

**2nd Erwin Schrödinger Symposium 2016**  
of the Erwin Schrödinger Society for Nanosciences

**„Zero Dimensional Nanostructures“**



May 23-25, 2016  
Schönbrunn Castle  
Vienna, Austria

<http://www.esg-nano.ac.at/>

**Chair:** Wolfgang Kautek

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



## Foreword

The **2nd Erwin Schrödinger Symposium 2016 of the Erwin Schrödinger Society for Nanosciences "Zero Dimensional Nanostructures"** is intending to instil vivid scientific communication and discussion on all kinds of zero-dimensional nanomaterials in respect to their fabrication methods, characterization properties, size effects, applications, and modelling for relating the features and structures. Starting with two-dimensional nanostructures, which have been treated at the 1st Erwin Schrödinger Symposium 2014, the present symposium is now extrapolating the attention to zero-dimensional nanostructures. "Zero-dimensional nanostructures" are mainly represented by nanoparticles which show different properties from the (three-dimensional) bulk properties, exhibiting unique shape-dependent characteristics and subsequent utilization as building blocks for the key components of nanodevices, such as e.g. sensors, photocatalysts, nanocontainers, nanoreactors, and contrast agents in medical applications.

International invited experts will illustrate the importance of zero dimensional nanostructured materials in future applications. The symposium features active discussions in oral and poster sessions. No parallel sessions are being scheduled due to the coherent topic of the meeting, and to allow full attendance.

Vienna, May 2016

Wolfgang Kautek  
(President of the Erwin Schrödinger Society for Nanosciences)





## Organizer



Erwin Schrödinger Gesellschaft für Nanowissenschaften

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# Program

## Monday, May 23, 2016

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

10:00 – 10:30 **Opening Ceremony**

10:30 – 11:30 **Keynote Lecture 1:** S. Barcikowski  
University of Duisburg-Essen, Germany  
*“Laser Synthesis of Colloidal Nanoparticles - From Fundamentals to Upscaling”*

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

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

14:30 – 15:30 **Keynote Lecture 2:** N.S. Sariciftci  
Johannes Kepler University Linz, Austria  
*“From Organic to Bio-organic Nanostructures and Devices”*

15:30 – 16:00 **Lecture 1:** W.E.G. Hansal  
Happy Plating GmbH, Austria  
*“Electrochemical Pulse Deposition of Functional Nano-Particle Dispersion Coatings”*

16:00 – 16:30 **Lecture 2:** C. Zaba  
University of Natural Resources and Life Sciences Vienna, Austria  
*“Quantum Dot Synthesis Towards Integrin Receptor Detection”*

16:30 – 17:00 **Coffee Break**

17:00 – 17:30 **Lecture 3:** M. Orlandi  
University of Trento, Italy  
*“Three Strategies to Make  $Fe_2O_3$  a Competitive Material for Water Splitting Anodes and Photoanodes”*

17:30 – 18:00 **Lecture 4:** W.E. Ernst  
Graz University of Technology, Austria  
*“Creating Nanoparticles in Superfluid Helium Droplets”*

18:00 **Guided Tour Through Schönbrunn Castle**



## Tuesday, May 24, 2016

- 09:00 – 10:00 **Keynote Lecture 3:** O. Diwald  
Paris Lodron University of Salzburg, Austria  
*“Stability & Function of Interface Determined Oxide Nanocrystals”*
- 10:00 – 10:30 **Lecture 5:** K.-M. Weitzel  
Philipps University Marburg, Germany  
*“Towards Electrochemical Formation of Zero-Dimensional Metal Islands”*
- 10:30 – 11:00 **Lecture 6:** O. Bomati-Miguel  
University of Vienna, Austria  
*“Laser Ablation in Liquid Synthesis of Biocompatible Nanoparticles for Medical Imaging Applications”*
- 11:00 – 11:30 **Coffee Break**
- 11:30 – 12:00 **Lecture 7:** A. Kaiser  
University of Innsbruck, Austria  
*“Production of Reactive Fullerene Carbenes by Addition of Atomic Carbon to Fullerene Doped Helium Nanodroplets”*
- 12:00 – 12:30 **Lecture 8:** U. Kreibitz  
Rheinisch-Westfälische Technische Hochschule Aachen, Germany  
*“Size Dependences of the Electronic Band Structure of Noble Metal Nanoparticles”*
- 12:30 – 14:30 **Lunch Break & Poster Session**
- 14:30 – 15:30 **Keynote Lecture 4:** T. Hofmann  
University of Vienna, Austria  
*“Nanotechnology and Water: Threats and Solutions”*
- 15:30 – 16:00 **Lecture 9:** M. Zehetbauer  
University of Vienna, Austria  
*“Potential of Crystal Defects for Enhancing Bulk Functional Nanomaterials”*
- 16:00 – 16:30 **Lecture 10:** B.S. Shaghasemi, M.M. Virk  
University of Natural Resources and Life Sciences Vienna, Austria  
*“Control Over Drug Delivery Liposome Release Kinetics Using Magnetic Fields”*
- 16:30 – 17:00 **Coffee Break**
- 17:00 – 17:30 **Lecture 11:** T. Werzer  
University of Vienna, Austria  
*“Polymeric Model Membrane Systems on Gold: An Electrochemical Quartz Microbalance Analysis”*
- 17:30 – 18:00 **Lecture 12:** D. Velic  
Comenius University in Bratislava, Slovakia  
*“Cyclodextrin Based Host-Guest Supramolecules: From Double Confinement in Micelles to Surface Nanostructures”*





## Wednesday, May 25, 2016

- 09:00 – 10:00 **Keynote Lecture 5:** M. Parlinska-Wojtan  
Polish Academy of Sciences, Poland  
*“Playing Around with Shape and Composition of 0-Dimensional Nanostructures for Various Applications”*
- 10:00 – 10:30 **Lecture 13:** T.A. Klar  
Johannes Kepler University Linz, Austria  
*“STED Nanolithography”*
- 10:30 – 11:00 **Lecture 14:** T. Waitz  
University of Vienna, Austria  
*“Nanoparticles Studied by Transmission Electron Microscopy”*
- 11:00 – 11:30 **Coffee Break**
- 11:30 – 12:00 **Lecture 15:** C. Hrlescu  
Johannes Kepler University Linz, Austria  
*“Complex Shaped Plasmonic Nanoparticles”*
- 12:00 – 12:30 **Lecture 16:** Y. Salinas  
Johannes Kepler University Linz, Austria  
*“Nanoscope Molecular Gates Based on Doped Quantum Dots for Oxidative Stress Damage Detection”*
- 12:30 – 14:30 **Lunch Break & Poster Session**
- 14:30 – 16:00 **ESG-Nano-Prize 2016**
- 16:00 – 17:00 **Keynote Lecture 6:** E. Reimhult  
University of Natural Resources and Life Sciences Vienna, Austria  
*“Synthesis and Assembly of Superparamagnetic Core-Shell Nanoparticles into Functional Colloidal Systems”*
- 17:00 – 17:30 **Closing Remarks**
- 17:30 **Farewell Wine & Cheese**





## Keynote Lectures



## Keynote Lecture 1

### Laser Synthesis of Colloidal Nanoparticles - From Fundamentals to Upscaling

S. Barcikowski

University of Duisburg-Essen, Technical Chemistry I, Essen, Germany  
Center for Nanointegration Duisburg-Essen (CENIDE), Duisburg, Germany

After decades of intensive nanoresearch, nanoparticles are widely implemented as functional elements on surfaces, into volumes and as nanohybrids, with a wide spectrum of applications such as optics, biomedicine and catalysis or energy science. However, integration of the “nanofunction” into products is still limited due to drawbacks of gas phase and chemical synthesis methods regarding particle aggregation and contamination causing deactivation of the building blocks’ surface.

