DS 16: Functional Oxides

Time: Tuesday 17:00–19:45 Location: H 2032

Invited Talk DS 16.1 Tue 17:00 H 2032

Zinc Oxide Nanostructures: Optical resonators and lasing — •Klaus Thonke[1], Anton Reiser[1], Martin Schirra[1], Martin Feneberg[1], Guenther M. Prinz[1], Tobias Röder[1], Rolf Sauer[1], Johannes Fallert[2], Felix Stelzl[2], Heinz Kalt[2], Stefan Gsell[3], Matthias Schreck[3], and Bernd Stritzker[3] — [1]Institut für Halbleiterphysik, Universität Ulm, D-89069 Ulm — [2]Institut für Angewandte Physik, Universität Karlsruhe (TH), D-76128 Karlsruhe — [3]Experimentalphysik IV, Universität Augsburg, D-86135 Augsburg

ZnO allows to grow a wide variety of nanostructures: Simple nanoclusters, -wool, ribbons, comb- and tree-like structures, tetrapods, pillars etc. All kinds of growth methods are used like metal-organic vapour phase epitaxy, molecular beam epitaxy, magnetron sputtering, pulsed laser deposition, vapour deposition with or without catalysts, electrodeposition, spray pyrolysis, or even simple wet chemistry methods. For application as sensors and optoelectronic devices nano-pillars are of special interest. Best structural quality and purity can be obtained with high temperature-processes around 900°C. We will show here examples of rather well-faceted hexagonal pillars grown on sapphire and silicon/iridium (fcc) substrates. Performing CL with high spatial resolution on as-grown single pillars we find UV light standing waves in pillars with appropriate diameters. These pillars show competing well-resolved spectral laser modes. Time-resolved measurements reveal the transition from spontaneous to stimulated emission and allow to study the electron-hole plasma driven lasing dynamics in more detail.

DS 16.2 Tue 17:30 H 2032

Switching and microstructural characterization of a Pt/TiO_2/Pt capacitor stack as nonvolatile ReRAM — •Herbert Schroeder, Jun Miao, and Doo Seok Jeong — IEM im Institut für Festkörperforschung und CNI, Forschungszentrum Jülich GmbH, D-52425 Jülich

Switchable resistors are discussed as nonvolatile resistive memory (NV-ReRAM) devices for future ultra-large scale-integrated memory chips in cross-bar architecture because of their simple geometry. A large variety of candidates is presently under discussion including paraelectric oxides. We have produced metal/insulator/metal (MIM) capacitor stacks with thin TiO_2 films between platinum electrodes and investigated the electrical and microstructural properties. As they are highly insulating they have to be electroformed to show the desired memory switching. In this contribution detailed experimental data on electrical and microstructural characterization are presented in order to demonstrate correlations and conclude on mechanisms controlling the forming and the switching. Besides ex-situ, sequential investigations also first results on in-situ experiments in electron microscopes are reported, i.e. the electrical current/voltage was applied during observation in a SEM and TEM. Main results are: a) Both memory switching modes, the symmetrical unipolar switching and the asymmetrical bipolar switching have been observed dependent on the forming sequence. b) Using very thin, electron transparent top electrodes (10-30 nm) and thin TiO_2 film (27nm) we could observe localized structural changes dependent on the forming sequence and the polarity of the forming.

DS 16.3 Tue 17:45 H 2032

Sputter deposited $LiCoO_2$ films as cathode material in thin-film batteries — •Tobias Stockhoff, Frank Berkemeier, and Guido Schmitz — Institut für Materialphysik, Westfälische Wilhelms-Universität Münster, 48149 Münster (Westf.), Germany

