

OCTOBER  
31, 2022

# 8<sup>th</sup> NANO BOSTON CONFERENCE

MONDAY

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## Impact of Nanobiotechnology on the Future of Medicine: The Road from Nanomedicine to Precision Medicine – Case Studies

### Shaker A. Mousa

*Albany College of Pharmacy and Health Sciences  
Vascular Vision Pharmaceuticals Co. & NanoPharmaceuticals LLC,  
One Discovery Drive, Rensselaer, New York 12114*

### Abstract:

Over the past decade, evidence from the scientific and medical communities has demonstrated that nanobiotechnology and nanomedicine have tremendous potential to affect numerous aspects of cancer and other disorders in term of early diagnosis and targeted therapy. The utilization of nanotechnology for the development of new Nano-carrier systems has the potential to offer improved targeted delivery through increased solubility and sustained retention and more importantly active targeting. One of the major advantages of this innovative technology is its unique multifunctional characteristics. Targeted delivery of drug incorporated nanoparticles, through conjugation of site-specific cell surface markers, such as tumor-specific antibodies or ligands, which can enhance the efficacy of the anticancer drug and reduce the side effects. Additionally, multifunctional characteristics of the Nano-carrier system would allow for simultaneous imaging of tumor mass, targeted drug delivery and monitoring (**Theranostics**).

A summary of recent progress in nanotechnology as it relates to nanoparticles and drug delivery will be reviewed. Nano Nutraceuticals using combination of various natural products provide a great potential in diseases prevention. Additionally, various Nanomedicine approaches for the detection and treatment of various types of organ specific delivery, vascular targeting, and vaccine will be briefly discussed. Additionally, novel Ligand-Drug Conjugates and Ligand conjugated Nano loaded with active Pharmaceuticals versus Antibody-Drug Conjugates will be briefly highlighted.

### Biography:

Dr. Mousa is a Professor and Chairman at Albany College of Pharmacy and Health Sciences, New York. Prof. Mousa has a track record in bringing novel concept from the bench to the bedside along with the great vision in selecting the right target. Among Dr. Mousa's professional accomplishments are his contributions to several patents and to the discovery and development of novel anti-platelet, anti-thrombotic therapies, noninvasive myocardial perfusion, and thrombus imaging agents. His work has been reported in over 1,000 peer reviewed publications and holds over 400 US and International Patents. He has been awarded with numerous national and international awards for his work.

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## The Dynamic, Motile and Deformable Properties of RNA Nanoparticles Lead to Efficient Tumor Vasculature Targeting, Fast Renal Excretion and Low Toxicity.

### Peixuan Guo

*Center for RNA Nanobiotechnology and Nanomedicine; College of Pharmacy; James Comprehensive Cancer Center; College of Medicine. The Ohio State University, Columbus, Ohio, 43210, United States.*

### Abstract:

The dynamic nature of RNA leads to its motile and deformable behavior. These conformational transitions, such as strands breathing, pseudoknot formation, induced fitting, conformational capture, and base shifting are important for their biological functions. Their dynamics, catalytic and motile features have led to the belief that RNA is the origin of life. We recently reported that the motile, dynamic and shape-shifting properties of RNA nanoparticles enhance their penetration through the leaky blood capillary, leading to spontaneous targeting to tumor vasculature and passing through the kidney glomerulus to overcome the filtration size limit, resulting in rapid renal excretion and fast body clearance, therefore low or no toxicity. Targeting efficiency can be improved by incorporating cancer- targeting ligands. Their inherent negative charge properties reduce nonspecific cell binding due to the repulsion with the cell membrane which is also negatively charged. The favorable biodistribution multivalency, self-assembly, programmable synthesis, advantageous size; antigenicity free, large volume distribution, CMC ease, solubilizing drugs, and high payload make them an excellent material for pharmaceutical applications. RNA drug has become the third milestone in pharmaceutical drug development!

### Biography:

Dr. Peixuan Guo, a pioneer of RNA nanotechnology, has held three endowed chair positions at three different prestigious universities, and currently is the Sylvan G. Frank Endowed Chair in Pharmaceutics and Drug Delivery and the director of the Center for RNA Nanobiotechnology and Nanomedicine at The Ohio State University. He is the president of the International Society of RNA Nanotech and Nanomedicine. He served as the Director of the NIH Nanomedicine Development Center (NDC) from 2006-2011, was the Director of NCI Cancer Nanotech Platform Partnership Program from 2012-2017. To date, Dr. Guo invented 70 patents (13 granted and 57 in Provisional and PCT). He was nominated as the 2021 Innovator of the Year of the Ohio State University.