As an alternative synthesis route, nanoparticle generation by lasers in liquids has proven its capability to generate and conjugate totally ligand-free colloidal nanoparticle building blocks, just started getting commercial. Recent studies highlight unique properties of laser-generated nanoparticles potentially harvested in real-world applications. At the same time, the community discovered novel process routes and describe unique material properties yielded by this exceptional, scalable synthesis method. In this talk, an overview on high-power laser synthesis of colloids will be presented including in situ synchrotron experiments addressing the formation mechanism, rules for size control, and technical innovations for upscaling. This includes explanation of the material properties intrinsic to the unique synthesis approach, and its exemplarily evaluation in catalysis and biomedicine.

#### References

- [1] Barcikowski, S. ; Compagnini, G.: Advanced Nanoparticle Generation and Excitation by Lasers in Liquids. *Phys. Chem. Chem. Phys.* 15 (2013), 9, 3022–3026
- [2] Wagener, P. ; Barcikowski, S. ; Baersch, N.: Fabrication of nanoparticles and nanomaterials using laser ablation in liquids. In: *Photonik international* (2011), 20–23
- [3] Rehbock, C. ; Jakobi, J. ; Gamrad, L. ; Van der Meer, S. ; Tiedemann, D. ; Taylor, U. ; Kues, W. ; Rath, D. ; Barcikowski, S.: Current state of laser synthesis of metal and alloy nanoparticles as ligand-free reference materials for nano-toxicological assays. *Beilstein Journal of Nanotechnology* 5 (2014), S. 1523-1541.
- [4] YouTube Channel (of open access videos shown during the talk): <http://youtube.com/nanofunction>



Keynote Lecture 2

**From Organic to Bio-organic Nanostructures and Devices**

N.S. Sariciftci

Johannes Kepler University, Linz Institute for Organic Solar Cells (LIOS) /  
Institute of Physical Chemistry, Linz, Austria

In order to account for a sustainable future, the application of biodegradable and biocompatible nanostructures for organic optoelectronics are needed. The use of cheap electronic devices in a large scale will introduce a shift “from consumer electronics to consumable electronics”. As such the contribution of electronic devices to urban waste is already increasing rapidly today. Therefore, environmentally friendly materials are important to use. This is a next great challenge to material science in organic electronics. New developments of bio-inspired and/or bio-origin, bio-compatible materials and nanostructures are interesting. Such materials can also be used to interface the biological and biomedical research with the organic electronics field.



## Keynote Lecture 3

### Stability & Function of Interface Determined Oxide Nanocrystals

O. Diwald

Paris Lodron University of Salzburg, Department of Chemistry and Physics of Materials, Salzburg,  
Austria

The implementation of metal oxides and hydroxides into functional and structural materials requires knowledge about their growth and stability in changing chemical environments. In this regard tailored particle systems with interface properties which are accessible to experimental methods are indispensable model systems [1]. This presentation deals with examples where structure-property relationships have been established for metal oxide nanocrystals and their transformation behavior in aqueous environments. Particle interface functionalization processes via the gas- or the liquid phase will be compared.

#### References

- [1] T. Berger and O. Diwald, "Defects in Metal Oxide Nanoparticle Powders", in Defects at Oxide Surfaces, ed. J. Jupille and G. Thornton, Springer International Publishing, ISBN: 978-3-319-14366-8, 2015.



## Nanotechnology and Water: Threats and Solutions

T. Hofmann

University of Vienna, Department of Environmental Geosciences, Vienna, Austria

The production and use of engineered nanoparticles (ENPs) inevitably leads to their release into aquatic environments, with the quantities involved expected to increase significantly in the future. Concerns therefore arise over the possibility that ENPs might pose a threat to drinking water supplies. Investigations into the vulnerability of drinking water supplies to ENPs are hampered by the absence of suitable analytical methods that are capable of detecting and quantifying ENPs in complex aqueous matrices. Analytical data concerning the presence of ENPs in drinking water supplies is therefore scarce. The eventual fate of ENPs in the natural environment and in processes that are important for drinking water production are currently being investigated through laboratory based-experiments and modelling. Although the information obtained from these studies may not, as yet, be sufficient to allow comprehensive assessment of the complete life-cycle of ENPs, it does provide a valuable starting point for predicting the relevance of ENPs to drinking water supplies. This talk will address specific problems of water work operations in regard to trace contaminants including nanoparticles. Beside classical hydrogeological approaches including statistical analysis and groundwater modelling, possible threads by nanoparticles from consumer products, their analyses, but also groundwater remediation with engineered nanoparticles will be addressed.



## Keynote Lecture 5

### Playing Around with Shape and Composition of 0-Dimensional Nanostructures for Various Applications

M. Parlinska-Wojtan, G. Gruzeł, E. Roga, J. Depciuch, A. Kowal

Polish Academy of Sciences, Institute of Nuclear Physics, Krakow, Poland

Chemical synthesis routes allow fabricating zero-dimensional nanomaterials with fancy shapes and sizes between 2 to 50 nm, which can be applied in materials science, chemistry, catalysis, medicine or biology. This study will be focused on several types of catalytic nanoparticles (NPs), silver nanoparticles synthesized using green chemistry methods and in particular on their morphological and chemical analysis using transmission electron microscopy (TEM). In particular, a novel concept of three-dimensional (3D) catalysts [1] with a potential application in fuel cells will be introduced. These nanoparticles have a dodecahedron shape with Pt skin at the edges and a Ni core. When etching away the core, the remaining Pt frame will offer a much larger active surface compared to spherical nanoparticles. The morphology of these 3D PtNi particles strongly depends on the synthesis parameters allowing to fabricate dodecahedrons, core-shell or even dendritic structures.

SnO<sub>2</sub> nanoparticles are excellent supports for noble metal NPs, as their combination exhibits good catalytic activity towards ethanol oxidation reaction [2]. Various synthesis routes including polyol and microwave assisted methods allowed producing different SnO<sub>2</sub> NPs. The disruption of the ethanol molecule occurs at the interface between PtRh and SnO<sub>2</sub> particles. Therefore, their physical contact is of crucial importance for having an effective catalyst. Structural aspects and advanced characterization techniques by TEM of the PtRh/SnO<sub>2</sub>/C catalysts will be shown. Last but not least, silver nanoparticles deposited on special supports obtained via green synthesis processes, which can be applied in medical and food industry will be presented.