$LiCoO_2$ films of a thickness between 50 and 200 nm are deposited onto a Si-substrate by ion beam sputtering using Ar as sputter gas. The films are prepared under different deposition conditions by varying substrate temperature and the partial pressure of the oxygen, respectively. The chemical, structural, and electrical properties of the films are studied by means of TEM, XRD, and electrical measurements. Analytical TEM shows an oxygen deficiency in films sputtered under pure argon atmosphere and demonstrates the increase of the oxygen content if films are sputtered under an argon-oxygen ratio of 1:2. Due to the increased oxygen content, a significant increase of the specific dc-conductivity of the layers of about two orders of magnitude is observed in the electrical measurements. While at lower substrate temperatures XRD measurements show a film structure similar to the LT-phase of $LiCoO_2$, at a substrate temperature of 600°C and an oxygen-argon ratio of 3:2 the HT-phase of $LiCoO_2$ is found, preferential orientated in <00l> direction. An electrochemical analysis of the films proves their potential for application in electrochemical cells.

Invited Talk DS 16.4 Tue 18:00 H 2032

Electrochromic coatings and windows — •Sabine Heusing — INM-Leibniz-Institut für Neue Materialien gGmbH, Campus D2 2, D-66123 Saarbrücken, Germany, e-mail: sabine.heusing@inm-gmbh.de

Electrochromic (EC) windows, also called "smart windows", change their optical properties (transmittance or reflection) in a reversible manner when a voltage is applied and a current flows through them. Large EC glazing are of considerable interest for architectural, automotive and aeroplane applications in order to control the solar radiation entrance to save energy costs for air conditioning in summer and for heating in winter (especially for buildings and automotives) and also to add comfort factors like privacy and to avoid glare and fading. EC windows have usually the configuration glass/ TCO/ EC-layer(1)/ electrolyte/ EC-layer(2) or ion-storage (IS) layer/ TCO/ glass, whereby TCO means transparent conductive oxide as e.g. tin doped indium oxide (ITO). As EC layer different metal oxides as cathodic electrochromic tungsten oxide and niobium oxide or anodic electrochromic nickel oxide can be used. These materials change their transmission reversibly by reduction (or oxidation) and insertion (extraction) of small ions (e.g. H+, Li+). The most studied EC material is the tungsten oxide due to its high coloration efficiency. The electrochromic materials and the electro-optical methods for characterisation of the EC-layers and the EC-windows will be presented. Furthermore the different techniques for the production of EC-layers and EC-windows will be shown and an overview of the large area EC glazing on the market or in prototype production and their typical features will be given.

Invited Talk DS 16.5 Tue 18:30 H 2032

Semiconducting metal oxides for gas sensors — •Tilman Sauerwald and Thorsten Wagner — Institut für Angewandte Physik, Justus Liebig Universität Giessen, Germany

Gas sensors based on semiconducting metal oxides like SnO_{2-x}, WO_{3-x} and Ga_2O_{3-x} are useful devices for the detection of hydrocarbons e.g. solvents. The sensor effect is based on a change in conductivity of the material caused by chemical reactions on the surface. In ambient air the surface of the metal oxide is covered by adsorbed, negatively charged oxygen. This leads to a depletion of electrons close to the surface (typically ∼10 nm). In granular films (commonly used) the conductivity is determined by the resulting surface barrier. For optimal sensing properties the structural size has to be comparable to the size of the depletion layer. Such structures can be obtained by a classical sol-gel process but they are not thermally stable. Methods utilizing selfassembly processes like endo- and exotemplating produce highly ordered nanostructures with enhanced stability. The reactivity of the metal oxide surface depends on different properties such as the acidity/basicity or the coverage with surface oxygen. Different surface acidity can be obtained by using different metal oxides and surface additives, this can be used for selective detection of solvents. The coverage with surface oxygen can be modulated by the modulation of the density of bulk donors by electrochemical polarisation of the sensor film

DS 16.6 Tue 19:00 H 2032

Structure and electronic properties of Scandate/Titante multilayers determined by high-resolution TEM/STEM and EELS — Martina Luysberg[1], •David Avila[1], Markus Boese[1], Tassilo Heeg[2], and Jürgen Schubert[2] — [1]Institut für Festkörperforschung und Ernst Ruska-Centrum, Foschungszentrum Jülich, 52425 Jülich — [2]Institut für Bio- und Nanosysteme, Foschungszentrum Jülich, 52425 Jülich

Because of their large dielectric constant rare earth scandates are promising candidates for the replacement of conventional gate oxides in MOSFET devices. In addition, they have a large potential to serve as substrate material for the epitaxial growth of perovskites, which are strained according to the lattice mismatch. The strain engineering of earth alkali titanate layers allows to tune their dielectric properties.

