure below $2 \cdot 10^{-10}$mbar.

Examination of prepared tips is focused on scanning tunneling spectroscopy (SPS). Ex-situ (Off-site) scanning electron microscopy (SEM) is also availabe.

MI 8: Crystallography in Materials Science (KR, DF, MI)

Time: Thursday 15:40–17:00 Location: H26

MI 8.1 Thu 15:40 H26

Low temperature synthesis of $CuFeO_2$ (delafossite) between 50°C and 90°C: A new process solely by precipitation and ageing — •Melanie John[1], Aladin Ullrich[2], and Soraya Heuss-Assbichler[1] — [1]Ludwig-Maximilians-Universität München, München, Deutschland — [2]Universität Augsburg, Augsburg, Deutschland

Due to the large variability of technical applications of delafossite compounds e.g. as a catalyst, in p-type conduction oxides or as a cathode in Li-ion batteries, the synthesis of ABO_2 structures have received much attention the last years. Delafossite syntheses have been reported via solid state reaction and sol-gel processes using high temperatures between 900-1200°C or hydrothermal synthesis methods using at least autogenous pressure so far. We now synthesized $CuFeO_2$ nanoparticles, the parent mineral of the Delafossite group, solely by precipita-

tion and subsequent ageing at temperatures between 50°C and 90°C and without any additives controlling the oxidation state of copper for the first time. With this method, it is possible to synthesize a mixture of 2H (space group (SG): $P6_3/mmc$) and 3R polytype (SG: R-3m) of delafossite showing hexagonal morphology within 10 hours. The experimental conditions regulate the phase assemblage, size and the necessary ageing time. The synthesized material was analyzed by ICP-OES, FTIR, XRD, SEM, TEM and magnetic measurements.

MI 8.2 Thu 16:00 H26

Investigation of the sodium solid electrolyte $Na_5YSi_4O_{12}$ — •Wolfram Münchgesang[1], Anastasia Vyalikh[1], Falk Meutzner[1], Tina Nestler[1], Dörte Wagner[2], Axel Rost[2], Ulrike Langklotz[2], Jochen Schilm[2], Tilmann Leisegang[1], and Dirk C. Meyer[1] — [1]Technische Universität Bergakademie Freiberg, Institut für Experimentelle Physik, Leipziger Straße 23, 09596 Freiberg, Germany — [2]Fraunhofer Institute für Ceramic Technologies and Systems IKTS, Winterbergstraße 28, 01277 Dresden, Germany

Beside the well-known sodium solid electrolytes β-Alumina and NASICON, $Na_5YSi_4O_{12}$ (NYS) is another promising crystal structure with a high ionic conductivity. Its main advantage over the two abovementioned structures is the reduced production complexity and the associated costs. However, very little is known about its complex crystal structure and properties. Starting from a crystallographic point of view, sodium ion conduction pathways have been considered with the Voronoi-Dirichlet and the energy-scaled bond valence approaches, and compared with the pathways in other ion conductors.
In the present work, the crystal structure and ionic conductivity in polycrystalline NYS-materials, obtained by a glass-ceramic process, has been analysed using solid-state NMR and Electrical Impedance Spectroscopy respectively, and interpreted in respect to the theoretical predictions.
This work was financed by the BMWi within the project BaSta (0325563D) and the BMBF within the project SyNeSteSia (05K2014).

MI 8.3 Thu 16:20 H26

Measuring electron-phonon coupling by RIXS: the showcase of anatase TiO2 — •Simon Moser[1], Sara Fatale[1], Peter Krüger[2], Helmuth Berger[1], Philippe Bugnon[1], Arnaud Magrez[1], Hideharu Niwa[3,4], Jun Miyawaki[3,4], Yoshihisa Harada[3,4], and Marco Grioni[1] — [1]Ecole Polytechnique Federale de Lausanne, Switzerland — [2]University of Chiba, Japan — [3]University of Tokyo, Japan — [4]SPring-8, Japan

Anatase TiO2 has been proposed for many applications from transparent conducting panels to photovoltaic- and photocatalytic- devices, as well as memristors. However, little is known about the dynamics of the doped-in charge carriers in this textbook insulator. Recently, we have shown by angle resolved photoemission (ARPES) that these populate the bottom of the conduction band and strongly couple to an optical phonon mode, forming so called large polarons (Moser et al., PRL 110, 196403, 2013).

In the present study, we take the point of view of the phonon. By means of bulk-sensitive resonant inelastic X-ray scattering (RIXS) at the Ti L3 edge. We find that the formation of the polaron cloud involves a single 95 meV phonon along the $c-$axis, besides the 108 meV ab-plane mode previously identified by ARPES. The coupling strength to both modes is the same within error bars, and it is unaffected by the carrier density. This establishes RIXS as a directional and bulk-sensitive probe of electron-phonon coupling in solids (Moser et al. PRL 115, 096404, 2015).

MI 8.4 Thu 16:40 H26

Polycrystalline organic semiconductors studies by X-ray nano diffraction — •Clemens Liewald[1,2], Simon Noever[1,2], Stefan Fischer[1], Janina Roemer[1], and Bert Nickel[1,2] — [1]Fakultät für Physik & Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 München — [2]Nanosystems Initiative Munich, Schellingstrasse 4, 80799 München

The efficiency and reliability of organic semiconducting devices depends strongly on the knowledge of the nanoscale arrangement in the active organic layers. Here, we report on the possibilities of X-ray nanodiffraction to characterize polycrystalline organic thin films at beamline ID01, ESRF, before and after its upgrade. The beam diameter in our measurements is 110 nm at 8.9 keV and 350 nm at 20 keV. We find a high beam damage at 8.9 keV compared to only little damage at 20 keV. First, we apply the focused X-ray beam to a multilayer device, with different organic and inorganic layers, and demonstrate the possibility to measure buried microstructures in e.g. the active organic layer under and next to gold electrodes. Second, we explore the local distribution of two polymorphs in a single pentacene thin film. The lateral shape and distribution of these polymorphs can be mapped with infrared (IR) scanning near-field optical microscopy (SNOM) and is compared to the amplitude from the focused X-ray beam at ID01. In future, the combination of X-ray nanodiffraction with e.g. IR-SNOM as a correlated microscopy will allow to gain various new insights to the influence of the nanoscale crystallinity on the efficiency of organic electronics devices.