Thin Films Division
Fachverband Dünne Schichten (DS)

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Overview of Invited Talks and Sessions

(lecture rooms GER 37 and GER 38; Poster P5)

Invited Talks

DS 4.1	Mon	10:15–11:00	GER 38	**Semiconductor Nanolasers with Nanowire and Plasmonic Waveguides** — •Cun-Zheng Ning
DS 12.1	Tue	9:30–10:15	GER 38	**Nanoscale Profiling of Electron Transport in Metallic and Semimetal films** — Chaehwi Chong, Yunfei Wang, •Robert Geer
DS 14.1	Tue	14:15–15:00	GER 38	**Optimal plasmonic focusing with thin film metrology applications** — •Qiwen Zhan, Weibin Chen
DS 19.1	Wed	14:45–15:30	GER 37	**Integrated Inductors using Amorphous Magnetic Materials** — •Donald S. Gardner, Gerhard Schrom, Fabrice Paillet, Tanay Karnik, Shekhar Borkar
DS 32.1	Thu	9:30–10:15	GER 38	**Optimizing Electronic Properties of Misfit Layered Compounds** — •David Johnson, Colby Heideman, Qiyin Lin, Clay Mortensen
DS 34.1	Thu	14:15–15:00	GER 38	**Metal/Semiconductor Superlattices as Thermoelectric Metamaterials for Solid-State Energy Conversion** — •Timothy D Sands

Gaede Prize

DS 27.1	Wed	14:00–14:45	HSZ 02	**Engineering surfaces, interfaces and structural phases to tailor magnetic properties** — •Jürgen Fassbender

Sessions

DS 1.1–1.7	Mon	10:15–12:00	GER 37	**Thin Film Characterisation: Structure Analyse and Composition (XRD, TEM, XPS, SIMS, RBS, ...) I**
DS 2.1–2.6	Mon	14:00–15:30	GER 37	**Thin Film Characterisation: Structure Analyse and Composition (XRD, TEM, XPS, SIMS, RBS, ...) II**
DS 3.1–3.6	Mon	15:45–17:15	GER 37	**Layer Deposition Processes**
DS 4.1–4.1	Mon	10:15–11:00	GER 38	**Invited Ning**
DS 5.1–5.3	Mon	11:15–12:30	GER 38	**Nanophotonics - Theory of Nanophotonic Devices I**
DS 6.1–6.3	Mon	14:00–15:15	GER 38	**Nanophotonics - Theory of Nanophotonic Devices II**
DS 7.1–7.4	Mon	15:30–17:00	GER 38	**Nanophotonics - Theory of Nanophotonic Devices III**
DS 8.1–8.6	Mon	15:00–17:00	WIL B321	**High-k and low-k dielectrics**
DS 9.1–9.5	Tue	9:30–10:45	GER 37	**Metal Layers**
DS 10.1–10.7	Tue	11:00–12:45	GER 37	**Surface Modification**
DS 11.1–11.8	Tue	14:00–16:00	GER 37	**Layer Growth: Evolution of Structure and Simulation**
DS 12.1–12.1	Tue	9:30–10:15	GER 38	**Invited Geer**
DS 13.1–13.5	Tue	10:30–12:00	GER 38	**Thin Film Metrology for Electronics, Photonics, and Photovoltaics I**
DS 14.1–14.1	Tue	14:15–15:00	GER 38	**Invited Zhan**
DS 15.1–15.4	Tue	15:15–16:30	GER 38	**Thin Film Metrology for Electronics, Photonics, and Photovoltaics II**

DS 16.1–16.39	Tue	9:30–12:30	P5	**Poster I**
DS 17.1–17.6	Wed	9:30–11:00	GER 37	**Layer Properties: Electrical, Optical and Mechanical Properties I**
DS 18.1–18.5	Wed	11:15–12:30	GER 37	**Layer Properties: Electrical, Optical and Mechanical Properties II**
DS 19.1–19.1	Wed	14:45–15:30	GER 37	**Invited Gardner**
DS 20.1–20.4	Wed	15:45–17:30	GER 37	**Amorphous Thin Magnetic Films**
DS 21.1–21.6	Wed	9:30–11:00	GER 38	**Organic Thin Films I**
DS 22.1–22.7	Wed	11:15–13:00	GER 38	**Organic Thin Films II**
DS 23.1–23.6	Wed	14:45–16:15	GER 38	**Organic Thin Films III**
DS 24.1–24.5	Wed	16:30–17:45	GER 38	**Organic Thin Films IV**
DS 25.1–25.4	Wed	18:00–19:00	GER 37	**Organic Thin Films V**
DS 26.1–26.61	Wed	9:30–12:30	P5	**Poster II**
DS 27.1–27.1	Wed	14:00–14:45	HSZ 02	**Gaede Prize: Jürgen Fassbender**
DS 28.1–28.6	Thu	9:30–11:00	GER 37	**Nanoengineered Thin Films I**
DS 29.1–29.6	Thu	11:15–12:45	GER 37	**Nanoengineered Thin Films II**
DS 30.1–30.7	Thu	14:15–16:00	GER 37	**Application of Thin Films I**
DS 31.1–31.6	Thu	16:15–17:45	GER 37	**Application of Thin Films II**
DS 32.1–32.1	Thu	9:30–10:15	GER 38	**Invited Johnson**
DS 33.1–33.5	Thu	10:30–12:00	GER 38	**Thermoelectric Thin Films and Nanostructures I**
DS 34.1–34.1	Thu	14:15–15:00	GER 38	**Invited Sands**
DS 35.1–35.5	Thu	15:15–17:00	GER 38	**Thermoelectric Thin Films and Nanostructures II**

Annual General Meeting Thin Films Division (DS)

Monday 17:30–18:00 Raum GER37

Annual General Meeting of the German Vacuum Society (DVG)

Monday 18:00–18:30 Raum GER37

DS 1: Thin Film Characterisation: Structure Analyse and Composition (XRD, TEM, XPS, SIMS, RBS, ...) I

Time: Monday 10:15–12:00 Location: GER 37

DS 1.1 Mon 10:15 GER 37

Epitaxial growth of ZnO on $CuInS_2$(112) — Stefan Andres[1], •Carsten Lehmann[2], and Christian Pettenkofer[2] — [1]Oerlikon, Lichtenstein — [2]Helmholtz-Zentrum Berlin, Germany

We report on epitaxial growth of ZnO on (112) orientated $CuInS_2$ thin films. The preparation of the samples was performed in an ultra high vacuum system at the Helmholtz-Zentrum Berlin. An alternating step-by-step growth and investigation by photoelectron spectroscopy (PES) and low energy electron diffraction (LEED) provided insight on the growth dynamics and structure of the ZnO-$CuInS_2$-interface. We find that during the initial growth no ZnO is deposited. Instead a monolayer of ZnS is formed by depleting the $CuInS_2$ surface of excess sulfur. Thereafter, the ZnO growth starts on this ZnS buffer layer. Band alignment considerations show that the ZnS buffer layer is thin enough to provide a beneficial band alignment situation concering photovoltaic application.

DS 1.2 Mon 10:30 GER 37

Sputter deposition of vanadium pentoxide (V_2O_5) as electrode material in rechargable Li-ion batteries — •Tobias Gallasch, Tobias Stockhoff, and Guido Schmitz — Institut für Materialphysik, Westf. Wilhelms-Universität Münster , Wilhelm-Klemm-Str.10, 48149 Münster, Germany

V_2O_5 is a candidate as intercalation compound for rechargable Li-ion batteries due to its orthorhombic layered crystal structure, which allows reversible Li^+ intercalation. V_2O_5 thin films (thickness: 300nm) were deposited on silicon or glass substrates by ion beam sputtering from a sintered V_2O_5 powder target. The influence of different sputter parameters (such as: substrate material, temperature, oxygen partial pressure) and post-annealing conditions on the structure were investigated by XRD and TEM; Electronic properties were analysed by dc-conductivity measurements. It is demonstrated that the desired intercalation structure is only achieved by adding oxygen during sputtering and post-annealing under oxygen atmosphere. It is shown that the electronic conductivity spreads over several orders of magnitude depending on the preparation conditions.

Futhermore, electron energy-loss spectroscopy (EELS) was carried out to determine the V-oxidation state in dependence on sputter parameters and a comparison to well-defined powder materials is given. In first experiments using a liquid electrolyte ($LiClO_4$ as salt solved in ethylene carbonate/dimethyl carbonate mixtures) the efficiency of the sputtered V_2O_5 films for Li storage is demonstrated.

DS 1.3 Mon 10:45 GER 37

Photoactive TiO_2 Thin Films: Domination of Phase Formation or Microstructure — •Darina Manova, Jürgen Gerlach, Thomas Höche, and Stephan Mändl — Leibniz-Institut für Oberflächenmodifizierung, 04318 Leipzig

For several years, TiO_2 is receiving increasing scientific attention as one of the most promising photo catalysts with a huge potential for solving several different types of environmental problems. While TiO_2 powders and nanoparticles are well known and widely used, thin film surfaces are less investigated but still highly desired for applications. For TiO_2 polymorphs, anatase powder is reported to be a more potent photo catalyst than rutile. Metal plasma immersion ion implantation and deposition is employed to form titanium oxide films on different substrates at varying ion energies and substrate heating. At low temperatures, amorphous or nanocrystalline films were observed with TEM, while a columnar structure is present at 200 - 300 °C. XRD and Raman measurements indicate a transition from an anatase/rutile mixture at low temperatures and low ion energies towards pure rutile at high temperatures and high ion energies. It is shown that the photoactivity correlates closely with the phase formation and not with the microstructure of the thin films.

DS 1.4 Mon 11:00 GER 37

Formation of Ge NC's out of (GeO_x-SiO_2) superlattice structures — •Nicole M. Jeutter, Manuel Zschintzsch, Johannes von Borany, and Carsten Baehtz — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf, 01328 Dresden, Germany

Semiconductor Nanocrystals (NC), consisting only of a few hundred of atoms, are of great interest for new generations of light emitters, non-volatile memories or high efficiency solar cells [1]. However, it remains a remarkable challenge to achieve a high density ($>10^{12}cm^2$) of equal-sized, small (<5 nm) NC's of Ge or Si embedded in dielectric films. In this study we present the fabrication of Ge-NC's by decomposition of GeO_x (1<x <2) out of a (GeO_x -SiO_2) superlattice structure (SL). The SL was grown by dual reactive DC magnetron sputtering from elemental targets. Different Ge/O ratios in the SL structures were realized by the variation of oxygen flow and deposition temperature. Using *in-situ* x-ray reflectivity and grazing incidence diffraction at the CRG Beamline ROBL at ESRF we studied the deposition of the SL and the Ge NC's evolution during subsequent annealing. Depending on the GeO_x stoichiometry closed nanocrystalline films or separated Ge NC's with grain or particle sizes between 2-5 nm have been obtained with grazing incidence x-ray diffraction. The size of the NC's can be tuned with thickness of the GeO_x sublayer, its density exceeds $10^{12}cm^2$.

[1] A.Rogach (ED.), Semiconductor nanocrystal quantum dots, Springer, Wien 2008, ISBN 978-3211752357

DS 1.5 Mon 11:15 GER 37

Characterization of Sr-Ta-O/TiN/Si stacks by means of XPS, AES and TOF-SIMS — •Canan Baristiran Kaynak, Mindaugas Lukosius, and Christian Wenger — IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Strontium tantalate (STA) films has been deposited on TiN/Si(100) substrates by Atomic Vapor Deposition (AVD) technique using a single source $Sr[Ta(OEt)_5(methoxyethoxide)]_2$ as precursor for metal-insulator-metal (MIM) applications. The deposition of STA films was investigated in dependence on different deposition conditions. X-Ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES) and Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS) were used for chemical and interface characterization of STA thin layers. The AES and TOF-SIMS depth profiles revealed a uniform and homogeneous STA films. Furthermore, electrical properties have been investigated in MIM capacitors after deposition of Au as top electrode. The correlation between chemical compositions of STA based MIM capacitors and their electrical properties are presented.

DS 1.6 Mon 11:30 GER 37

Characterization of the diffusion process in Al_2O_3 thin films based on ToF-SIMS measurements — •Pawel Piotr Michalowski[1], Malte Czernohorsky[1], Volkhard Beyer[1], Gert Jaschke[2], and Steffen Teichert[2] — [1]Fraunhofer-Center for Nanoelectronic Technologies, Königsbrücker Strasse 180, D-01099 Dresden, Germany — [2]Qimonda Dresden GmbH & Co. OHG, Königsbrücker Strasse 180, D-01099 Dresden, Germany

In next generation charge trapping non-volatile memory devices the blocking oxide material (currently SiO_2) has to be replaced by a high-k dielectric thin film. The appropriate selection of a suitable material from a large variety of potential candidates requires precise analytical characterization techniques. This work focuses on Secondary Ion Mass Spectroscopy (SIMS) of Al_2O_3 thin films which were fabricated by atomic layer deposition on Si(001) wafers. These samples were treated by rapid thermal annealing in wide range of temperatures ($750-1100°C$) and gas ambiences (N_2, O_2, H_2). SIMS depth profiles indicate that Si diffuses from the substrate through the alumina during annealing which leads to a segregation of Si on the Al_2O_3 layer surface. Grain boundary diffusion was identified to have the most significant impact in the diffusion process. Furthermore the activation energy of the diffusion was found to be 0.6 eV/atom and 2.3 eV/atom for amorphous and crystalline samples, respectively. The influence of different Al_2O_3 sublayers (e.g. SiO_2, Si_3N_4) and annealing conditions on the diffusion process will be discussed.

DS 1.7 Mon 11:45 GER 37

Structural and magnetic properties of CoFeB/MgO multilayers — •Kirill Zhernenkov[1], Miriana Vadala[1], Boris Toperverg[1], Hartmut Zabel[1], Hitoshi Kubota[2], and Shinji Yuasa[2] — [1]Department of Physics and Astronomy, Ruhr-Universität

Bochum 44780 Bochum, Germany — [2]National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1, Umezono, Tsukuba, Ibaraki 305-8568, Japan

CoFeB/MgO/CoFeB tunnel junctions display one of the highest TMR values at room temperature[1], only surpassed by Fe/MgO/Fe(001) MTJs. In the latter case, it is argued that the giant TMR effect is due to the textured epitaxial growth properties which leads to a coherent tunneling process instead of a diffuse tunneling. However, CoFeB films are amorphous and the MgO layer is microcrystalline. Nevertheless, very high TMR values of more than 350% have been achieved. We have investigated multilayers of CoFeB/MgO fabricated by different preparation procedures and annealed at temperatures between 240 - 360°C. High resolution x-ray scattering, polarized neutron reflectivity (PNR) and MOKE measurements have been done. It was found that the multilayers have different interfacial sharpness and structural quality depending on the way of preparation. At certain conditions the interfaces remain sharp up to the highest annealing temperature, whereas recrystallization or texturization is not observed. PNR experiments indicate a dependence of the CoFeB layer magnetization upon annealing temperature and method of MTJ sample fabrication. 1. S. Yuasa and D. D. Djayaprawira, J. Phys. D: Appl. Phys. 40 (2007) R337

DS 2: Thin Film Characterisation: Structure Analyse and Composition (XRD, TEM, XPS, SIMS, RBS, ...) II

Time: Monday 14:00–15:30 Location: GER 37

DS 2.1 Mon 14:00 GER 37

Nickeldotierung von Diamantnanokristallen zur Erzeugung robuster Einzelphotonquellen — •Marco Wolfer[2], Armin Kriele[1], Oliver Williams[1], Harald Obloh[1], Crenguta-Columbina Leancu[1], Lutz Kirste[1] und Christoph Nebel[1] — [1]Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastraße 72, 79108 Freiburg i. Br. — [2]Albert-Ludwigs-Universität Freiburg, Fakultät für angewandte Wissenschaften, Georges-Köhler-Allee101, 79110 Freiburg

Farbzentren in Diamant haben sich als robuste Quantenemitter erwiesen und stellen aufgrund ihrer niedrigen Linienbreiten und hohen Repeditionsraten die Basis für eine Vielzahl zukünftiger opto-elektronischer Anwendungen dar (Quantenkryptographie, Quantencomputer, optische Transistoren). Ein besonders attraktives Single-Photon Zentrum ist der Nickel-Stickstoffkomplex NiN_x, dessen reproduzierbare Erzeugung sich allerdings als sehr schwierig darstellt. Gegenstand der vorliegenden Untersuchung ist die gezielte Nickeldotierung von dünnen Mikrowellen-Plasma-CVD abgeschiedenen Diamantschichten. Als Dotierquellen werden benutzt: a) gasförmiges Nickelocene, b) Nickelpulver, das zu Diamant-Nanopartikeln hinzu gemischt wird und c) Nickeldraht. Alle drei führen zu einer Anreicherung des Wasserstoffplasmas mit Ni Atomen was mit optischer Emissionsspektroskopie nachgewiesen wird. Der substitutionelle Einbau von Nickel in die Diamantstruktur wird mittels Photolumineszenz, konfokaler Mikroramanmikroskopie und SIMS untersucht. Die Ergebnisse dieser Dotierversuche werden im Detail vorgestellt und diskutiert.

DS 2.2 Mon 14:15 GER 37

Texture analysis on the system Mn_4Si_7@Si(001): Combining statistical and microscopical information — •Herbert Schletter[1], Steffen Schulze[1], Michael Hietschold[1], Koen De Keyser[2], Christophe Detavernier[2], Gunter Beddies[1], and Meiken Falke[1,3] — [1]Institute of Physics, University of Technology, 09107 Chemnitz, Germany — [2]Department of Solid State Physics, Ghent University, Belgium 9000 — [3]at present Bruker AXS, Germany

Higher manganese silicides (HMS) are promising candidates for opto- and thermoelectrical applications. They are stable, environmentally friendly and cheap. Since these materials show a strong anisotropy in their electrical properties, it is important to know the texture of HMS thin films on silicon. The system Mn_4Si_7@Si(001) was investigated with electron backscatter diffraction (EBSD) to reveal both, statistical information on crystallite orientation (i.e. texture) and microscopical information on crystallite sizes.

Besides the known epitaxial orientations of this system, new texture components were found, including epitaxial and axiotaxial relations. The latter component (which can be described as an off-normal fibre texture) is of special interest since it has been known for only few years and has been investigated on a small number of materials up to now.

By combining the statistical and microscopical information provided by EBSD, a correlation between the respective texture components and the grain size could be drawn, which showed, that the degree of periodicity at the interface strongly influences the size of the growing crystallite.

DS 2.3 Mon 14:30 GER 37

Studies of interdiffusion and magnetism in magnetic multilayers — •Mathias Schmidt, János Major, Adrian Rühm, Márton Major, Max Nülle, and Helmut Dosch — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

Strongly reflecting so-called supermirrors are frequently used in neutron optics in many ways, for example in neutron guides or as magnetic polarizing mirrors. They consist of aperiodic multilayers of two materials with a layer thickness in the nanometer range. The properties of such multilayers are strongly dependent on the quality of the interfaces (geometrical and magnetic roughness, intermixing). Irregularities usually are introduced in the production phase. To improve the understanding of the technological processes, we investigated the interdiffusion of the components in periodic Ni-Ti and Fe-Si multilayers. The samples were annealed at different temperatures from 100°C to 300°C and neutron and x-ray reflectivity and neutron off-specular scattering experiments have been performed. In the case of the Fe-Si samples, the neutron experiments were performed also in spin-resolved mode. The results of the experiments, their detailed analysis and the obtained annealing-dependent interface roughnesses (chemical and magnetic), as well as the interdiffusion properties of the samples will be presented.

DS 2.4 Mon 14:45 GER 37

Non-destructive speciation of buried nanolayer systems by angle-corrected GIXRF-NEXAFS — •Beatrix Pollakowski and Burkhard Beckhoff — Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin

The photon-in photon-out spectroscopic method GIXRF-NEXAFS[1] has proved to be a reliable tool for the non-destructive analysis of deeply buried single layers. In recent investigations even species of buried double layer systems, consisting of different bonds of the same element were addressed. This approach becomes relevant for the characterization of interfaces or gradient layers as alternative methods may involve drawbacks such as sample modifications by sputtering or limited information depths. The intensity of the x-ray standing wave (XSW) field determining GIXRF characteristics is to be well known for each kind of layered material to keep the mean penetration depth constant in the respective layer of interest. Moving on, one may even keep the XSW intensity constant in only one part of a buried nanolayer, thus providing access to interfaces by a differential approach employing angle-adapted NEXAFS.

The double layer systems investigated consist of a titanium oxide (TiO_2 or Ti_2O_3) and metallic Ti layer, separated from each other by a 2 nm C layer. First GIXRF-NEXAFS measurements at the Ti-$L_{iii,ii}$ absorption edges with angular correction based upon prior XSW simulation demonstrate the high potential of the approach for analyzing novel materials nanolayers.

[1] B. Pollakowski et al., Phys. Rev. B **77**, 235408 (2008)

DS 2.5 Mon 15:00 GER 37

Channeling irradiation of $LiNbO_3$: Influence of ion energy and ion species — •Tobias Steinbach, Frank Schrempel, Thomas Gischkat, and Werner Wesch — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena

Ion irradiation of $LiNbO_3$ causes the formation of defects due to nuclear as well as electronic energy deposition ϵ_n and ϵ_e, respectively. However, the defect formation is influenced by the orientation of the crystal. In order to investigate the effect of ϵ_n and ϵ_e on the damage

formation x-cut $LiNbO_3$ single crystals were irradiated on- and off-axis using Si^+ and Cu^+ ions with energies ranging from 550 keV to 2 MeV. We demonstrate for on-axis irradiation that at low ion energies where ϵ_n dominates the formation of defects, the defect distribution is shifted to larger depths compared to off-axis irradiation. The investigation of the shift shows a square-root dependence on both ion energy and ion species. Furthermore, on-axis irradiation was done using high-ion energies where defects are formed in the near-surface region due to electronic energy loss. Compared to off-axis irradiation a thinner amorphous surface layer was formed as a result of the reduced electronic energy loss in the case of on-axis irradiation. For on-axis irradiation ϵ_e has been estimated in two different ways considering the layer thickness and the penetration range of the incident ions.

DS 2.6 Mon 15:15 GER 37

Gracing incidence FTIR of thin high-k dielectrics — •Wenke Weinreich[1], Johannes Müller[1], Martin Rose[1], Lutz Wilde[1], Martin Lemberger[2], Marco Steinert[3], and Uwe Schröder[3] — [1]Fraunhofer CNT, Dresden, Germany — [2]Fraunhofer IISB, Erlangen, Germany — [3]Qimonda, Dresden, Germany

High-k dielectrics are under intensive study for transistor and memory applications. The crystallinity mainly determines the permittivity and, thereby, the electrical performance of the built capacitor. We will present a new method that uses a common Fourier transform infrared spectroscopy (FTIR) in a gracing incidence configuration to investigate the crystallization behaviour of thin 6 to 10 nm dielectric films. The advantage of this standard FTIR technique is the enhanced spectral range compared to attenuated total reflection (ATR)-FTIR which is generally used to analyze especially thin films. More precisely, the required ATR-FTIR method for dielectrics would only provide 670 cm^{-1} as minimum wavelength. In this study, ideal measuring settings for standard FTIR are identified and the investigation of thin films annealed at various temperatures is performed. Phase analysis, crystallization temperature and the influence of doping concentration on the structure of dielectrics and, especially, on the phase stabilization are determined. The studied material systems are Al- or Si-doped ZrO_2 and HfO_2, and also TiO_2 grown by atomic layer deposition. It will be shown that the analysis can be done on different substrates if suitable references for the background measurement are available. The obtained results are correlated to gracing incidence X-ray diffraction.

DS 3: Layer Deposition Processes

Time: Monday 15:45–17:15 Location: GER 37

DS 3.1 Mon 15:45 GER 37

Growth of carbon nanotubes on different support/catalyst systems for interconnect and sensor applications — •Sascha Hermann[1], Ramona Ecke[1], Barbara Pahl[2], and Stefan E. Schulz[1,3] — [1]Chemnitz University of Technology, Center for Microtechnologies, 09126 Chemnitz, Germany — [2]Fraunhofer Institute for Reliability and Microintegration, 13355 Berlin, Germany — [3]Fraunhofer ENAS for Electronic Nanosystems, 09126 Chemnitz, Germany

This work is focused on the growth of aligned densely packed multi walled carbon nanotubes (MWNT) for the application as Via-interconnects. We have conducted a parametric study on different support/catalyst systems and investigated its influence on CNT growth performed with thermal CVD. Basic studies with the support/catalyst combination SiO_2/ Ni were conducted to study the influence of gas composition, temperature and catalyst thickness. Furthermore, we have prepared bi-catalytic systems like NiMo and CoMo and investigated its influence on catalyst effectiveness and CNT growth temperature. As a step towards integration, we have prepared patterned substrates with a complete metallization system including a Cu/TiN/Ni layer stack. We have achieved selective growth of densely packed vertical aligned MWNTs. Electrical measurements of flip-chip connections indicate good electrical properties of the CNT-arrays.

DS 3.2 Mon 16:00 GER 37

Vapor–liquid–solid growth of silicon on glass — •Robert Heimburger[1], Nils Dessmann[1], Thomas Teubner[1], Rainald Mientus[2], and Torsten Boeck[1] — [1]Leibniz–Institut für Kristallzüchtung, Max–Born–Straße 2, D–12489 Berlin, Germany — [2]OUT e.V., Köpenicker Straße 325, D–12555 Berlin, Germany

Development of low cost deposition techniques leading to high quality polycrystalline silicon films on glass is of great interest for solar cell industry. By taking advantage of growth from metallic solutions, vapor–liquid–solid processing promises both, cheap processing and good crystalline quality. In a first step, a liquid metallic solvent (indium) is deposited on glass, which was previously coated with thin conductive layers, to form well distributed microdroplets on the surface. These droplets act as nucleation sites for silicon deposited in a second step. Outgrowth of separated silicon seed crystals is done using specially adopted steady–state liquid phase epitaxy equipment [1].

One key factor for process development is the proper selection of backside contact material regarding thermodynamic stability, adhesion and wettability. Thermodynamic stability, i.e. the ability to withstand the silicon saturated solution during outgrowth, depends crucially on heat treatment during deposition process. Wettability is shown to be a function of deposition temperature, rate and surface pretreatment. Fully processed samples exhibit significant outgrowth of seeds into typically {111} faceted silicon crystals demonstrating the feasibility of the process.

[1] T. Teubner et al., Cryst. Growth Des. 2008 8 (7), 2484–2488

DS 3.3 Mon 16:15 GER 37

Epitaxial Growth of Ni on Si(100) Substrate by DC Magnetron Sputtering — •Wolfgang Kreuzpaintner, Michael Störmer, Dieter Lott, Danica Solina, and Andreas Schreyer — GKSS Forschungszentrum GmbH, Max-Planck-Str. 1, 21502 Geesthacht

The influence of the substrate temperature on the growth of highly textured Ni(111) and epitaxial Ni(200) with the epitaxial relationship Ni[100]||Si[110] and Ni(001)||Si(001) on hydrogen terminated Si(100) wafer substrates by means of direct current magnetron sputtering will be reported. To minimize crystal defect formation and in order to achieve a high quality epitaxial growth of Ni on Si a two step deposition process was developed whereby different deposition conditions were used for an initial nickel seed layer and the remaining nickel film. In-plane and out-of-plane structural properties of the deposited films were investigated using x-ray scattering techniques whereas magneto-optical Kerr effect and neutron reflectometry were used to confirm their magnetic nature.

DS 3.4 Mon 16:30 GER 37

Sputtering of TiO_2 under PEM-control — •Dieter Mergel, Farhad Mohtascham, and Özgür Aktas — Universität Duisburg-Essen, FB Physik, 47048 Duisburg

16 layers of TiO(2) have been deposited by sputtering from a metallic target. Three process parameters have been varied:

* deposition temperature (ambient or 300°C),
* O(2)-admixture to Ar (3
* plasma excitation (DC or RF).

In every run, a glass and a silicon substrate were coated simultaneously. The process was controlled by a plasma-emission monitor of the Ti-line, whose sensitivity had been gauged by systematic experiments beforehand.

On every sample, the packing density and the intensity of the Raman anatase line was determined and related to the deposition conditions.

The reproducibility of the process was improved before this deposition series and was tested by depositing two layers on two glass substrates in the same run.

DS 3.5 Mon 16:45 GER 37

Process Conditions for Atomic Layer Deposition of HfO_2 from Alkylamides and Consequences for Reactor Design — •Thomas Zilbauer, Torsten Sulima, and Ignaz Eisele — Universität der Bundeswehr München, Institut für Physik, 85577 Neuiberg

Atomic Layer Deposition (ALD) has been established as a manufacturing process for ultra thin films with high precision of conformal thickness control due to its ability of self-terminating deposition steps. To take advantage of this process stability gain, special precursors

are needed, which must be very reactive in order to allow for fast chemisorption on the substrate surface without any desorption within the deposition cycle time. This high precursor reactivity on the other hand puts stringent demands on the delivery system and the reactor to prevent preliminary precursor decomposition.

Starting from a theoretical insight into the basic of the self-terminating ALD-chemistry, we will demonstrate the challenges and limitations for reactor design on the example of HfO_2-ALD using a Hafnium Alkylamide as precursor and a commercially available reactor. Additionally, we will present suggestions on potential improvements and results from their successful implementation.

DS 3.6 Mon 17:00 GER 37

Preparation of thin biaxial strained functional oxides and multilayers — •Sascha Trommler, Thomas Freudenberg, Ruben Hühne, Bernhard Holzapfel, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Functional oxides with a perovskite structure as well as structurally related compounds have attracted great interest within the last years. It was shown, that novel electronic phases can be formed at interfaces of epitaxial grown oxides as well as that the biaxial strain induced by the lattice mismatch may significantly affect the physical properties in these materials. A major prerequisite to study these effects is the controlled growth of epitaxial heterostructures on an atomic level in order to achieve smooth interfaces with a low density of defects. Therefore, pulsed laser deposition was used in combination with real time RHEED investigations to prepare heterostructures on single terminated substrates using layer-by-layer growth. Results on the deposition of atomically flat $La_{2-x}Ba_xCuO_4$, $LaAlO_3$ and $La_{1-x}Sr_xCoO_3$ layers on different substrates will be presented and discussed together with their structural and physical properties. Furthermore, the preparation of complex multilayers will be exemplarily shown for the $LaCoO_3|SrTiO_3$ system.

DS 4: Invited Ning

Time: Monday 10:15–11:00 Location: GER 38

Invited Talk DS 4.1 Mon 10:15 GER 38

Semiconductor Nanolasers with Nanowire and Plasmonic Waveguides — •Cun-Zheng Ning — Center for Nanophotonics at Arizona Institute of NanoElectronics and Department of Electrical Engineering, Arizona State University

This talk presents theoretical aspects of a nanolaser made of semiconductor nanowire or nano pillar. A semiconductor nanowire or nanopillar is a unique nanolaser structure since it serves both as a gain material and a waveguide of high index contrast at the same time. Due to the small size and high index contrast, nanowire lasers show many features that are distinct from those of a conventional laser. These include strongly size and frequency dependent cavity loss, large confinement factor, diverging beam profile, and large spontaneous emission factor. To reduce the size of nanowire laser further, we exploit the possibility of coating a nanowire with a metal, thus forming a surface plasmonic waveguide. We will show that, despite the well-known large metal loss, it is possible to have a metal-coated nanowire to have large enough modal gain to exceed the necessary threshold, leading to our prediction of the first surface-plasmonic semiconductor nanolaser. Recent experimental work on this type of lasers will be presented and compared with the theoretical results, showing the first possible evidence of lasing in a surface-plasmonic waveguide.

DS 5: Nanophotonics - Theory of Nanophotonic Devices I

Time: Monday 11:15–12:30 Location: GER 38

Topical Talk DS 5.1 Mon 11:15 GER 38

Quantum modelling of nanophotonic laser devices — •Christina Bückers[1], Stephan W. Koch[1], Angela Thränhardt[2], Jörg Hader[3,4], and Jerome V. Moloney[3,4] — [1]Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany — [2]Fakultät für Naturwissenschaften, Technische Universität Chemnitz, 09107 Chemnitz, Germany — [3]Optical Sciences Center, University of Arizona, Tucson, AZ 85721, USA — [4]Nonlinear Control Strategies Inc., 3542 N. Geronimo Ave., Tucson, AZ 85705, USA

A microscopic theory is used to model the optical properties of semiconductor laser materials and modern devices. Typically, these devices are structured on the nanoscale such that any quantitative modelling requires a consistent quantum mechanical theory. In this talk, we show how such a many-particle approach can be used to compute the laser gain, absorption, photoluminescence as well as the radiative and Auger recombination processes. The predictive power of this modelling is demonstrated by detailed comparisons to quantitative experiments. In particular, so-called VECSEL (Vertical External Cavity Surface Emitting Laser) systems are analysed. It is shown that systematic design studies allow for device optimisation for a wide variety of different application conditions, such as high output power, emission at a particular wavelength, or low threshold.

Topical Talk DS 5.2 Mon 11:45 GER 38

Photon statistics and time evolution of photon correlations in semiconductor microcavity lasers — •Jan Wiersig[1], Christopher Gies[2], and Frank Jahnke[2] — [1]Institut für Theoretische Physik, Universität Magdeburg, 39016 Magdeburg — [2]Institut für Theoretische Physik, Universität Bremen, 28334 Bremen

Nanophotonic devices made of semiconductor quantum dots coupled to microcavities have a variety of potential applications including ultralow threshold lasers and single-photon sources. In this talk we discuss a microscopic theory for the photon correlation functions $g^{(1)}(\tau)$ and $g^{(2)}(\tau)$ describing the first and second-order coherence of semiconductor quantum-dot-based microcavity lasers [1,2]. Our theory predicts interesting and unexpected decay properties of the correlation functions. We explain these findings and compare them to recent experiments [3-5].

[1] C. Gies, J. Wiersig, M. Lorke, and F. Jahnke, Phys. Rev. A **75**, 013803 (2007).

[2] C. Gies, J. Wiersig, and F. Jahnke, Phys. Rev. Lett. **101**, 067401 (2008).

[3] S.M. Ulrich *et al.*, Phys. Rev. Lett. **98**, 043906 (2007).

[4] S. Ates *et al.*, Phys. Rev. B **78**, 155319 (2008).

[5] J. Wiersig *et al.*, submitted (2008).

DS 5.3 Mon 12:15 GER 38

Sensitivity of Quantum-Dot Lasers to Optical Feedback — •Christian Otto, Kathy Lüdge, Ermin Malić, and Eckehard Schöll — Institut für Theoretische Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Low sensitivity of a laser to back reflected light, a property needed for industrial device application, is predicted for semiconductor quantum dot (QD) lasers. In this work we investigate the complex dynamics of QD lasers subjected to weak external optical feedback from a distant mirror. The system is modeled with a modified Lang-Kobayashi equation for the electric field combined with microscopically based rate equations for the carriers in the quantum dots and surrounding wetting layer.

By varying the feedback strength we obtain complex bifurcation scenarios. For large linewidth enhancement factors (α>3) we find a bifurcation cascade leading to chaotic regions alternating with short regions of stable cw operation. This resembles the behaviour found in quantum well lasers. However, for low α-factors around α=1, typical for QD devices, the laser exhibits a reduced feedback sensitivity and performs stable cw operation over a wide range of increasing feedback strength.

DS 6: Nanophotonics - Theory of Nanophotonic Devices II

Time: Monday 14:00–15:15 Location: GER 38

Topical Talk DS 6.1 Mon 14:00 GER 38

All-optical memory based on a two-mode laser diode — •Andreas Amann, Simon Osborne, and Stephen O'Brien — Tyndall National Institute, University College Cork, Ireland

We present a method for tailoring the spectrum of an optical resonator by the use of additional perturbative features. For a predefined mode spectrum, the position of the features are obtained by solving an associated inverse problem. We have employed this method to design a two-mode edge emitting Fabry-Perót laser diode with a primary mode spacing in the THz regime.

Under optical injection into one of the modes this two-mode laser shows experimentally a number of complex dynamical phenomena as the injection strength and the detuning of the injected mode are varied. In particular the observed bistability between a single-mode locked state and a two-mode lasing state allows us to realize an all-optical memory element, where the switching is realized via a modulation of either the strength or the detuning of the injected mode. We are able to accurately reproduce and understand the observed phenomena on the basis of a surprisingly simple rate equation model.

Topical Talk DS 6.2 Mon 14:30 GER 38

Novel Concepts of High Power Diode Lasers: High Brilliance and Wavelength Stabilization — •Vitaly Shchukin[1,2], Nikolai Ledentsov[1,2], and Dieter Bimberg[1] — [1]Technische Universitaet Berlin, Berlin, Germany — [2]Present address: VI Systems GmbH, Berlin, Germany

Novel concepts of high power diode lasers enable solving the problem existing since decades: poor beam quality and an unstable wavelength of lasing rapidly shifting upon current and temperature variations.

i) Photonic Band Crystal Laser provides a strong discrimination of a fundamental mode localized at an optical defect against the rest not localized modes, which enables a single mode lasing from an ultra-broad waveguide (WG), and thus high brilliance narrow beam operation.

ii) Tilted Cavity Laser contains a narrow cavity and a multilayer interference reflector (MIR). Different angular behavior of the cavity mode wavelength and MIR reflectance maximum provides wavelength-selective leakage loss from the cavity through the MIR and enables wavelength-stabilized operation. The theory predicts a possibility to reach zero and even negative thermal shift of the lasing wavelength.

iii) Tilted Wave Laser contains a narrow WG coupled with a broad WG. Light generated in the narrow WG leaks to the broad WG, propagates there as a tilted wave, is reflected back, and returns to the narrow WG. The phase matching conditions between the wave propagating along the narrow WG and the returned wave govern the wavelength-stabilized lasing, and the broad WG promotes an ultra-narrow beam.

Modeling and experimental proof-of-concepts will be presented.

DS 6.3 Mon 15:00 GER 38

Control of the Linear Polarization of Excitonic Emission from Group-III-nitride Quantum Dots — •Momme Winkelnkemper, Gerald Hönig, Andrei Schliwa, and Dieter Bimberg — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Control of the polarization of emission from single QDs is of major importance for applications, such as QD-based single-photon emitters for quantum cryptography. The properties of excitonic emission from bulk wurtzite group-III nitrides are governed by the valence band (VB) structure of these materials. A, B, and C excitons can be unambiguously identified analyzing the linear polarization of their emission in different detection geometries. Order and character of the VBs can be altered if the material is strained. Here, we show that a structural anisotropy of InGaN/GaN quantum dots (QDs) leads to a linear polarization of confined A- and B-type excitonic states in orthogonal directions. Moreover, we predict a similar polarization effect for GaN/AlN QDs and show that it is, in fact, evoked by an anisotropy of the strain field within the QDs. Using strain-dependent eight-band k.p theory we calculate the polarization of the optical transitions in either elongated QDs or QDs under externally applied stress. For both cases a pronounced linear polarization is found. By performing a quantitative study we show that the polarization of the ground state transition can be effectively controlled by externally applied uniaxial stresses.

DS 7: Nanophotonics - Theory of Nanophotonic Devices III

Time: Monday 15:30–17:00 Location: GER 38

Topical Talk DS 7.1 Mon 15:30 GER 38

Theory of carrier dynamics in quantum dot light emitters — •Ermin Malic[1], Marten Richter[1], Jeong-Eun Kim[1], Janik Wolters[1], Matthias-Rene Dachner[1], Ulrike Woggon[2], and Andreas Knorr[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin — [2]Institut für Optik und Atomare Physik, Technische Universität Berlin

We present a microscopic theory describing the charge carrier dynamics in quantum dot light emitters, such as lasers and amplifiers. The theoretical approach is based on quantum dot Bloch equations including microscopically calculated Coulomb and electron-phonon scattering rates between bound quantum dot, continuous wetting layer, and bulk states. After electrical injection of charge carriers, their subsequent transfer from bulk into the wetting layer and quantum dot is considered via phonon induced relaxation processes. The latter generate hot non-equilibrium carriers. As a result the electronic temperature is increased. At high charge carrier densities, Coulomb scattering modifies the picture. Here, we focus on two typical aspects: i) Gain dynamics of QD amplifiers at high electrical injection, ii) Switch-on dynamics of QD-VCELS and edge emitters.

We discuss the importance of the interplay between scattering contributions and induced emission and absorption processes on the device properties. These investigations are performed at different temperatures, for different density regimes, and for various pulse areas.

Topical Talk DS 7.2 Mon 16:00 GER 38

Photo- and spin current generation and dynamics in semiconductor nanostructures — Huynh Thanh Duc, Jens Förstner, and •Torsten Meier — Deparment Physik, Fakultät für Naturwissenschaften, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn

The band structure and wave functions of GaAs quantum wells are computed via k.p band structure theory including anisotropy and spin splitting. Using these results, the process of generating photocurrents by optical excitation is analyzed. Depending on the symmetry of the material, the direction of the laser beam, and the polarization direction of the light field/s, one can coherently generate charge and/or spin photocurrents on ultrashort time scales. The direction, the strength, and the dynamics of these photocurrents are computed and discussed.

DS 7.3 Mon 16:30 GER 38

Microscopic modelling of Auger losses in wide bandgap nitrides — •Jörg Hader[1,2], Jerome V. Moloney[1,2], Bernhard Pasenow[3], and Stephan W. Koch[3] — [1]Nonlinear Control Strategies Inc., 3542 N. Geronimo Ave., Tucson, AZ 85705, USA — [2]College of Optical Sciences, University of Arizona, Tucson, AZ 85721, USA — [3]Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps-Univrsität Marburg, Renthof 5, 35032 Marburg, Germany

The internal quantum efficiency in GaN-based light emitting diodes is generally found to have a maximum at very low pump densities and to fall off for higher densities. Using phenomenological models, this efficiency 'droop' can be fitted asuming a non-radiative loss mechanism that has the cubic density dependence usually associated with Auger recombination losses. Here, we use a set of fully microscopic models to investigate the actual importance of Auger losses in these systems. We give a brief description of the involved models for absorption/gain, spontaneous emission and carrier losses due to radiative

and direct and phonon-assisted Auger losses. The predicitve nature of these fit-parameter free models is demonstrated and shortcomings of simplified phenomenological models are discussed - in particular, the general failure of the cubic density dependence for Auger losses. It is shown that direct Auger losses cannot explain the efficiency droop[1] and the possible impact of phonon-assisted processes is analyzed.

