DS 26: Layer Properties: Electrical, Optical, and Mechanical Properties

Time: Wednesday 15:00–19:00 Location: H 2032

DS 26.1 Wed 15:00 H 2032

Tunable Ion Bombardment Induced by Altering Plasma Confinement in Magnetron Sputtering — •Mathis Trant, Maria Fischer, Kerstin Thorwarth, Hans Josef Hug, and Jörg Patscheider — Empa, Laboratory for Nanoscale Materials Science, Überlandstr. 129, CH-8600 Dübendorf, Switzerland

Ion bombardment is known to influence deposition processes and is widely used to control thin film growth. It offers a variety of possibilities including growth of non-equilibrium phases, changes in residual stress and defect densities. In the case of magnetron sputtering this topic is of special interest, since there is an intrinsic bombardment of particles with typically low kinetic energy.

In this contribution a variety of approaches for altering the ion bombardment are re-viewed by making use of additional plasma confinement. The implementation of an additional magnetic field from an electromagnetic coil in a reactive magnetron co-sputtering process is presented, showing the potential of this method. Among other improvements, an increase of the ion saturation current by a factor of 7 has been achieved. The influence on film properties of different magnetic configurations are discussed on the basis of aluminum sputter deposition in reactive and non-reactive atmospheres.

DS 26.2 Wed 15:15 H 2032

Challenges in Depositing Aluminum Oxynitride Films by Reactive DC Magnetron Sputtering — •Maria Fischer, Mathis Trant, Kerstin Thorwarth, Hans Josef Hug, and Jörg Patscheider — Empa, Laboratory for Nanoscale Materials Science, Überlandstr. 129, CH-8600 Dübendorf, Switzerland

Thin, transparent coatings of aluminum oxynitride with different oxygen contents were prepared by reactive direct current (DC) magnetron sputtering from a pure aluminum target. The simultaneous use of the two reactive gases O_2 and N_2 poses challenges due to their different chemical behavior towards metallic targets. Various experimental parameters, including the position of the O_2 gas inlet inside the deposition chamber, have a strong influence on film properties and reproducibility. This applies also to the target poisoning and erosion state; experiments conducted at otherwise equal conditions yielded deposition rates varying by a factor of 2.5.

The setup in a conventional sputter deposition system was altered to improve the controllability of deposition processes conducted with an O_2/N_2 gas mixture. The influences of the different experimental configurations on resulting films were investigated in terms of reproducibility, deposition rate, crystallinity, morphology, biaxial stress and hardness.

DS 26.3 Wed 15:30 H 2032

Mechanische Spannungen in Cr-dotierten α-Al_2O_3-Schichten — •Sebastian Schipporeit[1], Ali Haligür[1], Markus Neubert[1,2] und Volker Buck[1] — [1]Arbeitsgruppe Dünnschichttechnologie, Fakultät für Physik, Universität Duisburg-Essen und CENIDE, 47057 Duisburg — [2]Eifeler Werkzeuge GmbH, Duderstädter Str. 14, 40595 Düsseldorf

Oberflächentemperaturen sind ein entscheidender Parameter bei der Herstellung dünner Schichten. Insbesondere in stark leuchtenden Medien stößt die Temperaturbestimmung mit Hilfe der thermischen Emission an ihr Grenzen. Daher sind in dieser Arbeit die Erzeugung und der Einsatz von Cr-dotierten Al_2O_3-Schichten als thermographische Phosphore mittels HF-ICP/CCP-PECVD untersucht worden.

In dieser Arbeit ist es gelungen mit dem Einsatz eines induktiv gekoppelten Plasmas, die Temperaturen zur Erzeugung Cr-dotierter α-Al_2O_3-Schichten auf 780 °C bei Si-Substraten herabzusenken. Die Experimente fanden in einer Niederdruck-Ar-Atmosphäre, bzw. Ar-O_2-Atmosphäre statt, wobei das Gas je einen Tiegel mit den pulverförmigen Precursoren $Al(acac)_3$ und $Cr(acac)_3$ überströmte.

Die hergestellten Cr-dotierten Al_2O_3-Schichten weisen die R1 und R2 Emissionen der Rubin-Fluoreszenz auf. Die Intensität der Phosphore ist vom angeregten Volumen abhängig, daher sollten möglichst dicke Schichten hergestellt werden. Mit zunehmender Schichtdicke nimmt jedoch die Schichthaftung auf Grund innerer Spannungen in der Schicht ab. Daher ist hier die Schichtspannung in Abhängigkeit verschiedener Beschichtungsparameter und Schichtdicken untersucht worden.

