DS 16: Layer Properties: Electrical, Optical, and Mechanical

Time: Tuesday 9:30–13:00 Location: H11

DS 16.1 Tue 9:30 H11

About the optical properties of $Li_xV_2O_5$ — •Marina Muñoz-Castro[1], Frank Berkemeier[1], and Guido Schmitz[2] — [1]Institute of Material Physics, University of Münster, Wilhelm-Klemm.Str.10, D-48149, Germany — [2]Institute of Material Science, University of Stuttgart, Heisenbergstr. 3, D-70569, Germany

This work investigates the influence of lithium intercalation on the optical properties of vanadium pentoxide films. V_2O_5 films with a thickness between 700 and 800 nm, were prepared by DC magnetron sputter deposition. Afterwards, cyclic voltammetry and chronopotentiometry were used to set different well defined lithiation states of the $Li_xV_2O_5$ films, between $x = 0$ and $x = 1$. The optical properties of these films were examined in the wavelength range between 500 and 1700 nm by optical reflectometry. From the reflectance data, the refractive index and the extinction coefficient of the films were calculated as a function of wavelength using Cauchy's dispersion model. The results confirm that the optical behavior of $Li_xV_2O_5$ films varies upon lithium intercalation, and that these changes in the optical properties are completely reversible for low states of lithiation.

DS 16.2 Tue 9:45 H11

Ultrafast dynamics of coherent acoustic phonons in thin gold films investigated by surface plasmon resonance — •Felix Noll, Nico Krauss, and Thomas Dekorsy — Universität Konstanz, Fachbereich Physik, Konstanz, Germany

Coherent acoustic phonons are studied in pump-probe experiments with femtosecond temporal resolution and shot-noise limited detection sensitivity [1]. The measured photo-induced differential reflectivity change is expected to increase by several orders of magnitude when probing under surface plasmon resonance (SPR) condition [2].

In this work, high-speed asynchronous optical sampling is combined with SPR in Kretschmann geometry for highly sensitive pump-probe experiments on gold films with thicknesses ranging from 30 nm to 50 nm. Angular resolved transients yield parameters for optimum enhancement of the coherent acoustic phonons. The fundamental thickness oscillations and their higher harmonics are discussed with regard to frequency and damping time.

[1] Bartels, A. et al., Rev. Sci. Instrum. **78**, 035107 (2007)
[2] Wang, J. et al., Opt. Lett. **32**, 719-721 (2007)

DS 16.3 Tue 10:00 H11

The Effect of Layer Thickness on the Magnetic and Magneto-optical Properties of Sputtered and Annealed $La_{1-x}Sr_xMnO_3$ Thin Films on Silicon — •Manuel Monecke, Oana-Tereza Ciubotariu, Peter Richter, Patrick Thoma, Georgeta Salvan, and Dietrich R.T. Zahn — Semiconductor Physics, Technische Universität Chemnitz, D-09107 Chemnitz, Germany

$La_{1-x}Sr_xMnO_3$ (LSMO) is a conductive oxide with a perovskite crystal structure. Moreover, the high spin polarization makes this material an ideal electrode material for spintronic applications. In particular, the composition $La_{0.67}Sr_{0.33}MnO_3$ was used in spintronic devices due to the nearly 100 % spin polarization at the Fermi level [2]. Here LSMO films with varying film thicknesses between 10 nm and 300 nm were deposited by magnetron sputtering at room temperature on silicon substrates covered with a native oxide. The films were annealed in ambient atmosphere at 775 °C for 20 min, 1 h, 3 h, and 9 h. Afterwards the layers were investigated by spectroscopic ellipsometry, magneto-optical Kerr effect spectroscopy and magnetometry. The main goal of this work is to understand how the magnetic properties, the dielectric function, and the magneto-optical response of post deposition annealed LSMO are influenced by the layer thickness and annealing time. The results show that the magnitude of the off diagonal elements of the dielectric tensor decreases drastically when the layer thickness is smaller than 20 nm. Furthermore, the remanence and coercive field increase with annealing time for films thicker than 20 nm. [1] E. Dagotto *et al.* Physics Reports 344 (2001) [2] J.-H. Park *et al.* Nature Vol 392 (1998)

