KFM 7: Microstructure of thin films / TEM-based Nanoanalysis

Time: Monday 15:00–18:20 Location: E 124

KFM 7.1 Mon 15:00 E 124

Scanning Transmission Helium Ion Microscopy on 1nm Thick Carbon Nanomembranes — •Daniel Emmrich[1], Annalena Wolff[2], André Beyer[1], and Armin Gölzhäuser[1] — [1]Bielefeld University, Germany — [2]Queensland University of Technology, Australia

The Helium Ion Microscope (HIM) offers a lateral imaging resolution of 0.3 nm and is known for its excellent sub 10 nm milling capabilities [1]. While imaging with secondary electrons (SE) is well established for this microscope, the ion transmission signal attracts growing attention. Imaging in bright or dark field transmission offers additional information on membranes [2], core shell nanoparticles [3]and can be used for the inspection of milled features, e.g., membrane pores. Monolayer thin membranes have not been studied so far. Here we show a dark field transmission imaging study on 1nm thick Carbon Nanomembrane (CNM) by using a SE conversion plate. CNM are made of self-assembled monolayers that are cross-linked by low energy electrons resulting in a 1 nm thick carbon membrane with tunable conductivity [4]. Imaging the same sample site with different acceptance angles, we are able to compare the measured contrasts with simulated scattering angles from SRIM [5] and discuss the applicability of those simulations on ultimate thin membranes. [1] G. Hlawacek, A. Gölzhäuser (Eds.), Springer Int., Switzerland 2016. [2] A. R. Hall, Microsc Microanal 2013, 19, 740. [3] T. J. Woehl et al., Microsc Anal, 2016, 22, 544. [4] A. Turchanin, A. Gölzhäuser, Adv. Mater 2016, 28, 6075. [5] J. F. Ziegler et al., Nucl. Instr. Meth. Phys. Res. 2010, 268, 1818.

KFM 7.2 Mon 15:20 E 124

Self-assembly of organic semiconducting material at the liquid-liquid interface — •Manuel Johnson, Tim Hawly, and Rainer H. Fink — Lehrstuhl für Physikalische Chemie II, Friedrich-Alexander Universität Erlangen-Nürnberg, Egerlandstr. 3, D-91058, Erlangen, Germany

Charge transport in organic electronic devices like organic field-effect transistors (OFETs) crucially depends on the structural properties of the active organic layer [1].For their successful preparation homogenous and highly ordered thin films of semiconductor material are required. Since vacuum sublimation induces polycrystalline film growth and therefore limits the performance of thus prepared devices, different solution based techniques have been developed for the fabrication of long-range ordered and single-crystalline organic thin films [2]. We tested a preparation technique where we utilize the self-organization of molecules with sufficiently strong $\pi\pi$-interaction at the liquid-liquid interface and discuss the influence of different preparation parameters. The liquid surrounding offers better chance for molecular diffusion and self-organization and consequently the near-equilibrium growth of crystalline organic films with lateral extensions in the range of several 100um. First microspectroscopic results already confirm the long range order and crystallinity inside the organic thin films.

[1] M. Halik et al, Adv. Mat. 2003, 15

[2] C. Xu, et al., Angewandte Chemie (Intern. Ed.) 55, (2016)

KFM 7.3 Mon 15:40 E 124

Vibrational fingerprints of lithium niobate on insulator and technological aspects for domain inversion in z-cut $LiNbO_3$ thin films — •Peter Mackwitz[1], Michael Rüsing[1], Kai Spychala[1], Minglong Zhai[3], Hui Hu[3,4], Gerhard Berth[1,2], and Artur Zrenner[1,2] — [1]Department Physik, Universität Paderborn, 33098 Paderborn, Germany — [2]Center for Optoelectronics and Photonics Paderborn (CeOPP), 33098 Paderborn, Germany — [3]NanoLN, 250101 Jinan, P.R. China — [4]School of Physics, Shandong University, 250100 Jinan, P.R. China

For applications in the field of integrated optics especially lithium niobate on insulator (LNOI) represents a promising layer stack. Here, the outstanding nonlinear optical properties of $LiNbO_3$ and the realizable quasi phase matching via periodic domain inversion can be combined with opportunities from functional layer sequences of thin film lithium niobate and SiO_2. These offer a large built-in vertical refractive index contrast as well as strong confinements. Overall, the LNOI technology offers similar waveguide bending radii and cross-sections as the established silica on insulator technology. Within this work we report on a fundamental characterization of the vibrational properties of lithium niobate on insulator and first steps towards submicron domain inversion in z-cut thin film lithium niobate. In this context a systematic analysis for various annealing conditions interface configurations was performed by confocal Raman-spectroscopy. Furthermore here the successful periodic submicron domain patterning was demonstrated by microscopic and nonlinear imaging.

