

**3rd Erwin Schrödinger Symposium 2018**  
of the Erwin Schrödinger Society for Nanosciences

**„ Progress in Interfacial Nanosciences“**



July 2-4, 2018  
Vorarlberg University of Applied Sciences  
Dornbirn, Austria  
<http://www.esg-nano.ac.at/>

**Chair:** Wolfgang Kautek

**Organization committee:** Oskar Armbruster, Wolfgang Kautek, Aida Naghilou



## Foreword

The **3rd Erwin Schrödinger Symposium 2018** of the Erwin Schrödinger Society for Nanosciences **“Progress in Interfacial Nanosciences”** is intending to instil vivid scientific communication and discussion in synthetic, biogenetic, and biomimetic Interfacial Nanosciences in respect to their fabrication methods, characterization properties, size effects, applications, and modelling for relating features and structures.

This symposium is organized by the Erwin Schrödinger Society for Nanosciences in a series of successful predecessor events, the **1st Erwin Schrödinger Symposium 2014 “Two Dimensional Nanostructures”** (November 2014, Vienna, Austria) and the **2nd Erwin Schrödinger Symposium 2016 “Zero Dimensional Nanostructures: Science and Technology of Nanoparticles”** (May 2016, Vienna, Austria).

International invited experts will illustrate the importance of Interfacial Nanosciences in future applications. Scientists can contribute their recent research in poster sessions. The conference features active discussions in oral and poster sessions. No parallel sessions are being scheduled due to the coherent topic of the meeting, and thus allowing full attendance.

Vienna, June 2018

Wolfgang Kautek  
(Chair of the 3rd Erwin Schrödinger Symposium 2018  
& Vice President of the Erwin Schrödinger Society for Nanosciences)





## Organizer



Erwin Schrödinger Gesellschaft für Nanowissenschaften

### Erwin Schrödinger Society for Nanosciences

Währinger Straße 42  
A-1090 Vienna, Austria  
Tel.: +43 1 4277 52401  
wolfgang.kautek@univie.ac.at  
<http://www.esg-nano.ac.at/>



### Austrian Ministry for Transport, Innovation and Technology

Radetzkystraße 2  
A-1030 Vienna, Austria  
Tel: +43 1 711 62 65 0  
<http://www.bmvit.gv.at/>



## Partners

 **Spectra-Physics®**

**High Q Laser GmbH**  
**MKS Instruments, Inc.**  
 Feldgut 9  
 A-6830 Rankweil, Austria  
<http://www.spectra-physics.com/>  
<http://www.mksinst.com/>

**FH Vorarlberg**

University of Applied Sciences



**FH Vorarlberg**  
 Hochschulstraße 1  
 A-6850 Dornbirn  
<https://www.fhv.at/>



**Austrian Chemical Society**  
Working Group „Physical Chemistry“  
Nibelungengasse 11/6  
A-1010 Vienna, Austria  
<http://www.goech.at/>

**EuCheMS**   
**European Chemical Sciences**  
**Division of Physical Chemistry**

**European Association for Chemical and Molecular Sciences**  
EuCheMS Physical Chemistry Division  
Avenue E. van Nieuwenhuysse 4  
B-1160 Brussels, Belgium  
<http://www.euchems.eu/divisions/physical-chemistry.html>





# Program

## Monday, July 2, 2018

09:00 – 10:00 **Registration & Coffee**

10:00 – 10:30 **Opening Ceremony**

10:30 – 11:30 **Keynote Lecture 1:** R. Tenne  
Weizmann Institute of Science, Israel  
*“Inorganic nanotubes and fullerene-like nanoparticles at the crossroad between materials science and nanotechnology and their applications”*

11:30 – 12:30 **Poster Short Lectures**

12:30 – 14:30 **Lunch Break & Poster Session**

14:30 – 15:30 **Keynote Lecture 2:** A. Dommann  
Swiss Federal Laboratories for Materials Science and Technology, Switzerland  
*“Contributions of X-ray analytical methods to biology and biomedicine”*

15:30 – 16:00 **Invited Lecture 1:** J. Kunze-Liebhäuser  
University of Innsbruck, Austria  
*“DEMS and surface science studies of electrochemical CO and ethanol oxidation on TiOC supported Pt catalysts”*

16:00 – 16:30 **Coffee Break**

16:30 **Tour: Spectra Physics**



## Tuesday, July 3, 2018

- 09:00 – 10:00 **Keynote Lecture 3:** M. Tarek  
Université de Lorraine, France  
*“Synergic use of molecular dynamics simulations and experiments reveal key aspects of lipid membranes electroporation”*
- 10:00 – 10:30 **Invited Lecture 2:** E. Reimhult  
University of Natural Resources and Life Sciences, Vienna, Austria  
*“Thermoresponsive core-shell nanoparticles”*
- 10:30 – 11:00 **Invited Lecture 3:** A. Offenhäusser  
Forschungszentrum Jülich, Germany  
*“Mind the gap - designing the neuroelectronic interface”*
- 11:00 – 11:30 **Coffee Break**
- 11:30 – 12:00 **Invited Lecture 4:** K. Wassermann  
AIT Austrian Institute of Technology, Austria  
*“Applications & Novel Considerations for Electric Fields in Biotechnology - The Importance of the Interface”*
- 12:00 – 12:30 **Invited Lecture 5:** M. Pfaffeneder-Kmen  
University of Vienna, Austria  
*“Graphene Coating Generation by the Electrochemical and Femtosecond Laser-Assisted Reduction of Graphene Oxide”*
- 12:30 – 14:30 **Lunch Break & Poster Session**
- 14:30 – 15:30 **Keynote Lecture 4:** S. Szunerits  
Université de Lille, France  
*“Antiviral and Antibacterial Inhibitors: From C-dots to Nanodiamonds”*
- 15:30 – 16:00 **Invited Lecture 6:** T.A. Klar  
Johannes Kepler University Linz, Austria  
*“Strangely Shaped Plasmonic Nanoparticles”*
- 16:00 – 16:30 **Invited Lecture 7:** M. Leutenegger  
Max Planck Institute for Biophysical Chemistry, Germany  
*“Blinking, photolysis and photoconversion of synthetic fluorophores”*
- 16:30 – 17:00 **Coffee Break**
- 17:00 **Tour: Vorarlberg University of Applied Sciences**





## Wednesday, July 3, 2018

- 09:00 – 10:00 **Keynote Lecture 5:** M. Aeschlimann  
University of Kaiserslautern, Germany  
*“Probing ultrafast electron and spin dynamics in momentum, space, and time”*
- 10:00 – 10:30 **Invited Lecture 8:** S. Partel  
Vorarlberg University of Applied Sciences, Austria  
*“Lift-Off free fabrication approach for periodic structures with nanogaps and its application”*
- 10:30 – 11:00 **Invited Lecture 9:** Y. Ekinici  
Paul Scherrer Institute, Switzerland  
*“Hydrogen Spillover: Seeing is believing”*
- 11:00 – 11:30 **Coffee Break**
- 11:30 – 12:00 **Invited Lecture 10:** A. Högele  
Ludwig Maximilian University of Munich, Germany  
*“Bright and dark excitons in atomically thin semiconductors”*
- 12:00 – 12:30 **Invited Lecture 11:** D. Amans  
Claude Bernard University Lyon 1, France  
*“Nanoparticle generation by laser ablation in liquids: basics, state of the art and opportunities”*
- 12:30 – 14:30 **Lunch Break & Poster Session**
- 14:30 – 16:00 **ESG-Nano-Prize 2018**
- 16:00 – 17:00 **Ceremonial Lecture:** E. Mazur  
Harvard University, USA  
*“Extreme Optics with Zero Refractive Index”*
- 17:00 – 17:30 **Closing Remarks**
- 17:30 **Farewell Wine & Cheese**





## Ceremonial Lecture



## Extreme Optics with Zero Refractive Index

E. Mazur

Harvard University, USA

Nanotechnology has enabled the development of nanostructured composite materials (metamaterials) with exotic optical properties not found in nature. In the most extreme case, we can create materials which support light waves that propagate with infinite phase velocity, corresponding to a refractive index of zero. This zero index can only be achieved by simultaneously controlling the electric and magnetic resonances of the nanostructure. We present an in-plane metamaterial design consisting of silicon pillar arrays, embedded within a polymer matrix and sandwiched between gold layers. Using an integrated nanoscale prism constructed of the proposed material, we demonstrate unambiguously a refractive index of zero in the optical regime. This design serves as a novel on-chip platform to explore the exotic physics of zero-index metamaterials, with applications to super-coupling, integrated quantum optics, and phase matching.



**3rd Erwin Schrödinger Symposium 2018**  
of the Erwin Schrödinger Society for Nanosciences  
„Progress in Interfacial Nanosciences“  
July 2 - 4, 2018, Vorarlberg University of Applied Sciences, Austria





## Keynote Lectures



## Keynote Lecture 1

### Inorganic nanotubes and fullerene-like nanoparticles at the crossroad between materials science and nanotechnology and their applications

R. Tenne

Weizmann Institute of Science, Israel

This presentation is aimed at demonstrating the progress with the high-temperature synthesis and characterization of new inorganic nanotubes (INT) and fullerene-like (IF) nanoparticles (NP) from 2-D layered compounds. Two important categories of new IF/INT nanostructures will be discussed in particular: 1. Synthesis of doped IF/INT of  $WS_2$  ( $MoS_2$ ) by rhenium and niobium; 2. Synthesis of IF and in particular INT from the ternary misfit compounds, like  $LnS-TaS_2$  ( $Ln = La, Ce, Gd, Ho, Er$ ),  $CaCoO-CoO_2$  and various other similar nanostructures [1]. The synthesis of 1-D nanostructures (nanotubes) from this vast group of ternary and quaternary layered materials is particularly promising.

Major progress has been achieved in elucidating the structure of INT and IF using advanced microscopy techniques, like aberration corrected TEM and electron tomography. Recent optical, electrical (e.g. superconductivity [2]) and mechanical measurements of  $WS_2$  nanotubes will be discussed. Strong capillary forces were observed upon withdrawal of individual nanotubes from water surface [3]. Applications of the IF/INT as superior solid lubricants and for reinforcement of variety of polymers and light metal alloys was demonstrated. Few recent studies indicate that this brand of nanoparticles is non-toxic and biocompatible. With expanding product lines, manufacturing and sales, this generation of superior lubricants is becoming gradually an industrial commodity.

- [1] L.S. Panchakarla et al., J. Phys. Chem. Lett. 5, 3724 (2014)  
[2] F. Qin et al., Nature Comm., DOI: 10.1038/ncomms14465 (2017)  
[3] O. Goldbart et al., PNAS 113, 13624 (2016)





## **Contributions of X-ray analytical methods to biology and biomedicine**

A. Dommann

Swiss Federal Laboratories for Materials Science and Technology, Switzerland

The development of new materials is strongly connected to the possibilities for a comprehensive analysis of their properties. Enhanced simulation possibilities also require more detailed analysis. However, analytical methods do not only provide knowledge about the materials, but also support understanding of the production process of these materials. The analytical methods of X-ray diffraction and scattering techniques like HRXRD, 2D-XRD, GI-XRD and SAXS are used to support the research in biology and biomedicine. Examples of recent research activities will be given.



## Keynote Lecture 3

### **Synergic use of molecular dynamics simulations and experiments reveal key aspects of lipid membranes electroporation**

M. Tarek

Université de Lorraine, France

The application of short and intense electric pulses enables to transiently alter the properties of cell membranes, making them permeable to a wide range of chemical species. This phenomenon is routinely used in medical applications as well in biotechnology and industrial processing. The key features of electroporation of cell membranes are based on theories involving stochastic pore formation. The direct observation of the formation of nano-sized pores in general is however not possible with conventional techniques. Furthermore, due to the complexity and heterogeneity of cell membranes, it is difficult to describe and characterize their electroporation in terms of atomically resolved processes. Atomistic simulations in general and molecular dynamics (MD) simulations in particular, have proven to be effective for providing insights into both the structure and the dynamics of model lipid membranes in general. Few years ago, pioneering MD simulations have been conducted in order to model the effect of electric fields on membranes, providing perhaps the most complete molecular model of the electroporation process of lipid bilayers. Here we show how such “computer experiments” combined with wet lab experiments provide a significant insight into the processes affecting, at the molecular level, the integrity of various types of lipid membranes when these are subject to voltage gradients of magnitude and duration equivalent to those generated by electric pulses (microsecond and millisecond vs nanosecond pulses).



## Antiviral and Antibacterial Inhibitors: From C-dots to Nanodiamonds

S. Szunerits

Université de Lille, France

The constant emergence of new viruses with a global impact to public health and society at large together with the general absence of the availability of specific antiviral therapeutics for a variety of viruses have made the search for antiviral drugs and therapeutics a challenging research task. Viruses pose a considerable challenge to the body's immune system as they hide inside cells making it difficult for antibodies to reach them. In contrast to bacterial infections, which are mostly treated using antibiotics, the immunization against viral infections is not always possible. Multivalent binding interactions have lately been considered for the development of new therapeutic strategies against bacterial and viral infections. Multivalent polymers, dendrimers and liposomes have successfully targeted pathogenic interactions. While a high synthetic effort is often needed for the development of such therapeutics, the integration of multiple ligands onto nanostructures turned to be a viable alternative. Particles modified with multiple ligands have the additional advantage of creating a high local concentration of binding molecules.

In this talk I will give several examples on the interest of carbon based nanostructures, notable C-dots and nanodiamonds for the treatment of viral and bacterial infections. Notable different glycan-modified nanodiamonds revealed themselves to be of great promise as useful nanostructures for combating microbial infections.