#### References

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- [2] A. Kowal, M. Li, M. Shao, K. Sasaki, M.B. Vukmirovic, J. Zhang, N.S. Marinkovic, P. Liu, A.I. Frenkel and R.R. Adzic, *Nature Materials* 9 (2009) 325-330.





## Synthesis and Assembly of Superparamagnetic Core-Shell Nanoparticles into Functional Colloidal Systems

E. Reimhult

University of Natural Resources and Life Sciences, Department of Nanobiotechnology,  
Vienna, Austria

Nanoparticles with ultrastable and carefully controlled core-shell structures can be used in biomedical applications, e.g., as biomedical imaging contrast agents, for hyperthermia and in drug delivery [1,2], as well as for biotechnological applications such as separation and purification. Using nanoscale inorganic cores, e.g. superparamagnetic iron oxide single crystals, unique material functions can be achieved, but to enable these functions in a biological environment a dense organic shell has to control colloidal interactions with biomolecules, cells and other nanoparticles [1,3]. Exquisite control over nanoparticle physical properties through an organic shell also allows us to tailor the assembly of nanoparticles into supramolecular structures, such as nanoscale vesicles that can be externally controlled through the strong interaction of the inorganic core with externally applied electromagnetic fields.

I will describe multiple recent developments in our lab regarding the synthesis of superparamagnetic core-shell nanoparticles following this design philosophy. The combination of new organic shell grafting methods [4-7] and control over nanoscale self-assembly [8,9,10-12] has allowed us to vastly improve performance of superparamagnetic core-shell nanoparticles, perform detailed investigations of interactions of colloidal responsive nanoparticles as well as demonstrate unprecedented control over magnetically controlled nanovesicular and nanoemulsion systems for transport and release.

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## Lectures



## Lecture 1

### Electrochemical Pulse Deposition of Functional Nano-Particle Dispersion Coatings

W.E.G. Hansal, S. Hansal, G. Sandulache, M. Halmdienst

Happy Plating GmbH, Wiener Neustadt, Austria

This presentation will introduce and critically discuss several systems combining both electrochemical pulse deposition and nano-particle dispersion coatings for technical applications. The incorporation of micro- and nano particles within a growing metal layer during the electrochemical deposition is a powerful method for generating functional coatings.

Engineered tribocoatings of all kinds are under increasing interest due to their capability of enhancing component reliability and reducing life-cycle cost. The substitution of hard chromium processes, which suffer from severe environmental problems due to the use or even emission of carcinogenic hexavalent chromium ions, would push the importance of environmental friendly alternative galvanic process routes. One possible way of realising such an alternative coating process is the use of dispersion coatings.

Nano-dispersion coatings using either nano particles or the benefits of modern pulse plating techniques are on the edge of their industrial implementation. The combination of both methods pulse plating and dispersion coatings offer a broad variety of new surface functionality. The embedment of nano particles within a metal matrix can offer the desired hardness, the friction and wear characteristics, the pulse deposition will provide the erosion and corrosion resistance and an excellent thickness distribution. Comparing pulse plated nano dispersion coatings with especially hard chromium coatings will reveal the capability of such layer systems. The electrochemical development, the surface layer characterisation and the tribological testing will be presented. The embedment of nano particles during a pulse plating process has to be based on fundamental electrochemical measurements as well as the adjustment of the Zeta-potential of the particles in the electrolyte solution.

This presentation will cover the fundamentals of as well pulse as dispersion deposition, will discuss the role of the Zeta-potential and will describe the resulting properties of the produced layers. It will be shown, that a combination of a nanocrystalline metal matrix of the pulse plated layer systems with the incorporation of nano-particles will lead to very durable, functional coatings, useable for various sectors of industrial production.



## Quantum Dot Synthesis Towards Integrin Receptor Detection

C. Zaba

University of Natural Resources and Life Sciences, Department of Nanobiotechnology,  
Vienna, Austria

Mammalian cells synthesize certain receptors on their surface relevant in the complex process of cell adhesion, proliferation and angiogenesis. However, such receptor family, the integrins, plays as well a crucial role in pathogenic processes, such as metastasis. An example for a relevant receptor species from the integrins had been assigned as integrin  $\alpha\beta3$ .

Integrin-related processes are typically studied on the surface of living cells. However, due to cellular integrin diversity and redundancy, the characterization of specific integrin interactions on cellular surfaces is often impeded, making the study on cell surfaces difficult. Set-ups based on isolated and surface-immobilized integrin receptors are also difficult to develop, as the isolation of integrin molecules from cells is notoriously difficult. To address this problem, we demonstrated for the first time the *in vitro* membrane-assisted protein synthesis (iMAPS) of an interdependent heterodimeric membrane receptor into a stable polymeric architecture. These membrane-stabilized integrins, so-called proteopolymersomes, had to be purified from the crude reaction mixture prior to characterization and use. To do this, we developed a specific immunoprecipitation technique in order to purify the proteopolymersomes. Immuno-staining however, often suffered in weak signals stemming from reduced signal-to-noise ratios due to non-specific antibody binding.

To enhance the specific signal intensity, we chose to address this need by developing a novel tracer strategy, based on Quantum Dot-nanocrystals (QDs).

We therefore chose to synthesize QDs, and functionalize them with a protein-resistant, water soluble surface. This required us to establish a novel synthesis method for the partial exchange of native ligands for dithiol-PEG on QDs. The adsorption conditions were fine-tuned until a balance between efficient surface passivation and a sufficiently dense polyethylene glycol grafting achieving strong colloidal stability and protein resistance. The QDs will serve as a precursor for further functionalization with an integrin specific target. Furthermore, the samples could also be used directly for transmission electron microscopy (TEM), as electron density and elemental composition of the QDs permit this extension.



## Lecture 3

### Three Strategies to Make Fe<sub>2</sub>O<sub>3</sub> a Competitive Material for Water Splitting Anodes and Photoanodes

M. Orlandi, A. Mazzi, S. Caramori, C.A. Bignozzi, A. Miotello

University of Trento, Physics Department, Trento, Italy

In recent years, iron oxides, conjugating earth-abundance and high market availability with their non-toxic and environmentally friendly nature, have attracted considerable attention for applications in catalysis where scalability is a central goal. Iron(III) oxide in particular, both amorphous ( $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>) and hematite ( $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>), has shown promising results as anodic material in electrochemical and photoelectrochemical water splitting cells, where it performs the oxygen evolution reaction. Hematite electrical properties are however far from ideal and severely limit its application as anodic material: in bulk form it is a Mott insulator, with resistivities of up to 10<sup>12</sup> Ω cm and poor carrier mobility, especially for the hole minority carriers, for which it has a diffusion length of about 2-4 nm only. Using a variety of fabrication techniques, from physical vapor deposition to wet-chemistry methods, we devised and implemented three strategies to overcome these problems:

- (a) nanostructuring by pulsed laser deposition yielding thin nanoparticle-assembled coatings of amorphous material, which couple robustness and stability to superior performance under electrocatalysis conditions;
- (b) tin doping by radio frequency magnetron sputtering, significantly improving conductivity and extending the visible light absorption range of the material;
- (c) functionalization of photoanodes with porous and transparent Fe<sub>2</sub>O<sub>3</sub> obtained by pulsed layer deposition leading to adaptive junctions which improve charge-separation and photovoltage generation.