KFM 7.4 Mon 16:00 E 124

Dopant distribution and octahedral distortions at superconducting complex oxide bilayer interfaces — Y. Eren Suyolcu, Yi Wang, •Wilfried Sigle, Federico Baiutti, Georg Cristiani, Joachim Maier, Gennady Logvenov, and Peter A. van Aken — MPI für Festkörperforschung, Heisenbergstraße 1, 70569 Stuttgart

We present results of doped lanthanum-cuprate (La2-xMxCuO4 (LMCO), x=0-0.4, M=Ca,Sr,Ba) systems where we systematically varied the dopant ionic radius while the dopant valence state was fixed [1]. Metallic LMCO layers were deposited on LaSrAlO4 followed by a second, insulating La2CuO4 layer, using atomic-layer-by-layer molecular beam epitaxy. Although none of the deposited layers is superconducting individually, the bilayer systems exhibit superconductivity. The critical temperature is found to depend on the dopant species. In order to elucidate possible mechanisms for interfacial superconductivity, the bilayer systems were structurally and chemically characterized in a probe-corrected JEOL JEM-ARM200F microscope. Perfect epitaxial growth is observed and dopants were found to be distributed depending on the dopant size. EELS spectrum imaging shows distinct differences among the three dopant species. Precise measurement of c-lattice parameters shows that the critical temperature is not, as expected, linearly related with the c-lattice parameter, i.e. with the distortion of oxygen octahedral [2]. [1] Y. E. Suyolcu et al., Sci. Rep. 7 (2017) 453. [2] Y. E. Suyolcu et al., Adv. Mater. Interfaces 1700737 (2017).

KFM 7.5 Mon 16:20 E 124

A study on Amorphous Silicon Films using SAXS and SANS to distinguish nano-crystals from voids. — •Eike Gericke[1], Armin Hoell[2], Jimmy Melskens[3], Dragomir Tatchev[4], Uwe Keiderling[2], Robert Wendt[1,2], Simone Raoux[1,2], Klaus Rademann[1], and Klaus Lips[1,5] — [1]Humboldt-Universität Berlin — [2]Helmholtz-Zentrum Berlin — [3]Technische Universiteit Eindhoven — [4]Bulgarian Academy of Sciences — [5]Freie Universität Berlin

Albeit amorphous silicon (a-Si:H) is used since the 70th as thin-film material for opto-electronic applications, its structural properties are still under discussion. a-Si:H contains up to 16 at% of hydrogen in a complex micro- and nano-structured Si-network. Generally, it is described as a continuous random network (CRN), but also models involving nanocrystalls are discussed. TEM hints at nano-voids. It was shown that even reduced-density-functions can be described by a pure CRN but also by a model including nanocrystals. Resolving the complex structure of a-Si:H is essential to correlate light-induced degradation to local inhomogeneities of the material. We revisit the structure of a-Si:H by SAXS and SANS, to distinguish density fluctuations from voids. We have studied differently prepared a-Si:H samples with morphologies from dense to porous. We will review the structure of a-Si:H and present our results, indicating nano-sized grains with enlarged mass density inside dense- and hydrogen decorated voids inside porous-aSi:H samples. We will present a new model for the a-Si:H structure which correlates the nanostructure with light-induced degradation.

20 min. break

KFM 7.6 Mon 17:00 E 124

New "transrotational" solid state order discovered by TEM in thin films — •Vladimir Kolosov — Ural Federal University, Ekaterinburg, Russia

Exotic thin crystals with unexpected **transrotational** microstructures [1] have been discovered by transmission electron microscopy (TEM) for crystal growth in thin (10-100 nm) amorphous films of different chemical nature (oxides, chalcogenide-based materials, metals and alloys) prepared by various methods. The unusual phenomenon can be observed ***in situ*** in TEM during local e-beam annealing. The dislocation independent regular internal bending of crystal lattice planes in a growing crystal takes place. We call it **transrotation**: unit cell **trans**lation is complicated by small **rotation** realized round an axis lying in the film plane. It can result in strong regular lattice orientation gradients (up to 300 degrees per μm) of different geometries: cylindrical, ellipsoidal, toroidal, saddle, etc. Transrotational microcrystal resembles ideal single crystal enclosed in a curved space. For some geometry types they have bending of atom/lattice planes similar (but much lower) to that of nanotubes and nanonions. Complex skyrmion-like lattice orientation texture is observed in some spherulite crystals. Transrotation is strongly increasing as the film gets thinner. Transrotational micro crystals have been recognized by other authors in some vital thin film materials, i.e. PCMs for memory, silicides, SrTiO3.