- [1] R. Jijie, A. Barras, F. Teodorescu, R. Boukherroub, S. Szunerits, *Molecular Systems Design & Engineering*, 2017, DOI: 10.1039/C7ME00048K, Advancements on the molecular design of nanoantibiotics: current level of development and future challenges.
- [2] A. Barras, F. A. Martin, O. Bande, J.-S. Baumann, J.-M. Ghigo, R. Boukherroub, C. Beloin, A. Siriwardena, S. Szunerits, *Nanoscale* 2013, 5, 2307-2316, Glycan-functionalized diamond nanoparticles as potent E. coli antiadhesives.
- [3] M. Khanal, F. Larsonneur, V. Raks, A. Barras, R. Boukherroub, J.-M. Ghigo, C. Ortiz Mellet, V. Zaitsev, J. M. Garcia Fernandez, C. Beloin, A. Siriwardena, S. Szunerits, *Nanoscale* 2015, 7, 2325-2335, Inhibition of Escherichia coli adhesion to biotic surfaces and of biofilm formation on abiotic surfaces by trimeric cluster mannosides conjugated to iamond nanoparticles.
- [4] M. Khanal, T. Vausellin, A. Barras, O. Bande; K. Turcheniuk, M. Benazza, Zaitsev, C. M. Teodurescu, R. Boukherroub, A. Siriwardena, J. Dubuisson, S. Szunerits, *ACS Applied Materials & Interfaces* 2013, 5, 12488-12498, Phenyl-acid-modified nanoparticles: potential antiviral therapeutics.
- [5] Barras, Q. Pagneux, F. Sané, R. Boukherroub, D. Hober, S. Szunerits, *ACS Applied Materials & Interfaces* 2016, 13, 9004-9013, Inhibition of Herpes simplex virus type 1 entry by functional carbon nanodots



## Keynote Lecture 5

### Probing ultrafast electron and spin dynamics in momentum, space, and time

M. Aeschlimann

University of Kaiserslautern, Germany

Optically excited (hot) electrons play a crucial role for many fundamental chemical and physical phenomena occurring at surfaces, interfaces, and in bulk materials. They, for instance, determine the properties of photo-induced catalysis at surfaces, and the efficiency of charge and spin transfer across interfaces between different materials. For the investigation of such processes, time-resolved photoelectron spectroscopy did turn out to be a very powerful tool through its direct access to transient band-structure dynamics. In particular, very recent progresses in the development of ultrashort pulsed light sources and electron spectrometers have paved the way for a completely new generation of real-time photoemission techniques. The review concludes with an outlook to the feasibility of future real-time studies in surface and material science.



**3rd Erwin Schrödinger Symposium 2018**  
of the Erwin Schrödinger Society for Nanosciences  
**„Progress in Interfacial Nanosciences“**  
July 2 - 4, 2018, Vorarlberg University of Applied Sciences, Austria





## Invited Lectures



## Invited Lecture 1

### DEMS and surface science studies of electrochemical CO and ethanol oxidation on TiOC supported Pt catalysts

J. Kunze-Liebhäuser

University of Innsbruck, Austria

Direct Ethanol Fuel Cells have been subject of numerous studies in recent years. However, the complete oxidation of ethanol to CO<sub>2</sub> at the anode side is still one of the main challenges. Efficient electro oxidation of ethanol (EOR) requires the use of elevated temperatures >60 °C [1], and catalysts are mainly supported on carbon, which can corrode under these conditions.

In this study, titanium oxycarbide (TiOC) is investigated as innovative support for Pt nanoparticles during the EOR [2,3]. The chemical composition of the TiOC surface has been characterized during its conversion from TiO<sub>2</sub> to TiOC, using X-ray photoelectron spectroscopy (XPS), via an ex-situ emersion approach and an operando study, which revealed that TiOC is thermodynamically less stable than anatase TiO<sub>2</sub> and carbon, and that it therefore decomposes at the surface [4]. This decomposition and the formation of a TiO<sub>2</sub> surface film upon exposure to ambient air protect the material from further oxidation when it is used in an electrochemical environment, without majorly influencing its electronic conductivity. To understand the role of TiOC as catalyst support, its surface chemistry is monitored during the EOR using ex-situ emersion XPS [5]. The activity of the catalysts is determined using cyclic voltammetry, and current transients in acidic electrolytes with ethanol. For a quantitative evaluation of the EOR products, differential electrochemical mass spectrometry (DEMS) is employed. CO oxidation and EOR studies are conducted to evaluate the CO<sub>2</sub> efficiencies of Pt nanoparticles supported on TiOC and on carbon (C). The results show that Pt/TiOC is less prone to poisoning than Pt/C which is most likely due to a stronger interaction of TiOC with ethanol [5,6] and with water. The reaction pathway of the EOR at Pt/TiOC is recorded and compared to that of Pt/C [6].

Financial support by the EU-FP7 program (DECORE, NMP4-SL-2012-309741) and the University of Innsbruck is gratefully acknowledged.

- [1] S. Sun, M.C. Halseid, M. Heinen, Z. Jusys, R.J. Behm, J. Power Sources 2009, 1, 190.  
[2] C. Rüdiger, F. Maglia, S. Leonardi, M. Sachsenhauser, I. D. Sharp, O. Paschos, J. Kunze, Electrochimica Acta 2012, 1, 71.  
[3] C. Rüdiger, J. Brumbarov, F. Wiesinger, S. Leonardi, O. Paschos, C. Valero-Vidal, J. Kunze-Liebhäuser, ChemCatChem 2013, 5, 3219.  
[4] L. Calvillo, D. Fittipaldi, C. Rüdiger, S. Agnoli, M. Favaro, C. Valero-Vidal, C. Di Valentin, A. Vittadini, N. Bozzolo, S. Jacomet, L. Gregoratti, J. Kunze-Liebhäuser, G. Pacchioni, G. Granozzi, J. Phys. Chem. C 2014, 118, 22601.  
[5] L. Calvillo, G. Garcia, A. Paduano, O. Guillen-Villafuerte, C. Valero-Vidal, A. Vittadini, M. Bellini, A. Lavacchi, S. Agnoli, A. Martucci, J. Kunze-Liebhäuser., E. Pastor, G. Granozzi, Appl. Mat. Interf. 2016, 8, 716.  
[6] N. Shakibi Nia, J. Kunze-Liebhäuser, in preparation.





## Thermoresponsive core-shell nanoparticles

E. Reimhult

University of Natural Resources and Life Sciences, Vienna, Austria

Thermoresponsive polymer materials have taken on a central role in research on smart materials due to the ease with which temperature can be applied as an external stimulus and their potential significance in biomedical and biotechnological applications, e.g. drug delivery, gene delivery, molecular separation and tissue engineering. Their attractiveness lies in the possibility to use materials for applications that radically change their solubility and colloidal interactions within a narrow temperature range.

Nanoparticles comprising an inorganic core and a thermoresponsive polymer shell are especially useful in biotechnology and medicine, since they combine thermoresponsiveness with other functions such as magnetism or optical excitation turned to localized heating and translocation for triggered extractions and drug release. While the theoretical basis and the experimental results for thermoresponsive polymer solutions are well developed, thermoresponsive core-shell nanoparticles can show much more complex phase behaviors that combine polymer brush phase transitions with colloidal phase transitions. Although this makes them more difficult to predict in a complex biological environment, it also creates possibilities to tailor much more detailed and hierarchical interactions with proteins, membranes, cells and ultimately tissue.

In my presentation I will describe our recent work on synthesizing thermoresponsive core-shell nanoparticles with exquisitely controlled architectures and our investigations of their phase behavior as function of temperature, environmental parameters relevant for biological experiments and core-shell nanoparticle morphology and topology. Our aim is to give a description of factors controlling thermoresponsive nanoparticle colloidal interactions that adds to both fundamental understanding and provides design principles for nanoparticles in applications.



## Invited Lecture 3

### Mind the gap - designing the neuroelectronic interface

A. Offenhäusser

Forschungszentrum Jülich, Germany

Silicon-based microstructures are gaining importance in fundamental neuroscience and biomedical research. Precise and long-lasting neuro-electronic hybrid systems are at the center of research and development in this field. Nowadays, the best approach to study the electrophysiological activity of neurons in vitro and in vivo is based on planar microelectrode arrays (MEA) or field-effect transistors (FET) which can be integrated with microfluidic devices. However, the weak coupling between cell membrane and electrode surface is one of the major limiting factors and technology of 3D nanostructures for cell-chip coupling is currently a vivid field of investigation. Our present study focuses on the investigation of cell-chip interfaces with in various geometries, from planar structures to optimized 3D nanoelectrodes for extracellular recordings.

A systematic characterization of cell–electrode interaction and an understanding of the interaction of cells with the electronic sensors is of utmost importance as the recorded signals are generally only in the 100  $\mu$ V range. In order to monitor in real-time the cell-metal interface and to measure in situ the gap distance of the cleft we employed surface plasmon resonance microscopy (SPRM) with the spatial resolution reaching to the optical diffraction limit. To allow a very detailed investigation of the neuro-electronic interface we developed an ultra-thin resin embedding method of individual neurons. To this end, we have performed focused ion beam cross-section cuts through the cell chip interface and subsequent imaging with scanning electron microscopy to determine the exact outline of the membrane deformation caused by the underlying nanoelectrode. Such membrane deformation measurements help to model better electric equivalent models of the seal resistances between the interface of cells and 3D nanoelectrodes.



## Applications & Novel Considerations for Electric Fields in Biotechnology - The Importance of the Interface

K. Wassermann

AIT Austrian Institute of Technology, Austria

Electric fields are utilized in a wide range of biotechnological applications. In the lab, electroporation is used for gene transfer and cell fusion. Pulsed electric field (PEF) treatment is also used for cell disruption and sterilization in food technology or for tissue ablation and tumor treatment in medicine. For molecular diagnosis and lab on a chip applications, electric fields could offer the possibility for fully integrated and automated sample preparation including cell-specific lysis. However, although first patents for biotechnological applications of electric fields were already filed in the 1960's, the electrode design has not changed significantly ever since. The use of such designs results in uncontrollable effects at the electrode/sample interface, significantly reducing its applicability. This lecture gives a brief overview of the theory of how electric fields act on cells, the applications in biotechnology as well as its current limitations. Also, our development of an alternative to the "classical" electrode design will be presented which considers the importance of the interface between electrode and biological sample. Its feasibility is exemplified by controlled cell specific lysis in the light of molecular diagnosis.



## Invited Lecture 5

### Graphene Coating Generation by the Electrochemical and Femtosecond Laser-Assisted Reduction of Graphene Oxide

M. Pfaffeneder-Kmen

University of Vienna, Austria

Graphene Oxide is a two-dimensional material, consisting of  $sp^2$ -hybridized carbon,  $sp^3$ -hybridized carbon, and a certain amount of oxygen-containing groups. Due to the non-planar structure, which results in a higher spacing between the sheets in graphite oxide, the attractive forces between the sheets are weaker as compared to graphite. Furthermore, the oxygen-containing groups cause hydrophilicity and solubility in water.

This and other properties make graphene oxide an interesting object of study. This work investigated the reduction of graphene oxide. Its reduction leads to reduced graphene oxide which exhibits a graphene-like structure. Therefore, it is proposed as a precursor material for many applications, which require a low-cost and easy to perform synthesis of graphene.

Two approaches are shown in this work: the one-step-approach and the two-step-approach. In the one-step-approach, the coating and reduction of graphene oxide occur concurrently directly out of the graphene oxide suspension. An electrochemical quartz crystal microbalance was utilized to perform mass-sensitive measurements during the electrochemical deposition of graphene oxide. Platinum coated quartzes served as working electrodes. Cathodic and anodic polarization resulted in the deposition by dissimilar mechanisms, which are electrochemical reduction and specific adsorption, respectively.

The two-step approach separates the coating and the reduction step. A reproducible coating procedure was developed. Graphene oxide coatings were deposited by spin-coating.

Moreover, the fs-laser-assisted reduction of graphene oxide coatings as an alternative to the electrochemical approach was demonstrated. The resulting reduced graphene oxide was characterized by Raman-spectroscopy and scanning electrochemical microscopy.

Finally, a scanning electrochemical microscope served to reduce graphene oxide coatings. A microelectrode was positioned on a graphene oxide coating. A cathodic polarization triggered the lateral growth of a reduced graphene oxide disk.

The mechanism of the electrochemical reduction was investigated by in-situ attenuated total reflection FTIR spectroscopy. A multivariate method was applied for evaluating the spectra. It could be shown that the reduction occurs in two steps.



## Strangely Shaped Plasmonic Nanoparticles

T.A. Klar

Johannes Kepler University Linz, Austria

Metallic nanoparticles are apt to modify the luminescence yield of fluorophores in their immediate nano-environment. They influence both the nonradiative and the radiative rate [1]. The latter can be tuned that much that even Purcell-like changes of the fluorescence spectra are observable [2]. Besides, nanoparticles have been identified to improve the intrinsic luminescence from gold by several orders of magnitude [3, 4]. In order to gain deeper insight into the interaction of luminescence and fluorescence with localized plasmons, we investigated a range of gold nanoparticles of complex shape such as bipyramids [5], stars [6-8] or sponges [9, 10]. We demonstrate applications of plain and silver-enhanced gold nanostars for random lasing [6-8,11] or for increasing the electroluminescence in organic light emitting devices (OLEDs) [12]. In the case of random lasing, we have shown that nanostars can support random lasing over a very wide spectral range, spanning almost a full octave from the visible to the IR [7]. As active materials, fluorophores in solution [7] or in a solid matrix [6] may be used, as well as pi-conjugated polymers [8] and quantum dots [11]. Plasmons can also substantially improve the quantum efficiency of the intrinsic luminescence from gold stemming from the recombination of d-band holes with sp electrons [3, 4]. While the fluorescence yield of extrinsic fluorophores is inherently linked to the hot spots of localized plasmonic resonances just outside the nanoparticles (e.g. at the intimate surface of, or in between two almost touching nanoparticles), we have actually observed an anticorrelation of the intensity of the d-band luminescence with the intensity of the hot spots between two gold nanoparticles [5]. It will be discussed that, instead of the hot spot intensity between two nanoparticles, it is the electric field intensity inside the nanoparticles as well as the spectral dispersion of the gold-intrinsic d-band hole recombination probabilities that matters. Besides, we also observed and simulated gold luminescence supported by higher order plasmonic modes. In the case of three dimensionally percolated, sponge-like gold nanoparticles, we observe highly polarized light scattering [9], which excludes the assignment of an effective medium dielectric constant to the nanosponges. In contrast to the scattering response, however, we find far less polarization dependence for the intrinsic fluorescence from small gold nanosponges [10].