Our results are a step forward towards the realization of efficient low-cost anodic materials for water splitting applications and highlight the critical role of morphology tuning at the nanometric level to determine materials properties.



## Creating Nanoparticles in Superfluid Helium Droplets

W.E. Ernst

Graz University of Technology, Institute of Experimental Physics, Graz, Austria

Superfluid droplets of  $10^4$  to  $10^7$  helium atoms (HeN) are doped with foreign atoms or molecules that move freely in or on the droplets and may form complexes in this cold environment [1].

In our labs, large Cu, Ag, Au, and Ni aggregates of different morphology are generated in helium droplets [e.g. 2] and their landing on a solid substrate was modelled in a molecular dynamics simulation [3]. Nanowires and core-shell clusters with one metal surrounding a core of different kind were observed, deposited on solid substrates [4,5], and analyzed by high resolution electron microscopy and tomography [6]. As it turns out, the temperature of the substrate [5] and the doping rate [7] have an important influence on the final cluster or wire structure. Our systematic studies will help to provide recipes for the creation of tailored nanoparticles.

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## Lecture 5

### Towards Electrochemical Formation of Zero-Dimensional Metal Islands

J. Martin, V. Wesp, M. Schäfer, K.-M. Weitzel

University of Marburg, Department of Chemistry, Marburg, Germany

Bombardment induced ion transport (BIIT) has been developed for investigating ion transport through solid materials under conditions where the sample is in contact with a single electrode. Here we discuss two recent examples.

In the first example we have investigated the transport of  $\text{Na}^+$  and  $\text{K}^+$  ions in a mixed borate glass. The transport has been induced by shining a  $\text{Cs}^+$  ion beam at the sample. Analysis of the electrodiffusion profiles provides access to the diffusion coefficients of all mobile species. Interestingly, charge balance is achieved by solely depositing elemental sodium (no potassium) in the form of nano grains at the glass/electrode interface.

In the second example we have investigated the transport of  $\text{Cs}^+$  ions through a 150 nm thick polymer film (poly-p-xylylene). In the course of the experiment cesium is deposited at the backside of the polymer film, turning the polymer/electrode interface into an interphase. In the case of homogeneous polymer film the deposition of cesium is also (apparently) homogeneous. If the film exhibits cracks, holes or other non-intermittent pathways for ion transport these are easily identified by the formation of cesium islands at the polymer/electrode interface. These islands can be imaged in 3D. Possible relevance for material testing will be discussed.





## Laser Ablation in Liquid Synthesis of Biocompatible Nanoparticles for Medical Imaging Applications

R. Lahoz<sup>a</sup>, N. Lasemi<sup>b</sup>, C. Rentenberger<sup>c</sup>, G. Reisinger<sup>d</sup>,  
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Nowadays, one of the areas of the medicine where the application of nanomaterials is obtaining better results, with higher economic impact, is the use of inorganic water stable colloidal nanoparticles as contrast agents in the in vivo diagnosis of pathological processes by medical imaging techniques [1]. However, the introduction in the clinical use of these contrast agents based is still very limited as consequence of the doubts about the possible adverse effects of these nanoparticles and the limited success to upscaled, standardised, and streamlined the synthesis methods [2]. Today, colloidal nanoparticles are synthesized fundamentally via liquid-phase bottom-up synthesis methods. These methods allow to synthesize colloidal nanoparticles with a broad variety of compositions and morphologies, which show fashionable properties [3]. However, these chemical procedures fail to be transferred from the laboratory to the industry, due to they involve numerous parameters which are difficult to control; moreover, they do not meet the requirements of energy efficiency and savings in raw materials and natural resources required by new global guidelines for environmental protection [3,4]. On the contrary, laser-induced synthesis methods, such as pyrolysis laser, photolysis and, more recently, laser ablation in liquids of massive materials have proven to be an excellent alternative for the production of biocompatible water stable colloidal nanoparticles, with a precise control of the size and composition [4,5]. Among these methods, laser ablation in liquids has allowed the synthesis of wide range of stable nanoparticles in a variety of liquid solutions, with minimal variation in the process parameters and replacing chemical precursors by much cheaper massive materials [5]. So that, an overview of recent investigations on direct laser ablation in liquids synthesis of water stable colloidal nanoparticles is here presented; with special attention to clarify the influence of the different experimental variables on the nanoparticles properties, as well as to outline the potential of this technique to produce hybrid nanoparticles showing multi-modal capabilities.

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## Lecture 7

### **Production of Reactive Fullerene Carbenes by Addition of Atomic Carbon to Fullerene Doped Helium Nanodroplets**

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The addition of atomic carbon to fullerene aggregates in helium nanodroplets has been shown to lead to carbenes of the type  $C_{60}(C:)_n$  with  $n < 7$  and to C-bridged fullerene aggregates including also the known dumbbell structure [1]. Mass spectra indicate an enhanced chemical reactivity towards chemical adsorption of  $n$  hydrogen or  $n$  water molecules, whereas bare fullerenes in helium droplets only physisorb these species. The cold environment efficiently quenches fullerene cage growth, which is preferred under energetic conditions, and instead favors carbene formation and subsequent functionalization.

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## Size Dependences of the Electronic Band Structure of Noble Metal Nanoparticles

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Measurement of Surface Plasmon Polaritons in uncontaminated, free metal nanoparticles yields information about interband transitions, and, thus, about valence and conduction bands. Results will be presented for laser ablation produced free noble metal nanos and for matrix embedded nanos which clearly exhibit strong size dependences below, say, 3 nm particle diameters. These dependences may be either due to a break-down of the band structure or to changes of the optical transition matrix elements.



## Lecture 9

### Potential of Crystal Defects for Enhancing Bulk Functional Nanomaterials

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In the past decennia, several techniques have been developed to achieve bulk and dense solids consisting of nanocrystals, of which those with top-down processing schemes revealed as the most successful ones (“Severe Plastic Deformation - SPD”) [1]. Recently this method achieved outstanding performances also with functional materials such as electric conductors and superconductors, photovoltaic, and irradiation resistant materials [2]. This presentation reports on common activities of Austrian research groups which have focussed on SPD processed thermoelectrics, hydrogen storage materials, and biomedical alloys [2]. Excellent as well as even world-record high functional properties could be reached in p- and n-type high-temperature thermoelectrics by optimizing the SPD processing applied with regard to crack minimization. SPD processing achieved a significant enhancement in the capacity and stability of hydride materials for hydrogen storage, and also in mechanical and corrosion properties of biomedical alloys. It is shown, however, that the highest functional improvements have not been induced by grain refinement but by the nanostructures formed by SPD induced lattice defects such as dislocations and/or vacancy agglomerates. The type and arrangement of these defects seem to play an important role for the optimization of functional properties which appears feasible by suitable combination of different SPD techniques and of specific thermal treatments.