DS 16.4 Tue 10:15 H11

Resonance X-ray reflectivity — a tool to extract chemical and valence profiles and its application to SmB_6. — •Volodymyr Zabolotnyy[1], Katrin Fürsich[1], Robert Green[2], Abdul Tcakaev[1], Ronny Sutarto[3], Feizhou He[3], Maurits Haverkort[4], Dmytro Inosov[5], and Vladimir Hinkov[1] — [1]Universität Würzburg — [2]UBC, Vancouver, Canada — [3]CLS, Saskatoon, Canada — [4]MPI-CPS, Dresden — [5]TU Dresden

SmB_6 is a renowned example of a Kondo (mixed valent) insulator. The recently proposed topologically protected surface state upgraded SmB_6 to being likely the first topological Kondo insulator, and thus renewed interest in the material, particularly in the Sm^{2+} to Sm^{3+} ratio at the sample surface.

To address this question we combine cluster calculations, providing optical constants for different Sm valences, with x-ray reflectivity measurements — an established method for a non-destructive analysis of heterostructures with high probing depth (∼100 nm) and element/valence sensitivity on a nm-scale. Here we report detailed atomic and valence profiles for *in situ* cleaved single crystals of SmB_6, which ensures clean surfaces with negligible traces of air-related contaminants. As the analysis of in-air prepared surfaces is known to be hampered by an uncontrolled built up of a contamination layer that may render reconstruction of chemical profiles very ambiguous, or even modify the surface via unwanted doping, etc., the well controlled surface chemistry proves to be a crucial aspect of the current study.

DS 16.5 Tue 10:30 H11

Surface anchored metal organic framework for direct light emission. — •Nicolò Baroni[1], Ian Howard[1], Andrey Trushtov[1], Redel Engelbert[2], Christof Wöll[2], and Bryce Sydney Richards[1,3] — [1]Institute of Microstructure Technology, Karlsruhe institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [2]Institute of Functional Interfaces, Karlsruhe institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [3]Light Technology Institute, Karlsruhe Institute of Technology, Engesserstrasse 13, 76131 Karlsruhe, Germany

The control of light emission of luminescent molecules is an important goal in the field of luminescent solar concentrators (LSCs) in order to enhance the efficiency of total internal reflection (TIR). Porous metamaterials called surface anchored metal organic frameworks (SURMOFs) provide different kinds of pore sizes and different orientations in the channels that connect all the pores. Our aim is using SURMOFs as host materials for luminescent molecules in order to have loaded molecules aligned in the same direction as the channels.

DS 16.6 Tue 10:45 H11

Plasmonic Gold nanocross array for efficient solar to chemical energy conversion — •Wenxin Wang, Yan Zheng, and Yong Lei — Fachgebiet 3D-Nanostrukturierung, Institut für Physik, Technische Universität, Ilmenau, Germany

Large area plasmonic Au nanocross array with different size and height are fabricated by an novel anodic aluminum oxide (AAO) template in physical vapor deposition (PVD) for efficient solar water splitting. The optical prosperity of Gold nanocross is revealed by systematic experimental and computed extinction spectra. And their performance of solar water splitting is exhibited via photoelectrochemical (PEC) device.

DS 16.7 Tue 11:00 H11

Study of the properties of sputtered ZnO:Al layers on ultra-thin glass — •Jasper Westphalen[1,2], Manuela Junghähnel[1], and Edda Rädlein[2] — [1]Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP — [2]Technische Universität Ilmenau

Ultra-thin glass is a new type of transparent and flexible substrate material. It is a glass with a thickness less than 200 μm. The many advantageous properties, such as the excellent barrier to water and oxygen and the temperature stability up to 700 °C open up new possibilities for transparent electronics, display technology and in photovoltaics. Transparent conductive oxide (TCO) can be used for different functional layers for these topics. As an alternative to the expensive indium doped tin oxide (ITO) aluminum doped zinc oxide ZnO:Al is already used in some devices. In this study, ZnO:Al films were deposited by magnetron sputtering on ultra-thin glass. The influence of the deposition power on the electrical, optical and mechanical prop-

erties of the films were investigated. In order to improve the optical and the electrical properties, we used flash lamp annealing (FLA) as a post-deposition annealing method for ultra-short thermal treatment in the millisecond range.

15 min. break.

