DS 8: Layer Deposition I: Inorganic Thin Films

Time: Monday 15:00–16:30 Location: CHE 89

DS 8.1 Mon 15:00 CHE 89

High quality vanadium dioxide thin films grown by a simple and low cost spray pyrolysis technique — •Oisín Murtagh[1], David Caffrey[1], Karsten Fleischer[2], Daragh Mullarkey[1], and Igor Shvets[1] — [1]School of Physics and Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College, University of Dublin, Dublin 2, Ireland — [2]School of Physical Sciences, Dublin City University, Dublin 9, Ireland

Vanadium dioxide is a well-known electronic phase change material due to strong electron correlation. In this presentation the details of VO2 thin film growth on Al2O3(0001) substrates using a low temperature solution based method (spray pyrolysis) and a subsequent annealing step in an inert atmosphere are described. The dependence of the growth on solvent, precursor, growth temperature and annealing conditions are examined. The resulting films show high crystallinity, homogeneity and a metal-insulator transition (MIT) at 70°C accompanied by a resistivity change of over 4 orders of magnitude. Structural, morphological, chemical and electronic properties are characterised using XRD, XPS, profilometry, AFM and 4 point probe electrical measurements. Triggering of the MIT through the application of an electric-field is also shown using microlithographic channels. The simplicity, scalability and cost of this growth method make it a promising candidate for large scale implementation of VO2 in modern applications, with an emphasis on non-conventional computing electronics.

DS 8.2 Mon 15:15 CHE 89

Optical temperature management for high-quality ZnO molecular beam epitaxy — •Maximilian Albert[1], Christian Golla[1], Christian Kaspari[2], Thomas Zettler[2], and Cedrik Meier[1] — [1]Department Physik, Universität Paderborn, 33098 Paderborn, Germany — [2]LayTec AG, Seesener Str. 10-13, 10709 Berlin, Germany

Zinc oxide is a wide gap semiconductor with a high exciton binding energy and significant nonlinear susceptibility. ZnO grown by molecular beam epitaxy (MBE) has already been used in various photonic or plasmonic structures taking advantage of those properties. For these structures the crystal quality is of great importance, which crucially depends on growth parameters, such as growth rate and substrate temperature. Both parameters are challenging to manage and analyze in-situ due to the non-opaque substrates and films. Therefore, novel techniques have to be researched and investigated. In our case we investigate a combined optical approach, promising insights into both growth temperature and growth rate of ZnO. We find that emissivity-corrected pyrometry together with band gap thermometry and reflectometry can address all needs and substantially improves quality control and monitoring of the growth process.

DS 8.3 Mon 15:30 CHE 89

Tailoring material properties of SiOx thin films by applying an electric field during plasma enhanced atomic layer deposition — •Vivek Beladiya[1,2], Martin Becker[3], Marek Sierka[3], and Adriana Szeghalmi[1,2] — [1]Institute of Applied Physics, Friedrich Schiller University, Jena, Germany. — [2]Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Jena, Germany. — [3]Otto Schott Institute of Materials Research, Friedrich Schiller University, Jena, Germany.

SiO2 is a widely used metal oxide in microelectronics, optics, barrier coatings, and solar cells. Excellent optical, mechanical, chemical and structural properties are required for the optimum performance of these devices. These properties can be tailored by controlling ion energies by varying average bias voltage at the substrate stage during oxygen plasma in PEALD process.

In this work, the effect of applied average-bias voltage on SiO2 thin films properties, deposited in two different deposition tools were investigated. The average bias voltage up to -300 V was applied during the oxygen plasma exposure. A very low average-bias voltage (< -10 V) was sufficient to alter material properties indicating an influence on the surface chemical reactions. The stoichiometric and dense SiO2 thin films with low OH content were deposited by applying substrate biasing. The observed experimental trends were supported by atomistic simulations. It is shown that relevant surface reaction can be influenced by applying electric field during plasma step.

DS 8.4 Mon 15:45 CHE 89

Synthesis of Porous Silicon, Nickel and Carbon Thin Films by Vapor Phase Dealloying — •Stefan Saager, Bert Scheffel, Olaf Zywitzki, and Thomas Modes — Fraunhofer-Institut für Organische Elektronik, Elektronenstrahl- und Plasmatechnik FEP

Porous thin films have various application fields, e.g., for energy conversion in fuel cells, energy storage in lithium ion batteries or supercapacitors as well for catalysis, filtration and sensing. We synthesized porous thin films by co-evaporating a low-vapor-pressure material (e.g., Si, Ni or C) together with zinc and depositing a compact layer of resulting composite. High-rate deposition process up to 100 nm/s was realized by electron beam evaporation of the materials from two graphite crucibles with a fast deflected electron beam in high vacuum. Immediately after deposition, the coated stainless steel substrates were heated up in vacuum to a temperature above 500 °C and thereby zinc is removed selectively. Due to it's higher vapor pressure against that of remaining component, zinc is expelled from the layer and vacancies are generated by so called vapor phase dealloying. We investigated the feasibility of vapor phase dealloying process for the elements silicon, nickel and carbon. The elemental composition and the morphology of the layers prior and after thermal annealing were analyzed by scanning electron microscopy, by energy-dispersive X-ray spectrometry and by X-ray diffraction.

DS 8.5 Mon 16:00 CHE 89

Growth of epitaxial (110) oriented Mn2Au thin films via Molecular Beam Epitaxy — •Daniel Casey, Daragh Mullarkey, and Igor V. Shvets — School of Physics, Trinity College Dublin, The University of Dublin, Dublin 2, Ireland

Here we explore the crystallographic nature and growth of antiferromagnetic Mn2Au (110) oriented thin films deposited by molecular beam epitaxy.

By co-evaporating Mn and Au from separate Knudsen cells, (110) oriented films were obtained when deposited on a Pt (111) seed layer on Al2O3 (0001) substrates. A combination of high-resolution X-ray diffraction, low and high energy electron diffractions are used to elucidate the epitaxial relation of these films. The influence of substrate temperature during growth on the quality of the Mn2Au thin films is also explored.

DS 8.6 Mon 16:15 CHE 89

Superconducting titanium nitride thin films deposited by plasma enhanced atomic layer deposition — •Luisa Ehmcke[1], Stefanie Haugg[1], Kaline Furlan[2], Gerold Schneider[2], Robert Blick[1], and Robert Zierold[1] — [1]Center for Hybrid Nanostructures (CHyN), University of Hamburg, 22761 Hamburg, Germany — [2]Institute of Advanced Ceramics, Hamburg University of Technology, 21073 Hamburg, Germany

Titanium nitride is a widely used material in microelectronics due to its low resistivity and high thermal stability. Moreover, titanium nitride is a type 1 superconductor with a critical bulk temperature of 5.6 K. Herein, we report about thin film titanium nitride, which was grown by plasma enhanced atomic layer deposition (PE-ALD) by utilizing tetrakis(dimethylamino)titanium (TDMAT) and a nitrogen/hydrogen mixture as precursor. By investigating the sheet resistance, the critical temperature, and the critical field the deposition process was optimized with respect to plasma power, plasma time, gas composition, and process temperature. We observed (i) a transition to an effective 2D electronic system and (ii) weak antilocalization in our films in low temperature magnetotransport studies [1,2]. These observations in combination with structural and compositional analysis prove the low impurity content of our thin film samples.

[1] Postolova et al., Sci. Rep., (2017) DOI: 10.1038/s41598-017-01753-w [2] Gupta et al., J. Magn. Magn. Mater., (2019) DOI: /10.1016/j.jmmm.2019.166094