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## Control Over Drug Delivery Liposome Release Kinetics Using Magnetic Fields

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Stealth (PEGylated) liposomes have taken a central role in drug formulation and delivery combining efficient transport with low nonspecific interactions. Controlling rapid release at a certain location and time still remains a challenge dependent on environmental factors. Liposome-nanoparticle composite vesicles can overcome the dependence on the local environment by providing the possibility to directly manipulate the vesicle structure by external fields. We demonstrate that the rate and amount released using actuation by alternating magnetic fields can be precisely controlled with very low passive release from stable liposomes with high membrane melting temperature, as essentially an add-on to existing stealth liposome technology. This is achieved by a new method for incorporating monodisperse, hydrophobic, superparamagnetic iron oxide nanoparticles in the membrane at controlled density and distribution. The effect of lipid composition, particle concentration and magnetic field actuation on stability, magneto-thermally actuated release and passive release rates could thereby be independently investigated for stealth drug delivery liposomes.



## Lecture 11

## Polymeric Model Membrane Systems on Gold: An Electrochemical Quartz Microbalance Analysis

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Recently, polymersomes have proven to be interesting model systems for studying polymeric membranes [1], in vivo tumor-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. 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 behavior 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.

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## Cyclodextrin Based Host-Guest Supramolecules: From Double Confinement in Micelles to Surface Nanostructures

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A concept of zero dimensional nanomaterial is based on three dimensional confinement. The three dimensional confinement is demonstrated on three systems with focus on structure and dynamics. The first system [1] represents a host-guest supramolecular complex of  $\beta$ -cyclodextrin (CD) - coumarin (C522) which is doubly confined in a reverse sodium dioctyl sulfosuccinate (AOT) micelle. Varying the diameters of the reverse micelle proportionally to the value of  $w = 3, 5, 10, 20,$  and  $40,$  can determine the level of confinement. The ultrafast fluorescence decays of  $12.6$  and  $11.8$  ps for C522 / AOT and C522 / CD / AOT, respectively, support a double confinement in the C522 / CD / AOT ( $w = 3$ ) system. The dynamics in the small and large micelles clearly show two different trends, where the average lifetimes are determined to be  $12.6$  and  $6.5$  ps for the small ( $w = 3$ ) and the large ( $w = 40$ ) micelles, respectively.

The second system [2] represents a supramolecular complex between cyclodextrin and iron species where the iron species are prepared by pulsed laser ablation of bulk iron in water. A mass spectrometry peak at  $1210$  m/z is observed and assigned as  $C_{42}H_{67}O_{35}FeNa^+$ , which indeed corresponds to a cyclodextrin molecule with Fe atom.

The third system [3] represents a supramolecular surface nanostructure based on thiolated cyclodextrin chemisorbed on Au surface (Au-S-CD) and deposited Fe species. The mass spectrometry peaks at  $1227$  m/z,  $1243$  m/z, and  $1260$  m/z are observed and assigned as  $C_{42}H_{68}O_{34}SNa-Fe^+$ ,  $C_{42}H_{68}O_{34}SK-Fe^+$  together with  $C_{42}H_{68}O_{34}SNa-FeO^+$ , and  $C_{42}H_{68}O_{34}SK-FeO^+$ , respectively. Laser ablation results in supramolecular host-guest surface nanostructures formation in the form of Au-S-CD-Fe and in the adduct formation in the form of Au-S-CD-FeO.

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## Lecture 13

### STED Nanolithography

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It was proposed already in the early reports of STED microscopy that the confined excitation volume can be applied to spatially control chemical reactions on the nanometer scale [1]. Recently, this prediction has been experimentally realized in the field of optical nanolithography [2-4]. Nanoscale structures written with some acrylate compositions show good biocompatibility and allow for bio-functionalization with proteins, down to the single protein level [5-6]. The ability to place individual proteins into nano-confined spaces plays a growing role in bioscience, from basic studies in biology to the development of nanoscopic sensors. Other compositions of acrylates, specifically those containing polyethylene glycol, are protein repellent. This allows writing two-component structures, where non-adhesive scaffolds are written in three dimensions and later on, protein adhesive nanoscale regions are added for targeted protein attachment.

While such two-component acrylate structures already allow for many applications in physiological and medical research, it would be even more appealing, if proteins and other biomolecules could be attached covalently to nanoscale structures. We will also address routes in this direction [7].

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## Nanoparticles Studied by Transmission Electron Microscopy

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Transmission electron microscopy (TEM) is a powerful tool to analyse the size, structure, chemistry, and phase transformations of nanoparticles. In this work, TEM methods were applied to study functional nanoparticles including ligand separated Au nanoparticles synthesized by reduction of  $\text{HAuCl}_4$ , nanoparticles obtained by laser ablation using a shape memory NiTi target, and in-situ heating and straining experiments of NiTi shape memory particles obtained by nanocrystallization of an amorphous matrix.



## Lecture 15

### Complex Shaped Plasmonic Nanoparticles

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Complex shaped nanoparticles are of particular interest for many applications, where an optimal interaction between light and nanoscale objects is desirable, since such nanoparticles provide easily accessible hot-spots and exhibit multiple plasmon resonances in the visible-NIR spectral range. Single nanostars have been shown to provide high Raman enhancement factors [1] due to the hot-spots located on the tips [2,3]. Moreover, the individual tips of a single nanostar can be selectively excited [2]. Furthermore, nanostars are more efficient for random lasing than conventional nanoparticle shapes, such as rods [4].

Here, I present two different types of complex shaped nanoparticles, which manifest several plasmon resonances with strong polarization dependence, namely nanostars and sponge-like nanoparticles that consist of fully percolated gold and air filaments.

The correlation of the scattering spectra with the corresponding nanosponge morphology reveals that the plasmonic properties depend only weakly on the surface roughness, but are decisively influenced by the for each nanosponge unique 3D percolation.

Further, different strategies to modify the luminescence of gain materials upon addition of spectrally matching plasmonic nanostars are described, such as substantially enhanced electroluminescence and enhanced photoluminescence of OLEDs [5]. Financial support was partially provided by the European Research Council (ERC Starting Grant 257158 'Active NP'), by the Austrian Klima- und Energiefonds (SolarTrap, Grant 843929) and by Erasmus GATE.