[1] J. Hader, et al., Appl. Phys. Lett. 92, 261103 (2008)

DS 7.4 Mon 16:45 GER 38

Numerical simulation of tilted wave lasers — •Jan Pomplun[1], Frank Schmidt[1], Kristijan Posilovic[2], Vitaly A. Shchukin[2], Nikolai N. Ledentsov[2], and Dieter Bimberg[2] — [1]Zuse Institut Berlin, Takustr. 7, 14195 Berlin, Deutschland — [2]Institut für Festkörperphysik, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Deutschland

The tilted wave concept offers the possibility to realize ultrahigh-brightness wavelength-stabilized lasers, which are important for many applications like data transmission and solid state laser pumping.

In a tilted wave laser (TWL) the narrow active waveguide is coupled to a broad second waveguide. The lasing mode leaks from the active region creating a mode in the second waveguide. The coupling of both modes results in wavelength stabilization but is also very sensitive to the design of the system. Numerical simulations are therefore very important to obtain desired properties and increase the performance of TWLs.

In our contribution we analyze tilted wave lasers numerically. The influence of design parameters on the propagating lasing eigenmodes and the emitted far field is analyzed. Our results are compared to experimental measurements of different TWLs.

DS 8: High-k and low-k dielectrics

Time: Monday 15:00–17:00 Location: WIL B321

DS 8.1 Mon 15:00 WIL B321

Dielectric properties of $A_{2/3}Cu_3Ti_4O_{12}$ (A = La, Pr, Nd, Sm, Eu, Gd, Tb, Dy) — •Jürgen Sebald[1], Stephan Krohns[1], Peter Lunkenheimer[1], Stefan Riegg[2], Stefan G. Ebbinghaus[3], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany — [2]Solid State Chemistry, University of Augsburg, 86135 Augsburg, Germany — [3]Institute for Chemistry, Martin-Luther University Halle-Wittenberg, 06120 Halle, Germany

New materials showing the phenomenon of a very high dielectric constant ($\epsilon' > 10^3$), similar to the famous $CaCu_3Ti_4O_{12}$ (CCTO), are in the focus of scientific interest. Materials with extremely high ("colossal") dielectric constants (CDC) are urgently needed for future electronics. Today it is more or less commonly accepted that the CDC is due to extrinsic effects like "internal barrier layer capacitors"(IBLC) or "surface barrier layer capacitors"(SBLC). Polarisation effects at grain boundaries or other internal barriers can generate nonintrinsic colossal values of ϵ' (IBLC). In addition, SBLCs, arising, e.g., from a formation of Schottky diodes at the contact-bulk interfaces, can generate a contribution to the colossal value of ϵ' as has been shown for $CaCu_3Ti_4O_{12}$. To investigate these models and to search for alternatives for CCTO, frequency- and temperature-dependent dielectric measurements on differently treated samples of various CCTO related materials were performed. To check for possible correlations of magnetic structure and dielectric properties, magnetic-field dependent dielectric spectroscopy was carried out.

DS 8.2 Mon 15:20 WIL B321

Characterization of $(SrO)_x(ZrO_2)_{(1-x)}$ thin films for use in metal insulator metal capacitors — •Matthias Grube[1], Oliver Bierwagen[2], Dominik Martin[1], Lutz Geelhaar[3], and Henning Riechert[3] — [1]Namlab GmbH, 01187 Dresden — [2]University of California, Santa Barbara 93106 CA, USA — [3]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin

$(SrO)_x(ZrO_2)_{(1-x)}$ is a promising candidate as high-k dielectric for metal-insulator-metal capacitors of future memory cells. The dielectrics were grown by co-evaporating SrO from a high temperature effusion cell and ZrO_2 from an electron beam evaporator in a molecular beam deposition chamber. As substrates, n^{++}-Si-wafers were used that were covered with a pre-deposited 5 nm-thin TiN layer. In order to reveal the correlation between process conditions and film properties, especially high-k values and leakage currents, a series of samples with different thicknesses ranging form 10 to 40 nm were fabricated while the growth temperature was varied from 100°C to 800°C. X-ray fluorescence analysis (XFA) and X-ray reflectometry (XRR) were employed to determine the thickness and the stoichiometry of the films, while the electrical properties of the dielectrics were determined through current-voltage and capacitance-voltage measurements before and after a post deposition anneal.

DS 8.3 Mon 15:40 WIL B321

Ternary rare-earth based alternative gate-dielectrics for future integration in MOSFETs — •Jürgen Schubert, Joao Marcelo Lopes, Eylem Durgun Özben, Roman Luptak, Steffi Lenk, Willi Zander, and Martin Roeckerath — IBN 1-IT, Forschungszentrum Jülich, 52425 Jülich

The dielectric SiO_2 has been the key to the tremendous improvements in Si-based metal-oxide-semiconductor (MOS) device performance over the past four decades. It has, however, reached its limit in terms of scaling since it exhibits a leakage current density higher than 1 A/cm^2 and does not retain its intrinsic physical properties at thicknesses below 1.5 nm [1,2]. In order to overcome these problems and keep Moore's law ongoing, the use of higher dielectric constant (k) gate oxides has been suggested. These high-k materials must satisfy numerous requirements such as the high k, low leakage currents, suitable band gap und offsets to silicon. Rare-earth based dielectrics are promising materials which fulfill these needs. We will review the properties of $REScO_3$ (RE = La, Dy, Gd, Sm, Tb) and $LaLuO_3$ thin films, grown with pulsed laser deposition, e-gun evaporation or molecular beam deposition, integrated in capacitors and transistors. A k > 20 for the $REScO_3$ (RE = Dy, Gd) and around 30 for (RE = La, Sm, Tb) and $LaLuO_3$ are obtained. Transistors prepared on SOI and sSOI show mobility values up to 380 cm^2/Vs on sSOI, which are comparable to such prepared with HfO_2. [1] X. Gou, and T. P. Ma, IEEE Electron Device Lett. 19, 207 (1998). [2] D. A. Muller, T. Sorsch, S. Moccio, F. H. Baumann, K. Evans-Lutterodt, and G. Timp Nature 399, 758 (1999).

DS 8.4 Mon 16:00 WIL B321

The deposition of rare-earth oxide ultrathin-films with inorganic precursors — •Maraike Ahlf[1], Hanno schnars[1], Oliver Skibitzki[1], Marvin Zöllner[1], Katharina Al-Shamery[1], Mareike Ahlers[2], and Mathias Wickleder[2] — [1]University of Oldenburg, Institute for Pure and Applied Chemistry, Physical Chemistry I — [2]University of Oldenburg, Institute for Pure and Applied Chemistry, Inorganic Chemistry

Semiconductor industry is searching for new materials as gate-oxides in MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) because the goal to shrink the size is limited due to the quantum mechanical tunnelling of electrons through a very thin oxide layer. Therefore it is necessary to replace the conventionally used gate-oxide material SiO_2 by new metarials with higher κ-value and a bigger band gap, which could be rare-earth oxides (REO's) e.g..To prevent interfacial layers of SiO_2 in our investigation, the Si-wafers are prepared by a wet chemical etching using HF and NH_4F before depositing new RE-based inorganic precursors. The mechanism of decomposition of RE-nitrates is studied in UHV by using STM, XPS and TPD. The used precursors are expected to decompose carbonfree to form the REO and gaseous decomposition products under mild, sputter free heating conditions. Deposition is done by using a liquid injection doser, drop-cast and dip applying different organic solvents. SEM and HRTEM images are utilized to assess the effectiveness of the different deposition conditions to form uniform, defectfree REO-ultrathin-films on Si with filmthickness of less then 10 nm state of the art related to our research.

DS 8.5 Mon 16:20 WIL B321

High performance MIM capacitors with Atomic Vapour Deposited HfO_2 dielectrics — •Mindaugas Lukosius, Christian Wenger, Christian Walczyk, and Hans-Joachim Müssig — IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Metal-Insulator-Metal (MIM) capacitors are widely used in ICs for Radio-Frequency (RF) applications. Currently, capacitors fabricated by performing MIM structures use silicon oxide or silicon nitride as an insulating layer. However the capacitance density of these materials is limited by low dielectric constant values. Therefore, for further integration of passive components such as capacitors into CMOS devices, dielectric materials with higher permittivity than SiO_2 (k = 3.9) are required. Using the high dielectric constant (high-k) material HfO_2 as a dielectric in MIM capacitor seems to be a very promising approach. Atomic Vapour Deposition (AVD*) technique was used for the preparation of hafnium oxide films on 20nm TiN/2nmSiO_2/Si (200mm) substrates using $Hf(NEtMe)_4$ precursor for MIM applications in back-end of line (BEOL). The influence of process temperature (320 - 425 °C) and process pressure (2-10mbar) on the structural and electrical properties of HfO_2 were investigated. The optimized dielectric layers obtained at 320 °C and 4 mbar possess k value of 18, capacitance density of 3.5 fF/μm^2 combined with required capacitance voltage linearity (<100 ppm/V^2) and quality factor of 50. Films with thickness of 35 nm exhibit leakage current density of $2{\cdot}10^{-7}$ A/cm^2 and breakdown strength of 5.8 MV/cm, therefore AVD* deposited HfO_2 layers are possible alternative dielectric candidates for MIM applications.

DS 8.6 Mon 16:40 WIL B321

Growth investigation of thin Ti-based high-k films — •Andreas Krause, Dominik Martin, Matthias Grube, and Walter M. Weber — namlab gGmbH, D-01187 Dresden

With the further increase in integration density of microelectronics, ordinary SiO_2-based stacks reach their limits as leakage currents increase significantly. Therefore, dielectric materials are required that combine a high dielectric constant (k) and low leakage currents, such as Ti-based oxides. Different titanates, like $HfTiO_x$ or $CaTiO_x$ with thicknesses up to 100 nm were deposited via an UHV sputtering tool. As substrates, n^{++}-Si-wafers were used as well as Si-wafers coated with TiN or noble metal (Ru, Pt) layers. The morphology was studied with atomic force microscopy and capacitor-voltage measurements were performed to extract the k-value.

DS 9: Metal Layers

Time: Tuesday 9:30–10:45 Location: GER 37

DS 9.1 Tue 9:30 GER 37

Electromigration and Heat Distribution in Silver Nanowires — •Christian Wirtz, Niemma M. Buckanie, Sven Stienen, Ralf Meckenstock, Frank-Joachim Meyer zu Heringdorf, and Günter Dumpich — Universität Duisburg Essen, Experimentalphysik and Centre for Nanointegration Duisburg-Essen , Lotharstr.1 , 47048 Duisburg

We investigate the electromigration behaviour and thermal properties of single-crystalline silver nanowires subjected to high electrical current densities.

The electromigration measurements are conducted within a Scanning Electron Microscope using an experimental setup which provides SEM imaging and four-wire electrical resistance monitoring simultaneously. Current densities in excess of 10^7 A/cm^2 are applied, and the direction of electromigration mass flow is found opposite to that of the net electronic momentum.

For thermal measurements, Scanning Thermal Microscopy (SThM) is employed, revealing the heat distribution within an electrically stressed nanowire.

Further research efforts will comprise a combination of the aforementioned techniques with ferromagnetic resonance as well as resistance measurements on carbon nanotubes.

DS 9.2 Tue 9:45 GER 37

A Quantum-stabilized Mirror for Atoms — Daniel Barredo[1], Fabián Calleja[1], Pablo Nieto[1], Juan José Hinarejos[1], Guillaume Laurent[1], Amadeo Vázquez de Parga[1], •Daniel Farías[1], and Rodolfo Miranda[1,2] — [1]Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, Spain — [2]Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA-Nanociencia), Spain

Helium atom scattering is a well-established technique for investigating the structural and dynamical properties of surfaces. Because of the low energies used (100 meV), neutral He atoms probe the topmost surface layer of any material in an inert, completely nondestructive manner. This means that a Scanning Helium Atom Microscope using a focused beam of He atoms would be a unique tool for reflection or transmission microscopy, with a potential lateral resolution of ca. 50 nm. It could be used to investigate insulating glass surfaces, delicate biological materials and fragile samples which are difficult to examine by other methods. However, the practical realization of such a microscope requires the development of a mirror able to focus a beam of low energy He atoms into a small spot on the sample.

Here we show that Quantum Size Effects can be exploited to produce an ultraperfect, atomically flat film of Pb of magic thickness on a highly perfect Si(111) thin wafer. The metal film reproduces the structural perfection of the substrate, is atomically flat over micron-wide areas and stable up to 250 K. As a consequence, more than 15% of the incoming He atoms are scattered into the specular direction, which allows its use as an ultra smooth mirror for neutral atoms.

DS 9.3 Tue 10:00 GER 37

Scaling and stress effects on freestanding and substrate-attached TiNiCu thin film microbridges — •Dennis König, Michael Ehmann, Sigurd Thienhaus, and Alfred Ludwig — Ruhr-Universität, Bochum, Deutschland

TiNiCu shape memory alloys are known for their high inherent energy density and their small thermal hysteresis. Therefore, TiNiCu thin films are promising candidates for actuator materials in micro electrical mechanical systems. Due to the difference of the thermal expansion coefficients of the thin film and the substrate, after deposition and subsequent annealing, thin films are under stress. This affects the transformation temperatures. The stress-dependency of the TiNiCu phase transformation was investigated by comparing substrate-attached and freestanding thin film bridges utilizing temperature-dependent resistivity measurements. A difference of over 30 K in the transformation temperatures of freestanding and substrate-attached film was observed. Furthermore it was found that a change of the lateral dimensions of the bridges also causes a shift of the transformation temperatures. With regard to a further miniaturization of the micro-bridges to the nanometer scale, the bridges were reduced in width by focused ion beam. The phase transformation behavior was again characterized using temperature-dependent resistivity measurements. It was found that reducing the bridge width from 4 μm to 1 μm leads to a transformation temperature shift of over 30 K.

DS 9.4 Tue 10:15 GER 37

Dielectric properties of ultra-thin metal films around the percolation threshold — •Martin Hövel, Martin Alws, Bruno Gompf, and Martin Dressel — 1.Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

The dielectric properties of percolating metal films around the insulator-to-metal (IMT) transition are not well understood [1]. By combining Fouriertransform infrared spectroscopy (FITR), spectroscopic ellipsometry, and dc-conductivity measurements on ultra-thin Au films on Si/SiO_2 the effective dielectric properties around the IMT can be described Kramers-Kronig consistent over a very brought frequency range from 500 to 27 000 cm^{-1}. Above a critical thickness d_c, the so called percolation threshold, the films show for low frequencies a typical metallic-like behavior which can be fitted by a simple Drude-Model [2]. Below d_c the frequency behavior is dominated by a "Maxwell-Garnett resonance" which shifts to lower frequencies with increasing film thickness and dies out well above the IMT. A dielectric anomaly with a maximum of ϵ_1 at d_c is observed and can be described by the interplay of this resonance and the onset of the Drude-component. Additionally the temperature dependence of the films were studied. Here also a transition from an activated to a metallic like behavior at d_c was found.

[1] B. Gompf, J. Beister, T. Brandt, J. Pflaum, M. Dressel, Optics Letters 32, 1578 (2007)

[2] T. Brand, M. Hövel, B. Gompf, M. Dressel, Phys. Rev. B 78, 205409, (2008)

DS 9.5 Tue 10:30 GER 37

Surface and Surface Self-diffusion of Pt thin films on Si_3N_4/Si and ZrO_2 Substrates — •Henning Galinski, Thomas Ryll, Pierre Elser, Anja Bieberle-Hütter, Jennifer Rupp, and Ludwig Gauckler — Nonmetallic Inorganic Materials, ETH Zurich, Zurich, Switzerland

Metals and ionic bonded ceramics possess distinct diametric bonding characteristics. Thus, the stability of a metal thin film on a ceramic substrate is conditioned by the interactions between the different bonding types across the interface. In the case of weak adhesion the minimization of free surface energies gives rise to decomposition and agglomeration of thin metallic films. The morphological evolution of Pt thin films has been investigated by means of scanning electron microscopy (SEM) and atomic force microscopy (AFM). Pt thin films were deposited on Si_3N_4/Si and yttria stabilized ZrO_2 substrates and subjected to heat treatments up to 800°C for 2 hours. Three main observations have been made: i) the dominating mechanism of initial film rupture is the nucleation of holes at the triple junctions of the Pt thin film as shown by means of Minkowski measures. ii) The evolution of the film at this stage is in agreement with Brandon and Bradshaw's theory of surface energy driven diffusion. The kinetics of the hole growth were used to calculate the surface self-diffusion coefficient of Pt. iii) at high temperature, holes coalesce and Pt islands are formed that undergo an Ostwald ripening process. The evolution of the particle size distribution allowed deducing the mass transfer surface diffusion coefficient of Pt on Si_3N_4 and ZrO_2.

DS 10: Surface Modification

Time: Tuesday 11:00–12:45 Location: GER 37

DS 10.1 Tue 11:00 GER 37

Interface modification by fluorinated aromatic SAMs — •Christian Schmidt and Gregor Witte — Philipps-Universität Marburg

One of the key issues of organic electronic devices is a precise control of metal-organic heterojunctions. Recently, Gundlach et al. demonstrated that pre-treatment of Au-electrodes with pentafluorobenzenethiol (PFBT) largely improves device characteristics of diF-TESADT based OTFTs [1] which was attributed to enhanced crystal growth and a lowering of injection barrier. However, our previous works revealed only a poor ordering for benzenethiol-SAMs (BT) [2] which becomes even worse for PFBT. Motivated by this apparent contradiction, we investigated the adsorption of the differently fluorinated aromatic thiol based SAMs (benzenethiol, p-fluoro-BT, p-trifluoromethyl-BT and PFBT) on the model substrate Cu(100) which provides well ordered films. By combining various techniques including LEED, UPS, NEXAFS and TDS the microstructure of the films and their influence on the work function have been thoroughly studied and will be discussed.

[1] D. J. Gundlach et al., nature materials, 7, 216 (2008)
[2] D. Käfer, A. Bashir and G. Witte, JPC C, 111, 10546 (2007)

DS 10.2 Tue 11:15 GER 37

Fundamentals of surfactant sputtering — •Hans Hofsäss and Kun Zhang — II. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-PLatz 1, 37077 Göttingen, Germany

We introduce a new, versatile sputter technique, utilizing the steady state coverage of a substrate surface with up to 10^{16} cm^{-2} of foreign or self atoms simultaneously during sputter erosion by combined ion irradiation and atom deposition. These surfactant atoms strongly modify the substrate sputter yield on atomic to macroscopic length scales. The sputter yield can be attenuated in a controlled way from the value of the pure substrate down to zero or even to negative values (growth). Depending on the surfactant-substrate combination, the technique allows enhanced smoothing of surfaces, the generation of surface patterns and nanostructures and shaping of surfaces. The new method may be comparable to ion beam assisted deposition operated beyond the resputtering limit. In this contribution we present examples of surface morphology evolution, smoothing and shaping and shaping of surfaces using surfactant sputtering and we describe analytical and numerical approaches to predict the sputter yield attenuation and the steady state surface coverage. Experiments were done with 5 keV Xe ions at variable incidence angle and fluences up to 10^{18} cm^{-2}. Sputter yield attenuation is demonstrated for sputtering of Si, SiO_2, a-C and Fe with different surfactant species. We analyze in detail sputtering of Si under the influence of Au surfactants, leading to a steady state buried Au silicide layer and enhanced surface smoothing.

DS 10.3 Tue 11:30 GER 37

Importance of internal ionbeam parameters on the self-organized pattern formation withlow-energy broad beam ion sources — •Marina Cornejo, Bashkim Ziberi, Michael Tartz, Horst Neumann, Frank Frost, and Bernd Rauschenbach — Leibniz-Institut für Oberflächenmodifizierung (IOM), Permoserstrasse 15, D-04318Leipzig, Germany

Self-organized pattern formation during low energy ion beam erosion of solid surfaces is a simple bottom-up approach for the generation of nanostructures. Using broad beam sources, large-area nanostructured surfaces can be produced in a cost-efficient single-step process. A critical parameter for the patterning with ion beams is the ion beam incidence angle. However, inherent to all broad beam sources, the ion beam exhibits a certain divergence. This generates a spread of the local incidence angle with respect to the geometrically defined beam incidence angle. Recent studies showed that the divergence angle and angular distribution of the ions, here called internal beam parameters, also affect the surface topography. In this contribution we focus on the effect of the internal beam parameters on the surface topography. It was analyzed the effect on the topography on Si surfaces of some experimental parameters that affect the internal beam parameters by changing the ion-optical parameters and the shape of the plasma sheath boundary. Explicitly, the influence of the discharge voltage, the operation time and the distance between the screen and accelerator grid is shown. Additionally, first result of quantitative measurements of divergence and angular distribution within the ion beam will be presented.

DS 10.4 Tue 11:45 GER 37

Influence of the ion distribution on shape and damage in Xe-induced ripple formation on Si — •Andreas Biermanns[1], Ullrich Pietsch[1], Antje Hanisch[2], Jörg Grenzer[2], Stefan Facsko[2], and Hartmut Metzger[3] — [1]Universität Siegen, Germany — [2]Foschungszentrum Dresden-Rossendorf, Germany — [3]ID01 beamline, ESRF, France

In recent years, the creation of surface-nanostructures due to ion-beam sputtering has gained much interest due to the possibility to pattern large surface areas with tunable morphologies in a short time. One kind of those nanostructures are wave-like patterns (ripples) produced by an interplay between a roughening process caused by ion beam erosion (sputtering) of the surface and smoothening processes caused by surface diffusion. For the creation of such ripple patterns with medium energy ions, the ion beam has to be inclined with respect to the surface normal of the target by an angle between 60° and 80°. In this presentation we show that the resulting inhomogeneity within the irradiated sample area is essential for the ripple formation. We report on investigations of the ion distribution on ripple formation on Si (001) surfaces after irradiation with medium-energy Xe^+-ions. We studied the change of average surface morphology and the damage imposed to the crystal by means of grazing-incidence - small angle scattering (GISAXS) and diffraction (GID) using synchrotron-radiation. We show that changing the asymmetry of the ion distribution changes both morphology and degree of damage of the crystalline material.

DS 10.5 Tue 12:00 GER 37

Xe^+ ion beam induced rippled structures on Si miscut wafers — •Antje Hanisch[1], Jörg Grenzer[1], Andreas Biermanns[2], and Ullrich Pietsch[2] — [1]Forschungszentrum Dresden-Rossendorf, Dresden, Germany — [2]Institute of Physics, University of Siegen, Germany

We report on the influence of the initial roughness and crystallography of the substrate on the formation of self-organized ripple structures on semiconductors surfaces by noble gas ion bombardment. The Bradley-Harper theory predicts that an initial roughness is most important for starting the sputtering process which in the ends leads to the evolution

of regular patterns. We produced periodic structures with intermediate Xe^+ ion energies (5-70 keV) at different incidence and azimuthal angles which lead to the assumption that also crystallography plays a role at the beginning of ripple evolution. Most of the previous investigations started from the original roughness of a polished silicon wafer. We used (001) silicon wafers with a miscut angle of 1°, 5° and 10° towards [110]. We studied the ripple formation keeping the ion beam parallel to the [111], [-1-11] or [-111] direction, i.e. parallel, antiparallel or perpendicular to the miscut direction [110]. The parallel and antiparallel case implies a variation of the incidence angle with increased roughness over the surface step terraces. The perpendicular orientation means almost no roughness. The results were compared to normal Si(001) and Si(111) wafers.

DS 10.6 Tue 12:15 GER 37

Mechanisms in low-energy ion beam erosion of fused silica surfaces — •Jens Völlner, Bashkim Ziberi, Frank Frost, and Bernd Rauschenbach — Leibniz-Institut ür Oberflächenmodifizierung (IOM), Permoserstrasse 15, D-04318 Leipzig, Germany

In a recent study the topography evolution of fused silica surfaces under low-energy Ar^+ ion beam erosion was studied. It was shown that, for ion incidence angles between 50° and 70° the surface topography of fused silica is dominated by regular ripple structures with an orientation perpendicular to the ion beam direction. In contrast, at incidence angles < 50° stable and very smooth surfaces were observed.

Based on this study two special cases have been examined, where rippled surfaces are used as initial surfaces. First a ripple pre-pattern was formed with a characteristic ripple wave vector parallel to ion beam projection. Afterwards the sample was rotated azimuthal by 90° and irradiated again at an (polar) ion incidence angle of 50°. Consequential, the original ripple structures disappear slowly and, simultaneously, a new superimposed ripple pattern emerges. In a second set of experiments rippled surfaces are irradiated at incidences angles < 50° and at azimuth angles parallel and perpendicular to the original ripple orientation, where in both cases surface smoothing should be dominating. Based on a detailed analysis of the temporal and the angle dependent evolution of the surface topography gradient dependent sputtering has been identified as the dominating mechanisms responsible for surface topography evolution in this system.

DS 10.7 Tue 12:30 GER 37

Development strategy of new liquid metal and alloy ion sources for focussed ion beam technology — •Kirill Trunov, Paul Mazarov, Alexander Melnikov, Rüdiger Schott, and Andreas D. Wieck — Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

Liquid metal ion and alloy sources (LMIS and LAIS) are widely used in focused ion beam (FIB) technology. Since many years our group develops and produces a lot of different LMIS and LAIS for micromachining and surface treatment in the submicron and nano-scales. For very successful approach to high sputter efficiency, Bi and Au ion species are employed, partially with heavy and big clusters. The development of rare-earth element LAISs (Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm) opens new applications in superconductivity, optical and magnetic material research. Silicon is n-type doped with elements from the fifth group of the periodic table (P, As, Sb, Bi) and p-type doped with elements from the third group (B, Al, Ga, In) giving the possibility of a large range of ionization energy for donors and acceptors in Si. For producing these and another LMIS and LAIS, we apply completely new methods for mechanical and chemical treatment of the sources, testing and the use in commercial FIB systems.

DS 11: Layer Growth: Evolution of Structure and Simulation

Time: Tuesday 14:00–16:00 Location: GER 37

DS 11.1 Tue 14:00 GER 37

Material dependent smoothing of rippled surfaces — •Johanna Röder and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany

Any kind of processing of materials like thin film deposition, ion beam treatment or polishing often creates structures, which have lateral length scales of 20-200 nm. For many applications, like optical mirrors or thin multilayer structures, it is important to avoid roughnesses in these dimensions. Up to now a lot of experimental and theoretical work has been done to investigate the roughness evolution during film growth on a smooth substrate. Another approach is the investigation of the growth of films deposited on already rough surfaces, where smoothing mechanisms influence the evolution of the surface and can be analysed more easily. In this contribution, the successive smoothing of artificially created rough surfaces has been studied by atomic force microscopy. Therefore periodic structured Si(100) surfaces (height of 4,5nm, period of 55nm) produced by sputter erosion were chosen as model system and systematically covered by thin layers of different material classes like oxides (ZrO_2), simple carbides (C) and polymers (PC). The results were discussed with respect to the dominating smoothing mechanisms that occur during deposition. The scaling behaviour of the roughness evolution was investigated in Fourier space using power spectral densities (PSD). The three material classes will be compared and the differences during the smoothing process discussed. All samples were deposited by pulsed laser deposition.

DS 11.2 Tue 14:15 GER 37

Stacking fault suppression in ion assisted growth of Ir on Ir(111) — •Sebastian Bleikamp and Thomas Michely — Institute of Physics 2, University of Cologne, Germany

Due to their low energy, stacking faults are among the most frequent defects in thin films.

In homoepitaxy of Ir on Ir(111) around room temperature, stacking faults are formed in large numbers, which propagate through the growing film, causing extended defect structures. Eventually thin Ir films become heavily twinned and grow rough due to the twin associated defects.

Here we present kinetic strategies for the avoidance of stacking fault propagation and defect structure formation based on ion assistance. Ir is evaporated with ion assistance of 100eV Ar^+ ions at normal incidence with an ion to atom arrival ratio of R=1:2 or with ion assistance of 500eV Ar^+ ions incident at an angle of 85° with respect to the surface normal with R=1:10. Based on scanning tunneling microscopy investigations we find that this treatment transfers the growth mode to layer-by-layer growth and no twin crystallites are formed. The result is backed up by low energy electron diffraction measurements. Annealing shows that a significant amount of noble gas is incorporated in the films during growth. Gas incorporation could be avoided if the necessary energy could be supplied to the Ir atoms themselves.

Analysis of the atomic processes involved indicates that the key action of the ions is to destroy the defect structures stabilizing the faults, rather than to suppress fault nucleation.

DS 11.3 Tue 14:30 GER 37

Ion induced Burying Effect of Au Nanoparticles on SiO_2: Influence of Sputtering — A. Klimmer[1], M. Trautvetter[1], B. Kuerbanjiang[2], •P. Ziemann[1], J. Biskupek[2], and U. Kaiser[2] — [1]Universität Ulm, Institut für Festkörperphysik, D-89069 Ulm — [2]Universität Ulm, ZE Elektronenmikroskopie, D-89069 Ulm

Ordered arrays of spherical Au nanoparticles (NP) exhibiting narrow size distributions were fabricated on top of SiO_2 substrates applying a micellar preparation technique [1]. Ion irradiating such NP arrays of different starting diameters with 200 keV Ar^+ and Xe^+, respectively, leads to a burying effect until the NP are completely covered. Combining HRTEM data with AFM height measurements delivering the necessary statistics allows a quantitative analysis of the phenomenon. It will be demonstrated that in addition to the necessary thermodynamic driving forces related to an ion induced enhancement of the substrate viscosity and to the various surface and interface energies [2], sputtering of the NP with a size-dependent sputter yield has to be included in the description of the experimental results in order to improve agreement.

[1] Micellar Nanoreactors: Preparation and Characterization of Hexagonally Ordered Arrays of Metallic Nanodots, G. Kästle at al., Adv. Funct. Mater. 13, 853 (2003). [2] Burrowing of Pt nanoparticles into SiO_2 during ion-beam irradiation, X. Hu, D. G. Cahill, R. S.

Averback, J. Appl. Phys. 92, 3995 (2002).

DS 11.4 Tue 14:45 GER 37

Basics of the atomic layer deposition of HfO_2 onto Si/SiO_2 substrates: *in-situ* investigations with XPS, XAS and UHV-AFM — •Massimo Tallarida, Konstantin Karavaev, Krzysztof Kolanek, and Dieter Schmeisser — Brandenburgische Technische Universität, LS Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee, 17, 03046, Cottbus, Germany

We developed a reactor for investigating *in-situ* the atomic layer deposition (ALD) of HfO_2. X-ray photoelectron and X-ray absorption spectra were collected after each ALD cycle using synchrotron radiation at the beamline U49-2/PGM2 - BESSY II, Berlin. The morphology of the substrate and thin film surfaces was investigated after each ALD cycle with an UHV-AFM microscopy attached to the ALD reactor. We studied the ALD on differently prepared substrates, at different substrate temperatures, and using different Hf-precursors ($HfCl_4$, TEMAHf, TDMAHf). We observed the evolution of the $Si/SiO_2/HfO_2$ system during the formation of the first three Hf-oxide layers [1]; we detected the incorporation of Cl into the Hf-oxide films and proposed a mechanism responsible for the Cl contamination [2]; we found evidence of the interfacial-SiO_2 growth during the initial ALD cycles and of dipole formation at the HfO_2/SiO_2 interface. In this contribution we illustrate the basics of the technique used, and discuss the physical-chemical properties of ALD on the basis of the experimental results.
[1] M. Tallarida, K. Karavaev, and D. Schmeisser, J. Appl. Phys. **104**, 064116 (2008); **[2]** M. Tallarida, K. Karavaev, and D. Schmeisser, J. Vac. Sci. Technol. B, accepted for publication.

DS 11.5 Tue 15:00 GER 37

Evolution of the interfacial layer during the atomic layer deposition of HfO_2 on Si/SiO_2 substrates — •Konstantin Karavaev, Massimo Tallarida, and Dieter Schmeisser — Brandenburgische Technische Universität, LS Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee, 17, 03046, Cottbus, Germany

We studied the formation of the interfacial layer in the $Si/SiO_2/HfO_2$ system using the *in-situ* Atomic Layer Deposition (ALD) reactor developed in our group [1,2]. We measured the X-ray photoelectron and X-ray absorption spectra with synchrotron radiation at the beamline U49-2/PGM2-BESSY II. The ALD growth was obtained using different Hf-precursors ($HfCl_4$,TEMAHf and TDMAHf) on various prepared substrates at different temperatures. The investigation was carried out *in-situ* giving the possibility to determine the properties of the grown film after every ALD cycle without breaking the vacuum. We observed the evolution of the $Si/SiO_2/HfO_2$ system during the formation of first three Hf-oxide layers, detecting the interfacial growth of SiO_2 during the initial ALD cycles from the XPS spectra of Si2p. We discuss how the interfacial layer growth depends on the various ALD parameters.
[1] M. Tallarida, K. Karavaev, and D. Schmeisser, J. Appl. Phys. **104**, 064116 (2008); **[2]** M. Tallarida, K. Karavaev, and D. Schmeisser, J. Vac. Sci. Technol. B, accepted for publication.

DS 11.6 Tue 15:15 GER 37

***In-situ* investigations of the atomic layer deposition of HfO_2 with UHV/AFM** — •Krzysztof Kolanek, Konstantin Karavaev, Massimo Tallarida, and Dieter Schmeisser — Brandenburgische Technische Universität, LS Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee, 17, 03046, Cottbus, Germany

We studied *in-situ* the atomic layer deposition (ALD) of HfO_2 with ultra high vacuum (UHV) atomic force microscope (AFM), using the ALD reactor developed by our group [1, 2]. The reactor was attached to the Omicron Large Sample-UHV/AFM system in the AFM-Lab of the Angewandte Physik-Sensorik chair at the BTU-Cottbus. We investigated different $Si(001)/SiO_2$ substrates and surface preparation techniques performed before the ALD process. After each ALD cycle (using TDMAHf and H_2O as precursors), we studied the influence of the HfO_2 growth on the root mean square (RMS) roughness; the surface fractal dimension and the height histogram: the surface skewness and kurtosis. We focused on the influence of the substrate temperature on the surface topography during the ALD. The *in-situ* studies of the ALD process with the UHV/AFM system correlated with the experiments performed with photoelectron spectroscopy can be used for understanding the fundamental properties of the ALD of HfO_2 on $Si(001)$.
[1] M. Tallarida, K. Karavaev, and D. Schmeisser, J. Appl. Phys. **104**, 064116 (2008); **[2]** M. Tallarida, K. Karavaev, and D. Schmeisser, J. Vac. Sci. Technol. B, accepted for publication.

DS 11.7 Tue 15:30 GER 37

Pattern Formation in Langmuir-Blodgett Transfer Systems — •Michael Hubert Köpf and Rudolf Friedrich — Institut für Theoretische Physik, Wilhelm-Klemm-Str. 9, 48149 Münster

Self-organized regular patterns have been observed in experiments when phospholipid monolayers were transferred onto solid substrates via Langmuir-Blodgett technique. These patterns consist of broad areas of lipid in the liquid-expanded phase divided by equidistant groove-like liquid-condensed areas.

We present a theoretical investigation of the mechanism behind these phenomena. In our approach two coupled equations, one for the surfactant and one for the subphase, serve as a theoretical model of the experimental setup. The observed pattern formation occurs, when the monolayer on the subphase is close to the so-called main transition, the phase transition between the liquid-expanded and the liquid-condensed phase. We expect this transition to play a key role in the process of pattern formation. Within our framework, a transition of the surfactant phase directly affects the fluid by a change of surface tension. The interplay of surface thermodynamics and film evolution then builds up oscillations which finally lead to the observed structure. Linear stability analysis is applied in order to trace the instabilities behind the pattern formation and the dynamics of the system are investigated by means of numerical simulation.

DS 11.8 Tue 15:45 GER 37

Wachstum dünner $Ni_{63}Al_{37}$-Legierungsschichten auf Cu(001) — •Wolfgang Donner[1] und Noureddine Anibou[2] — [1]Fachgebiet Materialwissenschaften, Strukturforschung, Technische Universität Darmstadt — [2]XStream Systems Inc., Sebastian (FL), USA

Wir untersuchen den Einfluß epitaktischer Spannungen auf die Phasenstabilität dünner NiAl Schichten, die mittels Kathodenstrahlzerstäubung auf Kupfer Pufferschichten auf Silizium aufgewachsen wurden. Mit Hilfe systematischer Messungen an Proben unterschiedlicher Dicke und unter Nutzung der Tiefenselektivität von Röntgenbeugung unter streifendem Einfall kommen wir zu dem Schluß, daß die wachsenden Schichten eine Reihe struktureller Änderungen als Funktion der Schichtdicke erleiden. Die strukturelle Phase, die sich zuerst auf der Cu(001) Oberfläche bildet, stimmt nicht mit der von der mittleren Zusammensetzung her erwarteten Struktur überein. Vielmehr bildet sich zunächst die Phase, die die geringste Fehlanpassung zum Substrat aufweist. Dieser Effekt ("composition pinning") ist von kovalent gebundenen Halbleiterschichten her bekannt, unter Metallschichten aber selten.

DS 12: Invited Geer

Time: Tuesday 9:30–10:15 Location: GER 38

Invited Talk DS 12.1 Tue 9:30 GER 38

Nanoscale Profiling of Electron Transport in Metallic and Semimetal films — Chaehwi Chong, Yunfei Wang, and •Robert Geer — College of Nanoscale Science and Engineering, University at Albany, Albany, NY, USA

As lithographic feature sizes in nanoelectronics drop below the electron scattering length for conventional metals, it is essential to characterize nanoscale variations in electron transport due to compositional heterogeneity or interfacial nonuniformity. For conventional nanoelectronics a case in point is ultra-thin barrier layers and interconnect lines in Cu-damascene on-chip wiring. Local two-point conductance profiling via scanning-probe microscopy has been used to quantitatively map electrical side-wall continuity in as-deposited ALD Ta-based barriers (thickness < 2nm) and local electrical transport in Cu interconnects ($<$ 90 nm) on a 300mm wafer back-end-of-line test structure. Nanoscale electrical continuity profiling on Ta barrier films reveal a strong depen-

dence on sidewall topography stemming from lithographic line-edge roughness from cross-correlation analysis. Also, Cu interconnect conductance profiling reveals strong nanoscale variations attributed to local oxidation. These data are compared to FEA modeling for thin-film electron transport. A second case of interest is the use of similar techniques to investigate electron transport in linearly-dispersive semimetals (graphene). Results on exfoliated and CVD graphene deposited on split-gate structures are presented in terms of electrostatic doping for electron current focusing (e.g. Veselago lens) from monolayer graphene. Preliminary results are consistent with model predictions.

DS 13: Thin Film Metrology for Electronics, Photonics, and Photovoltaics I

Time: Tuesday 10:30–12:00 Location: GER 38

Topical Talk DS 13.1 Tue 10:30 GER 38

Metrologie der Mikro- und Nanostrukturen mittels Rastersondenmikroskopie — •Teodor Gotszalk — ul. Janiszewskiego 11/17; Technische Universitatet zu Wroclaw; 50-372 Wroclaw

Der Fortschritt in der Nanotechnologie ist sowohl durch den Fortschritt in der Fabrikation der Mikro- und Nanostrukturen, wie auch durch die Entwicklung neuer Methoden zu ihrer Charakterisierung stimuliert. Von den neuen Charakterisierungsmethoden erwartet man vor allem hohe Empfindlichkeit, die in vielen Fällen die Beobachtung der quantenmechanischen Effekte in Nanometerskala ermöglichen soll. Im Gegenteil zu den Detektionsmethoden, die nur die qualitative Analyse erlauben, sollten die Messmethoden zusätzlich quantitativ die untersuchenden Phänome beschreiben. In diesem Vortrag werden die Beispiele zu den lokalen Messungen im Nanometerbereich von mechanischen, elektrischen und thermischen Eigenschaften der Metal-, Halbleiter- und biologischen Mikro- und Nanostrukturen mit Hilfe von piezoresistiven Silizium-Mikrosystemen vorgestellt. Die Messungen der Änderung der adsorbierter Masse, der Kraft und der Auslenkung mit der Auflösung von 10 ag, 1 pN und 0,01 nm Kraft, sind mit den hochauflösenden Kalibrierungsmethoden des verwendenten Messsystems verbunden. Diese Kalibrierungsmethoden, zu denen lichtfaseroptische Interferometrie, Untersuchungen des Rauschenverhaltens und der elektrischen Eigenschaften der Mikrosysteme mit Hilfe von modernen zählen, werden zusätzlich in diesem Vortrag vorgestellt.

DS 13.2 Tue 11:00 GER 38

Utilizing near-field and depolarization effects for tip-enhanced Raman spectroscopy on semiconductor nanostructures — •Peter Hermann[1], Zhijiat Chong[2], Michael Hecker[2], Phillip Olk[3], Martin Weisheit[2], Jochen Rinderknecht[2], Yvonne Ritz[2], Peter Kücher[1], and Lukas M. Eng[3] — [1]Fraunhofer-Center für Nanoelektronische Technologien, 01099 Dresden, Germany — [2]AMD Saxony LLC& Co KG, 01099 Dresden, Germany — [3]Institut für Angewandte Photophysik TU-Dresden, 01069 Dresden, Germany

Noble metal particles show very interesting and complex optical properties. One of the most striking phenomena encountered in these particles are electromagnetic resonances due to collective oscillations of the conduction band electrons. The excitation of plasmons leads to an increased light scattering and to an enhanced electromagnetic near-field in the vicinity of these particles. The depolarization of the incident light excites additional modes usually not observed in the far-field spectra. Therefore, beside the far-field polarization modes, the observed Raman enhancement contains also near-field contributions and additional modes excited by the scattered light. These contributions can be exploited to improve the optical resolution of conventional Raman spectroscopy thus allowing the characterization of stress in semiconductor structures on the nano-meter scale. For the evaluation of the achieved resolution, TERS scans across silicon-germanium line structures were performed.

