DS 13 Internal Symposium "Nanoengineered thin films"

Time: Wednesday 14:00–18:00 Room: GER 37

Invited Talk

DS 13.1 Wed 14:00 GER 37

Adventures in Atomic Aggregation — •Kevin Robbie, Kate Kaminska, Jian Yang, Chelsea Elliott, and Cristina Buzea — Department of Physics, Queen's University, Kingston, ON, Canada, K7L 3N6

The conceptually simple experiment of sequentially depositing atoms onto a flat surface can yield surprisingly complex results. The resulting thin film coatings are seen to depend strongly, in structure and physical behaviour, on the arrival geometry of condensing atoms, in addition to the manifest dependence on chemistry, temperature, etc. Dynamic control of geometry during the growth of thin films, particularly under conditions of glancing vapour incidence, allows atomic-scale engineering of uniquely structured matter, exhibiting anomalous birefringence, chiral optical activity, magnetic anisotropy; and likely bioactivity, novel superconductivity and more.

This talk examines the origin of structure in atomically aggregated materials, and questions their usefulness as a nano-technology. Specific examples discussed will include: molecular ordering and light switching in a hybrid liquid crystal device, interference filters with continuously varying refractive index, highly anisotropic magnets, nanostructured silicon with an absolute birefringence of 0.4, and noble-metal 'pyramids' that arise through an as-yet unexplained mechanism. Atomic granularity is seen to play a central role in the emergence of complex form in these structures, suggesting that fundamental questions of predictability and chaos might be probed with this experiment.

Invited Talk

DS 13.2 Wed 14:45 GER 37

Ion beam assisted growth of chiral sculptured thin films — •Eva Schubert[1], Frank Frost[1], Bodo Fuhrmann[2], Frank Heyroth[2], Mathias Schubert[3], and Bernd Rauschenbach[1] — [1]Leibniz-Institut für Oberflächenmodifizierung e.V., 04318 Leipzig, Permoserstr. 15 — [2]Martin-Luther-Universität Halle-Wittenberg, Interdisziplinäres Zentrum für Materialwissenschaften, Hoher Weg 8, D-06120 Halle(Saale) — [3]University of Nebraska-Lincoln, Department of Electrical Engineering, 209 WSEN, Lincoln, NE 68588-0511

The controlled preparation of materials with sizes smaller than 100 nm in at least one dimension is an up to date challenge in modern material science. Their functionality may exceed beyond knowledge and understanding gathered until today. Nanomaterials continue to spark research in science and engineering and are expected to emerge into wide-spread applications. Porous sculptured thin films (STF) consist of three-dimensional nanostructure components and are one example for nanoengineered materials. The films originate from self organization processes during a highly directional growth mode under an extremely oblique particle flux angle of incidence combined with an appropriate substrate rotation. The growth regime allows for the customized fabrication of anisotropic thin films with different chiral morphologies. Novel material properties caused by the nanostructure morphology are discussed and predicted for new materials design.

Invited Talk

DS 13.3 Wed 15:30 GER 37

Emerging Directions in Sculptured-Thin-Film-Research — •Akhlesh Lakhtakia — Department of Engineering Science and Mechanics, Pennsylvania State University, University Park, PA 16802-6812, USA

Sculptured thin films are assemblies of shaped, parallel, identical nanowires generally grown by vapor deposition techniques on substrates [1]. Their optical applications have advanced significantly during the last five years, but other applications have not progressed beyond the embryonic stage. In this lecture, several new directions in STF research shall be presented. These include: (a) STFs with transverse architectures; (b) deposition of polymeric STFs by replamineform, multibeam lithographic, and mixed vapor deposition techniques; (c) growth of bioscaffolds on STFs; (d) STF light emitters; (e) energetic STFs; and (f) electrically controlled STFs and punctuated STFs.

[1] A. Lakhtakia and R. Messier, Sculptured Thin Films: Nanoengineered Morphology and Optics (SPIE Press, 2005)

— 15 min. break —

Invited Talk

DS 13.4 Wed 16:30 GER 37

From Nanostructured ZnO-Based Thin Films to Arrays of Free-Standing Nanowires: Self-Organized Growth by Pulsed Laser Deposition — •Michael Lorenz — Universität Leipzig, Institut für Experimentelle Physik II

Currently, the wide-bandgap material zinc oxide attracts considerable research interest in view of envisaged applications as fast scintillators, light emitting diodes, and UV lasers by taking advantage of efficient excitonic effects even at room temperature. Pulsed laser deposition (PLD) has proved to be a flexible and fast exploratory tool for the self-organized growth of ZnO-based, nanostructured thin films [1-2] and nanowire arrays [3-5]. The formation of nanosized grain structures in ZnO thin films that promote the outcoupling of luminescence light and determine electrical properties can be controlled via the background gas pressure in PLD. With further increasing gas pressure, arrays of free-standing ZnO-based nanowires can be grown reproducibly by PLD. This unique, high-pressure PLD process allows for a wide-range control of morphology, diameter, and composition of the nanowires and works successfully on various growth templates and in a wide temperature range. The PLD grown nanostructured thin films and nanowires show superior luminescence properties and are serving therefore as materials base for selected device demonstrations.

[1] E. M. Kaidashev, M. Lorenz et al., Appl. Phys. Lett. 82 (2003) 3901.
[2] M. Lorenz et al., Thin Solid Films 486 (2005) 205.
[3] M. Lorenz et al., Ann. Phys. (Leipzig) 13 (2004) 39.
[4] Th. Nobis et al., Phys. Rev. Lett. 93 (2004) 103903.
[5] M. Lorenz et al., Appl. Phys. Lett. 86 (2005) 143113.

Invited Talk

DS 13.5 Wed 17:15 GER 37

Self-assembled $Al_{0.53}In_{0.47}N$ nano-grass with intrinsically curved crystal structure — •Jens Birch[1], Timo Seppänen[1], György Z. Radnoczi[2], Bela Pécz[2], and Lars Hultman[1] — [1]IFM, Linköping University, SE-58216 Linköping, Sweden — [2]Res. Inst. for Tech. Phys. and Mat. Sci. of the Hungarian Academy of Sciences, H-1525 Budapest, P. O. Box 59, Hungary

$Al_{1-x}In_xN$ is a very attractive semiconductor as the direct bandgap, ranging from 0.9 eV for InN to 6.2 eV for AlN, opens possibilities to engineer opto-electronic devices operating from near infra-red to deep ultra-violet. However, a miscibility gap in $Al_{1-x}In_xN$ between $0.1 < x < 0.9$ implies a necessity of low-temperature growth under kinetically limited adatom conditions. In this work epilayers of semiconducting $Al_{1-x}In_xN$ were grown by reactive magnetron sputter epitaxy (MSE) with directional fluxes of Al and In onto static (111)-oriented single crystal ZrN seed layers under ultra-high-vacuum conditions at a temperature of 300 °C. High resolution electron microscopy of $Al_{0.53}In_{0.47}N$ reveals densely packed ≈10 nm wide single crystal whiskers growing with curvature of approximately 0.09°/nm, giving about 26.5° for the entire length (300 nm) of the column, as confirmed by X-ray diffraction. It is shown that a generically new materials structure is formed which is characterized by extreme crystal lattice curvature caused by a lateral 2-dimensional lattice parameter gradient due to a gradual intra-domain lateral compositional variation. We present a model for this unique, self-assembled, nanograss-like curved crystal structure and its implications are discussed.