Here we report on structural and electronic properties of epitaxi-

ally grown $DyScO_3/SrTiO_3$ multilayers. Aberration corrected, high resolution TEM reveals prefect epitaxial layers, and allows for measurements of the strain. Aberration corrected STEM in connection with high resolution EELS gives information about the chemical and electronic properties. In particular, the near edge fine structure of the titanium $L_{2,3}$-edge shows a reduced crystal field splitting within the strained STO layers compared to cubic STO substrates. These results will be discussed in view of ferroelectric properties.

DS 16.7 Tue 19:15 H 2032

Optical characterization of individual, thermally reduced graphene oxide sheets — Inhwa Jung[1], •Matthias Vaupel[2], Richard Piner[1], and Rod Ruoff[3] — [1]Dept of Mechanical Engineering, 2145 Sheridan Road, Northwestern University, Evanston, IL 60208-3111, USA — [2]Nanofilm Technologie GmbH, 37081 Göttingen, Germany — [3]Dept of Mechanical Engineering, The University of Texas, 1 University Station, C2200, Austin, TX 78712-0292, USA

Graphite oxide is a layered material that can be exfoliated to form stable colloidal suspensions in water. At an appropriate concentration, evaporation of droplets of such a colloidal suspension on a surface yields individual graphene oxide sheets. This material is of interest as a filler for nano-composites as well as for use in new paper-like materials. A few layers or even one single layer of graphene oxide, including in its reduced form, where the O/C ratio is lower than in graphene oxide, are of potential interest in device applications. The optical dispersion functions of the refractive index and extinction coefficient of graphene oxide were measured by imaging spectroscopic ellipsometry on single and triple layers of graphene oxide. The results are compared with the results from confocal microscopy [1]. Dispersion parameters of a heap of graphene oxide sheets were also measured by conventional spectroscopic ellipso- metry and fit as effective medium. The effect of thermal treatment of graphene oxide, which renders the material conductive and reduces layer thickness, was explained. [1] Jung, I.; Pelton, M.; Piner. R.; Dikin. D.; Stankovich, S.; Watcharotone, S.; Hausner, M.; Ruoff, R. S. Nano Lett. 2007, NL0714177.

DS 16.8 Tue 19:30 H 2032

Density functional investigation of the dielectric constant for bilayer graphene under electric field — •Ruijuan Xiao, Manfred Taut, Ferenc Tasnadi, and Manuel Richter — IFW Dresden, Germany

Single and bilayer graphene have attracted much current interest not only because of their novel electronic structure but also for their potential application in future electronic devices. Several methods have been reported to open an energy gap in bilayer graphene, including application of gate-voltage, which may allow to switch off the electric conduction in bilayer graphene devices. In the present work, we evaluated the gap width and the dielectric constant of bilayer graphene in an external electric field (E_{ext}) using the full-potential local-orbital (FPLO) code. We obtain a dielectric constant reaching a minimal of 2.76 when the E_{ext}=0.3 V/Å, then increasing with the E_{ext}, reaching 2.84 when the E_{ext}=0.8V/Å. The calculated gap width increases with the E_{ext}, reaching a saturated value of 0.26eV when the E_{ext}=0.8V/Å. We also studied the effect of layer distance on the gap and dielectric constant of this system. The calculations indicate that the dielectric constant decreases linearly with the reduction of distance between the two graphene layers.