O 107: Nanostructured Surfaces and Thin Films

Time: Friday 10:30–12:15 Location: MA 042

O 107.1 Fri 10:30 MA 042

Morphology of nanostructured surfaces — •Jens Uwe Neurohr[1], Michael Klatt[2], and Karin Jacobs[1] — [1]Experimental Physics and Center for Biophysics, Saarland University, Saarbrücken, Germany — [2]Institut für KI Sicherheit, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Wilhelm-Runge-Straße 10, 89081 Ulm, Germany

Nanorough surfaces are often classified by the root mean square (RMS) roughness. However, a single scalar value can capture only limited geometric information about the complex structured surface. Indeed, there are different families of nanorough surfaces that are clearly distinguished by their geometric features, but they can have the same RMS values. As an important consequence, the RMS fails to predict the adhesive behavior of bacteria on nano-structured surfaces (in fact, even within one family) [1]. A solution to this problem is offered by the so-called Minkowski functionals that provide a complete characterization of „additive shape information"as rigorously proven in integral geometry [4]. These comprehensive shape descriptors have been successfully applied to a broad range of applications [1,2,3]. Here, we will use the Minkowski functionals to distinguish families of nanorough surfaces. This presentation will, moreover, show how they can predict the adhesive behavior of Staphylococcus aureus on Black Si.

[1] Spengler et al., Nanoscale 11:19713 (2019); [2] Schröder-Turk et al., Adv. Mater. 23, 2535 (2011); [3] Wagner, Physik Journal 14, 41 (2016); [4] Schneider and Weil, Stochastic and integral geometry (2008), Vol. 1 Springer

O 107.2 Fri 10:45 MA 042

Geometric tuning of the structural and magnetic properties of magnetic thin films via deposition onto highly ordered arrangements of nanospheres — •Asmaa Qdemat[1], Emmanuel Kentzinger[1], Johan Buitenhuis[2], Sabine Pütter[3], Mai Hussein Hamed[1,4], Connie Bednarski-Meinke[1], Oleg Petracic[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS-2, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Institute for Biological Information Processes, Biomacromolecular Systems and Processes (IBI-4), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, 85747 Garching Germany — [4]Faculty of Science, Helwan University, 11795 Cairo, Egypt

Using curved surfaces as substrates for thin film deposition induces lateral thickness variation, allowing deposited properties to vary. [Co/Pd]n multilayers with different Co thicknesses were deposited on a flat silicon substrate, and densely packed two-dimensional arrays of silica nanospheres with different radii of curvature were formed by the drop-casting method [1]. Scanning electron microscopy, X-ray reflectivity (XRR), grazing incidence small-angle X-ray scattering, SQUID and neutron reflectivity were used to characterise the obtained nanostructure. Compared to the flat multilayer, the cap multilayer showed a different anisotropy axis direction. A change in coercivity as a function of film thickness and radius of curvature was also observed. [1] A. Qdemat, et.al., RSC Adv., 10, 2020.

O 107.3 Fri 11:00 MA 042

Fabrication of Nanofluidic Channels by Pulsed Laser Irradiation of SiOx-coated Fused Silica — •Nastaran Bakhtiari[1,2] and Jürgen Ihlemann[1] — [1]Institut für Nanophotonik Göttingen e.V., Hans-Adolf-Krebs-Weg 1, 37077 Göttingen, Germany — [2]Theoretical Physics and Center of Interdisciplinary Nanostructure Science and Technology, FB10, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany.

Considerably, nanofluidic channels have recently garnered attention. Existing methods for fabricating nanochannels are complex, costly, and time-intensive. In this study, we efficiently created transparent nanofluidic channels on fused silica substrates (SiO2) using a simple two-step process. Employing single-pulse excimer laser irradiation with a rear configuration treated a UV-absorbing silicon suboxide (SiOx) film through the transparent SiO2 substrate. A polydimethylsiloxane (PDMS) superstrate applied before laser exposure served as a confinement for controlled structure formation. Under optimal laser fluence, the thin SiOx film buckled, leading to the formation of channels with a width ranging from 10 to 20 μm and a height of 800 to 1200 nm, exhibiting a bell-like cross-sections following the so-called Euler buckling mode. Wider channels displayed varicose or telephone cord morphologies. Subsequent high-temperature annealing oxidized SiOx, resulting in transparent SiO2 channels. These nanochannels show promise in effectively transporting fluids of various viscosities, demonstrated through capillary action and in line with the Lucas-Washburn equation.

O 107.4 Fri 11:15 MA 042

Phase-Resolved Sum-Frequency Generation Microscopy of Lipid Rafts in Model Membranes — •Alexander Fellows, Ben John, Martin Wolf, and Martin Thämer — Fritz-Haber-Institut der MPG, Berlin, Germany

Since the lipid raft model was developed, it became clear that the lateral assembly and packing of phospholipids in cell membranes is a critical parameter controlling their physiological function. However, whilst studies of model systems have observed and characterised many structural aspects of such condensed lipid domains, their exact structure down to the molecular level remains unknown.