- [1] E. Dulkeith et al., "Fluorescence Quenching of Dye Molecules near Gold Nanoparticles: Radiative and Nonradiative Effects", *Phys. Rev. Lett.*, 89, 203002 (2002).
- [2] M. Ringle, A. Schwemer, M. Wunderlich, A. Nichtl, K. Kürzinger, T. A. Klar, and J. Feldmann, "Shaping Emission Spectra of Fluorescent Molecules with Single Plasmonic Nanoresonators", *Phys. Rev. Lett.*, 100, 203002 (2008).
- [3] G. T. Boyd, Z. Yu, and Y. R. Shen, "Photoinduced luminescence from the noble metals and its enhancement on roughened surfaces", *Phys. Rev. B*, 33, 7923 (1986).
- [4] E. Dulkeith, T. Niedereichholz, T. A. Klar, J. Feldmann, G. von Plessen, D. I. Gittins, K. S. Mayya, and F. Caruso, "Plasmon emission in photoexcited gold nanoparticles", *Phys. Rev. B*, 70, 205424 (2004).
- [5] D. Sivun, C. Vidal, B. Munkhbat, N. Arnold, T. A. Klar, and C. Hrelescu, "Anticorrelation of photoluminescence from gold nanoparticle dimers with hot-spot intensity", *Nano Lett.*, 16, 7203 (2016).
- [6] J. Ziegler, M. Djiango, C. Vidal, C. Hrelescu, and T. A. Klar, "Gold nanostars for random lasing enhancement", *Opt. Exp.*, 23, 15152 (2015).
- [7] J. Ziegler, C. Wörister, C. Vidal, C. Hrelescu, and T. A. Klar, "Plasmonic nanostars as efficient broadband scatterers for random lasing", *ACS Photonics*, 3, 919 (2016).
- [8] B. Munkhbat, J. Ziegler, H. Pöhl, C. Wörister, D. Sivun, M. C. Scharber, T. A. Klar, and C. Hrelescu, "Hybrid Multilayered Plasmonic Nanostars for Coherent Random Lasing", *Journal of Physical Chemistry C*, 120, 23707 (2016).
- [9] C. Vidal, D. Wang, P. Schaaf, C. Hrelescu, and T. A. Klar, "Optical Plasmons of Individual Gold Nanosponges", *ACS Photonics*, 2, 1436 (2015).
- [10] C. Vidal, D. Sivun, J. Ziegler, D. Wang, P. Schaaf, C. Hrelescu, and T. A. Klar, "Plasmonic Horizon in Gold Nanosponges", *Nano Lett.*, ASAP, DOI: 10.1021/acs.nanolett.7b04875 (2018).
- [11] C. Gollner et al., "Random Lasing with Systematic Threshold Behavior in Films of CdSe/CdS Core/Thick-Shell Colloidal Quantum Dots", *ACS Nano*, 9, 9792 (2015).
- [12] B. Munkhbat, H. Pöhl, P. Denk, T. A. Klar, M. C. Scharber, and C. Hrelescu, "Performance boost of organic light emitting diodes with plasmonic nanostars", *Adv. Opt. Mat.*, 4, 772 (2016).



## Invited Lecture 7

### Blinking, photolysis and photoconversion of synthetic fluorophores

M. Leutenegger

Max Planck Institute for Biophysical Chemistry, Germany

Single-molecule localization microscopy overcomes the diffraction limit by analyzing an image sequence of blinking fluorophores for extracting the positions of individual fluorophores. Based on these positions a high-resolution image of the fluorophore distribution in the sample can be reconstructed. The quality of the reconstructed image relies chiefly on photophysical and -chemical properties of the fluorophore [1,2]. Important properties of a large number of synthetic fluorophores were investigated under typical imaging conditions. For this purpose, the nuclear pore protein NUP153 in Vero cells was immunostained by secondary antibody labeling and imaged with a commercial GSDIM microscope by Leica. The reconstructed images and the event lists of fluorophore localizations were analyzed. The fluorophores were screened in different buffer solutions: an imaging buffer containing glucose oxidase (Glox) enzyme and  $\beta$ -mercaptoethylamine (MEA), an oxygen-depleting thiol-containing buffer that improves the performance of many fluorophores decisively [3,4]; phosphate-buffered saline (PBS); and for some fluorophores Mowiol as well. Numerous fluorophores were applicable with the GloxMEA buffer and some in Mowiol. Some fluorophores performed well in PBS and may be applicable in live cell microscopy. For all buffers, spectrally different fluorophores were found suitable, which can be particularly useful for multicolor imaging. A detailed analysis of the localization events to estimate key parameters – such as the duration and the number of detected photons per blink event, the photobleaching rate and the number of localizations per nuclear pore complex – showed a heterogeneous behavior of many fluorophores. The interaction of fluorophores with the antibody or in-situ photoconversion may be responsible for this heterogeneity. Complex behavior was also observed during multicolor STED microscopy experiments, where spectral shifts hampered linear unmixing of multiple color channels. While cyanine fluorophores in aqueous solutions were studied in detail [5] and multistep photobleaching was shown for a hydrophobic tris(diethylamino)-triocatriangulenium fluorophore in organic solvents [6], little is known on the photolysis of carbopyronine fluorophores in aqueous solutions. For these reasons, photolysis experiments with the carbopyronine fluorophores 610CP and 580CP were performed. Both fluorophores were recently synthesized in our department [7]. To investigate multistep photolysis of 610CP and 580CP, aqueous solutions of these fluorophores were irradiated in a cuvette with laser light. The photolysis was monitored by UV-VIS absorption and emission spectroscopy and by high-pressure liquid chromatography (HPLC) and liquid chromatography mass spectrometry. A blue shift of about 10 nm was measured in the absorption and emission spectra of the bulk solution. Several intermediate fluorescent species with up to 40 nm shifted absorption and emission spectra were measured. The sequential photolysis of carbopyronine dye 610CP leads to loss of methyl groups and can photoconvert it to 580CP. Further irradiation of 580CP leads to the formation of blue-shifted fluorescent photoproducts by sequential photolysis of the remaining methyl groups. Thus, photolysis of 610CP involves the dealkylation of the carbopyronine core with subsequent reactions that finally result in non-fluorescent photoproducts. Spectrally resolved single-molecule experiments corroborated photoconversion events – observed as abrupt spectral changes of individual fluorophores during irradiation. Further investigation of the complex fluorophore behavior in aqueous solutions and its specific causes might lead to new antibodies and fluorophores that mitigate or inhibit artifacts in fluorescence microscopy and spectroscopy measurements.

- [1] G. T. Dempsey et al., *Nature Methods* 8, 1027–1036 (2011)
- [2] M. Lehmann et al., *J. Biophoton.* 9, 161–170 (2016)
- [3] J. Vogelsang et al., *Chem-PhysChem* 11, 2475–2490 (2010)
- [4] S. van de Linde et al., *Photo-chem. Photobiol. Sci.* 10, 499–506 (2011)
- [5] R. R. Nani et al., *Chem. Sci.* 6, 6556–6563 (2015)
- [6] Z. Liao et al., *J. Phys. Chem. A* 120, 3554–3561 (2016)
- [7] Butkevich et al., *Angew. Chem. Intl. Ed.* 55, 3290–3294 (2016)





## Lift-Off free fabrication approach for periodic structures with nanogaps and its application

S. Partel

Vorarlberg University of Applied Sciences, Austria

We developed a simple, low-cost and lift-off free fabrication approach for periodic structures with adjustable nanogaps. The fabrication of patterns in the nanometer dimension generally requires advanced manufacturing technologies such as e-beam, focused ion beam, nano imprint, deep ultra violet-, extreme ultra violet- or projection photolithography. To form metal electrodes a subsequent lift-off process is necessary, which is the most critical step and specific requirements regarding the photoresist profile are mandatory. However, in our approach, both the lift-off process and the advanced manufacturing technologies are obsolete. It combines an initial structure and two deposition process steps; first a dielectric layer is deposited, followed by a metal evaporation. The initial structure can be realized by lithography or any other structuring technique (e.g. hot embossing or injection molding). Compared to other fabrication methods the nanogap distance is not primarily dependent on the lithography and therefore tunable. We demonstrated a successful utilization of this approach by the fabrication of an electrochemical biosensor with remarkable performance. Electrochemical characterization (Chronoamperometry) shows a very high amplification (to our knowledge the highest reported amplification in bulk solution) in the range of 160 with high collection efficiency.



## Invited Lecture 9

### Hydrogen Spillover: Seeing is believing

Y. Ekinici

Paul Scherrer Institute, Switzerland

Nano-sized particles, such as platinum, are often the active component in heterogeneous catalysts. However, more often than not, the support for these particles is not innocent and it may actively participate in one or more catalytic steps. The process of spillover is often invoked. This phenomenon describes the reaction of a species on one particle, which then exerts an action on a different particle that is not in contact with the first [1]. The reactive species is, thereby, spilled over onto the support and diffuses to reach and react with the second particle. This phenomenon is often assumed, however, experimentally very difficult to verify and is, therefore, controversially discussed.

To observe the phenomenon of hydrogen spillover, we designed a model system in which 15 pairs of platinum and iron oxide particles are deposited onto a specific support with a distance between the two starting from 0 nm (overlapping pair) and progressively increasing to 45 nm. This inter-particle distance is controlled with nanometer precision using top-down nanofabrication. Thus, the only difference between the iron oxide particles is their distance to the closest platinum particle. In addition, a lone iron oxide particle, which has no interaction with any platinum over a distance of 1  $\mu\text{m}$  was also deposited within the same field-of-view. Two catalytically relevant supports, alumina and titania, were employed. Using an X-ray photoemission electron microscope installed at the SIM beamline of the Swiss Light Source, Fe  $L_{2,3}$  edge XAS of all 16 iron oxide particles could be measured simultaneously at the single particle level. After the controlled dosing of hydrogen, the extent of reduction of the iron oxide particles as function of their distance to the hydrogen splitting platinum particle is a measure to what extend hydrogen spills over onto the support and diffuses from platinum to the iron oxide particle.

There is a strong difference in the extent of spillover over titania and alumina, which was interpreted with the help of theoretical calculations. The ability of reduction of the support, which readily occurs on titania, and the ability of a hydride and proton to diffuse, as in case of alumina, determines the degree of hydrogen spillover. The theory predicted that three-coordinate aluminum in the alumina surface is essential for hydrogen spillover on alumina to occur. Such low-coordinated aluminum sites were observed in Al K edge XANES spectra. These results provide a unique insight into what are the parameters that govern a fundamental process in heterogeneous catalysis [2].

[1] R. Prins, Chem. Rev. 112 (2012) 2714–2738

[2] W. Karim et al. Nature 541 (2017) 68-71





## Bright and dark excitons in atomically thin semiconductors

A. Högele

Ludwig Maximilian University of Munich, Germany

Atomically thin semiconductors in the form of transition metal dichalcogenides have emerged recently as novel truly two-dimensional materials with remarkable opto-electronic properties. In response to an optical excitation, they host strongly bound electron-hole pairs, so-called excitons, with unique spin and valley degrees of freedom. In my presentation, I will discuss the basic opto-valleytronic signatures of bright monolayer excitons and highlight the role of dark excitons for the elementary optical response of layered semiconductor systems.



## Invited Lecture 11

### Nanoparticle generation by laser ablation in liquids basics, state of the art and opportunities

D. Amans

Claude Bernard University Lyon 1, France

Nanoparticles are widely implemented as functional elements on surfaces, into volume, and as nanohybrids, with a wide spectrum of applications. Each application requires specific features regarding size, morphology, surface chemistry, purity, colloidal stability, defects, or doping. The development of new synthesis methods, which can be reliably scaled up to industrial levels of production, is mandatory to widen the application prospectives of nanomaterials. Laser/matter interaction in liquids offers several synthesis routes for nanoparticle generation: laser ablation in liquid of a solid target (LAL), laser melting in liquid (LML), and laser fragmentation in liquid (LFL).

LAL appeared in the nineties. However, the rise of the method starts in 2000, with a significant increase of the produced nanomaterials, including metals and their alloys, doped and undoped oxides, semiconductors, carbon based materials, core-shell particles, complex stoichiometries... LAL has proven its versatility for the generation of surfactant and reactant-free nanoparticles. Continuous multigram nanoparticle synthesis has been demonstrated, with a productivity record of 4 g/h. LAL nanoparticles are now distributed by suppliers of chemical products.

Although, the processes involve in LAL are not fully understood. The reason being that the issue involves ablation processes, plasma physics, hydrodynamics, and chemistry, over a large range of values for the thermodynamic parameters (pressure, temperature), and a large range of characteristic times. In this lecture, we shall present the basics of LAL, the state of the art regarding the current understanding of the nanoparticles formation, and the opportunities.



