

O 27: Poster Session I (Methods: Scanning probe techniques; Methods: Atomic and electronic structure; Methods: Molecular simulations and statistical mechanics; Oxides and Insulators: Clean surfaces; Oxides and Insulators: Adsorption; Oxides and Insulators: Epitaxy and growth; Semiconductor substrates: Clean surfaces; Semiconductor substrates: Epitaxy and growth; Semiconductor substrates: Adsorption; Nano- optics of metallic and semiconducting nanostructures; Electronic structure; Methods: Electronic structure theory; Methods: other (experimental); Methods: other (theory); Solutions on surfaces; Epitaxial Graphene; Surface order interface magnetism; Phase transitions; Time-resolved spectroscopies)

Time: Tuesday 18:30–21:00

Location: P2

O 27.1 Tue 18:30 P2

Design of an XSTM head for low temperature high magnetic field studies of III-V heterostructures — ●BRUNO CHILIAN, JENS WIEBE, and ROLAND WIESENDANGER — Institute of Applied Physics, University of Hamburg, Germany

With the ultimate goal of future spintronic applications, dilute magnetic semiconductors like Mn doped GaAs have been heavily studied because of the possibility to tune their magnetic properties and thereby control the charge carrier's spin degree of freedom. However, a detailed understanding of how the local moments of magnetic impurities couple has yet to be achieved.

One technique which combines the power of atomic scale characterization with the ability to probe deeply buried impurities in MBE grown samples is cross sectional scanning tunneling microscopy (XSTM). However, few instruments have demonstrated the ability to provide atomic scale spectroscopic capability of such systems with high energy resolution. Here, we describe a homebuilt STM head which can be utilized in UHV conditions in a 300mK 14T environment.

To be able to locate the MBE grown layer of interest on the cleaved wafer surface, our STM head is capable of coarse XY sample movement. Its small diameter fits into the narrow bore of the 14 T superconducting magnet in our 300 mK facility. While constituting one of the main design challenges, the compact build simultaneously ensures mechanical stability, thereby promoting low noise levels.

O 27.2 Tue 18:30 P2

A STM with a scan width from 500 microns down to sub-nanometers — ●FATIH KALKAN and KARINA MORGENSTERN — Institut für Festkörperphysik, Gottfried Wilhelm Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany

The scanning tunnelling microscope (STM) is a very powerful tool for exploring the atomic-scale realm of surfaces, and for investigating adsorbate-surface interactions. However, for imaging, e.g. of prestructured surfaces, it would be desirable to bridge the gap between optical spectroscopy and the usual STM scan width. We have constructed a room temperature STM, which has the special ability of scanning with two different scan widths from the optical region down to atomic resolution. We have realised it with two different stages: The first one is a commercial Piezo stage which gives us the possibility of scanning an area up to $500 \times 500 \mu\text{m}^2$. The second one is a custom-built beetle type STM which scans from several microns down to atomic resolution. This newly designed STM with its wide scan width will allow us to connect the results from atomic-sized structures to the large-scale environment for prestructured surfaces.

O 27.3 Tue 18:30 P2

Characterization of Epitaxial Layers of Organic Molecules by Three-Dimensional Force- and Dissipation-Spectroscopy — ●GERNOT LANGEWISCH, DANIEL BRAUN, HARALD FUCHS, and ANDRE SCHIRMEISEN — CeNTech (Center for Nanotechnology) and Institute of Physics, University of Münster, Germany

Thin films of π -conjugated organic molecules are of high relevance for organic semiconductor applications. A widely studied organic semiconductor is 3,4,9,10-perylenetetracarboxylic-dianhydride (PTCDA). We applied non-contact atomic force microscopy in ultrahigh vacuum to investigate PTCDA deposited on Ag(111) by molecular beam epitaxy. Single PTCDA-molecules, arranged in the herringbone structure, were resolved in the topography scans. By site-specific force and dissipation versus distance measurements three-dimensional maps of tip-sample forces and dissipation with submolecular resolution were obtained. These maps are interpreted with respect to mechanical relaxation processes of the individual molecules.

O 27.4 Tue 18:30 P2

Controlled Atmosphere High Temperature SPM for electrochemical measurements — ●NILS OHMER¹, MOGENS MOGENSEN¹, BJØRN JOHANSEN¹, and TORBEN JACOBSEN² — ¹Fuel Cells and Solid State Chemistry Division, Risø National Laboratory for Sustainable Energy, DTU, DK-4000 Roskilde, Denmark. — ²Department of Chemistry, Technical University of Denmark, DK-2800 Lyngby, Denmark.

The Controlled Atmosphere High Temperature Scanning Probe Microscope (CAHT-SPM) works in principle like a normal AFM, but makes it possible to take, additional to the topography images, electrical images at the same time and at temperatures of up to 800 °C in a controlled atmosphere. Furthermore it is possible to use the tip as a working electrode to perform electrochemical impedance measurements at selected points. This poster provides information about the set up of the CAHT-SPM, in-house-made probes for electrical measurements at high temperatures and some results of measurements at 650 °C.

O 27.5 Tue 18:30 P2

Development of a combined AFM-STM for measurements under transport conditions and at low temperatures — ●JAN RAPHAEL BINDEL, MARCUS LIEBMAN, and MARKUS MORGENSTERN — II. Physikalisches Institut B, RWTH Aachen and JARA-FIT, Otto-Blumenthal-Straße, 52074 Aachen

We present a microscope combining atomic force (AFM) and scanning tunneling microscopy (STM) capabilities using a tuning fork. The device allows the investigation of a sample by AFM and to take STM images on spots of interest.

To use the full scope of the microscope, it is equipped with an *xy* drive which has a traverse path of 2 mm x 2 mm. Furthermore, the microscope can operate in two different modes, the AFM-STM constellation which makes it possible to apply a gate voltage on the sample and the pure STM mode, in which four point transport measurements can be done simultaneously with scanning.

The whole concept allows the usage in ultra high vacuum (UHV), at low temperatures down to 300 mK and in magnetic fields up to 14 T. Therefore, it has a compact symmetric design with a diameter of only 30 mm, which guarantees stability and high resonance frequencies. First test measurements of the microscope are presented.

O 27.6 Tue 18:30 P2

Force-field spectroscopy on KBr(001): Experiment and simulation — ●KAI RUSCHMEIER¹, ANDRÉ SCHIRMEISEN¹, and REGINA HOFFMANN² — ¹Physikalisches Institut, Westfälische Wilhelms-Universität Münster and Center for Nanotechnology (CeNTech), 48149 Münster, Germany — ²Physikalisches Institut and DFG-Center for Functional Nanostructures, Universität Karlsruhe, 76128 Karlsruhe, Germany

An atomic force microscope (AFM) is capable of imaging the surface of insulating samples with atomic precision by scanning an atomically sharp tip over the surface. Furthermore, the force field representing the spatial orientation and magnitude of the force acting between the AFM probe and the sample surface can be measured by force field spectroscopy. These measurements depend on the respective sample atoms but also crucially on the particular tip structure and material.

We compare force field measurements on KBr(001) at room temperature with atomistic simulations for two individual tip configurations, a K⁺- and a Br⁻-terminated tip, assuming that the tip was contaminated with sample material during the experiments [1]. The 2-dimensional force fields were obtained at two different sample positions: along the corrugation maxima and almost halfway between the

corrugation maxima and minima. We find good agreement between our measurements and simulations for the K^+ -terminated tip for both sample positions confirming a previous analysis [2].

- [1] R. Hoffmann *et al.*, Phys. Rev. Lett. **92**, 146103 (2004).
 [2] K. Ruschmeier *et al.*, Phys. Rev. Lett. **101**, 156102 (2008).

O 27.7 Tue 18:30 P2

Indium microsoldering of graphene on silicon dioxide substrate — ●ANN-KATRIN MICHEL¹, VIKTOR GERINGER¹, TIM ECHTERMEYER², MARCUS LIEBMANN¹, and MARKUS MORGENSTERN¹ — ¹II. Physikalisches Institut, RWTH Aachen and JARA-FIT, Otto-Blumenthal-Straße, 52074 Aachen — ²Advanced Microelectronic Center Aachen (AMICA), Otto-Blumenthal-Straße 25, 52074 Aachen

Electron beam lithography is the standard method to produce electrical contacts for nanostructures made e.g. from graphene. A major disadvantage of this method is, apart from high costs, the contamination of the sample due to the residual photoresist. This problem gets even more severe, if scanning probe techniques are applied. Therefore, a more simple technique to make ohmic contacts to graphene without contamination is desirable and has been developed recently [1].

We reproduced this method by designing a setup for microsoldering of graphene flakes on silicon dioxide with multiple indium solder contacts. Mobility measurements on graphene samples using four point indium contacts have been used to characterize the contacts. Moreover, we describe the application to scanning tunneling microscopy (STM) of the microsoldered graphene samples.

- [1] C. Ö. Girit and A. Zettl, Appl. Phys. Lett. **91**, 193512 (2007)

O 27.8 Tue 18:30 P2

Controlled nanoparticle manipulation along defined vector pathways — ●MICHAEL FELDMANN, DIRK DIETZEL, and ANDRÉ SCHIRMEISEN — Institute of Physics and Center for Nanotechnology, University of Münster, Germany

Manipulation of nanoparticles with an atomic force microscope (AFM) is a very promising approach to measure friction of nanoscale objects with well defined contact area. For example, the phenomenon of frictional duality was revealed for Sb nanoparticles on graphite in vacuum [1]. However, so far the manipulation was performed during conventional image scanning with a commercial AFM control unit [2]. To optimize the control over the manipulation process a new AFM control system has been developed. This system enables AFM tip translations along arbitrary programmable vector pathways while allowing to select distinct control parameters like normal force and velocity for each single vector. Due to the systems ability to simultaneously record the lateral force along the x axis, it is thus possible to conduct nanotribological experiments with individually chosen nanoparticles in a highly controlled and reproducible fashion.

- [1] Dietzel *et al.*, Phys. Rev. Lett., **101**, 125505 (2008)
 [2] Dietzel *et al.*, J. Appl. Phys., **102**, 84306 (2007)

O 27.9 Tue 18:30 P2

Nanoscale charge transport measurements using a multi-tip scanning tunneling microscope — PHILIPP JASCHINSKY, JAKOB WENSORRA, MIHAIL ION LEPSA, and ●BERT VOIGTLÄNDER — Institute of Bio- und Nanosystems (IBN) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, D-52425 Jülich, Germany

We demonstrate the ability of a multi-tip scanning tunneling microscope (STM) combined with a scanning electron microscope (SEM) to perform charge transport measurements on the nanoscale. The STM tips serve as electric probes that can be precisely positioned relative to the surface nanostructures using the SEM control and the height reference provided by the tunneling contact. The tips work in contact, noncontact, and tunneling modes. We present vertical transport measurements on nanosized GaAs/AlAs resonant tunneling diodes and lateral transport measurements on the conductive surface of 7x7 reconstructed Si(111). The high stability of the double-tip STM allows nondestructive electrical contacts to surfaces via the tunneling gaps. We performed two-point electrical measurements via tunneling contacts on the Si(111)(7x7) surface and evaluated them using a model for the charge transport on this surface.

O 27.10 Tue 18:30 P2

s-SNOM from IR to the THz with tuned scatterers — ●HANS-GEORG VON RIBBECK^{1,2}, MARC TOBIAS WENZEL¹, and LUKAS MATTHIAS ENG¹ — ¹Institute of applied photo physics, TU Dresden, Germany — ²Forschungszentrum Dresden-Rossendorf, Dresden, Ger-

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Here we present a scattering near-field optical microscope (s-SNOM) set-up established at the free-electron laser source (FEL) at the Forschungszentrum Dresden-Rossendorf. This microscope is capable to perform optical observations at nanometer scale resolution over the full wavelength range of the FEL, i.e. 3 to 250 micron (1.2 to 100 THz). Furthermore, the optical resolution governed by the near-field interaction between tip and sample and the signal-to-noise ratio is enhanced by specially designed, optically resonant probes. This ultimately results in a much better spatial confinement achieving a resolution preferably of $\lambda/1000$ for the THz region. Also, coupling both a resonant tip and sample will lead to giant polaritonic resonances. Finally the described setup will grant access to new areas of nanoscale applications, such as observing the optical behavior of strained and mixed silicon structures, high-Tc superconductors, single quantum dots, and superlattices at THz frequencies.

Basis to our approach is the recent work [1] where an optical confinement of the near field in z-direction was achieved through tuned scatterers in the form of metallic nanoparticles (MNPs) attached to the AFM tip, serving as non-resonant antennas. Tunability in the THz range will be achieved through geometrically tuned metal wires [2].

O 27.11 Tue 18:30 P2

High Order Field Emission Resonances on W(110) and Fe/W(110) studied by Scanning Tunneling Spectroscopy — ●ANIKA EMMENEGGER, STEFAN KRAUSE, ANDRÉ KUBETZKA, GABRIELA HERZOG, and ROLAND WIESENDANGER — Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

Above metal surfaces a Rydberg-like series of states exists close to the vacuum level due to the potential well created by the attractive image potential and the surface projected bulk band gap [1]. In scanning tunneling microscopy (STM) experiments these so-called image-potential states (IPS) experience a Stark Shift [2], hence they are often called field emission resonances in this context.

Neglecting the influence of the image potential, a simple triangular potential model can be applied to determine the effective electric field in the constant current spectroscopy of IPS [3]. Whereas commercial STM electronics typically provide a maximum gap voltage of 10 V, we present scanning tunneling spectra of field emission resonances above the W(110) and Fe/W(110) surface up to the order of $n=30$ and voltages up to 20 V. The results will be discussed in terms of electric field determination, revealing that the assumption of a constant electric field is only applicable to voltages exceeding 10 V.

- [1] U. Thomann *et al.*, Phys. Rev. B **61**, 16163 (2000).
 [2] S. Crampin, Phys. Rev. Lett. **95**, 46801 (2005).
 [3] J. H. Coombs and J. K. Gimzewski, J. of Microsc. **125**, 841 (1988).

O 27.12 Tue 18:30 P2

Microscopically high speed friction measurements — ●FENGZHEN ZHANG¹, OTHMAR MARTI¹, STEFAN WALHEIM², and THOMAS SCHIMMEL^{2,3} — ¹Institute of Experimental Physics, Ulm University, 89069 Ulm — ²Forschungszentrum Karlsruhe — ³University of Karlsruhe

Quartz crystals have been found to be the best substrates for the Atomic Force Microscopy (AFM) high speed friction measurements. To prove the oscillation of the quartz crystals, we prepared Fischer Patterns on the surface. During the oscillation of the quartz crystals, the topographies of the Fischer Pattern show clearly the oscillation information (in tapping mode AFM). The result of the comparison of the friction under different oscillation speeds and after oscillation will be discussed. We will also present the measurement data of friction at high speeds of surfaces without and with adsorbed monolayers.

O 27.13 Tue 18:30 P2

Non-contact Atomic Force Spectroscopy using Field Ion Microscope characterized Tips — ●JENS FALTER¹, DANIEL-ALEXANDER BRAUN^{1,2}, UDO SCHWARZ⁴, HENDRIK HÖLSCHER³, ANDRÉ SCHIRMEISEN^{1,2}, and HARALD FUCHS^{1,2} — ¹Physikalisches Institut, Universität Münster, Germany — ²CeNTech, Münster, Germany — ³IMT, Forschungszentrum Karlsruhe, Germany — ⁴Department of Mechanical Engineering, Yale University, New Haven, USA

Although atomic force microscopy (AFM) is a tool for resolving surfaces with atomic resolution, the underlying contrast mechanisms is not yet fully understood. Beyond imaging this technique is capable

to measure the interaction potential of tip and sample atoms in force spectroscopy experiments. What remains completely unknown is the atomic scale configuration of the tip. One method which allows determining the configuration of the probing tip apex with atomic precision is the field ion microscope (FIM). We present a home-built ultrahigh vacuum system, which combines these two microscopy techniques. The AFM head [1] is capable to operate at liquid helium temperatures and the force sensor is based on a tuning fork system [2]. The tuning fork concept allows to chose a material for the tip, which is suitable for FIM operation. A home build tip-holder is used for the in-situ tip exchange between the two microscopes. First results of both microscopy methods correlate the force spectroscopy curves from the AFM with the tip apex radii obtained from the FIM analysis.

[1] B.Albers et al., Rev. Sci Instrum. 79 033704 (2008)

[2] F.J.Giessibl, Appl. Phys. Lett. 76 1470 (2000)

O 27.14 Tue 18:30 P2

Scanning Tunneling Spectroscopy at the [110]-[1 $\bar{1}$ 0] Cleaved Edge of GaAs — S. SIEWERS, M. WENDEROTH, L. WINKING, •P. KLOTH, and R. G. ULBRICH — IV. Phys. Inst. Georg-August-Universität Göttingen

We report the first cross-sectional scanning tunneling spectroscopy (STS) study of zincblende [110]-[1 $\bar{1}$ 0] cleaved edges with atomic resolution. The samples were prepared in-situ by a double cleavage procedure applied to $6 \cdot 10^{18} \text{ cm}^{-3}$ Si-doped GaAs in UHV. In edge-approaching scans and for positive sample bias we observed a monotonically decreasing tunnel current within a few tens of nm from the edge. For negative bias we found the onset of this decrease within a few nm from the edge, followed by a considerable increase directly at the edge. Comparing these observations with scans over charged defects embedded in plane surfaces, we conclude that the edge contains a negative line charge density. The data suggests that the observed effect is not simply caused by tip-induced band bending and screening of bulk states confined within the 90°-edge geometry. Spectroscopic measurements on edges support the concept of a negatively charged quasi-1d electronic state localized along the edge. It is laterally confined within ~ 2 lattice constants and is clearly observed in the local density of states derived from the STS data. To estimate the absolute value of its charge density we simulated the shape and spatial extension of the screening cloud of a negative line charge located at the center of the "quarter-space" geometry. By adjusting this potential to the spectroscopic data we find a line charge density of ~ 0.7 electrons per unit cell.

O 27.15 Tue 18:30 P2

Frictional properties of a mesoscopic contact with engineered surface roughness — •JOHANNES SONDHAUSS¹, HARALD FUCHS^{1,2}, and ANDRÉ SCHIRMEISEN^{1,2} — ¹Institute of Physics, University of Münster, Münster, Germany — ²Center for Nanotechnology (CeN-Tech), University of Münster, Münster, Germany

Friction force microscopy (FFM) is a standard tool to measure friction down to atomic scales. In this work, we use FFM to investigate the influence of interface roughness of mesoscopic contacts on friction, where both sliding partners, tip and sample, have precisely engineered properties. We use a focused ion beam (FIB) to modify commercial cantilevers in order to firmly attach spherical titanium particles with diameters between 4 and 15 μm . As sample we produce groove-like patterns on a silicon surface with the FIB with a lattice periodicity ranging from 1 to 9 μm and a depth of 25 nm. The average friction force was measured systematically for different tip radii as a function of load and lattice periodicity of the sample grooves. For the 5 μm tip the maximum friction force was found where the geometry of the spherical tip and the lattice are commensurate. These findings highlight the importance of surface structure on tribological properties of mesoscale contacts.

O 27.16 Tue 18:30 P2

SFM manipulation techniques applied to graphene — •STEFAN EILERS, TOBIAS LIEBIG, and JÜRGEN P. RABE — Humboldt-Universität zu Berlin

The properties of graphene render it a promising candidate for future generation electronic devices. For the investigation of properties and possible applications or devices structuring and manipulation techniques are needed. Thinness, flexibility and flatness make it possible to apply SFM techniques to single or multilayer graphene well known from using with molecules on graphite. Here, some effects produced by a SFM tip are demonstrated. First, manipulation of graphene itself is shown, in detail sawing were a gap and a nanoribbon is produced and

manipulating parts of graphene without destruction. In both cases the manipulation is started on SiO₂ substrate and kept in contact with it while moving the SFM tip. It appears that the graphene can only be desorbed and turned when the manipulation is done near an edge of graphene or when the graphene piece is small enough because there the adsorption force between graphene and the substrate is smaller than the force to break the bonds in graphene. Second, adsorption and manipulation of DNA on an amphiphile interlayer is presented. The interlayer is needed to make sure that the DNA is mobile enough to be manipulated. It appears that a force can be found large enough to manipulate DNA but to small to damage the graphene.

