DS 1: Layer properties: electrical, optical, and mechanical properties

Time: Monday 9:30–12:15 Location: H 0111

DS 1.1 Mon 9:30 H 0111

Emission of x-rays produced by peeling adhesive tape in vacuum — •Daniel Krämer, Dirk Lützenkirchen-Hecht, and Ronald Frahm — Bergische Universität Wuppertal

Adhesive tapes can produce x-rays with energies up to about 100 keV when being peeled in a vacuum. The spectra of the emitted photons were measured with an Amptek Si-PIN-Detector and their dependence on several parameters like type of adhesive tape, gas pressure and peeling speed was investigated in detail.

The mechanism for x-ray emission is: Charge separation at the peeling vertex and build-up of an electric field with an accelerating potential up to typically 100 kV, acceleration of free electrons of the residual gas, and x-ray photon production by bremsstrahlung on the tape, thus leading to continuous spectra without characteristic emission peaks. A maximum count rate was found at $p_{Max} = 10^{-2}$ mbar. Below p_{Max} fewer photons are produced because of less molecules in the gas which could be ionized and be a source for free electrons. Above p_{Max} the separated charges are neutralized by ions, resulting in a decreasing count rate that vanishes at ∼1 mbar.

DS 1.2 Mon 9:45 H 0111

Characterizing periodic gratings and metamaterials using spectroscopic ellipsometry — •Thomas Oates[1], Babak Dastmalchi[2], Goran Isic[3], Iris Bergmair[4], Kurt Hingerl[2], and Karsten Hinrichs[1] — [1]Leibniz Institut für Analytische Wissenschaften - ISAS - e.V., 12489 Berlin — [2]Johannes Kepler University, Linz — [3]Institute of Physics Belgrade, Belgrade — [4]PROFACTOR GmbH, Steyr-Gleink, Austria

The recent availability of relatively large area Vis-NIR metamaterials (cm2) now allows accurate optical measurements by well established plane-wave reflection and transmission techniques. In this work we use spectroscopic ellipsometry (SE) to characterize subwavelength periodic gratings and fishnet metamaterials with artificial magnetic resonances. The materials are fabricated by nanoimprint lithography (NIL). Three samples are investigated, all with period of 365 nm; a single layer square silver grating on silicon; a 3 layer silver/SiO2/silver grating on silicon; and an identical 3 layer grating on glass. VASE data is measured from 245 - 1700 nm. We will show that a comparative study of the same metamaterials on different substrates assists in mode identification, but changes the effective material parameters. Any ellipsometric investigation necessarily requires consideration of the angular-dependent optical response. We will show that this aids in the identification of the physical origin of the optical modes. We will conclude by exploring the potential of standard ellipsometric analysis to identify magnetic-type resonances and negative refraction.

DS 1.3 Mon 10:00 H 0111

In Situ-Controlled Oxidation of High-Speed Surface Emitting Lasers and Single-Photon Sources — •Gunter Larisch, Werner Hofmann, and Dieter Bimberg — Institute of Solid State Physics & Center of Nanophotonics, Technische Universität Berlin

Precise control of the oxidation progress is needed for the production of the apertures of oxid-confined VCSELs and single photon sources [1]. So far, the size of the aperture was determined by ex situ measuring of the electrical resistance of oxidized test samples [2]. This method proved to be very time consuming and not reliable. Therefore, an optical in situ method was developed that will be presented here. Problems such as vibration-free mounting of the microscope (used for imaging) and high-contrast fluoroscopy of the top DBR with a suitable light source are presented and illustrated with examples. Test structures adapted to the new method are introduced and discussed. The improved process of oxidation control allows the visualization of the progress of oxidation during the oxidation. This enables a significant reduction of processing time and cost. In addition, a higher yield of precision components processed by increasing the processing accuracy is achieved.

[1] Mutig, A. et al.: "Progress on High-Speed 980 nm VCSELs for Short-Reach Optical Interconnects," IEEE J. Sel. Top. Quantum Electron., 2011. [2] Choquette, K. et al.: "Advances in Selective Wet Oxidation of AlGaAs Alloys," IEEE J. Sel. Top. Quantum Electron., 1997.