**3rd Erwin Schrödinger Symposium 2018**  
of the Erwin Schrödinger Society for Nanosciences  
**„Progress in Interfacial Nanosciences“**  
July 2 - 4, 2018, Vorarlberg University of Applied Sciences, Austria





## Posters



## Poster 1

## A nanobiotechnology-advanced lab-on-a-chip for blood cell phenotyping

M. Rothbauer<sup>1</sup>, M. Frauenlob<sup>2</sup>, K. Gutkas<sup>2</sup>, M.B. Fischer<sup>3,4</sup>, E.-K. Sinner<sup>2</sup>, S. Küpcü<sup>2</sup>, P. Ertl<sup>1</sup>

<sup>1</sup> Vienna University of Technology, Faculty of Technical Chemistry, Institute of Applied Synthetic Chemistry & Institute of Chemical Technologies and Analytics, Getreidemarkt 9, 1060 Vienna, Austria

<sup>2</sup> University of Natural Resources and Life Sciences, Department of Nanobiotechnology, Institute for Synthetic Bioarchitectures, Muthgasse 11, 1190 Vienna, Austria

<sup>3</sup> Department of Life Science and Biomedicine, Danube University Krems, Dr. Karl Dorrekstrasse 30, 3500 Krems, Austria

<sup>4</sup> Clinic for Blood Group Serology and Transfusion Medicine, Medical University Vienna, Währinger Gürtel 18-20, 1090 Vienna, Austria

Identification, isolation, separation as well as analysis of subpopulations of cells from complex cellular samples such as blood is crucial for early detection of human diseases. For instance, iterations of cell phenotypes including surface receptor expression, cell size and frequency are of known diagnostic value. A major challenge in this field lies in reproducible immobilization of antibodies thus cell capture within biochips. In particular, poor antibody binding and site-oriented antibody binding is a well-known issue for state-of-the-art plastic surfaces commonly used for industrial mass production. Here, we present a microfluidic chip with a selective nanobiointerface for on-chip cell capture and in situ cell phenotyping.



## Creation of nanoparticle/nanorods arrays. Possible application

D. Hetemi

Pharmacy Department, Medical Faculty, University of Prishtina “Hasan Prishtina”, Rr. “Dëshmorët e Kombit”  
p.n., 10000 Prishtina, Kosovo

The recent nanotechnological methods enable the assembly and characterization of well-defined objects in nanometer scale. The quantum-dot colloid particles of diameter 1-10 nm are usually low-soluble CdTe compounds and their solubility is increased by surface covering of thiol containing compounds (e.g. mercaptopropionic acid, glutathione, cysteine, etc.) and also by increase of solution pH which leads to dissociation of functional carboxylate and/or protonated amine groups. Their exceptional physico-chemical and optical properties as well as higher photostability compared with organic fluorophores can be used for development of new analytical methods for the detection and determination of ions and molecules important in biology and medicine. QD-based nanoparticles exhibit broad excitation and narrow emission band where their position depends on their kind, morphology and size and thus the maximum of emission band can be tuned by synthetic process. This contribution deals with synthesis, characterization and application of various QD-CdTe nanoparticles. Some of them were employed for analytical determination of Cu(II) and Pb(II) ions by means of laser-induced luminescence spectroscopy. The analytical procedure was optimized for experimental conditions (pH, concentration of nanoparticles and analyte) and then it was utilized for determination of both metal ions in water samples. The proposed method is simple and fast and it can be employed for environmental analysis out of lab.



## Poster 3

## Synthesis and Characterisation of Germanium-based Nanowires with Metastable Composition

S. Barth<sup>1</sup>, M.S. Seifner<sup>1</sup>, M. Sistani<sup>2</sup>, A. Lugstein<sup>2</sup>

<sup>1</sup> Institute of Materials Chemistry, TU Wien, 1060 Vienna, Austria

<sup>2</sup> Institute of Solid State Electronics, TU Wien, 1040 Vienna, Austria

This contribution will address the formation of nanowires and nanorods of materials with metastable compositions. The growth of highly crystalline  $\text{Ge}_{1-y}\text{Ga}_y$  ( $y < 0.03\%$ ) as well as  $\text{Ge}_{1-x}\text{Sn}_x$  ( $x = 0.17$  and  $x = 0.28$ ) nanowires and nanorods at temperatures below  $210\text{ }^\circ\text{C}$  will be presented [1, 2]. These structures can be grown either via the solution-liquid-solid (SLS) or the vapor-liquid-solid (VLS) mechanism using the specific metal as growth initiator. The materials have been characterized by different analytical methods including TEM, EDX as well as XRD and the homogeneous incorporation of unusually high contents of metals in the Ge lattice have been observed. The incorporation of high concentrations of metal in the semiconductor matrix alters the physical properties of the obtained materials dramatically. For instance, the electrical properties have been investigated in single nanowire device configurations showing high conductivity values [1, 3]. Complementary, changes in the optical absorption have been recorded for  $\text{Ge}_{1-x}\text{Sn}_x$  leading to the expected transition from indirect to direct semiconductor upon Sn incorporation. In addition, the thermal stability of  $\text{Ge}_{1-x}\text{Sn}_x$  has been investigated in high temperature XRD and in situ TEM studies leading to the conclusion that unusual dissolution and recrystallization can occur in these materials during a Sn segregation process [4].

[1] M. S. Seifner, M. Sistani, F. Porrati, G. DiPrima, P. Pertl, M. Huth, A. Lugstein, S. Barth ACS Nano 2018, 12, 1236.

[2] M. S. Seifner, F. Biegger, A. Lugstein, J. Bernardi, S. Barth Chem. Mater. 2015, 27, 6125.

[3] M. Sistani, M. S. Seifner, A. Lugstein, S. Barth submitted.

[4] M. S. Seifner, S. Hernandez, J. Bernardi, A. Romano-Rodriguez, S. Barth Chem. Mater. 2017, 29, 9802.







## Two-Photon Lithography for Microfluidics and Microneedles

C. Plamadeala<sup>1</sup>, S.R. Gosain<sup>1</sup>, S. Purkhart<sup>1</sup>, B. Buchroithner<sup>2</sup>,  
J. Jacak<sup>2</sup>, F. Hischen<sup>3</sup>, J. Heitz<sup>1</sup>, W. Baumgartner<sup>3</sup>

<sup>1</sup> Institute of Applied Physics, Johannes Kepler University Linz, 4040 Linz, Austria

<sup>2</sup> Upper Austrian University of Applied Sciences, Campus Linz, 4020 Linz, Austria

<sup>3</sup> Institute of Biomedical Mechatronics, Johannes Kepler University Linz, 4040 Linz, Austria

Here we present a biomimetic approach in producing microneedles (MNs) with micro-ornamented surfaces, which facilitate liquid transportation. Animal world offers numerous examples of integument surface structures, which enable their owners to collect and transport different liquids on their bodies, as self-defence mechanisms, or for drinking purposes. Using the technique of two-photon lithography, we fabricated pyramidal microneedles (MNs) of two different geometries, namely flat MNs and structured MNs. In the latter case, the surfaces of the MNs were ornamented with integument surface structures found in the external scent efferent systems of true bugs, in order to facilitate the liquid transport on the pyramidal surfaces towards the tip of the MNs. Later on, the microneedles were subjected to wetting tests, using small amounts of soap-water solutions, and the liquid behaviour was recorded. We think that our results will be useful in enabling easier loading of the microneedles with drugs or vaccines.



## Poster 5

### Surface properties of in-situ doped sol-gel derived silicon carbide microcrystals

O. Kettner<sup>1</sup>, S. Simic<sup>1</sup>, B. Kunert<sup>1</sup>, R. Schennach<sup>1</sup>, R. Resel<sup>1</sup>, T. Grießer<sup>2</sup>, B. Friedel<sup>3</sup>

<sup>1</sup> Technische Universität Graz, 8010 Graz, Österreich

<sup>2</sup> Montanuniversität Leoben, 8700 Leoben, Österreich

<sup>3</sup> FH Vorarlberg, 6850 Dornbirn, Österreich

Silicon carbide (SiC) is a semiconductor with high thermal stability, charge carrier mobility and luminescence properties, attractive for high-power electronics and optoelectronics. Additionally, its corrosion resistance encourages applications in (photo)electrocatalysis. SiC nanocrystals have even been suggested as potential inorganic acceptor in hybrid organic-inorganic solar cells. However, in all these applications, a defined surface termination is vital for functionality of the device. Especially charge transfers across a organic/inorganic donor/acceptor interface or a semiconductor / catalyst / electrolyte interface are known to be sensitive against surface defects or insulating barriers and limit device efficiency. Of course, traditional SiC single crystal growth via sublimation or epitaxy allow good control of the surface, but they are costly and limited in design options.

Here, we demonstrate that the synthesis of in-situ doped SiC microcrystals by carbothermal reduction of a sol-gel derived silicon oxycarbide (SiOC) glass, provides such desired design options in terms of material appearance and surface structure. In our study, the impact of two different dopants in the process, nitrogen and aluminum, on the preferential formation of polytypes and surface termination has been investigated. The dopants are introduced already at the wet-chemical stage of synthesis as soluble additives. At thermal decomposition of the SiOC glass, nitrogen and aluminum are directly incorporated into the SiC lattice during its formation and lead to the desired optical/electronic properties as a consequence of the n- and p-doping, respectively. Further, the dopant's presence during SiC formation has considerable effect on polytype composition and surface formation. This has been found by X-ray diffraction with Rietveld refinement and by X-ray photoelectron spectroscopy. Hereby, the nitrogen-doped sample (SiC:N) consists by 93% of the cubic polytype 3C-SiC and crystals exhibit the typical, but unfavorable SiO<sub>2</sub> surface termination. The aluminum-doping (SiC:Al) on the other hand, leads to equal formation of cubic 3C-SiC and hexagonal polytypes 6H-SiC and 4H-SiC. But more importantly, the SiC:Al crystals showed a surface structure of hydrogenated silicon bonds, aluminum carbonate traces and a graphene sub-bilayer. The results on SiC:Al demonstrate that our simple approach can generate SiC with a stable surface passivation against oxidation and with deactivated surface defects by hydrogen-saturated dangling bonds, within a one-pot-synthesis. Material with these characteristics would be highly interesting in multiple areas of energy storage and conversion.





## Dithioalkyl-substituted Poly(p-phenylene vinylene)s (S-PPVs)

F. Glöcklhofer, M. Rimmele, K. Ableidinger, J. Fröhlich

Institute of Applied Synthetic Chemistry, TU Wien, Getreidemarkt 9/163, 1060 Vienna, Austria

Poly(p-phenylene vinylene)s (PPVs) are a class of conjugated polymers that have shaped the field of organic electronics. However, despite extensive research, the synthetic chemistry of PPVs is considered to be “far from being mission accomplished” and exciting new applications using nanoparticles of PPVs (e.g. in bioimaging and drug delivery) are emerging, making use of the excellent fluorescence properties, the low toxicity, and the biocompatibility of PPVs.

For many applications, substituents are attached to the conjugated PPV backbone. The substituents are necessary to render the polymers soluble and to adjust the electronic, spectral, morphological, and self-assembly properties. Alkoxy substituents are most frequently applied; dialkoxy-substituted MEH-PPV and MDMO-PPV (O-PPVs) are perhaps the best investigated substituted PPVs.

Interestingly, despite the manifold applications of O-PPVs, their dithioalkyl-substituted analogs (S-PPVs) have not yet been reported in the peer-reviewed literature. This is surprising, as possible structural variations are very limited (owing to the structural simplicity of PPV) and replacing oxygen by sulfur is known to be a small, but very effective variation.

Hence, it was our aim to (i) develop a short and simple low-cost synthesis of monomers for S-PPVs, (ii) find convenient polymerization conditions based on most recent developments, and (iii) measure the photophysical and electrochemical properties of the polymers. The preparation of nanoparticles and applications in devices are subject of ongoing and future research.



## Poster 7

## Quantized structuring of transparent thin films using ultrashort pulsed lasers

M. Domke<sup>1</sup>, S. Ho<sup>2</sup>, H. Huber<sup>3</sup>, P. Herman<sup>2</sup>

- <sup>1</sup> Josef Ressel Center for Material Processing with Ultrashort Pulsed Lasers, Research Center for Microtechnology, Vorarlberg University of Applied Sciences, Hochschulstraße 1, 6850 Dornbirn, Austria  
<sup>2</sup> Department of Electrical and Computer Engineering, University of Toronto, Toronto, ON, M5S 3G4, Canada  
<sup>3</sup> Department of Applied Sciences and Mechatronics, Munich University of Applied Sciences, Lothstrasse 34, 80335 Munich, Germany

The combination of ultrafast laser nonlinear interaction with optical interference in thin transparent film drives multi-layered ablation dynamics from which novel three-dimensional nanostructures can be tailored with mesoscopic properties. In this paper, we examine the laser-induced formation and subsequent dynamics of multi-level plasma disks in silica (SiO<sub>x</sub>) coated silicon substrates by pump-probe reflection microscopy. The time-resolved microscopy unveils the timing of electron plasma disk formation in the film and underlying SiO<sub>x</sub>-Si interface, and a competition of ablation dynamics governed by multi-layered pressure-wave physics. With increasing exposure, intra-film cleaving takes over from the interface interaction to drive quantized silica disk ejection from positions of optical interference maxima. Newton rings show both the opening and closing of inter- and intra-film nanocavities. A new method of holographic tracking further follows the clustering of ejected film fragments in distinct speed groups matching with the number of half-wavelength film segments cleaved open by the shaped femtosecond laser interaction.





