

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 EFFERTZ¹, INGOLF SEGGER¹, PHILIP SCHULZ¹, STEFAN LAHME¹, MATTHIAS WUTTIG¹, ARNO CLASSEN², GREGOR DARLINSKI³, and RAINER WASER³ — ¹Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany — ²Institute of Organic Chemistry, RWTH Aachen University, 52056 Aachen, Germany — ³Institut 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 dielectric surface modifications (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) derivatives 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 focused 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 SiO₂, 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 SiO₂ 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 $L = 17 \mu\text{m}$, $38 \mu\text{m}$, $86 \mu\text{m}$, and $187 \mu\text{m}$. 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/SiO₂ 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 BORCZYKOWSKI — Chemnitz University 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 transistors (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-8CN₂) [1] on top on a 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 TIPPO¹, CHANCHANA THANACHAYANONT², STEFFEN SCHULZE³, MICHAEL HIETSCHOLD³, and APINUNT THANACHAYANONT¹ — ¹Faculty of Engineering and College of Data Storage Technology and Applications, King Mongkut's Institute of Technology Ladkrabang, Chalokkrung Road, Ladkrabang Bangkok 10520, Thailand — ²National Metal and Materials Technology Center, Thailand Science Park, Klong 1, Klong Luang, Pathumthani 12120, Thailand — ³Chemnitz 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/SiO₂ 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 VOLLMER¹, XINLIANG FENG², XUAN WANG², LINJIE ZHI², KLAUS MUELLEN², JUERGEN P. RABE³, and NORBERT KOCH³ — ¹HZB-BESSY II, Berlin, Germany — ²Max Planck Institute for Polymer Research, Mainz, Germany — ³Institut f. Physik, Humboldt-Universität zu Berlin, Berlin, Germany

We demonstrate that graphene-based transparent and conductive thin films (GTFCs), 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 GTFCs 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.

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Highly efficient organic blue light emitting devices using doped transport layers — ●NICO SEIDLER¹, SEBASTIAN REINEKE¹, KARSTEN WALZER¹, BJÖRN LÜSSEM¹, AUSRA TOMKEVICIENE², JUOZAS V. GRAZULEVICIUS², and KARL LEO¹ — ¹Institut für Angewandte Physik / Photophysik, Technische Universität Dresden, D-01062 Dresden — ²Department 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]picolate (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 outcoupling 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 central 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.

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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 characterizing 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 Alq₃ (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 SCHÄFER¹, CAMELIU HIMCINSCHI¹, VASILE CHIS², and DIETRICH R. T. ZAHN¹ — ¹Chemnitz University of Technology, Semiconductor Physics, 09107 Chemnitz, Germany — ²Babes-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]) proves 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 (H₂Pc) 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 films — ●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 their potential technical applications as organic semiconductors. Still only few publications cover rare-earth diphthalocyanines. Double-decker phthalocyanines like the here investigated LuPc₂ may yield better properties for technical applications than the commonly studied ones. Almost all phthalocyanines form films with strong optical anisotropy 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 LuPc₂ 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.

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The growth of thin phthalocyanine films probed by Raman scattering — ●BRITT-ELFRIEDE SCHUSTER¹, CAMELIU HIMCINSCHI², PHILIPP SCHÄFER², HEIKO PEISERT¹, THOMAS CHASSÉ¹, and DIETRICH R. T. ZAHN² — ¹Institute of Physical and Theoretical Chemistry, University of Tübingen, Germany. — ²Semiconductor 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 pre-resonance 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.

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Energy levels of new perfluoroalkyl-substituted phthalocyanines derived from electrochemical characteristics — ●STEFFI NAGEL¹, MARTIN LENER¹, CHRISTOPHER KEIL¹, ROBERT GERDES², SERGIU GORUN², and DERCK SCHLETTWEIN¹ — ¹Justus-Liebig-Universität Gießen, Institut für Angewandte Physik, Heinrich-Buff-Ring 16, D-35392, Gießen. eMail: schlettw@uni-giessen.de — ²New Jersey Institute of Technology, Department of Chemistry and Environmental Science, Newark, NJ 07102, USA

Octa(perfluoropropyl) octafluoro phthalocyanine complexes (F₆₄Pc), 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 VRDOLJAK¹, ACHIM SCHÖLL¹, FRIEDRICH REINERT¹, and EBERHARD UMBACH² — ¹Universität Würzburg, Experimentelle Physik II, 97074 Würzburg — ²Forschungszentrum Karlsruhe, 76021 Karlsruhe

Interfaces in electronic devices based on organic semiconductors have a strong influence 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.

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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 BORCZYKOWSKI — 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 and contact angle hysteresis was nearly constant.