[1] V.Yu. Kolosov and A.R.Tholen, Acta Mater., 48 (2000) 1829.

KFM 7.7 Mon 17:20 E 124

Generation of Attosecond Electron Pulse Trains for Ultrafast Transmission Electron Microscopy — •Christopher Rathje[1,3], Katharina E. Priebe[1], Sergey V. Yalunin[1], Armin Feist[1], Thorsten Hohage[2], Sascha Schäfer[1,3], and Claus Ropers[1] — [1]IV. Physical Institute - Solids and Nanostructures, University of Göttingen, Germany — [2]Institute for Numerical and Applied Mathematics, University of Göttingen, Germany — [3]Institute of Physics, University of Oldenburg, Germany

Ultrafast transmission electron microscopy (UTEM) allows for the investigation of dynamics with both nanometer spatial and femtosecond temporal resolution. The highly coherent electron beam of the Göttingen UTEM [1] facilitates detailed studies of inelastic electron-photon scattering [2-4]. Here, we employ intense phase-locked optical fields to coherently control and characterize the longitudinal electron wave function [5]. In particular, we experimentally demonstrate the self-compression of electron pulses due to dispersive pulse propagation into a train of attosecond bursts with peak widths of 655 as [5]. Such pulse trains will enable the study of nanoscale field-driven processes at optical frequencies in UTEM.

[1] Feist et al., Ultramicroscopy 176 (2017) [2] Barwick et al., Nature 462, 902 (2009) [3] Feist et al., Nature 521, 200-203 (2015) [4] Echternkamp et al., Nat. Phys. 12, 1000-1004 (2016) [5] Priebe, Rathje et al., Nat. Photonics 11, 793-797 (2017)

KFM 7.8 Mon 17:40 E 124

Model-based geometry reconstruction of quantum dots from TEM — •Anieza Maltsi[1], Thomas Koprucki[1], Karsten Tabelow[1], and Tore Niermann[2] — [1]Weierstraß-Institut für Angewandte Analysis und Stochastik, Berlin, Germany — [2]Inst. f. Optik und Atomare Physik, TU Berlin, Berlin, Germany

The growth of semiconductor quantum dots (QDs) with desired electronic properties would highly benefit from the assessment of QD geometry, distribution, and strain profile in a feedback loop between growth and analysis of their properties. One approach to assist the optimization of QDs consists in imaging bulk-like samples (thickness 100-300 nm) by transmission electron microscopy (TEM) instead of high resolution (HR) TEM of thin samples (thickness 10 nm). For HRTEM the relaxation of the lamella-like samples may strongly modify the strain field or the preparation may potentially destroy the QDs. However, a direct 3D geometry reconstruction from TEM of bulk-like samples by solving the tomography problem is not feasible due to its limited resolution (0.5-1 nm), the highly nonlinear behavior of the dynamic electron scattering and strong stochastic influences due to uncertainties in the experiment, e.g. excitation conditions. Here, we present a novel concept for 3D model-based geometry reconstruction (MBGR) of QDs from TEM images. The approach includes an appropriate model for the QD configuration in real space, a database of simulated TEM images and a statistical procedure for the estimation of QD properties and classification of QD types based on machine learning techniques.

KFM 7.9 Mon 18:00 E 124

Structural properties of InGaAs Quantum dots investigated by Transmission Electron Microscopy — •Laura Meissner, Tore Niermann, and Michael Lehmann — Technische Universität Berlin, Institut für Optik und Atomare Physik, Straße des 17.Juni 135, Berlin, Deutschland

Optical characteristics of semiconductor quantum dots (QDs) depend closely on their structural properties, like composition, shape, and strain state. By controlling the growth process, these structural properties can be changed and in turn the optical properties are improved. In order to understand the behaviour of the QDs these structural properties have to be monitored.

We report on investigations of composition and strain of InGaAs QDs embedded in GaAs by means of Transmission Electron Microscopy. Microscopic techniques like Geometric Phase Analysis and Dark-field-Electron-Holography are employed to record amplitude and phase of different reflected beams.

In order to avoid relaxation effects and hence observe the strain field of the QDs in a bulk-like state, thick samples (over 100 nm) must be investigated. For these conditions, we discuss the effects of dynamic diffraction on the reflection specific sensitivity to composition and strain.