

## CPP 45: Poster: Two Dimensional Functional Materials

Time: Wednesday 18:15–21:00

Location: Poster B2

CPP 45.1 Wed 18:15 Poster B2

**Resonant energy-transfer in plasmonic hybrid arrays** —

•JULIAN SINDRAM, JOSEPH P. S. FITZGERALD, and MATTHIAS KARG — Physical Chemistry I, University of Bayreuth, Bayreuth, Germany

Energy transfer between plasmonic nanoparticles (NPs) and fluorophores drastically alter the spectral response of the involved species and can be harnessed to create plasmonic nanolasers. Such lasers can be nanoscopic sources of coherent light with high potential for many applications in the field of nano-optics. Energy transfer rates depend on various parameters, including the NP material and size, the optical properties of the fluorophore, the distance between NPs and fluorophores and the concentration of fluorophores. In order to achieve a better understanding of energy transfer processes, a screening of numerous parameter combinations is necessary.

We present a new and efficient approach, allowing us to prepare and analyze large parameter sets on a single substrate. A bottom-up preparation procedure is used to fabricate substrate supported silver NP arrays with a spatial gradient of particle sizes. These plasmonic arrays are embedded in a fluorophore host matrix. Position-dependent steady-state and time resolved fluorescence spectroscopy, as well as extinction spectroscopy, are employed to examine energy transfer.

CPP 45.2 Wed 18:15 Poster B2

**Fabrication of functional carbon nanomembranes** —•KATRIN WUNDERLICH<sup>1</sup>, POLINA ANGELOVA<sup>2</sup>, ARMIN GÖLZHÄUSER<sup>3</sup>, MARKUS KLAPPER<sup>1</sup>, and KLAUS MÜLLEN<sup>1</sup> — <sup>1</sup>Max Planck Institute for Polymer Research, Mainz, Germany — <sup>2</sup>CNM Technologies GmbH, Bielefeld, Germany — <sup>3</sup>University of Bielefeld, Department of Physics, Bielefeld, Germany

Carbon nanomembranes (CNMs) are important materials for technological applications e.g. filtration of gases or water purification.

Here, we report direct access to functional CNMs starting from small molecules. Three different types of molecules were synthesized: nonfused oligophenyl derivatives with a linear molecular backbone (biphenyl, para-triphenylene), condensed polycyclic precursors (naphthalene, anthracene) and bulky molecules (hexaphenylbenzene, hexaperi-hexabenzocoronene). These aromatics on gold were crosslinked by electron irradiation and pyrolysis. Thus, homogeneous carbon nanomembranes with thicknesses of less than 0.8 nm were obtained.

The thickness, conductivity, chemical functionalization, and appearance of nanopores can be adjusted dependent on the molecule and the resistivity correlates with the thickness of the pyrolysed nanomembrane, with lower resistivity for the thicker sheets.

CPP 45.3 Wed 18:15 Poster B2

**Assembly of proteins and oriented purple membrane on functionalized carbon nanomembranes** —NATALIE FRESE<sup>1</sup>, •PAUL PENNER<sup>1</sup>, MATTHIAS SCHÜRMANN<sup>1</sup>, DANIEL RHINOW<sup>2</sup>, MARK SCHNIETZ<sup>1</sup>, POLINA ANGELOVA<sup>1</sup>, ANDREY TURCHANIN<sup>3</sup>, CHRISTIAN KALTSCHMIDT<sup>1</sup>, ROBERT TAMPÉ<sup>4</sup>, NORBERT HAMP<sup>5</sup>, and ARMIN GÖLZHÄUSER<sup>1</sup> — <sup>1</sup>University of Bielefeld — <sup>2</sup>Max Planck Institute of Biophysics, Frankfurt — <sup>3</sup>Friedrich Schiller University Jena — <sup>4</sup>Goethe University, Frankfurt — <sup>5</sup>Philipps University, Marburg

This presentation is about hybrid structures comprising carbon nanomembrane (CNM) as a functional substrate and oriented assembled purple membranes (PMs). CNMs are monomolecular cross-linked layers of aromatic amphiphilic molecules with lateral dimensions of several square centimeters and a thickness of about 1 nm. PM from *Halobacterium salinarum* is a membrane consisting of bacteriorhodopsin (BR), which is a light-driven proton pump, and lipids. CNM has already been successfully tested as a substrate for electron cryo-microscopy of PM. To realize the oriented assembly of PM patches on CNM, we used a PM mutant, which has histidine (HIS) tags selectively on one side of the membrane and a nitroliotriacetic acid (NTA) terminated NBPT-CNM. The functionalized CNM has also been tested with different HIS-tagged proteins.