O 27.17 Tue 18:30 P2

Development of a Scanning Tunneling Microscope for measurements below 100mK — •MAXIMILIAN ASSIG, FABIAN ZINSER, WOLFGANG STIEPANY, ANDREAS KOCH, PETER ANDLER, CHRISTIAN R. AST, and KLAUS KERN — Max-Planck-Institut für Festkörperforschung,

The investigation of novel physical phenomena implies the design and the construction of new setups and measurement techniques, which can break through instrumental limitations and open new areas in measurement accuracy. Scanning Tunneling Microscopy (STM) is a technique for probing the electronic structure of single adsorbed atoms and nanostructures at surfaces with atomic resolution. As the energy resolution increases with decreasing temperature, cooling the STM below 100mK results in an energy resolution which is better than $24\mu\text{eV}$. To achieve this goal, we want to connect a home-built STM to the mixing chamber of a custom-designed bottom-loading dilution cryostat. Tip and sample can be transferred directly from the preparation chamber into the STM without breaking the ultra high vacuum (UHV), which allows *in situ* sample preparation. Measurements can be performed in high magnetic fields of 14T perpendicular and 500mT parallel to the sample surface. We present design and concept of the STM as well as milestones in the project realization.

O 27.18 Tue 18:30 P2

Eddy current microscopy — •BENEDICT KLEINE BUSSMANN, TINO ROLL, MARION MEIER, and MARIKA SCHLEBERGER — Universität Duisburg-Essen, Fachbereich Physik, Lotharstrasse 1, D-47048, Germany

We present eddy current microscopy [1] measurements on geometrically confined conductive structures on insulating substrates. The principle of eddy current microscopy is as follows: A magnetic tip of an Atomic Force Microscope oscillates above a sample and induces eddy currents in the conducting areas of the sample due to the time-dependent magnetic field they are exposed to. This leads to an electromagnetic interaction between the sample and probe: Thus, according to Lenz's rule a damping of the oscillation occurs and leads to a contrast in the phase and/or dissipation signal[2,3]. By using the well established technique of AFM this method can thus be used to perform conductivity measurements on submicron scale without any need to contact the sample (like for example four-point-probe techniques). We will present measurements we recently performed under ambient conditions as well as in situ measurements.

[1]B. Hoffmann, R. Houbertz, and U. Hartmann, Appl. Phys. A: Mater. Sci. Process. 66, S409 *1998*.

[2]T. Roll, M. Meier, S. Akcöltekin, M. Klusmann, H. Lebius and M. Schleberger Conductive nanodots on the surface of irradiated CaF₂ phys. stat. sol. (RRL) 2, 209 (2008) [3] Tino Roll, Marion Meier, Ulrich Fischer and Marika Schleberger Distance dependence of the phase signal in eddy current microscopy Thin Solid Films 516, 8630 (2008)

O 27.19 Tue 18:30 P2

Detecting resonant modes of plasmon-polaritons and phonon-polaritons using a NSThM — •DAVID HELLMANN, ACHIM KITTEL, and ULI F. WISCHNATH — EHF, Fak. V, Physik, Carl von Ossietzky Universität Oldenburg

With a Near-field Scanning Thermal Microscope (NSThM) the heat transfer between a sample and a probe can be measured [1,2]. The NSThM combines a STM tip with a coaxial thermocouple sensor and, thus, can collect data concerning the heat transfer a few nm above the scanned surface along with usual STM maps. Evanescent thermal radiation has been investigated recently by De Wilde et al. at larger sample-tip distances (200 nm to some μm) [3]. The authors find resonant modes of surface plasmon-polaritons and phonon-polaritons on certain structures. Subject of this study are NSThM measurements on structures where such resonances can be expected. With the NSThM

it is possible to investigate the influence of those resonant modes on the heat transfer in the direct vicinity of the samples surface in the range from about 1 nm to a few tens of nanometers.

Literature [1] A. Kittel et al., PRL 95, 224301 (2005) [2] U. Wischnath, RSI 79, 073708 2008 [3] Y. De Wilde et al., Nature Vol 444, 7.12.2006, p.740-743

O 27.20 Tue 18:30 P2

Near-field Scanning Thermal Microscope: From temperature to heat flow — •LUDWIG WORBES, ULI F. WISCHNATH, and ACHIM KITTEL — Universität Oldenburg EHF EPKOS

The Near-field Scanning Thermal Microscope (NSThM) developed in our group combines the function of a normal STM with the ability to use the scanning probe as a thermocouple temperature sensor [1].

By operating in UHV in our experiment the heat transfer mechanism is restricted to radiative transfer in contrast to other SThM devices. The radiative transfer is dominated by evanescent modes of the thermal electromagnetic field for small distances. The heat transfer mediated by these modes between sample and sensor has been calculated using different theoretical approaches.

In order to compare the theoretical predictions with the experiment, we need to know the relation between the measured thermovoltage and the heat flow. This is up to now done by calculating the thermal conductivity of the tip based on the geometry and material properties. Here we present a calibration procedure based on measuring the heat flow through a bridge structure, whose thermal conductivity is easier to quantify. We use the so called 3ω method, using the bridge as a heater and as a resistive temperature sensor at the same time.

[1] U. F. Wischnath, J. Welker, M. Munzel, and A. Kittel, Rev. Sci. Instrum. 79, 073708 (2008).

O 27.21 Tue 18:30 P2

A Novel Scanning Tunneling Potentiometry Setup with Microvolt Resolution — •T. DRUGA¹, M. WENDEROTH¹, M. A. SCHNEIDER², and R. G. ULBRICH¹ — ¹IV. Phys. Inst., Georg-August-Universität Göttingen — ²Lehrstuhl für Festkörperphysik Univ. Erlangen-Nürnberg

In Scanning Tunneling Potentiometry (STP) the tunneling tip is used as a weakly coupled voltage probe to determine the spatial variation of the electrochemical potential due to a lateral surface current or temperature difference between tip and sample. We have developed a potentiometric technique based on a standard STM setup allowing to measure the local potential with μV and Angstrom resolution. Unlike recent implementations [1,2] that use alternating voltages as transport fields or for controlling the tip sample distance similar to the scheme suggested by Murali and Pohl [3] our STP method uses DC-voltages only. Hence it not only allows standard STS being conducted in parallel but also ensures correct assignment of the energy of tunneling electrons. Further advantages of our technique is that (i) the sample bias for the topography can be chosen independently from the potentiometry and (ii) the potential can be mapped simultaneously for reverse current directions. It has been implemented in both a room temperature and low temperature STM-setup. The performance is demonstrated by measuring local transport fields on $\text{Si}(111)\sqrt{3} \times \sqrt{3}$ -Ag and thermovoltage maps on Ag(111). This work was supported by the DFG as part of SFB 602 Tp A7. [1] Rev. Sci. Int. 79, 083704 (2008) [2] Rev. Sci. Int. 79, 073904 (2008) [3] Appl. Phys. Lett. 48, 514 (1986)

O 27.22 Tue 18:30 P2

Studies towards Tip Enhanced Raman Scattering with Scanning Capability — •SETH WHITE^{1,2}, MORITZ BRENDEL¹, PETER LEMMENS¹, DIETRICH WULFERDING¹, and VLADIMIR GNEZDILOV^{1,3} — ¹IPKM, TU Braunschweig, Germany — ²MPI-FKF, Stuttgart, Germany — ³ILTP, Kharkov, Ukraine

Tip- and surface-enhanced Raman scattering methods combined with scanning probe microscopy should enable precision measurements on finely structured samples while simultaneously providing local topographical information. A single etched Au[1,2] nano-apex scanning tip could thus be used both for scanning probe investigation and micro-Raman signal enhancement in one instrument. Samples with molecular scale structuring such as impregnated nano-porous silica and alumina are of particular interest in our studies.

[1] Ren et al. (2004), Rev. of Sci. Inst. 75, 4, April 2004

[2] Anderson, Pike (2002), Rev. of Sci. Inst. 73, 3, March 2002

O 27.23 Tue 18:30 P2

Mechanical and electronic characterization of individual single-walled carbon nanotubes by scanning probe microscopy — •MARTIN BOHRISCH, FLORIAN SZILLAT, PHILIPP ZEIGERMANN, HANS KLEEMANN, and BERND SCHRÖTER — Universität Jena, Institut für Festkörperphysik, Max-Wien-Platz 1, 07743 Jena, Deutschland

The selective growth of carbon nanotubes with particular structural and electronic properties is a prerequisite to utilize them in electronic and sensor devices. Single-walled carbon nanotubes were grown by catalyst-assisted chemical vapor deposition on insulating substrates. A horizontal alignment in predefined directions has been achieved by a growth on single-crystalline substrates like sapphire. Scanning electron microscopy is used to observe the orientation of the nanotubes. The high purity of the nanotubes is demonstrated by x-ray photoelectron and raman spectroscopy. Scanning probe techniques are utilized to determine mechanical and electronic properties of individual carbon nanotubes. The influence of the substrate-nanotube interaction on the radial deformation of single-walled carbon nanotubes was examined by contact atomic force microscopy (AFM). Electrical measurements were done by conductive AFM.

O 27.24 Tue 18:30 P2

New scan mode for the NSThM — •LARS HOELZEL, ULI F. WISCHNATH, and ACHIM KITTEL — Energy and Semiconductor Research Laboratory - University of Oldenburg

The near-field scanning thermal microscope (NSThM)[1] is able to measure the thermal flux between a sharp tip of a STM and a heated or cooled sample surface under ultra-high vacuum conditions. Hence, the main contribution is mediated by evanescent electro-magnetic fields. Up to now the heat flux was investigated in scanning tunnelling mode of the STM on which the NSThM is based on [2]. While the tunnelling current decays on a short length scale the heat flux decays on a roughly ten times larger length scale. First data achieved by a new scanning mode are presented in this contribution. This mode employs a control loop which keeps the heat current constant. Therefore, it is possible to investigate the influence of the surface morphology on the heat flux at larger distances.

[1] Uli F. Wischnath et al., Rev. Sci. Instrum. 79, 073708 (2008)

[2] Achim Kittel et al., Appl. Phys. Lett. 93, 193109 (2008)

O 27.25 Tue 18:30 P2

Infrared antennas for near-field microscopy and enhanced near-field spectroscopy — •THOMAS TAUBNER^{1,2}, MARK BRONGERSMA², and JON SCHULLER² — ¹I. Physikalisches Institut, RWTH Aachen, Germany — ²Department of Material Science, Stanford University, USA

Scattering-type near-field optical microscopy (s-SNOM) relies on the scattering of light at a sharp metallic tip to obtain images with a resolution independent of the wavelength. The use of infrared light enables the acquisition of spectroscopic information on a samples chemical, structural and electronic properties at nanoscale resolution. Currently, the main limitation of this technique comprises of the low signals that demand tunable laser sources and restrict the spectral range of operation.

We present new concepts to increase the sensitivity of IR near-field spectroscopy in order to apply s-SNOM over a broader spectral range in the mid-IR. We suggest to employ resonantly enhanced near-fields of metallic nanostructures: The optical properties of materials of such structures can be tuned by changing their size to create optical antennas that concentrate light into tiny, subwavelength volumes. Specifically, we investigate the antenna properties of modified, metal-coated AFM tips in order to enable high-resolution near-field microscopy with increased sensitivity. We also show that the near-field probing process can be enhanced by suitable substrates, increasing both signals and contrasts in infrared s-SNOM when probing thin sample layers.

O 27.26 Tue 18:30 P2

Ab initio investigation of the $\text{LiNbO}_3(0001)$ surface — •SIMONE SANNA¹, ALEXANDER V. GAVRILENKO², and WOLF GERO SCHMIDT¹ — ¹Lehrstuhl für Theoretische Physik, Universität Paderborn, 33095 Paderborn, Germany — ²Norfolk State University, Center for Materials Research, 700 Park Avenue Norfolk, VA 23504 USA

Lithium niobate (LN) is frequently used for various (nonlinear) optical and acoustic applications. While traditional applications mainly exploit LN bulk properties, more recently the (microscopic) surface and interface properties of LN have become important (1). Therefore the

understanding and analysis of LN surfaces and interfaces is indispensable to optimise and fully implement LN based devices. Unfortunately up to date very little information is available about the LN surfaces and their structure on atomic level (2). We present here an *ab initio* simulation of ferroelectric LN (0001) surfaces with different stoichiometry based on density functional theory within the generalised gradient approximation. This approach was recently shown to yield reliable structures and energies for bulk LN both in its paraelectric and ferroelectric phase (3). We discuss the stability of a series of candidate structures with varying stoichiometry and surface reconstructions in dependence of the chemical environment. The effect of the dipole corrections and of the cell size on the total local potential and on the electronic and structural properties of the surfaces are shown in detail.

(1) G. Namkoong *et al.*, Appl. Phys. Lett. 87 (2005), 171107.

(2) S. V. Levchenko *et al.*, Phys. Rev. Lett. 100 (2008) 256101.

(3) W. G. Schmidt *et al.*, Phys. Rev. B 77 (2008), 035106.

O 27.27 Tue 18:30 P2

Auger spectroscopy of the ion neutralization at epitaxial transition metal surfaces — ●CHRISTIAN TUSCHE and JÜRGEN KIRSCHNER — MPI für Mikrostrukturphysik, D-06120 Halle, Germany

The neutralization of ground state He^+ at a metal surface proceeds by Auger neutralization, emitting an Auger electron from the conduction band of the metal. In ion-neutralization-spectroscopy (INS), developed by Hagstrum [1], the distribution of emitted electrons is related to the surface density of states (DOS). In contrast, He^{++} neutralization starts with a double electron capture into the outer He-2s and -2p shells, forming double excited He^{**} . Subsequent auto-ionization (AI) emits a He-KLL Auger electron from the projectile.

We prepared clean surfaces of the transition metals Mn, Fe, and Ni by epitaxial growth on a W(110) substrate. He^+ and He^{++} ions ($E_{kin} \leq 30\text{eV}$) were scattered at the clean surface and after adsorption of sub-monolayers of carbon, oxygen, or caesium. INS provides detailed information on changes of the work-function and electronic structure. All adsorbates are found to reduce the number of electrons emitted close to the Fermi energy. In the He^{**} AI decay we observe a changed spectral weight of *triplet* and *singlet* terms with adsorbate coverage, like reported before by Busch *et al.* [2]. Our experiments give evidence that this can be related to the adsorbate induced changes in the DOS. We hope that our experiments will stimulate detailed theoretical studies of the electron transfer processes in ion-neutralization.

[1] Hagstrum: Phys. Rev. **150**, p. 495-515 (1966)

[2] Busch, Wethekam, Winter: : Phys. Rev. A **78**, 010901 (2008)

O 27.28 Tue 18:30 P2

Ar gas discharge lamp with heated LiF window: A monochromatized light source for photoemission — MICHAEL BUDKE, ●ALEXANDER WITTKOWSKI, and MARKUS DONATH — Westfälische Wilhelms-Universität Münster, 48149 Münster, Deutschland

We present a simple, inexpensive, and highly effective method for monochromatizing the vacuum ultraviolet light emitted from an Ar gas discharge for use, e.g., in photoemission experiments [1]. By using a slightly heated window of LiF acting as low-pass filter, the emission spectrum of the Ar gas discharge is reduced to the Ar line at 11.62 eV (106.7 nm). The performance of the low-pass filter is demonstrated by photoemission measurements on Cu(111). Furthermore, we compare our light source with an unmonochromatized He gas discharge, which represents the most widely used laboratory photon source in photoemission.

[1] M. Budke and M. Donath, Appl. Phys. Lett. 92, 231918 (2008)

O 27.29 Tue 18:30 P2

High-resolution electron gun for inverse photoemission — ●ANNA ZUMBÜLTE, THOMAS SAERBECK, and MARKUS DONATH — Physikalisches Institut, Westfälische Wilhelms-Universität Münster, 48149 Münster

Inverse photoemission (IPE) is an applied method to investigate the unoccupied part of the electronic structure above the Fermi level. The setup of such an experiment consists of an electron gun and a detection system for photons. A high energy and angle resolution is necessary for a k-resolved separation of as many electronic states as possible in the spectra. Therefore the improvement of the setup components is always an object. State-of-the-art setups achieve an energy resolution of about 150 meV and an angular resolution of 2° - 5° [1].

We present a spin-polarized electron gun with comparable energy resolution and an improved angular resolution. It consists of a GaAs photoemitter combined with a toroidal 90° electrostatic deflector act-

ing as monochromator. With this we achieve an energy resolution of 150 meV to 250 meV, depending on the current. Measurements of the beam profile indicate a low divergence that can be verified by IPE spectra of Cu (111). Here, the intensity ratio between the two surface states observed at normal incidence is an indicator of the angular resolution. In our case, measurements show a divergence smaller than 2° .

[1] M. Budke *et al.*, Rev. Sci. Instrum. 78, 113909 (2007)

O 27.30 Tue 18:30 P2

Simulation of photoelectron diffraction at high kinetic energies — ●AIMO WINKELMANN¹, CHARLES S. FADLEY^{2,3}, and JAVIER GARCIA DE ABAJO⁴ — ¹Max Planck Institut für Mikrostrukturphysik, Halle, Germany — ²Department of Physics, University of California Davis, Davis, CA 95616, USA — ³Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA — ⁴Instituto de Optica – CSIC, Serrano 121, 28006 Madrid, Spain

The theoretical modelling of x-ray photoelectron diffraction (XPD) with hard x-ray excitation of up to 20 keV energy is discussed using the dynamical theory of electron diffraction [1]. Via calculations for diamond and silicon it is demonstrated that the dynamical theory explains available current data for kinetic energies around 1 keV very well. The XPD patterns for energies above about 1 keV are dominated by Kikuchi bands which are created by the dynamical scattering of electrons from lattice planes. The origin of the intensity distribution in such bands is discussed from the point of view of atomic positions in the unit cell. The profiles and positions of the element-specific photoelectron Kikuchi bands are found to be sensitive to lattice distortions and the position of impurities or dopants with respect to lattice sites. These results thus suggest several future uses of such hard XPD for studies of the bulk structure of complex materials. The dynamical calculations are compared to results from a cluster model that is more often used to describe lower-energy XPD.

[1] A. Winkelmann, C.S. Fadley, F.J. Garcia de Abajo
New J. Phys. **10** (2008) 113002

O 27.31 Tue 18:30 P2

(SP)VLEED: A spin-polarized very-low-energy electron-diffraction experiment — ●KATHRIN WULFF, ULRICH BURGBACHER, ANKE B. SCHMIDT, and MARKUS DONATH — Physikalisches Institut, Westfälische Wilhelms-Universität Münster

The shape of the surface-barrier potential at conductive surfaces dictates the appearance and spin dependence of surface states. Currently, parameterized polynomials are incorporated in theoretical calculations to connect the Coulomb-like asymptotic regime far from the surface to the bulk muffin-tin zero. In intensity versus energy profiles $I(V)$ of elastically scattered electrons fine structures appear, which are sensitive to the shape of the surface-barrier potential [1]. So far, spin-polarized low-energy electron-diffraction measurements on W(100) have already shown a strong spin dependence of the $I(V)$ profiles due to spin-orbit interaction [2].

We present a new experimental setup for spin-polarized very-low-energy electron-diffraction (SP-VLEED) measurements to investigate the spin dependence of the surface-barrier potential of ferromagnets. Spin-polarized electrons emitted from a GaAs photocathode are directed onto the sample with a variable angle of incidence and with energies in the range of 0 to 50 eV. The specular reflected intensity is measured as a function of the primary-electron energy with a retarding field analyser. To access certain crystallographic axes, the sample can be rotated around an azimuthal axis.

[1] R.O. Jones, P.J. Jennings, Surf. Sci. Reports **9** (1988) 165.

[2] E.G. McRae, D.T. Pierce, Phys. Rev. B **24** (1981) 4230.