DS 13.3 Tue 11:15 GER 38

Strain analysis of embedded SiGe structures by Raman spectroscopy and FEM modelling — •Marek Roelke[1], Michael Hecker[1], Yvonne Ritz[1], Ehrenfried Zschech[1], and Victor Vartanian[2] — [1]AMD Fab 36 LLC & Co. KG Dresden, Wilschdorfer Landstraße 101, D-01109 Dresden, Germany — [2]International Sematech Manufacturing Initiative (ISMI), 2706 Montopolis Drive, Austin, TX 78741-6499 University of Technology

Strained silicon below the transistor gate increases significantly the charge carrier mobility thus improving the performance of present leading-edge CMOS devices. For better understanding of structure-strain relationship at the nanoscale and for the development of improved device structures, measurement of the strain state has become essential. To enable the characterization of structures close to the production process the applied measurement technique has to be fast, with low preparation-induced impact onto the sample surface, and sensitive to local strain in silicon thin film structures. Raman spectroscopy meets these requirements very well. Thus it is used in the present investigation to analyze the strain distribution in and close to embedded SiGe structures in silicon wafers in conjunction with finite element (FE) analysis. After verifying our model by comparing experimental to theoretical outcomes we show how the stress state in both SiGe and Si regions is modified when scaling down the geometric dimensions. Analysis shows that the stress state in the strained Si-channel is very sensitive to the geometry of the surrounding materials as well as the proportion of Germanium in the SiGe regions.

DS 13.4 Tue 11:30 GER 38

Electromigration simulation for on-chip Cu interconnects — •Matthias Kraatz[1], Dieter Schmeisser[1], Ehrenfried Zschech[2], and Paul S. Ho[3] — [1]BTU Cottbus, Germany — [2]AMD Fab 36 Limited Liability Company & Co. KG — [3]University of Texas at Austin, USA

We are investigating the influence of copper microstructure on electromigration degradation effects and interconnect lifetimes using computer simulation. The simulation is carried out in three dimensions. For the copper microstructure, a Monte Carlo technique was used to model the Cu grain growth. Different diffusivities where applied to grain boundaries and top interface of the interconnect model according to the qualitative crystallographic orientation of adjacent grains. The grain boundary network and the top interface form the diffusion paths for the electromigration mass transport. Along the diffusion paths, the fluxes of vacancies where calculated including mechanical stress and electromigration driving forces using a finite difference method. Positive flux divergent sites of the FDM lattice are treated as void nucleation sites after a critical vacancy concentration is reached. The resistance increase due to void growth was calculated using a cellular automaton, masking current free regions as quasi voids and adding the resistance of the slices of the lattice normal to the electron flow direction in series. A parallel computing environment was used to generate large numbers of interconnect models in order to obtain a pool of data for statistical analysis of interconnect lifetimes. The results of this analysis will be shown

DS 13.5 Tue 11:45 GER 38

Metrology of nano-thin films by use of atomic force acoustic microscopy — •Malgorzata Kopycinska-Müller[1,2], Andrey Striegler[1,2], Arnd Hürrich[3], Bernd Köhler[1], Norbert Meyendorf[1], and Klaus-Jürgen Wolter[2] — [1]Fraunhofer IZFP-D, Dresden, Germany — [2]Technical University Dresden, Germany — [3]Fraunhofer IPMS, Dresden, Germany

We characterized using the atomic force acoustic microscopy (AFAM) technique the mechanical properties of nano-thin films of silicon oxide grown on silicon substrate. The films thicknesses ranged from 7 nm to 28 nm, as measured by ellipsometry method. The results of AFAM measurements showed that it is possible to determine the elastic properties of the film if its thickness is known. In addition, the preliminary analysis of the AFAM results indicated that it may be possible to use the AFAM technique to determine the thickness in a thin-film system if the elastic properties of the system components are known.

AFAM is a contact based method and as such provides information on the sample effective elastic properties from a certain volume that is compressed under an AFM tip. The information on the sample stiffness is obtained from the analysis of resonant vibrations of an AFM cantilever beam.

DS 14: Invited Zhan

Time: Tuesday 14:15–15:00 Location: GER 38

Invited Talk DS 14.1 Tue 14:15 GER 38

Optimal plasmonic focusing with thin film metrology applications — •Qiwen Zhan and Weibin Chen — Electro-Optics Graduate Program, University of Dayton, 300 College Park, Dayton Ohio, 45469-0245, USA

Surface plasmon polaritons (SPPs) are collective oscillation of free electrons at metal/dielectric interface. As a wave phenomenon, surface plasmon can be focused using appropriate excitation geometry and metallic structures. This allows the generation of strongly localized SPP in a controllable manner. Combined with its strong field enhancement, focused SPPs are very attractive for near-field optical imaging and sensing with potential applications in high resolution thin film metrology. The challenges are to optimize the focus shape, size and strength. In this talk, I will present our recent works in the generation and manipulation of spatially engineered optical polarization and show that optimal plasmonic focusing can be achieved through a combination of polarization engineered beams and axially symmetric dielectric/metal plasmonic lens structures. Experimental confirmation of the optimal plasmon focusing with strongly focused radial polarization will be presented. A strongly localized evanescent Bessel focal field is realized. Such a focal field may be used for high resolution dielectric and metal thin film characterization. A near field Raman system using radial polarization illumination as well as specially fabricated probes has been built and tested. Preliminary experimental results for enhancing near field Raman signal will be presented.

DS 15: Thin Film Metrology for Electronics, Photonics, and Photovoltaics II

Time: Tuesday 15:15–16:30 Location: GER 38

Topical Talk DS 15.1 Tue 15:15 GER 38

Investigations of electrophysical properties of thin films with embedded nanoparticles by means of an immitance meter — Viktoria V. Malyutina-Bronskaya, •Valerii B. Zalesskii, and Tamara R. Leonova — B. I. Stepanov Institute of Physics NAN of Belarus, Minsk, Belarus

Recently we have undertaken an attempt to use the C-V characteristics measurement method for analyses of the properties of thin films with embedded nanoparticles on a silicon substrate. We have produced ZnO thin films doped with rare earth's elements on silicon by the reactive magnetron sputtering. C-V dependences measurements at frequencies of 500 kHz and 1 MHz were carried out by the E7-20 immitance meter at room temperature. SEM images of surface and cross-section of the films show the presence of large grains in the size range $\approx$ 0.1 - 0.3 mkm. Characteristic properties of the C-V dependences, in the forms of humps were observed for both frequencies in the capacitance modulation area. Magnitude of the hump decreases with lowering frequency. Calculations show, that similar characteristics take place when the discreet states have energy level sufficiently narrow energy distribution and are in close vicinity of the Fermi level. Therefore, the results obtained in our investigation show a good conformance of theoretical and experimental data. This gives one a possibility to use this method for investigations of the films with embedded nanoparticles.

DS 15.2 Tue 15:45 GER 38

Characterization of strained Si films by variable angle spectroscopic ellipsometry and Raman spectroscopy — •Zhijiat Chong, Martin Weisheit, Michael Hecker, and Ehrenfried Zschech — AMD Fab 36 LLC & Co. KG, Wilschdorfer Landstr. 101, D-01109 Dresden, Germany

Strain applied to silicon films modifies the mobility of charge carriers and is thus employed to enhance the performance of semiconductor devices. Methods to determine the thickness and the stress in these films non-destructively are indispensable in the manufacturing process, in which both precision and speed are crucial for high yield. Two optical methods are investigated here for this purpose. Due to the effect of stress on the electronic band structure and the lattice phonon frequencies, stress can be measured via variable angle spectroscopic ellipsometry (VASE) and Raman spectroscopy respectively. Based on bending experiments to induce stress in silicon-on-insulator stripes, VASE was used to characterize the change of the dielectric function at 1.2-6.4 eV due to stress. A novel stress-parameterized model of the dielectric function was constructed from the data using a summation of Tauc-Lorentz functions. This can be applied to determine the stress in silicon layers from ellipsometric measurements. The stress induced on the sample was also measured by the sample curvature and verified by Raman spectroscopy. The result shows that stresses can be measured with a sensitivity of about 30 MPa in thin silicon films by VASE.

DS 15.3 Tue 16:00 GER 38

Polarization dependent interface properties of ferroelectric Schottky barriers studied by soft X-ray — •Hermann Kohlstedt[1], Adrian Petraru[1], Matthias Meiner[1], Jonathan Denlinger[2], Jinghua Guo[2], Wanli Yang[2], Andreas Scholl[2], Byron Freelon Freelon[2], Theo Schneller[3], Rainer Waser[3], Pu Yu[4], and Ramamoorthy Ramesh[4] — [1]Institut für Festkörperforschung, Forschungszentrum Juelich, D-52425 Juelich, Germany — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley California 94720, USA — [3]Institute of Materials for Electronic Engineering 2, RWTH-Aachen, Sommerfeldstr. 24, D-52074 Aachen, Germany — [4]Department of Materials Science and Engineering and Department of Physics, University of California, Berkeley, California 94720 USA

We applied soft X-ray absorption spectroscopy to study the Ti L-edge in $Pt/PbZr_{0.3}Ti_{0.7}O_3/Pt$ ferroelectric capacitors using a modified total electron yield method. The inner photo currents and the X-ray absorption spectra were polarization state dependent. The results are explained on the basis of photo electric effects and the inner potential in the ferroelectric capacitors as a result of back-to-back Schottky barriers superimposed by the potential due to the depolarization field. In general, the presented method offers the opportunity to investigate the electronic structure of buried metal-insulator and metal-semiconductor interfaces in thin film devices by applying simultaneously soft X-rays and an electric dc field.

DS 15.4 Tue 16:15 GER 38

Piezoelectric phenomena in barium titanate thin films observed in nanoscale using piezoresponse force microscopy — •Grzegorz Wielgoszewski[1], Teodor Gotszalk[1], Piotr Firek[2], Jan Szmidt[2], and Aleksander Werbowy[2] — [1]Wrocław University of Technology, Faculty of Microsystem Electronics and Photonics, ul. Z. Janiszewskiego 11/17, PL-50372 Wrocław, Poland — [2]Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, ul. Koszykowa 75, PL-00662 Warszawa, Poland

Piezoelectric effect in the nanoscale, especially in single crystals of piezoelectric materials, is getting attention of microelectronics researchers very quickly. Thin films of ferroelectric materials (e.g. barium titanate) have a wide variety of application, e.g. high-density dynamic random access memories (DRAMs) or infrared detectors. In order to apply those materials in the most optimal way, one have to completely analyze and diagnose the piezoelectric effect in materials of various thickness and composition. One of the most expected result of the research is calculating the piezoelectric constant of the material.

To investigate such thin films in nanoscale, we constructed a piezoresponse force microscope (PFM). Applying ac voltage between the microtip of a PFM's probe and metal layer placed under the piezoelectric layer causes mechanical oscillation in the investigated film, which is measured using a lock-in amplifier.

We present the PFM construction and results of simultaneous measurements of the topography and piezoelectric response of the barium titanate layers, which thickness was less than 100 nm.

DS 16: Poster I

Time: Tuesday 9:30–12:30 Location: P5

DS 16.1 Tue 9:30 P5

Novel dielectric surface modifications for high-performance perylene based thin-film-transistors — •Christian Effertz[1], Ingolf Segger[1], Philip Schulz[1], Stefan Lahme[1], Matthias Wuttig[1], Arno Classen[2], Gregor Darlinski[3], and Rainer Waser[3] — [1]Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany — [2]Institute of Organic Chemistry, RWTH Aachen University, 52056 Aachen, Germany — [3]Institut für Werkstoffe der Elektrotechnik II, RWTH Aachen University, 52056 Aachen, Germany

Organic Thin-Film Transistors (OTFTs) are intensely studied due to their adaptability, e.g. as an active matrix for flexible displays or in low-cost RFID tags. Recent reports indicate that OTFTs can match their inorganic counterparts based on hydrogenated amorphous silicon (a-Si:H) in terms of mobility and on/off-current-ratio. We have shown that dielectic surface modifictions (DSM) can improve the performance of OTFTs dramatically. The use of the organic chainmolecule octadecyltrichlorosilane (OTS) is leading to transistors with superior performance. In order to both gain a deeper insight into the phenomenon of performance enhancement and to facilitate high mobility transistors, perylene-based devices utilizing novel DSM have been studied. The employed surface modifications are based on a) derivates of OTS with differently modified end-groups and b) a polymeric dielectric (PDMS) with a chain length comparable to OTS. The OTFTs were characterized by temperature-dependent electronic measurements, scanning probe microscopy and x-ray diffraction (XRD).

DS 16.2 Tue 9:30 P5

Trap-state influence on charge carrier transport in dielectric surface modified OTFTs — •Ingolf Segger, Christian Effertz, Stefan Lahme, Philip Schulz, and Matthias Wuttig — Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

Organic Thin Film Transistors (OTFT) offer a promising alternative to amorphous silicon technology, as they show a comparable performance regarding the carrier mobility and the $\frac{I_{on}}{I_{off}}$-ratio. In contrast to inorganic semiconductors, organic materials can be processed using low-cost techniques such as vacuum-evaporation at room temperature or spin-coating from a solution. These processes allow the deposition of organic thin-films on flexible substrates, as needed for several applications, e. g. flexible displays as used in E-Paper.

In order to gain insight into the carrier transport in OTFTs, we have focussed on the influence of interfacial and bulk-like trap states on the transfer characteristics of perylene-based TFTs, in particular in the sub-threshold region. Perylene thin films are deposited by thermal evaporation on top of thermally grown SiO_2, which is surface-modified with different organic-based chain molecules to vary density and type of interfacial trap states. Both film properties and device characteristics have been studied employing a range of techniques including atomic force microscopy, x-ray diffraction and temperature-dependant electronic measurements.

DS 16.3 Tue 9:30 P5

Characterization of organic thin-film transistors using metal phthalocyanines as active layers — •Iulia Genoveva Korodi, Daniel Lehmann, and Dietrich R.T. Zahn — Chemnitz University of Technology, Semiconductor Physics, D-09107 Chemnitz, Germany

In this work organic thin-film transistors (OTFTs) using Copper Phthalocyanine (CuPc), Cobalt Phthalocyanine (CoPc), and Titanyl Phthalocyanine (TiOPc) as active layers were prepared. The 20 nm thick films were deposited on highly doped Si(100) substrates with 100 nm SiO_2 by Organic Molecular Beam Deposition (OMBD) under high vacuum (HV) conditions at room temperature (RT). Source and drain electrodes of gold were deposited through a shadow mask on top by thermal evaporation under the same HV conditions, defining four OTFTs with a channel width of $W = 3$ mm, but four different channel lengths of $L = 17\,\mu$m, $38\,\mu$m, $86\,\mu$m, and $187\,\mu$m. The electrical characterization of the OTFTs was performed *in situ* and also *ex situ* under ambient conditions. The influence of annealing on the mobility was probed by measuring the structure *in situ* at elevated temperatures up to 200°C. The results for the various phthalocyanine derivatives are compared and discussed.

DS 16.4 Tue 9:30 P5

Ambipolar charge carrier transport in evaporated layers of copper-phthalocyanine: Field-effect transistors and metal-insulator-semiconductor diodes — •Michael Kraus, Julia Wagner, Andreas Opitz, and Wolfgang Brütting — Institute of Physics, University of Augsburg, Germany

Copper-phthalocyanine (CuPc) is a common semiconductor used in organic electronics, e.g. as hole-transport layer in organic field-effect transistors or as light absorber in organic photovoltaic cells. As shown recently, CuPc can exhibit bipolar charge carrier transport [1].

We fabricated top-contact field-effect transistors (FETs) and metal-insulator-semiconductor (MIS) diodes with thermally evaporated CuPc on passivated Si/SiO_2 substrates. The field-effect mobility parallel to the semiconductor–substrate interface is determined with the help of $I-V-$characteristics (for FETs) and the bulk mobility perpendicular to the surface with impedance spectroscopy (for MIS diodes). By variation of the electrode material, we achieved unipolar hole, unipolar electron and ambipolar charge carrier transport in the FETs. In the case of the MIS structures, diodes showing accumulation of holes, electrons or both charge carrier types are realized. We investigated the charge carrier mobilities and their thermal activation processes in both devices. The difference between electron and hole mobility is less than one order of magnitude but the mobilities do not depend on the electrode material and can thus be considered to be intrinsic properties of CuPc.

[1] A. Opitz et al., *New J. Phys.* **10** (2008) 065006

DS 16.5 Tue 9:30 P5

Potentiometry of Operating High-Mobility n-Type OFETs — •Franziska Lüttich, Harald Graaf, Daniel Lehmann, Dietrich R. T. Zahn, and Christian von Borczyskowski — Chemnitz Universtity of Technology, Chemnitz, Germany

Semiconductive organic materials are of great interest for low-cost and flexible applications like organic light-emitting diodes (OLEDs), organic solar cells and organic field-effect transitors (OFETs). For the most organic devices the charge carrier mobility and stability under ambient conditions have to be improved for the everyday use compared to common anorganic devices. On that score a better understanding of the charge transport in organic devices is necessary.

We will present recent results for an air-stable n-type OFET with and without gate insulator treatment using the Kelvin probe force microscopy (KPFM). The top-contact OFETs were fabricated in a high-vacuum chamber ($p < 4{\cdot}10^{-7}$ mbar) by evaporating about 20 nm N,N'-bis(n-octyl)-dicyanoperylene-3,4:9,10-bis(dicarboximide) (PDI-8CN_2) [1] on top on an p-doped silicon substrate with 100 nm SiO_x. Afterwards 20 nm thick gold-electrodes were evaporated through a shadow-mask on top of the organic.[2] For the gate-insulator treatment we used monolayers of N-octadecyltrichlorosilane (OTS).

It can be shown that the OTS monolayer changes the charge transport in the organic material and therefore the electric field distribution as well as the channel-edge forming.

[1] Appl. Phys. Lett. 88, 082104 (2006)
[2] Phys. Stat. Sol. (a) 205, No.3 (2008)

DS 16.6 Tue 9:30 P5

A microstructural investigation of components of bottom-gate bottom-contact organic thin-film transistors to improve their performance — •Tossapol Tippo[1], Chanchana Thanachayanont[2], Steffen Schulze[3], Michael Hietschold[3], and Apinunt Thanachayanont[1] — [1]Faculty of Engineering and College of Data Storage Technology and Applications, King Mongkut's Institute of Technology Ladkrabang, Chalongkrung Road, Ladkrabang Bangkok 10520, Thailand — [2]National Metal and Materials Technology Center, Thailand Science Park, Klong 1, Klong Luang, Pathumthani 12120, Thailand — [3]Chemnitz University of Technology, Solid Surface Analysis Group, D-09107 Chemnitz, Germany

Organic thin film transistors (OTFTs) were fabricated on glass substrate with a gate aluminum contact using evaporation in high-vacuum. Patterning was conducted by metallic mask. Gate dielectric poly(methyl methacrylate) (PMMA) was spin-coated via thin-film solution process. Source-drain gold contacts were patterned by metallic mask and thermal evaporation, respectively. Finally, pen-

tacene organic semiconductor was thermally evaporated. Electrical characteristics were measured by using a source measure unit. The OTFTs demonstrated drain currents in the order of microamperes. All measurements and characterizations of OTFTs comply with the IEEE 1620TM standard test methods. We conduct cross-sectional and plan-view investigations of OTFT components by Scanning Electron Microscopy and EDX to relate the thin films and interfaces morphologies and compositions to the performance of the OTFTs in order to improve it.

DS 16.7 Tue 9:30 P5

Insulator Thickness Dependence of Organic Field-Effect Transistors. — •Atefeh Yousefi Amin, Arne Hoppe, Benedikt Gburek, and Veit Wagner — Jacobs University Bremen, School of Engineering and Science, Campus Ring 1, 28759 Bremen, Germany

Organic electronics and especially organic field effect transistors (OFETs) present a promising route for future cost-efficient electronics. A crucial point in the fabrication of OFETs is to find insulators which combine low leakage current with high capacitance. To allow for low voltage operation, i.e. below 20 V, typically insulator thicknesses below 1 μm are required. In this study OFETs were fabricated in top-gate architecture with poly-methylmethacrylate (PMMA) of different molecular weight as organic gate insulator and a thiophene-based semiconductor. Both were deposited by spin-coating under atmospheric conditions.

According to theory the FET capacitance, which is inversely proportional to the insulator thickness, is directly related to the drain-source current. Therefore a thinner insulator layer results in a lower value of the threshold voltage and higher source drain current. The dependence of device characteristics on the insulator thickness was analyzed. In addition the homogeneity of the insulator film was found to be crucial for low leakage current. This layer homogeneity for fixed film thickness was found to be tunable by the right combination of molecular weight, solution concentration and coating speed. The minimum value of PMMA thickness for the reproducible production of short-circuit free devices was found at about 400 nm.

DS 16.8 Tue 9:30 P5

Contact degradation of pentacene field-effect transistors — •Dagmawi Belaineh, Benedikt Gburek, and Veit Wagner — Jacobs University Bremen, School of Engineering and Science, Campus Ring 8, 28759 Bremen, Germany

The performance of organic semiconductors in organic field-effect transistors (OFETs) has been steadily increasing. One of the major hindrances in realizing reliable OFET devices is the degradation of the active organic semiconductor layer in air. The negative influence of the contact properties at the interface between the metallic contacts and the organic semiconductors on the transport properties of OFETs is a well known problem. Therefore it is crucial to investigate the degradation of the organic semiconductor at the contacts as compared to the sheet semiconductor. For this analysis OFETs with bottom-gate geometry were produced with gold source and drain electrodes patterned by optical lithography on n-doped Si/SiO_2 substrates, on top of which pentacene was deposited as the active layer in vacuum. The degradation of the active layer was observed over three months for samples stored in air and others kept in an oxygen and water free nitrogen-atmosphere. The contact properties were determined by the transmission line method, i.e. by analyzing the channel conductance in dependence of the channel length L=1 to 50 μm. We find that the contact resistance of samples kept in air increases significantly as compared to the sheet resistance. In parallel AFM measurements were performed to analyze the pentacene layer structure close to the contacts.

DS 16.9 Tue 9:30 P5

Electronic and structural properties of graphene-based transparent and conductive thin film electrodes — •Antje Vollmer[1], Xinliang Feng[2], Xuan Wang[2], Linjie Zhi[2], Klaus Muellen[2], Juergen P. Rabe[3], and Norbert Koch[3] — [1]HZB-BESSY II, Berlin, Germany — [2]Max Planck Institute for Polymer Research, Mainz, Germany — [3]Institut f. Physik, Humboldt-Universität zu Berlin, Berlin ,Germany

We demonstrate that graphene-based transparent and conductive thin films (GTCFs), fabricated by thermal reduction of graphite oxide, have very similar electronic and structural properties as highly oriented pyrolytic graphite (HOPG). Electron spectroscopy results suggest that the GTCFs are also semi-metallic and that the individual graphene sheets of the film are predominantly oriented parallel to the substrate plane. These films may therefore be considered as a technologically relevant analogue to HOPG electrodes, which cannot be easily processed into thin films.

DS 16.10 Tue 9:30 P5

Highly efficient organic blue light emitting devices using doped transport layers — •Nico Seidler[1], Sebastian Reineke[1], Karsten Walzer[1], Björn Lüssem[1], Ausra Tomkeviciene[2], Juozas V. Grazulevicius[2], and Karl Leo[1] — [1]Institut für Angewandte Physik / Photophysik, Technische Universität Dresden, D-01062 Dresden — [2]Department of Organic Technology, Kaunas University of Technology, Kaunas LT-50254, Lithuania

In contrast to red and green OLEDs, blue light emitting devices are still far away from the theoretical limit of about 20 % external quantum efficiency. The best results so far have been achieved involving ultrahigh energy gap organosilicon compounds [1]. Due to their poor transport properties, high efficiencies are obtained only at low current densities and high voltages.

We used the blue phosphorescent emitter iridium(III)bis[(4,6-difluorophenyl)-pyridinato-$N, C^{2'}$]picolinate (FIrpic) as a dopant in the host material 3,6-di(9-carbazolyl)-9-(2-ethylhexyl)carbazole, which possesses both a large triplet exciton energy and good charge carrier transport properties. It was therewith possible to efficiently confine the triplet excitons on the emitting molecules and keep the recombination zone away from the blocking layers. This results in a high external quantum efficiency of 13.1 % at a brightness of 1,000 cd/m^2. Due to the superior charge carrier injection properties provided by the doped transport layers, this brightness could be achieved at low voltages of only 4.0 V, resulting in a high power efficiency of 22.5 lm/W.

[1] X. Ren et al., Chem. Mater. **16**, 4743 (2004)

DS 16.11 Tue 9:30 P5

Top emitting white OLEDs — Patricia Freitag, Björn Lüssem, and •Karl Leo — Technische Universität Dresden, Institut für Angewandte Photophysik, George-Bähr-Strasse 1, 01069 Dresden, Germany

Top emitting organic light emitting diodes (TOLEDs) provide a number of interesting opportunities for new applications, such as the opportunity to fabricate ITO-free devices by using opaque substrates. This makes it possible to manufacture low cost OLEDs for signage and lighting applications.

A general top emitting device consists of highly reflecting metal contacts as anode and semitransparent cathode, the latter one for better outcouling reasons. In between several organic materials are deposited as charge transporting, blocking, and emission layers.

Here, we show a top emitting white organic light emitting diode with silver electrodes arranged in a p-i-n structure with p- and n-doped charge transport layers. The centrical emission layer consists of two phosphorescent (red and green) and one fluorescent (blue) emitter systems separated by an ambipolar interlayer to avoid mutual exciton quenching.

By adding an additional dielectric capping layer on top of the device stack, we achieve a reduction of the strong microcavity effects which appear due to the high reflection of both metal electrodes. Therefore, the outcoupled light shows broad and nearly angle-independent emission spectra, which is essential for white light emitting diodes.

DS 16.12 Tue 9:30 P5

Charge carrier injection in organic light-emitting diodes studied by impedance spectroscopy and Kelvin probe measurements — •Stefan Nowy, Wei Ren, Julia Wagner, Josef A. Weber, and Wolfgang Brütting — Institute of Physics, University of Augsburg, Germany

Impedance spectroscopy (IS) is a powerful method for characterising the electrical properties of materials and their interfaces. In this study we use IS to investigate the charge carrier injection properties of different anodes and anode treatments in bottom-emitting organic light-emitting diodes (OLEDs). These are ITO-based (indium tin oxide) hetero-layer devices with TPD (N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4-diamine) as hole transporter and Alq_3 (tris-(8-hydroxyquinoline) aluminum) as emission and electron transporting layer. The charge carrier injection is mainly determined by the work functions of the materials used as electrodes. Kelvin probe measurements allow the quantification of the work functions and the estimation of the energy level alignment inside the OLED. A more detailed analysis of the (not very well known) interfaces is provided by IS, yielding information about trapped and interfacial charges as well

as the dynamics of injected charges. Furthermore we show that IS can be used to identify degradation processes in OLEDs.

DS 16.13 Tue 9:30 P5

In situ **Raman Spectroscopy and On-line Growth Monitoring of Indium Deposited on Copper Phthalocyanine Films** — •Philipp Schäfer[1], Cameliu Himcinschi[1], Vasile Chis[2], and Dietrich R. T. Zahn[1] — [1]Chemnitz University of Technology, Semiconductor Physics, 09107 Chemnitz, Germany — [2]Babes-Bolyai University, Faculty of Physics, 400084 Cluj-Napoca, Romania

Different types of phthalocyanine (Pcs) are well-known for their potential in a huge variety of applications [1]. Copper phthalocyanine (CuPc) and possible applications for novel organic semiconductor devices have been studied intensively in recent years. For technical applications, interfaces between metals and organic semiconducting materials are of special interest, as they form the contact to the organic semiconductor devices. In this study CuPc and afterwards indium are deposited under ultra high vacuum conditions via molecular beam deposition onto hydrogen passivated Si(111) substrates. *In situ* Raman Spectroscopy (as described in ref. [2]) prooves to be a versatile and non-destructive technique to investigate the growth process. Cluster formation of indium and surface enhanced Raman spectroscopy (SERS) effects are observed during the indium deposition process. The analysis of the evolution of the observed Raman features is performed taking density functional theory calculations into account.

[1] N. B. McKeown, Phthalocyanine Materials (Cambridge University Press, 1998)
[2] V. Wagner *et al.*, Journal of Applied Physics 75, 7330 (1994)

DS 16.14 Tue 9:30 P5

Ordered Phthalocyanine Films Investigated by Means of the Magneto-Optical Kerr Effect — •Michael Fronk, Björn Bräuer, Dietrich R.T. Zahn, and Georgeta Salvan — Physics Department, Chemnitz University of Technology, Reichenhainer Str. 70, D-09126 Chemnitz

The efficiency of organic electronic devices depends among other factors markedly on the morphology and the alignment of the molecules. There are several strategies for aligning molecules on surfaces. One of them is the so-called template effect. Perylene-tetracarboxylic-dianhydride (PTCDA) [1] was deposited on Si by means of molecular beam deposition as a template and phthalocyanine molecules were deposited on top of PTCDA. PTCDA molecules are known to grow with their molecular plane nearly parallel to that of the substrate, while the phthalocyanine molecules can adopt various orientations with respect to the substrate depending on the substrate surface or the growth parameters such as base pressure and deposition rate. The influence of the PTCDA template layer on the molecular orientation of the phthalocyanine molecules was investigated by means of magneto-optical Kerr effect (MOKE) spectroscopy. The Voigt constant of phthalocyanine (H_2Pc) films was calculated using the experimental results of polar MOKE spectroscopy and variable angle spectroscopic ellipsometry (VASE) investigations. MOKE was shown to be very sensitive for different orientations and the degradation of the molecules present in the films with and without PTCDA.

[1] O.D. Gordan et al., *Organic Electronics 7*, **2006**, 521.

DS 16.15 Tue 9:30 P5

In situ **and** *ex situ* **Ellipsometry and Reflection Anisotropy Spectroscopy of rare-earth-diphthalocyanine filmes** — •Falko Seidel, Cameliu Himcinschi, and Dietrich R. T. Zahn — Technische Universität Chemnitz, Institut für Physik, Halbleiterphysik, D-09107 Chemnitz

Phthalocyanines are commonly known to possess semiconducting properties and are studied for there potential technical applications as organic semiconductors. Still only few publications cover rare-earth diphthalocyanines. Double-decker phthalocyanines like the here investigated $LuPc_2$ may yield better properties for technical applications than the commonly studied ones. Almost all phthalocyanines form films with strong optical anisotropic if they are deposited on hydrogen passivated Si(111) substrates by sublimation in high vacuum. To measure the optical response Variable Angle Ellipsometry Spectroscopy (VASE) and Reflection Anisotropy Spectroscopy (RAS) are employed. Since optical properties can change throughout the growth process and chemical reactions may occur after the sample is removed from the vacuum *in situ* ellipsometry and RAS are far superior to their *ex situ* counterparts. For the evaluation of VASE data the program WVASE32 is used. Since $LuPc_2$ does not possess the usual transparent region in the near infrared, special care is taken to evaluate the correct thickness. The high anisotropy of the layer allows to draw conclusions about the orientation of the molecules with respect to the substrate: mostly the Pc-rings are standing. With increasing thicknesses the line shape of the Q-band changes. Also electrochromical behaviour is observed.

DS 16.16 Tue 9:30 P5

The growth of thin phthalocyanine films probed by Raman scattering — •Britt-Elfriede Schuster[1], Cameliu Himcinschi[2], Philipp Schäfer[2], Heiko Peisert[1], Thomas Chassé[1], and Dietrich R. T. Zahn[2] — [1]Institute of Physical and Theoretical Chemistry, University of Tübingen, Germany. — [2]Semiconductor Physics, Chemnitz University of Technology, Germany.

Thorough investigations of thin organic films are basic prerequisites for a comprehensive understanding of morphological, structural and electronic properties of thin organic films. In this context the organic thin film growth is a critical factor, because it is closely connected with e.g., polymorphism and molecular orientation that can depend on the type of substrate material, preparation conditions, and post-growth treatment. Due to their unique properties, phthalocyanines are highly attractive materials and promising candidates for various applications. In this work the growth of thin films of titanyl(IV)phthalocyanine and copper phthalocyanine on silicon prepared by organic molecular beam deposition (OMBD) is assessed by in situ Raman spectroscopy. By monitoring internal vibrational modes under resonance and preresonance conditions the evolution of the polymorphic modifications during the thin film growth and/or the molecular arrangement within the organic layers can be studied. The deposition of silver onto the organic thin films under UHV conditions causes surface enhanced Raman scattering signals and provides further information about the metal/organic interface. Atomic force microscopy measurements reveal different surface morphologies after deposition of silver.

DS 16.17 Tue 9:30 P5

Energy levels of new perfluoroalkyl- substituted phthalocyanines derived from electrochemical characteristics — •Steffi Nagel[1], Martin Lener[1], Christopher Keil[1], Robert Gerdes[2], Sergiu Gorun[2], and Derck Schlettwein[1] — [1]Justus-Liebig-Universität Gießen, Institut für Angewandte Physik, Heinrich-Buff-Ring 16, D-35392, Gießen. eMail: schlettwein@uni-giessen.de — [2]New Jersey Institute of Technology, Department of Chemistry and Environmental Science, Newark, NJ 07102, USA

Octa(perfluoropropyl) octafluoro phthalocyanine complexes ($F_{64}Pc$), new molecules with high electron affinity and small intermolecular coupling energies, were investigated. Studies of charge transfer across the interface under varied controlled potential in the electrolyte (cyclic voltammetry) were used to determine the molecular energy levels of the molecules. Optical spectroscopy was used to analyze details of the charged molecular state. Furthermore, optical absorbance measurements at thin films revealed a small extent of intermolecular electronic coupling. The use as n-conducting air stable semiconductors and electrochromic switches will be discussed.

DS 16.18 Tue 9:30 P5

First optical investigation of the charged states of PTCDA in solid state — •Andreas Krause, Thomas Dienel, Roman Forker, and Torsten Fritz — Institut für Angewandte Photophysik, TU-Dresden, George-Bähr-Str. 1, 01069 Dresden

Perylene-3,4,9,10-tetracarboxylic dianhydride (PTCDA) is a well known molecule, often used in research for epitaxial growth on all kinds of substrates. The arrangement of the molecules in herringbone structured crystal planes can be traced with (sub-) monolayer sensitivity by a combination of organic molecular beam epitaxy and optical in situ spectroscopy [1]. Once potassium or cesium is stepwise added to a closed monolayer of neutral PTCDA molecules, the spectral development towards PTCDA anions can be followed and assigned to the reached levels of charging. The emerging peak at 1.85 eV can be assigned to the PTCDA anion, in agreement with previous experiments without intentional doping on natural mica. However, with direct doping it is possible to identify clearly at least one further charged state, namely the PTCDA dianion.

[1] H. Proehl et al. PRL 93, 097403 (2004)

DS 16.19 Tue 9:30 P5

Investigation of buried metal-organic interfaces with Pho-

toelectron Spectroscopy (PES) — •Pavo Vrdoljak[1], Achim Schöll[1], Friedrich Reinert[1], and Eberhard Umbach[2] — [1]Universität Würzburg, Experimentelle Physik II, 97074 Würzburg — [2]Forschungszentrum Karlsruhe, 76021 Karlsruhe

Interfaces in electronic devices based on organic semiconductors have a strong in-fluence on the device performance. The layer morphology and the resulting electronic structure at the contact have to be controlled in order to optimize the charge carrier transport. In case of a metal top contact deposited on an organic layer the established metal-organic interface is morphologically rough and the contact properties can be substantially different if compared to model systems like single crystalline or amorphous metal substrates with organic adsorbates. However, the investigation of buried contact interfaces by surface sensitive techniques such as photo electron spectroscopy (PES) and atomic force microscopy (AFM) requires a sophisticated preparation technique to provide access to this region. We present an experimental approach which allows the removal of the metal top-contact in the UHV and subsequent in-situ analysis with surface sensitive spectroscopies. Moreover, we will present PES and AFM results of Ag/PTCDA and of PTCDA on amorphous Ag substrates. In the latter case a comparison of the PES data to single crystalline samples indicates that the interface is mainly built up by Ag(111) and Ag(110) domains.

DS 16.20 Tue 9:30 P5

Optical observation of charged organic molecules on metal surfaces — •Christian Golnik, Roman Forker, and Torsten Fritz — Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany

We report on the *in situ* optical absorbance spectroscopy of ultrathin films of the organic semiconductor 3,4,9,10 perylene-tetracarboxylic-dianhydride (PTCDA) on the metal single crystals Au(111), Ag(111) and Al(111). As Differential Reflectance Spectroscopy (DRS) has a sensitivity in the range of submonolayers, we could extract the dielectric function from the DR-spectra in dependency of the film thickness in the monolayer regime. A broad absorption due to strong interaction with the metal surface in the first monolayer and a monomeric absorption in the second monolayer were observed in the ϵ"-spectra. Different charged states of PTCDA related to the direction of the interface dipole [1] between the metal surface and the organic film were found, namely PTCDA-anions in the first monolayer on aluminium and PTCDA-cations in the second monolayer on gold. The absorption signatures of the charged states are in good agreement with PTCDA-anions obtained by potassium doping on mica [2] and absorption spectra of charged PTCDA-related molecules in solution [3].

[1] A. Kahn et al., J. of Polymer Science Part B 41 (2004), 2529-2548
[2] A. Krause et al., submitted
[3] T. Kircher et al., Phys. Chem. Chem. Phys. 1 (1999), 3987-3992

DS 16.21 Tue 9:30 P5

Static and dynamic contact angle measurements on self-assembled monolayers covalently bond on silicon surfaces. — •David Polster, Harald Graaf, and Christian von Borczyskowski — Center of Nanostructured Materials and Analytics, University of Technology Chemnitz, 09107 Chemnitz, Germany

Contact angle measurements were carried out on self-assembled monolayers, which were prepared by covalently bond 1-decene and methyl-10-undecenoate (UND) on silicon surfaces. Beside the pure monolayers also mixtures of the two molecules were investigated, where the surface mole fraction of UND was tuned by different mixture solution ratios. The prepared films have been studied with static and dynamic contact angle measurements, using water as a polar liquid and diiodmethane as a dispersive liquid. By the static contact angle measurement the surface energy of the monolayers as well as their polar and dispersive parts were determined. Dynamic contact angle measurements, where the advancing and the receding angles of droplets of the probe liquids are measured, give information on the surface roughness and heterogeneity and furthermore are used to calculate the molar free energies of the surface. For the mixed monolayers a decrease in the contact angles and molar free wetting energy was found with increasing ratio of UND in the monolayer. In contrast, molar free dewetting energy und contact angle hysteresis was nearly constant.

DS 16.22 Tue 9:30 P5

Self-assembled Silane monolayers on silicon oxide — •Harald Graaf, Christian Belgardt, David Polster, and Christian von Borczyskowski — Center of Nanostructured Materials and Analytics, University of Technology Chemnitz, 09107 Chemnitz, Germany

Chemical modification of silicon oxide surfaces by various Silane molecules is a well known method. As a standard Silane the octadecyltrichloro-silane (OTS) is used to prepare highly ordered monolayers with a pure hydrophobic character. For example, it is also used in organic electronics to minimize trap states on the surface of the gate isolator to improve the output characteristics as well as the long time stability in organic field effect transistors.

Here we will report the influence of silicon oxide of different thickness and the reaction time on the formed monolayer of OTS. The characterization of the self-assembled monolayer was done by static contact angle measurements. By using different liquids the surface energies of the samples with its polar and dispersive components were determined.

DS 16.23 Tue 9:30 P5

Investigation of the highly crystalline morphology of a low molecular weight oligoquaterthiophene fraction with low polydispersity — •Patrick Pingel[1], Dieter Neher[1], Markus Breusing[2], Thomas Elsaesser[2], Thomas Fischer[3], Joachim Stumpe[3], Jian Zhang[4], Norbert Koch[4], Sybille Allard[5], and Ullrich Scherf[5] — [1]Institut für Physik und Astronomie, Universität Potsdam — [2]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Berlin — [3]Fraunhofer-Institut für Angewandte Polymerforschung, Potsdam — [4]Institut für Physik, Humboldt-Universität zu Berlin — [5]Institut für Chemie, Universität Wuppertal

We have recently shown that spin-cast layers of an oligomeric polyquaterthiophene fraction (PQT-12, M_w= 1,700 g/mol, PDI=1.03) exhibit a field-effect mobility of 10^{-3} cm^2/Vs, which is unusually high for low-M_w polyalkylthiophenes. Here we show that these layers exhibit a hierarchical architecture with structural order on different length scales. AFM studies reveal that they consist of needle-like crystallites that form oriented domains at the μm-scale. We even observe optical anisotropy in conventional polarization microscopy, meaning that adjoining domains exhibit a common orientation over tens of micrometers. Using broadband confocal spectroscopy with high lateral resolution, we identified regions rich in chains with lower conjugation, which we ascribe to partially ordered domains in between highly crystalline areas. Combined with a flat-on molecular orientation on the substrate, we conceive that the presence of disordered domains determines the field-effect mobility in these polycrystalline layers.

DS 16.24 Tue 9:30 P5

Study of Alkane Structure and Phase Transitions with X-Ray Reflectivity — Valeria del Campo[1], Edgardo A. Cisternas[1], Ignacio Vergara[1], Tomás Corrales[1], •Ulrich G. Volkmann[1], Haskell Taub[2], Haiding Mo[3], and Steven Ehrlich[3] — [1]Surface Lab, Facultad de Física, Pontificia Universidad Católica de Chile, Chile — [2]Department of Physics and Astronomy, University of Missouri-Columbia, USA — [3]NSLS, Brookhaven National Laboratory, USA.

