DS 38: Layer Properties: Electrical, Optical and Mechanical Properties

Time: Thursday 14:00–16:45 Location: H8

DS 38.1 Thu 14:00 H8

Modification of coherent acoustic phonon lifetimes in thin gold films by self-assembled monolayers — •Mike Hettich[1], Axel Bruchhausen[1], Oliver Ristow[1], Daniel Issenmann[1], Tobias Geldhauser[1], Ingo Wenke[2], Jürg Bryner[2], Jürg Dual[2], and Thomas Dekorsy[1] — [1]Department of Physics and Center of Applied Photonics, Universität Konstanz, Germany. — [2]Institute for Mechanical Systems, ETH Zürich, Switzerland.

The damping of coherent acoustic phonons in thin gold films has been investigated by asynchronous optical sampling (ASOPS)[1].

In order to measure the damping constants for various frequencies gold films are grown in a wedge shape. Different film thicknesses correspond to changes in the phonon oscillation frequencies which can therefore be measured by scanning over the sample surface.

For lower frequency phonons in the range of 50 GHz to ∼ 75 GHz a significant change in damping times is observed when a self assembled monolayer is added between the gold film and the substrate. The damping behaviour with and without self-assembled monolayer has been modelled with good agreement by a visco-elastic simulation.

[1] A. Bartels et al., Rev. Sci. Instr. 78, 035107 (2007).

DS 38.2 Thu 14:15 H8

Preparation and optical properties of metal–insulator–metal devices based on Ti and Ta for Photocurrent and Chemocurrent applications — •Kevin Stella[1], Domocos Kovacs[1], Detlef Diesing[1], Wolfgang Brezna[2], and Jürgen Smoliner[2] — [1]Institut für Physikalische Chemie, Universität Duisburg Essen — [2]Institut für Festkörperelektronik, Technische Universität Wien

The optical and electrical properties of amorphous titanium and tantalum oxide films with thicknesses of 2.5-5 nm are investigated. As characterisation methods we used experiments with bias and photoinduced currents in the respective metal-metal oxide-gold junctions. The photoyield recorded for wavelengths between 200 and 1600 nm shows significant increases for higher energies than 3.5 eV and 4.4 eV for the titanium respectively tantalum samples. These values coincide with the band gaps found in literature for bulk samples of the oxides. Deviations from the ideal behaviour can be observed in bias induced currents. Voltage pulse experiments and the subsequent recording of the current transient let us assign a trap density of several $10^{15} cm^{-2}$. Since the photoyield with energies below 2 eV shows a broadband like behaviour, one can discuss the role of the traps as midgap states in the oxide film. The bias dependence of the photocurrent is explained within a two flux model of photoelectrons and photoholes.

DS 38.3 Thu 14:30 H8

Preparation of polymer/metal-multilayers by pulsed laser deposition — •Susanne Seyffarth, Britta Lena Fuchs, Sarah Hoffmann, Inga Knorr, Cynthia Volkert, and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen

Polymer/metal multilayer structures are model systems to study the mechanical behaviours of composite materials. Layered polymer/metal nanocomposites consisting of poly(methyl methacrylate) PMMA and Cu were deposited by pulsed laser deposition (PLD) at room temperature. At this, a laser fluence of 120 mJ/cm^2 close to the deposition threshold was used to obtain smooth PMMA films without droplets, while for Cu a much higher laser fluence of 6 J/cm^2 is necessary. On the smooth polymer layers, the metal shows Volmer-Weber island growth leading for thin Cu-films to layered PMMA/Cu nanostructures with spherical metallic particles. For larger metal layer thicknesses, the metal layers are closed and PMMA/Cu multilayers are formed. The composition of PMMA was studied by infrared spectroscopy (FTIR). Atomic force microscopy (AFM) was used to study the surface morphology. Cross-section slices of the layered structures cut by focused ion beam (FIB) were examined by electron microscopy (SEM, TEM). It was found that indeed well layered PMMA/Cu-structures can be formed by PLD, but stress formation leads to buckles and waves of the metal layers as long as the PMMA layers are soft. In this contribution it is discussed how smooth metal and polymer layers can be obtained.

DS 38.4 Thu 14:45 H8

Investigation of structural and mechanical properties of pulsed laser deposited PMMA films — •Felix Schlenkrich[1], Britta Lena Fuchs[1], Peter Grossmann[2], Klaus Mann[2], and Hans-Ulrich Krebs[1] — [1]Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen — [2]Laser-Laboratorium Göttingen e.V., Hans-Adolf-Krebs-Weg 1, D-37077 Göttingen

Smooth poly(methyl methacrylate) (PMMA) films without any droplets were pulsed laser deposited at a wavelength of 248 nm and a laser fluence of 125 mJ cm^{-2}. After deposition at room temperature the films obey a low universal hardness of only 3 N mm^{-2}. Thermal treatments up to 200°C, either during deposition or afterwards lead to a film hardening up to values of 200 N mm^{-2}.