DS 26.4 Wed 15:45 H 2032

Solution Processed Deposition of Large-Size MoS2 Nanoflakes — •Xaoling Zeng, Marlis Ortel, and Veit Wagner — Jacobs University Bremen, 28759 Bremen, Germany

The gap in understanding MoS2 deposition processes needs to be closed in order to utilize all its excellent properties in nano-electronics. In this work, deposition of MoS2-flakes from precursor solution by dip-coating on Si-substrates was investigated. Ammonium tetrathiomolybdate (ATTM) dissolved in deionized water was used as precursor solution. The MoS2-flakes obtained from the precursor solutions were analyzed by atomic force and optical microscopy, PL, UV-Vis and Raman spectroscopy.

The deposition process of the flakes was found to obey Landau-Levich mechanism with respect to the relationship between the withdraw speed and film size and thickness. By optimization of deposition parameters, MoS2 flakes exceeding 150 micro meter in lateral size were obtained. The thickness in the range of 2-5ML was confirmed by AFM and Raman measurements. Raman and PL measurements indicate that the quality of the film strongly depends on the post thermal treatment and its atmospheric composition. This low-cost solution-based deposition method is simple and non-toxic, which is also suitable for preparation of large transition metal dichalcogenides nanoflakes for various applications.

DS 26.5 Wed 16:00 H 2032

Structural and electrical characterization of the ferecrystals $[(SnSe)_{1+\delta}]_m(NbSe_2)_1$ — •Corinna Grosse[1], Matti Alemayehu[2], Olivio Chiatti[1], Anna Mogilatenko[1,3], David C. Johnson[2], and Saskia F. Fischer[1] — [1]Novel Materials, Humboldt-Universität zu Berlin, 10099 Berlin, Germany — [2]Department of Chemistry, University of Oregon, Eugene, OR, 97401, USA — [3]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, 12489 Berlin, Germany

Ferecrystals are layered intergrowth compounds consisting of few-atomic-layers thin transition metal dichalcogenide (TMDC) layers alternately stacked with monochalcogenide layers. TMDCs exhibit interesting electrical properties such as charge density waves, superconductivity or an ultralow thermal conductivity. In contrast to conventional misfit layer compounds, ferecrystals show a turbostratic disorder and have a freely tunable stacking sequence.

In this work, we investigate the structural and electrical properties of $[(SnSe)_{1+\delta}]_m(NbSe_2)_1$ ferecrystals as a function of the thickness of the SnSe layers separating single $NbSe_2$ layers. The atomic structure of the thin films was visualized using scanning transmission electron microscopy. In-plane resistivity, Hall coefficient and magnetoresistance were measured for temperatures down to 300 mK. The magnetoresistance measurements were analyzed using a two-band model. A superconducting transition is observed and the in-plane and cross-plane coherence lengths of superconductivity were determined. The influence of the ferecrystal structure on the electrical properties is discussed.

DS 26.6 Wed 16:15 H 2032

Weak antilocalization and disorder induced electron-electron-interaction in DC-magnetron-sputtered Sb_2Te_3 and Bi_2Te_3 thin films — •Tobias Schäfer[1], Hanno Volker[1], and Matthias Wuttig[1,2] — [1]I. Physikalisches Institut (IA), RWTH Aachen University, 52056 Aachen, Germany — [2]JARA FIT, RWTH Aachen

Recently Sb_2Te_3 and Bi_2Te_3 have raised notable interest as topological insulators (TIs). A usual deposition technique for TI specimen is molecular beam epitaxy (MBE) as it ensures the required high crystalline and surface quality. Besides ARPES, low temperature magneto-transport measurements have become common techniques for characterization of Sb_2Te_3 and Bi_2Te_3 TI samples[1].

Apart from that, the materials are also interesting as phase change materials (PCM). Particularly Sb_2Te_3 is known for its fast and reversible switching between an amorphous and a crystalline phase[2]. In this context DC-magnetron sputtering followed by subsequent annealing is the commonly used deposition technique, which leads to more disordered films that do not suit the needs of TI surface states.

Here we present a magneto-transport study on highly disordered Sb_2Te_3 and Bi_2Te_3 thin films. The thicknesses are chosen to be smaller than the inelastic mean free path in order to achieve a quasi 2d be-

havior. The measurements are analyzed in the framework of HLN-theory[3] and compared to literature on MBE grown TI samples.