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## Clusters of Catalytic Nanocompartments for Complex Cascade Reactions: Application in Biomedicine

**Cornelia G. Palivan**

*Department of Chemistry, University of Basel, Mattenstr. 24A, 4002, Basel, Switzerland  
University of Basel, Swiss Nanoscience Institute, Mattenstr. 24a, 4002 Basel, Switzerland*

### Abstract:

Compartmentalization is fundamental in nature, where the spatial segregation of biochemical reactions within and between cells ensures optimal conditions for the regulation of cascade reactions. One of the most promising strategies to mimic nature compartmentalization is to combine synthetic nano-compartments with biomolecules in order to develop artificial organelles and to generate a more complex architecture and functionality, as cell mimics. Here, we present how clusters of bioinspired catalytic nanocompartments support cascade reactions able to enhance production of specific compounds *in vitro*. First, we generate individual catalytic nanocompartments (CNCs) by encapsulating within polymersomes enzymes involved in a cascade reaction and then, tether the polymersomes together into clusters. DNA hybridization between single DNA strands and complementary DNA strands exposed on different CNCs drives the clusterization process and controls the distance between the respective catalytic nanocompartments. The cascade reaction between spatially segregated enzymes is significantly more efficient than when the catalytic nanocompartments are not linked together by DNA duplexes. Additionally, single DNA strands not engaged in clustering CNCs could be used to attach clusters to the cell surface, as evidenced by A549 cells, where clusters decorating the surface endowed them with a non-native enzymatic cascade. The self-organization into clusters of catalytic nanocompartments confining different enzymes of a cascade reaction allows for a distance control of the reaction spaces which opens new avenues for highly efficient applications in domains such as catalysis or nanomedicine, as for example as theranostics systems.

### Biography:

Prof. Dr. Cornelia Palivan is currently Professor in the Chemistry Department at the University of Basel. The main focus of her research group is at the interface between physical-chemistry, nanoscience and biophysics, with particular emphasis on bio-nano-systems for translational applications. Her research interests are in the field of developing hybrid functional materials based on combinations of biomolecules with synthetic assemblies, and their interactions with cells or microorganisms. She published more than 170 research articles and reviews in the field, and received various prizes. She is international expert for evaluation of research projects (e.g. ERA-Chemistry and ERC grants program EU).

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## Long Acting Slow Effective Release Antiretroviral Therapy

**Howard E. Gendelman**

*University of Nebraska Medical Center, USA*

### **Biography:**

Dr. Howard E. Gendelman is the Margaret R. Larson Professor of Internal Medicine and Infectious Diseases, Chairman of the Department of Pharmacology and Experimental Neuroscience, and Director of the Center for Neurodegenerative Disorders at the University of Nebraska Medical Center. Dr. Gendelman is credited in unraveling how functional alterations in brain immunity induce metabolic changes and ultimately lead to neural cell damage for a broad range of infectious, metabolic and neurodegenerative disorders. Dr. Gendelman has authored over 550 peer-reviewed publications, edited 12 books and monographs, holds 38 patents. He has been an invited lecturer to more than 200 scientific seminars and symposia and the recipient of numerous local, national and international honors.

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## Cancer Nanotherapeutics: Combination of Nanoparticles with Current Anticancer Drugs to Overcome the Challenges in Current Radiotherapy

**Devika B. Chithrani**

*Department of Physics and Astronomy, University of Victoria, Victoria, BC, Canada*

### Abstract:

Approximately 50 percent of all cancer patients can benefit from radiotherapy in the management of their disease; of these, approximately half present early enough to pursue curative intent. The major limitation to reaching a curative RT dose in high-risk (locally advanced) non-metastatic tumors is the high sensitivity to radiation and subsequent damage to the surrounding normal tissues. Currently, we are at the limit of radiotherapy dose given to patients, creating a clear need for novel methods to enhance it to further improve the survival while reducing side effects. In an effort towards reducing the side effects while increasing the damage to the tumour, targeting of high atomic number materials such as gold nanoparticles (GNPs) as radiosensitizers to the tumour tissue has shown promising results. Moving forward, understanding of the complex biological system present in and around the tumour is essential for optimizing the use of the radiosensitizing GNPs, as outlined by a consortium of labs, including our own. In this talk, I will discuss the importance of using GNP-based novel strategies to overcome current challenges imposed by the tumour microenvironment.