We study the structure and phase transitions of vapor-deposited films in the range of monolayers of n-dotriacontane with synchrotron X-Ray Reflectivity. The films as deposited present a complete bilayer adjacent to the substrate where the alkanes lay parallel to the surface, and one layer in which the molecules are oriented perpendicular to the surface with an occupancy of ∼70%. After an initial temperature cycle up to 350 K the film forms two perpendicular layers. On heating to 338 K, thickness of the perpendicular layers decrease from 42.5 to 40.7 Å. At 344 K we only detect the signal from the parallel bilayer, which has increased its thickness from 9.2 to 10.4 Å. These transitions are consistent with those found by Bai *et al.* [1] with temperature dependent AFM measurements performed on samples grown by dip-coating from solution instead of physical vapor deposition in high vacuum.

[1] M. Bai *et al.*, Europhys. Lett. **79**, 26003 (2007).

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DS 16.25 Tue 9:30 P5

Reflectance spectroscopy of PMMA implanted with 50 keV silicon ions — •Bojana Florian[1], Ivan Stefanov[2], and Georgi Hadjichristov[3] — [1]Bulgarian Institute of Metrology, 2 Prof. P. Mutafchiev Str., 1797 Sofia, Bulgaria — [2]Department of Quantum Electronics, Faculty of Physics, Sofia University, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria — [3]Institute of Solid State Physics, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria

Recently, the modification of the specular reflectivity of PMMA implanted with low-energy (50 keV) silicon ions was studied and nano-

clusters formed in PMMA by Si^+ implantation were evidenced by Raman spectroscopy [1] and electrical measurements [2]. Further, the optical loss due to off-specular (diffuse) reflectivity of this ion-implanted polymer is also of practical interest for applications such as micro-optical lenses, diffraction gratings, Fresnel lenses, waveguides, etc.

We examined both specular and diffuse reflectivity of Si^+ implanted PMMA in the UV-Vis-NIR. The effect from Si^+ implantation in the dose range 10^{14}-10^{17} ions/cm^2 is linked to the structure formed in PMMA where the buried ion-implanted layer has a thickness up to 100 nm. As compared to the pristine PMMA, an enhancement of the reflectivity of Si^+ implanted PMMA is observed, that is attributed to the modification of the subsurface region of PMMA upon the ion implantation.

[1] G.B. Hadjichristov, V. Ivanov and E. Faulques, Appl. Surf. Sci. 254, 4820-4827 (2008). [2] G.B. Hadjichristov et al., Org. Electron. 9, 1051-1060 (2008).

DS 16.26 Tue 9:30 P5

Dünne Schichten starker organischer Donor-Akzeptor-Systeme — •Milan Rudloff und Michael Huth — Physikalisches Institut, Max-von-Laue-Str. 1, D-60438 Frankfurt am Main

Unsere Experimente konzentrieren sich auf die Präparation und Charakterisierung dünner Schichten organischer Ladungstransfersalze (CT-Verbindungen). Derartige Donor-Akzeptor-Systeme besitzen zusätzliche Coulomb-Bindungsenergie-Anteile. CT-Verbindungen besitzen je nach Kristallstruktur, Druck und Temperatur Isolator-, Halbleiter-, metallische und sogar Supraleiter-Eigenschaften.
Die Präparation der Dünnschichten erfolgt über die organische Molekularstrahlepitaxie, bei der die Quellmaterialien unter UHV-Bedingungen aus Effusionszellen (ko-)sublimiert und auf einem Substrat abgeschieden werden. Charakterisiert werden die Schichten anschließend durch Licht- und Rasterkraft-Mikroskopie, Röntgendiffraktometrie sowie temperaturabhängige Transportmessungen.
Das Projekt ist auf neue Kombinationen von Donoren und Akzeptoren ausgerichtet und zielt auf die Präparation bzw. den Nachweis bisher unbekannter Ladungstransferverbindungen. Die hier präsentierten Resultate beziehen sich auf die ersten Experimente mit einigen dieser neuen Donor(D)-Akzeptor(A)-Paare, z.B. Dithieno-Thiophen (D) + Dicyanomethylen-Trinitrofluoren (A) und Tetrathiafulvalen (D) + Tetrachlor-Hydrochinon (A).

DS 16.27 Tue 9:30 P5

Mechanical characterization of nanoscale silicon structures — Sven Niese[1], Michael Hecker[1], Yvonne Ritz[1], Ehrenfried Zschech[1], Paul S. Ho[2], and •Zhiquan Luo[2] — [1]AMD Fab 36 LLC & Co. KG Dresden, Wilschdorfer Landstraße 101, D-01109 Dresden, Germany — [2]Microelectronics Research Center, University of Texas; Austin, Texas 78712

Mechanical properties of nanoscale silicon structures are of high relevance for leading-edge and future CMOS devices. In particular for interconnect copper-filled structures, deep trenches with high aspect ratio, rectangular cross sections and nearly atomically flat sidewalls are needed. Such structures have been manufactured with varying geometry, e.g. line widths and trench depths, by electron beam lithography and anisotropic wet etching. We evaluated techniques for in-situ characterization of mechanical properties on a single silicon lamella with a force sensor in a SEM. Unusual mechanical properties, deviating from those of silicon bulk material, have been derived. The results are compared with those of finite element analysis. Apart from the mechanical properties, the particular optical properties of the trench structures where investigated by Raman spectroscopy. Significant enhancements of the Raman scattering related to the geometry were analyzed. These effects are important for stress measurements on nanoscaled strained silicon structures.

DS 16.28 Tue 9:30 P5

Interface Trap Density Extraction from Capacity- and Current-Voltage Measurements of Leaky High Dielectric Films — •Thomas Zilbauer, Torsten Sulima, Hermann Baumgärtner, and Ignaz Eisele — Universität der Bundeswehr München, Institut für Physik, 85577 Neuiberg

The voltage dependent capacity and current measurement of high dielectric oxides on silicon substrates is a powerful tool for electrical characterization of the insulating thin film. Parameters such as the equivalent oxide thickness, the flatband voltage or the interface trap density and distribution can be extracted from C(V)-G(V)-measurements. However, uncertainties arise from difficulties in obtaining the correct insulator capacity and from the question whether assumptions made for the conventional extraction of interface trap density with SiO_2 hold with high-k materials.

We suggest a simple method of determining interface trap density of a leaky HfO_2 film using the C(V)-G(V)-measurement at only one frequency. Based on experimental results we will prove the implied assumption of a Gaussian distributed, frequency normalized interface trap conductance depending on band bending and present typical parameters needed for interface trap density extraction.

DS 16.29 Tue 9:30 P5

Dependence of the deposition conditions on ZnO Surface morphology — •Viola Mönkemöller[1], Florian Lükermann[1], Marc Sacher[1], Armin Brechling[1], Ulrich Heinzmann[1], Henning Kurz[2], Frank Hamelmann[2], and Helmut Stiebig[2] — [1]Molecular and Surface Physics, Bielefeld University, Germany — [2]Malibu GmbH, Bielefeld, Germany

Boron doped ZnO films deposited by Low Pressure Chemical Vapour Deposition are used as transparent conductive oxide (TCO) for thin film solar cells. The films show an interesting surface morphology composed of pyramidal grains, which are formed due to a pronounced orientation of the $[11\bar{2}0]$ crystallographic axis perpendicular to the surface. [1]

We performed AFM measurements on ZnO films to investigate the change in surface morphology with respect to the depostion conditions such as deposition time, temperature and the boron doping concentration. We found that the thicker the films, the larger the pyramids and in contrast the higher the boron doping, the smaller the pyramids. For a varied depostion temperature we observed a change in crystallographic orientation by XRD measurements arround 160 °C from a pronounced [0002] to a $[11\bar{2}0]$ axis growth. This change was also detected by AFM measurements due to a drastic change in surface morphology. Films below 160 °C show a nearly flat surface whereas films above that temperature show a rough surface of pyramidal structures.

[1] E. Vallat-Sauvain, Mat. Res. Soc. Symp. Proc 664 (2001).

DS 16.30 Tue 9:30 P5

Combined MOKE and (GI)XRD studies on non-epitaxial and epitaxial thin magnetic films — •Timo Kuschel[1], Tobias Becker[1], Hauke Bardenhagen[1], Oliver Hoefert[1], Martin Suendorf[1], Bernd Zimmermann[1], Florian Bertram[1], Daniel Bruns[1], Michael Paulus[2], Christian Sternemann[2], Lars Boewer[2], and Joachim Wollschlaeger[1] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrueck, Germany — [2]DELTA, Universität Dortmund, Maria-Goeppert-Mayer-Str. 2, 44227 Dortmund, Germany

The behaviour of thin magnetic films concerning the magnetization is important for spintronic applications. Therefore MOKE measurements as well as (GI)XRD experiments were performed on non-epitaxial and epitaxial thin magnetic films.

We investigated an uniaxial magnetic anisotropy of amorphous as well as polycrystalline Co films grown on glass (SiO_2). As a result from our research we can exclude growth conditions and strain of the substrate as an origin of this anisotropy. Also the atomic structure of the Co films can not be the reason for the magnetic anisotropy. The structure depends on the film thickness, because thinner Co films grow amorphous and thicker Co films grow polycrystalline.

In contrast to this we analyzed the magnetic behaviour of epitaxial Fe on MgO(001). The MOKE measurements verify a fourfold magnetic anisotropy concerning the cubic crystal structure. Untypical hysteresises in some directions point to an out-of-plane magnetization during the reversal process.

DS 16.31 Tue 9:30 P5

Effect of annealing and thickness of MgO films on magnetoresistive and electrical properties of CoFeB/MgO granular system — •Khalid Mehmood Bhutta, Jan Schmalhorst, and Günter Reiss — Thin Films and Physics of Nano structures, Department of Physics, University of Bielefeld, 33615 Bielefeld Germany

Granular metals are inhomogeneous mixtures of metals and nonmetals. Recently granular metals of ferromagnetic grains embedded in the matrix of oxides have been investigated because of their applications in electronic devices. The electrical and magnetic properties of such metals can be manipulated by the thickness of ferromagnetic and oxide layers. In the present work, the magnetic and electrical properties of CoFeB/MgO granular metal having various thicknesses

of oxide layer as well as the effect of annealing temperature and time have been studied. The optimum value of GMR was achieved at 0.7nm MgO thickness. A nominal change in the MgO thickness strongly affects the Magnetoresistance of the granular metal. Multiple annealing steps at constant temperature of 250^{o}C improve the GMR ratio. However, a deteriorated GMR ratio at the annealing temperature of 300^{o}C points to the crystallization of CoFeB. Regarding the low temperature measurements, the electron transport follows the Mott's Law of Variable Range Hopping. However, at temperature lower than 50 Kelvin a deviation from Mott's Law has been observed.

DS 16.32 Tue 9:30 P5

Heusler thin film superlattices as model systems for thermoelectric materials — •Gerhard Jakob[1], Tobias Eichhorn[1], Joachim Barth[2], Gerhard Fecher[2], Claudia Felser[2], and Anke Weidenkaff[3] — [1]Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — [2]Institute of Anorganic and Analytical Chemistry, Johannes Gutenberg-University, 55099 Mainz, Germany — [3]Empa - Swiss Federal Laboratories for Materials Testing and Research, 8600 Duebendorf, Switzerland

Research on thermoelectric materials has strongly increased in recent years due to their high application potential. We use Heusler type materials of C1b structure as model system for thermoelectric materials. TiNiSn is known to possess a high thermoelectric power factor and we show data of epitaxial film growth and the resistive and thermoelectric transport properties of these films. We do band structure calculations in order to find suitable partner systems with a similar Fermi surface but a different phonon structure. Free standing films are achieved using deposition on solvable substrates. Using a multilayer deposition system we prepare Heusler type superlattices with the aim to reduce thermal conductivity while keeping electrical conductivity high.

DS 16.33 Tue 9:30 P5

Cerium oxide-based thin nanocrystalline Solid Oxide Fuel Cell electrolyte films — •Petr Straumal[1,2], Ata Myatiev[2], Sergiy Divinski[1], and Gerhard Wilde[1] — [1]Institut für Materialphysik, Universität Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany — [2]Moscow Institute of Steel and Alloys (Technological University), Leninsky Prospect 4, 119049 Moscow, Russia

Solid oxides fuel cells can have very high efficiencies in converting chemical energy to electrical energy (70-80%). However, there are some problems with existing materials, namely, high operation temperature (900-1000°C), high manufacture costs. Conventional electrolyte materials (as Zr oxide doped with metals like Y, Ca, Sc Yb, Sm), have reached their limit. New materials are needed with enhanced ionic conductivity and catalytic activities. Ionic conductivity in conventional solid electrolytes is limited by lattice diffusion. Nanoscaled and nanocrystalline materials may be a solution due to the abundance of grain boundaries.

This work studies the conductivity and nanostructure of thin nanocrystalline cerium oxide-based electrolyte films which may be the answer to this challenge. The oxide films are produced using a novel deposition method from metal-organic precursors at relatively low (400-500°C) temperatures. The cerium oxide was doped by bismuth and gadolinium. The conductivity was measured using impedance spectroscopy and the structure was investigated using TEM.

DS 16.34 Tue 9:30 P5

Preparation of thin cobaltate and manganite films for thermoelectric applications — •Stefanie Wiedigen, Thilo Kramer, Jörg Hoffmann, and Christian Jooss — Institute of Material Physics, University of Goettingen, Germany

Complex oxides like cobaltates and manganites are promising thermoelectric materials because of their large Seebeck coefficient and their chemical and thermal stability at elevated temperatures. Due to their poor electric conductivity, ZT is relatively low (≈ 0.02). It is therefore interesting to evaluate the potential for ZT enhancement by decoupling of the electric and the thermal transport. In this contribution we analyze structural and transport properties of cobaltate and manganite thin films prepared by ion-beam sputtering. For the manganite system, we choose the hole doped $Pr_{1-x}Ca_xMnO_3$ (x=0.32) system with strong electron-phonon coupling. It is shown that the electric conductivity is governed by small polaron hopping. For the cobaltate system we choose $CaCoO_3$ and $PrCoO_3$ compositions as the starting point for the analysis of electric and thermal conductivity at low electron and hole doping. First results concerning such cobaltate films produced by ion-beam sputtering are presented. The relation between doping, structure and electric conductivity is analyzed. We discuss our results in the light of polaron conductivity mechanism and its impact on designing thermoelectric properties.

DS 16.35 Tue 9:30 P5

Thermoelectric measurements on artificially structured ZnO/ZnS bars — •Gert Homm, Torsten Henning, Bruno K. Meyer, and Peter J. Klar — Institute of Experimental Physics I, Justus-Liebig-University Gießen, Germany

ZnO layers of about 700 nm thickness were grown by RF Sputtering on glass substrates. The layers are n-type with electron concentrations of about 10^{21} cm^{-3}. Arrays of the as grown samples were artificially structured by photolithography. The patterns consist of regular arrays of bars with different spacings and bar width. The bars can be arranged in different angles with respect to the temperature gradient applied in the measurement. The patterns were transferred by wet-chemical etching. In a second sputter process a thin layer (500 nm) of ZnS was grown on the structured array to achieve the ZnO/ZnS bar structure. The Seebeck coefficient is measured in the temperature range from 50 to 300 K. The influence of the artificial structuring and the orientation of the wires with respect to the temperature gradient on the Seebeck coefficient is discussed.

DS 16.36 Tue 9:30 P5

High resolution electron microscopy and EELS investigations of arrays of Si nanopillars for thermoelectric applications — •Martin Schade[1], Nadine Geyer[1,2], Bodo Fuhrmann[1], Frank Heyroth[1], Peter Werner[2], and Hartmut S. Leipner[1] — [1]Interdisziplinäres Zentrum für Materialwissenschaften, Nanotechnikum Weinberg, Martin-Luther-Universität, 06099 Halle — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle

We report on the fabrication of hexagonally ordered, vertically aligned silicon nanopillars (Si NP) and their characterization by means of transmission electron microscopy. Combining colloidal lithography, plasma etching, and catalytic wet etching, Si NP with well defined diameter, length, and density were obtained. The porosity of the Si NP, which seems to be decisive for their thermoelectric properties, was varied by the fabrication procedure. High resolution transmission electron microscopy and electron energy loss spectroscopy have been applied in order to investigate the morphology, the internal structure and the composition of the catalytically etched SiNW. The analysis yielded a single crystalline, porous structure composed of crystalline silicon and SiO_x with $x \leq 2$.

DS 16.37 Tue 9:30 P5

Thermoelectric wires of $Pb_{5+x}Sb_{4-x}S_{11+x/2}$ with micro- and nanodimensions containing various metal ordering — •Gerald Wagner[1], Ronny Kaden[1], Klaus Bente[1], and Hartmut S. Leipner[2] — [1]Institut für Mineralogie, Kristallographie und Materialwissenschaft, Scharnhorststraße 20, Universität Leipzig, 04275 Leipzig — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Nanotechnikum Weinberg, Martin-Luther-Universität Halle, 06099 Halle

The synthesis of p-type boulangerite ($x = 0$) and n-type falkmanite ($x = 0.5$, Pb-rich boulangerite) allows us to produce a novel type of powerful thermoelectic material. Native metal ordering parallel and perpendicular to the wire axis can be used for lowering the thermal conductivity. Moreover, a one-dimensional metal order and $Pb_{5+x}Sb_{4-x}S_{11+x/2}$ superlattices can be realized. We compare the physical properties of micro- and nanodimensional material. The specific influence of metal ordering (order–disorder phenomena) by thermal treatment is investigated. First results on structure investigations by high-resolution electron microscopy and electrical measurements are presented.

DS 16.38 Tue 9:30 P5

Thermoelectric Multilayered Nanowires Grown by Single-Bath Electrodeposition — •William Töllner[1], Johannes Kimling[1], Renbin Yang[2], and Kornelius Nielsch[1] — [1]University of Hamburg, Institute of Applied Physics, Jungiusstrasse 11, 20355 Hamburg — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle

Thermoelectric (TE) modules offer tremendous advantages over conventional cooling and power conversion systems such as scalability and reliability. However, poor efficiency has prevented the commercial breakthrough for TE coolers and generators. Theoretical works pre-

dict a huge increase of ZT, the TE figure of merit, in nanostructured materials. One promising approach to achieve higher ZT values are superlattices and nanowires, both reducing thermal conductivity due to phonon scattering effects while keeping a high electrical conductivity. In this work, we have grown Bi-Sb-Te alloy superlattice nanowires in porous alumina membranes by electrodeposition. Deposition of multilayered wires has been performed out of one electrolyte by modulating the electrochemical potential. The aqueous solution containing bismuth, antimony, and telluride ions has been investigated by voltammetric methods. Alumina membranes with a pore diameter of about 50 nm were fabricated by two-step anodization. The composition of Bi-Sb-Te alloyed nanowires has been investigated using TEM-EDX. Preliminary results for filled membranes will be presented: Xenon-Flash-, 3-Omega-measurements (thermal diffusivity/conductivity) and Seebeck-micro-probe scans.

DS 16.39 Tue 9:30 P5

Thermoelectrically effective mixed crystals in the system PbS - SnS — •Dzianis M. Unuchak[1], Vasiliy A. Ivanov[2], Klaus Bente[1], Reinhard Denecke[3], Igor Konovalov[3], Gert Kloess[1], and Valeriy F. Gremenok[2] — [1]Institut für Mineralogie, Kristallographie und Materialwissenschaft, Universität Leipzig, Scharnhorststraße 20, D-04275 Leipzig, Deutschland — [2]Joint Institute of Solid State and Semiconductor Physics, National Academy of Sciences of Belarus, P. Brovka str. 19, 220072 Minsk, Belarus — [3]Wilhelm-Ostwald-Institut, Universität Leipzig, Linnéstr. 2, D-04103 Leipzig, Deutschland

The ternary semiconductor $PbSnS_2$ (teallite), which shows complete miscibility with SnS is very rarely described in literature. The changing of the thermoelectric coefficient of those mixed crystals by variation of chemical composition is of great interest for thermoelectrical applications. The targets of PbS-SnS alloys were synthesized from stoichiometric mixtures of the elements in a vacuum-sealed quartz ampoule. Thin films were prepared from these starting materials by hot wall evaporation method on chemically cleaned glass and Ge substrates at 70-200 ^{o}C at vacuum pressure of $7{\cdot}10^{-4}$ Pa. X-ray characterization revealed that thin films were polycrystalline. XRD patterns of the thin films showed a minimization of interface misfits by increase of Pb-content. Surface morphology and cross sections of the films were investigated using SEM and TEM including EDX measurements. Absorption coefficient of PbS-SnS thin films ($>10^4$ cm^{-1}) was optically determined. Its fundamental absorption edge is 1.2-1.65 eV. At room temperatures Seebeck coefficients from 0.02 to of 0.4 mV/K were found.

DS 17: Layer Properties: Electrical, Optical and Mechanical Properties I

Time: Wednesday 9:30–11:00 Location: GER 37

DS 17.1 Wed 9:30 GER 37

Physical and electrochemical properties of anodic oxides on combinatorial valve metal libraries. An application of the Scanning Droplet Cell — •Andrei Ionut Mardare[1], Alan Savan[2], Alfred Ludwig[2], Andreas Dirk Wieck[2], and Achim Walter Hassel[1] — [1]Max-Planck-Institut für Eisenforschung, Düsseldorf, Germany — [2]Ruhr-Universität, Bochum, Germany

Usually, the electrochemical properties of valve metal alloys and their anodic oxidation are investigated in a small component concentration range limited by the number of available samples. A combinatorial approach has the advantage of offering a very broad compositional distribution of the alloys using a minimum number of samples. A vapor phase co-deposition technique, (co-sputtering), is successfully used for deposition of thin film binary and ternary composition spreads from various valve metals. The basic properties of the newly created alloys are mapped using SEM and XRD as a function of their composition. An automated version of a scanning droplet cell (SDC), with a tip diameter of 0.2mm, is used for local growth of anodic oxides on the surface of the combinatorial valve metal libraries. Using a step-wise increase of the oxide thickness combined with electrochemical impedance spectroscopy (EIS) allow the in-situ measurement of the oxide capacitance and electrical resistance. These lead further to the calculation of the permittivities and electrical resistivities of the anodic oxides and the computer-controlled SDC allows a mapping of these properties as a function of the parent metal concentrations.

DS 17.2 Wed 9:45 GER 37

Annealing experiments of Sb doped SnO_2 thin films — •Janika Boltz, Dominik Köhl, and Matthias Wuttig — 1.Physikalisches Institut 1A, RWTH Aachen University, Aachen, Germany

Sb-doped SnO_2 films posses a high optical transparency and good electrical conduction, which makes them attractive for TCO applications. In order to deposit suitable films on large area substrates we have explored the properties of Sb-doped SnO_2 thin films that have been prepared by reactive dc magnetron sputtering from a metallic target. Films with reasonable quality can only be produced in a narrow process window. Therefore the films were subsequently annealed at 350 °C in an Ar atmosphere. Samples were optically and electrically characterised employing spectroscopic methods (transmission, reflectance and ellipsometry) and 4-point probe resistivity measurements. In order to investigate the structure and stoichiometry of the sputtered films X-ray diffraction and RBS (Rutherford Backscattering) measurements have been performed. At the transition to highly transparent films the specific resistivity drops to a minimum of $5{\cdot}10^2\Omega{\cdot}$cm and the films transform to crystalline SnO_2. By subsequent annealing the transmission and specific resistivity of Sb-doped SnO_2 films are improved and a wider process window is observed.

DS 17.3 Wed 10:00 GER 37

Influence of substrate temperature and oxygen partial pressure on the electrical properties of Al-doped ZnO grown by reactive pulsed magnetron sputtering — •Steffen Cornelius, Mykola Vinnichenko, Anatoly Rogozin, Natalia Shevchenko, Andreas Kolitsch, and Wolfhard Möller — Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Dresden-Rossendorf e.V., Bautzner Landstraße 128, 01328 Dresden, Deutschland

The study is focused on improvement of the free electron mobility in Al-doped ZnO films grown by reactive pulsed magnetron sputtering. At optimum growth conditions low-absorbing films are obtained with a Hall mobility of 46 cm^{2}V^{-1}s^{-1}, a free electron density of $6.0{\cdot}10^{20}$ cm^{-3}, and an electrical resistivity of $2.26{\cdot}10^{-4}$ Ωcm. The relation between the mobility and free electron density for different growth conditions is discussed in terms of ionized impurity scattering, impurity clustering, and grain boundary limited transport.

DS 17.4 Wed 10:15 GER 37

Deposition, characterization and biological application of ZnO double-layers — •Angela Vlad[1], Sergii Yakunin[1], Erich Kolmhofer[2], Vikotoriia Kolotovska[3], Leila Muresan[4], Alois Sonnleitner[3], Dieter Bäuerle[1], and Johannes Pedarnig[1] — [1]Institute of Applied Physics, Johannes Kepler University, A-4040 Linz, Austria — [2]DICE GmbH & Co KG, Freistädter Straße 400, A-4040 Linz, Austria — [3]Center for Biomedical Nanotechnology, Upper Austrian Research GmbH, A-4020 Linz, Austria — [4]Department of Knowledge-Based Mathematical Systems, Johannes Kepler University, A-4040 Linz, Austria

Double-layers of Lithium doped ZnO (LZO) and Aluminum doped ZnO (AZO) are grown on r-cut sapphire (r-Al_2O_3) crystal substrates by pulsed-laser deposition. The epitaxial double-layers are a - axis lattice oriented to the substrate. The LZO / AZO / r-Al_2O_3 samples have high optical transmission in the visible range and a band-gap energy of E_g = 3.23 eV according to the absorption edge of ZnO. The AZO bottom layers are electrically conductive (resistivity at room temperature $\rho = 10^{-3}$ Ω cm) and LZO top layers are highly resistive ($\rho = 10^5$ Ω cm). Acoustic shear mode resonances in r-Al_2O_3 are excited by employing electric fields to the piezoelectric LZO layer (frequency interval 1.5 - 3 GHz). For biological applications, madine darby canine kidney cells are cultivated on Platinum coated LZO / AZO / r-Al_2O_3 samples. Osmotic pressure applied to the cells increases or reduces the cell volume depending on the osmolarity of the medium.

DS 17.5 Wed 10:30 GER 37

Ultrathin SiO films on Si(111) studied by infrared spectroscopy - Probing the Si/SiO interface — •Markus Klevenz,

Steffen Wetzel, and Annemarie Pucci — Kirchhoff-Institut für Physik der Universität Heidelberg; INF 227; 69120 Heidelberg

The growth of an ultrathin SiO film on clean Si(111) was studied *in situ* by infrared spectroscopy. The film was produced by thermal evaporation from a Knudsen cell with a final average film thickness of 12 Å. A large shift of the SiO main vibrational frequency from about 880 cm^{-1} for very low thicknesses to the bulk value of SiO about 984±6 cm^{-1} for thicknesses larger than 10 Å was observed. Possible reasons for this strong shift will be discussed.

DS 17.6 Wed 10:45 GER 37

Conductivity of nanocrystalline chromium from infrared spectra — •Robert Lovrincic and Annemarie Pucci — Kirchhoff-Institut für Physik der Universität Heidelberg

During the growth of Cr on diamond C(100) a structural phase transition from a disordered phase to the crystalline bulk phase is observed. The nature of the phase transition is clarified by analysing thickness dependent infrared transmittance spectra with a Drude-Smith type dielectric function. In particular, there is an evident memory effect in the electronic collisions below a critical thickness of 2.5 nm and a clear Drude-type behaviour above that thickness. The thickness of that phase transition well agrees with the predicted maximum diameter value for stable fcc Cr nanoclusters. It is hence concluded that a phase transition from fcc nanoclusters to the bulk bcc phase is the origin of the observed spectral behaviour.

Supported by EC Integrated Infrastructure Initiative Hadron Physics, Project RII3-CT-2004-506078 and the Gesellschaft für Schwerionenforschung, Darmstadt.

DS 18: Layer Properties: Electrical, Optical and Mechanical Properties II

Time: Wednesday 11:15–12:30 Location: GER 37

DS 18.1 Wed 11:15 GER 37

Switchable electro-optical properties of chromophore/ polymer/ metal nanocomposites near the percolation threshold — •Christina Pakula[1], Christian Hanisch[1], Vladimir Zaporojtchenko[1], Thomas Strunskus[1], Franz Faupel[1], and Rainer Herges[2] — [1]Materialverbunde, Institut für Materialwissenschaft, CAU Kiel, Kaiserstr. 2, 24143 Kiel — [2]Otto Diels-Institut, CAU Kiel, Otto-Hahn-Platz 3/4, 24118 Kiel

Chromophores are under interest nowadays because of their light induced conformational change leading to e.g. a higher dipole moment. Inside a polymer matrix the isomerization leads to switchable changes in the physical properties. The optical switching of two different azobenzene ethers dissolved in a PMMA matrix in combination with a 2D nanoparticle gold array were studied. These may be used as light switchable sensors. The chromophore/polymer film was prepared by spin-coating. The metal clusters were deposited either by thermal evaporation or sputtering. Different mixing ratios of PMMA and the two azobenzene ethers and their absorption behaviors in the UV/Vis region have been examined. The new azobenzene ether with a branched side chain had a higher absorption at the same conditions and filling factors than the first azobenzene ether. Furthermore there was no separation of polymer and azobenzene ether with the second molecule. Also the time dependencies of the switching behavior exposed to UV and visible light and the influence of the gold clusters on the switching times were examined. Finally the photoswitchable changes in resistance of the 2D-Au nanocomposite films will be discussed.

DS 18.2 Wed 11:30 GER 37

From cross-linked self-assembled monolayers to nanosheet multilayers — •Christoph T. Nottbohm, Andrey Turchanin, Andre Beyer, and Armin Gölzhäuser — Fakultät für Physik, Universität Bielefeld, Postfach 10 01 31, 33501 Bielefeld, Germany

Self-assembled monolayers of biphenylthiol on gold substrates have been cross-linked by electron irradiation resulting in the formation of nanosheets with a thickness of ∼1 nm. They have been released from the original substrate by etching and transferred to new substrates such as oxidized Si-wafers or transmission electron microscopy (TEM) grids. Transfer of multiple nanosheets onto the same substrate allows the preparation of nanosheet multilayers. Annealing at temperatures of up to ∼1200 K in ultrahigh vacuum leads to structural changes in the multilayers. These were systematically studied for different annealing temperatures and thicknesses ranging from ∼1 nm to ∼5 nm with the aid of x-ray photoelectron spectroscopy (XPS), UV/Vis spectroscopy and electrical 4-point measurements.

DS 18.3 Wed 11:45 GER 37

Freestanding nanomembranes with adjustable stiffness from self-assembled monolayers — •Xianghui Zhang, Christoph T. Nottbohm, Andrey Turchanin, Andre Beyer, and Armin Gölzhäuser — Fakultät für Physik, Universität Bielefeld, Postfach 10 01 31, 33501 Bielefeld, Germany

We report on the fabrication and mechanical characterization of novel nanomembranes with a thickness of approximately 1 nm, whose stiffness is adjustable by an annealing treatment. The nanomembranes are prepared from electron cross-linked aromatic self-assembled monolayers (SAMs). Subsequent etching of the supporting substrate and transferring to window-structured substrates provides freestanding nanomembranes. Bulge testing within an atomic force microscope (AFM) is utilized to investigate their mechanical properties. To determine the Young's modulus, the deformation of a nanomembrane is measured after applying a pressure to one side. Pristine membranes display elastic moduli ranging from 8 to 12 GPa, which are adjustable by the electron dose. After a thermal treatment in ultra high vacuum (UHV) they show a higher mechanical stiffness. Annealing gives rise to a systematic increase of the Young's moduli from ∼10 GPa to ∼45 GPa for an annealing temperature of ∼1000 K. Strain relaxation lowers the residual strain from 0.9 % to ∼0.35 % for temperatures of 800 K and above. This indicates that the relevant structural transformation is completed at that temperature.

DS 18.4 Wed 12:00 GER 37

Mechanical stress impact on thin film thermodynamic properties - investigated by hydrogen loading — •Stefan Wagner and Astrid Pundt — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Thermodynamic properties of thin films deviate strongly from those of bulk. The deviations are reported to originate from microstructure and from mechanical stress, while the contribution of both is unknown in particular. Focussing on the mechanical stress impact and applying PdHx and PdyFe1-yHx as model systems, it is shown that mechanical stress strongly changes phase transition pressures. Hydrogen absorption and hydride formation are monitored by in situ four point resistance measurement. For PdHx films the hydride formation pressures shift up to 400 mbar in contrast to 18 mbar for bulk. These shifts relate to the films adhesion to the substrate and can be affected by film detachment. It will be shown that freestanding PdHx films down to 30 nm film thickness behave bulk-like.

DS 18.5 Wed 12:15 GER 37

Mechanical characterization of glancing angle deposited Si Nanostructures — •André Miessler[1], Christian Patzig[1], Bernd Rauschenbach[1], and Bodo Fuhrmann[2] — [1]Leibniz Institute of Surface Modification, Permoserstraße 15, 04318 Leipzig, Germany — [2]Martin-Luther-Universität Halle, Heinrich-Damerow-Straße 4, 06120 Halle, Germany

In physical vapour deposition processes the incoming particle flux strikes perpendicular to the surface, whereas a compact film is deposed on the substrate. However, at the glancing angle deposition (GLAD) process the sample is tilted with respect to the substrate normal, so the particle flux strikes the surface under an highly oblique angle β (typically $\beta > 80°$ with respect to the substrate normal). Self-shadowing of the deposed particles lead to a non-closed and highly porous film, which is compose of needle-like nanostructures, toward the incoming particle flux. By means of substrate rotation, different structures such as pillars, zigzags, screws or spirals can be obtained.

Although in recent years a series of fundamentally findings have been published, mechanical properties remain unknown. Our goal was to determine the mechanical properties (such as hardness, Young's Modulus and spring constants of spiral structures) by employing nanoindenta-

tion with a flat punch to these 3D silicon nanostructures.

DS 19: Invited Gardner

Time: Wednesday 14:45–15:30 Location: GER 37

Invited Talk DS 19.1 Wed 14:45 GER 37

Integrated Inductors using Amorphous Magnetic Materials — •Donald S. Gardner[1], Gerhard Schrom[2], Fabrice Paillet[2], Tanay Karnik[2], and Shekhar Borkar[2] — [1]Intel Research, Santa Clara, CA USA — [2]Circuits Research, Intel Corp., Hillsboro, OR USA

On-chip inductors with magnetic material are integrated into a 90 nm CMOS processes. The inductors use copper metallization and amorphous CoZrTa magnetic material. Increases in inductance of up to 30 times corresponding to an inductance density of up to 1.7 μH/mm^2 were obtained, significantly greater than prior values for on-chip inductors. With such improvements, the effects of eddy currents, skin effect, and proximity effect become clearly visible at higher frequencies. The CoZrTa was chosen for its good combination of high permeability, good high-temperature stability (¿250 °C), high saturation magnetization, low magnetostriction, high resistivity, minimal hysteretic loss, and compatibility with silicon technology. The CoZrTa alloy can operate at frequencies up to 9.8 GHz, but trade-offs exist between frequency, inductance, and quality factor. The inductors with thick copper and thicker magnetic films have resistances as low as 0.04 Ω, and quality factors of up to 8 at frequencies as low as 40 MHz.

DS 20: Amorphous Thin Magnetic Films

Time: Wednesday 15:45–17:30 Location: GER 37

Topical Talk DS 20.1 Wed 15:45 GER 37

Amorphous magnetostrictive thin films for sensor applications — •Eckhard Quandt — Lehrstuhl für Anorganische Funktionsmaterialien, Institut für Materialwissenschaft, Technische Fakultät, Christian-Albrechts-Universität zu Kiel, Kaiserstr. 2, 24143 Kiel

Magnetron sputtered amorphous FeCoBSi thin films are attractive for different sensor applications due to their softmagnetic properties, their high piezomagnetic coefficient and their good high frequency properties.

The presentation describes mainly the dependency of the magnetic properties of FeCoBSi films on strain. Vibration sample magnetometer (VSM), Kerr-effect, magneto-optical indicator film (MOIF) techniques, and high frequency permeameter measurement data obtained with special test jigs are discussed in view of applications as remote interrogated stress sensors or as multiferroic magnetic field sensor.

Funding of this work by DFG, BMBF and ONR (Office of Naval Research, US) is gratefully acknowledged.

Topical Talk DS 20.2 Wed 16:15 GER 37

Thermodynamic stability and crystallization of amorphous thin magnetic films — •Ulrich Herr[1], Andreas Grob[1], Mohammad Mujeebuddin[1], Xiaoxi He[1], Senthilnathan Mohanan[1], Rolf Diebolder[2], and Raimund Hibst[2] — [1]Institut für Mikro- und Nanomaterialien, Universität Ulm, 89081 Ulm — [2]Institut für Laseranwendungen in der Medizin und Meßtechnik, Universität Ulm, 89081 Ulm

The thermodynamic stability of thin films is strongly affected by the presence of surfaces and interfaces. We present results of the stabilization of FeZr films on different substrates. The initially amorphous films undergo a crystallization at a critical thickness, which depends on the thermodynamic driving forces. The crystallization occurs spontaneously at room temperature and can be monitored by changes of the magnetic and mechanical properties of the films. The results demonstrate the importance of the structural mismatch at the film-substrate interface for the stabilization effect. In the second part we report on crystallization of thin amorphous CoFeB films which are of interest for application in TMR devices with MgO tunnel barriers. The annealing treatment necessary for the crystallization may lead to unwanted interdiffusion and degradation of device properties. The intention of our study is to limit the interdiffusion by pulsed heating with nanosecond laser pulses. The progress of the crystallization is monitored by measurements of electrical resistivity, magnetic properties and structural investigation by X-ray diffraction. The effect of CoFeB film thickness and laser intensity on the crystallization process has been investigated.

Topical Talk DS 20.3 Wed 16:45 GER 37

Magnetism in FeZr-based multilayers – stability, coupling, dimensionality — •Andreas Liebig[1], Panagiotis Korelis[2], Gabriella Andersson[2], Hans Lidbaum[3], Klaus Leifer[3], and Björgvin Hjörvarsson[2] — [1]Inst. of Physics, TU Chemnitz, Chemnitz, Germany — [2]Dep. of Physics, Uppsala University, Uppsala, Sweden — [3]Dep. of Engineering Sciences, Uppsala University, Uppsala, Sweden

We present a study on the magnetism of FeZr-based multilayers with either insulating or metallic interlayers, using MOKE and SQUID magnetometry. The structure was determined using X-ray reflectivity as well as HR-TEM and the chemical composition was determined by RBS.

A brief overview over the $Fe_{91}Zr_9/Al_2O_3$ system, where the interplay between dewetting and phase separation leads to the formation of nanocrystallites at the interface, will be given. For $Fe_{90}Zr_{10}/Al_{70}Zr_{30}$ multilayers, however, the formation of a nanocrystalline phase can be excluded from structural and magnetic measurements. Therefore, these can be used as a prototype to study magnetic coupling phenomena in amorphous systems in low dimensions. The interlayer exchange coupling over the $Al_{70}Zr_{30}$ turns out to be negligible, and the ordering temperature scales therefore only with the thickness of the magnetic layers. Above the apparent ordering temperature a phase with exceedingly high magnetic susceptibility is found. Similarities to the hypothetic Aharony-Pytte phase of infinite magnetic susceptibility are discussed, and a conceptual model for the transition is given.

DS 20.4 Wed 17:15 GER 37

Long range order on atomic scale induced at CoFeB/MgO interfaces — •Gerrit Eilers[1], Marvin Walter[1], Kai Ubben[1], Henning Ulrichs[1], Michael Seibt[2], Andy Thomas[3], Günter Reiss[3], and Markus Münzenberg[1] — [1]I. Phys. Inst., Universität Göttingen — [2]IV. Phys. Inst., Universität Göttingen — [3]Physics Department, Bielefeld University

Magnetic tunnel junctions (MTJs) based on amorphous (a-) CoFeB / crystalline (c-)MgO / a- CoFeB trilayers have been of great interest in research just recently. Due to their high tunnel magneto resistance (TMR) they are a promising candidate spin torque MRAM devices. For future writing concepts like current induced magnetic switching MTJs with thin barriers are necessary to provide sufficient high current densities. Therefore, the quality of the interfaces is of great significance and should be optimized on the nano-scale. The a-CoFeB / c- MgO interface has been studied by means of quantitative high resolution transmission electron microscopy (HRTEM) from atomic to micrometer length scales with increasing annealing temperatures. On the micron scale crystallisation is governed by nucleation processes. On the atomic scale a long range order is induced by the MgO interface, explaining the high TMR values >100% even for not fully crystallized CoFeB/ MgO/ CoFeB tunnel junctions. We compared the subnanometer atomic order induced at the interface with a simulated HRTEM data set generated by a multislice method from a two dimensional atomic distribution function.

Research was funded by DFG, SFB 602

DS 21: Organic Thin Films I

Time: Wednesday 9:30–11:00 Location: GER 38

DS 21.1 Wed 9:30 GER 38

In-situ STXM investigations of pentacene-based OFETs during operation — Christian Hub[1], •Martin Burkhardt[2], Marcus Halik[2], George Tzvetkov[1], and Rainer Fink[1] — [1]Department Chemistry and Pharmacy, Universität Erlangen-Nürnberg, Egerlandstraße 3, 91058 Erlangen — [2]Institute of Polymer Materials, Universität Erlangen-Nürnberg, Martensstraße 7, 91058 Erlangen

Thin-film pentacene-based organic field-effect transistors on commercially available silicon nitride membranes produced by high-vacuum deposition are demonstrated. The produced devices show excellent electronic performance. Due to their overall thickness below 150 nm scanning transmission x-ray microspectroscopy (STXM) experiments are possible. Zone-plate based STXM at the PolLux beamline at the Swiss Light Source provides both high chemical sensitivity and a spatial resolution less than 35 nm. Thus a correlation of the local structural and electronic properties of our devices may be established by this microspectroscopic method. Through the subtle design of our experimental setup an in-situ investigation at highest spatial and spectral resolution during OFET operation is possible to observe modifications in the electronic structure. Recorded NEXAFS spectra show a significant local dichroism. Detailed analysis of the NEXAFS spectra revealed different orientations of the pentacene nanocrystals within the film. Unfortunately spectral changes while the OFET is operated can hardly be detected with the current experimental setup. We will discuss these experimental findings in terms of relevant interface properties. This project is funded by the BMBF, contract 05 KS7WE.