### Laser amplification in excited dielectrics

T. Winkler, L. Haahr-Lillevang, C. Sarpe, B. Zielinski, N. Götze, N. Jelzow, A. Senftleben,  
P. Balling, T. Baumert

University of Kassel - Institute of Physics (Germany)

University of Aarhus - Department of Physics and Astronomy (Denmark)

Wide-band-gap dielectrics like glasses or water are transparent at visible and infrared wavelengths. This changes in a flash when those materials are exposed to ultrashort and highly intense laser pulses. Different interaction mechanisms lead to the appearance of an entire catalogue of transient nonlinear optical phenomena. Utilizing these, the optical properties of dielectrics were controlled from the transparent to the metal-like state. We expand this palette by a so far unexplored mechanism in excited dielectrics: amplification. In a two-colour pump-probe experiment, we show that a 400 nm femtosecond laser pulse is coherently amplified inside an excited sapphire sample on a scale of a few micrometres. Simulations strongly support the proposed two-photon stimulated emission process, which is temporally and spatially controllable. Consequently, we expect applications in all fields that demand strongly localized amplification.



## Poster 9

### Single Temporally Tailored Femtosecond Laser Pulses for Controlled High Aspect Ratio Nanomachining of Dielectrics

N. Götte, T. Winkler, T. Meinl, T. Kusserow, B. Zielinski, C. Sarpe, A. Senftleben, H. Hillmer,  
T. Baumert

University of Kassel

We report on the generation of sub-wavelength channel structures with very high aspect ratios in fused silica with a single laser shot. To that end, femtosecond laser pulses with a wavelength centred around 785 nm are temporally tailored to match different electron excitation and recombination mechanisms at play. Laser pulses are focused above, on and below a fused silica surface under ambient conditions with a long distance microscope objective. Deep channels are created without making use of self-focusing and filamentation processes and analysed by focused ion beam milling.

The channel depth as a function of focus position and pulse shape is reproduced by numerical calculations within a single parameter set. Channel depths in the range of several  $\mu\text{m}$  and diameters below 250 nm are demonstrated. Besides machining of nanophotonic devices in dielectrics, the technique has the potential to enhance laser based nano-cell surgery and cell poration techniques.





## Two-photon fluorescence microscopy to analyze femtosecond laser produced nanochannels

R. Ciobotea, C. Sarpe, B. Zielinski, R. Savulea, A. Senftleben, T. Baumert

University of Kassel

Femtosecond laser pulses (785 nm) focused above, on and below a fused silica sample generate deep channels with a very high aspect ratio. The need of investigating the depth of the channels much faster and in a more accessible way lead to a new technique. By the help of two photon fluorescence microscopy we can investigate the depth and the diameter of the channels. The excitation of the fluorescent dye (Sodium Fluorescein) inside the channels was performed by a two-photon laser beam, in sections for different focus positions. By combining and measure the difference between the first fluorescent signal and the last one, the depth of the channels was identified. The resulting fluorescent signal for the three types of channels shows that the channels made with BWL pulses were close to the surface of the sample, whereas the TAP- and TAP+ pulses make much deep channels. This method is much faster, cheaper and does not require special conditions like AFM, SEM or FIB require, everything was performed in ambient conditions, except filling the channels that was performed under vacuum.



Poster 11

**Femtosecond Material Processing Kassel:  
Live Cell Poration, Starter-Notches, LIBS and LIPSS**

B. Zielinski<sup>1</sup>, N. Götte<sup>1</sup>, J. Mildner<sup>1</sup>, G. Campargue<sup>2</sup>, S. Courvoisier<sup>2</sup>, C. Sarpe<sup>1</sup>, A. Senftleben<sup>1</sup>,  
T. Baumert<sup>1</sup>

<sup>1</sup> University of Kassel, Institute of Physics, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

<sup>2</sup> GAP-Biophotonics, University of Geneva, ch. de Pinchat 22, 1211 Geneva 4, Switzerland

We present three topics of material processing with femtosecond laser pulses on the nano- to micrometer scale: for the first time, producing transient pores in living human cancer cells with single temporally shaped laser pulses and examining the effect on transfection efficiency and viability. Furthermore, spectrochemical analysis with laser induced breakdown spectroscopy (LIBS) for investigation of surface-micro-crack growth triggered by laser-produced micro-notches in TiAl. Finally, we present large number analysis of the dependence of LIPSS period and structured surface area on the laser pulse's peak fluence and the number of pulses for fused silica and titanium.







## Plasmonic Influence on Nanostructured Organic Solar Cell Performance

M.J. Haslinger<sup>1,2</sup>, H. Pöhl<sup>2</sup>, B. Munkhbat<sup>2</sup>, M. Mühlberger<sup>1</sup>, N.S. Sariciftci<sup>3</sup>, T.A. Klar<sup>2</sup>,  
M.C. Scharber<sup>3</sup>, C. Hrelescu<sup>2,4</sup>

<sup>1</sup> PROFACTOR GmbH; Functional Surfaces and Nanostructures, 4407 Steyr-Gleink, Austria

<sup>2</sup> Institute of Applied Physics, Johannes Kepler University, 4040 Linz, Austria

<sup>3</sup> Institute for Organic Solar Cells (LIOS), Johannes Kepler University, 4040 Linz, Austria

<sup>4</sup> School of Physics and CRANN, Trinity College Dublin, Dublin 2, Ireland

The main incentives for adding dielectric and metallic nanostructures to thin film solar cells are to reduce reflective losses, to increase light absorption, to replace ITO as transparent electrode, as well as to enhance the charge carrier mobility and to manipulate the solar cell performance with plasmonic excitations [1-4]. We present an organic bulk heterojunction solar cell fabricated on a nanoimprinted periodic pillar pattern. Our ITO free solar cells show good external quantum efficiencies. Side dependent differences in the solar cell performance are observed when excited with light incident through the bottom or top side of the cell. The differences can be attributed to the excitation of different plasmonic modes of the non-identical structured electrodes. As a consequence, the performance of our plasmonic solar cell is highly sensitive to the excitation polarization when excited from the top side.

The authors acknowledge financial support by the Austrian Klima-und Energiefonds (SolarTrap, Grant No. 843929 )

- [1] Nootchanat, S.; Pangdam, A.; Ishikawa, R.; Wongravee, K.; Shinbo, K.; Kato, K.; Kaneko, F.; Ekgasit, S.; Baba, A. Grating-Coupled Surface Plasmon Resonance Enhanced Organic Photovoltaic Devices Induced by Blu-Ray Disc Recordable and Blu-Ray Disc Grating Structures. *Nanoscale* 2017, 9 (15), 4963–4971.
- [2] Ou, Q.-D.; Li, Y.-Q.; Tang, J.-X. Light Manipulation in Organic Photovoltaics. *Adv. Sci.* 2016, 3 (7).
- [3] Mandal, P.; Sharma, S. Progress in Plasmonic Solar Cell Efficiency Improvement: A Status Review. *Renew. Sustain. Energy Rev.* 2016, 65, 537–552.
- [4] Weickert, J.; Dunbar, R. B.; Hesse, H. C.; Wiedemann, W.; Schmidt-Mende, L. Nanostructured Organic and Hybrid Solar Cells. *Adv. Mater.* 2011, 23 (16), 1810–1828.



## Poster 13

### Plasmon-magnetic nanoparticles for biomolecular sensing fabrication with UV based nanoimprint lithography

M. Haslinger<sup>1</sup>, T. Mitteramskogler<sup>1</sup>, A. Shoshi<sup>2</sup>, J. Schotter<sup>3</sup>, S. Schrittwieser<sup>3</sup>, M. Mühlberger<sup>1</sup>,  
H. Brueckl<sup>2</sup>

<sup>1</sup> Functional Surfaces and Nanostructures, Profactor GmbH, Im Stadtgut A2, 4407 Steyr, Austria

<sup>2</sup> Department for Integrated Sensor Systems, Danube University Krems, Wiener Neustadt, Austria

<sup>3</sup> AIT Austrian Institute of Technology, Molecular Diagnostics, Vienna, Austria

We present a novel technique to realize stacked multifunctional nanoparticles with small size distribution in large quantity based on Ultraviolet Nanoimprint Lithography (UV-NIL) and lift-off processes in order to suspend these particles in analyte solution and carry out biomolecular sensing of relevant species. The underlying homogeneous biosensing method is based on the optical detection of changes in the rotational dynamics of anisotropic hybrid nanoparticles immersed in the analyte such as whole-blood.

We chose this new approach because it has potential advantages compared to other fabrication methods. For example, if the nanoparticles are made by chemical synthesis, one faces issues with particle size distribution and homogeneity of layer thicknesses when dealing with core-shell particles. Both these issues directly relate to the plasmonic behavior of the nanoparticles and lead to degraded sensitivity of the sensing method. By using the proposed physical fabrication method, i.e., UV-NIL combined with a lift-off process, where the materials are deposited layer wise by vapor deposition, we are confident to achieve small size variation of the nanoparticles and homogenous core and shell layer thicknesses. Furthermore, we gain two other important advantages. First, since the top side of the nanoparticles is defined by lithography, arbitrary shapes (round, elliptical, rectangular) can be fabricated. Secondly, due to using vapor deposition, a broad range of materials like noble metals (Au, Ag), oxides (SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>) and magnetic substances (Fe, Ni, Co) are available to us for the stacking of all the different layers. For this work we use UV-NIL with soft stamps to imprint elliptical patterns into the organic UV-curable NIL resist mr-NIL212\_XP on top of the lift-off layer LOR1A. Both resins are spin coated on top of a silicon wafer and after the UV-NIL step, etched by oxygen plasma. Afterwards the desired materials are deposited and the lift-off can be achieved and so a large number of homogeneous nanoparticles are generated. These nanoparticles can be used for biomolecular diagnostics, based on optical measurements of rotational dynamics. First tests reveal lowest detectable particle concentration in the picomolar (ng/mL) regime.





## Novel method for nanostructuring of complex surface presented on 3D printed implants and lenses

M.J. Haslinger, E. Guillén, V.R. Mosali, L. Schranzhofer, D. Fechtig, M. Mühlberger

Functional Surfaces and Nanostructures, Profactor GmbH, Im Stadtgut A2, 4407 Steyr, Austria

Several studies point out the crucial role of surface topography on cell adhesion, migration, and proliferation. Nanotexture can promote osteoconduction and osteoinduction in bone implants [1]. Chondrocyte density and protein production have been also shown to be promoted on cartilage nanoembossed scaffolds compared with conventional, plain polymer scaffolds [2]. Micromoulding and soft lithography have been used to generate micro and nanoscale topographical features in planar substrates. Some developments aim at incorporating nanoscale features directly on the surface of 3D fabricated implants (e.g. chemical etching or plasma surface modification). Nevertheless, it is still a challenge to produce controlled patterned nanostructures on the surface of complex 3D Objects.

In this work, we describe an effective and simple method for surface patterning of 3D Objects via soft UV Nano Imprint Lithography (UV-NIL). A flexible PDMS stamp, exhibiting periodically distributed nanofeatures, is used to achieve a conformal large area contact with the surface [3]. Process feasibility is demonstrated on several 3D objects fabricated by Stereolithography (SLA), Fused Deposition Modeling (FDM) and PolyJet Printing. First attempts for real shape implants fabricated by SLA, using a photoreactive resin for dental models, and by FDM, using a PLA filament material, are also shown.

Atomic Force Microscopy measurements at different positions along the 3D objects prove the replication fidelity of the imprinted nanostructures. A successful nanoimprint can be obtained even at an elongation of 122% of the stamp. This proves the ability of the flexible PDMS to obtain a conformal contact with complex 3D structures. Differences between the two 3D-printed implants and the effect of the shape complexity on the imprint process are evaluated by optical microscopy. The adhesion of the imprint materials to the surface of the implants is measured with cross-cut tests.

A successful nanopattern transfer from flexible stamps to 3D objects was established using soft UV-NIL. The potential of this simple and effective process for nanostructuring of 3D Objects will be presented.

The Austrian Federal Ministry for Transport, Innovation and Technology in the multiLINK project and Minaelm (Eurostars-2 CoD 6 2016, 859127) project are gratefully acknowledged.

- [1] Shaheer et al. ACS Appl. Mater. Interfaces 9, 29562–29570 (2017).
- [2] Balasundaram et al. Int. J. Nanomedicine 9, 1845–1853 (2014).
- [3] Köpplmayr et al. Surf. Topogr. Metrol. Prop. 3, (2015).



Poster 15

## Ambient Pressure - XPS Study of Self-Assembled of Glutathione (GSH) with co-adsorption of Water on Gold

R. Prakash, H. Raschke, M. Ahmad, N. Esser, R. Hergenröder

Leibniz-Institut für Analytische Wissenschaften - ISAS - e.V., 44139 Dortmund, Germany

The adsorption of biomolecules (amino acids, peptides, and proteins) on metals or oxidized surfaces is of importance in understanding bio-interface phenomena in the fields of biomaterials, biocompatibility, and chiral recognition. Indeed the collective behavior is much more complex than that of their isolated segments. Knowledge of the binding mode and chemical structure of biological molecule on metal or oxide surfaces under native conditions is a significant step toward the application of bio-functionalized materials in a biological environment. Study of biomolecule-surface interactions in water/solvent environments are quite numerous, but only in a few cases it is possible to reach an understanding of the molecule-water-surface interaction with a level of detail comparable to that accomplished in the UHV studies [1,2]. Amino acid and small peptides serve as a model in the process of chemisorption of biomolecules. New spectroscopic techniques enable the characterization of surfaces under wet atmosphere as they are found in physiological conditions.

The emergence of surface chirality is studied under wet conditions and the addition of solvated ions. The co-adsorption of water to the molecular system will induce hydrogen bonding as an additional ordering factor, co-adsorption of ionic electrolytes will result in charge-competition and influences the self-assembly of the molecular layer [3]. Both investigations will result in a more realistic picture of chiral, self-assembled monolayer under ambient, wet conditions.