O 27.32 Tue 18:30 P2

Liquid Interface Scattering Apparatus (LISA) for Petra III: Stability and Characterization — ●CHRISTIAN KOOPS¹, BRIDGET MURPHY¹, MATTHIAS GREVE¹, ANNIKA ELSSEN¹, JOCHIM STETTNER¹, OLIVER SEECK², and OLAF MAGNUSSEN¹ — ¹IEAP, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — ²PETRA III at DESY, Notkestr. 85, D-22603 Hamburg, Germany

The study of liquid - liquid interfaces by x-ray scattering methods requires special diffractometers, capable of tilting the beam at precise angles down onto the interface. We have developed a new, dedicated instrument, the liquid interface scattering apparatus (LISA) for the High Resolution Diffraction Beamline at PETRA III. By means of a non-dispersive tilting double crystal monochromator this diffractometer will allow reflectivity measurements without moving the sample.

The planned instrument will operate in the energy range from 6.4 keV to 30 keV and provide access in momentum space out to $q_z = 2.5 \text{ \AA}^{-1}$. For monitoring and calibration the high-precision x-ray optics employed for beam tilting a novel optical position detection system was developed. This alignment aid system consists of small lasers and position sensitive diodes, capable of detecting movements in the submicron range during operation. Results on the diffractometer characterization by this optical system will be described.

The work is supported by BMBF-05-KS7KF3

O 27.33 Tue 18:30 P2

Liquid Interfaces Scattering Apparatus (LISA) for PETRA III: Design and Modelling — ●BENJAMIN RUNGE¹, BRIDGET MURPHY¹, MATTHIAS GREVE¹, ANNIKA ELSSEN¹, JOCHIM STETTNER¹, OLIVER SEECK², and OLAF MAGNUSSEN¹ — ¹IEAP, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — ²PETRA III at DESY, Notkestr. 85, D-22603 Hamburg, Germany

With the completion of PETRA III at DESY Hamburg a high brilliance synchrotron source will be available. This will create new opportunities for studies of buried interfaces, such as liquid-liquid interfaces.

Our Liquid surface diffractometer, LISA, currently under construction, will operate in the energy range from 6.4keV to 30keV and provide access to a momentum space of up to $q_z = 2.5 \text{ \AA}^{-1}$. LISA will take advantage of the low vertical and horizontal divergence available at the high resolution X-ray beamline by employing a double crystal setup instead of a single beam tilt crystal as in current liquid surface diffractometers. As a result the angle of incident can be simply varied through a rotation of the crystal stage eliminating the need to move the sample during reflectivity measurements. Furthermore, the sample stage will be mechanically decoupled from both the beam tilt element and the detector stage. This setup will allow to minimize mechanical vibrations of the liquid interface, a key issue in such studies. We present the design concept for LISA and model calculations for the performance of the x-ray optics.

This work is supported by BMBF-05-KS7KF3.

O 27.34 Tue 18:30 P2

Coverage dependence of capture numbers in kinetic thin film growth and its impact on island size distributions — ●MARTIN KÖRNER, MARIO EINAX, and PHILIPP MAASS — Institut für Physik, Technische Universität Ilmenau, Germany

The growth of self-organized structures in thin film metal epitaxy is governed by the nucleation kinetics in the submonolayer regime. In the theoretical description of this nucleation kinetics in terms of mean-field rate equations a long-standing problem is the determination of capture numbers, which describe the ability of clusters on the substrate surface to capture further adatoms. Using extensive Kinetic Monte Carlo simulations we present for the first time a systematic analysis of these capture numbers as functions of coverage and cluster size for both fractal and compact island shapes. This allows us to perform a quantitative check for the validity of the mean-field rate equations and to compare the island size distribution from KMC simulations with numerical results from the corresponding rate equations.

O 27.35 Tue 18:30 P2

A High-Dimensional Neural Network Potential-Energy Surface for Zinc Oxide — ●NONGNUCH ARTRITH, MARCUS MASCHKE, and JÖRG BEHLER — Lehrstuhl für Theoretische Chemie, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Zinc oxide is a technologically important material, for example as support in heterogeneous catalysis. In order to study a variety of interesting problems it is necessary to perform long simulations of large systems, which are beyond the capabilities of established methods like density-functional theory. Recently, artificial Neural Networks (NN) trained to first-principles data have shown to provide accurate potential energy surfaces for condensed systems, which are computationally very efficient to evaluate. However, so far these potentials have been applicable only to elemental systems. We show that by including physically derived terms it is possible to extend the NN methodology to multicomponent systems. The capabilities of the method are illustrated by first applications to zinc oxide.

O 27.36 Tue 18:30 P2

The cross-linked (1×2) surface reconstruction of rutile TiO₂ (110) — ●HANS HERMANN PIEPER, STEPHAN BAHR, STEFAN TORBRÜGGE, and MICHAEL REICHLING — Institute of Physics, University of Osnabrueck, Germany

Titanium is one of the most investigated metal oxides and its surfaces are frequently taken as model catalysts for the partial oxidation of hydrocarbons. There is a large number of publications dedicated to investigations of the pure unreconstructed rutile (110) surface and its interaction with atoms and molecules. However, the different surface reconstructions found for reduced crystals are still under discussion. We investigate the cross-linked (1 × 2) reconstruction by atomic resolution dynamic scanning force microscopy. We interpret images considering that the atomic tip termination and the tip surface distance have a huge influence on the tip-surface interaction, therefore, strongly influencing the atomic contrast formation. We compare our data to three frequently discussed surface reconstruction models and a perfect agreement with one of them is demonstrated.

O 27.37 Tue 18:30 P2

Acrolein decomposition on cerium-oxide model-catalysts: Correlation between structure and reactivity — ●JAN MARKUS ESSEN, CONRAD BECKER, and KLAUS WANDEL — Institute of Physical and Theoretical Chemistry, University of Bonn, Wegelerstrasse 12, D-53115 Bonn, Germany

The mechanism of reversible oxygen transfer by cerium oxide based catalysts is still quite unclear. Depending on order, oxygen vacancies and the presence of noble metals oxygen exchange with the oxide surface respectively oxidation of adsorbed organic molecules takes place in two temperature regimes, at about 600 K and at about 950 K. While on well ordered ceria on Pt(111) acrolein desorbs completely intact, annealing to 1000 K leads to an oxygen vacancy related coupling of acrolein on the surface. Electron bombardment of ceria on Pt(111) at 300 K results in hydroxylated surfaces with adsorbed CO₂ and H₂O. Acrolein TPD shows no defect formation. Disordered reduced oxides are generated by oxygen adsorption on 2 ML Ce/Pt(111). Acrolein decomposition here proceeds via C₁-O bond cleavage at 600 K. The remaining propylidene decomposes at 950 K in combination with CO/CO₂ desorption. Finally, Pd deposited on ceria on Pt(111) shows a carbon removal by recombinant CO desorption at about 600 K. The reaction with the surface oxygen at 600 K is suggested to be caused by an enhanced oxygen diffusion starting at this temperature, while the oxidation at 950 K is assumed to result from desorbing oxygen forming O₂ vacancies.

O 27.38 Tue 18:30 P2

Correlation between structural and optical properties of PTCDA monolayers on NaCl/Ag(100) — ●MATHIAS MÜLLER, ERIC LE MOAL, OLIVER BAUER, and MORITZ SOKOŁOWSKI — Institut für Physikalische u. Theoretische Chemie, Universität Bonn, Wegelerstraße 12, 53115 Bonn

We have investigated the structural and optical properties of PTCDA-(sub)monolayers adsorbed on NaCl. Using thin epitaxial NaCl films grown on Ag(100) it was possible to characterize the PTCDA layers by spot profile analysis-LEED and in parallel with in-situ photoluminescence spectroscopy. Under optimized evaporation conditions we succeeded to obtain ordered PTCDA films, which can be described as a 3×3 superstructure. This superstructure is similar to the one of PTCDA observed on Ag(100), but the lattice constant and azimuthal broadening prove that PTCDA is adsorbed on NaCl. Presumably due to the commensurability and the high order of the structure we observed sharp peaks in the photoluminescence spectra (similar to [1]) which also show interesting finestructure at low temperature. Furthermore, by cooling the sample at 20 K during evaporation, we prepared a disordered PTCDA phase. By annealing the sample, we could observe a phase transition to the ordered structure by SPA-LEED. This phase transition can also be seen as a redshift in the photoluminescence which we explain by the dipole-dipole-coupling in the PTCDA monolayer. Funding by DFG research unit 557 is gratefully acknowledged. [1] T.Dienel et al., Adv. Mater. 20 (5), 959-963 (2008).

O 27.39 Tue 18:30 P2

The local adsorption structure of glycine on TiO₂(110) — T J LEROTHOLI¹, W UNTERBERGER², E A KRÖGER², M KNIGHT¹, D J JACKSON¹, ●D KREIKEMEYER LORENZO², K HOGAN³, C LAMONT³, and D P WOODRUFF¹ — ¹University of Warwick, UK — ²Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — ³University of Huddersfield, UK

Scanned-energy mode photoelectron diffraction (PhD) is a well-known technique to determine quantitatively the local structure of adsorbates at surfaces. Here we report the application of this method to study

the adsorption of glycine on TiO₂(110). The adsorption of such small biologically-related molecules has potential relevance to issues of biocompatibility, and in this context TiO₂ is of particular interest, since many medical implants are fabricated from Ti metal. We know from previous studies on Cu(110) that the deprotonated glycine (glycinate) bonds to the surface through both the carboxylate O atom and the amino N atom in one-fold coordinated sites. However, if the glycinate carboxylate O atoms adopt the same geometry as formate on TiO₂(110), the spacing of the Ti atoms along [1-10] is much larger than the equivalent Cu-Cu spacing, and has bridging O atoms between, so a similar lying-down geometry seems unlikely. We therefore expect glycine to bond to TiO₂ through either carboxylate O atoms or the amino N atoms. O1s PhD spectra show much stronger modulations than N1s PhD, consistent with bonding only through the carboxylate O atoms which occupy off-atop Ti sites, and a standing-up geometry. Quantitative evaluations of the data confirm this conclusion.

O 27.40 Tue 18:30 P2

DFT study of TMA on Rutile TiO₂(110) — ●ANDREAS GREULING, PHILIPP RAHE, and MICHAEL ROHLFING — Universität Osnabrück, Barbarastr.7,D-49069,Osnabrück

TiO₂ is a semiconductor which is used in many applications. For instance, it is used in biotechnology, cosmetic industry, paint industry, in catalysis or photocatalysis. In addition, it is also an ideal system for studying self-assembly of organic molecules aiming at the construction of nanoscale devices. This results from the combination of moderate molecule-substrate interaction, quasi-one-dimensional behavior, and the possibility of anchoring molecules to surface defects. Motivated by preliminary experimental data for TMA(trimesic acid) on TiO₂(110)[1] we explore the system within DFT using the SIESTA code to investigate several possible adsorbing orientations. Starting from various initial configurations of TMA molecule we relax the system until mechanical equilibrium is achieved. The adsorption energy of each configuration is corrected for basis-set superposition error. Our results predict that orientations where the TMA lies on the surface are energetically favorable with respect to upright configurations.

[1] P. Rahe will give a talk about TPA (terephthalic acid) on TiO₂ at this conference.

O 27.41 Tue 18:30 P2

Scanning Tunneling Microscopy and Spectroscopy of Phthalocyanine Molecules on Insulating Films —

●CHRISTOF UHLMANN¹, MAURICE ZIOLA¹, NIKO PAVLIČEK¹, TOBIAS SONNLEITNER¹, GERHARD MEYER², and JASCHA REPP^{1,2} — ¹Institute of Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — ²IBM Research, Zurich Research Laboratory, CH-8803 Rüschlikon, Switzerland

Ultrathin insulating films on metal substrates facilitate the use of the scanning tunneling microscope to study the electronic properties of individual molecules, which are electronically decoupled from the metallic substrate. This geometry represents a double-barrier tunneling junction, in which at the resonances in conductance spectra an electron is temporarily added to or removed from the molecule. To gain a detailed understanding of the spectra, it is desirable to systematically vary the electronic structure of molecules step by step without changing the geometrical structure too strongly. We addressed this issue by studying a series of metal-phthalocyanine molecules. In this series, the lowest unoccupied (LUMO) and the highest occupied molecular orbital (HOMO) can differ greatly in symmetry for the different metal cores [1]. In addition to the variation of the electronic structures of the molecule itself we also varied the level alignment with respect to the Fermi level. The latter was done by varying the substrate system, which is accompanied by a variation in the work-function.

[1] M.-S. Liao and S. Scheiner, J. Chem. Phys. 114, 9780 (2001).

O 27.42 Tue 18:30 P2

Investigation of the adsorption of CO and simple alcohols on the Rutile(110) surface with He atom scattering and spectroscopic methods — ●DAVID SILBER¹, MARTIN KUNAT¹, FRANZISKA TRAEGER¹, HENGSHAN QUI¹, YUEMIN WANG¹, CHRISTOF WÖLL¹, PIOTR KOWALSKI¹, BERND MEYER², and CHRISTOF HÄTTIG¹ — ¹Lehrstuhl für Physikalische Chemie I, Lehrstuhl für Theoretische Chemie an der RUB, Bochum — ²Interdisziplinäres Zentrum für Molekulare Materialien (ICMM), Erlangen

We have studied the adsorption of CO on the rutile TiO₂(110) surface. He-atom angular distributions were recorded to characterize the ordering of adsorbed CO and revealed a (1x1) diffraction pattern along both

high-symmetry directions. Surprisingly, the width of the diffraction peaks was strongly different also the two high-symmetry directions. We explain this anomaly by the presence of a structure containing grows of CO-molecules tilted in an alterante fashion, yielding either a (2x1) or a (2x2) superstructure. Both structures exhibit glide planes, leading to peak extinctions along both high symmetry directions. The binding energy of the CO molecule to the surface as determined by using He-TDS and conventional TDS amounts to 8.0 kcal/mol. We also report first results about overlayer structures observed for different alcohols and their binding energies on the same substrates. For methanol and ethanol we provide evidence that the interaction with the surface leads to deprotonation. Data from near edge x-ray absorption spectroscopy supports this conclusion.

O 27.43 Tue 18:30 P2

Preparation and Investigation of one-dimensional ZnO nanostructures using the CVD process — ●PATRICIA THOMASEN, YONG LEI, and GERHARD WILDE — Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, Germany

The preparation of one-dimensional (1D) ZnO nanostructures via the CVD process is reported here. The growth follows the VLS process in a self-built CVD system. From the powder source, consisting of equal molar amounts of ZnO and C powders, the reactant vapor is transported to the substrate with the help of constant Argon flow. For the oxidation of the nanowires, only the leakage of oxygen inside the system is used. To obtain a good regularity of the wires, a UTAM (Ultra Thin Alumina Mask) surface nano-patterning process was used to produce regular arrays of catalyst dots on the substrate. The UTAMs were first tested for having a highly ordered arrangement of pores themselves. This was done by AFM measurements and a following Fourier transformation of the data. The so grown nanowires were afterwards characterized by SEM, XRD and PL measurements.

O 27.44 Tue 18:30 P2

The growth of ultrathin Praseodymia films on passivated highly boron-doped Si(111) surfaces — ●SEBASTIAN GEVERS¹, DANIEL BRUNS¹, FLORIAN BERTRAM¹, TIMO KUSCHEL¹, MARTIN SUENDORF¹, LARS BOEWER², CHRISTIAN STERNEMANN², MICHAEL PAULUS², and JOACHIM WOLLSCHLÄGER¹ — ¹Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrück — ²DELTA, Universität Dortmund, Maria-Goeppert-Mayer-Str. 2, D-44227 Dortmund, Germany

The Germanium On Insulator (GOI) technology is a cost-effective method to integrate III-V optoelectronic materials like GaAs on the dominating Si material platform. This is due to the negligible thermal and lattice mismatch between Ge and GaAs. Good candidates for the insulating buffer material are lattice matched high quality praseodymia films to grow dielectric heterostructures on Si(111) with low defect density. However, it is essential to use passivated silicon substrates in order to prevent the formation of silicate at the substrate-oxide interface.

In this work hexagonal Pr₂O₃ films were grown on passivated highly boron-doped Si(111) substrates at different temperatures to realize and characterise high quality praseodymia films on passivated Si(111). During and after the growth process the surface structure and morphology were analysed with Spot Profile Analysis Low Energy Electron Diffraction (SPALED). Additional X-Ray Reflection (XRR) investigations at DELTA were performed to analyse the formation of both oxide film and interfacial silicate.

O 27.45 Tue 18:30 P2

The growth of ultrathin Praseodymia films on passivated highly boron-doped Si(111) surfaces — ●SEBASTIAN GEVERS¹, DANIEL BRUNS¹, FLORIAN BERTRAM¹, TIMO KUSCHEL¹, MARTIN SUENDORF¹, LARS BOEWER², CHRISTIAN STERNEMANN², MICHAEL PAULUS², and JOACHIM WOLLSCHLÄGER¹ — ¹Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrück — ²DELTA, Universität Dortmund, Maria-Goeppert-Mayer-Str. 2, D-44227 Dortmund, Germany

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boron-doped Si(111) substrates at different temperatures to realize and characterise high quality praseodymia films on passivated Si(111). During and after the growth process the surface structure and morphology were analysed with Spot Profile Analysis Low Energy Electron Diffraction (SPA-LEED). Additional X-Ray Reflection (XRR) investigations at DELTA were performed to analyse the formation of both oxide film and interfacial silicate.

O 27.46 Tue 18:30 P2

Epitaxial Europiumoxide on Ni(100) — •DANIEL F. FOERSTER, JÜRGEN KLINKHAMMER, CARSTEN BUSSE, and THOMAS MICHELY — II. Physikalisches Institut, Universität zu Köln, Zùlpicher Str. 77, 50937 Köln, Germany

Stoichiometric EuO is one of the rare ferromagnetic semiconductors. Slightly Eu-rich EuO contains oxygen vacancies which cause an additional semiconductor to metal transition (SMT) with resistivity changes up to 12 orders of magnitude simultaneously with the ferromagnetic transition.

We report on the growth of EuO on Ni(100) using molecular beam epitaxy with film thicknesses ranging from below one atomic layer up to several layers. The growth process is characterised at the atomic scale by in-situ variable temperature scanning tunneling microscopy (STM) and low energy electron diffraction (LEED). Using substrate temperatures of 350°C EuO films grow quasi-pseudomorphically with their [100] direction oriented along the [110] direction of Ni, whereat two Ni nearest neighbour distances fit the EuO lattice constant. In consequence this quasi-pseudomorphic EuO phase is compressed by 3.1%. Based on density functional calculations the compressed EuO must be assumed to possess a significantly higher Curie temperature compared to bulk EuO. Besides the quasi-pseudomorphic phase also EuO islands with a second epitaxial relation are observed as a minority phase of EuO films on Ni(100). This phase grows with the EuO [100] direction oriented along the [100] direction of Ni, thus being rotated 45° compared to the quasi-pseudomorphic phase.

O 27.47 Tue 18:30 P2

Structure and morphology of epitaxial manganese oxide films on Ag(001) — •KLAUS MEINEL, MICHAEL HUTH, SEBASTIAN POLZIN, KONRAD GILLMEISTER, and WOLF WIDDRA — Martin-Luther-Universität Halle-Wittenberg, Germany

STM, SPALEED, AES and HREELS have been applied to study the formation and thermal stability of manganese oxide films on Ag(001). The films have been grown by reactive Mn deposition in an O₂ atmosphere. Whereas films deposited at room temperature show a layer-like growth mode, deposition at slightly higher temperatures yields an embedding of film islands in the substrate due to Ag surface diffusion. Film deposition in an O₂ atmosphere of 2x10⁻⁸ mbar and postannealing to 620 K results in a MnO(001)-(1x1) rock salt structure which may display a moiré-like relaxation pattern in SPALEED. For film deposition in 8x10⁻⁸ mbar O₂ and postannealing, a MnO(001)-(2x1) row structure is observed with STM and SPALEED. At a film thickness around 5 ML a new structure develops which is indicated by a brilliant (2x2) diffraction pattern. It is assigned to the formation of a spinel-like Hausmannite Mn₃O₄(001) film structure where the lattice vectors are aligned along the [110]-like directions of the Ag(001) substrate. This specific orientation implies an almost vanishing misfit which may explain the high structural perfection of the Mn₃O₄ films. These results will be compared with recent data for manganese oxide thin films on Pd(001) and Pt(111) [1,2].