DS 21.2 Wed 9:45 GER 38

Potential mapping in the channel of organic thin film transistors. — Peter Bakalov, •Torsten Balster, and Veit Wagner — Jacobs University Bremen, Bremen, Germany

For the analysis of transport properties of organic semiconductors additional information about the potential distribution within the channel of organic thin film transistor (OTFT) would be extremely helpful, which is not easily accessible by integral IV measurement.

For this purpose we have patterned sense fingers in the channel of a transistor in bottom gate geometry by lithographic means on a silicon substrate with 58 nm silicon oxide as insulator. Therefore, the potential within the conducting channel can be directly accessed by high impedance electrometers attached to the sense fingers. As organic semiconductors thiophene oligomers and polymers have been investigated.

The measured current and potential data are evaluated using a combined model of contact resistance and charge carrier density dependent mobility. P3HT devices with and without an additional protection layer of PMMA were analyzed this way. The latter shows superior performance and stability, e.g. the mobility increases almost by a factor of 2, while the threshold voltage shifts by +15 V. The potential data recorded allow to reveal laterally inhomogeneous trapping efficiencies in the device, e.g. resulting in hysteresis.

DS 21.3 Wed 10:00 GER 38

Microscopic Origin of Pentacene OFET improvement by usage of Pd electrodes — •Daniel Käfer[1], Gregor Witte[2], Claudia Bock[3], Ulrich Kunze[3], and Christof Wöll[1] — [1]Physikalische Chemie I, Ruhr-Universität Bochum, 44780 Bochum — [2]AG Molekulare Festkörperphysik, Philipps-Universität Marburg, 35032 Marburg — [3]Lehrstuhl für Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, 44780 Bochum

Due to its high charge carrier mobility pentacene is a promising molecular semiconductor for the fabrication of organic field-effect transistors (OFETs). While gold has been commonly used as electrode material in pentacene-based thin film transistors a strong increase in the charge carrier mobility and decrease in contact resistance and activation energy can be achieved using Pd electrodes instead. On the one hand, the improved device characteristics for Pd electrodes are caused by an advantageous morphology and a different microscopic orientation compared to the growth of pentacene on Au electrodes as revealed by a combination of microscopic (AFM, SEM), spectroscopic (NEXAFS) and diffraction (XRD) techniques. A detailed UPS study, on the other hand, indicates that also different electronic properties like the absence of an interface dipole and a low hole injection barrier cause the superior device performance. The importance of these pentacene film parameters for a resulting OFET will be discussed.

DS 21.4 Wed 10:15 GER 38

Intermolecular bipolaronic nature of electroluminescence in Organic Light Emitting Field Effect Transistor — •Eugenio Lunedei, Paolo Annibale, Fabio Biscarini, and Carlo Taliani — Institute for the Study of Nanostructured Materials ISMN-CNR, Bologna, Italy

Spectrally resolved light emission from an operating α-Sexithienyl (α-T6) thin film Field Effect Transistor (FET) was measured and its electroluminescence properties put in relation to the ns-time resolved fluorescence. Light emission, following charge carrier injection, matches closely the delayed (Δt>5ns) photoluminescence, but not the prompt one and exhibits a non-excitonic character. Injection of electrons in the FET channel takes place via high-electric field induced tunnelling through the drain electrode contact barrier. The spatial sites of radiative recombination inside FET channel are correlated to regions located at interfacial areas between layered domains where inter-molecular bipolarons (π-dimers) are effectively formed. The formation of such stacks of radical cations gives rise to new allowed optical transitions, with a spectroscopic fingerprint markedly different from that of the bulk crystalline states. Radiative emission from π-dimer states appears to be the fundamental mechanism involved in light emission from electro-optical organic devices based on well ordered layered thin films.

DS 21.5 Wed 10:30 GER 38

Contacts for spin injection into organic semiconductors: Energy level alignment and interactions — •Mandy Grobosch, Katrin Dörr, Ramesh B. Gangineni, and Knupfer Martin — IFW Dresden, D-01069 Dresden, Germany

The energy level alignment at interfaces between $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) and two archetype organic semiconductors, copper-phthalocyanine (CuPc) and sexithiophene (6T) has been studied by combined X-ray photoelectron spectroscopy (XPS) and ultraviolet photoelectron spectroscopy (UPS). $La_{0.7}Sr_{0.3}MnO_3$ is a ferromagnetic metal and can be used to inject spin-polarized current into organic semiconductors. Thin films of this material have been grown using pulsed laser deposition. Prior to the deposition of the organic semiconductors the LSMO has been cleaned by either an ex-situ treatment only, or by annealing in an oxygen atmosphere. The former results in surfaces that are covered by a thin contamination layer while the latter yields atomically clean surfaces. All interfaces are characterized by a rather large interface dipole and substantial charge injection barriers. Moreover, at the interfaces between clean $La_{0.7}Sr_{0.3}MnO_3$ and the two organic semiconductors there is a chemical reaction resulting in a partial oxidation of the organic molecules. At such interfaces the energy level alignment considerably depends on the LSMO cleaning procedure prior the deposition, i.e. whether there is still a contamination layer present.

DS 21.6 Wed 10:45 GER 38

Optimisation of the insulator/organic interface for DIP/sapphire OFETs — •Sönke Sachs[1], Matthias Bräuninger[1], Achim Schöll[1], and Eberhard Umbach[1,2] — [1]Universität Würzburg, Experimentelle Physik II, Am Hubland, 97074 Würzburg — [2]Forschungszentrum Karlsruhe, Weberstraße 5, 76021 Karlsruhe

The quality of the insulator/organic interface, where the charge carrier channel is located in organic field-effect transistors (OFETs), decisively determines the performance, particularly the charge carrier mobility of the devices. A high structural order of the organic film, as well as a small number of defects like grain boundaries are desirable. To optimise the insulator/organic interface diindenoperylene (DIP) microcrystallites were grown by organic molecular beam deposition (OMBD) on highly ordered, atomically flat, and clean sapphire single crystals. The properties of the surface and of the deposited organic films were analysed in situ by means of analytical tools such as LEED, XPS, and NEXAFS, as well as by AFM. The parameters for the OMBD deposition as well as for the substrate preparation were systematically optimised in order to increase the crystalline domain sizes in the organic film. After contacting, first measurements of the charge carrier

mobility were performed in order to correlate the device characteristics with the film properties.

DS 22: Organic Thin Films II

Time: Wednesday 11:15–13:00 Location: GER 38

DS 22.1 Wed 11:15 GER 38

Real-time detection of optical changes of diindenoperylene thin films during growth — •Ute Heinemeyer[1], Reinhard Scholz[2], Alexander Gerlach[1], and Frank Schreiber[1] — [1]Institut für Angewandte Physik, Auf der Morgenstelle 10, 72076 Tübingen — [2]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching

Organic semiconductors have attracted increasing interest, mainly due to their potential optoelectronic applications like organic light emitting diodes and organic solar cells. Optimization of device performance requires the understanding of the underlying structure and growth behavior. Therefore, real-time measurements are particularly powerful since they detect possible changes in the functional properties already during growth. Diindenoperylene (DIP) shows a particularly well defined ordering and promising electronic transport properties together with a highly anisotropic dielectric function [1]. Differential reflectance spectroscopy (DRS), a non-invasive optical technique with high sensitivity, is used to follow the film growth of DIP on glass in the spectral range between 1.4 eV and 3.1 eV. The optical spectra show the well known vibronic progression together with an additional transition, which is related to the coupling between the molecules. The real-time growth experiments show how this additional transition arises during growth, indicating that the intermolecular coupling changes with increasing film thickness, whereas the vibronic progression is only slightly changed.

[1] U. Heinemeyer, R. Scholz *et al.*, PRB **78**, 085210 (2008)

DS 22.2 Wed 11:30 GER 38

***In-situ* optical spectroscopy of ultrathin quaterrylene films epitaxially grown on graphite and mica** — •Roman Forker, Christian Golnik, Christian Wagner, Moritz Esslinger, and Torsten Fritz — Institut für Angewandte Photophysik, Technische Universität Dresden, 01062 Dresden, Germany

Profound knowledge of the growth behavior of aromatic molecules on insulating and conducting substrates is highly desired since an alignment of the planar π-electron cores in face-on or edge-on geometry, respectively, will have a direct impact on the performance of devices, such as solar cells or OFETs. Here we report the epitaxial growth of quaterrylene (QT, $C_{40}H_{20}$) deposited on single-crystalline graphite and mica, as examined *in-situ* by a variant of optical absorption spectroscopy, namely differential reflectance spectroscopy (DRS). We found substantial differences in the shape and in the film-thickness-dependent evolution of the spectra that can only be understood in terms of dissimilar growth modes on these substrates. While the optical behavior of QT films on graphite resembles that of QT reported for a face-on heteroepitaxial arrangement on Au(111) [1], the growth of QT films on mica can more likely be described by an edge-on assembly, as also observed on SiO_2 [2]. With the help of low-energy electron diffraction (LEED) measurements we can evidence the occurrence of flat-lying QT molecules on graphite. In turn, we can exclude such a growth mode on mica, due to the fundamentally different optical spectra in that case.

[1] R. Forker *et al.*, Adv. Mater. *in press*, 10.1002/adma.200801112.
[2] R. Hayakawa *et al.*, J. Phys. Chem. C **111** (2007), 18703.

DS 22.3 Wed 11:45 GER 38

Crystalline to semi-crystalline phase transitions in thin *n*-Dotriacontane films on solid surfaces — Edgardo A. Cisternas[1], Tomás Corrales[1], Valeria del Campo[1], •Ulrich G. Volkmann[1], Haskell Taub[2], and Flemming Y. Hansen[3] — [1]Surface Lab, Facultad de Física, Pontificia Universidad Católica de Chile, Chile — [2]Department of Physics and Astronomy, University of Missouri-Columbia, USA — [3]Department of Chemistry, Technical University of Denmark, Denmark.

We present evidence from ellipsometric measurements of crystalline to semi crystalline or rotator transitions on molecularly thin films of the intermediate length alkane *n*-Dotriacontane (n-$C_{32}H_{66}$), grown on Si(100) substrates covered with their native oxide layer. We are able to grow films with three different morphologies: 1) submonolayer coverage with the molecules perpendicular to the surface, 2) multilayered films with high coverage of the first perpendicular layer without bulk and 3) multilayered films with bulk particles. For submonolayer coverage films we found one step in the ellipsometer signal at ∼331 K which can be correlated to a rotator phase transition. For multilayered films we observe additional steps in the ellipsometric signal which are correlated to changes in upper molecular layers and to rotator phases in bulk crystallites, respectively. A theoretical interpretation of the ellipsometric data is presented to explain these steps in the signal as changes in the anisotropy of the polarizability tensor of the alkane molecules.

DS 22.4 Wed 12:00 GER 38

Optical modelling of organic light emitting diodes — •Mauro Furno, Robert Nitsche, Rico Meerheim, Björn Lüssem, and Karl Leo — Institut für Angewandte Photophysik, Technische Universität Dresden, George-Bähr-Straße 1, 01062 Dresden, Germany

The general structure of an organic light emitting diode (OLED) consists of various organic and metallic layers with different functionalities [1]. Since the complexity of the device structures is rapidly increasing, optical models are more and more required for the effective design and optimization of OLEDs. We present in this contribution a numeric optical model suitable for planar OLED structures. The model exploits the well-established equivalence between light emission from electrical dipole transitions and radiation from mutually-incoherent classical electromagnetic antennas, and a transfer matrix description of the OLED coherent multilayered structure [2]. To validate model results, we fabricated and electrically and optically characterized small-molecule p-i-n type OLED [3]. The whole of angularly and spectrally resolved radiometric and photometric intensities, as well as current, power and quantum efficiencies, and CIE coordinates are fitted by calculation results exploiting consistent parameters for devices with different structural features. Due to the excellent overall agreement betweeen measurements and calculations, we generalize the model results and provide design guidelines for optically optimized OLEDs.

[1] K. Walzer et al., Chem. Rev. 107, 1233 (2007)
[2] H. Benisty et al., J.Opt. Soc. Am. A 15, 1192 (1998)
[3] R. Meerheim et al. Appl. Phys. Lett. 93, 043310 (2008)

DS 22.5 Wed 12:15 GER 38

Effects of annealing and UV irradiation on pulsed laser deposited PMMA films — •Britta Lena Fuchs, Andreas Meschede, and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen

Smooth thin films of Poly(methyl methacrylate) (PMMA) are of interest as photoresist or for coating applications. Here pulsed laser deposition (PLD) at a wavelength of 248 nm is used at low laser fluences slightly above the deposition threshold of PMMA (between 80 and 160 mJ cm^{-2}) to prepare completely smooth films free of droplets [1]. The chemical behaviours were measured by infrared spectroscopy (FTIR) and size exclusion chromatography (SEC). By indentation measurements we find that these films are very soft after preparation and possess a universal hardness of only HU=5 N mm^{-2}. But after UV irradiation a strong hardening of the PMMA films occurs due to a higher cross-linking of the polymer. When depositing the PMMA films at higher substrate temperatures, we also observe a hardening of the films (above 200 N mm^{-2}). But additionally a strong dewetting from the substrates occurs. Above 250 °C partial evaporation of the polymer becomes observable and the FTIR specra do not show the characteristic vibration bands any more.

[1] B. Lösekrug, A. Meschede, H.U. Krebs, Appl. Surf. Sci. **254** (2007) 1312

DS 22.6 Wed 12:30 GER 38

Hierarchy of adhesion forces in patterns of photoreactive surface layers — •Quan Shen[1], Nurdogan Gürkan[1], Gregor Hlawacek[1], Christian Teichert[1], Alexandra Lex[2], Gregor Trimmel[2], and Wolfgang Kern[3] — [1]Institute of Physics, University of Leoben, 8700 Leoben, Austria — [2]Institute of Chemistry and

Technology of Organic Materials, Graz University of Technology, 8010 Graz, Austria — [3]Institute of Chemistry of Polymeric Materials, University of Leoben, 8700 Leoben, Austria

In this contribution we focus on the investigation of ultrathin layers of the new photosensitive molecule trimethoxy[4-(thiocyanatomethyl)phenyl] silane. The photosensitive tail group, benzyl thiocyante, undergoes a photoisomerization to the corresponding isothiocyanate upon illumination with UV light. The illuminated regions can now react with amines to give regions with modified surface properties.

By illumination through a contact mask and subsequent modification, photochemically patterned surfaces are achieved [1]. Friction Force Microscopy (FFM) is used to distinguish between the chemically different areas in the pattern. Indeed, a significant friction contrast between up to four different tail groups is observed simultaneously on the same sample [2].

Supported by Austrian Science Fund FWF NFN projects S9702-N08, S9707-N08.

[1] A. Lex, et al., Chem. Mater. 20, 2009-2015 (2008).
[2] G. Hlawacek, et al., arXiv:0810.2625v1 [cond-mat.mtrl-sci].

DS 22.7 Wed 12:45 GER 38

Chemical and electronic properties of the In-on-CuPc contact: a photoemission study — •Teodor Toader[1], Jan Ivanco[1], Alexander Firsov[2], Walter Braun[2], and D.R.T. Zahn[1] — [1]Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]BESSY GmbH, Albert-Einstein-Straße 15, D-12489 Berlin, Germany

The interfacial chemistry and the evolution of electronic structure was studied during the formation of a top indium contact on CuPc in ultra-high vacuum. The In 4d core level revealed two components: the metallic component and a second one shifted towards higher binding energy. In recent studies, such a shifted component was associated with the formation of a reactive In/CuPc interface. The appearance of so-called gap states near the Fermi level would also provide an argument in favor of a reactive interface. However, probing the interface at different photon energies revealed that the origin of the shifted component is located at the surface of In rather than buried at the In/CuPc interface, as one would expect for reactive components. Given also the fact that the other core levels C 1s and N 1s indicated no reaction between In and CuPc, we assume that both the shifted component in the In 4d core level and the gap states are due to final state effects and/or charging related to the formation of metallic nanoclusters instead of a continuous metallic film. The presence of indium nanoclusters on the CuPc surface is corroborated by the secondary electron microscopy (SEM).

DS 23: Organic Thin Films III

Time: Wednesday 14:45–16:15 Location: GER 38

DS 23.1 Wed 14:45 GER 38

Adsorption of bay-substituted perylene bisimide dyes on Ag(111) investigated by PES and NEXAFS — •Markus Scholz[1], Stefan Krause[1], Rüdiger Schmidt[2], Marc Häming[1], Achim Schöll[1], Frank Würthner[2], and Friedrich Reinert[1,3] — [1]Universität Würzburg, Experimentelle Physik II, 97074 Würzburg — [2]Universität Würzburg, Institut für Organische Chemie, 97074 Würzburg — [3]Gemeinschaftslabor für Nanoanalytik, Forschungszentrum Karlsruhe, 76021 Karlsruhe

Perylene tetracarboxylic acid bisimides (PBI) are among the best available n-conducting organic materials. Halogen substituents attached to the perylene bay positions change the molecular structure by introducing a twist angle into the usually planar perylene backbone. This influences the optical properties, the stacking of the molecules, as well as the electronic properties. Moreover, the molecular conformation is also expected to effect the interaction with metal contacts, an aspect of crucial importance for electronic devices. We report on a high resolution photoemission (PES) and x-ray absorption (NEXAFS) study of the electronic structure and the molecular orientation of ultra-thin films of the planer $PBI\text{-}H_4$, and the core twisted $PBI\text{-}Cl_4$ on Ag(111) substrates. In the monolayer regime, substantial changes in the UPS and XPS data with respect to the bulk samples clearly indicate a covalent interaction at the interface. In the valence regime charge transfer induced occupied states are observed at the Fermi-level. This is corroborated by the NEXAFS results, which allow probing a possible change of the molecular conformation due to the interfacial interaction.

DS 23.2 Wed 15:00 GER 38

Correlating bonding distance and interfacial electronic structure: The role of molecular side groups — •Steffen Duhm[1,2], Alexander Gerlach[3], Georg Heimel[1], Benjamin Bröker[1], Takuya Hosokai[3], Tien-Lin Lee[4], Jens Pflaum[5], Satoshi Kera[2], Nobuo Ueno[2], Frank Schreiber[3], and Norbert Koch[1] — [1]Humboldt-Universität zu Berlin, Germany — [2]Chiba University, Japan — [3]Universität Tübingen, Germany — [4]European Synchrotron Radiation Facility, Grenoble, France — [5]Universität und ZAE Würzburg, Germany

The interplay of energy level alignment and bonding distance of conjugated organic adsorbates on metal substrates is not yet fully understood. We studied the interfaces formed between pentacene (PEN) and its oxo-derivatives pentacenequinone (PQ) and pentacenetetrone (PT) on Ag(111) using X-ray standing waves (XSW) and ultraviolet photoelectron spectroscopy (UPS). A strong correlation could be found between the XSW and UPS results: The interaction of PEN and PQ with Ag(111) is rather weak, which is reflected in larger bonding distances and almost identical electronic structures for mono- and multilayer. In contrast, PT is strongly chemisorbed on Ag(111) through a charge transfer reaction leading to a metallic monolayer and a partial filling of the lowest unoccupied molecular orbital. This strong interaction results in a rather low bonding distance of PT on Ag(111) and an additional bending of the oxygen atoms towards the metal substrate.

DS 23.3 Wed 15:15 GER 38

Diindenoperylene on rutile TiO_2 (110) — •Britt-Elfriede Schuster, Maria Benedetta Casu, Heiko Peisert, and Thomas Chassé — Institute for Physical and Theoretical Chemistry, University of Tübingen, Auf der Morgenstelle 8, 72076 Tübingen, Germany

In order to optimize device performance, a comprehensive knowledge of the electronic, structural and morphological properties of organic materials is indispensable. In this regard, a crucial aspect in this field is the growth because the understanding of growth phenomena is extremely significant for many technical applications dealing with systems ranging from thin films to single crystals. Diindenoperylene (DIP) is a perylene-based aromatic hydrocarbon that exhibits besides its good film forming properties a very high hole mobility already in thin films and high thermal stability. In this work we present X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM) measurements taken on thin DIP films (nominal thicknesses: 1-90 Å) on rutile TiO_2(110). Diindenoperylene was deposited onto the well-characterized TiO_2(110) substrate with a (1x1) reconstruction using strictly controlled evaporation conditions (evaporation rate: 3Å/min, substrate temperature 298K). The decrease of the FWHM of the C1s peak with increasing film thickness indicate a different intermolecular interaction in the monolayer regime. By analyzing the attenuation of the substrate XPS signal, we find evidence for a Stranski-Krastanov growth mode (layer plus islands) under these preparation conditions. This observation is corroborated by AFM measurements showing a distinctive island formation.

DS 23.4 Wed 15:30 GER 38

Structure and Lateral Conduction in a monolayer of molecular nanographenes — •Asif Bashir[1], Carsten Busse[1,2], Xi Dou[3], Daniel Käfer[1], Zhihong Wang[1], Gregor Witte[1,4], Klaus Müllen[3], and Christof Wöll[1] — [1]Lehrstuhl für Physikalische Chemie I, Ruhr-Universität Bochum, Germany — [2]Physikalisches Institut, Universität zu Köln, Germany — [3]Max Planck Institute for Polymer Research Mainz, Germany — [4]AG Molekulare Festkörperphysik, Philipps-Universität Marburg, Germany

The molecular nanographenes hexa-peri-hexabenzocoronene (HBC) and HBC-derivatives can self-assemble in form of columnar film structures, which have recently attracted a paramount interest in connection with one-dimensional charge transport. The fabrication of such

columnar system was carried out by using thiolated HBC-derivates, where one-dimensional monomolecular columns are formed by the self organization of HBC molecules modified by thiol (-SH) anchors upon adsorption on Au(111) substrates. The HBC self-assembled monolayer (SAMs) are found to form long range ordered domains consisting of equidistant paired rows with closely stacked HBC units. Data from scanning tunneling microscopy (STM) and near-edge x-ray absorption spectroscopy (NEXAFS) allows to derive a detailed structural model. The charge transport along the columns within the SAM is investigated by embedding the thiolated HBC-derivates into a matrix of alkanethiols (C_{10}-SH). The temperature dependence of apparent height on the HBC-thiol-islands and the electronic coupling between closely packed aromatic molecules exhibited by the lateral transport will be presented.

DS 23.5 Wed 15:45 GER 38

Formation of a Polymer-Metal Interface: Deposition of Ca on Poly(3-hexylthiophene) Films — •Fabian Bebensee[1], Jack Hess Baricuatro[2], Junfa Zhu[3], Wanda Lew[2], Hans-Peter Steinrück[1], J. Michael Gottfried[1], and Charles T. Campbell[2] — [1]Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg — [2]Department of Chemistry, University of Washington — [3]National Synchrotron Radiadion Laboratory, University of Science and Technology of China

The interface between Ca and poly(3-hexylthiophene) (P3HT) belongs to the technologically important class of interfaces between low work function metals and semiconducting polymers, which can be found in many applications in the rapidly developing field of organic electronics. We used various complementary techniques, including ISS and HR-XPS, to study the morphology, the chemical composition, and the electronic structure of this interface. In addition, we applied adsorption microcalorimetry to quantitatively study the energetics of Ca adsorption on the polymer, a measurement that has only recently become technically feasible. We find a strong interaction between Ca and P3HT, as indicated by a high initial heat of adsorption (629 kJ/mol). Furthermore, the appearance of a new peak doublet in the S2p XP spectra indicates that Ca interacts mainly with the sulphur in the polymer. The XPS data also allow for the determination of the penetration depth of Ca into P3HT, which is between 2.7 and 3.7 nm. Support by the DAAD, the NSF, and the Excellence Cluster "Engineering of Advanced Materials" is gratefully acknowledged.

DS 23.6 Wed 16:00 GER 38

Ionic Liquids at the Solid-Liquid Interface - Monolayer Systems Studied Using ARXPS — •Kevin Robert John Lovelock[1], Claudia Kolbeck[1], Till Cremer[1], Florian Maier[1], Natalia Paape[2], Matthias Schmidt[2], Bastian Etzold[2], Peter Wasserscheid[2], and Hans-Peter Steinrück[1] — [1]Lehrstuhl für Physikalische Chemie II, Egerlandstr. 3, 91058 Erlangen — [2]Lehrstuhl für Chemische Reaktionstechnik, Egerlandstr. 3, 91058 Erlangen

Ionic liquids (ILs), molten salts with a melting point below 100 °C, are promising candidates for many applications such as electrochemistry, separation, lubrication and catalysis. Many of the processes for these applications are governed by the solid-liquid interface. Two different approaches have been used to study this interface, both using angle-resolved X-ray photoelectron spectroscopy (ARXPS). Firstly, an IL vapour deposition process has been established capable of producing sub-monolayer coverages. Investigations of specific IL-substrate interactions, surface modification and film growth modes are therefore possible. Results will be presented for a range of surfaces. Secondly, the ex-situ covalent attachment of a functionalised IL to a silicon substrate has been investigated as a model system for microreactors. Such systems can be used for supported ionic liquid phase (SILP) catalysis.

DS 24: Organic Thin Films IV

Time: Wednesday 16:30–17:45 Location: GER 38

DS 24.1 Wed 16:30 GER 38

Structure and morphology of cobalt phthalocyanine (CoPc) organic film on silicon dioxide (SiO_2) — •Monamie Sanyal — Max Planck Institute for Metals Research, Heisenbergstrasse 3, Stuttgart - 70569, Germany

Phthalocyanines (Pc) are of great interest as functional molecular building blocks for organic electronics, partly on account of their enormous versatility and because of their unusually high chemical and thermal stabilities. In order to optimize their functional properties, the detailed knowledge of their film structure is a prerequisite. So far, majority of the investigations have been carried out on metal free phthalocyanine (H_2Pc) and its metal derivative (CuPc). Cobalt phthalocyanine (CoPc) is interesting for applications in optoelectronics and additionally is considered for application as a low dimensional molecular magnet due to magnetic properties of Co ion.

Here we show that CoPc on SiO_2 /Si forms very well ordered multilayer films of standing molecules. By combining x-ray diffraction studies and Atomic Force Microscopy (AFM) we present results on the structure (perpendicular and parallel to the film surface) and morphology.

DS 24.2 Wed 16:45 GER 38

Model calculations on the in-plane optical anisotropy of copper-phthalocyanine films — •Michael Fronk, Dietrich R.T. Zahn, and Georgeta Salvan — Physics Department, Chemnitz University of Technology, D-09107 Chemnitz

Copper-phthalocyanine (CuPc) films prepared by organic molecular beam deposition on H-passivated silicon and Si covered with native oxide were investigated by means of ellipsometry and reflection anisotropy spectroscopy (RAS). In addition to the in-plane − out-of-plane anisotropy found from the evaluation of the ellipsometry data [1] an in-plane anisotropy in the order of 10^{-2} was observed by RAS. In a first step model calculations assuming homogeneous in-plane anisotropy over the whole layer thickness were performed in order to extract the anisotropy in the optical constants n and k. While the spectral shape of the anisotropy in k indicates that each optical transition dipole has a different preferential azimuthal orientation in the CuPc film on H-Si, all transition dipoles appear to be aligned in the same direction for CuPc on Si+SiO_2. For the latter films the in-plane anisotropy was also found to increase with increasing thickness. For a detailed understanding of the azimuthal orientation of the optical transition dipoles the angle resolved RAS data were fitted. More advanced models taking into account a change in the anisotropy with film thickness were built in order to describe the spectral evolution with film thickness.

[1] O.D. Gordan et al., *Organic Electronics* 5, **2004**, 291

DS 24.3 Wed 17:00 GER 38

Characterization of perfluoroalkyl- substituted phthalocyanine films, a new material for organic electronics — •Christopher Keil[1], Martin Lener[1], Steffi Nagel[1], Robert Gerdes[2], Sergiu Gorun[2], and Derck Schlettwein[1] — [1]Justus-Liebig-Universität Gießen, Institut für Angewandte Physik, Heinrich-Buff-Ring 16, D-35392, Gießen. eMail: schlettwein@uni-giessen.de — [2]New Jersey Institute of Technology, Department of Chemistry and Environmental Science, Newark, NJ 07102, USA

Octa(perfluoropropyl) octafluoro phthalocyanine complexes ($F_{64}Pc$) with different central metal groups (Cu, Zn, VO) were investigated as robust organic n-conducting semiconductor materials. Thin films were prepared by physical vapour deposition in high vacuum. The optical absorbance and electronic properties were measured in-situ during film growth in order to reveal the formation of conducting pathways, the mechanism of film growth as well as potential microscopic intermolecular electronic coupling. The molecular energy levels of the materials were studied by potential dependent measurements of the charge transfer to the molecules in solution or in thin films. Possible applications of these new molecules as n-conducting and air stable materials in organic electronic devices like field effect transistors, chemical sensors and organic photovoltaic cells are discussed.

DS 24.4 Wed 17:15 GER 38

The morphology and optical properties of CuPc thin films on passivated Si(111) — •Li Ding[1], Falko Seidel[1], Mario Zerson[2], Cameliu Himcinschi[1], Marion Friedrich[1], and Dietrich R. T. Zahn[1] — [1]Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany — [2]Chemistry Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany

Phthalocyanines (Pcs), chemically and thermally stable p-type organic semiconductors, are of great importance as promising materials for optical and electrical devices [1-2]. They show strong visible and UV absorption, which can be tuned e.g. by different central metal ions. Copper phthalocyanine (CuPc), one of the most intensively studied metal phthalocyanines, is deposited onto H-passivated Si(111) wafers with different offcut angles by organic molecular beam deposition (OMBD) under ultra-high vacuum (UHV) condition. The morphology of Si(111) surfaces passivated in HF of different concentrations is investigated by atomic force microscopy (AFM) before and after CuPc deposition. Variable angle spectroscopic ellipsometry (VASE) and reflectance anisotropy spectroscopy (RAS) are employed to study optical properties of CuPc thin films and their dependence on substrate surface roughness and offcut angles.

Reference

[1] N. B. McKeown, Phthalocyanine Materials, Synthesis, Structure and Function, Cambridge University Press, Cambridge, 1998.

[2] J. Simon, J. J. Andre, Molecular Semiconductors, Springer Verlag, Berlin, 1985

DS 24.5 Wed 17:30 GER 38

Long-range ordered PTCDA layers on epitaxially grown NaCl films on Ag(100) — •Eric Le Moal, Oliver Bauer, Mathias Müller, and Moritz Sokolowski — Institut f. Physikalische u. Theoretische Chemie, Universität Bonn, Wegelerstr. 12, 53115 Bonn

Organic thin films on insulators attract increasing attention for both fundamental properties and promising applications in optoelectronics. Structural or chemical characterization on a long-range scale generally requires measurements by electron diffraction or spectroscopy, which cannot be conducted on insulators due to charge accumulation. This can be avoided by growing the organic films on thin insulating films on metallic substrates. Here we report the ordering of perylene-3,4,9,10-tetracarboxylic acid dianhydride (PTCDA) molecules on thin NaCl films grown on Ag(100), studied by spot-profile-analysis low energy electron diffraction (SPA-LEED). We show that high structural order can be achieved at the metal/insulator and insulator/organic interfaces and that LEED is operable on NaCl films about ten atomic layers in thickness. In agreement with Burke *et al.* [PRL 100, 186104 (2008)], the first monolayer (ML) of PTCDA forms a commensurate $(3\sqrt{2} \times 3\sqrt{2})R45°$ superstructure with a quadratic unit cell (a=16.95 Å) and a T-shape in-plane molecular arrangement. This commensurate structure is metastable and can evolve to bulk-like nanocrystallites upon annealing above 273 K or exceeding 1 ML in coverage. However, growth at low temperature (223 K) yields PTCDA multilayers which are aligned with the first monolayer and exhibit an incommensurate structure. This project is financed by the A. v. Humboldt Foundation.

DS 25: Organic Thin Films V

Time: Wednesday 18:00–19:00 Location: GER 37

DS 25.1 Wed 18:00 GER 37

Controlled Surface Modification by Electrospray Ion Beam Deposition: Coverage, Homogeneity and Soft Landing Energy — •Stephan Rauschenbach[1], Nicha Thontasen[1], Zhitao Deng[1], Ralf Vogelgesang[1], Nikola Malinowski[1,4], Jürgen Gerlach[3], and Klaus Kern[1,2] — [1]Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [2]Institut de Physique des Nanostructures, Ecole Polytechnique Fèdèrale de Lausanne, CH-1015 Lausanne, Switzerland — [3]Leibniz-Institut für Oberflächenmodifizierung e. V., Permoserstr. 15, D-04318 Leipzig, Germany — [4]Central Laboratory of Photographic Processes, Bulgarian Academy of Sciences, 1113 Sofia, Acad. G. Bonchev St., Bl. 109, Bulgaria

The soft landing ion beam deposition (IBD) of Rhodamine dye molecules on solid surfaces in high vacuum is investigated with the goal to fabricate molecular nanostructures from non-volatile molecules for in-situ analysis. Molecular ion beams created by electrospray ionization with controlled composition and energy are deposited on SiO_x surfaces. Fluorescence spectroscopy and time-of-flight secondary-ion-mass-spectrometry (TOF-SIMS) are employed in order to characterize the sample with respect to coverage, homogeneity and soft landing ratio. We find that homogeneous films of material can be produced at energies of 2-75 eV. The coverage is found to be proportional to the ion dose and soft landing is found for energies up to 24 eV.

DS 25.2 Wed 18:15 GER 37

Investigation of the structure of TCNQ molecules on Cu(100) by Helium Atom Scattering — •Katrin Fladischer[1,2], Antonio Politano[1], Daniel Farías[3], and Rodolfo Miranda[1,3] — [1]Instituto Madrileño de Estudios Avanzados en Nanociencia (IMDEA-Nanociencia) Cantoblanco, 28049 Madrid, Spain — [2]Institute of Experimental Physics, Graz University of Technology, Petersgasse 16, 8010 Graz, Austria — [3]Departamento de Física de la Materia Condensada and Instituto de Ciencia de Materiales Nicolás Cabrera, Universidad Autónoma de Madrid, 28049 Madrid, Spain

The relatively young field of organic electronics can be related to the discovery of the conducting charge-transfer salt TTF-TCNQ in 1973. The salt consists of the two organic compounds TTF (Tetrathiafulvalene) and TCNQ (Tetracyanochinodimethan). We have studied the structure formed by TCNQ on Cu(100) by Helium Atom Scattering (HAS), LEED and Temperature Programmed Desorption (TPD). We have found that adsorption at 110 K followed by thermal annealing leads to the appearance of a well-ordered structure, as demonstrated by the presence of pronounced diffraction peaks in the HAS spectra. The corresponding LEED pattern suggests that molecular self-assembly is accompanied by a reconstruction of the Cu(100) substrate. This information was used to determine the lattice parameters of the TCNQ adlayer structure. Three desorption peaks were observed in the TPD spectra, which indicates that TCNQ desorbs in the temperature range between 200-350K. Finally, HAS was used to measure the phonon dispersion curves of TCNQ/Cu(100) at different scattering conditions.

DS 25.3 Wed 18:30 GER 37

Smoothening and efficient void filling in Perfluoropentacene-templated growth of Pentacene — •Alexander Hinderhofer, Stefan Kowarik, Alexander Gerlach, and Frank Schreiber — Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen

Pentacene (PEN) and perfluoropentacene (PFP) have been found to be promising candidates for organic electronic and opto-electronic applications due to their high mobilities[1].

We use *in situ* real-time x-ray reflectivity to monitor crystallinity and roughness evolution during growth of a heterojunction of PEN and PFP. PEN evaporated on PFP leads to efficient gap filling of the rough PFP surface so that the heterojunction is coherently ordered throughout the complete bilayer. The growth of such a coherent crystalline system is facilitated by similar geometry and similar crystalline lattice spacing of the molecules. In addition the growth of PEN on PFP has a smoothening effect, i.e. the top roughness of the PEN film is lower than the roughness of the underlying PFP film and far lower compared with PEN growth on a SiO_2 substrate.

The data analysis of a coherently ordered PFP-PEN bilayer is presented and possible explanations for the anomalous growth behavior are discussed.

[1] A. Hinderhofer, U. Heinemeyer, A. Gerlach, *et al.*, *J. Chem. Phys.* **127**, 194705 (2007).

DS 25.4 Wed 18:45 GER 37

Structured Polymer Brushes by AFM Lithography — •Michael Hirtz[1], Marion K. Brinks[2], Saskia Miele[2], Armido Studer[2], Harald Fuchs[1], and Lifeng Chi[1] — [1]Physikalisches Institut, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Straße 10, 48149 Münster (Germany) and Center for Nanotechnology (CeNTech), Heisenbergstraße 11, 48149 Münster (Germany) — [2]Organisch-Chemisches Institut and NRW Graduate School of Chemistry, Westfälische Wilhelms-Universität, Corrensstraße 40, 48149 Münster (Germany)

Structured polymer brush films (i.e. films covalently linked to the substrate) of different polymers (polystyrene (PS), poly n-butyl acrylate (PNBA) and poly N-isopropylacrylamide (PNIPAM)) with thicknesses from 20 to 30 nm on silicon wafers were obtained by AFM lithography. In comparison to corresponding spin-coated films considerable differ-

ences in concern to AFM lithography were observed. Well-defined line pattern with a constant line width around 100 nm and a periodicity of 200 nm are obtained on polymer brushes, whereas the spin-coated films show extensive line broadening and ablation. The finding indicates less lateral crosslink in the polymer brush film thus allowing the high resolution AFM lithography. In addition, site selective immobilization of dye and bioactive molecules into the structured brushes was demonstrated as well as the possibility of parallel large area writing with cantilever arrays.

[1] M. Hirtz, M. K. Brinks, S. Miele, A. Studer, H. Fuchs, L. F. Chi, Small, in print. (DOI: 10.1002/smll.200801339)

DS 26: Poster II

Time: Wednesday 9:30–12:30 Location: P5

DS 26.1 Wed 9:30 P5

Glancing angle deposition on differently patterned substrates: influence of pattern period — •Christian Patzig[1], Joachim Zajadacz[1], Klaus Zimmer[1], Renate Fechner[1], Bodo Fuhrmann[2], and Bernd Rauschenbach[1] — [1]Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstraße 15, 04318 Leipzig — [2]Interdisziplänéres Zentrum für Materialwissenschaft, Martin-Luther-Universität Halle, Heinrich-Damerow-Straße 4, 06120 Halle

If in a physical vapour deposition process the substrate is tilted with respect to the particle source, the particle flux reaches the substrate under a highly oblique angle to the substrate normal, thus leading to self-shadowing of the particles on the substrate surface on a shadowing length $l = h \cdot tan(90° - \beta)$ (h... seed height, β... deposition angle). As a result, arrays of needle-like structures, slanted towards the particle flux grow, that can be tailored with a suitable substrate rotation. If the deposition is performed on patterned substrates, the template acts as an array of artificial seeds with period s, giving the possibility to grow periodically arranged nanostructures. If $s \leq l$, no inter-seed- growth should occur, resulting in a layer of periodically arranged structures. Here, the growth of Si nanostructures by ion beam sputter glancing angle deposition on bare and patterned substrates will be compared, and the influence of the patterns on the growth of the structures will be discussed. Additionally, a method to overcome the geometrical restriction $s \leq l$, by using a two-step lithography process will be shown. This method allows the growth of isolated structures with arbitrary periods that are independent from the shadowing length l.

DS 26.2 Wed 9:30 P5

Amorphous / nanocrystalline metal-silicide films prepared by surfactant sputtering with low energy ion-beam — •Kun Zhang, Hans Hofsäss, and Hayo Zutz — II. Physikalisches Institut , Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The self-aligned silicide process have been widely applied to very large-scale integrated metal-oxide semiconductor devices due to their important properties such as low resistivity and low contact resistance to Si as well as excellent process compatibility with the standard Si process technology. Nickel-silicide is gradually replacing $TiSi_2$ and $CoSi_2$ (the most commonly used silicides), due to its low temperature of formation and less Si consumption. Platinum-silicide has relatively low Schottky barrier of 0.3 eV to p-type Si and excellent thermal stability. Surfactant sputtering is a novel, versatile sputter technique utilizing the steady state coverage of a substrate surface with up to 10^{16} /cm^2 of foreign or self atoms simultaneously during sputter erosion by combined ion irradiation and atom deposition. These surfactant atoms give rise to a steady state surface coverage of the substrate and strongly modify the substrate sputter yield on atomic to macroscopic length scales. In this study, surfactant sputtering was used to form nickel-silicide and platinum-silicide films. Si(100) substrates were eroded using 5 keV Xe-ions and 10 — 20 keV Ar ions under continuous deposition of platinum and nickel from surfactant targets, which were sputtered simultaneously by the same ion-beam. The surface topography, the composition, and the microstructure of the silicide nanocomposites have been analyzed via RBS, XRD, AFM and TEM.