CPP 45.4 Wed 18:15 Poster B2

**Stimuli-responsive nanosheet thin film sensors** —•PIRMIN GANTER<sup>1,2</sup>, KATALIN SZENDREI<sup>1,2</sup>, DANIEL WEBER<sup>1,2</sup>, and BETTINA LOTSCH<sup>1,2</sup> — <sup>1</sup>Max Planck Institute for Solid State Research, Heisenbergstraße 1, 70569 Stuttgart — <sup>2</sup>Department of Chemistry, University

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Environmental monitoring as well as breath analysis are of crucial importance in various fields such as health care, agriculture, industrial processes, air quality monitoring and pollution control. Therefore, the development of sensors with a fast response time, high sensitivity and selectivity to specific analytes such as water, ethanol, or other stimuli is highly desirable. Ultrathin sensors can offer several advantages such as cost efficiency or faster response and recovery times. Nanosheet-based sensors inherently feature at least one miniaturized dimension due to their single layer thickness. On this poster we show that phosphatoantimonate nanosheets  $\text{H}_3\text{Sb}_3\text{P}_2\text{O}_{14}$  can be spin-coated into thin films. These thin films can be used for humidity sensors as well as touchless positioning interfaces due to their extremely high sensitivity, selectivity towards water vapor and fast response time. Furthermore, we present our latest developments on sensing different stimuli such as temperature or trace amounts of water with nanosheet-based thin films.

CPP 45.5 Wed 18:15 Poster B2

**Graphene-Enhanced Optical Spectroscopy of Molecular Nano**Systems — BITA REZANIA<sup>1</sup>, •PHILIPP LANGE<sup>1</sup>, NIKOLAI SEVERIN<sup>1</sup>, JANINA KNEIPP<sup>2</sup>, and JÜRGEN P. RABE<sup>1</sup> — <sup>1</sup>Department of Physics & IRIS Adlershof, Humboldt-Universität zu Berlin — <sup>2</sup>Department of Chemistry, Humboldt-Universität zu Berlin

Graphene enhanced Raman Spectroscopy (GERS) is a newly emerged field. That is, Raman cross sections of molecules located in a close proximity to graphene has been demonstrated to be increased. However, the mechanism of the Raman enhancement in GERS is still not well understood. We investigated GERS on rhodamine 6G (R6G) molecules and we demonstrate a GERS enhancement factor for R6G confined between graphene and mica of about an order of magnitude. To get further insight into the GERS mechanism, we deposited CdTe quantum dots (QD) on top of graphene which covered R6G molecules. The presence of QD on top of graphene results in further enhancement of R6G Raman peaks confined between graphene and mica. The enhancement factor is different for different Raman peaks of R6G. Possible interpretations will be discussed

CPP 45.6 Wed 18:15 Poster B2

**2D-sheets covering and replicating single dendronized poly-**mers — •MOHAMMAD FARDIN GHOLAMI<sup>1</sup>, SIMONE DELL'ELCE<sup>1</sup>, VITALIJ SCENEV<sup>1</sup>, NIKOLAI SEVERIN<sup>1</sup>, BAOZHONG ZHANG<sup>2</sup>, A. DIETER SCHLÜTER<sup>2</sup>, and JÜRGEN P. RABE<sup>1</sup> — <sup>1</sup>Institute für Physik & IRIS Adlershof, Humboldt-Universität zu Berlin — <sup>2</sup>Department of Materials, Institute of Polymers, ETH Zurich

Graphene can replicate the topography of a substrate with a precision down to single macromolecules. Here we use this capability and investigate graphene and derivatives thereof for single macromolecules with increasing cross-sections. We deposited dendronized polymers (denpols) onto mica substrates and covered them with graphene oxides (GO), reduced graphene oxides (rGO), and graphenes. The denpols consist of a linear backbone surrounded by a cladding of structurally regular dendritic branches (dendrons), anchored to each repeat unit. The diameter of denpols can be systematically tuned by varying the dendron generation. The height of the molecular imprints in GO agrees well with the height of uncovered molecules. The height of molecular imprints in graphenes is smaller than the height of uncovered molecules with the difference growing with the dendron generation. First results for rGO indicate that the heights of molecular imprints in rGO are in between those for graphene and GO. We attribute the smaller heights under graphenes and rGO to a larger interaction between the sheets and the substrate, effectively squeezing the molecules, implying that the GO-substrate interaction is smaller than that of graphene, allowing for less distortion of the single macromolecules.