[1] Bayer et al., Phys. Rev. B 76, 165428 (2007).

[2] Hagendorf et al., Phys. Rev. B 77, 075406 (2008).

O 27.48 Tue 18:30 P2

STM study of the structure and morphology of TiO₂ thin films epitaxially grown on Re(10 $\bar{1}$ 0) — •SEBASTIAN SCHWEDE, SUSANNE SCHUBERT, WILHELMINE KUDERNATSCH, and KLAUS CHRISTMANN — FU-Berlin, Berlin, Germany

We have studied the epitaxy of TiO₂ (rutile) films grown on the oxygen precovered rhenium(10 $\bar{1}$ 0) surface using LEED and STM. These rutile *films* provide, by varying their thickness systematically, an easy method to generate model catalysts with a well-defined roughness.

As a first step, we prepared the well-known (1x3) oxygen superstructure on the Re surface [1], which provides an appropriate template for the subsequent growth of the (2x1) reconstructed rutile(011) phase on the Re(10 $\bar{1}$ 0) surface. STM images taken from the (1x3)-2O structure confirm that it is a reconstructed phase of the 'buckling' type.

Atomically resolved STM images of the rutile films prepared accord-

ing to ref. [2] reveal a clear zig-zag structure of the TiO₂ films and thus confirm their glide mirror symmetry, whereby periodic intensity protrusions in the images provide additional structural information. Larger scale images also support our previous conclusions concerning the growth mechanism and morphology of the (011) rutile films.

[1] J. Lenz et al., Surf. Sci. **269/270** (1992) 410

[2] D. Rosenthal et al., Surf. Sci. **600** (2006) 2830.

O 27.49 Tue 18:30 P2

Vanadium oxide films on W(110) and on natively oxidized Si: flat and nanostructured model catalysts — •BENJAMIN BORKENHAGEN¹, JÖRAN BAUCHROWITZ², GERHARD LILIENKAMP¹, and WINFRIED DAUM¹ — ¹IPPT TU Clausthal — ²MPI Hannover

We present results on structural and chemical properties of VO_x films prepared in two different ways: by V evaporation in an UHV system under O₂ atmospheres on W(110) and by a sol-gel process on Si substrates covered with a native oxide. Under oxidizing or reducing conditions at elevated temperatures the ultrathin VO_x films on W(110) can be transformed into several superstructures, e.g. (3x1), (2x1) or nearly hexagonal superstructures the latter observed in several orientations relative to the substrate as revealed by LEED. By analysis of AES we are able to relate these superstructures to W-V surface alloys, WO_x or VO_x in various oxidation states. We have derived a preliminary diagram of the existence range of surface phases of VO_x on W(110). We investigated the films with Low Energy Electron Microscopy (LEEM) to determine domain sizes and alignment and to see how transformations between different superstructures occur. Ultrathin VO_x films with low roughness were prepared by a sol-gel process. Depending on subsequent heating, our AFM studies show the formation of multiple surface topographies such as plateaus, needle-like crystallites and tubs. AES and tunneling AFM (TUNA) were used to determine chemical and physical properties of the structures. LEEM has been applied to distinguish between conducting and insulating crystallites and to study changes in conductivity during annealing of the samples in UHV.

O 27.50 Tue 18:30 P2

SPA-LEED investigations on highly boron-doped Si(111) Surfaces after annealing in UHV — •DANIEL BRUNS, SEBASTIAN GEVERS, TIMO KUSCHEL, FLORIAN BERTRAM, MARTIN SUENDORF, THOMAS WEISEMOELLER, GREGOR STEINHOFF, and JOACHIM WOLLSCHLAEGER — Fachbereich Physik, Universitaet Osnabrueck, Barbarastr. 7, 49069 Osnabrück

'Dangling bonds' at the Si(111) surface benefit the formation of thick interface layers between the silicon substrate and oxide films during the deposition process. This is often unwanted for potential electronic applications such as MOSFET or GOI. Therefore it is needful to investigate passivated silicon surfaces which may prevent intermixing of substrate and adsorbate.

Highly boron-doped Si(111) substrates were annealed at 1000°C and cooled down very slowly to achieve complete saturation of the 'dangling bonds' under reconstruction to the Si(111)($\sqrt{3} \times \sqrt{3}$)R30° phase. The surface morphology of the prepared substrates was analyzed by SPA-LEED. The diffraction peaks show multiple splittings caused by faceting of the surface. A model with big step-bunches and large terraces was developed to explain our experiments. Afterwards the stability of the ($\sqrt{3} \times \sqrt{3}$)R30° phase was tested under UHV conditions at temperatures from 300°C to 700°C.

O 27.51 Tue 18:30 P2

Decomposition of the Si(111)-2x1 Surface Reconstruction at Room Temperature: an STM Study — •THOMAS K. A. SPAETH¹, MARTIN WENDEROTH¹, KAROLIN LÖSER¹, JENS K. GARLEFF², and RAINER G. ULBRICH¹ — ¹IV. Phys. Inst., Georg August Univ. Göttingen, Germany — ²PSN, Eindhoven University of Technologie, the Netherlands

The π -bonded chains of the Si(111)-2x1 reconstructed surface are highly anisotropic with quasi 1-d electronic properties [1, 2]. We prepared the surfaces by cleaving bulk crystals. During STM measurements in UHV (8 · 10⁻¹⁰ mbar to 6 · 10⁻¹¹ mbar) we observed a gradual decomposition of the Si(111)-2x1 surface structure. It starts with small holes which grow gradually. The new surface shows no reconstruction or any periodic structure. Comparing the topographic height with monatomic step as a reference we find that the step height between the original reconstruction and the new surface is only half the height difference of the monolayer. By measurements at diverse UHV pressures we find a variation of the rate of decomposition: with increasing pressure the decomposition takes several days at 6 · 10⁻¹¹ mbar, and

only a few hours at $8 \cdot 10^{-10}$ mbar. Finally the surface ordering vanishes completely. For this type of surface no further degradation is observed. Our findings indicate that the partial and finally even complete removal of the first atomic layer leads to a more stable surface structure which is not long-range ordered.

- [1] M. Roling and S. G. Louie, PRL 83 (4), 856 (1999)
 [2] J. K. Garleff et al., PRB 76, 125322 (2007)

O 27.52 Tue 18:30 P2

Direct measurement of surface stress anisotropy on Si(100) surfaces by means of SSIOD and homoepitaxial growth — •FRIEDRICH KLASING and MICHAEL HORN-VON HOEGEN — University of Duisburg-Essen, Institute for Experimental Physics

Surface stress is one of the most important physical quantities for the formation of structure and morphology of solid surfaces due to its large contribution to the total energy. Unfortunately, the direct measurement of surface stress is not possible, but it can be determined via the elastic response of a thin substrate as utilized in bending sample techniques like surface stress induced optical deflection (SSIOD) [1]. The morphology of bare Si(100) surfaces is strongly influenced by the anisotropic stress of the (2×1) dimer structure. Theory predicts compressive stress along the dimer bond ($\sigma_{\parallel} > 0$) and tensile stress perpendicular to the dimer bond ($\sigma_{\perp} < 0$). For the technologically most important semiconductor surface - Si(100) - there still is no direct method to measure this important parameter.

Utilizing the formation of a single (2×1) domain structure during homoepitaxial growth under kinetic limitations at $400^{\circ} - 500^{\circ}C$ on a slightly vicinal surface it was possible to directly determine the difference of the tensor components $\Delta\sigma = \sigma_{\perp} - \sigma_{\parallel}$ via SSIOD for the first time. The presented findings are well within predictions.

- [1]: A. Schell-Sorokin et al., Phys. Rev. Lett. 64(9), 1039 (1990)

O 27.53 Tue 18:30 P2

Surface Characterisation of GaSb-films grown by MOCVD — •ANDREAS SEEMAYER¹, ALEXANDER HOMMES¹, SASCHA HÜMANN², DIRK VOGEL², STEPHAN SCHULZ³, and KLAUS WANDEL¹ — ¹Institute for Physical Chemistry, University of Bonn, Germany — ²Max Planck Institut für Eisenforschung, Düsseldorf, Germany — ³Department of Chemistry, University of Essen, Germany

III-V semiconductor films used for opto- and microelectronic devices have traditionally been grown by (MO)MBE and LPE processes. An alternative metal-organic CVD-process, which has been established in the last two decades for high-throughput and low-cost fabrication works for nitrides, phosphides and arsenides, but is problematic for antimonides. In particular, for GaSb films an alternative route is a CVD-process using the heterocyclic single source precursor [*t*Bu₂GaSbEt₂]₂.

Subject of the present work is the gas phase behaviour of the used precursor under UHV conditions and the surface characterisation of thin GaSb-films, which were grown in a self-made HV-MOCVD reactor on Si(001), by AES, S-XPS and AFM. The results are discussed in terms of a correlation of the electronic properties with the composition and structure of the films.

O 27.54 Tue 18:30 P2

The influence of diffusion anisotropy and strain on Ag nanowire formation on flat and vicinal Si(001) — •DIRK WALL, SIMON SINDERMANN, MICHAEL HORN-VON HOEGEN, and FRANK-JOACHIM MEYER ZU HERINGDORF — Address: Department of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE) Universität Duisburg-Essen, D-47057 Duisburg, Germany

Photoemission Electron Microscopy (PEEM) and Low Energy Electron Microscopy (LEEM) are used to study the self organized growth of Ag nanowires on flat and vicinal Silicon (001) surfaces. The nanowires form along the two dimer row directions on the flat Si substrate. During growth on substrates with higher vicinalities, between 0° and 4° along the [110] direction, the wires start to form predominantly aligned with the steps. Finally, on a 4° vicinal substrate, all wires are aligned with the steps [1]. This increasing alignment of the nanowires along the $[\bar{1}10]$ direction is attributed to the increase in diffusion anisotropy of Ag adatoms on increasingly vicinal Si substrates [1,2]. For strained islands, calculations predict that the islands will nucleate in a symmetrical shape on the surface until the lattice mismatch forces the islands to become elongated in one direction and shrink in the perpendicular direction [3]. We will show present results as to which of the two mechanisms, strain and/or diffusion anisotropy are affecting wire formation. [1] D. Wall et. al.; J. P.:Cond. Matt. (submitted) [2] D. Wall et. al.; Mater. Res. Soc. Symp. Proc. 1088E; 1088-W05-04(2008) [3]

J. Tersoff, R. M. Tromp; Phys. Rev. Lett. 70 (1993) 2782

O 27.55 Tue 18:30 P2

Metal induced faceting of Si (112) — •TOBIAS NABBEFELD, CHRISTIAN WIETHOFF, FRANK-JOACHIM MEYER ZU HERINGDORF, and MICHAEL HORN-VON HOEGEN — Department of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, 47057 Duisburg

In vapour-liquid-solid growth of Si-nanowires intense faceting of (112)-sidewalls is observed when Au is used as catalyst [1,2]. Other catalyst metals commonly used for the growth of nanowires are Ag and Al. We studied the faceting of Si (112) samples, prepared in ultra-high-vacuum by molecular-beam-epitaxy, in-situ by spot-profile-analysing low-energy-electron-diffraction (SPA-LEED). The SPA-LEED shows facet orientations with high accuracy. Several morphologic phases depending on Ag or Al coverage and temperature were found, and orientations of facets as well as the average step heights, the terrace widths and roughness were identified. The temperature dependence of the faceting process is analysed for temperatures between $380^{\circ}C$ and $740^{\circ}C$. This temperature range covers the temperatures of vapour-liquid-solid-growth mechanism and of vapor-solid-solid-growth mechanism for Al-catalysed Si-nanowires [3]. The results of these experiments will help to optimize the properties of nanowires, which are influenced by surface structures.

- [1] F.M. Ross et al., Phys. Ref. Lett. 95, 146104, 2005
 [2] C. Wiethoff et al., Nano Lett. 8, 3065, 2008
 [3] Y. Wang et al., Nature Nanotech. 1, 186, 2006

O 27.56 Tue 18:30 P2

2D electrical conductivity in the Bi(111) surface state — •HICHEM HATTAB¹, GIRIRAJ JNAWALI¹, THORSTEN WAGNER², ROLF MÖLLER¹, and MICHAEL HORN-VON HOEGEN¹ — ¹Fachbereich Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany — ²Johannes Kepler University Linz, Institute of Experimental Physics, Altenberger Str. 69, A-4040 Linz, Austria.

Bismuth is a semi metal with unique electronic properties. Recent investigations show that for atomically smooth ultra thin Bi(111) films the electronic density of states near the Fermi level is dominated by a highly metallic surface state [1]. Such films are ideally suited to study 2D electronic transport and roughness induced scattering effects.

Epitaxial Bi(111) films are grown on Si(001) at 150 K and annealed at 450 K [2]. The electric contact to the Bi surface is established by 4-point WSi₂ contacts. Since the conductivity of the Bi-films does not depend on the thickness for up to 60 nm, it has to be attributed to the electronic surface state.

Additional Bi deposition Θ_{Bi} at 80 K produces a high density of 2D-Bi islands. The island density in the sub-bilayer regime is determined by STM and increases with $\Theta_{Bi}^{1/3}$. This short scale roughness significantly decreases the surface state conductivity with $\Theta_{Bi}^{1/2}$. This behavior is explained by a simple Boltzmann transport theory for a 2D electron gas.

- [1] Hirahara et al., Appl. Phys. Lett. **91**, 202106 (2007)
 [2] Jnawali et al., Phys. Rev. B **78**, 035321 (2008)

O 27.57 Tue 18:30 P2

Angle-resolved inverse photoemission of the H-etched 6H-SiC(0001) surface — •NABI AGHDASSI, RALF OSTENDORF, and HELMUT ZACHARIAS — Physikalisches Institut, Westfälische Wilhelms-Universität Münster

The etching of 6H-SiC(0001) substrates in molecular hydrogen at elevated temperatures leads to an ordered silicate adlayer as it is confirmed by LEED and AES. LEED patterns clearly feature a $(\sqrt{3} \times \sqrt{3})R30^{\circ}$ periodicity while AES spectra are evidence for the presence of Si-O bonds. The generated surfaces appear to be fully passivated and therefore stable in ambient air. After cleaning the samples by heating in UHV up to temperatures around $750^{\circ}C$ angle-resolved inverse photoemission is performed on the SiO₂/SiC interface. The IPE spectra reveal five features above the Fermi level around 0.5 eV, 1.2 eV, 2.3 eV, 3.5 eV and 5.5 eV, respectively, which show only a weak dispersion along the $\Gamma - M$ and $\Gamma - K$ directions of the (1×1) surface Brillouin zone.

O 27.58 Tue 18:30 P2

Preparation and Characterization of Gold Micro-Crystals on an artificial SiO₂-Layer on Silicon — JAWAD SLIEH, •ANDREAS WINTER, ARMIN BRECHLING, WIEBKE HACHMANN, and ULRICH HEINZ-

MANN — Molecular and Surface Physics, Bielefeld University

We report on the fabrication of gold micro-crystals in the size range between several 100 nm and approximately 3 μm . Gold was deposited on dry oxidized silicon wafer pieces (001) by Ar-sputtering at a deposition rate of 0.11 nm/s and an Ar partial pressure of 13 Pa. The subsequent annealing was made in a nitrogen atmosphere at different temperatures (900°C – 1050°C) as well as at different annealing times (2 h – 10 h). The influence of the deposited gold layer thickness, of the annealing temperature and of the annealing time on the crystal size, on the crystal orientation and on the amount of single crystals were studied systematically. The lateral and vertical sizes of the gold clusters were characterized by means of Scanning Electron Microscopy and Atomic Force Microscopy, respectively. The orientation of the gold crystals relative to the substrate was characterized by X-Ray Diffraction and Laue Diffraction techniques.

O 27.59 Tue 18:30 P2

FTIR-Spectroscopy of MOCVD-Prepared Silicon (100) — ●PETER KLEINSCHMIDT, ANJA DOBRICH, HENNING DÖSCHER, SEBASTIAN BRÜCKNER, CHRISTIAN HÖHN, and THOMAS HANNAPPEL — Helmholtz-Zentrum Berlin für Materialien und Energie, Glienicke Str. 100, 14109 Berlin

Using silicon to replace III-V semiconductors or germanium as a substrate material in high-performance devices like high-efficiency multi-junction solar cells is attractive due to cost considerations and better availability. In order to achieve defect-free epitaxy on Si(100), the surface should exhibit double atomic steps. MOCVD-preparation of Si(100) typically results in single atomic steps where Si-Si dimer orientation alternates on adjacent terraces. In the MOCVD reactor, the presence of hydrogen may have a crucial impact on the step formation at the surface.

We have investigated MOCVD-prepared Si(100) using Fourier-transform infrared (FTIR) spectroscopy in an attenuated total reflection (ATR) configuration enabling sensitive measurements of the silicon-hydrogen bonds at the surface. The measurements showed Si-H mono-hydrides, which are characterized by absorption lines due to a symmetric and an antisymmetric stretch mode. This is in agreement with results from low-energy electron diffraction (LEED) and scanning tunneling microscopy (STM), which indicated that the surface unit cell consists of silicon dimers. The FTIR measurements suggest that the dangling bonds of the dimers are saturated with hydrogen.

O 27.60 Tue 18:30 P2

In-situ RAS analysis of homo- and hetero-epitaxial GaP(100) surfaces grown by MOVPE — ●HENNING DÖSCHER, SEBASTIAN BRÜCKNER, and THOMAS HANNAPPEL — Helmholtz-Zentrum Berlin für Materialien und Energie, Glienicke Str. 100, 14109 Berlin

Control over the atomic properties of III-V compound semiconductor surfaces is of crucial importance for the preparation of well-defined hetero-interfaces in many thin film devices, e.g. solar cells, lasers, and LEDs. Reflectance anisotropy spectroscopy (RAS) is an extremely surface sensitive optical probe applicable for in-situ measurements in the MOVPE environment. The MOVPE deposition of gallium phosphide on Si(100) is studied here as an exemplary model system for the hetero-epitaxial III-V growth on non-polar substrates since this material combination represents an almost perfect lattice match.

The created hetero-interface gives rise to the formation of anti-phase domains (APDs) according to the step structure of the substrate, which are considered as a crucial defect mechanism in these samples. Recently, RAS was applied for quantitative in-situ measurements for APDs on the surface of GaP/Si(100) thin films. The success of this approach depends on the correct consideration of all influences on the structure and intensity of the characteristic RA spectra. In the case of GaP(100) surfaces, not only the reconstruction, but also the sample temperature and the applied preparation route have to be regarded. In the investigated thin film system additional signal contributions arise due to APD content and interference with the interfacial reflection, which potentially is anisotropic in itself.

O 27.61 Tue 18:30 P2

Comparison on the local adsorption of cyclopentene and benzene on Si(100) — ●DANIEL WEIER¹, TOBIAS LÜHR¹, AXEL BEIMBORN¹, ANJA WADEWITZ¹, and CARSTEN WESTPHAL^{1,2} — ¹Fakultät Physik - Technische Universität Dortmund, Otto-Hahn-Str.4, D 44221 Dortmund, Germany — ²DELTA - Technische Universität Dortmund, Maria-Goepfert-Mayer-Str. 2, D 44227 Dortmund, Germany

There has been considerable interest in the behaviour of the bonding process of unsaturated hydrocarbons with semiconductor surfaces. These systems offer a potential route to optoelectronic and bioanalytical devices if functional groups are added to the base molecules. Examples of these systems are the interaction between cyclopentene and benzene on silicon. In our experiments at beamline 11 (DELTA) these structures were studied using XPS and x-ray photoelectron diffraction. The experimental data were compared to simulation calculations in order to investigate the molecules interaction with the surface. Angle-scanned photoelectron diffraction patterns were recorded within 0-358° and 0-80° for the azimuth and polar angle, respectively. The experimental patterns are compared to simulation calculations of both systems. It will be shown that the adsorption behaviour of cyclopentene and benzene differ from each other. Cyclopentene tends to form only one type of adsorption structure whereas benzene is forming two different structures. Our results showed a combination of the 'standard butterfly' and the 'tilted bridge' structure for benzene, but a upright standing tilted structure for the cyclopentene, respectively.