[1] e.g. Takagaki et al, Phys. Rev. B 86, 125137, (2012)
[2] Yamada et al, Jpn. J. Appl. Phys. 26 61, (1987)
[3] Hikami et al, Prog. Theor. Phys. 63 (2), (1980)

DS 26.7 Wed 16:30 H 2032

Tip-enhanced Raman spectroscopy (TERS) on La_2CoMnO_6 thin films: Field enhancement and polarisation effects — •Christoph Meyer, Sebastian Merten, Sebastian Hühn, Markus Jungbauer, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

B-site ordered La_2CoMnO_6 (LCMO) with monoclinic $P12_1/n_1$ structure can be derived from a perovskite ABO_3 by alternating layers of Co^{2+} and Mn^{4+} on the B-site. It is a promising material for spintronic applications due to ferromagnetic ordering, magnetodielectric coupling and multiferroic behavior. Since the performance of LCMO is strongly affected by the degree of B-site ordering, we applied Raman spectroscopy to correlate phonon spectra with the ordering. A study of the far-field Raman and tip-enhanced Raman spectroscopy (TERS) of LCMO thin films on $SrTiO_3(100)$ and $SrTiO_3(111)$ substrates, grown by metalorganic aerosol deposition (MAD), was performed. Polarization dependent TERS was carried out to determine the contributions for enhancement due to surface plasmon polariton (SPP) excitation and depolarization. Due to B-site cation ordering, the spectra exhibit a strong A_g mode at 645 cm^{-1}, generated by octahedral $(Co/Mn)O_6$ stretching vibrations with largest TERS contrast of $\sim 60-100$ in the crossed polarization configuration. A tip-induced depolarization effect and a significant enhancement due to general field amplification were observed. Financial support by the DFG via project SFB 1073/B04 is gratefully acknowledged.

15 min. break.

DS 26.8 Wed 17:00 H 2032

Nitrogen concentration dependence of the stiffness of silicon nitride layers formed by low-dose N+ ion implantation — •Marina Sarmanova[1], Helmut Karl[2], Stephan Mändl[1], Dietmar Hirsch[1], Stefan G. Mayr[1,3], and Bernd Rauschenbach[1,3] — [1]Leibniz Institute of Surface Modification, D-04318 Leipzig, Germany — [2]University Augsburg, Institute of Physics, D-86135 Augsburg, Germany — [3]University Leipzig, Institute for Experimental Physics II, D-04103 Leipzig, Germany

Si wafer material was implanted at room temperature with 100 keV N+ ions at fluences between 1 * 10^15 and 1 * 10^17 cm^-2. Substoichiometric SiNx layers were formed in the near-surface region. Subsequent thermal annealing was performed at 800°C in three half-hour steps. Elastic properties of implanted layers were measured nanometer-resolved by contact resonance atomic force microscopy (CR-AFM) as function of ion fluence after each annealing step. Strong correlation between the nitrogen content and the indentation moduli was observed while recovering defects caused by the implantation inside the material. The determined indentation moduli range between 100 and 180 GPa depending on the annealing duration and nitrogen content. Reduction of the indentation moduli of as-implanted samples is caused by the implantation induced amorphization. Long-term annealing led to the increase of the indentation moduli of the high-fluence implanted Si wafers over the value of indentation modulus for crystalline silicon material (165 GPa). The high indentation moduli can be explained by formation of Si-N bonds verified by X-ray photoelectron spectroscopy.

DS 26.9 Wed 17:15 H 2032

Optical and transport properties of epitaxial Nd1.83Ce0.17CuO4 thin films — •Anita Guarino[1], Adolfo Avella[1], Carmela Bonavolontà[2], Massimo Valentino[2], Corrado Di Lisio[2], Loredana Parlato[2], Antonio Leo[1], Gaia Grimaldi[1], Sandro Pace[1], Giampiero Pepe[2], Antonio Vecchione[1], and Angela Nigro[1] — [1]CNR-SPIN Salerno and Dipartimento di Fisica E R Caianiello, Università di Salerno, via Giovanni Paolo II, 132, Fisciano (SA), Italy — [2]CNR-SPIN Napoli and Dipartimento di Fisica Università Federico II di Napoli, via Cinthia, 80126 Napoli, Italy

Electrical transport measurements and transient optical pump-probe experiments have been performed on epitaxial films of the electron doped Nd1.83C0.17CuO4 compound for studying the non-equilibrium carrier dynamics in this material. In particular, the value of the quasiparticle relaxation time has been estimated in order to investigate the possible use of this compound as base material for superconducting optical detectors. Samples have been grown on (001)-oriented SrTiO3 substrates by dc sputtering in a mixed atmosphere of both Ar and O2. X-ray diffraction analysis and Scanning Electron Microscope equipped with a wavelength dispersive spectroscopy detector have been used to characterize the structure and the morphology and composition of the thin films. Time-solved femtosecond pump-and-probe spectroscopy has been also carried out on our samples in the temperature range 4.2K-300 K. The data demonstrate a clear correlation between electrical and optical features.