### Biography:

Dr. Devika Chithrani leverages nanotechnology to create innovations that advance the care of cancer patients. She is using gold nanoparticles as a radiation dose enhancer in cancer therapy. This work was featured on the cover of Radiation Research journal and it was awarded the Michael S. Patterson publication award. Dr. Chithrani is considered as one of the leaders in the field of nanotechnology and her publications have received over 10,000 citations in few years. She has developed three dimensional tumor models to optimize bio-nano interface in cancer therapy. This work is featured on the cover of Nano-Micro Letters journal. Her passion is to develop smart nanomaterials to improve exiting cancer therapeutics. She believes that many side effects due to chemotherapy can be reduced by controlled delivery of anticancer drugs using smart nanomaterials.

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**Molecular Mechanism of GPCR Signal Transduction - Filtering the Good from the Bad**

**Meng Zhang**

*Harvard University-Harvard Medical School, MA, USA*

**Biography:**

Dr. Zhang is a research associate at Harvard Medical School. She got her PhD. from University of Michigan in 2016. She has more than 15 publications in reputed journals and her skills sets and research interests include Cryogenic Electron Microscopy, Membrane Proteins, Protein-protein interactions and Nuclear Magnetic Resonance (NMR).

## Cell Mechanobiology Regulates Bio-nano Interactions in Cancer Cells

Marco Cassani<sup>1</sup>, Soraia Fernandes<sup>1</sup>, Jorge Oliver-De La Cruz<sup>1</sup>, Francesca Cavalieri<sup>2,3</sup>, Frank Caruso<sup>4</sup> and Giancarlo Forte<sup>1</sup>

<sup>1</sup>International Clinical Research Center, St Anne's University Hospital, Brno, Czech Republic

<sup>2</sup>School of Science, RMIT University, Melbourne Victoria, Australia

<sup>3</sup>Department of Chemical Sciences and Technologies, Tor Vergata University of Rome, Via Della Ricerca Scientifica, Rome, Italy

<sup>4</sup>ARC Centre of Excellence in Convergent BioNano Science and Technology, Department of Chemical Engineering, The University of Melbourne, Parkville, Victoria, Australia

### Abstract

Understanding the complex interactions between cells and nanoparticles has been one of the main objectives of nanomedicine since its dawn. The physico-chemical properties of nanoparticles have been studied over the past decades for improving the delivery of therapeutic anti-cancer drugs. Notwithstanding the recent clinical success of mRNA-based nanovaccines, these efforts have produced overall poor clinical translation of nanoparticle-based therapies. Therefore, a shift toward new paradigms, in which the inner molecular processes of the cells take the lead in the interpretation of bio-nano interactions, is desirable. In this context, the study of cell mechanics has emerged as a promising area of investigation. Indeed, the mechanical properties of cells have been recently proposed as new prognostic factors in cancer growth and dissemination. Mechanotargeting and mechano-therapeutics made their way through medical vocabulary as a new class of drugs and treatments targeting mechanically activated pathways involved in pathologies. By using nanoparticles with tunable size and surface coating, we demonstrate that the inhibition of mechanobiology pathways, responsible for cell stiffness regulation, affects nanoparticles uptake in cancer cells. This response is independent of nanoparticle's material or cell substrate's properties and rely on the activation or inhibition of specific intracellular molecular markers. Our study represents a proof-of-concept that the internalization of nanoparticles in target cancer cells might be controlled by tuning cell mechanosensing pathways, ultimately improving the specificity of the nanotherapy.

### Biography:

Marco Cassani obtained his PhD at the Italian Institute of Technology of Genoa in 2018. Since 2019 he works as Postdoc at the International Clinical Research Center of the Sant'Anne's University Hospital in Brno, Czech Republic. In 2019 he was honorary fellow at the University of Melbourne, for a period of six months, through an MSCA-RISE project. He won a Marie Curie fellowship (MSCA-COFUND) co-funded by the Italian Association for Cancer Research (AIRC) and the European Research Council (ERC) in 2019 and a Marie Curie Global Fellowship (MSCA-GF) in 2021. His work focuses on bio-nano interactions in cancer cells.