O 27.62 Tue 18:30 P2

Band bending via H₂O adsorption on titanium dichalcogenide surfaces — ●STEPHAN THÜRMER, ALEXANDER PAULHEIM, LENART DUDY, BEATE MÜLLER, HENDRIK VITA, CHRISTOPH JANOWITZ, and RECARDO MANZKE — Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin

With the method of photoemission it is possible to measure occupied electronic states of a material by detection of the emitted electrons. By means of angle-resolved photoemission (ARPES) the complex electronic structures in reciprocal k-space, such as energy-band dispersion, are accessible. Band bending can be induced by Schottky contacts and therefore normally unoccupied electronic states can be reached. Here, water adsorption onto the van der Waals-like surface of Ti compounds served as contact. Photoemission analysis of the TiSe₂ transition metal dichalcogenide has shown interesting effects of dipole induced band bending [1]. Presuming Schottky contact like effects, the semiconducting behavior of this material was revealed. In accordance, preliminary ARPES measurements of the semimetal TiTe₂ in similar conditions showed no bending of the bands due to charge carrier screening of the dipole field. To further investigate the effects of water physisorption, detailed measurements and comparisons of the isostructural Ti compounds TiSe₂, TiTe₂, and TiS₂ with high resolution ARPES will be shown.

[1] J. Rasch et al., Phys. Rev. Lett. 102 (2008)

O 27.63 Tue 18:30 P2

A spectroscopy study of water adsorption on diamond surfaces — ●SIMON QUARTUS LUD¹, DOMINIQUE VERREAULT², PATRICK KOELSCH², MARTIN HUTH³, BERT NICKEL³, HENDRIK BLUHM⁴, JOHN NEWBERG⁴, MARTIN STUTZMANN¹, and JOSE ANTONIO GARRIDO¹ — ¹Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany — ²Angewandte Physikalische Chemie, Universität Heidelberg, Im Neuenheimer Feld 253, 69120 Heidelberg, Germany — ³Department für Physik, Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 München, Germany — ⁴Chemical Sciences Division, Lawrence Berkeley National Laboratories, Berkeley, CA 94720, USA

We have explored the adsorption of water layers onto different diamond surfaces at the solid-gas interface. X-ray reflectivity (XRR), sum frequency generation (SFG) spectroscopy and X-ray photoelectron spectroscopy (XPS) have been used to investigate the adsorbed water onto the diamond films under controlled humidity. XRR reveals the presence of a water film on the hydrophilic O-terminated surfaces, with a thickness increasing with humidity. Interestingly, even if highly hydrophobic, the hydrogenated surface also shows a humidity-dependent water film. SFG spectroscopy, with its high surface sensitivity, revealed different vibrational modes of interfacial water, including the so-called free OH stretching mode at 3700 cm⁻¹. Temperature dependent SFG experiments were performed to investigate the stability of the water films on H-, F- and O-terminated surfaces, unveiling a surprisingly high stability for water even on the hydrophobic surfaces.

O 27.64 Tue 18:30 P2

HR-EELS and STM study of organic molecules on Si(001) — ●BOCHRA BOUGHALED ELLAKHMIS and ULRICH KÖHLER — Experimentalphysik IV/AG Oberflächen, Ruhr-Universität Bochum, 44780 Bochum, Germany

The reaction of acrylonitrile with Si(001)-(2x1)-surfaces is studied as a first step in the field of the fabrication of organic/inorganic semiconductor hybrid structures. Layers of nitriles are a possible candidate for a template layer on silicon to enable the anchoring of organic coatings.

A combination of an area averaging spectroscopy, high resolution electron energy loss spectroscopy (HR-EELS) and a local microscopy, scanning tunnelling microscopy (STM) is used to determine the internal structure of the adsorbed molecule and the adsorption geometry on the Si-substrate. A non-dissociative cross dimer row adsorption is present at room temperature and below. HR-EELS is used to study the thermal decomposition of acrylonitrile above room temperature. First results on the reaction of organic molecules with water covered Si(001) surfaces will be shown.

O 27.65 Tue 18:30 P2

Investigation of antenna resonances for SERS in the near infrared — ●DANIEL WEBER¹, FRANK NEUBRECH¹, CHRISTINA BAUER², ANNEMARIE PUCCI¹, and HARALD GIESSEN² — ¹Kirchhoff-Institut für Physik, Universität Heidelberg, Deutschland — ²4. Physikalisches Institut, Universität Stuttgart, Deutschland

Gold nanorod arrays were investigated by infrared (IR) microscopy using synchrotron radiation at the Angströmquelle Karlsruhe (ANKA). The regularly shaped gold nanorods (width and height about 100 nm) with lengths between 400 and 1200 nm were prepared by electron beam lithography at the 4th Physics Institute, University of Stuttgart. The nanorods are placed on quartz glass (HeraSil), which is transparent for IR radiation in the near infrared spectral range. Comparable to our results from former IR spectroscopic studies of gold nanowires deposited on zinc sulphide substrates, we observed antenna-like plasmon resonances, which are accompanied by an enhanced electromagnetic field in the vicinity of the nanorods. We intend to exploit this field enhancement for surface-enhanced Raman scattering (SERS) by using an IR laser as exciting light source

O 27.66 Tue 18:30 P2

attosecond technology towards combining ultrahigh spatiotemporal resolution * nanoplasmonic optical field microscopy — ●JINGQUAN LIN¹, ADRIAN WIRTH², SOO CHEW¹, NILS WEBER³, MICHAEL MERKEL³, MATTHIAS KLING², MARK STOCKMAN⁴, FERENC KRAUSZ^{1,2}, and ULF KLEINEBERG¹ — ¹Faculty of Physik, LMU, Garching, Germany — ²Max Plank Institute of Quantenoptics, Garching, Germany — ³Focus GmbH, Huestetten Kesselbach, Germany — ⁴Georgia State University, Atlanta, USA

Nanoplasmonics deals with collective electronic dynamics on the surface of metal nanostructures, which arise as a result of resonant excitations of surface plasmons by light pulse. Because of their broad spectral bandwidth, surface plasmons undergo ultrafast dynamics with timescales as short as a few hundred attoseconds. An approach, which combines photoelectron emission microscopy and attosecond streaking spectroscopy and will provide direct, non-invasive access to the nanoplasmonic collective dynamics with nanometre-scale spatial resolution and temporal resolution on the order of 100 attoseconds, has been proposed. To implement the approach, ToF-PEEM with 25 nm spatial resolution and 50 meV energy resolution has been developed and characterized by use of 400 nm/70ps diode laser. First experimental steps towards time-resolved 2PPE photoemission microscopy as well as vis-pump/XUV-probe attosecond microscopy to measure the temporal evolution of localized optical fields will be described.

O 27.67 Tue 18:30 P2

Near Field Distribution of Nanostructures with Electromagnetic Coupling — ●PASCAL MELCHIOR¹, MARTIN ROHMER¹, CHRISTIAN SCHNEIDER¹, DANIELA BAYER¹, ALEXANDER FISCHER¹, MIRKO CINCHETTI¹, DANIEL BENNER², JOHANNES BONEBERG², PAUL LEIDERER², and MARTIN AESCHLIMANN² — ¹Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany — ²Department of Physics, University of Konstanz, 78457 Konstanz, Germany

Nonlinear photoemission electron microscopy (PEEM) is a powerful tool to directly image the near field distribution of nanostructures. On the other hand, two-photon photoemission (2PPE) spectroscopy allows the investigation of electron dynamics following the excitation with a laser pulse. As follows from Fermi-liquid theory, the electron dynamics strongly depend on the energy.

We combined a PEEM instrument with time-resolved 2PPE and time-of-flight detector (ToF) to simultaneously access space, time and energy. This gives the unique possibility to study the electron dy-

namics at nanostructured surfaces and the influence of near field enhancement on the dynamics not only with highest spatial and temporal resolution but also with the option of spectroscopic analysis of the photoemitted electrons. In particular, we devoted our attention to investigate the influence of coupling effects on the near field distribution of nanostructures with varying dimer distance, the dominant parameter that characterizes the coupling.

O 27.68 Tue 18:30 P2

Coupling of Single NV-Centres to Surface Plasmons — ●MERLE BECKER, BERNHARD GROTZ, GOPALAKRISHNAN BALASUBRAMANIAN, ROMAN KOLESOV, FEDOR JELEZKO, and JÖRG WRACHTRUP — ³Physikalisches Institut, Universität Stuttgart, 70550 Stuttgart, Germany

Subwavelength light localization is the crucial condition to achieve strong coupling between single emitters and nanosystems. Controlling the coupling and therewith controlling light quanta is of great interest in the field of quantum science. Coupling of single emitters to surface plasmons was already shown previously, however when thinking about devices, it is of big importance to gain knowledge about coupling strengths that can be achieved experimentally. As model system, we show the coupling of single NV centres to Ag nanowires at different diameters in comparison to theoretical models. NV centres were chosen as single emitters due to absolute photostability at room temperature and growing importance in quantum optics and MRI [1].

[1] G. Balasubramanian et al. *Nature* 455, 648 - 651 (2008)

O 27.69 Tue 18:30 P2

Time-Resolved Near-Field Microscopy of Acoustic Vibrations — ●THORSTEN SCHUMACHER^{1,2}, MARKUS LIPPITZ^{1,2}, RALF VOGELGESANG¹, JENS DORFMÜLLER¹, and KLAUS KERN¹ — ¹Max-Planck-Institute for Solid State Research, Stuttgart - Germany — ²4th Physics Institute, University of Stuttgart, Stuttgart - Germany

The localized surface plasmon resonance (LSPR) of metal nanoparticles depends directly on the geometry and the dielectric constant of the nanoobject. The resonance is influenced by the electron density which can be modified by acoustic oscillations of the nanostructure. The optical near-field thus contains information on the structure's acoustic oscillation.

The combination of apertureless scanning near-field optical microscopy (aSNOM) and ultrafast pump-probe spectroscopy allows to detect the temporal and spatial dependence of the LSPR. We present our implementation of a pump-probe aSNOM which at the end will allow us to map out nanoscale Chladni figures. We show numerical simulation of the field changes caused by local plasma frequency changes, nanoacoustical modes as well as first experimental results.

O 27.70 Tue 18:30 P2

Analysis Tools for Time-Resolved Two-Photon Photoelectron Microscopy of Excitations in Metal Nanostructures — MARTIN AESCHLIMANN¹, MICHAEL BAUER², DANIELA BAYER¹, TOBIAS BRIXNER³, STEFAN CUNOVIC⁴, FRANK DIMLER³, ALEXANDER FISCHER¹, WALTER PFEIFFER⁴, MARTIN ROHMER¹, CHRISTIAN SCHNEIDER¹, FELIX STEEB¹, ●CHRISTIAN STRÜBER⁴, and DMITRI V. VORONINE³ — ¹University of Kaiserslautern, Kaiserslautern, Germany — ²University of Kiel, Kiel, Germany — ³Ludwigs-Maximilian-Universität, Würzburg, Germany — ⁴University of Bielefeld, Bielefeld, Germany

The application of coherent control schemes in nanooptics aims for steering the temporal and spatial evolution of localized excitations. Polarization shaped laser pulses allow tailoring the local excitation of a nanostructure simultaneously with subwavelength spatial resolution and femtosecond timing [1,2]. The investigation of the temporal evolution of the optical near-field is based on time-resolved two-photon photoemission microscopy (TR-2P-PEEM). In such experiments spatial resolution in the nm-scale requires long-term positioning stability of the acquired PEEM patterns. Here, methods are introduced that allow eliminating artefacts because of sample drift. In addition we present the methodology for time-resolved cross correlation measurements using polarization shaped pulses as pump excitation and bandwidth-limited probe pulses.

[1] T. Brixner et al. *Phys. Rev. Lett.* **95** (2005) 093901.

[2] M. Aeschlimann et al. *Nature* **446** (2007) 301

O 27.71 Tue 18:30 P2

3D-Nanofocusing through the superposition of dipole radiation from second-harmonic emitters — ●PHILIPP REICHENBACH,

PHILLIP OLK, and LUKAS ENG — Institut für Angewandte Photo-physik, Dresden, Germany

Much research has been carried out on the optical second-harmonic (SH) generation from single metallic nanoparticles (MNP). We theoretically investigate how the second-harmonic radiation from multiple MNP emitters can be superposed to form a nanofocus in 3-dimensional space.

At first we considered the possible SH radiation emitted by single spherical and cone-shaped particles, respectively. Especially nanocones seem to be good dipole SH emitters. Secondly, the SH radiation of multiple particles is then superposed. Arranging MNPs on a circle (for instance) results in a nanofocus of ca. $\lambda/3$ in diameter, where the focal position can be tuned in space through distinct phase conditioning, such as tilting of the exciting beam.

O 27.72 Tue 18:30 P2

Evaluation of near-field enhanced Raman spectroscopy on industrial silicon structures — ●BENJAMIN UHLIG¹, JENS-HENDRIK ZOLLONDZ², MARTIN HABERJAHN², PETER KÜCHER³, and LUKAS M. ENG⁴ — ¹Fraunhofer-Institut für Keramische Technologien und Systeme, Winterbergstrasse 28, 01277 Dresden, Germany — ²Qimonda Dresden GmbH & Co. OHG, Königsbrücker Strasse 180, D-01099 Dresden, Germany — ³Center of Competence CoC Metrology/Analytic, Fraunhofer-Center Nanoelektronische Technologien CNT, Königsbrücker Straße 180, D-01099 Dresden, Germany — ⁴Institut für Angewandte Photophysik, TU Dresden, George-Bähr-Straße 1, D-01069 Dresden, Germany

Following Moore's Law, semiconductor structures become smaller and smaller. The understanding of stress intentionally implemented in devices or stress in multi-layer components due to thermal mismatch is a major challenge for metrology. A promising technique to obtain highly localized stress information is Tip Enhanced Raman Spectroscopy (TERS). This paper discusses under which conditions TERS can be applied to industrial semiconductor structures and which effects can be expected. In order to obtain an idea of the enhancement effects on Silicon, we show several Surface Enhanced Raman Spectroscopy (SERS) experiments using gold and silver nanoparticles. Parameters like particle size, incident laser wavelength and polarization settings are discussed and a first prove of a near-field like, surface sensitive enhancement on a semiconductor sample is shown.

O 27.73 Tue 18:30 P2

Calculation of optical near and far fields at metal-semiconductor hybrids — ●PATRICK SCHOLZ, STEPHAN SCHWIEGER, DAVID LEIPOLD, and ERICH RUNGE — Fachgebiet Theoretische Physik I, Technische Universität Ilmenau, 98693 Ilmenau, Germany

We calculate electromagnetic field distributions on nanostructured metal-semiconductor hybrids that are illuminated with photons near the semiconductor exciton resonance. We solve Maxwell's equations in frequency (COMSOL, RF module) and time (Lumerical, inc, FDTD solutions) space. Further, we test an approximative boundary condition (SIBC) to avoid the calculation of the fields inside the metal and speed up the calculations. Surface plasmon polaritons (SPPs) and excitons can coexist in these structures and coupled SPP-exciton modes can be formed. The coupling allows to transfer energy from pumped excitons into SPP modes. This compensates the large SPP losses. We discuss the resulting enhancement of SPP life times and propagation lengths.

O 27.74 Tue 18:30 P2

Time- and energy resolved photoelectron emission microscopy on micro- and nanostructured samples — ●CHRISTIAN SCHNEIDER, MARTIN ROHMER, DANIELA BAYER, PASCAL MELCHIOR, and MARTIN AESCHLIMANN — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, 67663 Kaiserslautern, Germany

The electronic response on optical excitation of nanostructured samples exhibits fascinating effects, such as subwavelength variations of the field strength and local field enhancements. Combining photoelectron emission microscopy (PEEM) with a femtosecond laser pump-probe-setup enables us to investigate these effects with simultaneous subwavelength spatial and femtosecond temporal resolution. A microscopic understanding of the collective electronic oscillations in nanostructures, like localized surface plasmons (LSPs) or surface plasmon polaritons (SPPs) is still missing. The technique of time-resolved PEEM gives us the opportunity to directly measure the transient lo-

cal near field as well as the electron dynamics of metallic nanostructures. The electron dynamic is strongly energy dependent regarding the excited carriers. Therefore, we upgraded our imaging unit with a ToF energy analyser (delayline-detector). This novel setup allows us to simultaneously acquire data with high spatial resolution in the nanometer regime, femtosecond time resolution and energy resolution. We will show first spectra of well prepared surfaces as well as energy resolved lifetime-maps of micro- and nanostructured samples showing LSP- and SPP-resonances.

O 27.75 Tue 18:30 P2

Tip-Enhanced Optical Microscopy of Single-Walled Carbon Nanotubes — ●CARSTEN GEORGI¹, MIRIAM BÖHMLER¹, HUIHONG QIAN¹, LUKAS NOVOTNY², and ACHIM HARTSCHUH¹ — ¹Department Chemie und Biochemie & CeNS, Ludwig-Maximilians-Universität München, Germany — ²The Institute of Optics, University of Rochester, New York 14627, USA

Optical Microscopy with nanoscale spatial resolution is an essential technique for the characterization and investigation of individual nanoobjects. We use the field enhancement in the proximity of a laser-illuminated sharp metal tip to locally probe the optical response of single-walled carbon nanotubes. In particular we image their Raman scattering and photoluminescence properties with a spatial resolution of down to 10nm [1]. We can thereby directly observe the interaction of excitons with localized defects and the local environment of the nanotube, namely DNA-wrapping [2]. Inter-nanotube energy transfer was studied for different pairs of semiconducting nanotubes forming bundles and crossings, related to electromagnetic near-field coupling [3]. We also report on our recent experimental results on electrically contacted nanotubes and the photoluminescence of nanotubes on metal surfaces.

[1] A. Hartschuh, *Angew. Chem. Int. Ed.* 47, 8178 (2008)

[2] H. Qian et al., *Nano Lett.* 8, 2706 (2008)

[3] H. Qian et al., *Nano Lett.* 8, 1363 (2008)

O 27.76 Tue 18:30 P2

Metamaterial Bragg-Stacks — ●RALF AMELING and HARALD GIESSEN — 4th Physics Institute, University of Stuttgart, Germany

Double-fishnet metamaterials consist of two layers of crossed metal wires and can show a negative refractive index for visible or infrared light when the unit cell is smaller than the wavelength of light. We demonstrate coupling of the symmetric and anti-symmetric magnetic resonances of the metamaterial with Bragg-modes in the infrared, where the dielectric space between two double-fishnet meshes forms the Bragg-cavity. The meshes with typical periods of several hundred nanometers are fabricated using electron-beam lithography and a layer-by-layer stacking technique. Experiments and simulations of up to four stacked layers of gold meshes with different distances are performed. The behavior of the resonances (anti-crossing) as well as the influence of structure parameter variations is studied. The resonances are measured using FTIR-spectroscopy.

O 27.77 Tue 18:30 P2

Metamaterial Biosensors — ●MARTIN MESCH, ZHAOLU DIAO, NA LIU, and HARALD GIESSEN — 4th Physics Institute, University of Stuttgart, Germany

In our work we use the tailored optical properties of metallic metamaterial structures to measure the concentration of biologically relevant molecules in solution.

In metamaterials, the structures consist of a basic element, the well-known split ring resonator (SRR), periodically repeated in two dimensions. Combining two of those SRRs in a symmetry-breaking fashion results in a coupled system which displays a sharp resonance in transmission and reflection of incident light. The structure is very sensitive to its vicinity, and therefore a sensor can be built by observing the shift of the resonance position. To distinguish between different molecules, a sensitive biological element (e.g., antibodies, enzymes, cell receptors) is attached to the structure, which responds positively to the molecules that are supposed to be detected.

