DS 4: Layer Deposition

Time: Monday 16:00–17:15 Location: A 060

DS 4.1 Mon 16:00 A 060

Real-Time Investigations during Sputter Deposition on Polymer Thin Films. — •Matthias Schwartzkopf — DESY, Photon Science, Notkestr. 85, 22607 Hamburg, Germany

The reproducible low-cost fabrication of functional polymer-metal-nanocomposites remains a major issue in applied nanotechnology. In order to obtain full control over the nanostructural evolution at the metal-polymer interface, we employed time-resolved surface sensitive X-ray scattering during sputter deposition of gold on thin polystyrene films and silicon substrates [1,2]. We correlate the evolution of the metallic layer morphology with changes in the key scattering features. This enabled us to identify the impact of atomic deposition rate on the growth regimes with their specific thresholds even at high deposition rates [3,4]. Our study opens up the opportunity to improve nanofabrication of tailored metal-polymer nanostructures for organic electronics like photovoltaic applications and plasmonic-based technologies.

[1] Schwartzkopf et al., ACS Appl. Mater. Interfaces 7, 13547 (2015); [2] Schwartzkopf et al., Nanoscale 5, 5053 (2013); [3] Schwartzkopf et al., ACS Appl. Mater. Interfaces 9, 5629 (2017), [4] Schwartzkopf et al.,Nanoscale Horiz. 6, 132 (2021).

DS 4.2 Mon 16:15 A 060

Fast and efficient simulation of the FEBID process — •Alexander Kuprava and Michael Huth — Goethe University, Frankfurt, Germany

Over the last decade focused electron beam induced deposition or FEBID has been shown to be a promising technique for next generation nanofabrication. Unlike conventional lithography techniques, FEBID enables true free-form fabrication of 2D and 3D structures and opens a path for the development of novel nanomaterials. However, the shape-true transfer from a 3D CAD model to a deposit represents a serious challenge to a more widespread practical usage of the method. Different simulation approaches, e.g., and slicers or pattern optimizers have been reported, e.g., addressing various aspects of the shape-true transfer. Our effective hybrid Monte Carlo-continuum simulation of the FEBID process allows prediction of the resulting shape with the consideration of beam heating effects of the structure.

The simulation represents a material deposition model based on the dissociation of adsorbed precursor molecules by the electron beam. The deposition process is based on a reaction-diffusion continuum model describing the influence of precursor adsorption, desorption, diffusion and dissociation on the surface precursor coverage and consequently on the growth rate.

Owing to the reasonable execution speed on a regular desktop, the simulation can assist the laborious work of pattern file and parameter optimization during the fabrication of complex 3D structures.

DS 4.3 Mon 16:30 A 060

GaS - a Two-Dimensional UV emitting material: Challenges of MOCVD Synthesis — •Robin Günkel[1], Stefan Renato Kachel[1,2], Leonard Neuhaus[2], Lukas Erlemeier[2], Tigmanshu Sundrial[1], Johannes Glowatzki[1], Jürgen Belz[1], Carsten von Hänisch[2], J. Michael Gottfried[2], and Kerstin Volz[1] — [1]Material Sciences Center and Department of Physics, Philipps-Universität Marburg, Germany — [2]Material Sciences Center and Department of Chemistry, Philipps-Universität Marburg, Germany

Gallium sulfide (GaS), a 2D semiconductor similar to Transition Metal Dichalcogenides (TMD), has a band gap in the UV wavelength range, making it a candidate for UV LED applications. The goal of this study is to synthesize a 2D GaS crystal directly on a substrate, rather than producing it by mechanical exfoliation. Metal-Organic Chemical Vapor Deposition (MOCVD) enables the controlled growth of atomically thin films. This type of synthesis is scalable, with process adaptations limited primarily by substrate size and reactor dimensions. We use established MOCVD precursors such as di-tert-butyl sulfide (DTBS) and tri-tert-butyl gallium (TTBGa). First growth experiments show excess metallic Ga remaining on the surface of the 2D layered GaS. When we try to compensate for the excess Ga by increasing the supply of sulfur, growth is inhibited. To overcome this challenge, a pulsed growth sequence rather than a continuous one is applied. Furthermore, as additional approach the surface chemistry is investigated, and the application of single source precursor is under discussion.

DS 4.4 Mon 16:45 A 060

MBE growth and characterization of α-FeGe$_2$ films on GaAs(001) — •Moritz N. L. Hansemann, Michael Hanke, Achim Trampert, and Jens Herfort — Paul Drude Institut, Berlin, Germany

Layered 2D magnets are becoming a cornerstone in the realization of spintronic devices. The layered material α-FeGe$_2$ adds to the family of magnetic materials with a ferromagnetic antiferromagnetic phase transition, predicted by density functional theory calculations (DFT).

We show the growth by molecular beam epitaxy of the novel α-Phase of FeGe$_2$ on GaAs (001) and present comprehensive structural characterization by atomic force microscopy (AFM), X-ray diffraction (XRD), and high resolution transmission electron microscopy (hR-TEM). For the growth of α-FeGe$_2$ we utilize solid phase epitaxy of amorphous Ge on Fe$_3$Si. Subsequent annealing reveals the layered structure of α-FeGe$_2$ in the P4mm spacegroup. Reciprocal Space Maps (RSM) and TEM images show excellent epitaxial alignment and high structural quality. We experimented with off-stoichiometric growth by buffering Ge and report the formation of Ge agglomerates (droplets) on the surface. Additionally we present initial Hall- and I-V-measurements that show possible semimetallic behavior.

DS 4.5 Mon 17:00 A 060

Energetische Anpassung von Magnetron-Sputter-Abscheidungsprozessen für defektempfindliche Materialien: Transparente leitfähige Oxide und andere Halbleiter — •Klaus Ellmer — Optotransmitter-Umweltschutz-Technologie e.V., Köpenicker Str. 325, 12555 Berlin, Germany

Das Magnetronsputtern ist eine großflächige, plasmaunterstützte Abscheidungsmethode für viele industrielle Anwendungen, wie Architektur- und Glasbeschichtungen, von Spiegeln und Absorbern für Solarkonzentratoren, magnetische Schichten für Festplatten oder Hartstoffschichten. In der Dünnschicht-Photovoltaikindustrie wird Magnetronsputtern zur Abscheidung metallischer Rückkontakte (Ag, Mo) und transparenter, leitfähiger Fensterschichten (ITO, ZnO) oder für metallische Filme eingesetzt. Für die aktiven Halbleiter (Absorber) in Solarzellen wird es jedoch noch nicht im technischen Maßstab angewendet. Es werden Hindernisse aufgezeigt, die den Einsatz des Magnetronsputterns für aktive Halbleiterschichten verzögert haben. Die Energien der Spezies (gesputterte Atome, positive und negative Ionen, energiereiche Neutrale) werden diskutiert und ihr Einfluss auf das Filmwachstum. Aufgrund der geringen Defektbildungsenergien von Halbleitern ist die Anpassung der Entladungsbedingungen (niedrige Teilchenenergien) für die Herstellung defektarmer Halbleiterfilme mit hoher Qualität zwingend erforderlich. Die Möglichkeiten des Magnetronsputterns werden für die Abscheidung aktiver Chalkopyrit-Absorberfilme für effiziente Solarzellen (Cu(In,Ga)Se2), für Nitride für LEDs (GaInN) und für transparente leitende Oxide demonstriert.