Our study focused on characterization of self-assembled monolayer of GSH on gold surface at ambient pressure in the presence of water, by NAP-XPS, RAS and STM/AFM. Taking advantage of the robust and well-established method of self-assembly from the solution phase, the adsorption of a polypeptide glutathione (GSH) onto gold surfaces, which is the most abundant non-protein thiol in mammalian cells. GSH possesses the particularity of having one sulfur atom at the first position in its chain; therefore, it is a perfect candidate to form monomolecular layer on transition metals via thiol bonding. Intrinsically, this property is also leading to a straightway observation of the amino and carboxyl functional groups. We report here an investigation of GSH functional groups as a function of pH. Since the glutathione molecule has two carboxylic acid groups, one thiol and one amino group, having thus four possibilities for acidic dissociation, thus we demonstrate that the adsorption of GSH on gold substrate influenced by the pH of solution during assembly.

- [1] D. Costa, L. Savio, and C-M. Pradier, *J. Phys. Chem. B* (2016), 120, 7039-7052.  
[2] Dominique Costa, Claire-Marie Pradier, *Surface Science Reports* 70 (2015) 449-553.  
[3] A. Jürgensen, H. Raschke, N. Esser, R. Hergenröder, *Applied Surface Science* 435 (2018) 870-879.





## Self-assembly of amphiphilic designer peptides into ordered nanostructures and their interaction with lipid systems

K. Kornmüller<sup>1</sup>, B. Lehofer<sup>1</sup>, G. Leitinger<sup>2</sup>, H. Amenitsch<sup>3</sup>, R. Prassl<sup>1</sup>

<sup>1</sup> Medical University of Graz, Gottfried Schatz Research Center for Cell Signaling, Metabolism and Aging – Biophysics, Neue Stiftingtalstraße 6, 8010 Graz, Austria

<sup>2</sup> Medical University of Graz, Gottfried Schatz Research Center for Cell Signaling, Metabolism and Aging - Research Unit Electron Microscopic Techniques, Neue Stiftingtalstraße 6, 8010 Graz, Austria

<sup>3</sup> Graz University of Technology, Institute of Inorganic Chemistry, Stremayrgasse 9/4, 8010 Graz, Austria

Self-assembling amphiphilic designer peptides are a promising class of molecules to create new nanomaterials for medical and technological applications. They are exclusively composed of amino acids, but mimic lipid molecules in size and physicochemical behavior. These peptides are short, with only 4-10 amino acid residues. Their amphiphilic nature determines their fate when they are dissolved in water: the peptides spontaneously self-assemble into highly ordered nanostructures, similar to lipid mesophases. Little variations in the peptide sequence have a huge impact on the final morphology of the supramolecular assembly. This was demonstrated in a study where we engineered six systematically varied derivatives of the peptide V4WD2. Four peptide candidates readily self-assembled into lamellar structures: small angle X-ray scattering (SAXS) patterns revealed quasi Bragg peaks, which indicate long range order with a lamellar repeat distance of ~4-5 nm. Transmission electron microscopy (TEM) images confirmed the presence of stacked sheets. ATR-FTIR spectroscopy suggested a parallel internal arrangement of the peptide monomers. Other peptides assembled into twisted tapes or remained only as loosely connected aggregates.

To explore how these peptide systems respond when mixed with lipids, they were interfaced with dipalmitoyl phosphatidylcholine. At low concentrations all peptides induced the formation of a heterogeneous mixture of vesicles: large multilamellar vesicles (d-spacing ~6.3 nm) coexisted with oligo- or unilamellar vesicles (~50 nm in diameter) and a considerable fraction of bicelle-like structures (~45 nm in length, ~18 nm in width). At high peptide-to-lipid molar ratios (1/5) supramolecular peptide structures coexisted with highly uniform lipid-peptide mixed unilamellar vesicles (diameter ~260-280 nm). By SAXS a headgroup-to-headgroup distance of dHH~3.6 nm was found at  $T = 323$  K, while an interdigitated phase (dHH~3.0 nm) was induced at  $T = 298$  K.

Our results highlight the versatility of self-assembled peptide nanostructures and indicate that subtle changes in the amino acid composition are key design elements for both, the formation of peptide supramolecular structures and mixed lipid-peptide membrane systems.



## Poster 17

## 2D platform for orthogonal binding of proteins

B. Buchegger<sup>1</sup>, J. Kreutzer<sup>1</sup>, R. Wollhofen<sup>1</sup>, J. Jacak<sup>1,2</sup>, T.A. Klar<sup>1</sup>

<sup>1</sup> Institute of Applied Physics, Johannes Kepler University Linz, Altenberger Straße 69, 4040 Linz, Austria

<sup>2</sup> Upper Austria University of Applied Sciences, Campus Linz, Garnisonstraße 21, 4020 Linz, Austria

Using multiphoton polymerization (MPP) allows for fabrication of arbitrary micro- and nanoscale structures in two and three dimensions with minimum feature sizes of 100 nm and a resolution of about 200 nm. Photoresists with carboxy-functionality [1] enable writing polymer anchors capable of binding histidine-tagged proteins. Additionally, using a biotinylated supported lipid bilayer surrounding the polymer anchors in principle allows binding of arbitrary biotinylated proteins making use of the streptavidin/biotin linkage. This results in a versatile platform with one sort of proteins immobilized on the polymer anchors, while the other protein is freely moving within the supported lipid bilayer [2]. Importantly, the histidine-tag and the biotin-streptavidin interaction are independent, which allows orthogonal functionalization.

The shown platform can be used to achieve a wide range of physiological problems, e.g. T cell signaling or studies of epidermal growth factors. Additionally, MPP is cheaper compared to other lithography techniques and provides a three-dimensional writing capability.

- [1] Wollhofen, R.; Buchegger, B.; Eder, C.; Jacak, J.; Kreutzer, J.; Klar, T. A., Functional photoresists for sub-diffraction stimulated emission depletion lithography. *Opt. Mater. Express* 2017, 7 (7), 2538-2559.  
[2] Buchegger, B.; Kreutzer, J.; Mayr, S.; Wollhofen, R.; Axmann, M.; Plochberger, B.; Jacak, J.; Klar, T. A., Proteins on supported lipid bilayers diffusing around proteins fixed on acrylate anchors. Submitted.



### 3D Multiphoton Polymerized Protein Chips

B. Buchegger<sup>1</sup>, R. Wollhofen<sup>1</sup>, A. Tanzer<sup>1</sup>, C. Gabriel<sup>3</sup>, J. Jacak<sup>1,2</sup>, T.A. Klar<sup>1</sup>

<sup>1</sup> Institute of Applied Physics, Johannes Kepler University Linz, 4040 Linz, Austria

<sup>2</sup> Upper Austrian University of Applied Sciences, Campus Linz, 4020 Linz, Austria

<sup>3</sup> Ludwig Boltzmann Institute for Experimental and Clinical Traumatology, 1220 Vienna, Austria

Multiphoton polymerization (MPP) with near infrared femtosecond lasers enables fabrication of three dimensional micro- and nanoscale structures with complex geometries. Lateral and axial feature sizes of 100 nm and 240 nm can be achieved using this technique. Adding a second laser beam allows stimulated emission depletion (STED) in the outer rim of the excitation point spread function, resulting in even smaller structures below the diffraction limit.

Combining two or more photoresists, with different chemical and physical properties [1, 2], allows writing of complex three dimensional structures extending the applicability to bio-functionalization of the polymer structures. MPP platforms consisting of a protein-repellant scaffold with bio-adhesive binding sites can be used for three dimensional fluorescence linked immunosorbent assays (FLISA) [3]. As the binding sites are elevated off the substrate, signal-to-noise ratios exceeding three orders of magnitude could be achieved. In combination with microfluidics, such scaffolds with nano-anchors as protein adhesive binding sites can be used for e.g. thrombocyte activation studies.

- [1] Buchegger, B.; Kreutzer, J.; Plochberger, B.; Wollhofen, R.; Sivun, D.; Jacak, J.; Schütz, G. J.; Schubert, U.; Klar, T. A., Stimulated emission depletion lithography with mercapto-functional polymers. *ACS Nano* 2016, 10 (2), 1954-1959.
- [2] Wollhofen, R.; Buchegger, B.; Eder, C.; Jacak, J.; Kreutzer, J.; Klar, T. A., Functional photoresists for sub-diffraction stimulated emission depletion lithography. *Opt. Mater. Express* 2017, 7 (7), 2538-2559.
- [3] Wollhofen, R.; Axmann, M.; Freudenthaler, P.; Gabriel, C.; Röhr, C.; Stangl, H.; Klar, T. A.; Jacak, J., Multiphoton-polymerized 3D protein assay. *ACS Appl. Mater. Inter.* 2018, 10 (6), 1474-1479.



## Poster 19

## Detection of pH Dependent Gold Oxidation by Localized-Plasmon Voltammetry

B. Steinhauser<sup>1</sup>, C. Vidal<sup>1</sup>, R.-A. Barb<sup>1</sup>, J. Heitz<sup>1</sup>, A.I. Mardare<sup>2</sup>,  
A.W. Hassel<sup>2</sup>, C. Hrelescu<sup>1</sup>, T.A. Klar<sup>1</sup>

<sup>1</sup> Institute of Applied Physics, Johannes Kepler University Linz, 4040 Linz, Austria

<sup>2</sup> Institute for Chemical Technology of Inorganic Materials, Johannes Kepler University Linz, 4040 Linz, Austria

Gold is an excellent material for numerous plasmonic sensing applications due to its unique optical properties and extraordinary chemical stability. Recently, gold nanoparticles were used for localized plasmon voltammetry (LPV). There, the plasmonic response of a gold nanostructure to an electrochemical potential sweep is monitored optically either via the shift of the plasmonic resonance or via the increased plasmon damping as a function of the applied potential. It has been shown, that this method is capable of both, detecting electrochemical charging as well as ion adsorption [1]. However, applying large electrochemical potentials leads to surface oxidation of the gold nanostructures. As the structure of the interface is a crucial parameter in both, electrochemical and plasmonic sensing, it is of great necessity to investigate the plasmonic electrodes' response to surface oxidation.

We performed LPV in acidic electrolytes with different pH values on a gold nanowire array. Simultaneously recorded cyclic voltammograms (i.e. current versus potential) show excellent agreement with the LPV results up to the onset of oxygen evolution. Beyond that point, cyclic voltammograms are less useful due to the large current from water dissociation. In contrast, LPV still appears to provide meaningful signals. Further, with LPV the pH dependent reduction potentials of electrochemically grown gold oxides were determined and show a linear characteristic over the investigated pH range according to Nernst's equation [2].

- [1] Dondapati, S. K.; Ludemann, M.; Müller, R.; Schwieger, S.; Schwemer, A.; Händel, B.; Kwiatkowski, D.; Djiango, M.; Runge, E.; Klar, T. A., Voltage-Induced Adsorbate Damping of Single Gold Nanorod Plasmons in Aqueous Solution. *Nano Lett.* 2012, 12, 1247-1252.
- [2] Steinhauser, B.; Vidal, C.; Barb, R.-A.; Heitz, J.; Mardare, A. I.; Hassel, A. W.; Hrelescu, C.; Klar, T. A., Localized-Plasmon Voltammetry to Detect pH Dependent Gold Oxidation. *J. Phys. Chem. C* 2018, 122 (8), 4565–4571.





## Rotational optomechanics with levitated nanorods

S. Kuhn

University of Vienna, Quantum Optics, Quantum Nanophysics and Quantum Information, Boltzmannngasse 5,  
1090 Wien

Optical control over nano-mechanical objects has become a valuable tool for tests of fundamental physics and force sensing applications. To achieve optimal performance of such devices, their dissipation to the environment needs to be minimized. Levitating nanoparticles in external fields is a possible solution which opened up the growing field of levitated optomechanics. Here we extend this work to the rotational degrees of freedom of optically levitated silicon nanorods. We track and manipulate their linear and rotational motion by exploiting the polarization of two counter-propagating, focussed laser beams. This allows us to gain full control over the ro-translational dynamics of the rod and prepare them to perform ultra-stable rotations. We will discuss the prospects of our levitated system for sensing applications as well as for realising rotational optomechanics and cavity cooling experiments which may be an important step towards high-mass matter-wave interferometry with nanoparticles.



## Poster 21

## Spray pyrolysis of $Zn_{1-x}Mg_xO$ nanorods and compact films from water-based solutions as buffer layer in all-oxide solar cells

N. Winkler<sup>1,2</sup>, A.R. Wibowo<sup>1</sup>, W. Kautek<sup>2</sup>, T. Dimopoulos<sup>1</sup>

<sup>1</sup> AIT Austrian Institute of Technology, Center for Energy, Photovoltaic Systems, Vienna, Austria

<sup>2</sup> University of Vienna, Department of Physical Chemistry, Vienna, Austria

Mg-doping of ZnO increases the band gap linearly as a function of dopant concentration. This behavior is especially desired for solar cells to achieve an improved band alignment with various absorbers and enhance the cell efficiency.  $Zn_{1-x}Mg_xO$  films are commonly prepared by vacuum deposition methods (PLD, ALD, sputtering). To lower equipment costs, solution-based methods that are upscalable and yield high quality films are particularly attractive. Spray pyrolysis (SP) is a technique that fulfills these criteria.  $Zn_{1-x}Mg_xO$  films deposited by SP have been reported, but often high temperatures, toxic/flammable solvents or only low dopant concentrations were used.

We present Mg-doped ZnO nanorods and compact films deposited by SP from water-based solutions at low-temperature and atmospheric conditions. Depending on the solution composition, either nanorods or compact  $Zn_{1-x}Mg_xO$  films can be obtained. Mg concentrations up to 16 mol% were incorporated and the optical band gap can be adjusted between 3.28 and 3.50 eV. In order to show versatility of these nanostructures, a sprayed  $Zn_{1-x}Mg_xO$  film was applied as buffer layer in an all-oxide  $Cu_2O$ -type solar cell and characterized.