Several experimental examples will be demonstrated, and the limits to sensitivity will be discussed.

O 27.78 Tue 18:30 P2

New designs of scanning nearfield optical microscopy probes for the time resolved investigation of nanostructures — ●MARC SALOMO, BERNHARD SCHAUF, DANIELA BAYER, MARTIN AESCHLIMANN, and EGBERT OESTERSCHULZE — Technische Universität Kaiser-

slautern, D-67663 Kaiserslautern, Germany

Scanning Nearfield Optical Microscopy (SNOM) is a versatile tool to investigate nanostructured samples. Using a pump-probe setup with a femtosecond laser system as excitation source we have the ability to optically image nanostructures with high spatial and temporal resolution. Another advantage of the probes is the capability to simultaneously perform AFM, thus also gaining topographical information about the sample. This information is essential as local defects on the surface have strong influence on the damping of e.g. localized surface plasmons (LSPs). The nearfield emitted from the SNOM-aperture excites collective electron oscillations. These processes are strongly dependent on the characteristics of the interaction between the sample and the SNOM-tip. Simulations are presented to demonstrate the suitability of the proposed probe designs for time resolved measurements on the subwavelength scale, evaluating transmission capability and pulse dispersion. In the experiment antenna based aperture probes are tailored via focused ion beam milling as well as electron beam lithography of hollow metal coated silicon dioxide pyramids. First measurements on the characterization of the sensors are presented.

O 27.79 Tue 18:30 P2

Spectroscopy of superconducting $V_3Si(001)$ in tunneling and contact regime — NADINE HAUPTMANN, MICHAEL BECKER, JÖRG KRÖGER, and RICHARD BERNDT — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany

The energy gap of the superconductor V_3Si is monitored on a yet unknown surface reconstruction most likely induced by carbon. Depending on the surface position spectroscopy reveals an asymmetric energy gap. The evolution of the energy gap with decreasing tip-sample distance from the tunneling to the contact regime indicates Andreev reflections in contact spectroscopy. Financial support by the DFG is gratefully acknowledged.

O 27.80 Tue 18:30 P2

Controlling the Kondo Effect in $CoCu_n$ Clusters Atom by Atom — NICOLAS NÉEL¹, JÖRG KRÖGER¹, RICHARD BERNDT¹, TIM WEHLING², ALEXANDER LICHTENSTEIN², and MIKHAIL KATSNELSON³ — ¹Christian-Albrechts-Universität zu Kiel, D-24098 Kiel, Germany — ²Universität Hamburg, D-20355 Hamburg, Germany — ³Radboud University Nijmegen, NL-6525 AJ Nijmegen, The Netherlands

Clusters containing a single magnetic impurity were investigated by scanning tunneling microscopy, spectroscopy, and *ab initio* electronic structure calculations. The Kondo temperature of a Co atom embedded in Cu clusters on Cu(111) exhibits a non-monotonic variation with the cluster size. Calculations model the experimental observations and demonstrate the importance of the local and anisotropic electronic structure for correlation effects in small clusters. Financial support by the DFG through SFB 668 is acknowledged.

O 27.81 Tue 18:30 P2

Thin epitaxial $Bi(111)$ films on $Si(111)$ studied by ARPES — HOLGER SCHWAB¹, HENDRIK BENTMANN¹, FRANK FORSTER¹, LUCA MORESCHINI², MARCO GRIONI², and FRIEDRICH REINERT^{1,3} — ¹Universität Würzburg, Experimentelle Physik II, Am Hubland, D-97074 Würzburg, Germany — ²Ecole Polytechnique Fédérale de Lausanne (EPFL), Institut de Physique des Nanostructures, CH-1015 Lausanne, Switzerland — ³Forschungszentrum Karlsruhe, Gemeinschaftslabor für Nanoanalytik, D-76021 Karlsruhe, Germany

Employing angle-resolved photoelectron spectroscopy (ARPES) we have studied thin films of $Bi(111)$ on a $Si(111)$ substrate. The film growth was characterized by reflection high energy electron diffraction (RHEED). We present Fermi surfaces and band structures for different film thicknesses. Quantum well states (QWS) as well as the $Bi(111)$ surface state are observed. Our measurements are in good agreement with previous results. The variation of the line width of the QWS was measured over a broad temperature range from 70K to 300K. This allows for the determination of the electron-phonon coupling constant λ as a function of film thickness.

O 27.82 Tue 18:30 P2

Spin-resolved inverse photoemission experiments on $Ni/GaAs(001)$ — CHRISTIAN EIBL, ANDRÉ BERKEN, MANUEL PRÄTORIUS, ANKE B. SCHMIDT, and MARKUS DONATH — Physikalisches Institut, Westfälische Wilhelms-Universität Münster

To understand the interplay between crystal structure, electronic

states, and magnetism, it is worthwhile to compare the different ferromagnetic elements. Unfortunately, the thermodynamically stable crystal structures of Ni, Fe, and Co are face-centered cubic (fcc), body-centered cubic (bcc), and hexagonal close-packed (hcp), respectively. Thus, a direct comparison is hampered and scientists endeavor to crystallize Fe, Co, and Ni in a non-native structure.

Recently, it was shown by Tian *et al.* that Ni can be stabilized in the bcc structure on a GaAs(001) substrate. In contrast to the fcc structure, it was found that bcc Ni exhibits different magnetic properties, e.g., Curie temperature and magnetic anisotropy. Additionally, a photoemission experiment revealed differences in the electronic structure below the Fermi level [1].

To gain further insight into the electronic structure of bcc Ni also above the Fermi level, we used spin-resolved inverse photoemission to investigate Ni films on GaAs(001) as a function of thickness. Furthermore, we compared our results with measurements on fcc Ni/Cu(001).

[1] C.S. Tian *et al.*, Phys. Rev. Lett. **94**, 137210 (2005)

O 27.83 Tue 18:30 P2

Comparison of angular resolved photoemission on Pt(110) with DFT bulk band calculations — ALEXANDER MENZEL, CHRISTIAN BRAUN, PETER AMANN, and ERMALD BERTEL — Institute for Physical Chemistry, University of Innsbruck, Austria

Angular resolved photoemission (ARPES) experiments of clean and halogenated Pt(110) are compared with the DFT-derived bulk band structure of Platinum. Numerous dispersion features agree with the calculated one-dimensional density of states (kz-histogram) indicating emission from near surface transitions. In order to distinguish the effects of initial state (surface resonances), matrix element (surface photoemission) and final state (strong photoelectron damping), we varied incident polarization, photon energy, and surface phase symmetry.

O 27.84 Tue 18:30 P2

Electronic fine structures of perfluoropentacene films by ultraviolet photoelectron spectroscopy — SHUNSUKE HOSOMI, SHINICHI NAGAMATSU, SATOSHI KERA, and NOBUO UENO — Chiba University, Japan

Pentacene (PEN) and perfluoropentacene (PFP) are currently the most potential conjugated organic molecules as active materials in novel electronic devices[1]. The intramolecular charge reorganization energy (λ), which is related to the electron-phonon coupling, is important parameter for efficient transport of charges in organic materials and across related interfaces. However, λ has been discussed based on highly-resolved spectra of gas-phase molecules [2]. Recently, we have succeeded to assess λ directly from the fine features in high-resolution UPS of organic solid systems by fabricating a well-ordered monolayer deposited on graphite [3]. In this paper, we compare the electronic structures of the well-ordered monolayer both for PEN/graphite and PFP/graphite. The UPS band derived from the highest occupied molecular orbital (HOMO) for both monolayer systems shows fine structures clearly, indicating the molecular vibrational modes strongly couple to photoelectron (HOMO hole). The λ for PFP is about two times larger than PEN. The take-off angle dependence of the UPS spectra that the Franck-Condon principle is not strictly satisfied in the photoionization process will be discussed.

[1] Y. Inoue *et al.*, Jpn. J. Appl. Phys. **44**, 3663 (2005). [2] J-L. Bredas *et al.*, Chem. Rev. **104**, 4971 (2004). [3] H. Yamane *et al.*, Phys. Rev. B **72**, 153412 (2005).

O 27.85 Tue 18:30 P2

Tunneling Spectroscopy of nanoporous networks - comparison of experiment and modelization — WOLFGANG KRENNER¹, DIRK KÜHNE¹, FLORIAN KLAPPENBERGER¹, IÑAKI SILANES², ANDRES ARNAU², JAVIER GARCÍA DE ABAJO³, SVETLANA KLYATSKAYA⁴, MARIO RUBEN⁴, and JOHANNES BARTH¹ — ¹Physik Department E20, TU München, Germany — ²Donostia International Physics Center (DIPC) and Departamento de Física de Materiales and Unidad de Física de Materiales, E-20018 San Sebastian, Spain — ³Instituto de Óptica CSIC, Serrano 121, 28006 Madrid, Spain — ⁴Institute of Nanotechnology, Forschungszentrum Karlsruhe, Karlsruhe, Germany

We present spectroscopic data obtained by Scanning Tunneling Spectroscopy (STS) from self-assembled organic and metal coordinated carbonitrile polyphenyl (CN-Ph_x-NC) networks deposited on a Ag(111) surface under ultra high vacuum conditions. The molecules form highly regular organic networks depending on the length of the molecules and coverage. By further evaporating Co onto the sample, metal coordinated honeycomb networks are formed by three CN-Ph_x-NC molecules

binding to one Co atom.

These networks impose a modulation upon the local density of states (LDOS) of the quasi 2D electron system of the Ag surface state. Different types of networks were investigated by STS. The lateral confinement of the electrons manifested in various standing wave patterns in dI/dV maps at different energies. First results show good agreement with modelling by a boundary element method.

O 27.86 Tue 18:30 P2

Implementation of the HSE functional in the FLAPW method — ●MARTIN SCHLIPF, CHRISTOPH FRIEDRICH, and STEFAN BLÜGEL — Institut für Festkörperforschung und Institute for Advanced Simulation, Forschungszentrum Jülich, D-52425 Jülich, Germany

Despite the remarkable success of density-functional theory (DFT) in the local density (LDA) or the generalized-gradient approximation (GGA) for the exchange-correlation functional, these standard functionals do not properly describe the structural and magnetic properties of oxide materials. This failure can in many cases be attributed to the uncompensated self-interaction error in LDA and GGA. In hybrid functionals that incorporate a portion of Hartree-Fock-like exact exchange the self-interaction error is considerably reduced. Among these the HSE [1] functional proved to give exceptionally good agreement with experimental data. In this contribution, we discuss the realization of the HSE functional within the all-electron full-potential linearized augmented planewave (FLAPW) method, where space is partitioned into muffin-tin spheres centered at the atomic nuclei and the interstitial region. Within the muffin-tin spheres the wave functions are expressed by numerical functions on a radial grid time spherical harmonics, while planewaves are used in the interstitial region. The exchange potential is given by an integral over the attenuated Coulomb interaction and four of these basis functions. We discuss the implementation of these integrals.

[1] Heyd, Scuseria, Ernzerhof, J. Chem. Phys. **118**, 9207 (2003)

O 27.87 Tue 18:30 P2

In situ Epitaxy and Catalysis at the High Resolution Diffraction Beamline at PETRA III — ●CARSTEN DEITER and OLIVER H. SEECK — Hasylab am DESY, Notkestr. 85, 22607 Hamburg, Germany

In spring 2009 the new synchrotron radiation source PETRA III will become operational. At the High Resolution Diffraction Beamline (P08) the equipment and the beam parameters are highly suited for surface and interface studies. Beside traditional sample environments such as variable temperature (70K-700K) cells with vacuum (10^{-6} mbar) or inert gas inside, an ultra high vacuum chamber will be available to perform in situ molecular beam epitaxy, sputter cleaning and/or catalysis x-ray experiments. The temperature of the sample can be varied from 100K to 1000K for metals and insulators and from 100K to 1500K for semiconductors, respectively. This chamber will be installed in a six circle diffractometer (Kohzu) for extreme angular resolution and supported by an UHV infrastructure close by.

O 27.88 Tue 18:30 P2

Improved determination of the IMFP by extracting the optimum loss function from EELS — ●TINA GRABER¹, FRANK FORSTER¹, ACHIM SCHÖLL¹, and FRIEDRICH REINERT^{1,2} — ¹Universität Würzburg, Experimentelle Physik II, Am Hubland, 97074 Würzburg — ²Gemeinschaftslabor für Nanoanalytik, Forschungszentrum Karlsruhe, 76021 Karlsruhe

A precise knowledge of the inelastic mean free path (IMFP) of electrons in matter is of crucial interest in many respects. If electron spectroscopic techniques are applied in surface and interface science, the attenuation length of the involved electrons has to be established in order to gain information on, e.g., probing depth, adsorbate film thickness, or growth modes. In this work we present a systematic study on the IMFP of electrons in thin films of organic molecules by means of photoelectron spectroscopy (PES) and using the model system PTCDA/Ag(111). This system can be carefully controlled for a precise determination of the IMFP since layer-by-layer growth is necessary. Moreover, an appropriate description of the PES background is needed. For this purpose electron energy loss spectroscopy (EELS) provides valuable information on the relevant loss mechanisms. From the EELS data the optimum loss function can be determined. This loss function was subsequently applied for a Tougaard description of the PES background using the QUASES software[1]. In addition, the dependence of the IMFP on the emission angle has been investigated in order to find evidence for scattering channels or favored emission angles. [1] S. Tougaard, Software Package, Vers. 5.1 (2005)

O 27.89 Tue 18:30 P2

Soft x-ray standing wave excited photoemission experiments on Si/MoSi₂ multilayer mirrors — ●FRANK SCHÖNBOHM^{1,2}, SVEN DÖRING^{1,2}, DANIEL WEIER^{1,2}, ULF BERGES^{1,2}, FELIX LEHMKÜHLER^{1,2}, CHARLES S. FADLEY^{3,4}, and CARSTEN WESTPHAL^{1,2} — ¹Fakultät Physik - TU Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — ²DELTA - TU Dortmund, Maria-Goeppert-Mayer-Str. 2, 44227 Dortmund, Germany — ³Materials Sciences Division, LBNL, Berkeley, CA 94720, USA — ⁴University of California, Davis, CA 95616, USA

The structure of thin layers and the formation of interfaces is of particular interest in surface science. Element specific sample analysis can be performed by means of photoelectron spectroscopy but the method lacks of a good spatial resolution. On the other hand, reflectivity measurements show a good depth-resolution without chemical sensitivity. Thus x-ray standing wave measurements were conducted in order to combine the advantages of these methods. We used Si/MoSi₂ multilayer mirrors as a sample substrate in order to increase the reflectivity. The measurements were performed at the experimental endstation at Beamline 11 at DELTA at a photon energy of $h\nu = 650$ eV. The multilayer was handled in ambient air resulting in an oxidized silicon layer at the surface. This Si layer with its SiO₂ cap was used as a first test system for our XSW measurements. Analysis of the received data indicates that the surface oxidation of the upper most Si film results in a SiO₂ layer of 13 Å thickness with a non-oxidized Si-film of 15.5 Å beneath it. In order to check this result we performed hard x-ray reflectivity measurements at $h\nu = 15.2$ keV for comparison at DELTA.

O 27.90 Tue 18:30 P2

Prozessoptimierung der Sputterstrategie von fokussierten Ionenstrahlen mit Standard "Focused Ion Beam - FIB" Anlagen — ●RÜDIGER SCHOTT, PAUL MAZAROV, ROLF WERNHARDT and ANDREAS D. WIECK — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

Fokussierte Ionenstrahlen sind ein vielfältiges und nützliches Werkzeug in Gebieten der Forschung und Industrie. Die Verwendung von Bismutonen zum lokalen, maskenlosen Ionenätzen in Standard FIB-Anlagen ohne Massenseparator besitzt einige Vorteile gegenüber den meist verwendeten Galliumionen. Die Bismut Flüssigmetallionenquelle [1] liefert schwere, monoisotope Ionen (209 u) und deren Cluster, wobei Teilchen mit einfacher Ladung zu 95% dominant sind. Die schweren Ionen und besonders deren Cluster dringen weniger tief in die Oberfläche der Probe ein, wodurch ihr Energieübertrag an die Oberflächenatome erhöht wird. Dies führt zu einer deutlich höheren Sputterrate und einer geringeren Kontaminationstiefe der Oberfläche. Zusätzlich wird der Ionenätzprozess optimiert, indem Parameter wie die Haltezeit pro Punkt variiert und die Ionenätzbedingungen durch das Vorformen der Probenoberfläche verbessert werden.

[1] P.Mazarov, A. Melnikov, R. Wernhardt, and A. D. Wieck, "Long-life bismuth liquid metal ion source for focussed ion beam application", Applied Surface Science **254**, 7401-7404 (2008).

O 27.91 Tue 18:30 P2

Vielkanal-Spindetektion von niederenergetischen Elektronen — ●MICHAELA HAHN¹, PAVEL LUSHCHYK¹, GERD SCHÖNHENSE¹, ANDREAS OELSNER², DANIEL PANZER², ALEXANDER KRASYUK³ und JÜRGEN KIRSCHNER³ — ¹Institut für Physik, Johannes Gutenberg Universität, Mainz (Germany) — ²Surface Concept GmbH, Staudingerweg 7, 55128 Mainz (Germany) — ³Max-Planck-Institut für Mikrostrukturphysik, Halle (Germany)

Die Analyse der Spinpolarisation von Photoelektronen ist für Experimente im Bereich der Atom- und Molekülphysik, der Oberflächen- und Festkörperphysik und vor allem für Untersuchungen von ferromagnetischen Materialien von zentraler Bedeutung. Bisher verwendete Spindetektoren [1] arbeiten 'einkanalig', d.h. monoenergetisch und bei einem Detektionswinkel, was zu einer sehr geringen Messeffizienz führt. Um eine hocheffiziente spinaufgelöste Photoemissionsmessung zu ermöglichen, wird ein Multikanal-Spinpolarimeter in Betrieb genommen. Dieses wird Berechnungen zufolge durch einen Gewinn an Messeffizienz um 2-3 Größenordnungen gekennzeichnet sein. Der neue Spindetektor soll insbesondere in winkelaufgelösten Photoemissionsexperimenten mit Laborlichtquellen bei sehr niedrigen Energien (ARPES) und in Experimenten mit Synchrotronstrahlung im harten Röntgenbereich (HAXPES) zum Einsatz kommen. Ein deutlicher Vorteil ist die Reduzierung der Messzeit hinsichtlich Proben mit reaktiven Oberflächen oder für in-situ präparierte ultradünne Filme.

Gefördert durch DFG (SCHO341/9-1)

[1] J. Kessler, 'Polarized Electrons', Springer 1985

O 27.92 Tue 18:30 P2

Electrospray Ion Beam Deposition and in-situ Analysis of Functional Molecules — ●ZHITAO DENG¹, NICHIA THONTASEN¹, CHRISTIAN MICHAELIS¹, NIKOLA MALINOWSKI¹, STEPHAN RAUSCHENBACH¹, and KLAUS KERN^{1,2} — ¹Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — ²Institut de Physique des Nanostructures, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

An electrospray ion beam deposition source has been developed for the soft landing deposition in ultra high vacuum of nonvolatile particles such as molecules, clusters and nanoparticles. This enables the surface modification and subsequent in-situ analysis by scanning tunneling microscopy. This poster presents the experimental aspects of ion beam deposition in UHV and gives examples for its application to functional molecules.