DS 26.3 Wed 9:30 P5

Spectroscopic ellipsometry on large-area metamaterials — Julia Braun[1], •Bruno Gompf[1], Martin Dressel[1], and Georg Kabiela[2] — [1]1.Physikalisches Institut, Universität Stuttgart — [2]4.Physikalisches Institut, Universität Stuttgart

Metamaterials characterized by a negative refractive index form a promising new class of artificially structured materials with a large number of potential applications. In the near-infrared and visible region, the needed structures exhibit dimensions in the 100 nm range and can only be produced by electron beam lithography up to an area of some tenths of a mm^2.Unfortunately, a comprehensive ellipsometric study of their complex optical properties is not possible on such small areas.Therefore, we fabricated a large area „fishnet“ nano structure showing a periodicity of 300 nm and characterized it by variable angle spectroscopic ellipsometry and reflection Fourier-transform infrared spectroscopy in the frequency range of 4400 to 37000 cm^{-1}. As expected for a square lattice, the measured reflectance spectra are isotropic and resemble the optical behaviour of a thin gold layer with additional resonance features due to the nanostructure. A comparison of the measured reflection spectra with calculated scattering parameters S_{11} gives reasonable agreement. Contrary to this the ellipsometric data show a strong anisotropy, which can be modelled presuming an in-plane anisotropy of the sample within a multisample analysis.

DS 26.4 Wed 9:30 P5

Compositionally and structurally modified $SrTiO_3$ thin films prepared by chemical solution deposition — •Dirk Spitzner[1], Emanuel Gutmann[1], Boris Mahltig[2], Marianne Reibold[1], and Dirk C. Meyer[1] — [1]Institut für Strukturphysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]GMBU e.V., Arbeitsgruppe Funktionelle Schichten, PF 520165, D-01317 Dresden, Germany

For electronic and architectural design of functional electroceramic devices, materials with a perovskite-type of structure play a major role. For high-k dielectric, sensing and thermal switching applications the introduction of Barium into $SrTiO_3$ (STO) allows tuning the electrical properties by tuning the paraelectric-to-ferroelectric transition temperature. For thin film preparation a classic sol-gel route was modified by refluxing as well as solvothermal treatment of the as-synthesized sols. For treated sols the decomposition, phase evolution and transition behaviour differed and from X-ray diffraction (XRD) we observed a supression of foreign phases and a higher degree of compositional homogeneity. In this context also the homologous series of perovskite-related Ruddlesden-Popper (RP) phases promise an engineering of electrical properties by selecting a specific member. Exemplarily we realised the chemical solution deposition of epitaxial thin films of $SrO(SrTiO_3)_n$ RP phases ($n = 1, 2, 3$) on STO substrates [1]. Structural characteristics of the films were analysed by means of XRD and HRTEM. An application as buffer layers exhibiting tuneable dielectric properties is conceivable.

[1] E. Gutmann et al. J. Solid State Chem. **179**, 1864 (2006)

DS 26.5 Wed 9:30 P5

Erzeugung von Kupfer-Polypyrrol-Kompositschichten durch simultanen PVD/PECVD-Prozess — •Christian Walter und Volker Brüser — INP Greifswald e.V. - Germany

Nanokompositschichten aus Metallen und Polymeren haben vielfältige Eigenschaften wie beispielsweise antibakterielle Wirkung, Supraleitfähigkeit, Schutzwirkung gegen atomaren Sauerstoff sowie katalytische Aktivität und sind deshalb von sehr großem technologischen Interesse[1]. Polypyrrol-Metall-Kompositschichten sind dabei besonders interessant, da Polypyrrol durch Dotierungen mit z.B. PF_6 eine Leitfähigkeit von bis zu 1000 Scm^{-1} erreicht und an Luft sehr beständig ist[2]. Solche Polypyrrol-Schichten können mit plasmaunterstützter chemischer Gasphasenabscheidung (PECVD) erzeugt werden[3]. Durch eine Kombination dieses Verfahrens mit einer Magnetron-Sputterquelle wird es möglich, Metalle (hier Kupfer) in die Polymerschicht einzubringen. Auf diese Weise können verschiedenste Komposite erzeugt werden. Das Spektrum reicht hierbei je nach Leistung der Plasmaquellen von im Polymer eingebetteten Kupferpartikeln bis zu einer Größe von 50nm, über Kupfer(I)oxid Nanopartikel (Größe ca. 2nm) bis hin zu an das Polymer gebundenen Kupferatomen. Der Metallanteil variiert dabei von 3-30%. Gezeigt werden sowohl XPS,

XRD, Cyclovoltammetrie und IR-Messungen als auch REM und AFM-Bilder.
[1]A. Malinauskas *et al.*; Nanotechnology **16** (2005) R51*R62
[2]A.B. Kaiser; Reports on Progress in Physics **64** (2001) 1-49
[3]G.J.Cruz *et al.*; Thin solid films **342** (1999) 119-126

DS 26.6 Wed 9:30 P5

Low temperature aligned deposition of carbon nanotubes for nanoscale interconnects and NEMS applications — •Sascha Hermann[1], Sergei Loschek[1], Jens Bonitz[1], Liu Ping[2], and Stefan E. Schulz[1,3] — [1]Chemnitz University of Technology, Center for Microtechnologies, 09126 Chemnitz, Germany — [2]Shanghai Jiao Tong University, Shanghai 200030, PR China — [3]Fraunhofer ENAS for Electronic Nanosystems, 09126 Chemnitz, Germany

The outstanding physical properties of carbon nanotubes (CNTs) propose a variety of new applications but so far the direct integration of CNTs in electronic devices is very challenging as high temperature is necessary for the growth of high quality CNTs. In this work we demonstrate a scalable approach for aligned deposition of SWNT arrays with the AC-dielectrophoresis technique at room temperature. For that purpose, we developed a special experimental setup where removable microfluidic channels are applied to guarantee definite and reproducible deposition parameters. Dispersions with highly purified Arc-SWNTs and dispersing agents like sodium dodecylsulfate (SDS) or sodium deoxycholate (DOC) were prepared and characterized by AFM and UV-Vis spectrometry. Electrode structures with different geometrics were fabricated and deposition of CNTs under variation of dispersion- and AC-field-parameters was performed. SEM studies showed very homogeneous, selective and aligned CNT deposition between the electrodes. I-V measurements verify good and reliable contacts with comparatively low resistances. Furthermore, we show a possible routine for the effective removal of dispersing residuals after deposition.

DS 26.7 Wed 9:30 P5

Micrometer-sized Isolated Patterns of Conductive ZnO derived by Micromoulding — •Ole F. Göbel, Johan E. ten Elshof, and Dave A. H. Blank — Inorganic Materials Science, Mesa+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, the Netherlands

We succeeded in the fabrication of large-area patterns with micrometer-sized, isolated features of a simple oxide by a technically simple patterning method.

By micromoulding a polymeric precursor solution for ZnO with an elastomeric (PDMS) mould, and a subsequent heat treatment, patterned ZnO films could be obtained. The features of the various patterns, including parallel or crossed lines and arrangements of dots, were several micrometers in diameter, and so were the spaces between them. The features were nearly isolated from each other, as the micromoulding process left behind a thin residual layer of ZnO of only about 15 nm thickness. By applying a tempering step, the transparent films could be rendered conductive. The process was applied successfully also to other oxide materials such as Bi2212 or CoFe2O4.

DS 26.8 Wed 9:30 P5

Design and construction of a novel type of magnetron sputtering deposition system for the growth of multi-component thin films with advanced properties — •Michael Austgen, Dominik Köhl, and Matthias Wuttig — I. Institute of Physics (IA), RWTH-Aachen, D-52056 Aachen

A technical realization of a novel type of magnetron sputtering deposition system is presented, which is based on a technique known as "serial co-sputtering". The enormous advantages of this technique for the deposition of multi-component materials will be outlined. The concept of serial co-sputtering is based on the possibility of dynamic material mixing during a sputter process. Therefore the system utilizes two separate sputter cathodes, whereof at least one is a rotatable. The geometry of the system is such that the surface of the primary rotatable cathode can be doped with the material of the secondary cathode independently during the main deposition process. Therefore, serial co-sputtering allows e.g. the deposition of new and tunable binary (or even ternary, if more than one secondary cathode is utilized) compositions, which for technical reasons cannot be fabricated by standard magnetron sputtering sources. Other promising applications are the fabrication of TCOs with variable dopant concentration or sputtering with an increased deposition rate achieved by intentionally implanting adequate recoil centres into the surface of the primary target.

DS 26.9 Wed 9:30 P5

Deposition and physical properties of thin TiO_2 and N-doped TiO_2 films prepared by High Power Impulse Magnetron Sputtering — •Vitezslav Stranak[1], Marion Quaas[1], Hartmut Steffen[2], Robert Bogdanowicz[3], Harm Wulff[1], Zdenek Hubicka[4], and Rainer Hippler[1] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — [3]Gdansk University of Technology, Gdansk, Poland — [4]Institute of Physics, Academy of Science of the Czech Republic, Prague, Czech Republic

The chemical composition, optical, photocatalytic and crystallographic properties of TiO_2 and N-doped TiO_2 thin films prepared by High Power Impulse Magnetron Sputtering are studied. The phase formation on the films -anatase, rutile or amorphous TiO_2 - is adjusted by the pressure ($p \sim 0.75$ - 15 Pa) in the deposition chamber. The different crystallographic phases were determined by grazing incidence X-ray diffractometry (GIXD). XPS measurements revealed nearly stoichiometric TiO_2 composition with a small amount of incorporated N in the films. The photocatalytic activity was determined from decomposition of methylene blue. Optical parameters (n+ik, transmittance T, reflectance R and absorbance A) are measured as function of the photon energy in the UV-Vis range with spectroscopic ellipsometry (SE).

DS 26.10 Wed 9:30 P5

Preparation of dye-sensitised ZnO on textile electrodes by pulsed electrodeposition from nitrate-based aqueous solutions — •Melanie Rudolph[1], Thomas Loewenstein[1], Yvonne Zimmermann[2], Andreas Neudeck[2], and Derck Schlettwein[1] — [1]Justus-Liebig-Universität Gießen, Institut für Angewandte Physik, Heinrich-Buff-Ring 16, 35392, Gießen, Germany. E-mail: schlettwein@uni-giessen.de; Fax: +49 641 9933409; Tel: +49 641 9933400 — [2]Textilforschungsinstitut Thüringen-Vogtland e.V., Zeulenrodaer Straße 42, 07973, Greiz, Germany. E-mail: y.zimmermann@titv-greiz.de; Tel: +49 3661 611382

Metallized textile filaments were coated with ZnO/eosinY hybrid thin films by pulsed electrodeposition from aqueous mixed solutions containing zinc nitrate and eosinY. The applied potential, the pulse length and the time between two pulses were varied systematically to control the conditions of mass flow and to suppress parasitic currents. The current-time behaviour was analysed as a direct monitor of electrodeposition. The films were characterised in their structure and morphology by means of confocal laser microscopy, scanning electron microscopy and X-ray diffraction. Homogeneous and crystalline films with nanoporous structure were obtained. The variation of the pulse parameters allowed to modify the film morphology. Photoelectrochemical measurements revealed that the deposited films worked as photoelectrodes in dye-sensitised solar cells and their technical applicability as part of an energy supply of textile microelectronic systems was discussed.

DS 26.11 Wed 9:30 P5

Deposition of SiO_x thin films by microwave excited plasma jet — •Manuela Janietz and Thomas Arnold — Leibniz-Institut für Oberflächenmodifizierung, Leipzig

Thin silicon suboxide (SiO_x) films are deposited on silicon substrates using an atmospheric-pressure plasma jet that consists of two coaxial tubes. The feeding gases helium and oxygen in the inner capillary and nitrogen with small admixtures of hexamethyldisiloxane (HMDSO) vapor in the outer tube are excited by a pulsed microwave (2.45 GHz) and directed onto the substrate. Typical deposition rates range from $2{\cdot}10^{-5}$ to $1.5{\cdot}10^{-4}$ mm^3/s depending on plasma parameters. Stable and smooth films of several hundred nanometers thickness and refraction indices from 1.40 to 1.43 are grown and characterized using ellipsometry, Fourier transform infrared spectroscopy (FT-IR), X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM). FT-IR spectra show the presence of few Si-CH_3 and Si-H groups besides dominating Si-O-Si absorption bands. XPS confirms the low carbon content in film composition.

DS 26.12 Wed 9:30 P5

Influence of defects on the properties of the conductivity of the LAO/STO interface — •Felix Gunkel, Keisuke Shibuya, Regina Dittmann, and Rainer Waser — Forschungszentrum Jülich, Institut für Festkörperforschung, Elektronische Materialien, 52425 Jülich

The interface between $LaAlO_3$ (LAO) and $SrTiO_3$ (STO) is the most prominent example for the realization of highly conducting interfaces between two insulating oxides (e.g. [1],[2]). At least, two approaches have been made to explain the local accumulation of charge. On the one hand, STO/LAO interfaces possess a polarity discontinuity chasing electrons to move into the interface; on the other hand, oxygen vacancies are known to provide conductivity in STO. We have grown LAO thin films on (001)-STO single crystal substrates by RHEED controlled LASER-MBE. Clear RHEED intensity oscillations as well as thickness oscillations in the XRD-spectra indicate layer-by-layer growth mode and a smooth surface. For a wide range of process conditions, the STO/LAO interface is found to be conducting. The impact of stoichiometry variation in the cation or rather in the oxygen sublattice is addressed by the variation of deposition energy density and oxygen background pressure during growth. We will discuss the influence of point defects as well as extended defects on the electrical properties of the interfaces.

[1] H.Y. Hwang, A. Ohtomo, Nature 427, 423-426, 2004

[2] J. Mannhart, S. Thiel, G. Hammerl, A. Schmehl, C.W. Schneider, Science 313, 1942-1945, 2006

DS 26.13 Wed 9:30 P5

Multilayers as optical elements for X-ray microscopy — •Tobias Liese, Andreas Meschede, and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Soft X-ray imaging with high amplitude contrast in the water window regime (2.3 - 4.4 nm) has become an established technique for *in-vivo* investigation of biological structures e.g. in cytology. For soft X-ray wavelength all materials have a refractive index n close to 1, so that significant refraction cannot be accomplished by conventional lenses. Therefore multilayer interference coatings formed by depositing alternating layers of two materials of differing refractive index are applied as optical elements. Requirements for optimal film reflectance are a high difference in absorption coefficient as well as high quality interfaces. For this purpose, MgO/Ti and ZrO_2/Ti multilayers with double layer periods in the nanometer range were deposited by pulsed laser deposition (PLD) on Si(111) substrates in ultrahigh vacuum. The interface structures were studied by X-ray reflectometry (XRR), transmission electron microscopy (TEM) and *in-situ* stress measurements. In this contribution, the underlying growth processes and their influence on the interface roughnesses are presented.

DS 26.14 Wed 9:30 P5

Towards understanding the structure formation of dc magnetron sputtered TiO_2 thin films — •Azza Amin, Dominik Koel, and Matthias Wuttig — RWTH University, Aachen

TiO_2 thin films are applied in a wide range of applications comprising e.g. anti-bacterial coatings that utilize the excellent photocatalytic properties of the films or optical coatings where the high refractive index enables e.g. the production of highly effective AR layer stacks. The physical properties exploited for the different applications strongly depend on the crystal structure of the films. Crystalline TiO_2 thin films typically exhibit a mixture of the anatase and the rutile phase. The challenge in thin film production, therefore, is to tailor the structure composition with the aim to enhance the specific physical property needed for the targeted application. It is therefore highly desirable to develop a comprehensive understanding of the principle mechanisms that drive the nucleation of the film into the separate crystal structures. However, especially in the case of a magnetron sputter discharge, which is preferentially used in the industries large area coating tools, there is a large set of parameters determining e.g. growth velocity and energetic impact and thereby influencing structure formation. Consequently, the growth of sputtered TiO_2 thin films at the present time is only partially understood. We will present new approaches that are aimed to establish a growth model on an atomistic scale. Special emphasis is put on the investigation of the impact of energetic particles, both during the nucleation and the post-coalescence regime of film growth.

DS 26.15 Wed 9:30 P5

***In-situ* experimental approach to the study of atomic layer deposition with atomic force microscope, X-ray photoelectron and X-ray absorption spectroscopy** — •Massimo Tallarida, Konstantin Karavaev, Krzysztof Kolanek, and Dieter Schmeisser — Brandenburgische Technische Universität, LS Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee, 17, 03046, Cottbus, Germany

We describe our experimental approach to the investigation of atomic layer deposition (ALD). ALD is a powerful deposition technique for growing conformal thin films of composite materials with atomically accurate thickness on large area [1]. Despite the enormous industrial interest growing around ALD, its fundamental properties were not yet properly studied. We developed an ALD reactor for the *in-situ* investigations using XPS, XAS and AFM as experimental techniques. We studied the chemical-physical properties of the growing thin films after each deposition cycle. Here, we illustrate the recent results concerning the ALD of HfO_2 obtained using different Hf-precursors on various substrates [2]. We show how the *in-situ* investigations could deliver an important insight into the fundamental characteristics of ALD and how these information could be used to modify and optimize the deposition parameters.

[1] M. Leskelä, M. Ritala, Thin Solid Films, **409**, 138, 2002; **[2]** M. Tallarida, K. Karavaev, and D. Schmeisser, J. Appl. Phys. **104**, 064116 (2008).

DS 26.16 Wed 9:30 P5

Crystallization kinetics of ternary germanium-antimony-tellurium phase change alloys — •Malte Linn, Michael Klein, and Matthias Wuttig — I. Physikalisches Institut (IA), RWTH Aachen University, Aachen, Germany

Phase change materials, such as $Ge_2Sb_2Te_5$ and other pseudo-binary alloys, are widely used as optical storage media, especially in rewriteable DVDs or Blue Ray Disks. In the upcoming future, phase change RAMs will be competing with today's DRAM-cells and phase change memory cells replacing common Flash devices will enter the market soon. To understand and to control the optical writing and the electrical switching process in optical and electrical storage media, it is crucial to investigate the kinetic parameters, which are characteristic for each phase change alloy and which strongly depend on stoichiometry.

By isothermal annealing with a differential scanning calorimeter (DSC) and ex-situ atomic force microscope (AFM) measurements, nucleation and growth parameters can be determined and conclusions about growth velocity, activation energy and long term stability can be made. To find new and promising phase change alloys for applications, a comparison between well studied $Ge_2Se_2Te_5$ and rather unexplored materials like $Ge_8Sb_2Te_{11}$ is performed to investigate stoichiometric trends.

DS 26.17 Wed 9:30 P5

Gold work function reduction by 2.2 eV with an air-stable molecular donor layer — •Benjamin Bröker[1], Ralf-Peter Blum[1], Johannes Frisch[1], Antje Vollmer[2], Oliver T. Hofmann[3], Ralph Rieger[4], Klaus Müllen[4], Jürgen P. Rabe[1], Egbert Zojer[3], and Norbert Koch[1] — [1]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstrasse 15, D-12389 Berlin, Germany — [2]Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung mbH, D-12489 Berlin, Germany — [3]Institut of Solid State Physics, Graz University of Technology, Petersgasse 16, A-8010 Graz, Austria — [4]Max Planck Institut für Polymerforschung, Ackermannweg 10, D-55128 Mainz, Germany

Ultraviolet photoelectron spectroscopy was used to investigate neutral methyl viologen (1,1'-dimethyl-1H,1'H-[4,4']bipyridinylidene, MV0) deposited on Au(111) surfaces. As a result of molecule-to-metal electron transfer, the work function of Au(111) was decreased from 5.5 eV to 3.3 eV. The energy levels of electron transport layers deposited on top of modified Au surfaces were shifted to higher binding energy compared to layers on pristine Au, and the electron injection barrier was reduced by 0.8 eV for tris(8-hydroxyquinoline)aluminum (Alq3) and by 0.7 eV for C60. The air-stable donor MV0 can thus be used to facilitate electron injection into organic semiconductors even from high work function metals.

This work is financially supported by European Community project "IControl" (EC-STREP-033197).

DS 26.18 Wed 9:30 P5

Surface modification of Silicon-Based Light Emitters for smart Biosensing — •Charaf Cherkouk, Lars Rebohle, Wolfgang Skorupa, and Manfred Helm — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden Rossendorf, POB 510119, D-01314, Germany.

A new concept for measuring the concentration of estrogen in drinking

water by using Si-based integrated light sources for direct fluorescence analysis is presented.

One of the main steps for this sensor concept is the chemical modification of the chip surface. A novel Method to derivatize the surface of a silicon dioxide layer serving as a passivation layer for the sensor with N, N-Bis (3-aminopropyl)-2-butene-1, 4-diamine (APS), and N-(3-(Trimmethoxysilyl)-propyl)-diethyl (Det-APS) has been developed and optimized. This method uses a special chamber and is based on spin coating and spraying in nitrogen atmosphere. The electroluminescence measurements showed that there is no loss of transparency of the silicon dioxide layer due to the surface modification. The structure of the SiO_2 surface, the APS and the Det-APS layers was characterized by Infrared spectroscopy (FTIR) and X- ray photoelectron spectroscopy (XPS). Atomic force microscopy was used to investigate the roughness of the surface. The results give proof of a dense coverage with enough functional groups such as NH_2 for the adsorption of the estrogen receptor.

DS 26.19 Wed 9:30 P5

Titanium Oxynitride films by Unfiltered Arc Deposition — •Andreas M. Zoll and Roger Thull — Lehrstuhl und Abteilung für Funktionswerkstoffe der Medizin und Zahnheilkunde, Universitätsklinikum Würzburg, Pleicherwall 2, D- 97070 Würzburg

The presented titanium onynitride films are deposited using unfiltered arc sputtering technique on polycrystalline titanium and glass surfaces. The substrate temperature varied between 130 and 160 °C.

Starting with titanium oxide films an increasing fraction of oxygen was substituted with Nitrogen. Thereby the total pressure was kept constant for all coating processes.

While the titanium oxide film consisted mainly of anatase with only a small amount of rutile, titanium oxynitride films show an increasing amount of rutile although temperature was kept at the same level. Diffraction peaks orohinating from osbornite could not be detected.

Resistance measurements by means of the four-point probe show a nearly exponential decreasing of the electric resistance in terms of the fraction of Nitrogen.

A reduction of the band gap energy could also be determined by means of photoreflectance and electroreflectance spectroscopy.

DS 26.20 Wed 9:30 P5

Gold Nano-Dot Matrices for Light-Coupling into Wave-Guided Modes of Thin Membranes — •Susanne Perlt, Marisa Mäder, Thomas Höche, and Bernd Rauschenbach — Leibniz Institute of Surface Modification, Permoserstrasse 15, D-04318 Leipzig, Germany

Well-ordered gold dot arrays on membranes possess surface plasmons capable of interacting with optical waveguides underneath [1].

Such matrices can be obtained by Diffraction Mask Projection Laser Ablation (DiMPLA) [2]. A thin metal film is illuminated by a laser pulse (Excimer laser, 248 nm (KrF) and 193 nm (ArF), 25 ns and 10 ns, respectively) with a laterally modulated intensity distribution. The pattern is created by phase-mask projection interference and gets demagnified by passing through a Schwarzschild reflective objective. Parts of the thin film are ablated whereas the remaining material forms dot structures of minimized surface energy within the heat sinks.

The correlation between film thickness, dot size, and laser fluence, respectively, is studied here. Furthermore, the dependency between structure size of the phase mask and parameters of the ablated film (like dot size and distance of the dots) are discussed. This investigation is an important precondition to proceed with further studies of well-ordered gold nanostructures on thin membranes and their utilization to couple light into wave-guided modes of these membranes.

References

1) L. Eurenius et al., Nature Photonics 2 (2008) 360

2) M. Mäder et al., J. Laser Micro/Nanoeng. 3, 9 (2008)

DS 26.21 Wed 9:30 P5

A Silver Containing Liquid Alloy Ion Source — •Paul Mazarov[1], Lothar Bischoff[2], Wolfgang Pilz[2], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum — [2]Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Dresden-Rossendorf, PF 51 01 19, 01314 Dresden

A Silver-Germanium Liquid Alloy Ion Source (LAIS) was developed and is available. Good beam performance was obtained for application in any commercial focused ion beam (FIB) system. Emission current dependent measurements were carried out of the mass spectra and energy spreads of all ion components. The ratios of doubly- and single-charged clusters to single-charged monomer ions were determined.

The AgGe-LMAIS can be very helpful for controlled formation of silver quantum wires.

[1] Thibaut Capron et.al. Phys. Rev. **B77**, 033102 (2008).

DS 26.22 Wed 9:30 P5

Alloy Liquid Metal Ion Sources for new FIB applications — •Lothar Bischoff[1], Wolfgang Pilz[1], Paul Mazarov[2], and Andreas Wieck[2] — [1]Forschungszentrum Dresden-Rossendorf, Institut für Ionenstrahlphysik und Materialforschung,PF 510119,01314 Dresden, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany

Recently, mass separated focused ion beams (FIB) become an increasing interest for local doping in nano-devices for optical, electrical or magnetic applications [1]. So on the basis of very stable metallic glass alloys like AuSi or AuGe with a low melting point at 365°C different ion sources were developed and tested due to their performance in FIB systems. In detail, $Au_{68}Ge_{22}B_5Ni_5$, $Au_{80}Si_{12}Sb_8$, $Au_{68}Ge_{28}Mn_{10}$ alloys were analysed concerning the on-set and emission behaviour and the mass spectra. Among clusters, molecular ions, single and doubly charged species such important ions like boron for p-doping in silicon, antimony for n-doping in silicon or manganese for quantum dot fabrication in II-VI semiconductors (CdSe, CdS, ZnS) could be extracted.

[1] L. Bischoff, NIM B266 (2008) 1846.

DS 26.23 Wed 9:30 P5

Statistical slip step evaluation in CrMn and CrNi cold worked steels by atomic force microscopy — •Nurdogan Gürkan[1], Gregor Hlawacek[1], Christian Teichert[1], Robert Sonnleitner[2], and Gregor Mori[2] — [1]Institute of Physics, University of Leoben, 8700 Leoben, Austria — [2]Christian Doppler Laboratory of Localized Corrosion, 8700 Leoben, Austria

Austenite stainless steels like CrMnN 18-21-0.66 and CrNiMoN 27-30-3-0.3 are sensitive to stress corrosion cracking (SCC). To obtain the required strength this steel type has to be cold worked which will also influence their resistance against SCC. In this investigations solution annealed, 14%, and 27% cold worked samples are used. The samples are dynamically loaded with R=0.5 at 20 Hz. Reference samples are cycled in Glycerin and a corrosive environment is simulated with a 62% $CaCl_2$ solution at 120°. The resulting slip step patterns close to the crack initiation point are statistically evaluated using atomic force microscopy (AFM) in intermittant mode under ambient conditions. Height of the slip steps as well as their distance and distribution are analyzed. The results are compared and demonstrate the importance of slip steps for the corrosive attack.

DS 26.24 Wed 9:30 P5

Pulsed laser interference lithography — •Stephen Riedel, Matthias Hagner, Paul Leiderer, and Johannes Boneberg — Universität Konstanz, Fachbereich Physik, LS Leiderer, 78457 Konstanz

Laser interference lithography with a single ns-pulse is used to structure different substrates in a single illumination step. In constrast to the common cw-laser interference lithography no resists or other preparation steps are needed. For that purpose we use a frequency doubled Nd:YAG laser (FWHM = 13ns, λ=532nm) and intensities between 50-200mJ. We split the beam into several parts and redirect them onto the sample surface. We compare results for metal and semiconductor thin films as well as for bulk surfaces. We find distinct differences between silicon, germanium and bismuth films on the one hand and gold and tantalum films on the other hand. From these results we propose a model for the ongoing processes.

DS 26.25 Wed 9:30 P5

Optical, electrical and structural characterization of novel phase change materials — •Anja Herpers, Michael Woda, and Matthias Wuttig — 1. Physikalisches Institut IA, RWTH Aachen University, Aachen, Germany

Phase Change Materials (PCM) are alloys, which can be used in a variety of applications in information technology. Information is stored using the transformation of small regions of a thin film between the crystalline and amorphous state. This phase change is accompanied by a remarkable change of properties such as the electrical resistivity and the optical reflectivity. Furthermore the transition between both states is extremely fast at elevated temperatures but negligible at room

temperature. This property portfolio is attractive for storage applications. The corresponding materials are already used in rewriteable optical data storage media such as DVD and Blu-Ray-Discs, and are promising candidates for novel non-volatile electronic memory devices such as Phase Change Random Access Memories.

In this study the structural, optical and electrical properties of two materials, i.e. $Ag_4In_3Sb_{67}Te_{26}$ and GeSe are investigated. X-Ray diffraction and X-Ray reflection measurements reveal changes in the crystal structure and the film density upon crystallization. DSC measurements provide the crystallization temperature. The optical properties in an energy range of 0.025-5.3 eV are determined combining ellipsometry and FTIR experiments. Sheet resistance measurements in the van-der-Pauw-geometry enable the measurement of the electrical properties between 300 and 600 K.

DS 26.26 Wed 9:30 P5

Electronic properties of phase change materials — •Karl Simon Siegert, Carl Schlockermann, Hanno Volker, and Anja Herpers — 1^{st} Institute of Physics 1A, RWTH Aachen University, Aachen, Germany

Phase change materials such as $Ge_2Sb_2Te_5$ or GeTe offer unique physical properties that make them interesting for several technical applications. These materials show significant changes in optical and electrical properties upon an atomic rearrangement such as crystallization. The technological use of $Ge_2Sb_2Te_5$ in DVD-RAMs, for instance, is already well established. It is due to the profound optical contrast between the amorphous and the crystalline cubic phase as well as the fast crystallization kinetics. Because of their electronic properties, e.g. a high resistivity contrast between the different states, phase change materials are promising candidates for a new non volatile computer memory. Although some companies have already presented prototypes of new memory chips using this technology, the electronic properties of this class of materials are not well understood and are still subject of intensive research. Our work focuses on electronic properties of phase change materials. We have analyzed thin films of phase change material deposited by sputtering. The determination of the electrical resistance of the films and its dependence on several different parameters such as the temperature and thickness of the film was the object of our investigation. To determine the relevant properties, the van-der-Pauw method to obtain geometry-independent sheet resistance data was employed together with XRR measurements for film thickness determination.

DS 26.27 Wed 9:30 P5

Condensation of silicon monoxide studied by infrared spectroscopy — •Steffen Wetzel, Markus Klevenz, Elin Granas, and Annemarie Pucci — Kirchhoff-Institut für Physik der Universität Heidelberg, INF 227, 69120 Heidelberg

Silicon oxides are materials of big interest from microelectronics to astronomy; their dielectric properties determine emission spectra of stellar objects and the use as insulators in semiconductor industry. The condensation and annealing processes of silicon monoxide (SiO) under ultra-high vacuum (UHV) conditions have been studied in situ by infrared (IR) spectroscopy. The optical properties obtained from transmission and reflectance measurements will be presented and compared to the latest literature data. Upon annealing a temperature and time dependent shift of the main vibrational frequency was observed which will be discussed in detail.

DS 26.28 Wed 9:30 P5

Conductivity of ion tracks in doped tetrahedral amorphous carbon. — •Hans-Gregor Gehrke[1], Anne-Katrin Nix[1], Johann Krauser[2], Christina Trautmann[3], Alois Weidinger[4], and Hans Hofsäss[1] — [1]Georg-August Universität, Göttingen, Deutschland — [2]Hochschule Harz, Wernigerode, Deutschland — [3]Gesellschaft für Schwerionenforschung, Darmstadt, Deutschland — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Deutschland

Conductive ion tracks in tetrahedral amorphous carbon (ta-C) are created by swift heavy ion irradiation. The aspect ratio of the nanosized filaments with a diameter of about 8 nm depends on film thickness. Our group has studied the electrical conduction behavior in the past. The dominant transport mechanism of the ion tracks at low temperatures is variable range hopping. The conductivity of the ion tracks can be altered by doping the ta-C matrix with impurities. These new defects increase the number of hopping sides.

In this work we analyzed the conductance of ion tracks in doped ta-C. The films were prepared with Mass selected ion beam deposition (MSIBD), co-depositing carbon and the desired dopend, such as copper. The dopent concentration is kept below 2 at% ensuring the high sp^3 bond content of the ta-C matrix. The tracks were analyzed individually by atomic force microscopy (AFM) applying a conductive cantilever and by macroscopic measurements using metal pads to contact ensembles of tracks simultaneously. The macroscopic measurements were conducted between $20-300$ K. First results comparing the conduction behavior of different impurities are presented.

DS 26.29 Wed 9:30 P5

Time dependency of electric transport in epitaxial PCMO thin films — •Björn-Uwe Meyer, Peter Moschkau, Malte Scherff, Jörg Hoffmann, and Christian Jooss — Georg-August-Universität Göttingen, Göttingen, Germany

The great diversity of electrical properties in perovskite manganites vary from insulating to metallic behaviour. Depending on doping, temperature, magnetic- and electric field the insulating manganite $Pr_{1-x}Ca_xMnO_3$ (PCMO) shows colossal resistance effects like CMR and CER. Furthermore PCMO reveals the electric pulse induced resistance (EPIR) change effect at room temperature. These pronounced resistance changes are acompanied by structural transitions i.e. polaronic order-disorder transitions. The relevant timescales of these changes are observable by the transient behaviour of the electrical conductivity and range from 20ns to several minutes, whereas long timescales are typical for low temperature switching. By means of pulsed voltage biases we investigated the time dependence of conductivity at different temperatures and applied external magnetic fields. The patterned PCMO thin films were prepared on MgO and STO substrates by ion beam sputtering and pulsed laser deposition. In addition, the samples were characterized by X-ray diffraction and, with respect to electronic phase seperation, by TEM.

DS 26.30 Wed 9:30 P5

Seebeck and Hall measurements on p- and n-TCOs — •Wilma Dewald[1], Christina Polenzky[1], Volker Sittinger[1], and Stefan Götzendörfer[2] — [1]Fraunhofer IST, Bienroder Weg 54E, 38108 Braunschweig, Germany — [2]Fraunhofer ISC, Neunerplatz 2, 97082 Würzburg, Germany

For development in the field of transparent electronics, it is necessary to synthesize transparent n- and p-conducting materials. Possible applications are transparent diodes or transparent solar cells in the future.

To characterize the thin films, we started to build up a four-coefficent-setup after Young et al. for determining the conductivity, mobility, effective mass and carrier density in semiconductors by measuring conductivity, Hall, Seebeck, and Nernst-Ettinghausen effect. Furthermore, it is possible to determine the major conducting species of the thin films for classification in p- and n-TCO.

With this poster, we present our current four-coefficent-setup including temperature-dependent Seebeck and Hall measurements on p-conducting delafossites and n-conducting ZnO:Al that were synthesized by different deposition methods like sol-gel and magnetron sputtering. The measurements show dependencies of the Hall and Seebeck coefficients on process parameters and doping.

DS 26.31 Wed 9:30 P5

Transport properties and electronic structure of Al-doped ZnO/Ag/Al-doped ZnO multilayer systems — •Martin Philipp[1,2], Christian Hess[1], Hartmut Vinzelberg[1], Martin Knupfer[1], Bernd Büchner[1], Hadia Gérardin[2], and Jacques Jupille[3] — [1]Leibnitz-Institute for Solid State and Materials Research IFW Dresden, 01171 Dresden, Germany — [2]Saint-Gobain Recherche, F-93303 Aubervilliers Cedex, France — [3]Institut des NanoSciences de Paris, Université Pierre et Marie Curie - Paris 6, France

Al-doped ZnO/Ag/Al-doped ZnO layer stacks are widely used as low-emissivity coatings for building glazing due to their high reflectance in the infrared and high transmittance in the visible spectrum. For a fundamental understanding of their physical properties, the layer stacks, which were produced by magnetron sputtering, have been investigated regarding the transport properties and the electronic structure of the silver layer. As the conductivity of the film is proportional to the reflectance in the infrared, a higher conductivity also means an improvement of the low-emissivity properties. In order to investigate the electronic structure of the multilayer stack and to observe changes in the structure by changing the interface properties, electron energy-loss spectroscopy (EELS) was performed in the low energy region (0 - 14eV). Furthermore, crystallographic characteristics of the system

were determined by measuring the angular dependent elastically scattered electron pattern.

DS 26.32 Wed 9:30 P5

Charge transient spectroscopy measurements of Metal-Oxide-Semiconductor structures — Markus Arnold[1], •Axel Fechner[1], Joachim Bollmann[2], Bernd Schmidt[3], Heidemarie Schmidt[3], and Dietrich R.T. Zahn[1] — [1]Chemnitz University of Technology, Semiconductor Physics, 09107 Chemnitz, Germany — [2]Freiberg University of Mining and Technology, Institute of Electronic und Sensor Materials, 09596 Freiberg, Germany — [3]Research Center Rossendorf, Institute of Ion Beam Physics and Materials Research, 01314 Dresden, Germany

Charge transient spectroscopy (QTS) is an electrical measurement method related to deep-level transient spectroscopy (DLTS) developed originally by Lang [1]. Using QTS it is possible to measure fast charge reloading processes even in the absence of depletion regions as a function of time and temperature with different pulse voltages and pulse widths. As a result, one can determine the number and the energetic position of the traps.

Here, we will present QTS measurements on Metal-Oxide-Semiconductors structures $Al/SiO_2/Si$ Metal-Oxide-Semiconductor structures and the influence of manganese implantation into p- and n-doped silicon. The results will be compared to C-V and DLTS measurements on the same samples.

[1] D. V. Lang; Deep-level transient spectroscopy: A new method to characterize traps in semiconductors; J. Appl. Phys. 45, 3023 (1974).

DS 26.33 Wed 9:30 P5

VUV Ellipsometry of $BiFeO_3$ thin films grown by pulsed-laser deposition — •Cameliu Himcinschi[1], Ionela Vrejoiu[2], Li Ding[1], Marion Friedrich[1], Cristoph Cobet[3], Norbert Esser[3], Marin Alexe[2], and Dietrich R.T. Zahn[1] — [1]Chemnitz University of Technology, Semiconductor Physics, D-09107 Chemnitz, Germany — [2]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle, Germany — [3]Institute for Analytical Sciences, Department Berlin, D-12489 Berlin, Germany

The interest in ferroelectric and magnetoelectric multiferroic epitaxial films arises from their interesting properties and is stimulated by the potential applications in non-volatile ferroelectric memories or novel multiple state memories and devices based on magnetoelectric effects. Epitaxial thin films of bismuth ferrite, $BiFeO_3$, were deposited by pulsed laser deposition (PLD) on Nb-doped $SrTiO_3$ (100) and $DyScO_3$ (110) substrates, at Tg=650°C and 0.14 mbar O_2. Ellipsometry is a non-destructive and very sensitive surface and thin film measurement technique which can determine film thickness, surface roughness and dielectric properties of such materials with a very high precision. These materials absorb in the UV close to the end of the energy domain available in commercial ellipsometers, while the VUV range is hardly explored at all. By means of the BESSY ellipsometer, the complex dielectric constant of $BiFeO_3$ films is determined up to 9.8 eV. The optical gap of $BiFeO_3$ was determined to be 2.77 eV from a linear extrapolation of the $(\alpha E)^2$ to zero in the plot: $(\alpha E)^2$ vs. energy.[1]

[1] A. Kumar et. al, Appl. Phys. Lett. 92, 121915 (2008)

DS 26.34 Wed 9:30 P5

Determining the thermal conductivity of thin film single- and multilayers via the 3ω-method — •Erik Mehner[1], Sebastian Winkler[1], Stefan Braun[2], and Dirk C. Meyer[1] — [1]Nachwuchsgruppe Nanostrukturphysik, Institut für Strukturphysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Fraunhofer Institut für Werkstoff- und Strahltechnik, Röntgen- EUV-Optik Dresden, Germany

Since thin thermal barrier coatings are important for applications such as microelectronics, gas turbine engines or solar-cells, nanometer-multilayer structures consisting of metals and oxides, promising extremely low thermal conductivity are of interest. A large total thermal resistance can be reached by thermal boundary resistance combined with high interface density. [1]

Thermal conductivity measurements on thin films are complex and error-prone. The 3ω-method [2], an ac-technique, shifting the measurement into the frequency domain, provides a useful method for measuring the thermal conductivity.

The nanolaminates were made of W, Al, Zr and their oxides and deposited on different substrates employing ion beam sputtering.

[1] R. M. Costescu, David G. Cahill, F. H. Fabreguette, Z. A. Sechrist, and S. M. George. Science, 303(5660), 989-990, (2004)

[2] David G. Cahill. Rev. Sci. Instrum., 61(2), 802-808, (1989)

DS 26.35 Wed 9:30 P5

Tranport properties of ultrathin AlO_x interfaces — •Miroslava Dieskova[1], Peter Bokes[1], and Andrea Ferretti[2] — [1]Physics Department FEI STU, Bratislava, Slovak Republic — [2]INFM-S3 and Physics Department,University of Modena and Reggio Emilia, Modena, Italy

We study transport properties of the ultrathin AlO_x interfaces between aluminum electrodes. We employ combination of the Landauer formulation of the electronic transport within the framework of the maximally localized Wannier functions, implemented in the computational package WanT [1][2]. Furthermore, the knowledge of Wannier functions allows direct connection between electronic transport properties and the nature of chemical bonds. We characterise two different geometrical and chemical arrangements of the oxide interface with different local electronic structure and hence with different transmission spectra. Our results indicate how transport measurements can complement experimental structural studies of these technologically important interfaces.

The work has been performed under the Project HPC-EUROPA++ (RII3-CT-2003-506079) with the support of the European Community - Reaserch Infrastructure Action under the FP6 "Structuring the European Research Area" Programme.

[1] www.wannier-transport.org

[2] A. Calzolari, N. Marzari, I. Souza, and M. Buongiorno Nardelli, Phys. Rev. B , **69**, 035108, (2004).