DS 16.8 Tue 11:30 H11

Epitaxial growth of Fe on Ag(001) and magnetoelastic coupling in Fe — •Kenia Novakoski Fischer and Dirk Sander — Max Planck Institute of Microstructure Physics, Halle, Germany

Epitaxial atomic layers are often in a strain-state, which is determined by the lattice misfit to the substrate. This misfit contributes significantly to the magnetic anisotropy via magnetoelastic coupling. The magnetoelastic coupling coefficients are experimentally accessible from measurements of the stress change of the layers upon a magnetization reorientation [1]. In this work, we present results on the film stress and magnetoelastic stress for 4 to 30 layers of Fe on Ag(001). Our measurements of film stress show a non-monotonic stress change in the first layers, which indicates a deviation from an atomically sharp Ag-Fe interface. We measure an average film stress of 2 GPa, in qualitative agreement with lattice misfit stress. From our Auger measurements, even for 30 ML thick Fe films, we conclude that a few layers of Ag are on top of the Fe film. We measured the magnetoelastic coupling coefficient B2 from an in-plane reorientation of the magnetization along <110> directions of Fe, and we find +4.2, +3.1, +2.7, and +3.7 MJ/m^3 for films of 4, 8, 15, and 30 layers, respectively. These values differ from the respective bulk value of +7.83 MJ/m^3[2], and we discuss the results in view of the segregation of Ag and stress in the Fe films.

[1] Sander D. and Kirschner J., Phys. Status Solidi B 248, 2389, (2011).

[2] Sander D., Rep. Prog. Phys. 62, 809 (1999).

DS 16.9 Tue 11:45 H11

Material parameter determination for ScAlN sputtered layers — •Nicolas Kurz[1,2], Mohammadfazel Parsapourkolour[3], Paul Muralt[3], Yuan Lu[2], Agne Zukauskaite[2], Ulrike Roesler[4], Pascal Nicolay[5], Vadim Lebedev[1,2], and Oliver Ambacher[1,2] — [1]Department of Microsystems Engineering IMTEK, University of Freiburg, Freiburg, Germany — [2]Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg, Germany — [3]Ceramics Laboratory, Ecole Polytechnique Fédérale de Lausanne EPFL, Lausanne, Switzerland — [4]EPCOS AG, Munich, Germany — [5]CTR AG,Villach , Austria

Microelectromechanical systems operating at radio-frequencies (RF) provide excellent properties for RF front end devices like reference oscillators, filters, and duplexer. Today, AlN is commonly used as piezoelectric material for these devices since it provides low acoustic and dielectric losses, and is compatible with CMOS fabrication technology. However, AlN piezoelectric coefficient d33˜6 pC/N, and consequently, electromechanical coupling coefficient of ˜7 %, limit the available bandwidth for RF components. Akiyama, et al. showed experimentally that the d33 can be increased up to 400 % by alloying AlN with ScN.

In order to determine selected tensor components for AlScN material constants, a set of test resonators have been modeled in this work using finite element method. Based on these results, four different resonator structures operating in different modes were selected for fabrication and characterization by S-parameter analyses and laser Doppler vibrometry. A comparison between model prediction and experimentally obtained results for AlN and AlScN will be presented.

DS 16.10 Tue 12:00 H11

Reactive magnetron sputtering of stress-controlled piezoelectric AlScN thin films — •Yuan Lu[1], Markus Reusch[1,2], Tim Christoph[1], Vadim Lebedev[1], Nicolas Kurz[1,2], Lutz Kirste[1], Oliver Ambacher[1,2], and Agne Zukauskaite[1] — [1]Fraunhofer Institute for Applied Solid State Physics IAF, Tullastr. 72, 79108 Freiburg, Germany — [2]IMTEK, University of Freiburg, Georges-Köhler-Allee 103, 79110 Freiburg, Germany

AlN is a dominant choice for radio frequency microelectromechanical systems (RF-MEMS) used in mobile telecommunications. However, AlN's relatively low piezoelectric response (d_{33}≈6 pC/N) and electromechanical coupling (k_t^2≈7%) limit the bandwidth of the frequency filters. It was recently shown that AlScN has 400% higher d_{33}=27.6 pC/N (for $Al_{0.43}Sc_{0.57}N$) and k_t^2≈10-15%, making this material a very promising alternative to AlN. In addition to piezoelectric properties, parameters such as film stress need to be controlled to fabricate high performance AlScN-based piezoelectric devices. The aim of this work is to synthesize stress-controlled AlScN thin films suitable for RF-MEMS applications. Reactive RF magnetron sputtering with an $Al_{0.83}Sc_{0.17}N$ alloy target is used to produce 250-1000 nm thick AlScN films on Si(100) substrates. Film stress is investigated by wafer geometry measurements, the clamped d_{33} is measured by Berlincourt method, and the film quality is evaluated by using X-ray diffraction. Piezoresponse force microscopy is used to confirm the piezoelectric phase uniformity. The growth process optimization leading to the AlScN films with moderate stress values (<500 MPa) will be discussed.