O 27.93 Tue 18:30 P2

High resolution positron annihilation induced Auger spectroscopy on copper — ●JAKOB MAYER¹, KLAUS SCHRECKENBACH^{1,2}, and CHRISTOPH HUGENSCHMIDT^{1,2} — ¹Technische Universität München, Physikdepartment E21, James-Franck-Str., 85748 Garching — ²ZWE FRM II, Lichtenbergstr.1, 85747 Garching

The high intensity positron source NEPOMUC at the FRM-II in Munich with a stable remoderated positron beam of $> 10^7$ positrons/s at 20 eV enabled measurement times of 10 hours for one PAES (Positron annihilation induces Auger Electron Spectroscopy) spectrum [1]. Since the intrinsic advantages of PAES over EAES are known and have been shown (e.g. [2]), the reduction of the long measurement times is the main challenge for this non destructive technique for surface studies. For this reason, a new hemispherical electron energy analyzer was installed at the PAES facility of NEPOMUC. Compared to the former analyzer (opening angle $\pm 3^\circ$) it has a much higher solid angle which allows the detection of electrons which are emitted up to an angle of $\pm 13^\circ$ with respect to the lens system of the analyzer. In addition, the freely selectable pass energy (0-600 eV) guarantees a high transmission. Though a high energy resolution is achievable with the big mean radius of the analyzer (150 mm) and variable slits. The new setup and first spectra obtained for polycrystalline copper surfaces (15 min measurement time) will be presented. [1] C. Hugenschmidt, J. Mayer and K. Schreckenbach, Surf. Sci. 601 (2459-2466) 2007 [2] K. O. Jensen and A. Weiss, Phys. Rev. B 41 (3928-3936) 1990

O 27.94 Tue 18:30 P2

Reconstruction of surface morphology from coherent scattering of white x-ray radiation — ●TUSHAR SANT and ULLRICH PIETSCH — Solid State Physics Group, University of Siegen, 57068 Siegen, Germany

Static speckle experiments were performed using coherent white X-ray radiation from a bending magnet at BESSYII. Semiconductor and polymer surfaces were investigated under incidence condition smaller than the critical angle of total external reflection. The scattering pattern of the sample results from the illumination function modified by the surface roughness [1]. The periodic oscillations are caused by the illumination function whereas other irregular features are associated with sample surface. The speckle map of reflection from a laterally periodic structure like GaAs grating is studied [2]. Under coherent illumination the grating peaks split into speckles because of fluctuations on the sample surface. The surface morphology can be reconstructed using phase retrieval algorithms [3]. In case of 1D problem, these algorithms rarely yield a unique and converging solution. The algorithm is modified to contain additional propagator term and the phase of illumination function in the real space constraint. The modified algorithm converges faster than conventional algorithms. A detailed surface profiles from the real measurements of the sample are reconstructed using this algorithm. 1. Pietsch U, et al. Physica B- Condensed Matter, 357 (2005) 45.2. Panzner T, Gleber G, Sant T, Leitenberger W, Pietsch U, Thin Solid Films, 515 (2007) 5563. 3. Vartanyants I A, et al. PRB, 55 (1997) 13193.

O 27.95 Tue 18:30 P2

Unifit 2009 - Spectrum Processing, Analysis and Presentation Software for Photoelectron Spectra — ●RONALD HESSE, PETER STREUBEL, RÜDIGER SZARGAN, and REINHARD DENECKE — Wilhelm-

Ostwald-Institut, Universität Leipzig, 04103 Leipzig, Deutschland

The aim of the development of the program UNIFIT is to enable complete qualitative and quantitative analysis of photoelectron spectroscopy data by combining appropriate description of the spectra and their background using adequate models, convenient data handling, and excellent numerical performance for fast calculation with versatile opportunities for data transfer, comfortable handling, extensive graphical design options and fast export of high resolution graphics. To demonstrate the abilities, some major features will be addressed: (i) The three commonly applied models for fitting photoelectron spectra, i.e. product, sum, and convolution of Gaussian and Lorentzian functions, will be discussed. (ii) Improved methods for determination of valence-band edges are implemented. (iii) The determination of the transmission functions $T(E)$ of any photoelectron spectrometer will be shown. (iv) The batch-processing submenu serves as a fast and comfortable treatment of parameter-dependent experimental series. (v) UNIFIT permits the calculation of fit-parameter errors after peak fitting. (vi) The software offers nine different presentations.

O 27.96 Tue 18:30 P2

Surface structure of inorganic salt solutions — ●TOBIAS HAMMER, MANUELA REICHELT, and HARALD MORGNER — Universität Leipzig, Wilhelm Ostwald Institut

The aim of our research is the investigation of the molecular structure and composition of liquid surfaces and surface near range with spectroscopic methods and, furthermore, the correlation of this information with macroscopic properties of solutions (e.g. surface tension, density). One of our most powerful techniques is Neutral Impact Collision Ion Scattering Spectroscopy (NICISS) that makes use of the energy loss of Helium projectiles being backscattered from soft matter targets. With this tool it is possible to determine elemental depth profiles and the surface structure of liquid surfaces. The spectroscopic methods used here are vacuum based techniques. Up until now, this fact has limited the choice of usable solvents to those with low vapor. At present we are about to develop the experimental set up in order to investigate volatile liquids like water. The actual state of our equipment does allow to study aqueous solutions for high salt concentrations at low temperature, while the parts needed for handling low concentrations at ambient temperatures is still under construction. For the time being, we have carried out measurements on the influence of the ion radii of the cation or the anion to the surface structure, with alternative solvents including glycerol.

O 27.97 Tue 18:30 P2

Surface Structure of Imidazolium Based Ionic Liquids — ●MANUELA REICHELT, TOBIAS HAMMER, and HARALD MORGNER — Wilhelm-Ostwald Institute for Physical and Theoretical Chemistry, University of Leipzig

The focus of our research interest is the investigation of the composition and molecular structure of liquid surfaces with spectroscopic methods (e.g., XPS, UPS, MIES) and the correlation of these information with macroscopic properties of solutions (e.g., surface tension). One of our most powerful techniques is Neutral Impact Collision Ion Scattering Spectroscopy (NICISS) that uses the energy loss of Helium projectiles being backscattered from soft matter targets.

The last years have seen an increasing research interest in ionic liquids (ILs), salts that are fluid below 100°C and show numberless possible combinations of cations and anions. However, the physico-chemical behavior of ILs is still not completely understood. Additionally, the knowledge of the molecular surface structure and the surface composition of ILs is necessary for understanding chemical reactions at the surface (e.g., the mechanism of catalysis).

In the presented work we combined NICISS and XPS to investigate the elemental surface composition, elemental concentration depth profiles of the near surface area and the molecular surface structure of two homologous series of imidazolium based ILs. While the kind of anion namely hexafluorophosphate and bis(trifluoromethylsulfonyl)imide was fixed, respectively, the alkyl chain length of the cation was varied to analyze their influence on the properties under study.

O 27.98 Tue 18:30 P2

Surface Structure of Imidazolium Based Ionic Liquids — ●MANUELA REICHELT, TOBIAS HAMMER, and HARALD MORGNER — Wilhelm-Ostwald Institute for Physical and Theoretical Chemistry, University of Leipzig

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O 27.99 Tue 18:30 P2

Graphene-protected iron layer on Ni(111) — ●YURIY DEDKOV¹, MIKHAIL FONIN², ULRICH RÜDIGER², and CLEMENS LAUBSCHAT³ — ¹FHI Berlin — ²Uni Konstanz — ³TU Dresden

Magnetic thin films with out-of-plane (or perpendicular) magnetic anisotropy play an important role in nanotechnology. Such systems can be used as perpendicular recording media which are predicted to allow information storage densities of up to 1 Tbit/in.² a quadrupling of today's highest areal densities. Along with the widely used materials with out-of-plane magnetic anisotropy such as CoPt or FePt alloys, face-centered cubic (*fcc*) Fe thin films also showing perpendicular magnetic anisotropy have recently attracted considerable interest as possible candidates for applications in novel magnetic data storage devices. Here Fe which originally has body centered cubic (*bcc*) structure can be stabilized in γ phase (*fcc*) at room temperature in thin epitaxial films grown on suitable *fcc* substrates. Here we report a photoemission study of the Fe intercalation underneath a graphene layer on Ni(111). The process of intercalation was monitored by means of x-ray photoemission of corresponding core levels as well as ultraviolet photoemission of the graphene-derived π states in the valence band. Thin *fcc* Fe layers (2-5 ML thickness) at the interface between a graphene capping layer and Ni(111) form epitaxial films passivated from the reactive environment.

O 27.100 Tue 18:30 P2

STM growth study of epitaxial graphene on SiC(0001) — ●ANNE MAJERUS, VIKTOR GERINGER, SVEN RUNTE, MARCUS LIEBMANN, and MARKUS MORGENSTERN — II. Physikalisches Institut, RWTH Aachen and JARA-FIT, Otto-Blumenthal-Straße, 52074 Aachen

The easiest way to produce graphene is mechanical exfoliation from graphite crystals [K. S. Novoselov et al., Science 306, 666 (2004)]. However, the preparation of graphene under clean conditions requires the use of ultra high vacuum (UHV) [I. Forbeaux et al., Appl. Surf. Sci. 162, 406 (2000)].

In this work, we present a growth study of graphene on SiC. An untreated SiC(0001) crystal was put through several annealing cycles until we produced a few layers of epitaxial graphene. To determine the changes in the morphology during the different stages of graphitization, low-energy electron diffraction (LEED) and scanning tunneling microscopy (STM) measurements were performed. The surface structures determined by LEED could also be detected directly by STM, exhibiting atomic resolution.

O 27.101 Tue 18:30 P2

How does graphene grow? Easy access to well-ordered graphene monolayers — ●FRANK MÜLLER¹, HERMANN SACHDEV², STEFAN HÜFNER¹, ANDREW J. POLLARD³, EDWARD W. PERKINS³, JAMES C. RUSSELL³, PETER H. BETON³, STEFAN GSELL⁴, MATTHIAS SCHRECK⁴, and BERND STRITZKER⁴ — ¹Institut für Experimentalphysik, Universität des Saarlandes, 66041 Saarbrücken, Germany — ²Institut für Anorganische Chemie, Universität des Saarlandes, 66041 Saarbrücken, Germany — ³School of Physics and Astronomy, University of Nottingham, NG7 2RD, UK — ⁴Institut für Physik, Universität Augsburg, 86135 Augsburg, Germany

In the present study [1], the selective formation of large-scale graphene

layers on a Rh-YSZ-Si(111) multilayer substrate by a surface-induced chemical growth mechanism was investigated using low energy electron diffraction (LEED), x-ray photoelectron spectroscopy (XPS), x-ray photoelectron diffraction (XPD) and scanning tunnelling microscopy (STM). It is shown that well-ordered graphene layers can be grown using simple and controllable procedures. In addition, temperature dependent experiments provide insight into the details of the growth mechanisms. A comparison of different precursors shows that a mobile dicarbon species (e.g. C₂H₂ or C₂) acts as a common intermediate for graphene formation. These new approaches offer a scalable approach for the large scale production of high-quality graphene layers on silicon based multilayer substrates.

[1] F. Müller, EU-STREP (Specific Targeted Research Project) NanoMesh, Final Meeting, Orscholz, Germany 2008, in submission

O 27.102 Tue 18:30 P2

Low-temperature elastic and inelastic Scanning Tunnelling Spectroscopy on monolayer graphene on SiC — ●CARSTEN TRÖPPNER¹, NORBERT MAURER¹, FLORIAN SPECK², THOMAS SEYLLER², and M. ALEXANDER SCHNEIDER¹ — ¹Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen — ²Lehrstuhl für Technische Physik, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

We employ Scanning Tunneling Spectroscopy in liquid Helium to investigate the electronic structure of a monolayer graphene grown epitaxially on SiC(0001). Spatially resolved differential conductance maps reveal a richness of features that can partially attributed to the SiC/graphene interface. Area averages of such maps reveal a "standard" spectrum that agrees with spectra obtained in UHV [1]. Furthermore clear evidence for inelastic (phononic) contributions in the differential conductance of the tunnelling junction are found, offering a natural interpretation for the observed "zero bias anomalies" [2]. The spatial dependence of these features is discussed.

[1] P. Lauffer, et al. Phys. Rev. B **77**, 155426 (2008) [2] V.W. Brar et al. Appl. Phys. Lett. **91**, 122102 (2007)

O 27.103 Tue 18:30 P2

Comparative study of graphene films on two hexagonal SiC surfaces produced in different environments — ●K.V. EMTSEV¹, T. OHTA², TH. SEYLLER¹, L. LEY¹, A. BOSTWICK³, K. HORN⁴, G. KELLOG², J.L. MCCHESENEY³, E. ROTENBERG³, and A.K. SCHMID⁵ — ¹FAU Erlangen-Nürnberg — ²Sandia National Laboratories, USA — ³Advances Light Source, USA — ⁴FHI, Berlin — ⁵National Center for Electron Spectroscopy, USA

In present work we discuss the graphene formation on both hexagonal SiC surfaces carried out in different environments and in dependence of several processing conditions. As was shown recently [1] the domain size of graphene monolayer formed on SiC(0001) surface in an inert atmosphere can extend over several tens of micrometers in contrast to samples prepared in vacuum showing small domains. The graphene layers were characterized by X-ray photoelectron spectroscopy, atomic force microscopy, and low energy electron microscopy. As compared to vacuum annealing, graphitization in inert atmosphere takes place at higher temperature. This has a profound effect on the morphology of the surfaces. The time dependence of graphene film thickness is quite different for two crystal orientations. While the thickness saturates rapidly for graphene on the (0001) surface, the (000-1) surface of SiC shows an unsaturated growth for film thicknesses of up to tens of monolayers. The nucleation of graphene on the (0001) surface is more homogeneous and is initiated at the substrate steps. On the (000-1) surface an inhomogeneous multilayer nucleation is observed. [1] K.V. Emtsev, et al, arXiv:0808.1222v1.

O 27.104 Tue 18:30 P2

Preparation and investigation of graphene on Rh(111) — ●OLE ZANDER¹, MIKHAIL FONIN¹, SÖNKE VOSS¹, ULRICH RÜDIGER¹, and YURI S. DEDKOV² — ¹Fachbereich Physik, Universität Konstanz, 78457 Konstanz — ²Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin, Germany

Graphene, a flat monolayer of carbon atoms packed in a honeycomb-lattice, exhibits exceptional electronic properties characteristic for twodimensional Dirac fermions. There are three major ways of graphene preparation: exfoliation of graphite, thermal decomposition (graphitization) of SiC and low pressure chemical vapor deposition (CVD) on noble metals. The latter method is the most promising route for large-scale graphene preparation yielding excellent film qualities with low defect densities over large length scales. Depending on

the metallic substrate, graphene grows completely flat or corrugated.

By using CVD we succeeded in growing a monolayer of graphite on Rh(111). High resolution scanning tunneling microscopy (STM) imaging revealed a corrugated graphene superstructure of about 30 Å periodicity. Depending on the preparation conditions we observed either a mixture of several superstructures occurring at lower preparation temperatures with periodicities from 11 Å up to 30 Å, or a single phase, the 30 Å moiré-pattern, at higher temperatures. Moreover, we successfully used graphene nanomesh on Rh(111) as a template for the growth of highly-ordered d-metal cluster arrays as suggested in [1].

[1] N'Diaye et al., Phys. Rev. Lett. 97, 215501 (2006).

O 27.105 Tue 18:30 P2

Atomic Layer Deposition of Aluminum Oxide Films on Graphite and Graphene — ●FLORIAN SPECK, MARKUS OSTLER, JONAS RÖHRL, KONSTANTIN V. EMTSEV, LOTHAR LEY, and THOMAS SEYLLER — Lehrstuhl für Technische Physik, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, D-91058 Erlangen, Germany

The fabrication of top-gated graphene-based field effect devices requires the deposition of a suitable gate insulator on graphene. Atomic layer deposition (ALD) is a low-temperature process, which could be useful for this purpose. Therefore, we studied the growth of aluminum oxide (Al_2O_3) from trimethylaluminum (TMA) and water (H_2O) or ozone (O_3) on highly oriented pyrolytic graphite and graphene. Graphene was prepared by thermal decomposition of SiC. Three different processes were compared: (A) standard ALD growth of Al_2O_3 using TMA and H_2O ; (B) ALD growth using TMA and O_3 ; (C) pre-growth treatment of the substrate using O_3 pulses followed by standard growth according to (A). The films and interfaces were studied using photoelectron spectroscopy and atomic force microscopy. While process (A) leads to an inhomogeneous nucleation of Al_2O_3 , process (B) forms closed films with high nucleation density, but affects the integrity of the graphene layers. Process (C) leads to smooth and conformal Al_2O_3 films with little damage to the graphene substrate. The influence of the duration of the initial O_3 exposure as well as of the growth temperature on the properties of the ALD- Al_2O_3 films is discussed.

O 27.106 Tue 18:30 P2

Spin dependent surface barrier resonance studied by spin-polarized electron energy loss spectroscopy — YU ZHANG¹, JACEK PROKOP¹, IOAN TUDOSA¹, WEN XIN TANG¹, ●THIAGO R. F. PEIXOTO^{1,2}, KHALIL ZAKERI¹, and JÜRGEN KIRSCHNER¹ — ¹Max-Planck Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle — ²Instituto de Física, Universidade de São Paulo, São Paulo, Brazil

It has been shown that the surface barrier resonance can be detected by electron energy loss spectroscopy [1]. In this work, we use the spin-polarized electron energy loss spectroscopy (SPEELS) to investigate the spin dependence of the surface barrier resonance in the oxygen passivated Fe films grown on W(001). The peaks induced by the surface barrier resonance were observed when measuring the intensity of the specularly reflected electrons as a function of the primary energy from 3 to 40 eV. Depending on the spin polarization and the incident angle, the peaks showed different intensities and energies. Large spin asymmetries, up to 80%, were found at about 4 eV. The peaks due to the surface barrier resonance can be also clearly observed in the energy loss spectra measured in the off-specular geometry. The dispersion of the surface barrier resonances obtained from both the peak energies and the momentum transfer clearly shows the spin dependence.

[1] D. Rebenstorff, H. Ibach and J. Kirschner, Solid State Communications, 56, 885 (1985).

O 27.107 Tue 18:30 P2

Magnetism of Rh nano-structures on inert Xe buffer layers and in contact with Ag(100) surfaces — ●VIOLETTA SESSI¹, JIAN ZHANG¹, KLAUS KUHNKE¹, CARSTEN TIEG², AXEL ENDERS³, JAN HONOLKA¹, and KLAUS KERN¹ — ¹Max Planck Institut für Festkörperforschung, Stuttgart, Deutschland — ²European Synchrotron Radiation Facility, Grenoble, France — ³University of Nebraska, Lincoln, USA

Previous x-ray magnetic circular dichroism measurements have shown that sub-monolayer coverages of Rh directly deposited on Ag(100) at T=5K are not magnetic [1], in contrast to theoretical predictions [2]. We have investigated this discrepancy and studied the magnetism of Rh nano-structures prepared on inert Xe buffer layers (Buffer Layer Assisted Growth [3]) on Ag(100). For Rh nano-structures (monomers, dimers, trimers etc.) situated on the Xe buffer layer we find a cluster

size-dependent magnetic moment similar to the one measured on free clusters in the Stern-Gerlach experiment [4]. During desorption of the Xe layer the Rh nano-structures grow in size and make contact with the substrate, which leads to a full quenching of the magnetic moment. The results are discussed modelling the Rh cluster size distribution and magnetic ordering on Xe and Ag(100).

[1] J. Honolka et al., Phys. Rev. B 76, 144412 (2007) [2] P. Lang, V.S. Stepanyuk, K. Wildberger, R. Zeller, and P.H. Dederichs., Solid State Commun. 92, 755 (1994) [3] J.H. Weaver, G.D. Waddill, Science 251, 1444 (1991) [4] A.J. Cox, J. G. Louderback, and L.A. Bloomfield, Phys. Rev. Lett. 71, 923 (1993)

O 27.108 Tue 18:30 P2

n-Alkanes in Tubular Nanochannels: Phase Transition Behaviour and Capillary Filling — ●DANIEL RAU¹, PATRICK HUBER¹, and OSKAR PARIS² — ¹Faculty of Physics and Mechatronics Engineering, Saarland University, D-66041 Saarbrücken, Germany — ²Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Research Campus Golm, D-14424 Potsdam, Germany

We present time-dependent angle-dispersive and energy-dispersive small-angle x-ray diffraction experiments on the capillary filling of tubular nanochannels in a template-grown porous matrix (SBA-15) by a liquid hydrocarbon. These measurements reveal a square root of time, classical Lucas-Washburn law for the channel invasion dynamics. These spontaneous imbibition experiments are complemented by combined x-ray diffraction and specific heat measurements on the filled matrices, which allow us to study the phase transition behaviour of the spatially nanoconfined linear hydrocarbons.