DS 26.36 Wed 9:30 P5

Hydrogenated diamond-like carbon films deposited on UHMW-PE — Annett Dorner-Reisel[1], Guido Reisel[2], Gert Irmer[3], and •Christian Röder[3] — [1]Förderung der Materialentwicklung und Technologie Chemnitz e.V., Germany — [2]Sulzer Metco WOKA GmbH, Barchfeld, Germany — [3]Institut für Theoretische Physik, TU Bergakademie Freiberg, Germany

The wear resistance of ultrahigh-molecular weight polyethylene (UHMW-PE) can be increased by an optimized hydrogenated amorphous diamond-like carbon coating (DLC, a-C:H). Possible applications are inlays in endoprosthetics (artificial finger, knee or hip joints, etc.). The deposition of the hydrogenated DLC coatings with thicknesses between 1 μm and 3 μm was carried out by plasma enhanced chemical vapour deposition (r.f.-PECVD). In order to verify the cohesive and adhesive adherence of the DLC films, several tribological tests were performed (scratch test, pin-on-disk-test, simulated knee prostheses wear test, etc.). The microstructure of the coatings was analysed with scanning electron microscopy, atomic force microscopy and Raman spectroscopy.

DS 26.37 Wed 9:30 P5

Transport mechanisms in magnetron sputtered transparent conducting oxide thin films: Correlating electrical properties with deposition conditions and film structure — •Michael Wassen, Dominik Köhl, and Matthias Wuttig — 1. Institute of Physics (IA), RWTH Aachen University, Germany

For industrial applications, such as the fabrication of highly efficient thin film solar cells, one of the key points is to develop transparent conducting electrodes with exceptional optical and electrical properties. Typically ITO or ZnO:Al thin films are employed for this purpose.

The influence of deposition conditions on the structure of these films has already been comprehensively investigated. An equally detailed understanding of the influence on the electrical transport properties has not been achieved as yet. Hence, the major aim of our investigation is to enhance this knowledge by developing a thorough understanding of the electrical transport properties as a function of film structure and process conditions. This goal is achieved by combining optical and electrical measurements in a wide temperature range (4K to RT) in addition with investigations of the film structure. Advanced dispersion models are utilized to describe the optical spectra in a range of 400 to 50.000 cm^{-1}. Electrical parameters are extracted from the model parameters as well as Hall, Seebeck and van-der-Pauw measurements. These approaches lead to a comprehensive understanding of the transport mechanisms. First results are shown for ZnO:Al and ITO thin films deposited by reactive magnetron sputtering using both metallic as well as ceramic targets.

DS 26.38 Wed 9:30 P5

New microfocus source for X-ray diffractometry of thin films and nano-sized materials — •Jörg Wiesmann, Steffen Kroth, Bernd Hasse, and Carsten Michaelsen — Incoatec GmbH, Max-Planck-Strasse 2, 21502 Geesthacht

The increasing importance of X-ray diffractometry with 2-dimensional detectors for materials research has lead to a rising demand for highly intense X-ray sources enabling the analysis of small, weakly scattering samples in the home-lab. Therefore, various microfocusing sealed tube X-ray sources with focal spot sizes below 100μm are available. We present the new high-brilliance microfocus source IμS. The source incorporates a combination of an extremely bright stationary air-cooled 30 W microfocus source and the newest type of 2-dim beam shaping multilayer optics, the so called Quazar optics. Measurements of thin films and nanosized materials demonstrate the possibilities of new microfocus solutions for XRD. The comparison of IμS with typical sealed tube systems shows data of outstanding quality. Especially for measurements of powders in transmission geometry the IμS delivers very promising results. For small angle scattering a factor of 5 in comparison to a typical sealed tube instrument was observed when using an IμS with optics for a parallel beam.

DS 26.39 Wed 9:30 P5

GIXRD and XRD studies on epitaxial magnetite ultra thin films on MgO(001) — •Florian Bertram[1], Oliver Hoefert[1], Martin Suendorf[1], Bernd Zimmermann[1], Carsten Deiter[2], Daniel Bruns[1], Timo Kuschel[1], Lars Boewer[3], Christian Sternemann[3], Michael Paulus[3], and Joachim Wollschlaeger[1] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, D-49069 Osnabrück, Germany — [2]HASYLAB at DESY, Notkestr. 85, D-22607 Hamburg, Germany — [3]DELTA, Universität Dortmund, Maria-Goeppert-Mayer-Str. 2, D-44227 Dortmund, Germany

In recent years there is an increase in interest for ultra thin magnetic films. Magnetite films are promising candidates for room temperature spintronic devices, because magnetite is a semi-metallic material with full spin polarization on the Fermi level E_F. For such applications it is necessary to produce films of high crystal quality. MgO(001) is a good candidate as a substrate, due to the small lattice mismatch (0.31%). The samples were grown under UHV conditions and have been pre-characterized in situ by LEED and XPS.

Here we present the structure analysis of magnetite films on MgO(001) by kinematic diffraction theory to characterize the tetragonal distortion and relaxations of the magnetite films.

The GIXRD measurements were performed at HASYLAB/DESY at beamline BW 2 and at DELTA at beamline BL 9. The XRD measurements were carried out at HASYLAB/DESY at beamline W 1.

DS 26.40 Wed 9:30 P5

A Computer Program for the Analysis of High Resolution Rutherford Backscattering Spectra — •Christian Borschel[1], Martin Schnell[2], Carsten Ronning[1], and Hans Hofsäss[2] — [1]Institute for Solid State Physics, University of Jena, Max-Wien-Platz 1, 07743 Jena — [2]II. Institute of Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

A variety of ion beam analysis software for simulation and fitting of Rutherford backscattering spectra (RBS) is available, however, there are different reasons motivating us to develop a new simulation and fitting program for high resolution RBS spectra recorded with an electrostatic analyzer (ESA). We use an ESA for high resolution RBS analysis of thin films and their interfaces, providing a depth resolution down to 1 nm. ESA spectra exhibit various differences compared to conventional RBS spectra, necessitating special care in the data analysis, in particular the energy resolution ΔE scales with the energy E. The analysis of concentration gradients in thin films on the nanometer scale is an interesting application of high resolution RBS. A diffusion-like Monte Carlo fit algorithm suitable to find complex concentration gradients was developed.

We present our program and demonstrate its functionality on metal-carbon multilayer thin films prepared by mass selected ion beam deposition and on the analysis of concentration gradients in Gd/Ni bilayers.

DS 26.41 Wed 9:30 P5

Phase-contrast imaging in soft x-ray scanning transmission microspectroscopy — •Stephan Wenzel[1], Jörg Raabe[2], George Tzvetkov[1], Andreas Späth[1], and Rainer H. Fink[1] — [1]Physikal. Chemie 2, Universität Erlangen, Egerlandstr.3, 91058 Erlangen — [2]Paul Scherrer Institut, SLS, Villigen, Switzerland

Scanning transmission soft x-ray microspectroscopy (STXM) has proven excellent spatial resolution (down to 20 nm) in combination with spectroscopic information to investigate ultrathin samples. The superior information relies on photon-energy specific absorption which offers high contrast in the obtained images. However, in some cases - often in soft condensed materials (e.g. mixtures of polymers) - local absorption does not exhibit sufficient contrast. It has been demonstrated in hard x-ray microscopy that phase contrast imaging enhances egdes although absorption may be small and negligible. In the soft x-ray regime, phase contrast usually plays a minor role, however, in distinct cases it may give additional information to improve image contrast. In the present PolLux-STXM (installed at the Paul Scherrer Institut, Villigen, Switzerland), we have implemented a 2D detection system (fast read-out CCD), which monitors the angular differences of the transmitted x-rays for each sample spot. Thus, vertical and horizontal phase contrast images can be generated. We will show first examples from various samples to demonstrate the advantages in phase contrast imaging in STXM. The work is funded by the BMBF under contract 05 KS1WE7.

DS 26.42 Wed 9:30 P5

Electron Spectroscopy for Chemical Analysis of Copper Oxide thin films — •Andreas Laufer, Thomas Leichtweiss, Swen Graubner, Daniel Reppin, and Bruno K. Meyer — I. Physikalisches Institut, Justus-Liebig-Institut Giessen, Germany

The copper oxide thin films (Cu_2O and CuO) have been prepared by radio frequency sputter deposition using a sintered ceramic Cu_2O target and a metallic Cu target with oxygen as reactive gas, respectively. Electron spectroscopy for chemical analysis (ESCA) of the sputtered Cu_2O and CuO thin films was performed. In contrast to Cu_2O the (Cu) $2p$ photolines of CuO show satellite structures. The satellite lines are emitted with kinetic energies lowered by about 9 eV compared to the (Cu) $2p$ photolines. Furthermore we investigated and compared the valence band regions of the Cu_2O and CuO thin films. The quantification of the copper oxide thin films using the atomic sensitivity factors (ASF) has been done.

DS 26.43 Wed 9:30 P5

Deposition of magnesium films using an anodic arc plasma source — •Oleksiy Filipov and Volker Buck — Thin Film Technology Group, Dept. of Physics, University of Duisburg-Essen, Lotharstrasse 1, 47057, Duisburg, Germany

Mg films were obtained by anodic vacuum arc technique in UHV chamber with and without hydrogen atmosphere. The films were deposited on steel substrates in order to investigate their structural properties. The variation of process parameters such as substrate bias (from 0V to 200V) and hydrogen admixture (from 0 sccm to 1000 sccm) is used to influence the film properties. The plasma parameters (electron and ion energies) were monitored during deposition by Langmuir probe, retarding field energy analyser and mass-spectrometer. The surface morphology and the grain size of the deposited films were analysed using scanning electron microscopy (SEM). The structural properties of the films were ex-situ investigated by X-ray diffraction method (XRD) and Energy dispersive X-ray spectroscopy (EDX). It is shown that the grain size in the deposited films can be varied down to 1.8 nanometers just by variation of the deposition parameters.

DS 26.44 Wed 9:30 P5

XPS and UPS investigations of Cs_2Te photo cathodes — •Mike Sperling[1], Ruslan Ovsyannikov[1], Nadja Kath[1], Sara Canzio[1], Hermann Duerr[1], Antje Vollmer[1], Sven Lederer[2], Siegfried Schreiber[2], Frank Stephan[2], Paolo Michelato[3], Laura Monaco[3], Carlo Pagani[3], and Daniele Sertore[3] — [1]HZB-BESSY II, Berlin, Germany — [2]DESY, Hamburg and Zeuthen, Germany — [3]INFN Milano, LASA, Milano, Italy

Caesium Telluride (Cs_2Te) photo-cathodes are used as sources for electron beams because of their high Quantum Efficiency (QE) and their ability to release high peak current electron bunches in a high gradient RF-gun. A rapidly unexpected decrease of the initially QE, from 10

DS 26.45 Wed 9:30 P5

Ultrathin magnetite and pure iron films on MgO(100) studied by XRR and XPS — •Bernd Zimmermann[1], Oliver Höfert[1], Florian Bertram[1], Martin Suendorf[1], Carsten Deiter[2], Lars Böwer[3], Michael Paulus[3], Christian Sternemann[3], and Joachim Wollschläger[1] — [1]Fachbereich Physik, Universität Osnabrück, Bar-

barastr. 7, D-49069 Osnabrück, Germany — [2]HASYLAB at DESY, Notkestr. 85, D-22607 Hamburg, Germany — [3]DELTA, TU Dortmund, Maria-Goeppert-Mayer-Straße 2, D-44227 Dortmund, Germany

Thin magnetic films offer a wide range of technological applications and are of current interest in the field of spintronics. Here iron should be used used as an example. Iron oxide as a transition metal oxide has a pool of geometrical configurations. Our films were prepared by molecular beam epitaxy on MgO (100) substrates at different temperatures. Magnesiumoxide was used as substrate to study these films on an insulator. We produced these films in UHV at above room temperature from Molecular Beam Epitaxy (MBE). For this purpose, pure iron was evaporated from a rod in low pressure oxygen atmosphere at 10^{-6} mbar and adsorbed on the substrates. We did this at room temperature and at 600K. Comparison of the significant XPS peak intensities gave us an estimation of the adsorbat thickness. Its crystallinity was verified by LEED. All films were protected by a silicon capping. The samples were studied with both X-Ray Reflectometry (XRR) at beamlines HASYLAB W1, BW2 and DELTA BL 9 with an energy of 10 keV respectively 15.5 keV and XPS at Osnabrück.

DS 26.46 Wed 9:30 P5

Surface Electronic Structure Of Perovskite Oxides — •Christoph Raisch[1], Robert Werner[2], Reinhold Kleiner[2], Dieter Koelle[2], and Thomas Chassé[1] — [1]Universität Tübingen, Institut Für Physikalische Chemie, Auf der Morgenstelle 8 — [2]Universität Tübingen, Experimentalphysik II, Auf der Morgenstelle 14, 72076 Tübingen

We report on x-ray absorption (XAS) and photoemission spectroscopy (PES) on $La_{0.7}Ce_{0.3}MnO_3$ (LCeMO) and $La_{0.7}Ca_{0.3}MnO_3$ (LCMO) films with varying oxygen content grown by PLD on $SrTiO_3$ substrates. Our previous work[1] focused on bulk properties, but also showed how important the near-surface region is for the complete understanding of the electronic structure of the films. The samples have thus been further examined by PES and photoelectron diffraction (PED). To investigate effects of varying oxygen contents, the samples were heated in vacuum or in oxygen to adjust the amount of manganese valences, which were determined by PES. The experiments are supported by multiple scattering cluster calculations and atomic multiplet calculations. The simulations reveal the termination of the films, which is important considering all kinds of charge/spin injection experiments. Finally, the electronic structure of the surface also explains the behaviour of the XMCD signal, showing antiferromagnetic ordering at the surface and ferromagnetic coupling in bulk.

[1]Werner,R., Raisch,C., Leca,V. et al., 'Transport, magnetic, and structural properties of LCeMO thin films: Evidence for hole-doping' submitted to Phys. Rev. B.

DS 26.47 Wed 9:30 P5

Effect of annealing on surface morphology and mechanical properties on electroplated copper thin films — •Anastasia Moskvinova[1], Olena Chukhrai[1], Michael Hietschold[1], Inna Schuebert[2], and Ramona Ecke[2] — [1]Institute of Physics, TU Chemnitz , Germany — [2]Center for Microtechnologies, TU Chemnitz, Germany

The annealing influences on the morphological and mechanical properties in a copper interconnect layer deposited by electroplating (EP) were investigated. EP Cu films show a microstructural transformation at room temperature, known as self-annealing. That leads to the texture changes due to the recrystallization. The 500nm EP Cu films were deposited on the seed Cu(100nm)/TiN(20nm)/SiO_2/Si(100). Local mechanical properties were measured by nanoindentation. It was found that yield strengths of ECD Cu films are 500-600MPa. Microstructural evolution during self-annealing and annealing at different temperatures of copper thin films were investigated by electron backscattered diffraction (EBSD). Changes of the crystallographic texture of ECD Cu films were observed as a consequence of multiple twinning during self-annealing and annealing at different temperatures. It was found that texture formations depend strongly on the annealing temperatures. Increasing temperature leads to decreased sheet resistance and increased grain size and randomly oriented grains.

DS 26.48 Wed 9:30 P5

Formation of metal hydrides of 8b elements under plasma exposure — Marion Quaas[1], Heiko Ahrens[2], Oxana Ivanova[2], •Harm Wulff[1], and Christiane A. Helm[2] — [1]Ernst-Moritz-Arndt Universität Greifswald, Inst. f. Biochemie, F.-Hausdorff-Str. 4, 17487 Greifswald — [2]Ernst-Moritz-Arndt Universität Greifswald, Inst. f. Physik, F.-Hausdorff-Str. 6, 17487 Greifswald

We have found a new reaction pathway to form stable 8b (Ni, Pd) metal hydride compounds under soft plasma conditions (working pressure 50 Pa, substrate temperature 450 - 550 K) The applied bias voltage was varied from 0 to -100 V.

The films were investigated by x-ray diffraction, x-ray reflectometry and atomic force microscopy.

The hydrogen incorporation takes place discontinously. To understand the phase formation we performed synchrotron investigations (Hasylab, Hamburg "Surface layers in reactive plasmas" project I-20080137).

The macroscopic kinetics of formation and decomposition processes is complex. A modified isoconversional method was used to describe the competitive reactions.

DS 26.49 Wed 9:30 P5

In situ noise measurements on ion bombarded thin films: 1/f-noise as a fingerprint for amorphization — •Matthias Noske, Moritz Trautvetter, and Paul Ziemann — Institut für Festkörperphysik, Universität Ulm, D-89081 Ulm

As has been experimentally demonstrated, the crystalline binary alloy In_2Au can be transformed into an amorphous state by low temperature ion irradiation[1]. This transformation can be followed by measuring the ion induced increase of the electrical resistance as a function of the ion fluence. While this increase can be attributed to the built-up of static disorder, fluctuating atomic configurations may be present as well leading to resistance fluctuation and, as a consequence, to 1/f noise. To test such a possibility, patterned $AuIn_2$ films were irradiated with 350 keV Ar^+ ions of various fluences up to 10^{15} ions/cm^2 at 85 K. During the stepwise amorphization noise density SR spectra of the 1/f noise were taken by applying a correlation measurement technique[2] allowing detection of signals below the thermal noise. It could be shown that the spectral noise density is maximal at the percolation limit whereas the resistance approaches its final value.

[1] B. Heinz, P. Ziemann, Nucl. Instr. And Meth. B 132, 589 (1997).
[2] A.H. Verbruggen, H. Stoll, K. Heeck, R. H. Koch, Appl. Phys. A 48, 233 (1989).

DS 26.50 Wed 9:30 P5

Atom Probe Tomography (APT) on Ti-based Silicide Contact Materials — •Kirsten Wedderhoff[1], Ahmed Shariq[1], Clemens Fitz[2], and Steffen Teichert[2] — [1]Fraunhofer Center for Nanoelectronic Technologies, Koenigsbruecker Strasse 180, 01099 Dresden — [2]Qimonda Dresden GmbH Co. & OHG, Koenigsbruecker Strasse 180, 01099 Dresden

APT is based on the field evaporation of atoms from a needle. A position sensitive detector provides the spatial information of the ions, while, the elemental information is obtained by measuring the time of flight of these ionized atoms. The introduction of the laser assisted field evaporation extends the application of this method to semiconducting or insulating materials. However, there is a significant need for data demonstrating the reliability of the method for typical material systems used in the microelectronics due to the complex nature of laser assisted field evaporation.

In this contribution, APT is applied to Titanium based layer structures which are typically used for direct transistor contacts. The examined layer stack consists of a $TiSi_2$ layer with a TiN layer on top grown by PVD followed by an annealing on a p+ - doped Si(001) substrate. Such layer stacks are well known to the microelectronic community. Hence, this sample type can be used to evaluate the opportunities and limits of APT. Particularly, the usage of unstructured samples allows the direct comparison to more common analytical methods as TEM and SIMS.

Supported by BMBF (Project No 13N9432).

DS 26.51 Wed 9:30 P5

Investigations on the relaxation behavior of metastable tensile strained Si:C alloys — •Ina Ostermay[1], Andreas Naumann[1], Felix Ulomek[2], Thorsten Kammler[3], and Volker Mohles[2] — [1]Fraunhofer-Center Nanoelektronische Technologien, Königsbrücker Straße 180, D-01099 Dresden — [2]Institut für Metallkunde und Metallphysik, RWTH Aachen — [3]AMD Saxony LLC & Co. KG, Wilschdorfer Landstraße 101, D-01099 Dresden

In order to enhance the performance of CMOS transistors, embedded epitaxial layers of Si:C and SiGe are being investigated. It is crucial to the application to avoid strain relaxation of those layers. In this work,

a comparative study of the relaxation behavior of tensile strained Si:C layers as well as compressive strained SiGe due to thermal treatment is conducted. For both material systems, the relaxation phenomena were investigated by means of high resolution x-ray diffraction, reciprocal space maps around the 004 and 224 reflexes, as well as AFM and TEM analysis. The relaxation behavior of Si:C was found not to rely on the formation of dislocations as it is the case for SiGe alloys, but on the transition of substitutional carbon to interstitial carbon, or - if the thermal budget is sufficient - the precipitation of Carbides. Although the out of plane lattice constant decreases during the strain relaxation of Si:C layers, the in-plane lattice constant was found to remain unchanged from the as-deposited ones. For both alloys, models to describe the relaxation behavior are proposed.

DS 26.52 Wed 9:30 P5

Interfacial effects between thin PMMA-films and solid substrates — •Andreas Weber[1], Roland Klein[2], and Bernd Stühn[1] — [1]TU Darmstadt, Experimentelle Physik kondensierter Materie, 64289 Darmstadt, Germany — [2]TU Darmstadt, Makromolekulare Chemie, 64287 Darmstadt, Germany

Interfacial effects in thin polymer films affect applications of these films in nanotechnology. Hence there has been much research on this field. One observation is that there may be a few nanometer thick interfacial layer between the polymer and the supporting substrate. Many factors influence the development of these layers: chemical composition of the polymer, characteristics of the polymer as tacticity and molecular weight, character of the substrate and preparation method of the thin film.

X-ray reflectivity measurements allow to investigate the density profiles normal to the surface of such systems at the nanometer scale. The well-known Fresnel reflectivity of the subtrate is superposed by "Kiessig fringes" which are caused by interference due to the thin layer on top of the substrate. Periodicity and amplitude of these fringes are related to the thickness and density of the layers.

We investigate reflectivity data of thin PMMA-films of different tacticity on silicon wafers, glass substrates and polycarbonate discs to study which of the above mentioned factors lead to an interfacial layer. The polymer films are spin-coated onto the substrates. Data analysis is performed by means of a method proposed by Sanyal et al. which bases upon the distorted wave born approximation.

DS 26.53 Wed 9:30 P5

Electrical characterization of USJs in Boron doped Si — •Marcel Ogiewa[1], Michael Zier[2], and Bernd Schmidt[2] — [1]Fraunhofer Center for Nanoelectronic Technologies, Koenigsbruecker Strasse. 180, D-01099 Dresden, Germany — [2]Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, D-01328 Dresden, Germany

The demand for higher performance and better productivity in semiconductor industry causes device sizes to shrink continuously. The reduction in transistor area is achieved by shortening the length of the gate oxide. Due to the well-known scaling rules, this affects other size parameters as well, e.g. demands for ultra shallow dopant profiles to form the junctions. This in turn allows for shorter reaction times. Here, the dopant concentration is higher than the solubility in the substrate and thus the ion implantation dose only cannot yield sufficient information about the dopant behavior, e.g. the spatial profile and electrical activation.

Hence there is a need for techniques to determine these parameters in ultra shallow junctions (USJs). Due to the thin layers, conventional SPM methods cannot yield all the necessary information. We developed a measuring station to determine a depth profile by stepwise oxidation (SWOP) with nanometer resolution of electrical parameters, e.g. the sheet resistance. The dopant concentration can be obtained by hall measurements, where we also aim to obtain a depth profile. The feasibility of this technique is shown by calibration data and first measurement results on relevant doped samples.

DS 26.54 Wed 9:30 P5

Real-time STM growth observations of Mo/Si multilayer systems — •Vincent Fokkema, Jan Verhoeven, and Marcel Rost — Kamerlingh Onnes Laboratory, Leiden University, P.O.Box 9504, 2300 RA, Leiden, The Netherlands

For the very first time, in situ, real-time STM studies are performed on the formation of Mo/Si multilayer systems. These multilayers will be used as mirrors in the next generation extreme UV and X-ray lithography. An important figure of merit of these mirrors is the reflectivity, which scales with the Mo/Si interface smoothness. When Mo grows on Si, the formation of Mo_xSi_y at the interface degrades its sharpness and thus diminishes the reflectivity. In addition, it is suggested that the Mo-silicide introduces roughness by influencing the growth of the polycrystalline Mo layer. Little is known of the atomic details that govern the silicide formation and the growth processes that determine the Mo layer morphology. We have developed an STM that is capable of imaging film growth during deposition enabling a unique look on these processes. We present first results of our new STM when applying it to the Mo nucleation and growth on Si.

DS 26.55 Wed 9:30 P5

Monte Carlo simulations for focusing elliptical guides — •roxana valicu[1] and peter böni[2] — [1]FRM2, Garching,München — [2]E20, TU München

The aim of the Monte Carlo simulations using McStas Programme was to improve the focusing of the neutron beam existing at PGAA (FRM II) by prolongation of the existing elliptic guide (coated now with supermirrors with m=3) with a new part. First we have tried with an initial length of the additional guide of 7,5cm and coatings for the neutron guide of supermirrors with m= 4, 5 and 6. The gain (calculated by dividing the intensity in the focal point after adding the guide by the intensity at the focal point with the initial guide) obtained for this coatings indicated that a coating with m=5 would be appropriate for a first trial. The next step was to vary the length of the additional guide for this m value and therefore choosing the appropriate length for the maximal gain. With the m value and the length of the guide fixed we have introduced an aperture 1 cm before the focal point and we have varied the radius of this aperture in order to obtain a focused beam. We have observed a dramatic decrease in the size of the beam in the focal point after introducing this aperture. The simulation results, the gains obtained and the evolution of the beam size will be presented.

DS 26.56 Wed 9:30 P5

Electrochromic properties of WO_x thin films on ZnO:Al (AZO) substrates — •Thomas Leichtweiss, Jennifer Stiebich, Angelika Polity, and Bruno K. Meyer — Justus- Liebig- Universität Gießen, I. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen

Electrochromic materials such as tungsten oxide in contact with a suitable electrolyte change their optical transmission upon the application of a potential due to ion intercalation. Technical applications include switchable mirrors and smart windows. The latter are made up of several thin-film layers containing at least one electrochromic active material and make it possible to control the light- and energy-input of a building. In such a device the electrochromic layer is deposited on top of a transparent conductive oxide film (TCO) for electrical connection.

In this work we report on the deposition of optical active tungsten oxide layers on aluminum-doped zinc oxide films by sputtering. The effect of the deposition parameters on the electrochemical and optical properties of the films is discussed and layers with optimized coloration efficiency are presented.

Non stoichiometric WO_x layers have been therefore deposited by radio-frequency magnetron sputtering on aluminum-doped zinc oxide substrates. The electrochemical behavior of these films has been characterized by cyclic voltammetry and the Li^+-ion chemical diffusion coefficients have been evaluated by GITT (galvanostatic intermittent titration technique). Optical spectra have been recorded in-situ when charging the layers in order to calculate their coloration efficiency.

DS 26.57 Wed 9:30 P5

Influence of TCO substrate on electrochromic properties of WO_x thin films — •Jennifer Stiebich, Thomas Leichtweiss, Angelika Polity und Bruno K. Meyer — Justus- Liebig- Universität Gießen, I. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen

Electrochromic tungsten oxide thin films in contact with a suitable electrolyte change their optical transmission upon the application of a potential. A smart window device consists of an optical active and an ion storage layer which are seperated by an ion conducting electrolyte. Both electrodes are deposited on top of a transparent conductive oxide film (TCO).

In order to increase the optical tranmsission of uncoloured smart windows the substitution of the commonly used flourine-doped tin oxide (FTO) TCO by a more transparent material should be considered.

This work concerns the influence of the interface between the TCO and the electrochromic WO_x film on the switching properties. Non stoichiometric tungsten oxide layers have been deposited by radio-

frequency magnetron sputtering on flourine-doped tin oxide (FTO) and on aluminum-doped zinc oxide (AZO) substrates. The electrochemical behavior of these electrodes has been characterized by cyclic voltammetry and the Li^+-ion chemical diffusion coefficients have been evaluated by GITT (galvanostatic intermittent titration technique). The morphology of TCO- and WO_x-Layers has been analyzed by scanning electron microscopy (SEM) and atomic force microscopy (AFM).

The influence of the TCO's morphology on the electrochemical and optical properties of the tungsten oxide layers is discussed.

DS 26.58 Wed 9:30 P5

Measurements of structural and electrical properties of a pentacene layer in field effect transistors under bending stress — •Vitalij Scenev[1], Nikolaj Severin[1], Jörn-Oliver Vogel[1], Zhanh Jian[1], Stefan Eilers[1], Jürgen Rabe[1], Piero Cossedu[2,3], Analisa Bonfiglio[2,3], and E Orgiu[2,3] — [1]HU-Berlin, Newtonstr. 15, GErmany — [2]University of Cagliari, , Piazza di Armi, Cagliari, Italy — [3]CNR-INFM, via Campi 213A, I-41100 Modena, Italy

The increasing interest in organic thin-film transistors (OTFTs) for low cost flexible electronic devices has stimulated research into strain induced changes of OTFT's electrical characteristics. A pronounced sensitivity of the device characteristics to the organic layer deformation has been attributed to strain induced morphological changes. However, we are not aware of any in-situ measurements which would demonstrate the assumed morphological changes of the organic layer. Here we demonstrate an experimental setup and first results of simultaneous measurements of electric properties and surface morphology employing scanning force microscopy for a pentacene based OTFT. The strain of the device is induced in a controlled and reversible manner with a special grip construction.

DS 26.59 Wed 9:30 P5

Production and characterisation of periodic and chirped La/B_4C-multilayer-mirrors for the reflection of ultra short XUV-pulses — •Maike Lass[1], Stefan Hendel[1], Florian Bienert[1], Marc D. Sacher[1], Wiebke Hachmann[1], Franz Schäfers[2], and Ulrich Heinzmann[1] — [1]Molecular and Surface Physics, Bielefeld University, D-33615 Bielefeld — [2]Helmholtz-Zentrum Berlin für Materialien und Energie, Elektronenspeicherring BESSY II

The applicability of reflective optical components for the soft X-Ray region depends upon the existence of multilayer-optics. For the photon energy range of 100-190eV Lanthanum (La) is favoured as the absorber material and Boroncarbide (B_4C) as the spacer material. Thin periodic and aperiodic (chirped) layer systems of those materials with double layer periods of 3.5nm have been produced by UHV Electron Beam Evaporation combined with Ion Polishing to decrease the interface roughness and thus to increase the reflectivity. In-situ layer thickness control is done by X-Ray Reflectometry and single-wavelength Ellipsometry. The characterisation of the layer purity is done by ex-situ Sputter Auger Spectroscopy, whilst structural analysis is performed by X-Ray Diffraction, Transmission Electron Microscopy and at-wavelength reflectivity measurements with Synchrotron radiation at the BESSY II facility. We report on reflectivities of periodic and aperiodic multilayer-mirrors.

DS 26.60 Wed 9:30 P5

Properties of hydrogenated amorphous silicon thin film solar cells deposited at high base pressure — •Jan Woerdenweber[1], Tsvetelina Merdzhanova[1,2], Aad Gordijn[1], Wolfhard Beyer[1,2], Helmut Stiebig[2], and Uwe Rau[1] — [1]Forschungszentrum Juelich, Germany — [2]Malibu GmbH & Co. KG, Bielefeld, Germany

In thin film silicon solar cell technology, the base pressure of the process appears as an important cost factor. The intention of this study is to investigate to what degree deposition conditions like total process gas flow and deposition rate allow the preparation of solar cells with high stable efficiencies at high base pressures (up to 10^{-4} Torr). Series of solar cells with various oxygen contaminations were prepared using an intentional oxygen leak. A high total gas flow and high deposition rate (via high RF power) are found to favor the suppression of oxygen incorporation. Thus, the tolerated oxygen flow can be increased by two orders of magnitude. The increase in deposition rate (from ≈ 0.2 nm/s to ≈ 0.5 nm/s) reduces the oxygen incorporation in the intrinsic absorber layer only for low total gas flows (e.g., by a factor of 10 at 10^{-5} Torr). At high total gas flows no significant change of the incorporation probability with increasing deposition rate is observed. Degradation losses (1000 h of light-soaking at 100 W/cm^2 irradiation and at 50°C) in efficiency for uncontaminated cells are ≈ 18

DS 26.61 Wed 9:30 P5

Photoluminescence Properties of Thin Films of Nanoporous Alumina — •Piotr Hamolka, Igor Vrublevski, Vitaliy Sokol, Dmitriy Shimanovich, and Vladimir Parkoun — Hybrid Technology Lab, Department of Nano and Microelectronics, Belarussian State University of Informatics and Radioelectronics, P.Brovki str. 6, 220013, Minsk, Republic of Belarus

Thin nanoporous alumina films for this study were formed using anodizing of Al foils (99.999% purity) with thickness of 25.0 microns in 0.3M oxalic acid solution at 18 °C. The luminescence properties of as-anodized and annealed porous alumina films were investigated using a fluorescence spectrophotometer. Xe lamp was the excitation light source. Annealing of specimens was carried out in air at temperatures from 100 up to 600 °C. Based on photoluminescence (PL) measurements, it has been revealed that the observed blue PL band is asymmetrical. It can be divided into two sub-bands by Gaussian fit. Our experiments have shown that intensity of blue PL band increases with elevation of annealing temperature and reaches maximum for specimens annealed at temperature of about 500 °C.

DS 27: Gaede Prize: Jürgen Fassbender

Time: Wednesday 14:00–14:45 Location: HSZ 02

Invited Talk DS 27.1 Wed 14:00 HSZ 02

Engineering surfaces, interfaces and structural phases to tailor magnetic properties — •Jürgen Fassbender — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden-Rossendorf e. V., P. O. Box 51 01 19, D-01314 Dresden — Träger des Gaede-Preises

Surfaces and interfaces play an important role in order to determine the overall properties of ultrathin magnetic films and multilayers. In particular, the morphology and roughness of the surface and the sharpness of mutual interfaces between magnetic and non-magnetic thin films are crucial. All these parameters are easily accessible by means of ion irradiation [1,2], ion implantation [2,3] and ion erosion approaches [4]. Also structural phase transitions can be accompanied by magnetic ones [5] which allow the creation of nanomagnets in the sub-100 nm regime [6]. In this talk I am going to present a survey of ion beam modifications of magnetic materials with special emphasis on the basic phenomena including some technological applications. Supported by DFG FA 314/3-1, FA 314/6-1 and FA 314/7-1.

[1] J. Fassbender, D. Ravelosona, Y. Samson, J. Phys. D 37, R179 (2004). [2] J. Fassbender, J. McCord, J. Magn. Magn. Mat. 320, 579 (2008). [3] J. McCord, L. Schultz, J. Fassbender, Adv. Mater. 20, 2090 (2008). [4] M. O. Liedke et al., Phys. Rev. B 75, 220407(R) (2007). [5] J. Fassbender et al., Phys. Rev. B 77, 174413 (2008). [6] E. Menendez et al., Small, in press.

DS 28: Nanoengineered Thin Films I

Time: Thursday 9:30–11:00 Location: GER 37

DS 28.1 Thu 9:30 GER 37

Magnetic properties of ion beam induced ripple pattered Fe layers — •Felix Büttner, Hans Hofsäss, and Kun Zhang — II. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

There is a rapidly growing interest in nanopattered ferromagnetic films. Apart from fundamental investigations, one motivation is the search for materials which are ferromagnetic even at nanometer scales. It has been found that ion beam induced ripples of epitaxially grown Co induce a strong uniaxial magnetic anisotropy. Comparable experiments with epitaxial Fe films on MgO and polycrystalline Fe films on Si, both textured by ion beam erosion, showed similar magnetic properties. This study is about nanopattered thin epitaxial Fe layers grown on MgO by PLD. Pattering was done by grazing incidence sputter erosion using 5 keV Ar ions. Additional cosputtering of Fe was used to attenuate the effective sputter yield and to achieve a thickness gradient. Alternatively, pure MgO was irradiated with the same parameters using an Fe cosputtering target to achieve a very thin steady state Fe coverage on nanostructured MgO. We investigate the magnetic and structual properties of the nanopattered Fe layers as a function of the residual film thickness using MOKE, RBS and AFM. Both side polished MgO substrates were used to perform MOKE measurements of the Fe / MgO interface to determine the influence of the ion beam induced surface ripple patterns on the magnetic properties of the unirradiated underlying layer.

DS 28.2 Thu 9:45 GER 37

Transient electrical conductivity of W-based deposits during growth, relaxation and exposure to air — •Fabrizio Porrati, Roland Sachser, and Michael Huth — Johann Wolfgang Goethe University, Frankfurt am Main, Germany

W-based granular metals have been prepared by electron beam induced deposition from the tungsten-hexacarbonyl, $W(CO)_6$, precursor. In situ electrical conductivity measurements have been performed to monitor the growth process and to investigate the behavior of the deposit by electron beam post irradiation and by exposure to air. During the first part of the growth process, the electrical conductivity grows with the cube of time, $\sigma \sim t^3$, independently from the electron beam parameters. This behavior is interpreted as the result of the increase of the W-particles diameter. Once the growth process is terminated, the electrical conductivity decreases with the logarithm of time, $\sigma \sim ln(t)$. Temperature dependence conductivity measurements of the deposits reveal that the electrical transport takes place through two parallel channels: either by means of variable-range-hopping within the carbonaceous matrix or by electron tunneling between W-metal grains. After venting the electron microscope the electrical conductivity of the deposits shows a degradation behavior, which depends on the composition. Electron post-irradiation increases the electrical conductivity of the deposits, which can be attributed to the increase of charge carriers from the breakage of the carbon-carbon bonds in the matrix.

DS 28.3 Thu 10:00 GER 37

Development of α-$(Al_x,Cr_{1-x})_2O_3$ solid solution strengthened thin films by reactive magnetron sputtering — •Dominic Diechle, Michael Stüber, Harald Leiste, and Sven Ulrich — Forschungszentrum Karlsruhe GmbH, Institute for Materials Research I, Karlsruhe, Germany

Hard, tough, wear and oxidation resistant thin film materials are important for many applications such as cutting tools. We present a new combinatorial approach for the deposition of solid solution strengthened α-$(Al_x,Cr_{1-x})_2O_3$ thin films by reactive r.f. magnetron sputtering in an argon-oxygen atmosphere. The deposition experiments are carried out with a Leybold Z 550 PVD machine for the sputtering from a segmented target (Al and Cr) at non-equilibrium conditions. We adjusted the substrate temperature to 500 °C and we induced a substrate bias up to -400 V. The metastable thin films were characterized by determining their Vickers micro hardness, their residual stress, their chemical composition by Electron Probe Microanalysis, their microstructure by X-Ray diffraction and their constitution by scanning electron microscopy and transmission electron microscopy.

The chemical analysis revealed nearly stoichiometric $(Al_x,Cr_{1-x})_2O_3$ composition and the largest Vickers micro hardness was 2620 HV0,05. A comparison of the measured X-Ray diffraction spectrum with the peaks of α-Al_2O_3 and α-Cr_2O_3 showed six Bragg peaks positioned between the α-Al_2O_3 and α-Cr_2O_3 peaks of the same crystal lattice plane. Thus we assumed corundum-type α-$(Al_x,Cr_{1-x})_2O_3$ growth of the solid solution.

DS 28.4 Thu 10:15 GER 37

Reactive Magnetron Sputtering of (GeO_x-SiO_2) Superlattices for Nanocrystal Synthesis — •Manuel Zschintzsch, Nicole M. Jeutter, Johannes von Borany, and Arndt Mücklich — Institute of Ion Beam Physics and Materials Research, Forschungszentrum Dresden Rossendorf, 01328 Dresden, Germany

The underlying motivation of this research is the tailored growth of Ge nanocrystals (NC) for photovoltaic applications [1,2]. Of special interest is the study of confinement effects to design bandgap engineered materials enabling light absorption within a wide range of the solar spectrum. In this contribution, we enlighten the deposition process of (GeO_x-SiO_2) superlattice structures (SL) via reactive DC magnetron sputtering and the self-ordered Ge-nanocrystal formation during subsequent annealing. SL structure delivers a reliable method to control the NC size after phase separation. Main attention is directed to define proper deposition conditions for tuning the GeO_x composition between elemental Ge (x=0) and GeO_2 (x=2) by the variation of the deposition temperature and the oxygen partial pressure. A process window has been found which allows GeO_x / SiO_2 deposition without changing the oxygen flow during the deposition. The phase separation and Ge NCs formation after subsequent anneling was investigated with $in-situ$ X-ray diffraction, Raman spectroscopy and electron microscopy, confirming the existence of 2-5 nm Ge NCs. As the used technique allows to produce SL stacks with very smooth interfaces (roughness <1 nm), the Ge NC layers could be separated by very thin SiO_2 films (d >3 nm) which offers interesting possibilities for charge transport via tunneling.

DS 28.5 Thu 10:30 GER 37

Hierarchical nano-structuring of Si surfaces by combining top-down and bottom-up techniques — •Bashkim Ziberi, Frank Frost, Jochen Zajadacz, Klaus Zimmer, Renate Fechner, and Bernd Rauschenbach — Leibniz-Institut für Oberflächenmodifizierung (IOM), Permoserstrasse 15, D-04318Leipzig, Germany

Guided self-organization processes are currently in focus regarding their potential for hierarchical micrometer and nanometer scale structuring. In this regard, self-organized pattern formation due to low-energy ion beam erosion offers an alternative approach. A combination with conventional lithographic pre-patterning can lead to multi-scale structuring and an exact positioning of the nanostructures.

The principle of hierarchical nanostructuring is applied on Si surfaces during low energy Kr^+ ion beam erosion where different micron and nanometers scale pre-patterns fabricated by e-beam lithography and laser ablation technique are used. The results show that the formation of nanostructures depends strongly on the local incidence angle of ions, the orientation of the local surface with respect to the ion beam and the local surface curvature. Depending on these parameters and on the ion beam parameters different patterns like curved ripples, ripples with different orientations and perfectly squared dots form on the surface at exact defined positions. It is demonstrated that by combination of conventional lithography techniques with ion beam induced self-organization a hierarchical nanostructing with potential applications in micro- and nanooptics is possible.