DS 16.11 Tue 12:15 H11

Vibrational modes of ultrathin carbon nanomembrane mechanical resonators — •Xianghui Zhang[1], Reimar Waitz[2], Fan Yang[2], Carolin Lutz[2], Polina Angelova[1], Armin Gölzhäuser[1], and Elke Scheer[2] — [1]Fakultät für Physik, Universität Bielefeld, 33615 Bielefeld, Germany — [2]Fachbereich für Physik, Universität Konstanz, 78457 Konstanz, Germany

We report measurements of vibrational mode shapes of mechanical resonators made from ultrathin carbon nanomembranes (CNMs) with a thickness of approximately 1 nm. CNMs are prepared from electron irradiation induced cross-linking of aromatic self-assembled monolayers (SAMs) and the variation of membrane thickness and/or density can be achieved by varying the precursor molecule. The vibration of the membrane was actuated by applying a sinusoidal voltage to a piezoelectric disk on which the sample was glued. The vibrational mode shapes were visualized with an imaging Mirau interferometer using a stroboscopic light source. Several degenerate normal modes of a square membrane can be readily identified and their dynamic behavior can be well described by linear response theory of a membrane with negligible bending rigidity. Applying Fourier transformations to the time-dependent surface profiles, the dispersion relation of the transverse membrane waves can be obtained and its linear behavior confirms the membrane model. Comparing the dispersion relation to an analytical model, the static stress of the membranes was determined and found to be caused by the fabrication process.

DS 16.12 Tue 12:30 H11

High-temperature micro-mechanical testing of a thin-film CrN tooling system — •James P Best[1], Johannes Zechner[2], Jeffrey M Wheeler[3], Juri Wehrs[1], Marcus Morstein[4], and Johann Michler[1] — [1]EMPA, Thun, Switzerland — [2]KAI GmbH, Villach, Austria — [3]ETH, Zürich, Switzerland — [4]PLATIT AG, Selzach, Switzerland

Forging and cutting tools for high-temperature applications are often protected using hard nanostructured ceramic coatings. While a moderate amount of knowledge exists for material properties at room temperatures, significantly less is known about the system constituents at the elevated temperatures generated during service.

In this work, we present results on both the hard ceramic coating and the nitrided steel substrate using in situ micro-mechanical measurements at temperatures to 500 °C. FIB milled micro-pillars of plasma-nitrided tool steel were first investigated using in situ compression experiments. It was found that elevated temperature led to significant and reversible softening of the nitrided steel and transition from slip-based to more ductile plastic flow.

The fracture toughness behavior was then investigated using various micro-geometries and notching parameters. Toughness measurements at high temperatures highlighted the profound effect of the notching ion during small-scale fracture measurements. It was found that gallium ion implantation led to significant toughening of CrN, based on gallium dosage experiments and alternative notching using both xenon and helium sources.

DS 16.13 Tue 12:45 H11

Structural and optical properties of TiO2-films with thicknesses from 2 to 200 nm deposited with RF-diode sputtering — Jingyi Shi, •Sebastian Schippreit, Klaus Pärschke, and Dieter Mergel — Thin Film Technology Group, Faculty of Physics, University of Duisburg-Essen

TiO2-films with thicknesses from 2 nm to 200 nm have been produced by rf-diode sputtering at various temperatures and their structural and optical properties have been studied. The optical properties of the films were obtained by simulation of their (NIR/UV/VIS) optical

spectra with the computer program SCOUT. The films already show optical effects (absorptive and ellipsometric) at a thickness of 2 nm and the simulated film thicknesses suite well to the mechanically obtained values. Structural analysis was performed using X-ray diffraction, Raman spectroscopy and scanning electron microscopy. A phase change occurred in the TiO2-films from mainly rutile to a mixed rutile-anatase phase with increasing substrate temperature as well as with increasing film thickness.