O 27.109 Tue 18:30 P2

The Limits of Nanomechanical Applications of Shape Memory Alloys: An Optical Approach — ●ANDREAS KOLLOCH, JOHANNES BONEBERG, and PAUL LEIDERER — Universität Konstanz

Shape Memory Alloys (SMA), with their high strain and stress values for small temperature changes and their excellent durability against environmental influences, may prove to be ideal candidates for the driving force of nanomechanical devices. In spite of this promising potential, however, very little is known about the properties of SMA materials, and in particular thin films, on the nanoscale.

Our work concentrates on the classic SMA, Nitinol, an intermetallic compound consisting of nickel and titanium. While it is completely reversible, the martensite-austenite transition of this material is accompanied by large strain and stress changes of up to 6-8% and 600 MPa, respectively.

The project aims at employing an ultrafast thermo-optical approach to investigating whether there is a lower thickness limit of the martensitic phase transition in NiTi SMAs and what the transition speed for the phase change of these materials is.

O 27.110 Tue 18:30 P2

Time-resolved spectroscopy beyond optical wavelengths — ROBERT CARLEY¹, ●KRISTIAN DÖBRICH¹, CORNELIUS GAHL¹, MARTIN TEICHMANN¹, KAI GODEHUSEN², OLAF SCHWARZKOPF², PHILIPPE WERNET², FRANK NOACK¹, and MARTIN WEINELT^{1,3} — ¹Max-Born-Institut, Max-Born-Straße 2a, 12489 Berlin — ²Helmholtz-Zentrum für Materialien und Energie, Elektronenspeicherring BESSY II, Albert-Einstein-Str. 15, 12489 Berlin — ³Fachbereich Physik der Freien Universität Berlin, Arnimallee 14, 14195 Berlin

We are presenting characterization results of our newly developed high-order harmonics XUV source. The beamline will be used to perform time-resolved studies of metal- and semiconductor surfaces.

We use a commercial amplified Ti:Sapphire laser system generating 30 fs pulses at 20 kHz repetition rate. The beam is focused into an argon-filled gas cell to create high-order harmonics. Following separation from the IR with a thin Al filter, the XUV wavelength can be selected using a toroidal grating monochromator. Current efforts are the optimization for an energy resolution of 100 meV and a time resolution below 100 fs.

This beamline is a joint project between MBI and BESSY and will be open as a user facility to external users.

O 27.111 Tue 18:30 P2

Femtosecond electron dynamics in atomic wires: Si(557)-Au — ●KERSTIN BIEDERMANN¹, TILMAN K. RÜGHEIMER¹, THOMAS FAUSTER¹, and FRANZ J. HIMPSEL² — ¹Lehrstuhl für Festkörperfysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen — ²Department of Physics, University of Wisconsin-Madison, 1150

University Ave, Madison WI 53706, USA

Recent experiments on Si(557)-Au have proven the existence of a spin-split surface state band below E_F [1] and have provided first information on the unoccupied part of the electronic band structure [2,3]. The dynamics of electrons has not been investigated so far.

We have carried out time-resolved two-photon photoemission experiments using 37 fs infrared (IR, $E_{IR}=1.55$ eV) and 55 fs ultraviolet (UV, $E_{UV}=4.65$ eV) laser pulses. High intensity at 0.9 eV kinetic energy (work function $\Phi=4.88$ eV) and time delay zero corresponds to an image-potential resonance [2,3] and has a lifetime of less than 10 fs. At lower kinetic energies the intensity spreads towards positive as well as negative time delays indicating contributions from several transitions. An intensity pile-up at positive delays (IR before UV) indicates an indirect filling of a state in the bulk band gap of the Si(557) substrate by two long-lived states. We present a detailed analysis of the data by fitting the spectra with optical Bloch equations. Our interpretation involves electron scattering between several surface states.

- [1] I. Barke et al., Phys. Rev. Lett. **97**, 226405 (2006)
 [2] J. A. Lipton-Duffin et al., Phys. Rev. B **73**, 245418 (2006)
 [3] T. K. Rügheimer et al., Phys. Rev. B **75**, 121401 (2007)

O 27.112 Tue 18:30 P2

Themis1000 - A new analyzer for three dimensional measurements — ●JENS KOPPRASCH^{1,2}, MARTIN TEICHMANN¹, OLIVER SCHAFF³, SVEN MÄHL³, and MARTIN WEINELT^{1,2} — ¹Max-Born-Institut, Max-Born-Straße 2a, 12489 Berlin, Germany — ²Freie Universität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin, Germany — ³SPECS GmbH, Voltastraße 5, 13355 Berlin, Germany

We present a newly developed time-of-flight (TOF) spectrometer to measure the energy and two-dimensional angle distribution of emitted electrons. For the development of this wide-angle high-energy resolution electron analyzer a partnership between the company SPECS GmbH and the Max-Born-Institute has been arranged.

The electrostatic lens system of a PHOIBOS electron analyzer is used as a flight tube, with a delay-line detector at the end to detect both flight time and arrival position. Due to the axial symmetry of the lens system the angular distribution is measurable in the two dimensions parallel to the sample surface. We reach the same good angular resolution as for a PHOIBOS analyzer, and the same acceptance angle of about 13°. As opposed to an usual position-sensitive TOF spectrometer, the trajectory of the electrons are not linear. We could show that the mapping from arrival position to emission angle and flight time to energy is unambiguous, and by solving Hamiltons' equations numerically we were able to invert this mapping.

Furthermore, we will show the first measurement of a Cu(111) sample. This is a known system well suited for the characterization of the analyzer.

O 27.113 Tue 18:30 P2

Time-, energy- and angle-resolved photoelectron spectroscopy of surface dynamics using femtosecond XUV pulses — ●FREDERIK DEICKE¹, STEFAN MATHIAS¹, ANDREAS RUFFING¹, LUIS MIAJA-AVILA², MARGARET MURNANA², HENRY KAPTEYN², MICHAEL BAUER³, and MARTIN AESCHLIMANN¹ — ¹Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, D-67663 Kaiserslautern, Germany — ²JILA, University of Colorado, Colorado 80309-0440, USA — ³Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, D-24908 Kiel, Germany

The angle resolved photoelectron spectroscopy (ARPES) has emerged as a leading technique in identifying static key properties of complex systems such as the electronic band structure of adsorbed molecules, ultrathin quantum-well films or high temperature superconductors. We present an experimental setup combining the ARPES technique with a pump-probe scheme for time-resolved measurements using a 1 kHz femtosecond high-harmonic generation (HHG) XUV source [1]. The performance of the system with respect to time-, energy- and momentum-resolution will be discussed on the basis of ARPES spectra recorded with ultra short photon pulses of $\tau=7$ fs and $h\nu=42$ eV [2]. Furthermore, the potential of time-resolved ARPES to study surface dynamics in future experiments, as e.g. photo-induced phase transitions, is considered.

[1] S. Mathias et al., Rev. Sci. Instrum. **78**, 083105 (2007) [2] S. Mathias et al., Journ. of Phys. : conference proc., in print

O 27.114 Tue 18:30 P2

Space Charge Effects in the Photoemission Electron Micro-

scope — ●JAN GÖHRE, NIEMMA M. BUCKANIE, PING ZHOU, DIETRICH VON DER LINDE, MICHAEL HORN-VON HOEGEN, and FRANK-J. MEYER ZU HERINGDORF — University Duisburg-Essen, Germany

The illumination of samples in a spectroscopic Photoemission Electron Microscope (PEEM) with ultrafast laser pulses combines temporal and spatial resolution. To study the deexcitation of excited electrons, the laser should have sufficiently low pulse energy in order to minimize the space charge. Since most metals have a work function of about 5eV, a high photon energy is needed for a one photon photoemission process (1PPE). We built a regenerative Ti:sapphire amplifier system which generates ultrafast fs-pulses ($\lambda = 800nm$, corresponding energy of $E = 1.55eV$). The system has a variable repetition rate up to 250kHz. It uses chirped pulse amplification (CPA) to generate laser pulses with a duration of 150fs and variable pulse energies, e.g. 1.2μJ at 250kHz. We studied Ag islands which have been grown (*in-situ*) by self-assembly on Si(111) surfaces. We used the fundamental and the 4th harmonic ($E = 6.2eV$) of the amplifier system to study the origin of the space charge effect, i.e., whether the space charge effects are created at the sample surface or in the electron optics of the microscope (Boersch effect). The space charge effect is reflected in an energetic broadening of the electron distribution. Insertion of apertures into the way of the electrons changes the electron density in the electron optics. We report the influence of the laser energy, wavelength, and repetition rate on the energy spectra and the image distortions by space charge effects.

O 27.115 Tue 18:30 P2

Time resolved core level photoelectron spectroscopy for investigation of femto- and picosecond dynamics of iodophenylphenol monolayers on silicon — ●MARTIN MICHELWIRTH¹, HATEM DACHRAOUI¹, CHRISTIAN SCHÄFER², BJÖRN SCHNATWINKEL², WALTER PFEIFFER¹, MARKUS DRESCHER³, JOCHEN MATTAY², and ULRICH HEINZMANN¹ — ¹Molecular and Surface Physics, Bielefeld University — ²Organic Chemistry (OC I), Bielefeld University — ³Ultrafast X-ray Physics, Hamburg University

The photoinduced dynamics of iodophenylphenol adsorbed on silicon were investigated by use of time-resolved UV pump (266 nm)-EUV probe (95 eV) photoemission spectroscopy. The EUV probe pulses were produced by high harmonic generation (HHG). Picosecond and femtosecond dynamic changes of the iodine 4d core level spectra were observed in the pump probe experiment. Because of the localized character of core level spectra the observed dynamics can be directly related to electronic or binding environment changes of the C-I bond. The presented results demonstrate that time-resolved core level spectroscopy provides valuable information about photoinduced intra- and inter molecular dynamics in a complex molecular system environment.

O 27.116 Tue 18:30 P2

Performance of the XUV split-and-delay line at the free-electron laser in Hamburg — ●FLORIAN SORGENFREI¹, TORBEN BEECK¹, MARTIN BEYE¹, ALEXANDER FÖHLISCH¹, MITSURU NAGASONO², BILL SCHLOTTER¹, and WILFRIED WURTH¹ — ¹Department Physik, Universität Hamburg, Germany — ²XFEL Project head office, RIKEN, Hyogo, Japan

The high brilliance and short pulse duration of free-electron lasers like FLASH at Hamburg are the basis for novel experiments on ultrafast dynamics in various systems. Combining these properties with X-ray pump/probe techniques enlarges the class of possible experiments even more.

We have permanently implemented a Mach-Zehnder type autocorrelator at the PG2 beamline at FLASH in 2008 which is capable of splitting the XUV pulse from FLASH and introducing a delay between both pulses in the range of about +/- 6ps with a sub-femtosecond resolution. Here, we present the results of test experiments to demonstrate the performance of this device, namely measuring the temporal coherence length of the FLASH radiation and measuring the intensity autocorrelation by He two-photon double-ionization.

We acknowledge financial support from the BMBF priority program FSP301: "FLASH" and the GrK 1355 "Physics with new coherent light sources"

O 27.117 Tue 18:30 P2

Ultrafast Excitation and Deexcitation Dynamics of Adsorbates on Si-Surfaces: A Time Resolved Electron Diffraction Study — ●SIMONE MÖLLENBECK, ANJA HANISCH-BLICHARSKI, TOBIAS PELKA, PAUL SCHNEIDER, MARTIN KAMMLER, BORIS KRENZER, and MICHAEL HORN-VON HOEGEN — Department of Physics and Center

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We have set up an experiment for ultra fast electron diffraction. The surface sensitivity in a RHEED (reflection high energy electron diffraction)-geometry was used to analyze the structural dynamics on a ps-timescale upon excitation by fs-laserpulses. In the past we have shown that the nanoscale heat transport in heterolayers can be studied with TR-RHEED utilizing the Debye-Waller Effect. Here we used the unique possibilities of TR-RHEED to study monolayer adsorbate systems on Silicon. As an example we present time resolved measurements of the ($\sqrt{3} \times \sqrt{3}$) Pb/Si(111) adsorbate system. Pb was deposited on Si(111)-(7 × 7) at 100K. By desorption at 500K, the coverage was reduced to a ($\sqrt{3} \times \sqrt{3}$) reconstructed Pb adsorbate system with the coverage of 1 monolayer. We observed the transient surface temperature evolution of the Pb adsorbate system after excitation with a fs-laserpulse. The measured time constant for the cooling process is 150ps. This observation agrees well with a simple theoretical model. We may present further new results to other adsorbate systems.

O 27.118 Tue 18:30 P2

The cooling process on a picosecond timescale: from bulk to monolayer — ANJA HANISCH-BLICHARSKI, ●SIMONE MÖLLENBECK, TOBIAS PELKA, PAUL SCHNEIDER, MARTIN KAMMLER, BORIS KRENZER, and MICHAEL HORN-VON HOEGL — Department of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE), Universität Duisburg-Essen, 47048 Duisburg, Germany

We study the cooling rate of heteroepitaxial thin film systems after fs-laser excitation with ps time resolution by means of ultrafast time resolved electron diffraction in a grazing reflection geometry (RHEED). Diffraction patterns taken at different delays between pumping laser pulse and probing electron pulse are converted to the transient film temperature using the Debye-Waller effect. We present results on ultrathin epitaxial Bi(111)- and Pb(111)-films on Si(001) and Si(111) substrates. For a 6 nm thin Bi-film a rapid increase of the surface temperature from 80 K up to 190 K upon laser excitation is followed by a slow exponential decay with a decay constant of $\tau = 640$ ps which is determined by the thermal boundary resistance at the hetero interface between film and substrate. The large increase of the surface temperature is caused by the small absorption length of 15 nm for photons with $\lambda = 800$ nm. For Bi-films the cooling rate varies linearly from $\tau = 290$ to $\tau = 3200$ ps with the film thickness which has been varied between 2.5 and 35 nm while a Pb-monolayer within the ($\sqrt{3} \times \sqrt{3}$) reconstruction shows a cooling rate of only 150 ps.

O 27.119 Tue 18:30 P2

Nanosecond time-resolved measurements of acoustic waves — ●FABIAN KNEIER, TOBIAS GELDHÄUSER, JOHANNES BONEBERG, and PAUL LEIDERER — Fachbereich Physik, Universität Konstanz, 78457 Konstanz

We have built a Michelson interferometer that is capable of determining surface expansions and accelerations in the sub-nm range with a ns-temporal resolution. For that purpose the interferometer is stabilized by a piezoelectrically driven mirror in the reference arm. This setup is used to study Bulk Acoustic Waves (BAW) and their properties. This is achieved using a Nd:YAG laser to induce BAWs in a silicon wafer irradiating onto the back of the silicon wafer and measuring the surface displacement caused at the front surface. Included in our investigation are, for example, the effect of silicon wafer thickness or the effect of sacrificial layers of different materials on the back side of the wafer where the the BAW is generated. The information gained will be applied to get a deeper understanding of the underlying processes of dry-laser cleaning and particle adhesion on surfaces.

O 27.120 Tue 18:30 P2

Dynamics of electron transport at the PTCDA/Ag(111)-interface studied with time-resolved 2PPE — ●CHRISTIAN SCHWALB¹, SÖNKE SACHS², MANUEL B. MARKS¹, ACHIM SCHÖLL², EBERHARD UMBACH^{2,3}, and ULRICH HÖFER¹ — ¹Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität Marburg, D-35032 Marburg — ²Universität Würzburg, Experimentelle Physik II, D-97074 Würzburg — ³Forschungszentrum Karlsruhe, D-

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Time-resolved two-photon photoemission (2PPE) is able to provide very detailed information about the electronic structure and the dynamics of electron transfer processes of well-ordered interfaces between organic semiconductors and metals. As a model system we have investigated thin epitaxial PTCDA films on Ag(111). A dispersing unoccupied state with an effective electron mass of $0.39 m_e$ at the $\bar{\Gamma}$ -point emerges 0.6 eV above the metallic Fermi level E_F . Its short lifetime of 55 fs is a clear indication that this state has a strong overlap with the metal and essentially originates from an upshift of the Shockley surface state of the Ag substrate [1]. In order to investigate the role of the interface state for charge carrier injection, we populate the LUMO of PTCDA in films of varying thickness and simultaneously record fluorescence and photoemission spectra. A long lived component observed in the 2PPE signal close to E_F clearly correlates with film thickness and fluorescence lifetime.

[1] C.H. Schwalb *et al.*, Phys. Rev. Lett. **101**, 146801 (2008)

O 27.121 Tue 18:30 P2

Momentum-Resolved Dynamics of Electrons in Image-Potential States on Ag(111) and Cu(111) — ●A. DAMM¹, K. SCHUBERT¹, S.V. EREMEEV², A.G. BORISOV³, E.V. CHULKOV⁴, P.M. ECHENIQUE⁴, J. GÜDDE¹, and U. HÖFER¹ — ¹Fachbereich Physik und Zentrum für Materialwissenschaften, Philipps-Universität, D-35032 Marburg, Germany — ²Institute of Strength Physics and Material Science, 634021 Tomsk, Russia — ³Laboratoire des Collisions Atomiques et Moléculaires, Université Paris-Sud, 91405 Orsay Cedex, France — ⁴Donostia International Physics Center, 20018 San Sebastián, Basque Country, Spain

We report on the momentum-dependence of the decay rate of electrons in image-potential states on Ag(111) and Cu(111) investigated by time- and angle-resolved two-photon photoemission (2PPE). On these surfaces, the $n = 1$ image-potential state is located within the projected bulk band gap only close to the $\bar{\Gamma}$ -point, whereas it becomes degenerated with a projected bulk band at $k_{\parallel} \approx 0.2 \text{ \AA}^{-1}$. This offers the opportunity to investigate differences in the electron dynamics of surface gap states and resonances within one model system. While the lifetime of gap states is dominated by inelastic decay due to electron-hole-pair excitations, an additional decay channel due to elastic charge transfer into the bulk exists for resonances. We observe a continuous increase of the decay rate with k_{\parallel} on both surfaces without a sudden change at the band edge. We compare these results with a theoretical description based on many-body calculations for the inelastic decay and a wave-packet propagation method for the elastic charge transfer.

O 27.122 Tue 18:30 P2

Non-perturbative approach to photoemission by direct simulation of photo-currents — ●HENNING HUSSER, JAN VAN HEYS, and ECKHARD PEHLKE — Institut für Theoretische Physik und Astrophysik, Universität Kiel, Germany

We present a non-perturbative ab initio approach for the calculation of photo-currents by direct simulation of the photoemission process. The electronic structure of the solid surface, which is initially in its electronic ground state, is calculated within density functional theory using a slab geometry. In a first approach, we integrate the time-dependent single-particle Kohn-Sham equations only for a frozen-in effective potential. The excitation by a fs laser-pulse is accounted for within the dipole approximation. Decoupling of the slabs is achieved by an optimized absorbing potential in the vacuum region. Inelastic scattering of the photo-excited electrons in the solid is roughly accounted for by an absorptive gauge-invariant (constructed in analogy to [1]) optical potential, which is acting only on the excited-state admixtures to the time-dependent wave-functions. The spectra are derived from the Fourier transform of the time-dependent wave-functions. The integration of the time-dependent single-particle equations is carried through with an extended [2] version of the *himd* code from the Fritz-Haber-Institut in Berlin. We present photoemission spectra for the Si(001) surface. We argue how the method can be extended to highly excited systems.

[1] S. Ismail-Beigi *et al.*, Phys. Rev. Lett. **87**, 087402 (2001).

[2] J. van Heys *et al.*, Phase Transitions **78**, 773 (2005).