Using a combination of complementary methods, two main mechanisms could be made responsible for this temperature induced hardening effect well above the glass transition temperature of 200°C. The first process is induced by the evaporation of chain fragments and low molecular mass material, which are present in the film due to the deposition process, leading to an increase of the average molecular mass and thus to hardening. The second mechanism can be seen in the cross-linking of the polymer film as soon as chain scission occurs at higher temperatures and the mobility and reactivity of the polymer material is high enough.

DS 38.5 Thu 15:00 H8

Photo-switchable azomolecule containing nanocomposites — •Christina Pakula[1], Christian Hanisch[1], Thomas Strunskus[1], Dordaneh Zargarani[2], Vladimir Zaporojtchenko[1], Rainer Herges[2], and Franz Faupel[1] — [1]Materialverbunde, Institut für Materialwissenschaft, CAU Kiel, Kaiserstr. 2, 24143 Kiel — [2]Otto Diels-Institut, CAU Kiel, Otto-Hahn-Platz 3/4, 24118 Kiel

We report on the electro-optical properties of nanocomposites based on polymer thin films with dissolved azobenzene chromophores containing embedded gold nanoparticles. The physical properties of these composites can be changed reversibly by illumination with UV and visible light, due to the conformational change of the switchable azomolecules. We examined the isomerization and the time dependence in optical switching with UV and visible light of an azobenzene ether dissolved in a PMMA (and a PDMS) matrix in combination with 2D and 3D gold nanoparticle arrays. The chromophore/polymer film was prepared by spin-coating and the metal clusters were deposited either by thermal evaporation or via sputtering and subsequently embedded into the polymer matrix. We discuss the photo-switchable changes in resistance of the 2D/3D-Au nanocomposite films. To improve the reversible switching effect, composites with MWCNTs instead of gold nanoparticles have also been tested and the results will be discussed.

DS 38.6 Thu 15:15 H8

Electrical properties of magnetron sputtered ZnO:Al samples determined by Hall and Seebeck measurements — •Wilma Dewald[1], Volker Sittinger[1], Bernd Szyszka[1], Mark Wimmer[2], and Florian Ruske[2] — [1]Fraunhofer Institute for Surface Engineering and Thin Films (IST), Bienroder Weg 54E, 38108 Braunschweig, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Kekuléstraße 5, 12489 Berlin, Germany

Transparent conductive oxides (TCOs) play a big role in display and photovoltaic technology. One of the most promising materials for photovoltaic applications is aluminum doped zinc oxide. The electrical properties of differently prepared ZnO:Al films will be analyzed in this paper.

Carrier mobility and free carrier density are varying in a wide range depending on the preparation method and doping level. Reactive mid frequency magnetron sputtering of a metallic Zn:Al target, radio frequency and direct current magnetron sputtering of a ceramic ZnO:Al_2O_3 target are considered as well as the post deposition annealing of samples, which increases mobility significantly. The carrier mobility in polycrystalline aluminum doped ZnO is limited by scattering at grain boundaries and at ionized impurities. With Hall and Seebeck measurements insight will be given in transport and scatter mechanisms for the different samples.

DS 38.7 Thu 15:30 H8

$SnSe_2$: An XAS study on the atomic and electronic structure

— •Peter Zalden[1], Julia van Eijk[1], Carolin Braun[2], Wolfgang Bensch[2], Matthieu Micoulaut[3], and Matthias Wuttig[1] — [1]I. Physikalisches Institut (IA), RWTH Aachen, 52056 Aachen — [2]Institut für Anorganische Chemie, Univ. Kiel, 24118 Kiel — [3]Lab. de Physique Théorique de la Matière Condensée, UPMC, Paris 6

Phase-change materials (PCMs) show remarkable properties from a scientific and technological point of view: They are employed in nonvolatile memory applications, while the general motif of the fast crystallization mechanism is still under investigation. Data storage with PCMs is based on different optical reflectivities and electronic resistivites of the metastable amorphous and crystalline phases. Although being employed in devices, several PCMs are chemically unstable, thus limiting the number of switching cycles.

In this study, $SnSe_2$, a rather uncommon candidate for PCMs has been investigated because of the stability of its crystalline and amorphous phases. Therefore, long data retention as compared to other PCMs should be possible. EXAFS measurements have been performed on both K absorption edges of the amorphous and crystalline phases, resulting in structural models for both phases. Although $SnSe_2$ has a small contrast in reflectivity, the electronic conductivity changes by several orders of magnitude. This might enable the application in case of a lower demand for write speed.