## Homogeneous protein analysis by magnetic core-shell nanorod probes

S. Schrittwieser

Molecular Diagnostics, AIT Austrian Institute of Technology

We present an experimental proof of a universally applicable label-free homogeneous platform for rapid protein analysis and its application for molecular diagnostics by detecting the soluble domain of the human epidermal growth factor receptor 2 (sHER2), which serves as a breast cancer biomarker in human serum and saliva samples.

Our homogeneous platform is based on complex surface engineered cylindrical ferromagnetic nanorods immersed in the sample solution. The nanorods comprise a magnetic cobalt core encapsulated by a noble metal shell of platinum and gold and are initially dispersed in organic solvents. These all-metallic nanorods are further coated by an amphiphilic polymer to enable dispersion stabilization in aqueous solutions. Carboxylic groups of the polymer shell are used to covalently link trastuzumab antibodies onto the nanorods' surfaces to specifically target the sHER2 analyte protein. Binding of the target protein is detected directly in solution by optically analyzing the rotational dynamics of the applied nanorods within an external magnetic field. The nanorods follow the rotation of the external magnetic field. Here, the specific rotational behavior very sensitively depends on the hydrodynamic nanorod volume in solution. Upon binding of the analyte protein, the hydrodynamic volume increases, which results in altered rotational dynamics.

We show measurements on target protein binding to antibodies (trastuzumab) immobilized on the surface of our nanoprobe and demonstrate direct deduction of their respective sizes. Additionally, we examine the dependence of our measurement signal on the concentration of the analyte protein, and deduce minimally detectable sHER2 concentrations in spiked samples of buffer solutions, human serum and saliva by performing sandwich-type assay measurements with secondary antibodies.

This research has received funding from the European Community's 7th Framework Programme under grant agreement n° NMP4-LA-2010-246479.



Poster 23

## Physical properties of LaS-TaS<sub>2</sub> misfit layer compounds nanotubes

D. Stolovas, *et al.*

Weizmann Institute

A limited number of studies, most of them done several decades ago, were dedicated to the investigation of the properties of misfit layer compounds (MLC) in the bulk form. In the last few years, there has been increasing interest in these nanotubes, but most of the work focused on its synthesis and the elucidation of its structure. This research, which aims to experimentally reveal the electrical transport characteristics of the material, is the first of its type. The main goal of the research was to incorporate single LaS-TaS<sub>2</sub> MLC nanotubes (NTs) into electrical devices, using advanced lithographic techniques, in order to study their electrical behavior. The research includes two-probe electrical measurements at room and at low temperatures. In addition, Raman spectra of biased single MLC NT devices were acquired.



## Strong Light-Matter Interaction in Tungsten Disulfide Nanotubes

L. Yadgarov, B. Visic, *et al.*

Weizmann Institute of Science

Transition metal dichalcogenide materials have recently been shown to exhibit a variety of intriguing optical and electronic phenomena. Focusing on the optical properties of semiconducting WS<sub>2</sub> nanotubes, we show here that these nanostructures exhibit strong light – matter interaction and form exciton – polaritons. Namely, these nanotubes perform as quasi 1-D polaritonic nano-systems and sustain both excitonic features and cavity modes in the visible-near infrared range. This ability to confine light to subwavelength dimensions at ambient conditions is induced by the high refractive index of tungsten disulfide. Using “finite-difference time-domain” (FDTD) simulations we investigate the interactions between the excitons and the cavity mode and their effect on the extinction spectrum of these nanostructures. The results of FDTD simulations agree well with the experimental findings as well as with a phenomenological coupled oscillators model which suggests a high Rabi splitting of ~280 meV. These findings open up possibilities for developing new concepts in nanotube-based photonic devices.



## Poster 25

## Quantum Dot Photoconductivity in Plasmonic Gaps

D. Grimaldi, M. Gašparić, A. Hohenau, J.R. Krenn

Institut für Physik, Karl-Franzens-Universität Graz

Recent advances in the room-temperature synthesis and deposition techniques have made colloidal semiconducting quantum dots (QDs), on the one hand, important low-cost materials for optoelectronic devices such as photodetectors or solar cells [1, 2]. On the other hand, top-down fabrication with electron beam lithography allows nowadays to design well defined structures at the nanoscale. This is exploited to fabricate metal nanostructures (MNS) that display plasmonic effects such as the concentration of an incident laser light into a sub-wavelength region and, therefore, an enhanced local optical field. Applied to, e.g., photodetectors this could result in increased speed, lower noise detection and reduced power consumption [3].

The subject matter of this poster is the investigation of QD photoconductivity in plasmonic MNS and whether a plasmonic enhancement of photocurrent is possible. The MNS are so-called bowties, which consist of two opposed triangles with a gap in-between. In this gap the incoming light intensity gets enhanced up to a thousand times. Ligand-exchanged QD films of either the semiconducting materials CdSe or PbS are drop-casted on the plasmonic gaps. With the help of a scanning stage and a focused laser beam we create maps of the local photocurrent and of the local optical transmission. On selected points of the sample, viz. the bowties, we analyze the dependence of the photocurrent on the bias voltage, the laser power and -polarization, as well as photocurrent response to temporal changes in laser intensity. The measured data do not allow to conclude the existence of a plasmonic enhanced photocurrent, however, they indicate that it could be possible to validate it with an improved measurement setup and sample design.

- [1] C. R. Kagan, E. Lifshitz, E. H. Sargent, and D. V. Talapin, "Building devices from colloidal quantum dots", *Science* 353 (2016);
- [2] R. Saran and R. J. Curry, "Lead sulphide nanocrystal photodetector technologies", *Nature Photonics* 10, 81–92 (2016);
- [3] J. A. Schuller, E. S. Barnard, W. Cai, Y. C. Jun, J. S. White, and M. L. Brongersma, "Plasmonics for extreme light concentration and manipulation", *Nature materials* 9, 193–204 (2010).





## Novel temporal pulse shaper combined with a high-power femtosecond pulse laser oscillator: application for materials processing

A. Naghilou, O. Armbruster, S. Solé, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Straße 42, 1090 Vienna, Austria

Femtosecond pulse lasers provide a strongly growing field of applications in e.g. medicine, precision machining, photochemistry, and microscopy. Controlling the temporal shape of the pulse has been the subject of intensive research [1] and has led to important discoveries and applications [2]. One of the leading techniques in controlling the pulse shape utilizing liquid crystal spatial light modulators [3]. A complete manipulation of the phase and amplitude of each spectral component is possible [4].

A temporal pulse shaper in combination with a high-power oscillator has been designed and implemented. This novel system was applied for pulse compression and material processing with an evolutionary algorithm employing the transmission signal as feedback.

- [1] A.M. Weiner, D.E. Leaird, J.S. Patel, J.R. Wullert, Optics Letters, 15 (1990) 326-328.
- [2] W. WS, R. H, D. M., Science, 259 (1993) 1581-1589.
- [3] T. Baumert, T. Brixner, V. Seyfried, M. Strehle, G. Gerber, Applied Physics B, 65 (1997) 779-782.
- [4] M.M. Wefers, K.A. Nelson, Optics Letters, 20 (1995) 1047-1049.



## Poster 27

## Femtosecond laser generation of microbumps on stacked Cu/Ag thin films

A. Naghilou<sup>1</sup>, J. Schubert<sup>1</sup>, O. Armbruster<sup>1</sup>, L.V. Zhigilei<sup>1,2</sup>, W. Kautek<sup>1</sup>

1 University of Vienna, Department of Physical Chemistry, Vienna, Austria

2 University of Virginia, Department of Materials Science and Engineering, Charlottesville, Virginia, USA

Femtosecond ablation of metal thin films has been of vivid interest since decades [1,2]. Microbumps and nanojets have been observed on thin metal films below the ablation threshold [3,4]. The generation of microbumps has been attributed to two different mechanisms considering a loss of film strength without melting [5] and due to melting [3,4,6]. In order to resolve this contradictory issue, stacked copper/silver layers have been investigated in this study. The mixing of copper and silver is mainly restricted to the liquid phase. Thus, a mixing in the microbumps was taken as a criterion for the involvement of molten phases.

[1] W. Kautek, J. Krüger, Proceedings of SPIE 2207, 600-611 (1994).

[2] J. Krüger, W. Kautek, Proceedings of SPIE 2403, 436-447 (1995).

[3] A.I. Kuznetsov, C. Unger, J. Koch, B.N. Chichkov, Applied Physics A 106, 479-487 (2012).

[4] D. Wortmann, J. Koch, M. Reininghaus, C. Unger, C. Hulverscheidt, D. Ivanov, B.N. Chichkov, Journal of Laser Applications 24, 042017 (2012).

[5] Y.P. Meshcheryakov, N.M. Bulgakova, Applied Physics A 82, 363-368 (2006).

[6] K.J. Schridder, B. Torralva, S.M. Yalisove, Applied Physics Letters 107, 124101 (2015).





## Influence of laser irradiation area and pulse number on top-down and bottom-up processes

A. Naghilou<sup>1</sup>, O. Armbruster<sup>1</sup>, M. Kitzler<sup>2</sup>, W. Kautek<sup>1</sup>

<sup>1</sup> University of Vienna, Department of Physical Chemistry, Vienna, Austria

<sup>2</sup> Technische Universität Wien, Photonics Institute, Vienna, Austria

A model describing the reduction of laser ablation threshold fluence  $F_{th}$  with pulse number  $N$  and beam radius  $w$  was presented recently [1-3]. The reduction of  $F_{th}$  with  $w$  could be related to the coverage of low-density defects whereas incubation, i.e. the reduction of  $F_{th}$  with  $N$  is attributed to high-density defects.

In this study, the influence of the spot size  $w$  and the pulse number  $N$  on ablation (top-down process) and the formation of laser-induced periodic surface structures (LIPSS) as an example of a bottom-up process is investigated.

- [1] A. Naghilou, O. Armbruster, M. Kitzler, W. Kautek, The Journal of Physical Chemistry C 119, 22992-22998 (2015).
- [2] O. Armbruster, A. Naghilou, M. Kitzler, W. Kautek, Applied Surface Science 396, 1736-1740 (2017).
- [3] M.V. Shugaev, C. Wu, O. Armbruster, A. Naghilou, N. Brouwer, D.S. Ivanov, T.J.-Y. Derrien, N.M. Bulgakova, W. Kautek, B. Rethfeld, L.V. Zhigilei, MRS Bulletin, 42 (2016) 960-968.



Poster 29

## Graphene nano-strip generation by femtosecond laser-assisted apertureless scanning near-field optical lithography

I. Falcon Casas, M. Pfaffeneder-Kmen, A. Naghilou, G. Trettenhahn, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Straße 42, 1090 Vienna, Austria

Graphene oxide is a promising precursor for the production of graphene. Photothermal and/or photochemical interactions using laser radiation may result in the photoreduction of graphene oxide [1]. In the present study, the reduction of graphene oxide is demonstrated by near-field femtosecond laser irradiation [2]. The laser beam was focused onto an atomic force microscope tip placed a few nanometers above the substrate. Near-field enhancement and/or thermal conduction below the tip induced the local reduction on graphene oxide nanosheets below the diffraction limit.

- [1] Y.-L. Zhang, L. Guo, H. Xia, Q.-D. Chen, J. Feng, and H.-B. Sun, *Adv. Opt. Mater.* 2 (2014) 10–28.  
[2] I. Falcón Casas and W. Kautek, „Apertureless scanning near-field optical lithography“, in „Laser micro-nano-nanomanufacturing and 3D microprinting“, (Ed.) A. Hu, Springer 2018.



## Laser-induced particle desorption

I. Falcon Casas, O. Armbruster, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Strasse 42, A-1090 Vienna, Austria

Particle removal by pulsed lasers is of fundamental importance in cleaning technologies and conservation science. In the case of mechanical desorption processes [1,2] adhesion forces have to be quantified. This was realized by scanning force microscopy (SFM). Polystyrene spheres attached to SFM cantilevers served as model particles. Pull-off forces on polymer and silicon substrates in the range of 50-200 nN were detected, which is about one order of magnitude lower than the predictions by theoretical models [3]. Therefore multiple contacts, asperities on the spheres, and humidity have to be considered [4].

These investigations are correlated with particle acceleration measurements induced by surface acoustic waves generated by laser pulses. Thus, a quantitative experimental comparison between the adhesion force and repulsive force caused by the surface acceleration become accessible.

- [1] S. Arif, O. Armbruster, W. Kautek, Appl. Phys. A 111 (2013) 309-317.
- [2] S. Arif, O. Armbruster, W. Kautek, Appl. Phys. A 111 (2013) 539-548.
- [3] R. Jones, H.M. Pollock, J. A. S. Cleave, C.S. Hodges, Langmuir 18 (2002) 8045-8055.
- [4] G.W. Tormoen, J. Drelich, E.R. Beach III, J. Adhesion Sci. Technol, 18 (2004) 1-17.



Poster 31

## Laser-induced breakdown spectroscopy of copper and nickel coatings on steel: influence of laser wavelength

E. Paulis, U. Pacher, M.J.J. Weimerskirch, T.O. Nagy, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Straße 42, 1090 Vienna, Austria

Rapid and precise stratigraphic analyses of metal coatings are accessible by Laser-Induced Breakdown Spectroscopy (LIBS) where the plasma emission data are converted into stratigrams [1,2]. This is demonstrated for copper and nickel coating systems on steel. A ns-pulse Nd:YAG laser (1064 nm and 532 nm) was employed. The ablation rate depends strongly on the wavelength. This cannot be explained by the optical absorption of the substrates. The thermal diffusion length together with plasma shielding can explain the observed behavior semi-quantitatively. Plasma shielding affects the ablation process with the near-infrared wavelength in contrast to the visible case where it is negligible. These results show that the beam-plasma interaction not only plays an important role in the quantification of the ablation rate, the depth resolution and the analysis depth, but also in the plasma heating which itself affects the plasma emission efficiency.