DS 26.10 Wed 17:30 H 2032

Significant Band Gap Narrowing of ALD Deposited ZnO:Al by Correlated Spectroscopic Ellipsometry, Photoluminescence and Spectrophotometry — •Michael Latzel[1,2], Manuela Göbelt[1], Gerald Brönstrup[1,3], Cornel Venzago[4], Sebastian W. Schmitt[1], and Silke H. Christiansen[1,3] — [1]Max Planck Institute for the Science of Light, Günther-Scharowsky-Str. 1/Bau 24, Erlangen, Germany — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Institute of Optics, Information and Photonics, Staudtstr. 7/B2, Erlangen, Germany — [3]Helmholtz Center Berlin for Energy and Materials, Hahn-Meitner-Platz 1, Berlin, Germany — [4]AQura GmbH, Rodenbacher Chaussee 4, Hanau-Wolfgang, Germany

Knowing the dielectric function of a material for optoelectronic applications is essential for efficient device design and simulation. We investigated the contributions of different optical transitions in aluminum doped zinc oxide deposited by atomic layer deposition to a model dielectric function (MDF) over a wide range of photon energy. We found strong evidence for band gap narrowing due to aluminum doping and intrinsic defects and impurities. The derived MDF strongly depends on the actual band structure and therefore describes the dielectric properties very accurately. The presented MDF is solely based on physical parameters, in contrast to empirical models like e.g. widely used Sellmeier equation. This allows determining key electronic parameters like the band gap or even charge carrier lifetimes.

DS 26.11 Wed 17:45 H 2032

Detection of photoexcited hot charge carriers at the edges of metal nano films — •Marc Thomas[1,2], Steffen Franzka[2], Nils Hartmann[2], Detlef Diesing[1], Matthias Hensen[3], Dominik Differt[3], and Walter Pfeiffer[3] — [1]Institut für Physikalische Chemie, Universität Duisburg Essen — [2]Interdisciplinary Center for Analytics on the Nanoscale, Universität Duisburg Essen — [3]Institut für Experimentalphysik, Universität Bielefeld

Metallic nanostructures differ from metallic bulk materials concerning their electrical, optical and chemical properties. Structured nano films produced by evaporation through shadow masks exhibit thickness wedges at the edge of the nanostructure. A home-built microscope setup allows the laterally resolved scanning of the nanofilm's reflectivity with a lateral resolution of $3\mu m$. Experimentally observed reflectivity maps at the edge of the nanostructure are compared with calculated reflectivity maps derived by optical multi layer models taking into account the interference phenomena in nanostructures. When the structured metallic nano film is deposited on a metal–insulator sandwich, one can monitor photo excited hot charge carriers in the top nano film as a current in the backside metal under the oxide. This photocurrent is characterised with respect to the energy of the excited carriers by applying a bias voltage between the top metal nano film and the backside metal when scanning the edge of the metal nano structure by coupling a cw 532 nm laser to the microscope setup. Future applications of this technique as the spectral characterisation of localised optical excitations are addressed.

DS 26.12 Wed 18:00 H 2032

Optical and electrical properties of silicon nanocrystals based on a SiH4-O2 PECVD process — •Jan Laube, Sebastian Gutsch, Daniel Hiller, and Margit Zacharias — Laboratory for Nanotechnology, Department of Microsystems Engineering - IMTEK, University of Freiburg, Georges-Koehler-Allee 103, 79110 Freiburg im Breisgau, Germany

A monosilane (SiH4) and oxygen (O2) based plasma-enhanced chemical vapor deposition process (PECVD) for the growth of silicon-rich oxide / silicon dioxide superlattices was developed.[1,2] In contrast to the conventional nitrous oxide (N2O) based oxynitride-process,[3] we

achieved thereby PECVD-grown size-controlled silicon nanocrystals in pure, N-free silicon dioxide matrix.

We present a detailed study based on optical (PL), electrical (C-V, I-V) and structural (TEM) measurements that reveal the different properties of nominally identical Si nanocrystals in oxynitride and N-free oxide matrix. Most strikingly we find negligible differences in the optical performance (PL quantum yield), whereas substantial differences in the current transport and transient charging behaviour persist. The role of the pure oxide vs. oxinitride matrix on the properties of Si quantum dots is discussed in the context of potential applications in photovoltaics and optoelectronics.