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## Nanoscopic Molecular Gates Based on Doped Quantum Dots for Oxidative Stress Damage Detection

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The oxidation of biological systems involves the formation of radicals and reactive oxygen species (ROS) commonly related with cancer, mutation and other degenerative diseases. Nowadays, the detection of these short-lived and highly reactive molecules is very difficult by direct methods. However, this oxidative stress damage can be detected through measuring secondary products such as hydrogen peroxide ( $H_2O_2$ ), which concentration increases under pathological conditions such as acidic cancer cells environment. In this direction, early diagnosis and therapy are essential, and so the design of efficient drug delivery tools represents a challenge in nanomedicine. Multifunctional hybrid materials based on mesoporous silica nanoparticles (MSNs) are a promising candidate as a drug delivery system, compared to liposomes or emulsions, because of their thermally stability, rigid framework that prevents premature degradation, and easy to functionalize with stimuli-responsive gate-keeper, reducing side effects of conventional systems and controlling the release. Nevertheless, time tracking of these nanomaterials inside the body is also needed and the possibility to design hybrid materials for theranostics (therapy and diagnostic features in one nanodevice) applications is highly appealing. Hence, in this project is proposed the use of biocompatible ZnS quantum dots (QDs) as better alternative to organic dyes and fluorescent proteins. Their doping with  $Mn^{2+}$  ions will enable the QDs to be excited with Near Infrared light (NIR) sources, preventing the traditional drawback of ultraviolet-induced biological photodamage. Furthermore, presence of anticancer drugs decreases the fluorescence intensity of QDs, facilitating their tracking in cells. Consequently, a hybrid molecular gate-like nanomaterial based on biocompatible luminescent QDs containing pH and  $H_2O_2$  sensitive organic functionalities was prepared to control the release of anti-cancer drugs through a “close-opening gate mechanism” under oxidative stress conditions, typical of cancer cells. This project represents a major evolution of existing theranostic systems.





## Posters



## Poster 1

## Membrane Interaction of Pegylated Superparamagnetic Nanoparticles

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Iron oxide core-shell nanoparticles are gaining ever increasing interest for separation and imaging in biotechnology and biomedicine due to supposed low cytotoxicity and their superparamagnetic properties. Hydrophilic polymer-coated nanoparticles are believed to have low nonspecific interactions in biological systems, but much additional work in-vitro and in-vivo is needed to understand their detailed interactions with proteins, membranes and cells. We investigated monodisperse ( $SD < 5\%$ ), single-crystalline and superparamagnetic magnetite nanoparticles of different core size and densely grafted with poly(ethylene glycol) ( $M_w = 5$  kDa), with particular emphasis on their interaction with biological membranes. Membrane interactions will determine nonspecific recognition and uptake by cells. These nanoparticles demonstrated no cytotoxicity and low cell uptake in in-vitro culture of HeLa and HEK cell lines.

However, using Quartz Crystal Microbalance (QCM) a strong DLVO-type interaction could be demonstrated with anionic membranes that simulate eukaryote membranes. This interaction was only present in nonphysiological buffer with low ionic strength. Only low, weak and transient binding was observed to zwitterionic phosphocholine membranes. Core size seems to have an effect, with the smallest core size (3.3 nm) yielding the strongest interactions while 8 nm cores displayed almost no interaction. These results imply that dense polymer grafting and nanoparticle curvature are crucial parameters to control interactions between biomedical core-shell nanoparticles and their biomolecular environment, in particular cell membranes. The interaction between nanoparticle and membrane was furthermore shown to not perturb membrane structure by Differential Scanning Calorimetry (DSC).



## CdTe-QD Fluorosensor for Determination of Cu(II) and Pb(II) Ions

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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

## Effects of Synthesis Parameters on Shape of Bimetallic Pt-Ni Nanoparticles

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Platinum nanoparticles (NPs) have many interesting applications due to their catalytic, ferromagnetic, and electro-optical properties [1]. These properties may be improved by adding atoms of d-block transition metals (e.g. iron, cobalt, nickel) [2]. Improving catalytic properties of Pt NPs can also be achieved by controlled synthesis, resulting in nanoparticles having well defined shapes and sizes [3]. Unfortunately, such syntheses are very difficult to perform due to multiple factors, which can affect the size and shape of bimetallic nanoparticles produced in a solution through nucleation and growth process. Therefore, it is important to know the effect of each synthesis parameter on the obtained nanoparticles.

Herein, a series of syntheses of PtNi NPs were carried out in order to check the effect of temperature at which the metal precursors were added to the solution, their concentrations and duration of the reaction on the shape and size of the synthesized nanoparticles. The aim was to obtain nanoparticles having a shape of rhombic dodecahedrons, which are composed of a Pt frame around a Ni core.

The obtained nanoparticles were characterized using transmission electron microscopy (TEM) technique. The morphology of the nanoparticles and their size distribution was imaged in HAADF STEM mode. Energy-dispersive X-ray spectroscopy (EDS) was used to examine the distribution of chemical elements in the sample. The HAADF STEM structural analysis showed that dendritic rhombic dodecahedron NPs, regular rhombic dodecahedron and approximately spherical NPs were obtained depending on the synthesis parameters. In particular, the temperature of metal precursor addition strongly influenced the shape of the NPs. All samples had a crystalline structure, which was confirmed by HRTEM images. The size of the nanoparticles varied from 20 to 50 nm, depending on the synthesis method. EDS analysis of all samples confirmed the presence of platinum in the frame and nickel in the core of the nanoparticles. The obtained results allow to conclude that even a small change of a single parameter during the synthesis procedure, leads to a different morphology of the nanoparticles.

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## How to Synthesize and Characterize Effective Nanocatalysts for Ethanol Oxidation?

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Ethanol is a molecule of considerable interest because of its potential use as renewable fuel in fuel cells [1]. However, the reactions occurring in fuel cells are complex and generate a lot of by-products. Therefore, the main challenge is to design and develop an appropriate type of catalysts in form of nanoparticles. Nanocatalysts consisting of two or three metals often have a higher electrocatalytic activity and efficiency. The most promising combination seems to be ternary nanocatalysts containing a nanoalloy of Pt and Rh supported on  $\text{SnO}_2$  [2].

This study was conducted to better understand the synergistic effect between these three components in nanocatalysts. Moreover, by replacing expensive rhodium by cheaper rhenium we aim determining the selectivity of the PtRe/ $\text{SnO}_2$  nanocatalyst for a total oxidation of ethanol to  $\text{CO}_2$ . In a first step the  $\text{SnO}_2$  particles were synthesized using three methods: polyol [3], citrate [4], and microwave assisted [5]. The obtained nanoparticles were characterized by Photon Correlation Spectroscopy (PCS), Transmission Electron Microscopy (TEM) and Fourier Transform Infrared Spectroscopy (FTIR). PCS measurements and TEM observations showed that the  $\text{SnO}_2$  nanoparticles independently on the synthesis method were crystalline and strongly agglomerated with dimensions not exceeding 2 nm. Independently on the synthesis method in all obtained  $\text{SnO}_2$  samples the presence of  $\text{Sn}_4^+$  (stretching modes of O-Sn-O) and  $\text{Sn}_2^+$  (Sn-O stretching modes) was identified by FTIR. In the infrared spectrum of Sn oxide synthesized by both polyol methods stretching modes of Sn-O from the by-product  $\text{Sn}(\text{OH})_4$  were observed, while after increasing the heating time the by-product was transformed into the final  $\text{SnO}_2(\text{Sn}_4^+)$ . FTIR measurements showed, that in samples synthesized by the microwave method, larger amounts of Sn-O stretching modes ( $\text{Sn}_2^+$ ) were present. The next step is the synthesis of PtRh and PtRe nanoparticles on the obtained  $\text{SnO}_2$  supports. The obtained results clearly show that the crystalline structure, particle size and shape, and surface properties are highly dependent on the chosen method of synthesis.