[1] T. Nagy, U. Pacher, H. Pöhl, W. Kautek, *Appl. Surf. Sci.* 302 (2914) 189-193.

[2] U. Pacher, M. Dinu, T.O. Nagy, R. Radvan, W. Kautek, *Spectrochim. Acta B* 146 (2018) 36-40.



## Multiple wavelength stratigraphy by laser-induced breakdown spectroscopy

U. Pacher<sup>1</sup>, M. Dinu<sup>2</sup>, T.O. Nagy<sup>1</sup>, R. Rădvan<sup>2</sup>, W. Kautek<sup>1</sup>

1 University of Vienna, Department of Physical Chemistry, Vienna, Austria

2 National Institute of Research and Development for Optoelectronics, Bucharest, Romania

Many modern industrial, medical, and conservation scientific applications require rapid qualitative and quantitative stratigraphic analyses of metal coatings. One promising option to achieve this is Laser-Induced Breakdown Spectroscopy (LIBS). In order to make such applications possible, detailed investigation of ablation and emission behavior is a major task.

This study used Nd:YAG lasers emitting at 1064, 532, 355 and 266 nm for the systematic ablation analysis of a galvanically deposited Ni-Co alloy layer (20% w/w Co, layer thickness 20  $\mu\text{m}$ ). The resulting plasma emission data were converted into stratigrams [1,2] employing the linear correlation coefficient method [3]. These were then used to determine the effective absorption coefficients [4], which were compared to theoretical estimations [5]. This approach allowed a systematic insight into both the influence of heat diffusion in the sample and laser-plasma interactions on the ablation rate.

- [1] T. O. Nagy, U. Pacher, H. Pöhl and W. Kautek, Appl. Surf. Sci. 302 (2014), 189-193.
- [2] U. Pacher, M. Dinu, T.O. Nagy, R. Radvan, W. Kautek, Spectrochim. Acta B 146 (2018) 36-40.
- [3] M. P. Mateo, G. N. Costa, V. Piñon and A. Yañez, Surf. Interface Anal. 38 (2006), 941-948
- [4] J. Krüger, W. Kautek, Adv. Poly. Sci. 168 (2004), 247-289
- [5] E. Matthias, M. Reichling, J. Siegel, O. W. Kaeding, S. Petzoldt, H. Skurk, P. Bizenberger and E. Neske, Appl. Phys. A 58 (1994), 129-136



## Poster 33

## Hot electron electrochemistry induced by femtosecond laser pulses

O. Armbruster, H. Pöhl, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Straße 42, 1090 Vienna, Austria

High intensity laser pulses can generate high densities of electrons in matter. One technologically important follow-up process is the deterministic multiphoton-electron coupling [1]. In the present work, the generation of high electron densities in a solid by high intensity femtosecond laser pulses [2-5] was investigated.

The subsequent emission of hot electrons into an electrolyte and the electrochemistry of intermediates was monitored as a function of laser and electrochemical parameters. Results may lead to a new understanding of the fundamentals of fast hot electron electrochemical kinetics, intermediate species electrochemistry, nanomedicine [6], materials machining in liquid contact, and the generation of colloidal solutions [7,8].

- [1] W. Kautek, J. Krüger, M. Lenzner, S. Sartania, C. Spielmann, F. Krausz, Appl. Phys. Lett. 69, 3146 (1996).
- [2] A.G. Krivenko, J. Krüger, W. Kautek, and V.A. Benderskii, Ber. Bunsenges. Phys. Chem. 99 (1995) 1489.
- [3] A.G. Krivenko, W. Kautek, J. Krüger, and V.A. Benderskii, Russian J. Electrochem. 33 (1997) 394
- [4] A.G. Krivenko, V.A. Benderskii, J. Krüger, and W. Kautek, Russian J. Electrochem. 33 (1998) 1068.
- [5] V.A. Benderskii and A.V. Benderskii, Laser Electrochemistry of Intermediates, CRC Press 1995.
- [6] A. Vogel, J.Noack, G. Hüttman, G. Paltauf, Appl. Phys. B 81 (2005) 1015.
- [7] N. Lasemi, U. Pacher, C. Rentenberger, O. Bomati Miguel, W. Kautek, ChemPhysChem 18, 118–1124 (2017).
- [8] N. Lasemi, U. Pacher, L. V. Zhigilei, O. Bomati-Miguel, R. Lahoz, W. Kautek, Applied Surface Science 2018, 433, 772-779.



## Laser Ablation Mechanisms in Liquid Contact

N. Lasemi<sup>1</sup>, U. Pacher<sup>1</sup>, L.V. Zhigilei<sup>1,2</sup>, O. Bomati-Miguel<sup>1,3</sup>, R. Lahoz<sup>4</sup>, W. Kautek<sup>1</sup>

<sup>1</sup> University of Vienna, Department of Physical Chemistry, Vienna, Austria

<sup>2</sup> University of Virginia, Department of Materials Science & Engineering, Charlottesville, Virginia, USA

<sup>3</sup> Universidad de Cádiz, Departamento de Física de la Materia Condensada, Cádiz, Spain

<sup>4</sup> Instituto de Ciencia de Materiales de Aragón, CSIC-UNIZAR, Zaragoza, Spain

Pulse laser ablation of metals in liquids has attracted attention because it enables the production of biocompatible nanoparticles for medical and catalytic applications [1-4] and the in-situ study of corrosion and repassivation processes [5,6]. Incubation (the dependence of ablation rates and threshold fluences on the number of laser pulses and the contacting medium) has rarely been understood at metals in contrast to dielectric materials.

New models considering various materials properties and bulk modifications [3,4,7-10] - beyond the well described optical changes - are discussed and semi-quantitatively correlated with the observed contrasting behavior of metals and ox-ides in various media.

- [1] S. Barcikowski, G. Compagnini, *Phys.Chem.Chem.Phys.* 15, 3022-3026 (2013).
- [2] S. Barcikowski, V. Amendola, G. Marzun, C. Rehbock, S. Reichenberger, D. Zhang, B. Gökce: *Handbook of Laser Synthesis of Colloids*, (2016).
- [3] N. Lasemi, U. Pacher, C. Rentenberger, O. Bomati Miguel, W. Kautek, *ChemPhysChem* 18, 118–1124 (2017).
- [4] N. Lasemi, U. Pacher, L. V. Zhigilei, O. Bomati-Miguel, R. Lahoz, W. Kautek, *Applied Surface Science* 2018, 433, 772-779.
- [5] T.O. Nagy, U. Pacher, H. Pöhl, W. Kautek, *Applied Surface Science* 302, 189-193 (2014).
- [6] T.O. Nagy, M.J.J. Weimerskirch, U. Pacher, W. Kautek, *Zeitschrift für Physikalische Chemie* 230, 1303–1327 (2016).
- [7] A. Naghilou, O. Armbruster, M. Kitzler, W. Kautek, *The Journal of Physical Chemistry C* 119, 22992-22998 (2015).
- [8] E.T. Karim, M.V. Shugaev, C. Wu, Z. Lin, H. Matsumoto, M. Conneran, J. Kleinert, R.F. Hainsey, L.V. Zhigilei, *Applied Physics A* 122, 407 (2016).
- [9] M.V. Shugaev, C. Wu, O. Armbruster, A. Naghilou, N. Brouwer, D.S. Ivanov, T.J.-Y. Derrien, N.M. Bulgakova, W. Kautek, B. Rethfeld, L.V. Zhigilei, *MRS Bulletin* 41 (2016) 960–968.
- [10] A. Naghilou, O. Armbruster, W. Kautek, *Applied Surface Science* 418 (2017) 487-490.



Poster 35

### Adsorption of polymeric model membrane systems on gold: an electrochemical quartz microbalance analysis

T. Werzer<sup>1</sup>, O. Bixner<sup>2</sup>, G. Trettenhahn<sup>1</sup>, E.-K. Ehmoser<sup>2</sup>, W. Kautek<sup>1</sup>

<sup>1</sup> University of Vienna, Department of Physical Chemistry, Vienna, Austria

<sup>2</sup> University of Natural Resources and Life Sciences (BOKU) Institute of Synthetic Bioarchitectures, Vienna, Austria

Recently, polymersomes have proven to be interesting model systems for studying polymeric membranes [1], in vivo tumour-shrinkage [2] and drug delivery vehicles [3].

Polymersomes are composed of amphiphilic block copolymers, that is, they consist of a hydrophilic or polar part and a hydrophobic or apolar part. Some of their advantages are their ability of encapsulating drugs and molecules, as well as a low leakage rate, which can be tuned by adjustment of the hydrophobic block size. This makes them ideal model systems for investigations on the carrying and release activities of drugs and dyes in the human body [4]. Nevertheless, information of the interaction of polymersomes with proteins is not widely explored.

Polymersomes are also capable of forming 2-D lipid bilayers on solid supports, therefore making them attractive for the application as novel biosensors [5].

In this study, the adsorption behaviour of different polymersomes (charged and neutral) and liposomes on gold has been studied in phosphate buffered saline solution with the Electrochemical Quartz Microbalance (EQMB; or Quartz Crystal Microbalance, EQCM). Moreover, the influence of Bovine Serum Albumin on the stability of the adsorbed vesicles has been investigated.

- [1] D. Wu, M. Spulber, F. Itel, M. Chami, T. Pfohl, C. G. Palivan and W. Meier, *Macromolecules*, 2014, 47, 5060-5069.
- [2] F. Ahmed, R. I. Pakunlu, G. Srinivas, A. Brannan, F. Bates, M. L. Klein, T. Minko and D. E. Discher, *Molecular Pharmaceutics*, 2006, 3, 340-350.
- [3] E. Amstad and E. Reimhult, *Nanomedicine*, 2012, 7, 145-164.
- [4] K. Sato, E. Abe, M. Takahashi and J. I. Anzai, *Journal of Colloid and Interface Science*, 2014, 432, 92-97.
- [5] S. May, M. Andreasson-Ochsner, Z. Fu, Y. X. Low, D. Tan, H.-P. M. deHoog, S. Ritz, M. Nallani and E.-K. Sinner, *Angewandte Chemie*, 2013, 125, 777-781.







## Nanotribology of anions at gold electrodes: an in situ electrochemical lateral force microscopy study

K. Klingan, C. Zafiu, C. Huber, W. Kautek

University of Vienna, Department of Physical Chemistry, Währinger Strasse 42, A-1090 Vienna, Austria

A nanotribological evaluation of the electrochemical double layer at gold/electrolyte interfaces was undertaken by in-situ lateral force measurements. Chemisorption (specific adsorption) of sulphate, bromide and iodide caused a friction increase as has been reported on silver [1]. Chemisorbed bromide showed a greater friction than iodide due to a higher surface coverage, whereas fluoride exhibited no effect, as it did not chemisorb. Low normal forces (<11 nN) led to classical friction behavior according to the Amonton's law for non-specifically (in the Outer Helmholtz Plane) and specifically adsorbed anions (in the Inner Helmholtz Plane). At higher normal forces, the cantilever tip displaced the chemisorbed anions leading to a deviation from Amonton's law. When a two-dimensional gold hydroxide layer was generated at high normal forces (>11 nN), the friction remained on a finite high level because the tip replaced the chemisorbed anions but could not penetrate the hydroxide layer. This study demonstrates that solvated anions in the Outer Helmholtz Plane do not contribute to friction significantly, whereas specifically adsorbed (chemisorbed) anions in the Inner Helmholtz Plane increase the mechanical resistance. This can be controlled by electrochemical surface charging conditions, e.g. by a potentiostat, and by the chemical nature of the anions.

[1] W. Kautek, S. Dieluweit, and M. Sahre, J. Phys. Chem. 1997, 101, 2709





**3rd Erwin Schrödinger Symposium 2018**  
of the Erwin Schrödinger Society for Nanosciences  
**„Progress in Interfacial Nanosciences“**  
July 2 - 4, 2018, Vorarlberg University of Applied Sciences, Austria



<b>Monday, July 2, 2018</b>		<b>Tuesday, July 3, 2018</b>		<b>Wednesday, July 4, 2018</b>	
900 - 930	Registration & Coffee	Keynote Lecture 3: M. Tarek		Keynote Lecture 5: M. Aeschlimann	
930 - 1000		Lecture 2: E. Reimhult		Lecture 8: S. Partel	
1000 - 1030	Opening Ceremony	Lecture 3: A. Offenhäuser		Lecture 9: Y. Ekinici	
1030 - 1100	Keynote Lecture 1: R. Tenne	Coffee Break		Coffee Break	
1100 - 1130		Lecture 4: K. Wassermann		Lecture 10: A. Högele	
1130 - 1200	Poster Short Lectures	Lecture 5: M. Pfaffeneder-Kmen		Lecture 11: D. Amans	
1200 - 1230		Lunch Break & Poster Session		Lunch Break & Poster Session	
1230 - 1300	Lunch Break & Poster Session	Lunch Break & Poster Session		Lunch Break & Poster Session	
1300 - 1330		Keynote Lecture 4: S. Szunerits		ESG-Nano-Prize	
1330 - 1400		Lecture 6: T.A. Klar		Ceremonial Keynote: E. Mazur	
1400 - 1430	Keynote Lecture 2: A. Dommann	Lecture 7: M. Leutenegger		Closing Remarks	
1430 - 1500		Coffee Break		Farewell Wine & Cheese	
1500 - 1530	Lecture 1: J. Kunze-Liebhäuser	Coffee Break			
1530 - 1600		Tour: Spectra Physics			
1600 - 1630	Tour: FH Vorarlberg				
1630 - 1700					
1700 - 1730	Tour: Spectra Physics				
1730 - 1800					