[1] M. Zacharias et al., APL 80, 2002
[2] J. Laube et al., JAP 116, 2014
[3] A.M. Hartel et al., TSF 520, 2011
[4] S. Gutsch et al., JAP 113, 2013

DS 26.13 Wed 18:15 H 2032

Comparison of Al2O3 passivation layers by RF magnetron sputtering and ALD deposition — •Franz P. G. Fengler[1], Daniel K. Simon[1], Paul M. Jordan[1], Thomas Mikolajick[1,2], and Ingo Dirnstorfer[1] — [1]NaMLab gGmbH, 01187 Dresden, Germany — [2]Lehrstuhl für Nanoelektronische Materialien, TU Dresden, 01187 Dresden, Germany

Decreasing wafer thicknesses of latest high efficient solar cells cause an increasing demand for superior surface passivations. Due to a high content of negative fixed charges Al2O3 became the material of choice for p-type silicon. Today it is mainly deposited by atomic layer deposition (ALD) and plasma enhanced chemical vapour deposition. Both processes are rather slow and require toxic gases e.g. Trimethylaluminum. An alternative is the physical vapor deposition (PVD) by means of magnetron sputtering. However, silicon passivated with PVD-films typically do not achieve lifetimes in the millisecond range. This study will investigate the reasons for the low performance by using structural, lifetime and capacitance-voltage measurements to analyze the difference of PVD- and ALD-layers. It will be shown that the content of oxygen and the distribution of hydrogen in the as-grown layers are crucial for the passivation performance. ALD and PVD layers significantly differ in density, which influences the hydrogen transport within the layer during the post deposition anneal. As a consequence, a PVD process with a low percentage of oxygen is needed in combination with an anneal in hydrogen containing atmosphere.

DS 26.14 Wed 18:30 H 2032

Real-time monitoring mof crystals *breathing* upon humidity guest loading — •Theodoros Baimpos, Buddha Ratna Shrestha, and Markus Valtiner — Department for Interface Chemistry and Surface Engineering, Max Planck Institut fur Eisenforschung GmbH, D-40237, Dusseldorf, Germany

Porous Metal-organic frameworks (MOFs) are 3D crystalline coordination polymers consisting of metal ions linked each other by organic ligands. One of their main applications is as membranes for gas mixtures separation/purification where the MOF crystal act as internal molecular sieve by permitting only in the smaller molecules to pass their pore and get adsorbed in the available adsorption sites, excluding the bigger ones. If the adsorption affects the size of the crystal (expansion or shrinkage) then the performance of the membrane is significantly affected. In this study we examine with with Surface Force Apparatus (SFA) and its high time resolution (500 msec) the effect of humidity adsorption on the size of HKUST-1 crystals. With SFA, even complicated series of swelling phenomena may be visible, real time, even with naked eye, monitored and recorded on a TV screen by watching the motion of the fringes of equal chromatic order (FECO). In particular for the case of HKUST-1 and the loading/unloading with humidity vapors, a complex deformation behavior (contraction-expansion-contraction-expansion) is noticed for first time, upon humidity loading which is attributed to the gradual filling of the 4 different kinds of adsorption sites found in the unit cell of the crystal.

DS 26.15 Wed 18:45 H 2032

Damping of metallized bilayer nanomechanical resonators at room temperature — •Maximilian Seitner, Katrin Gajo, and Eva Weig — Universität Konstanz, Fachbereich Physik, Konstanz, Germany

Nanoelectromechanical systems (NEMS) enable both the study of fundamental physical effects and future applications as integrated devices in ultra sensitive sensor technology. As an important representative, freely suspended nanomechanical string resonators are exploited for their remarkable mechanical properties, providing high quality factors even at room temperature. Hybrid nanostructures frequently rely on metallization films, providing functionalization for coupling mechanical resonators to other degrees of freedom. For those purposes, it is inevitable to acquire a deeper understanding of the metal's impact on the damping of the system as well as its influence on elastic parameters, especially at room temperature. We investigate the influence of gold thin-films subsequently deposited on a set of initially bare, doubly clamped, high-stress silicon nitride string resonators at room temperature. Providing analytical expressions for resonance frequency, quality factor and damping for both in- and out-of-plane flexural modes of the bilayer system we find the inverse quality factor to scale linearly with the gold film thickness, indicating that the overall damping is governed by losses in the metal. We extract mechanical quality factors of the gold film for both flexural modes and show that they can be enhanced by complete deposition of the metal in a single step, suggesting that surface and interface losses play a vital role in metal thin-films.