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## Poster 5

## Plasmonic Nanosponges

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Here, we investigate the correlation between optical and morphological properties of three-dimensionally percolated gold/air nanoparticles, also called gold (Au) nanosponges. The Au nanosponges show a mesoporous structure throughout their volume with Au filament sizes below 20 nm. We show that the scattering spectra of single Au nanosponges depend only weakly on their outer shape and size. However, the multiple plasmon resonances are mainly influenced by the specific three-dimensional percolation of each nanosponge, in agreement with numerical calculations. Furthermore, we find that, unlike other plasmonic structures, the photoluminescence spectra of single nanosponges significantly differ from their scattering spectra. The photoluminescence of individual nanosponges displays a size-dependent polarization.



## Multi-layered Plasmonic Nanostars for Photon Management in Organic Light-Emitting Diodes

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Despite the enormous progress in improving the efficiency of organic light-emitting diodes (OLEDs) with new materials, optimal light management in OLEDs still remains an open problem. Here, we present promising possibilities for effective photon-management in OLEDs. We designed and synthesized silver-enhanced gold nanostars coated with a thin silica shell (~10 nm), so that the hot-spots at the tips of nanostars remain accessible, while the exciton quenching is reduced. The spectral position of the plasmon resonances of the nanostars is tuned in specific spectral regions for the optimal overlap with the emission of different organic semiconductors. We demonstrate that the luminescence of polymer solutions and thin films can not only be significantly enhanced upon addition of spectrally matching plasmonic nanostars, but also coherent random lasing can be facilitated. Furthermore, we successfully incorporated the nanostars in the active layer of fully working OLEDs. For a given current density, the plasmonic OLEDs show both: significantly enhanced electroluminescence as well as substantially different emission directionality as compared to the conventional plain OLED. We find that the nanostars act as nanoantennas, thus accelerating the radiative recombination of excitons as well as improving the out-coupling of light otherwise trapped inside the OLEDs. Our experimental results allow us to discuss beneficial and limiting factors of photon management in the plasmonic organic devices.



## Poster 7

### Photoluminescence of Gold Bipyramid Dimers

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Here, we report on the one-photon photoluminescence from gold bipyramid (BP) dimers. We use an atomic force microscope for the mechanical positioning of the two BPs. The possibility to precisely adjust the distance between two bipyramids, allows us control over the plasmonic coupling and strength of the hot-spot in the gap of a dimer. Photoluminescence as well as scattering of the dimers were measured for every adjusted distance. Furthermore, we experimentally and numerically show that the photoluminescence from gold bipyramid dimers anticorrelates with the local field enhancement in the gap between the two BPs.



## **Control Over Drug Delivery Liposome Release Kinetics Using Magnetic Fields**

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Stealth (PEGylated) liposomes have taken a central role in drug formulation and delivery combining efficient transport with low nonspecific interactions. Controlling rapid release at a certain location and time still remains a challenge dependent on environmental factors. Liposome-nanoparticle composite vesicles can overcome the dependence on the local environment by providing the possibility to directly manipulate the vesicle structure by external fields. We demonstrate that the rate and amount released using actuation by alternating magnetic fields can be precisely controlled with very low passive release from stable liposomes with high membrane melting temperature, as essentially an add-on to existing stealth liposome technology. This is achieved by a new method for incorporating monodisperse, hydrophobic, superparamagnetic iron oxide nanoparticles in the membrane at controlled density and distribution. The effect of lipid composition, particle concentration and magnetic field actuation on stability, magneto-thermally actuated release and passive release rates could thereby be independently investigated for stealth drug delivery liposomes.



Poster 9

### Coupling Quantum Dots to Plasmonic Nanowires

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We lithographically combine plasmonic nanowires and colloidal quantum dots (QDs) as a platform to modify emission characteristics, control energy transfer and possibly counter loss in the metal. First, we characterize by two-photon polymerization the plasmonic nanowire modes, in particular the phase shift at the nanowire end. We further demonstrate the precise positioning of QDs and energy transfer between two QD types through propagating plasmon modes. We then investigate the spectral modifications imposed by the nanowire modes on the QDs and aim at stimulated emission as to counteract plasmon loss.



## Classical simulations of decorated fullerene clusters

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A charge dependence in the ion distribution curves was found for clusters of carbon dioxide and fullerenes  $C_{60}(CO_2)_n^{+,-}$  assembled in a helium nanodroplet experiment [1]. The interaction of the charge of C60 with the quadrupole moment of the carbon dioxide is proposed to be responsible for the observed charge dependent adsorption capacity. The cation can accommodate ca. 10 more  $CO_2$  molecules in the first adsorption shell than the anion. We identified a region of rearrangement in between full coverage and the shell closure. In this region of rearrangement  $CO_2$  adjusts its angular position to allow for denser packing of the first shell before the onset of the second shell. It manifests itself in broad peaks in the ion abundances that were extracted from time-of-flight mass spectra of the electron ionized clusters. These effects have not been observed when decorating fullerenes with molecules without quadrupole moment.

The strong electric field of  $\sim 10^9$  V/m from the fullerene ion drives the effect of charge dependent adsorption. The steric arrangement leads to enhanced adsorption for cations although the calculated binding energies of single  $CO_2$  molecules on  $C_{60}^{+,-}$  are stronger for anions than for cations. Density functional calculations that include dispersion corrections also show a clear preference for adsorption perpendicular to the C60 surface for cations and for parallel adsorption in case of anions.

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### Acknowledgements

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Poster 11

## Laser Ablation Synthesis of Colloidal Dispersions of Nickel Nanoparticles

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Colloidal dispersions of nickel nanoparticles are applied as catalysts for important industrial reactions [1]. The catalytic activity of these nanoparticles depend on their colloidal stability, particle size distribution, and surface chemistry.

Laser ablation in liquids can generate colloidal dispersions of metal nanoparticles [2], such as gold [3] or iron [4]. Therefore, we have attempted to synthesize directly colloidal stable Ni nanoparticles via laser ablation of Ni bulk plates immersed in a liquid by using different pulsed laser systems working at different operational conditions (wavelength, laser fluence, frequency repetition rate, pulse duration and pulse overlap). The properties of the so-obtained nanoparticles were characterized by various characterization techniques.

Ablation in water as solvent yielded Ni nanoparticles inside a massive aggregate of Ni hydroxide. When alcohols were used, core-shell nanoparticles were obtained. Also, we found that the particle production rate, as well as the crystallinity, size and dispersity of these nanoparticles depend on the laser parameters. Thus, we have demonstrated the ability of the laser ablation in liquids to synthesize colloidal dispersions of Ni nanoparticles without the use of surfactants to control the particle size and dispersity.