DS 28.6 Thu 10:45 GER 37

A novel nanocomposite thin film deposition tool using plasma processes — •Ralph Schmittgens[1], Marcus Wolf[1], and Eberhard Schultheiss[1,2] — [1]Institut für Festkörperelektronik, Technische Universität Dresden — [2]Fraunhofer FEP, Dresden

Nanocomposites are a novel class of materials with a lot of promising applications. Many applications require the use of nanocomposites as thin films. Vacuum based deposition processes are specially suited to produce high quality thin films. In this work a novel vacuum deposition system is presented that allows a versatile deposition of thin film nanocomposites by incorporating inorganic nanoparticles into matrix materials made of plasmapolymers or inorganic composites. The system consists of a gas phase condensation process for the nanoparticle

fabrication using a hollow cathode discharge for the atomic vapor production and a very high frequency driven plasma for the deposition of the matrix materials. The design of the experimental setup allows the combination of metal, alloy and inorganic filler materials and polymeric and inorganic matrix materials. In this contribution details of the system concept and realization will be presented. Results of the characterization of copper nanoparticle size, size distribution and deposition rate will be demonstrated. Examples of the matrix film deposition process will be presented in the form of hydrophobic polymeric and titanium and silicon oxide coatings. First results of the nanoparticle incorporation of copper and copper oxide nanoparticles into plasmapolymer and inorganic matrices will be shown and possible applications discussed.

DS 29: Nanoengineered Thin Films II

Time: Thursday 11:15–12:45 Location: GER 37

DS 29.1 Thu 11:15 GER 37

Geometric properties and thermal stability of size selected Ag clusters on C_{60} films — •Stefanie Duffe[1], Lukas Patryarcha[1], Ben Wortmann[1], Bernd von Issendorff[2], Michael Moseler[2,3,4], and Heinz Hövel[1] — [1]TU Dortmund, Experimentelle Physik I, 44221 Dortmund, Germany — [2]Universität Freiburg, Fakultät für Physik, 79104 Freiburg, Germany — [3]Fraunhofer Institut für Werkstoffmechanik, 79108 Freiburg, Germany — [4]Freiburger Materialforschungszentrum, 79104 Freiburg, Germany

Mass selected clusters from Ag_{55}^{+} to $Ag_{923\pm9}^{+}$ were soft landed at 165 K on C_{60}/HOPG and C_{60}/Au(111) and imaged with STM at 77 and 5 K. We observed extremely narrow cluster height distributions. The cluster heights are in agreement with calculated heights for spherical clusters. We studied the thermally activated decay of the deposited clusters. Using C_{60}/HOPG or 2 ML C_{60}/Au(111) the cluster heights are stable for more than 12 h at RT. For 1 ML C_{60}/Au(111) the clusters decay atom by atom, which is revealed by atomistic calculations [1, 2]. For $Ag_{309\pm3}$ and $Ag_{923\pm9}$, we used scanning tunnelling spectroscopy at 5 K and measured identical spectral features for individual clusters with the same selected size. The spectra can be classified in different groups showing energetic shifts of the peaks due to different shapes of the STM tip. For this reason, we measured spectra of C_{60} molecules as reference. Besides, we observed for 2 ML C_{60}/HOPG three different orientations of the C_{60} molecules in STM images measured at 5 K. In contrast, the first ML C_{60} molecules/HOPG show only one orientation.

[1] S. Duffe et al., EPJD 45, 3 (2007), [2] S. Duffe et al., submitted

DS 29.2 Thu 11:30 GER 37

Nanostructured carbide surfaces prepared by surfactant sputtering — Hans Hofsäss, •Kun Zhang, and Hayo Zutz — II. Physikalisches Institut, Universität Göttingen Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Nanostructured surface layers of titanium carbide and tungsten carbide were prepared on tetrahedral amorphous carbon (ta-C) films using the surfactant sputtering technique. Surfactant sputtering is a novel ion beam erosion technique, which utilizes the steady state coverage of a substrate surface with foreign atoms simultaneously during sputter erosion by combined ion irradiation and atom deposition. These foreign atoms act as surfactants, which strongly modify the substrate sputtering yield on atomic to macroscopic length scales. The novel technique allows smoothing of surfaces, the generation of novel surface patterns and nanostructures, controlled shaping of surfaces on the nanometer scale and the formation of ultra-thin compound surface layers. We have sputter eroded ta-C films using 5 keV Xe ions under continuous deposition of either tungsten or titanium surfactants. This leads to the steady state formation of a W_xC or a TiC/a-C nanocomposite surface layer of few nm thickness. Depending on the ion angle of incidence the layer is either smooth or nanostructured with a ripple- or dot-like surface topography. We have analyzed the surface topography, the composition and microstructure of the metal-carbon nanocomposites, and compare coverage dependent sputtering yields with SRIM and TRIDYN simulations.

DS 29.3 Thu 11:45 GER 37

Self-organization in metal containing amorphous carbon nanocomposites — •Hayo Zutz[1], Dominika Lyzwa[1], Carsten Ronning[2], Michael Seibt[3], and Hans Hofsäss[1] — [1]II.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1,37077 Göttingen — [2]Institut für Festkörperphysik, Universität Jena, Max-Wien-Platz 1, 07743 Jena — [3]IV.Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1,37077 Göttingen

Carbon based nanocomposites gained much interest in the last years. The low energy ion deposition using a mass selected ion beam with carbon and metal quasi-simultaneously allows the formation of various compounds. Gerhards et.al. found a self-organization process resulting in alternating metal-rich and metal deficient layers with layer periods in the nm range for a-C:Au and a-C:Fe[1]. The self-organization process occurs in a certain parameter regime for ion energies and C^{+}/metal^{+} fluence ratios. By proper selection of the fluence ratio it is possible to deposit metal-carbon nanocomposite films with homogenously distributed metal clusters in an a-C matrix or a multilayer structure. In this presentation we will discuss results for the a-C:Cu and a-C:Ni system. The films are analyzed by Rutherford backscattering spectroscopy, energy dispersive X-ray spectroscopy and cross-section transmission electron microscopy. For both systems the results are in agreement with predictions and the model developed in [1] based on an interplay of sputtering, surface segregation and ion induced diffusion. Extensions to the simple model based on the new results will be discussed. [1] I Gerhards et.al., PRB70(2004)245418.

DS 29.4 Thu 12:00 GER 37

Effect of structure formation on electrical conductivity in thin ITO-films composed of nanoparticles — •Mahdi Mahajeri and Wolfgang Peukert — LFG, Friedrich- Alexander- Universität Erlangen- Nürnberg, Cauerstrasse 4, 91058 Erlangen

Due to high transparency in the visible wavelength region and excellent electrical conductivity, $In_2O_3 : Sn$ (ITO) is a promising candidate for application in printable electronics. Transparent conductive films of ITO are usually made by vapor deposition which results in high production costs. The use of ITO-nanoparticles in combination with wet deposition methods such as dip-coating offers a high potential for cost reduction. However, these techniques currently lead to an electrical conductivity, which order of magnitude is smaller than that of the layers produced by vapor deposition. The reasons for the low conductivity is the disperse nature and (surface / bulk) defects of the deposited ITO-thin films. The aim of our studies is to understand the correlation between structure formation and electrical conductivity. Therefore, we used ITO-suspensions with varying stabilities to fabricate the ITO-films. The morphology of the layer and structure formation was investigated with AFM, SEM, spectrophotometry and light microscopy. The conductivity was characterized by impedance spectrometry (IS), van der Pauw-method (vdP) and a four-probe setup. It was found that the charge transfer is directly correlated to the structure formation which is a function of the stabilization of the ITO-nanoparticles. The mechanism of charge transfer in the ITO-films is identified and found to be strongly dependent on the structure formation.

DS 29.5 Thu 12:15 GER 37

Investigation of Silver Release from 2d and 3d Metal/Polymer Nanocomposites — Vladimir Zaporojtchenko, •Thomas Strunskus, Venkata Girish Kotnur, Venkata Sai Kiran Chakravadhanula, Jan-Hendrik Pöhls, and Franz Faupel — Lehrstuhl für Materialverbunde, Technische Fakultät der CAU Kiel, Kiel

Metal-polymer nanocomposites have a host of functional applications ranging from optical and magnetic to antibacterial materials. While in the latter case metal ion release is essential for the antibacterial function, it is often detrimental and affects the stability and functionality of the nanocomposites during long-term aging. The mechanism and the kinetics of metal ion release from metallic nanoparticles on and in a polymer or ceramic matrix as function of the arrangement, composition, and filling factor of the nanoparticles and the properties of the polymer or ceramic matrix have been investigated following changes in particle plasmon resonance and x-ray photoelectron spec-

troscopy. Emphasis has been placed on pure Ag and combined Ag/Au nanoparticles.

DS 29.6 Thu 12:30 GER 37

Metal Nanostructures bound to Dielectric Substrates for Plasmonic Applications — •Marisa Mäder, Susanne Perlt, Markus Lippmann, Jürgen Gerlach, Thomas Höche, and Bernd Rauschenbach — Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstraße 15, 04109 Leipzig, Germany

Metal nanospheres, especially when arranged in a predefined way, facilitate surface plasmon related applications [1]. In this paper, a method called Diffraction Mask Projection Laser Ablation (DiMPLA) [2] is used to create such nanostructres. The straightforward method uses an Excimer laser pulse (KrF, 248 nm, 25 ns) whose intensity is laterally modified by a phase mask and subsequently demagnified (15x, 36x, 50x) by a reflective objective. Exposure of a thin metal film on a dielectric substrate leads to the formation of metal nanostructures. Dependent on the phase mask that is applied in the setup, the arrangement of nanospheres on the sample can be controlled as desired. It is even possible to create non-regular pattern arrangements. Dependencies of the nanospheres on different parameters and some first steps into plasmonic applications are presented in this paper.

[1] W. M. Saj, Optics Express 13, 2005, 4818
[2] M. Maeder et al., Phys. Stat. Sol. (RRL) 2, 2008, 34

DS 30: Application of Thin Films I

Time: Thursday 14:15–16:00 Location: GER 37

DS 30.1 Thu 14:15 GER 37

Extraction of nitride trap density distribution in SONOS (silicon-oxide-nitride-oxide-silicon) structures based on an advanced thermal emission model — •Kerstin Bernert[1], Jonas Schönlebe[2], Christiane Oestreich[2], and Thomas Mikolajick[2] — [1]Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, 01328 Dresden — [2]Institut für Elektronik- und Sensormaterialien, Technische Universität Bergakademie Freiberg, 09599 Freiberg

As a result of continued scaling and the emphasis on low power and low voltage operation, silicon-oxide-nitride-oxide-silicon (SONOS) nonvolatile memory has received more attention recently. In this talk we investigate the charge decay characteristics of SONOS devices at elevated temperatures. Based on the thermal emission model as the dominant charge loss mechanism, the trap density energy distribution is determined. Furthermore, we present an advanced model which includes the influence of subsequent tunneling through the bottom oxide after thermal excitation in the conduction band of the nitride.

DS 30.2 Thu 14:30 GER 37

Liquid Injection Atomic layer deposition of metallic Ru and RuO_2 thin films for electrode applications — •Susanne Hoffmann-Eifert, Seong Keun Kim, and Rainer Waser — Forschungszentrum Jülich, IFF-IEM and JARA-FIT, 52425 Jülich, Germany

In this project we studied the liquid injection atomic layer (LI-ALD) deposition of metallic Ru and RuO_2 thin films for application as electrode layers. The new capacitors will be built up from ultra thin films of higher-k materials like $SrTiO_3$ or (Ba, Sr)TiO_3 in order to decrease the equivalent oxide thickness. In order to have a conducting metallic or oxide electrode available for 3D integrated capacitor structures, we investigated the ALD growth process for Ru/RuO_2 thin films in detail. In this study, RuO_2 films were deposited using traveling wave type ALD reactor. Tris(2,2,6,6-tetra-methyl-3,5-heptanedionato)ruthenium(III)(Ru(TMHD)3) dissolved in ethylcyclohexane was used as a metal source. The Ru-solution was pulse injected and evaporated in a vaporizer at a temperature of 200 °C. The growth behavior of the ALD Ru/RuO_2 films was studied as a function of the substrate temperature and the type of oxidant. The films were characterized with respect to their structural, morphological and resistance properties. Special interest is layed on the effect of the solvent on the oxidation state of the conducting Ru based thin films. A model is suggested which explains the different growth behavior of Ru/RuO_2 films in "bubbler-type"and LI-ALD-type processes.

DS 30.3 Thu 14:45 GER 37

Liquid Injection Atomic Layer Deposition of Lead Zirconate Titanate Thin Films for Three Dimensional Ferroelectric Capacitor Structures — •Susanne Hoffmann-Eifert[1], Takayuki Watanabe[1], Cheol Seong Hwang[2], and Rainer Waser[1] — [1]Forschungszentrum Jülich, IFF-IEM and JARA-FIT, 52425 Jülich, Germany — [2]Dept. of Materials Science and Engineering, Seoul National University, Seoul, Korea

In order to combine the functionality of ferroelectric oxides with semiconductor memory devices, thin films with a thickness in the range of about 10 nm have to be integrated onto 3D stack structures with lateral diameter of about 100 nm and a height in the micrometer regime. The thin films have to be homogeneous in thickness and in composition. A fully conformal deposition onto extreme 3D structures can only be achieved by means of an atomic layer deposition (ALD) process. Here, we present an approach by which uniform coverage of multi-component oxide films over complex structures can be achieved in both, the cation composition and the film thickness. Quaternary PZT films were deposited using a combination of liquid injection ALD steps of binary PbO, ZrO_x, and TiO_x films. $Pb(TMHD)_2$, $Ti(OiPr)_4$, and $Zr(DIBM)_2$, dissolved in ethylcyclohexane, and H_2O were used as source materials. PZT films were grown on Pt or Ir-covered Si substrates at 240°C. A further annealing step after deposition was performed to crystallize the material. ALD-PZT films were grown onto 3D structures with homogeneous thickness and cation composition, even after crystallization.

DS 30.4 Thu 15:00 GER 37

Effect of the interface roughness on the performance of nanoparticulate zinc oxide field-effect transistors — •Koshi Okamura, Norman Mechau, Donna Nikolova, and Horst Hahn — Forschungszentrum Karlsruhe, Institute of Nanotechnology, Karlsruhe, Germany

Field-effect transistors (FETs) based on nanocrystalline inorganic materials have been attracting interests as a candidate for printable electronics. Nanocrystalline FETs take the advantage of compatibility with low-temperature and high throughput processes. However, the critical parameter of nanocrystalline FETs is the interface roughness between the nanocrystalline semiconductor and the insulator, where the channel of the FET is formed. Therefore, the correlation between the interface roughness and the performance of nanoparticulate ZnO FETs is systematically investigated. ZnO nanoparticles were dispersed in 2-methoxyethanol with stabilizer at a fixed concentration and processed by ultrasonic treatments. The agglomerate sizes were changed by the duration time, so that the resulting films had different degree of roughness at the interface. The FETs in the bottom-gate configuration were fabricated from suspensions, consisting of a Si substrate, a SiO_2 layer, a spin-coated nanoparticulate ZnO layer and Al source and drain electrodes. The FET with the lowest average roughness of 47.4 nm showed the best mobility of $8.4{\cdot}10^{-3}cm^2/Vs$. In contrast, the FET with the highest roughness of 70.6 nm showed two orders of magnitude lower mobility of $8.7{\cdot}10^{-5}cm^2/Vs$. These results indicate the strong correlation between the interface roughness and the FET performance.

DS 30.5 Thu 15:15 GER 37

Influence of Stabilizers in ZnO nanodispersions on the FET device performance — •Simon Bubel, Donna Nikolova, Norman Mechau, and Horst Hahn — Institute of Nanotechnology, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany

In order to build printable inorganic electronic devices, semiconducting suspensions which can be processed at low temperatures and low-cost manufacturing techniques are needed. Stabilized suspensions made of zinc oxide nanoparticles were used to fabricate field-effect transistors (FETs) by spin coating. The performance of the devices is strongly affected by the nature and concentration of the compounds added to stabilize the nanodispersions. An increase of the field-effect mobility by more than one order of magnitude is observed by increasing the stabilizer concentration from 3 to 13 wt %. A further increase of the concentration above 13 wt % results in a decrease of the field-effect

mobility. This behaviour can be explained by changes in the morphology, the particle-particle junction, and the passivation of surface defect sites.

DS 30.6 Thu 15:30 GER 37

Anomalous Nitrogen Diffusivity During Plasma Nitriding of CoCr Alloys at High Temperatures — •Johanna Lutz[1,2], Stephan Mändl[1], and Bernd Rauschenbach[1] — [1]Leibniz Institute of Surface Modification, Leipzig, Germany — [2]Translational Centre for Regenerative Medicine, University of Leipzig, Germany

Plasma immersion ion implantation is an important method to tailor and to increase the physical and chemical properties of numerous materials. In this presentation, the diffusion of nitrogen and the phase formation is investigated for face-centred-cubic CoCr alloys in the temperature range from 230 - 580 °C. Plasma immersion ion implantation was carried out using 10 kV pulse voltage and a process pressure of 0.5 Pa. X-ray diffraction patterns show two different phase structures depending on the temperature: a lattice expansion at temperatures lower than 450 °C while the decomposition of the base material into CrN precipitates and another Co-rich phase is observed at the upper end of the temperature range. A two-step nitriding process at different temperatures shows clearly that at a previous implantation at a temperature of 560 °C, no nitrogen diffusion is observed for a subsequent nitriding at any temperature. For preimplantation at 450 °C, normal diffusivities are observed during the latter process. This clearly indicates that the phase decomposition at elevated temperatures leads to a radical change in the nitrogen diffusivity.

DS 30.7 Thu 15:45 GER 37

Self-Aligned Field Emission Device Prepared by Swift Heavy Ion Irradiation. — •Han-Gregor Gehrke[1], Anne-Katrin Nix[1], Johann Krauser[2], Christina Trautmann[3], Alois Weidinger[4], Jürgen Bruns[5], Frank Wünsch[4], and Hans Hofsäss[1] — [1]Georg-August Universität, Göttingen, Deutschland — [2]Hochschule Harz, Wernigerode, Deutschland — [3]Gesellschaft für Schwerionenforschung, Darmstadt, Deutschland — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Deutschland — [5]Technische Universität, Berlin, Deutschland

Swift heavy ion irradiation of tetrahedral amorphous carbon (ta-C) results in conductive ion tracks with a diameter of about 8 nm. The goal of our work is the fabrication of self-aligned field emission devices. The ion tracks embedded in the insulating ta-C film form nanosized field emitters. The gate structure is produced by a thin insulating SiN_X and a chromium layer on top of the carbon film. Finally, a spin coated polycarbonate layer is placed on top of the sample. The irradiation of the layer package leads to latent tracks in the polycarbonate above each conducting track in the ta-C. Therefore, after opening the polycarbonate mask with chemical wet etching, the pores are well aligned with the ion track underneath. Finally, the chromium and the SiN_X can be opened by sputtering or plasma etching to create the complete structure. The advantage of this approach is stability of the layer package; no free standing nanowires can be damaged. We present first results of experiments with the described self-aligned field emission structure.

DS 31: Application of Thin Films II

Time: Thursday 16:15–17:45 Location: GER 37

DS 31.1 Thu 16:15 GER 37

Development of multilayer optics for modern X-ray analytics — •Steffen Kroth[1], Jörg Wiesmann[1], Frank Hertlein[1], Carsten Michaelsen[1], and Michael Störmer[2] — [1]Incoatec GmbH, Max-Planck-Strasse 2, 21502 Geesthacht — [2]GKSS Forschungszentrum, Max-Planck-Strasse 1, 21502 Geesthacht

In this contribution, we give an overview on the state-of-the-art beam-shaping multilayer and total reflection optics for XRD in the lab and for synchrotron beamlines. Nowadays a large variety of 1D and 2D optics are available with optimized properties for the customer's applications. We explain the manufacturing process of multilayer and total reflection optics, summarize the different type of optics and give some examples of typical applications. The optics for lab-instrumentation consist of bent substrates with shape tolerances below 100nm, upon which multilayers are deposited with single layer thicknesses in the nm-range and up to several hundreds of layer pairs. Most multilayers were designed with lateral thickness gradients within 1% deviation of the ideal shape. This means that a deposition precision in the picometer range is needed. We use magnetron sputtering for deposition, optical profilometry in order to characterize the shape and X-ray reflectometry to characterize the multilayers. The microstructure is investigated by TEM. The beam parameters like monochromaticity, flux, brilliance and divergence demonstrate the quality of the multilayer optics for different lab applications.

DS 31.2 Thu 16:30 GER 37

Effect of FEL induced ionization on X-ray reflectivity of multilayers — •Dmitriy Ksenzov, Souren Grigorian, and Ullrich Pietsch — University of Siegen, Siegen, Germany

The VUV-FEL in Hamburg (FLASH) emits short-pulse radiation with wavelengths from 6 to 30 nm and a pulse length of 10-50 fs. The FLASH wavelength allows x-ray diffraction experiments at periodical multilayer's structures acting as 1D crystal. The probe of depth selective interaction of the high-intense x-ray short pulse with these objects can be used to obtain information about possible electronic excitation and various recombination processes inside multilayers. As known from recent experiments at FLASH, the later ones are most likely using highly intense FEL radiation.

The ML reflectivity is analyzed for case of that the optical parameters are changing as function of the depth of the penetrating incident pulse into the multilayer. The response is studied for the model system La/B4C using two experimental conditions both at fixed incidence angle: 1) the energy of the incident pulses, E, coincides with the energy of the 1st order multilayer Bragg peak, E_B, of the reflection curve, and 2) the energy of incident pulse differs by a small dE from E_B. The ML response to a given sub-pulse differs for both conditions. However, there is a clear fingerprint of ionization for both conditions for the case that E is close to the K-absorption edge of B-atoms. Our results support respective efforts to measure the optical parameters of solids under high-intense FEL radiation.

DS 31.3 Thu 16:45 GER 37

Broadband multilayer soft X-ray mirrors for attosecond pulse formation at photon energies above 100 eV — •Michael Hofstetter[1], Andrew Aquila[2], Martin Schulze[3], Markus Fiess[3], Eleftherios Goulielmakis[3], Joerg Schuster[1], Martin Huth[4], Ferenc Krausz[3], and Ulf Kleineberg[1] — [1]LMU Physik — [2]CXRO — [3]MPQ — [4]LMU Chemie

We report on the development, fabrication and application of multilayer mirrors as broadband soft-X-ray optical components for the formation of attosecond (1 asec=10^{-18}s)pulses from high harmonic radiation. Until recently, attosecond physics was merely confined to the photon energy range below 100 eV due to the properties of Mo/Si multilayer and single isolated pulses of 80 asec pulse duration have been achieved [Goulielmakis et.al.]. For many applications, e.g. in the characterization of the photoemission dynamics from solid surfaces or the characterization of ultrafast surface plasmon dynamics in metallic nanostructures by attosecond pump-probe spectroscopy, higher photon energies are desirable to address deeper bound electronic core states or to increase the kinetic energy of the emitted photoelectrons [Cavalieri et.al., Stockman et.al.]. Here, we introduce new aperiodic broad bandwidth multilayer systems based on lanthanum (e.g. LaMo, LaB_4CMo, LaB_4C, MoB_4C),for the 100-190 eV photon energy range. Multilayer properties like interface roughness, interlayer formation and reflectivity are discussed. Finally, first applications for spectral filtering of the HHG comb above 100 eV are presented.

DS 31.4 Thu 17:00 GER 37

Influence of nitrogen flow on structure and magnetic properties of magnetron-sputtered FeCo/TiN multilayer films — •Christian Klever and Klaus Seemann — Forschungszentrum Karlsruhe, Institute of Materials Research I, D-76344 Eggenstein-Leopoldshafen, Germany

Soft magnetic thin films with appropriate high frequency properties are

interesting for applications, e. g., as core material for microinductors and for magnetoelastic sensors/actuators. For the use in such devices, tailoring of the magnetic film properties (e. g. saturation magnetization M_S, coercitive field H_C, anisotropy field H_K) is necessary.

In this study, multilayer films consisting of FeCo as the magnetic constituent and TiN as diffusion barrier are developed. The films are grown by sequential magnetron sputter deposition using a FeCo and a TiN target in an Ar atmosphere with an additional N_2 flow between 0 and 5 % of the total gas flow. The films are annealed *ex-situ* in a static magnetic field. The static and dynamic macroscopic magnetic properties of the films are determined by means of a vibrating sample magnetometer and a strip-line permeameter connected to a vector network analyzer, respectively. The microstructure and constitution of the films are examined by XRD, XRR, TEM and AES depth profiling.

It is shown that films with a coercitive field below 0.2 mT and a sufficient high frequency response can be produced by defining appropriate growth and film annealing conditions. Furthermore, the correlation between the nanoscale coating architecture, the films' microstructure and its macroscopic magnetic properties is presented.

DS 31.5 Thu 17:15 GER 37

Development of higher m supermirrors — •VALICU ROXANA and BORCHERT GUNTHER — FRM II

Supermirrors are important components of neutron guides used for performing neutron scattering experiments for from the reactor core to the instruments, where the background is low enough to permit measurements of even week signals. We will present the methods used at our facility to produce supermirros, the trials that we have made to increase the performances of supermirrors and the results obtained from the neutron reflectivity measurements. Using the Hayter and Mook algorithm we have simulated sequences with increasing number of Ni and Ti layers and we have achieved a neutron reflectivity of around 84% for m equal to 3. The next step in improving our facility was to try the reactive sputtering process (by using N and air as sputter gas together with Ar) in order to achieve the deposition of more layers and therefore of higher m-values. X-ray and neutron reflectivity measurements as well as X-ray diffraction and profilometry for the stress analysis were performed in order to determine the proper parameters for the sputtering of Ni. As a consequence we have produced supermirrors with higher m values that were not able to achieve without the reactive sputtering of Ni. Neutron reflectivity measurements for the produced supermirrors show promising results.

DS 31.6 Thu 17:30 GER 37

Nanostructured magnetic FeCo/TiN thin film composites — •HAYO BRUNKEN, ALAN SAVAN, and ALFRED LUDWIG — Institute of Materials, Faculty of Mechanical Engineering, Ruhr-University Bochum, 44780 Bochum, Germany

In this study, magnetic thin film composites consisting of a nanostructured wear-resistance-coating and a nanogranular ferromagnetic component are presented. The magnetic thin film composites were prepared from a precursor multilayer thin film (FeCo/Ti) using magnetron sputtering. The multilayer precursor structure was deposited as a continuous composition spread on Si/SiO_2 substrates and transformed into a multiphase microstructure by thermal activation (typically 850°C, 1 h) in a reactive atmosphere (N_2). The characterization of the annealed thin films' microstructure using X-ray diffraction indicated a FeCo (100) phase and the formation of a TiN (111) phase. Furthermore, it was found that the films show a coercivity below 2 mT and a high saturation magnetization. Funding by the DFG via the priority program 1299 is gratefully acknowledged.

DS 32: Invited Johnson

Time: Thursday 9:30–10:15 Location: GER 38

Invited Talk DS 32.1 Thu 9:30 GER 38

Optimizing Electronic Properties of Misfit Layered Compounds — •DAVID JOHNSON[1], COLBY HEIDEMAN[2], QIYIN LIN[3], and CLAY MORTENSEN[4] — [1]University of Oregon, Eugene, Oregon, USA — [2]University of Oregon, Eugene, Oregon, USA — [3]University of Oregon, Eugene, Oregon, USA — [4]University of Oregon, Eugene, Oregon, USA

Misfit layered compounds are naturally occurring nanostructured solids that have been reported to have low thermal conductivities on the order of 0.8 Wm-1K-1 and unoptimized figures of merit ZT as large as 0.3. We have recently reported thermal conductivity in [(PbSe)1.00]m[MoSe2]n and [(PbSe)0.99]m[WSe2]n misfit compounds as low as 0.06 Wm-1K-1. Here we describe annealing treatments of these misfit compounds in fixed chalcogen partial vapour pressures and demonstrate that samples equilibrate with the dominant source of vapour, resulting in controlled carrier concentrations. The thermal stability of these materials allows annealing times and temperatures in excess of 24 hours and 500° C to be used without destroying the layered structure. We present data showing the convergence of electrical properties for isostructural samples on annealing. In addition to control of carrier concentrations, the annealing treatments dramatically improve the carrier mobility. We report electrical resistivity, Seebeck coefficients and carrier concentrations as a function of annealing conditions.

DS 33: Thermoelectric Thin Films and Nanostructures I

Time: Thursday 10:30–12:00 Location: GER 38

Topical Talk DS 33.1 Thu 10:30 GER 38

Preparation and Charakterisierung von thermoelektrischen Nanodrähten — •FRIEDEMANN VÖLKLEIN[1], REINHARD NEUMANN[2], SVEN MÜLLER[2], OLIVER PICHT[2], HEIKO REITH[1] und MATTHIAS SCHMITT[1] — [1]Institut für Mikrotechnologien, FH Wiesbaden, Am Brückweg 26, D-65428 Rüsselsheim, Germa — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, D-64291 Darmstadt, Germany

Thermoelectrische Nanodrähte werden bei GSI Darmstadt durch Ionenspur-Technologie und elektrochemische Abscheidung hergestellt. Die thermoelektrischen Eigenschaften von Bismuth- und V/VI-Verbindungshalbleiter-Nanodrähten als Funktion der Kristallstruktur, der Zusammensetzung und der Draht-Abmessungen werden untersucht, um Modelle des Ladungs- und Wärmetransports in niederdimensionalen thermoelektrischen Materialien zu entwickeln. Microchips zur Messung der elektrischen und thermischen Leitfähigkeit und des Seebeck- Koeffizienten von einzelnen Nanodrähten wurden entwickelt und erfolgreich getestet. Diese Messungen gestatten die Bestimmung der thermoelektrischen Effektivität ZT und damit die Prüfung theoretischer Voraussagen hinsichtlich einer Steigerung von ZT in niederdimensionalen Thermoelektrika als Folge von Quantum-Size Effekten bzw. verstärkter Phononen-Streuung.

DS 33.2 Thu 11:00 GER 38

Thermoelectric transport in periodic 1D stacks of InAs/GaAs quantum dots — •VLADIMIR M. FOMIN[1,2,3] and PETER KRATZER[1] — [1]Fachbereich Physik and Center for Nanointegration (CeNIDE), Universität Duisburg-Essen, Germany — [2]TFVS, Departement Fysica, Universiteit Antwerpen, Belgium — [3]PMS, Department of Theoretical Physics, State University of Moldova, Chişinău, Moldova

Superlattices (SLs) of InAs/GaAs quantum dots (QDs) are presently of interest for possible thermoelectric applications. Due to the quantum confinement of electrons and phonons, such SLs are expected to provide an improved figure-of-merit. The present work is aimed at the investigation of a periodic 1D stack of InAs quantum disks in GaAs. Electron minibands for a 3D SL of InAs/GaAs QDs are calculated using the tight-binding approach. The essential features of the obtained minibands, e.g. the distribution of the probability density in

the xy-plane, can be understood within the Kronig-Penney model of a periodic 1D stack of quantum disks. Solution of the dispersion relation for acoustic phonons in a 1D SL with the parameters of the 3D SL of InAs/GaAs QDs confirms the accuracy of a model of an effective medium. Using the obtained electron wave functions and the phonon fields, the relaxation time is calculated and the electric and thermoelectric coefficients for a periodic 1D stack of InAs/GaAs quantum disks are analyzed as a function of their geometric characteristics. V.F. acknowledges the support by the ESF through Exchange Grant No. 2157 within the activity 'Arrays of Quantum Dots and Josephson Junctions'.

DS 33.3 Thu 11:15 GER 38

Fabrication of Si and Si-Ge nanopillars for the investigation of thermoelectric properties — •Nadine Geyer[1], Bodo Fuhrmann[2], Manfred Reiche[1], Trung-Kien Nguyen-Duc[1], Silko Grimm[1], Hartmut S. Leipner[2], and Peter Werner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle/Saale — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Heinrich-Damerow-Str. 4, 06120 Halle/Saale

A renewed interest in thermoelectric materials appeared in the last decade through the search for environment-friendly methods of power generation and the implementation of new concepts of nanotechnology due to the prospect of much higher conversion efficiency. Si nanopillars (NPs) and Si NPs containing a Si-Ge superlattice are expected to have superior thermoelectric properties (figure of merit ZT). Here, we report on the synthesis of the Si and the Si-Ge NPs with diameters below 25 nm. Starting from Si-Ge multilayer structures grown by MBE and combining lithography and metal-assisted chemical etching techniques, hexagonally ordered, vertically aligned Si and Si-Ge NPs were obtained, whose diameter, density and length can be controlled by localized etching. The morphology, the inner structure and the chemical composition were investigated by SEM, TEM and EDX. Future steps will be to investigate the thermoelectric properties of these etched Si and Si NPs containing a Si-Ge superlattice.

DS 33.4 Thu 11:30 GER 38

Thermoelectric properties of thin films made from doped Si and Ge nanoparticles — •Konrad Schönleber[1], Robert Lechner[1], Roland Dietmüller[1], Martin S. Brandt[1], Hartmut Wiggers[2], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching — [2]Institut für Verbrennungs- und Gasdynamik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg

We investigate the applicability of doped Si and Ge nanoparticles for future thermoelectronic devices. The nanoparticles are prepared by plasma decomposition of silane or germane in a microwave reactor and have average sizes between 5 and 50 nm, depending on the preparation conditions. The particles can be doped n- or p-type by phosphorus or boron, respectively. Thin films are prepared by dissolving the particles in a suitable solvent such as ethanol, followed by spin coating. Kapton, silicon, or glass are used as substrates. The doping level and alloy composition of the particle films can be varied by mixing highly doped with undoped and Si with Ge particles, respectively As-deposited films are highly resistive, even at high doping levels and after removal of the native oxide shell surrounding the nanoparticles by HF treatment. In order to obtain sufficiently high conductivity levels for thermoelectric energy conversion, the films are treated with pulsed high energy laser. Electrical and thermal conductivities as well as Seebeck coefficients will be presented as a function of doping level, alloy composition, and laser treatment parameters.

DS 33.5 Thu 11:45 GER 38

Potential & Seebeck Microprobe – Imaging of electrical and thermoelectric materials properties on the microscale — •Pawel Ziolkowski[1], Gabriele Karpinski[1], Dieter Platzek[2], Christian Stiewe[1], Ralf Hassdorf[1], and Eckhard Müller[1] — [1]German Aerospace Center (DLR), Institute of Materials Research, 51170 Cologne — [2]Physics Technology – Development and Consulting (PANCO), 56218 Mülheim-Kärlich

Recent developments turned the Potential & Seebeck Microprobe (PSM) into a powerful tool for electrical functional materials characterisation. A wide spectrum of applications has been demonstrated including thermoelectric cobalt antimonide and bismuth telluride thin films as well as nanostructured thick films. The principle involves a heated probe tip positioned at the surface of a sample coupled to a heat sink. The sample is scanned by mechanically touching and again lift-off from the surface at each position. The tip is heating up the sample in a microvicinity, forming a locally focused temperature gradient. By several measuring circuits, thermovoltages and the temperature drop over the gradient region are recorded, yielding the local Seebeck coefficient. With an electrical current feedthrough, the potential profile over the sample is monitored. Microresolving images both of the Seebeck coefficient and the potential obtained in a single run provide information on functional effects of the distribution of chemical components, phases, alloy constituents, or dopants. The method is particularly helpful in studying functionally segmented or graded materials and suitable for low resistivity materials due to its high-sensitive signal detection limit.

DS 34: Invited Sands

Time: Thursday 14:15–15:00 Location: GER 38

Invited Talk DS 34.1 Thu 14:15 GER 38

Metal/Semiconductor Superlattices as Thermoelectric Metamaterials for Solid-State Energy Conversion — •Timothy D Sands — Purdue University, West Lafayette, IN, USA

Thermoelectric (TE) generators have been used in niche applications, such as deep-space probes, that demand a compact and robust source of electrical power. A significant improvement in efficiency will be necessary to expand the applications of thermoelectrics to waste heat generators for vehicles and energy-intensive industrial processes. As an alternative to conventional thermoelectric materials based on degenerate semiconductors, we have explored an approach based on nitride metal/semiconductor superlattices such as (Zr,W)N/ScN. The metal provides a source of electrons, a fraction of which have energies above the Schottky barrier introduced by the metal/semiconductor interface. The transport is thermionic, yielding a differential conductivity that is asymmetric with respect to the Fermi energy. The high concentration of interfaces in superlattices with nanoscale periods suppresses the cross-plane thermal conductivity to values as low as 1.8 W/m-K, enhancing the figure-of-merit. In this presentation, the progress towards high performance metal/semiconductor thermoelectric metamaterials will be reviewed and remaining challenges will be highlighted.

DS 35: Thermoelectric Thin Films and Nanostructures II

Time: Thursday 15:15–17:00 Location: GER 38

Topical Talk DS 35.1 Thu 15:15 GER 38

Nanotechnological thin film concepts for new thermoelectric materials — •Harald Böttner — Fraunhofer Institut Physikalische Messtechnik Heidenhofstr.8 79108 Freiburg

Thermoelectric converters are multitalented: they cool or generate electricity and do so silently, without maintenance and in particular with extreme reliability. But: all thermoelectric applications depend mainly on the material quality, in the field of thermoelectric defined by the well known Z (thermoelectric figure of merit). It is the main goal for the material development to enhance Z for ZT (T = absolute temperature) values above the critical number of 1. For modern concepts, to achieve e.g. ZT values to up 2, the internal structure of thermoelectric semiconductors is based on different nanoconcepts. Here we will give an overview over different concepts and technological

procedures as well as the typical materials involved. We will focus on thin films nanoconcepts which, particularly, deal with the approach to reduce the thermal conductivity keeping high electrical conductivity, mainly as superlattices. The survey will cover the preparation via PVD methods like thermal evaporation MBE, sputter-techniques and chemical routes for structural self organizing thermoelectric material. The impact of those nanoscale layers stacks on the performance on thermoelectric devices will be discussed and compared to bulk like thin film devices.

Topical Talk DS 35.2 Thu 15:45 GER 38

Nanostructured layered thermoelectric oxides — •Anke Weidenkaff[1], Myriam Aguirre[1], Petr Tomes[1], Stefan Ebbinghaus[2], and Rosa Robert[1] — [1]Empa — [2]Uni Halle

Heat from e.g. solar insolation could be used to provide electricity if the direct thermoelectric energy conversion, i.e. the transformation of heat into electricity becomes fast and highly efficient. For the realisation of an innovative ceramic thermoelectric converter, stable p- and n- type thermoelectric oxides are developed to be tested in Thermoelectric Oxide Modules (TOM). A very promising approach to reduce the thermal conductivity, which is leading to very high theoretical values of ZT, is to increase the amount of grain boundaries by producing nano-scaled semiconductor thermoelectric materials. Suitable candidates are perovskite-type materials. Tailor-made materials with various compositions are chosen and synthesized by chimie douce methods. The power factor is improved by appropriate variations of the composition and the crystallographic structure.

DS 35.3 Thu 16:15 GER 38

Complete thermoelectric characterization of thin films — •Jan D. König — Fraunhofer IPM; Heidenhofstr. 8; 79110 Freiburg; Germany

An enhancement of the thermoelectric performance is needed for a wider use of thermoelectricity. The developments of nanostructured materials such as thin film superlattices have shown a considerable increase of the thermoelectric figure of merit. Such developments are based on the measured values of the physical transport properties and naturally on the accuracy of the measurement itself! So it is necessary to have a closer look on the commonly used thermoelectric measuring techniques and on new cross-plane thermopower and electrical conductivity measuring techniques for thin films. Some comments on standard thermopower and electrical conductivity measurements in the in-plane directions are given. The advantage and disadvantage of the 3Omega methode and the TDTR-methode will be investigated. The Völklein methode will be discussed exemplary as a bridge method to determine the in-plane thermal conductivity. The most challenging problems are the measurement of the cross-plane electrical conductivity and thermopower. The complexity of such measurements are illustrated at some principle approaches. These considerations will give a better understanding of the complexity of thermoelectric measurement techniques for thin films and should be a guideline for an accurate measurement of the thermoelectric properties for material development and verification of the theoretical nanoconcepts for an enhancement of the thermoelectric performance.

DS 35.4 Thu 16:30 GER 38

Thermoelectric properties of $FeSb_2$ thin films — •Peijie Sun[1], Niels Oeschler[1], Ye Sun[2], Simon Johnsen[2], Bo B. Iversen[2], and Frank Stelich[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Department of Chemistry, University of Aarhus, Denmark

$FeSb_2$ is a strongly correlated, narrow-gap semiconductor showing the largest thermoelectric power factor ($> 2000\ \mu W/K^2cm$) so far known at low temperatures [1]. The enhanced thermoelectricity is believed to result from a large electronic contribution from the narrow and correlated bands. However, the large thermal conductivity (> 300 W/Km in single crystals) prevents the realization of a high dimensionless figure of merit ZT for practical electronic cooling application in the cryogenic temperature range. The thermal conductivity might be largely reduced by introducing nanometer-scale internal structures to selectively scatter propagating phonons. In this work, we successfully deposited thin films of $FeSb_2$ by sputtering techniques on various substrates. Thermoelectric properties of the thin films will be presented in comparison to those of the bulk system.

[1] A. Bentien et al, Europhys. Lett. 80 (2007) 17008.

DS 35.5 Thu 16:45 GER 38

Investigation of thermoelectric properties of bismuth telluride thin films after controlled heat treatment — •Katrin Rothe[1,2], Matthias Stordeur[3], Frank Heyroth[1], Hartmut S. Leipner[1], and Bernd Engers[2] — [1]Interdisziplinäres Zentrum für Materialwissenschaften der Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]angaris GmbH, Halle, Germany — [3]HTC, Hallesche Str. 50 06122 Halle, Germany

Thermoelectric (TE) devices of bulk materials have been widely used for power generation or cooling systems based on the Seebeck and Peltier effect. For TE modules bismuth telluride compounds at room temperature are already used for instance in aerospace or sensor systems. Here, TE modules are the only alternative to get a power supply of the components. However, for low dimensional applications the development and further investigations of thin thermoelectric films are necessary. Here, we present a method to enhance the thermoelectric properties of thin film by a fast thermal treatment. Thin films of bismuth telluride were prepared by DC magnetron sputter deposition at different substrate temperatures. The enhancement of the power factor ($S^2\sigma$) depends on the temperature of the substrate and on the thermal treatment. The inner structure, the morphology and chemical composition were investigated by XRD, FESEM and EDX.