DS 38.8 Thu 15:45 H8

Preparation and characterization of $CuCrO_2$ — •Christina Polenzky, Kai Ortner, and Bernd Szyszka — Fraunhofer IST, Bienroder Weg 54E, 38108 Braunschweig, Germany

Transparent conductive oxides (TCOs) are promising materials for future application in the field of transparent electronics. The still existing lack of p-TCOs results from different reasons. Firstly, delafossites need high temperatures ($> 800\,°C$) for crystallization which makes the coating difficult for most of the substrates used in industry. Secondly, as state of the art, the carrier concentration (n) and mobility (μ) are too low for suitable application.

In our work, we present results of the preparation and characterization of $CuCrO_2$. The synthesis of these materials from the gas phase by PVD will be demonstrated: The hollow cathode gas flow sputtering process is used for these materials for the first time. The dependency of the correct stoichiometry from gas flow and target composition is shown. Post-preparation annealing leads to better results by using a special atmosphere. So, the synthesis temperature is lowered for $CuCrO_2$ below 700 °C. $CuCrO_2$ shows p-type conductivity because of a positive Seebeck coefficient of $+477\ \mu V/K$. Furthermore, our delafossite materials reach transparencies up to 70 % in the visible spectrum of light.

With our work, we are able to improve the preparation of p-type TCOs and to bring them on the way into the future of transparent electronics.

DS 38.9 Thu 16:00 H8

Electrical transport in Al-doped ZnO/Ag/Al-doped ZnO multilayer systems — •Martin Philipp[1,2], Christian Hess[1], Hartmut Vinzelberg[1], Bernd Büchner[1], Hadia Gerardin[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 Paris 6, CNRS UMR 7588, F-75015 Paris, 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 by means of electrical transport and Hall effect measurements. The resistivity was measured in dependence of temperature and magnetic field on layer stacks of different silver film thicknesses. The results were analyzed using different thin film resistivity models in order to understand the basic scattering mechanisms inside the films. Furthermore the effect of annealing was studied.

DS 38.10 Thu 16:15 H8

Characterization of ion beam modified polyimide layers — •Daniel Friedrich[1], Marcel Michling[1], Dieter Schmeisser[1], Yuri Koval[2], and Paul Müller[2] — [1]Brandenburgische Technische Universität Cottbus, Angewandte Physik/Sensorik, K.- Wachsmann-Allee 1, 03046 Cottbus — [2]Universität Erlangen Nürnberg, Experimental Physik/Supraleitung, Erwin-Rommel-Str. 1, 91058 Erlangen

Ion beam modified polyimide show high conductivity. In our investigation we focus on the electronic structure and the element composition, in order to understand the mechanism of conductivity. In our experiments we use the methods NEXAFS and PES. The measurements were done at the U49/2-PGM2 beam line of BESSY II, Berlin. We find an increase of the sp2 hybridized graphite contribution, after low Ar^+ ion doses bombardment while the temperature of the samples is varied from 300 K to 650 K. In addition we follow the He^+ bombardment induced changes by in-situ monitoring of the O1s, N1s content in the polyimide films.

DS 38.11 Thu 16:30 H8

In-situ investigation of swift heavy ion beam induced dewetting of thin oxide films — •Wolfgang Bolse[1], Sankarakumar Amirthapandian[1,2], and Florian Schuchart[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen, Universität Stuttgart — [2]on leave from: IGCAR, Kalpakkam, India

Recently we have reported dewetting of thin oxide films on Si during irradiation with swift heavy ions [1]. The dewetting patterns compared surprisingly well with those observed when melting polymer films on Si [2], although the irradiation was performed at 80 K, far below the melting point of the oxides. Hence, the dewetting processes and driving forces must be similar. In fact, we could identify the same hole nucleation mechanisms as reported for the polymers: heterogeneous nucleation at interfacial defects and spontaneous (homogeneous) nucleation due to (thermal) film density fluctuations. Using our new in-situ high resolution scanning electron microscope at the UNILAC accelerator of GSI, we are now able to follow the history of individual holes and determine their growth kinetics. In our first experiments we could show, that ion induced dewetting exhibits hole growth with rim formation, with the hole area being proportional to the applied ion fluence after the hole has fully evolved. This points at a growth mechanism which is controlled by the dissipation of the material removed from the hole. Capillary forces dominated growth (exponential increase with fluence) could be identified in the early stages of dewetting.

[1] T. Bolse, et al., Nucl. Instr. Meth. B 244 (2006) 113
[2] S. Herminghaus, et al., Science 282 (1998) 916