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## Core-Shell Tungsten-Iron Nanoparticles by Laser-Assisted Synthesis in Liquid Contact

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Laser ablation in liquid ambient is a potential technique to produce biocompatible nanoparticles for a variety of medical applications [1]. Tungsten-iron core-shell particle colloids may play a role as an absorbing medium for magnetic resonance imaging accompanied by high x-ray absorptivity [2].

The incubation behavior of laser ablation is still an open issue. Even more questions remain for this phenomenon in liquid contact. Therefore, special attention was paid to the study of the ablation threshold fluences of iron-tungsten ceramics as a function of the number of pulses  $F_{th}(N)$  [3]:

$$F_{th}(N) = F_{th}(1) N^{\xi-1}$$

The incubation coefficient  $\xi$  can be deduced from this evaluation. The more it deviates from the value of one, the higher is the incubation. Laser ablation with 532 nm pulses of 5 ns and a repetition rate of 20 Hz to a finite value ( $\xi = 0.52$ ) in conventional air contact. The presence of fluids causes more incubation than air. Water ( $\xi = 0.45$ ) introduced a somewhat higher incubation tendency than ethanol ( $\xi = 0.52$ ). The influence of the formation of conversion layers, such as oxides, carbonaceous, and/or the action of cavitation processes, will be discussed. In the later, density and surface tensions of the fluids, but also shielding by fluid-contained plasmas may determine the results.

Core-shell tungsten-iron NPs were prepared in ethanol and water varying the wavelength and the repetition rate. The size distribution, chemical composition, and crystallinity of the core-shell nanoparticles were identified by TEM, EDX, x-ray diffractometry, and selected area electron diffraction (SAED).

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## Poster 13

### Metal Nanoparticles synthesized by Laser Ablation of Metal Targets in Liquids

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Nowadays, colloidal metal nanoparticles are transforming many research fields, from biomedicine to energy conversion [1]. Generally, metallic nanoparticles with specific morphologies, sizes and compositions are prepared by using liquid-phase bottom-up synthesis methods, in which surfactants are used to control the nucleation and growth of the nanoparticles [2]. These methods allow to synthesize colloidal metal nanoparticles with fashionable properties; however, they fail to be transferred from the laboratory to the industry because they involve numerous experimental parameters which are difficult to control, such as: local reagent concentrations, local pH and temperature gradients, etc. Moreover, they do not meet the requirements of energy efficiency and savings in raw materials and natural resources required by new global guidelines for environmental protection, because chemical routes need to use high purity and very expensive precursor materials, and also require a high consumption of water and solvents, as well as chemical catalysts [3]. Recently, laser ablation in liquids of massive metal plates has proved as an efficient synthesis method to produce a wide range of stable nanoparticles in a variety of liquid solutions, with minimal variation in the process parameters and replacing chemical precursors by much cheaper massive materials [3]. Therefore, a systematic investigation of the direct synthesis of different pure colloidal metal nanoparticles (iron, tungsten and nickel) in aqueous and non-aqueous fluids is presented here. The size distribution, chemical composition, and crystallinity of the core-shell nanoparticles were identified by X-Ray Diffraction, Transmission Electron Microscopy, Selected Area Electron Diffraction and Energy-dispersive X-ray Spectroscopy. Moreover, an extensive investigation has been conducted in order to explore the influence of the experimental parameters of this procedure on the structure, size, size distribution, aggregation degree and colloidal stability of the as-synthesized nanoparticles. Incubation phenomena on the surface of the massive metal plates, which are produced for the overlap of laser pulses on same point on the surface, play a significant role to elucidate the relationship between the experimental parameters and the nanoparticles characteristics [4]. Therefore, special attention was paid to the study this phenomenon as function of the nature of the solvent and metal plate, laser fluence and laser pulse accumulation.

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## Polymeric Model Membrane Systems on Gold: An Electrochemical Quartz Microbalance Analysis

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Recently, polymersomes have proven to be interesting model systems for studying polymeric membranes [1], in vivo tumor-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. 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.

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**2nd Erwin Schrödinger Symposium 2016**  
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**„Zero Dimensional Nanostructures“**  
May 23-25, 2016, Schönbrunn Castle, Vienna, Austria



<b>Monday, May 23, 2016</b>		<b>Tuesday, May 24, 2016</b>		<b>Wednesday, May 25, 2016</b>	
9 <sup>00</sup> - 9 <sup>30</sup>	Registration & Coffee	Keynote Lecture 3	Keynote Lecture 5		
9 <sup>30</sup> - 10 <sup>00</sup>		O. Diwald	M. Parlinska-Wojtan		
10 <sup>00</sup> - 10 <sup>30</sup>	Opening Ceremony	Lecture 5: K.-M. Weitzel	Lecture 13: T. Klar		
10 <sup>30</sup> - 11 <sup>00</sup>	Keynote Lecture 1	Lecture 6: O. Bomati-Miguel	Lecture 14: T. Waitz		
11 <sup>00</sup> - 11 <sup>30</sup>	S. Barcikowski	Coffee Break	Coffee Break		
11 <sup>30</sup> - 12 <sup>00</sup>		Lecture 7: A. Kaiser	Lecture 15: C. Hrlescu		
12 <sup>00</sup> - 12 <sup>30</sup>	Poster Short Lectures	Lecture 8: U. Kreibitz	Lecture 16: Y. Salinas		
12 <sup>30</sup> - 13 <sup>00</sup>					
13 <sup>00</sup> - 13 <sup>30</sup>	Lunch Break & Poster Session	Lunch Break & Poster Session	Lunch Break & Poster Session		
13 <sup>30</sup> - 14 <sup>00</sup>					
14 <sup>00</sup> - 14 <sup>30</sup>					
14 <sup>30</sup> - 15 <sup>00</sup>	Keynote Lecture 2	Keynote Lecture 4	Keynote Lecture 6		
15 <sup>00</sup> - 15 <sup>30</sup>	N.S. Sariciftci	T. Hofmann	E. Reimhult		
15 <sup>30</sup> - 16 <sup>00</sup>	Lecture 1: W.E.G. Hansal	Lecture 9: M. Zehetbauer	Closing Remarks		
16 <sup>00</sup> - 16 <sup>30</sup>	Lecture 2: C. Zaba	Lecture 10: B.S. Shaghasemi, M.M. Virk			
16 <sup>30</sup> - 17 <sup>00</sup>	Coffee Break	Coffee Break			
17 <sup>00</sup> - 17 <sup>30</sup>	Lecture 3: M. Orlandi	Lecture 11: T. Werzer			
17 <sup>30</sup> - 18 <sup>00</sup>	Lecture 4: W.E. Ernst	Lecture 12: D. Velic			
18 <sup>00</sup> - 18 <sup>30</sup>	Guided Tour of		Farewell Wine & Cheese		
18 <sup>30</sup> - 19 <sup>00</sup>	Schönbrunn Castle				