DS 1.4 Mon 10:15 H 0111

Picosecond ultrasound spectroscopy on NiTi and NiMnGa thin film shape memory alloys — •Jan Mayer, Mike Hettich, Martin Schubert, and Thomas Dekorsy — Department of Physics, University of Konstanz, D-78457 Konstanz

Shape memory alloys are characterized by a reversible and diffusionless structural transition from a high-temperature austenitic phase to a low-temperature martensitic phase, induced by stress or temperature [1]. The material systems we investigate are NiTi and Ni_2MnGa thin films of 110 nm and 150 nm thickness, respectivly. Ni_2MnGa is ferromagnetic and has a great potential for applications due to the magnetic-field-induced shape memory effect with reversible strains of up to 9 % [2]. The films are investigated using asynchronous optical sampling (ASOPS). ASOPS is a novel technique for ultrafast time domain spectroscopy [3] and enables optical pump-probe measurements with femtosecond resolution. By measuring the change in reflectivity the vibrational dynamics of the samples are studied. The obtained coherent phonon spectra allow to study the structural phase transition in alloys of various stoichiometry. Due to the strong dependence of the transition temperature on composition [4], it is possible to investigate both phases at room temperature. The vicinity of the phase transition is analyzed by heating and cooling the samples.

[1] Martynov and Kokorin, J. Phys. III France 2, 739-749 (1992)
[2] Sozinov et al., Appl. Phys. Lett, 80, 1746 (2002)
[3] Bartels et al., Rew. Sci. Instr. 78, 035107 (2007)
[4] Chernenko et al., Acta Materialia 50, 53-60 (2002)

DS 1.5 Mon 10:30 H 0111

Influence of ion beam and geometrical parameters on properties of Si thin films grown by Ar ion beam sputtering — •Carsten Bundesmann, René Feder, and Horst Neumann — Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstr. 15, 04318 Leipzig, Germany

Ion beam sputtering (IBS) offers, in contrast to other physical vapour deposition techniques, such as magnetron sputtering or electron beam evaporation, the opportunity to change the properties of the layer forming particles (sputtered and scattered particles) by varying ion beam parameters (ion species, ion energy) and geometrical parameters (ion incidence angle, emission angle). Consequently, these effects can be utilized to tailor thin film properties [1].

The goal is to study systematically the correlations between the primary and secondary parameters and, at last, the effects on the properties of Si thin films, such as optical properties, stress, surface topography and composition. First experimental results are presented for Ar-ion sputtering of Si.

Financial support by DFG within project BU2625/1-1 is gratefully acknowledged.

[1] C. Bundesmann, I.-M. Eichentopf, S. Mändl, and H. Neumann; Thin Solid Films 516, 8604-8608 (2008).

DS 1.6 Mon 10:45 H 0111

Stress induced buckling in laser deposited polymer/metal-nanocomposites — •Susanne Schlenkrich, Felix Schlenkrich, Inga Knorr, Cynthia Volkert, and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich Hund Platz1, 37077 Göttingen

Multilayer thin films with dimensions at the nanometer scale represent a technologically important class of materials where the interface and size effects play an important role. Interestingly, when polymer/metal multilayers are deposited by pulsed laser deposition (248nm, 30ns pulse duration) one observes stress induced buckling of the metal layers in case of polymers with low young*s modulus. Compressive stress in the metal layers is induced due to the high energy of the deposited ions. The beam theory can be used to describe the relation between the wavelength of the buckles and the properties of both film components. This understanding makes it possible to use the wavelength as a measurement for the mechanical properties of the film components. Furthermore, the wavelength can be tuned by changing/adjusting the layer thicknesses of both components. In this contribution buckling effects of these periodic structures are discussed and a new measurement technique to characterize the mechanical properties of extremely soft and thin films will be presented.

DS 1.7 Mon 11:00 H 0111

Role of surfactants and defect generation in CdSe quantum dot layers for separation of photo-generated charge carriers — •Elisabeth Zillner, Steffen Fengler, and Thomas Dittrich — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin

Thin layers of CdSe quantum dots (QDs) were prepared by dip coating of ITO substrates in QD suspension. Surface modification of QDs was done by surfactant exchange in suspensions and layers. Interparticle distances between QDs in layers were monitored by transmission electron microscopy. Absorption and photoluminescence spectra showed an increase in defect states by proceeding surfactant exchange. The charge separation in the CdSe QD layers was strongly influenced by the surface modification. Both spectral and time dependent SPV showed a high dependency on surfactant exchange. Results are discussed on basis of asymmetric trapping at defect states within the first monolayer of QDs at the interface during initial charge separation.