Here, we utilise our new advancement in molecular imaging through phase-resolved SFG microscopy to investigate model lipid rafts in lipid monolayers with mixed chirality. Through rotationally-dependent hyperspectral imaging of the lipid domains, we fully determine their 3D structures, showing that their in-plane molecular packing is highly curved and that their mesoscopic structure is part of a hierarchal spiral motif. Furthermore, through enantiotopic substitution measurements, we demonstrate that all aspects of the structural directionality are dependent on the lipid chirality, but importantly also that the formed structures display a clear deviation in mirror symmetry for different chirality mixtures. Such an observation gives an important insight into the enantioselective interactions that dominate many membrane processes.

O 107.5 Fri 11:30 MA 042

Atomistic insights into surface roughening of palladium hydride thin films — Minaam Qamar[1], •Matous Mrovec[1], Apinya Ngoipala[2], Matthias Vandichel[2], and Ralf Drautz[1] — [1]ICAMS, Ruhr University Bochum, Germany — [2]University of Limerick, Ireland

Palladium is one of the primary electrocatalysts for the hydrogen evolution reaction. It has been observed experimentally that surfaces of Pd thin films roughen during hydrogenation, but atomic-scale mechanisms behind these degradation processes are still not clear. We carried out large-scale atomistic simulations of PdH surfaces of Pd substrates using the Atomic Cluster Expansion (ACE). ACE is a data-driven interatomic potential with a formally complete basis that can reach quantum accuracy while remaining highly computationally efficient. We generated a versatile ACE potential for the Pd-H system based on large database of density functional theory calculations and validated it extensively for a broad range of properties and atomic configurations. We will present findings of molecular dynamics and Monte Carlo simulations of Pd/PdH interfaces and discuss the mechanisms responsible for the surface roughening.

O 107.6 Fri 11:45 MA 042

A plasma process to enhance electrode performance for large scale hydrogen production — •Timo Wagner[1], Nicolas Wöhrl[1], Vineetha Vinayakumar[2], Christian Marcks[3], Anna Mechler[3], Doris Segets[2], and Axel Lorke[1] — [1]Faculty of Physics and CENIDE, University Duisburg-Essen, Germany — [2]Particle Science and Technology (IVG-PST) and CENIDE, University of Duisburg-Essen — [3]AVT.ERT, RWTH Aachen University

In the context of H2Giga, a flagship project by the German Federal Ministry of Education and Research (BMBF) focused on hydrogen, we devised a plasma treatment for industry-relevant material systems. A very optimized substrate for electrolysis is Nickel Foam. Nickel foams offer a substantial specific surface area, and are widely used in academic research. Though, their higher cost and handling challenges make them less ideal for industrial use compared to bulk nickel plates. With this plasma process we could improve the electrochemical performance of Nickel plate electrodes notably, while also significantly improving the mechanical stability of the electrodes, thus increasing

electrode lifetime. During this process, the surface of the sample undergoes a significant restructuring towards a hierarchical porous morphology. Nitrification can be observed by different methods, like XPS, XRD and EDX. This hierarchical structuring can also be observed on different substrate materials, e.g. Copper. Furthermore, we could successfully scale the plasma process from the lab scale of 1cm2 sample area to an industry testing scale of 100cm2.

O 107.7 Fri 12:00 MA 042

Anode surface engineering via ultrathin alumina membrane for dendrite-free sodium metal batteries — •Jiajia Qiu, Changfan Xu, Yu Duan, Huaping Zhao, and Yong Lei — Fachgebiet Angewandte Nanophysik, Institut für Physik & IMN MacroNano, Technische Universität Ilmenau, 98693 Ilmenau, Germany

Considerable growth in portable electronics and electric vehicles has stimulated the urgent demand for new battery systems. Owing to the high theoretical specific capacities (1166 mAh g-1) and low redox potentials (-2.71 V vs. a normal hydrogen electrode) of Na metals, Na metal batteries have attracted high research attention. But its large volume change and dendrite growth lead to low Coulombic efficiency, limited cyclability, and even a safety risk for high-energy-density Na metal batteries. Owing to chemical and electrochemical stability, Al2O3 coatings enable reduced Na dendrite growth, resulting in performance improvement. Simultaneously, a highly ordered ultrathin alumina membrane (UTAM) can change the traditional nucleation and growth modes from the origin, which can provide a porous 3D host to accommodate the large volume change of the Na anode. This novel nanostructure surface engineering via UTAM may bring in new opportunities for next-generation dendrite-free Na metal batteries.