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Self-assembled Silane monolayers on silicon oxide — ●HARALD GRAAF, CHRISTIAN BELGARDT, DAVID POLSTER, and CHRISTIAN VON BORCZYKOWSKI — 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 PINGEL¹, DIETER NEHER¹, MARKUS BREUSING², THOMAS ELSAESSER², THOMAS FISCHER³, JOACHIM STUMPE³, JIAN ZHANG⁴, NORBERT KOCH⁴, SYBILLE ALLARD⁵, and ULLRICH SCHERF⁵ — ¹Institut für Physik und Astronomie, Universität Potsdam — ²Max-Born-Institut für Nichtlineare Optik und Kurzzeit-spektroskopie, Berlin — ³Fraunhofer-Institut für Angewandte Polymerforschung, Potsdam — ⁴Institut für Physik, Humboldt-Universität zu Berlin — ⁵Institut 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} cm²/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 CAMPO¹, EDGARDO A. CISTERNAS¹, IGNACIO VERGARA¹, TOMÁS CORRALES¹, ●ULRICH G. VOLKMANN¹, HASKELL TAUB², HAIDING MO³, and STEVEN EHRlich³ — ¹Surface Lab, Facultad de Física, Pontificia Universidad Católica de Chile, Chile — ²Department of Physics and Astronomy, University of Missouri-Columbia, USA — ³NSLS, 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 $\sim 70\%$. 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 FLORIAN¹, IVAN STEFANOV², and GEORGI HADJICHRISTOV³ — ¹Bulgarian Institute of Metrology, 2 Prof. P. Mutafchiev Str., 1797 Sofia, Bulgaria — ²Department of Quantum Electronics, Faculty of Physics, Sofia University, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria — ³Institute 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 10¹⁴-10¹⁷ ions/cm² 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 NIESE¹, MICHAEL HECKER¹, YVONNE RITZ¹, EHRENFRIED ZSCHECH¹, PAUL S. HO², and ●ZHIQUAN LUO² — ¹AMD Fab 36 LLC & Co. KG Dresden, Wilschdorfer Landstraße 101, D-01109 Dresden, Germany — ²Microelectronics 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 Neubiberg

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 SiO₂ hold with high-k materials.

We suggest a simple method of determining interface trap density of a leaky HfO₂ 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 MÖNKEMÖLLER¹, FLORIAN LÜKERMANN¹, MARC SACHER¹, ARMIN BRECHLING¹, ULRICH HEINZMANN¹, HENNING KURZ², FRANK HAMELMANN², and HELMUT STIEBIG² — ¹Molecular and Surface Physics, Bielefeld University, Germany — ²Malibu 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 deposition 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 deposition temperature we observed a change in crystallographic orientation by XRD measurements around 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 KUSCHEL¹, TOBIAS BECKER¹, HAUKE BARDENHAGEN¹, OLIVER HOEFERT¹, MARTIN SUENDORF¹, BERND ZIMMERMANN¹, FLORIAN BERTRAM¹, DANIEL BRUNS¹, MICHAEL PAULUS², CHRISTIAN STERNEMANN², LARS BOEWER², and JOACHIM WOLLSCHLAEGER¹ — ¹Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrueck, Germany — ²DELTA, 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 (SiO₂). 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 hysteresis 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 non-metals. 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 0.7 nm 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°C improve the GMR ratio. However, a deteriorated GMR ratio at the annealing temperature of 300°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 JAKOB¹, TOBIAS EICHHORN¹, JOACHIM BARTH², GERHARD FECHER², CLAUDIA FELSER², and ANKE WEIDENKAFF³ — ¹Institute of Physics, Johannes Gutenberg-University, 55099 Mainz, Germany — ²Institute of Anorganic and Analytical Chemistry, Johannes Gutenberg-University, 55099 Mainz, Germany — ³Empa - Swiss Federal Laboratories for Materials Testing and Research, 8600 Dübendorf, 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 MYATIYEV², SERGIY DIVINSKI¹, and GERHARD WILDE¹ — ¹Institut für Materialphysik, Universität Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany — ²Moscow 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 $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ ($x=0.32$) 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 SCHADE¹, NADINE GEYER^{1,2}, BODO FUHRMANN¹, FRANK HEYROTH¹, PETER WERNER², and HARTMUT S. LEIPNER¹ — ¹Interdisziplinäres Zentrum für Materialwissenschaften, Nanotechnikum Weinberg, Martin-Luther-Universität, 06099 Halle — ²Max-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 $\text{Pb}_{5+x}\text{Sb}_{4-x}\text{S}_{11+x/2}$ with micro- and nanodimensions containing various metal ordering — ●GERALD WAGNER¹, RONNY KADEN¹, KLAUS BENTE¹, and HARTMUT S. LEIPNER² — ¹Institut für Mineralogie, Kristallographie und Materialwissenschaft, Scharnhorststraße 20, Universität Leipzig, 04275 Leipzig — ²Interdisziplinäres 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 thermoelectric 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 $\text{Pb}_{5+x}\text{Sb}_{4-x}\text{S}_{11+x/2}$ 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 TÖLLNER¹, JOHANNES KIMLING¹, RENBIN YANG², and KORNELIUS NIELSCH¹ — ¹University of Hamburg, Institute of Applied Physics, Jungiusstrasse 11, 20355 Hamburg — ²Max 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. UNUCHAK¹, VASILYI A. IVANOV², KLAUS BENTE¹, REINHARD DENECKE³, IGOR KONOVALOV³, GERT KLOESS¹, and VALERiy F. GREMENOK² — ¹Institut für Mineralogie, Kristallographie und Materialwissenschaft, Universität Leipzig, Scharnhorststraße

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The ternary semiconductor PbSnS₂ (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 °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.