DS 1.8 Mon 11:15 H 0111

Temperature dependent relaxation of separated charge carriers at CdSe-QD / ITO interfaces — •Steffen Fengler, Elisabeth Zillner, and Thomas Dittrich — Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin

One and 5 monolayers of CdSe quantum dots with fixed diameter were deposited on ITO substrates by dip coating and investigated by transient surface photovoltage (SPV) at temperatures up to 250°C. The SPV transients were excited with laser pulses (duration time 5 ns) and measured in vacuum at times up to 0.2 s. SPV transients arose within the laser pulse and could be well fitted with one (one monolayer of CdSe-QDs) or two (5 monolayers of CdSe-QDs) stretched exponentials. The parameters of the stretched exponentials changed depending on defect generation during heating as well as on thermal activation processes during heating and cooling. During cooling, the mean relaxation times of both processes were thermally activated with an activation energy of 0.9 eV. Defect generation strongly affected charge separation and relaxation within the first monolayer at the CdSe-QD / ITO interface and between the first monolayer of CdSe-QDs and following CdSe-QD layers.

DS 1.9 Mon 11:30 H 0111

Electrical conductivity of CNT modified surfaces: Theoretical model — •Fedor Semeriyanov, Alexander Chervanyov, and Gert Heinrich — Leibniz Institute of Polymer Research Dresden, Dresden, Germany

We use a combination of the Monte Carlo simulations and self-consistent field theory in order to calculate electrical conductivity of non-uniform layer of carbon nanotubes (CNT) deposited onto a glass surface. As a first step, we determine density structure of this CNT layer by using the self-consistent field theory with the effect of CNT stiffness taken into account. The developed method makes it possible to study the dependence of the CNT layer density structure (including relative amounts of loops, tails and trains) on the affinity of the substrate surface for CNT's. Next, we incorporate the obtained density structure into the Monte Carlo simulations of the electrical conductivity of CNT modified surface. As a final step, we obtain the relation between the number of CNT-CNT contacts in the film with depth dependent density and its dc conductivity. This work is supported by DFG SPP1369.

DS 1.10 Mon 11:45 H 0111

Electromigration in Ag Nanowires with a Controlled Single Grain Boundary — •Simon Sindermann, Michael Horn-von Hoegen, Guenter Dumpich, and Frank-J. Meyer zu Heringdorf — Faculty of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE) University Duisburg-Essen

The combination of epitaxial growth and focused ion beam (FIB) milling enables us to fabricate single- and bi-crystalline electromigration (EM) test structures. Depending on the growth parameters, epitaxial Ag islands on a Si(111) surface can consist of a composition of two areas of different lattice orientation [1]. Such islands are used to be structured into Ag nanowires. For electrical isolation, a silicon on insulator (SOI) substrate is used, the device layer of which is cut with FIB [2]. To monitor the EM process, an image sequence of the Ag nanowires during electrical stressing is captured *in-situ* with a scanning electron microscope (SEM). We are able to identify nm-sized voids and hillocks, and can follow them from nucleation up to the failure of the test structure. Amongst stationary (growing and shrinking) voids, some voids were found to propagate along the nanowire and merge with other voids. The shape of voids is strongly influenced by the crystal lattice symmetry [3], especially for voids overcoming the grain boundary. A correlation of the point of failure and the position of the grain boundary will be discussed.

[1] D. Wall et al. IBM J. Res. and Dev., **55** (2011) 9
[2] S. Sindermann et al. Rev. Sci. Instrum., (2011) in revision
[3] A. Latz et al. Phys. Rev. B, (2011) in revision

DS 1.11 Mon 12:00 H 0111

Simulation of electromigration effects on voids in monocrystalline Ag films — •Andreas Latz and Dietrich E. Wolf — Physics, University Duisburg-Essen, Duisburg, Deutschland

Due to the decreasing width and thickness of interconnects with each integrated circuit generation, electromigration phenomena in the different monocrystalline parts of the interconnects become of increasing interest. We investigate how voids penetrating a monocrystalline silver film are affected by electromigration. Based on the kinetic Monte Carlo method, we developed a three dimensional, atomistic simulation model that is fast enough to access the desired time scales to investigate electromigration phenomena on an atomistic scale. A clear dependency between the strongly facetted non-equilibrium shape of the voids and the crystallographic orientation of the film is found, which is in accordance with experimental results on bicrystalline silver wires. This work has been supported by German Science Foundation within SFB 616: Energy Dissipation at Surfaces.