CPP 45.7 Wed 18:15 Poster B2

**Towards high CO<sub>2</sub> capacity: Introduction of amine-containing linkers to HTFG-COF by pre- and post-synthetic methods** — •KERSTIN GOTTSCHLING<sup>1,2</sup>, LINUS STEGBAUER<sup>1,2</sup>, and BETTINA V. LOTSCH<sup>1,2</sup> — <sup>1</sup>Max-Planck-Institut für Festkörperforschung — <sup>2</sup>Ludwig-Maximilians-Universität München

The development of materials that are suitable for the capture, stor-

age and separation of carbon dioxide is an important goal of current research. In this regard, covalent organic frameworks, so-called COFs, stand out as they are light-weight, do not contain problematic elements such as heavy and toxic metals and often show high porosities and gas capacities. The tailoring of HTFG-COF, a hydrazone-based system, towards higher CO<sub>2</sub> capacities by the introduction of amine-containing linkers, was investigated. A linker containing terminal tertiary amines was introduced to HTFG-COF by pre- as well as post-synthetic methods. The resulting systems were fully characterized by solid-state NMR spectroscopy, FT-IR, X-ray diffraction and sorption analysis. A significant change of the gas adsorption properties was found and a functionalization grade of 4% for pre- and 8% for post-synthetically modified systems was derived.

CPP 45.8 Wed 18:15 Poster B2

**The Structure and Magnetism of Restacked Spin 1/2 honeycomb RuCl<sub>3</sub> single layers** — •DANIEL WEBER<sup>1,2</sup>, LESLIE M. SCHOOP<sup>1</sup>, VIOLA DUPPEL<sup>1</sup>, JUDITH M. LIPPMANN<sup>1,2</sup>, JÜRGEN NUSS<sup>1</sup>, and BETTINA V. LOTSCH<sup>1,2</sup> — <sup>1</sup>Max Planck Institute for Solid State Physics, Heisenbergstr. 1, 70569 Stuttgart — <sup>2</sup>University of Munich, Department of Chemistry, Butenandtstr. 5 - 13, 81377

Spin honeycomb materials have gained substantial interest due to their exotic magnetism. However, in all current materials out-of-plane interactions are interfering with the in-plane order, hence a true 2D magnetic honeycomb system is still of demand. Here, we report the exfoliation of the magnetic semiconductor  $\alpha$ -RuCl<sub>3</sub> into the first halide monolayers and the magnetic characterization of the spin 1/2 honey-

comb arrangement of turbostratically stacked RuCl<sub>3</sub> monolayers. The exfoliation is based on a reductive lithiation/hydration approach. After an oxidative treatment, cooperative magnetism due to the spin 1/2 state similar to the bulk can be observed. The oxidized pellets of restacked single layers feature a magnetic transition at  $T = 7$  K in the in-plane direction, while the magnetic properties in the out-of-plane direction vastly differ from bulk  $\alpha$ -RuCl<sub>3</sub>. The deliberate introduction of turbostratic disorder to manipulate the spin structure of RuCl<sub>3</sub> is of interest for research in frustrated magnetism and complex magnetic order as predicted by the Kitaev-Heisenberg model.

CPP 45.9 Wed 18:15 Poster B2

**Chemo- and Bio-Sensor Based on One Dimensional TiO<sub>2</sub>/SiO<sub>2</sub> Photonic Crystals** — •ANNA-KATHARINA HATZ<sup>1,2</sup>, IDA PAVLICHENKO<sup>1</sup>, and BETTINA LOTSCH<sup>1,2</sup> — <sup>1</sup>Ludwig-Maximilians-Universität — <sup>2</sup>Max-Planck-Institut für Festkörperforschung

Photonic sensor technologies represent an important milestone in monitoring complex physical, chemical and biological systems. We present a new, biocompatible chemo- and biosensor based on the integration of an one-dimensional (1D) stimuli-responsive photonic crystal (PCs) with an electrophotonic visualisation platform. We demonstrate various modi operandi, including the measurement of the relative pressure of an analyte and the in situ monitoring of adhesive cell cultures, enabled by the modular combination of stimuli-responsive 1D PCs with a LED as light emitter and a photodiode as detector.