## Transforming the Chemical Structure and Bio-Nano Activity of Doxorubicin by Ultrasound for Selective Killing of Cancer Cells

Soraia Fernandes<sup>1\*</sup>, Sukhvir Kaur Bhangu<sup>2,3,4</sup>, Giovanni Luca Beretta<sup>5,\*</sup>, Stella Tinelli<sup>5</sup>, Marco Cassani<sup>1</sup>, Agata Radziwon<sup>3</sup>, Marcin Wojniłowicz<sup>3</sup>, Sophia Sarpaki<sup>6</sup>, Irinaios Pilatis<sup>6</sup>, Nadia Zaffaroni<sup>6</sup>, Giancarlo Forte<sup>1</sup>, Frank Caruso<sup>3</sup>, Muthupandian Ashokkumar<sup>4\*</sup>, and Francesca Cavalieri<sup>2,7\*</sup>

<sup>1</sup>International Clinical Research Center (ICRC) St Anne's University Hospital, Brno 65691, Czechia <sup>2</sup>School of Science RMIT University Melbourne, Victoria 3000, Australia

<sup>3</sup>Department of Chemical Engineering, The University of Melbourne, Parkville, Victoria 3010, Australia

<sup>4</sup>School of Chemistry, The University of Melbourne Victoria 3010, Australia

<sup>5</sup>Molecular Pharmacology Unit Department of Applied Research and Technological Development Fondazione IRCCS Istituto Nazionale dei Tumori di Milano Via Amadeo 42, Milan 20133, Italy <sup>6</sup>BIOEMTECH27 Neapoleos st., Lefkippos Attica Technology Park - N.C.S.R. Demokritos, Athens 15341, Greece

<sup>7</sup>Dipartimento di Scienze e Tecnologie Chimiche Università degli Studi di Roma "Tor Vergata" via della ricerca scientifica 1, Rome 00133, Italy.

### Abstract:

Reconfiguring the structure and selectivity of existing chemotherapeutics represents an opportunity for developing novel tumor-selective drugs, with minimal side-effects for the patient. In this work, the use of high-frequency sound waves is used to transform - the nonselective and widely used for chemotherapy - anthracycline doxorubicin into a tumor selective drug. The newly transformed drug self-aggregates in water, following a simple procedure that does not require organic solvents, chemical agents or surfactants. By various imaging assays, including stochastic optical reconstruction microscopy (STORM), we showed that the nanodrugs preferentially interact with lipid rafts in the mitochondria of cancer cells, resulting in the production of high levels of ROS, which in turn leads to DNA damage and eventually cancer cell death. Contrarily, this phenomenon was less pronounced in other cells types. Therefore, when exposed to the effect of the nanodrug, only marginal cytotoxicity (0-20%) towards fibroblasts and cardiomyocytes is observed, even after administration of high doses of the nanodrug (25–40  $\mu\text{g mL}^{-1}$ ). Overall, penetration, cytotoxicity, and selectivity of the nanodrugs in tumor-mimicking tissues were validated *in vitro* using 3D cocultures of cancer and healthy cells and 3D cell-collagen constructs in a perfusion bioreactor. Moreover, *in vivo* biodistribution studies revealed that the nanodrugs exhibit tropism for lung with limited accumulation in the liver and spleen. Thus, further *in vivo* experiments will aim to exploit the application of nanodrugs for the treatment of lung cancer. Our findings highlight the potential of this method to transform anticancer drugs and antibiotics bearing sono-active moieties.

### Biography:

Dr. Soraia Fernandes, moved to Germany to complete her PhD at the University of Regensburg by May 2016. Her thesis focused on the synthesis of nanoparticles for biological applications. After, she moved to Italy to the Italian Institute of Technology, to study the use of magnetic nanoparticles to fight breast cancer. Recently, she moved to Czech Republic to the International Clinical Research Centre in Brno, where she uses patient-derived prostate cancer organoids to study the mechanisms behind cancer progression. Besides, she participates in a project aiming to develop novel nanodrugs for cancer treatment, in collaboration with the University of Melbourne.



## Secondary Metabolites in Functionalized Titanium Dioxide (TiO<sub>2</sub>) Nanoparticles Applied in Disinfectants and Antiseptics, Efficacy Against Viruses, Bacteria and Fungi

Gabriela León-Gutiérrez<sup>1,2</sup> and Armando Mejía<sup>2</sup>

<sup>1</sup>Inmolecule International Ltd, United Kingdom

<sup>2</sup>Universidad Autónoma Metropolitana – Iztapalapa, Mexico

### Abstract:

Several works of different nanoparticles have reported antimicrobial activity against bacteria, fungi and viruses, particularly the ones of TiO<sub>2</sub>. However, the problem so far has been its high cytotoxicity. In this work we report the successful use of functionalized TiO<sub>2</sub> nanoparticles, which significantly reduce their potential cytotoxic effect and to which it is possible to adsorb various bioactive secondary metabolites. With this nanobiotechnological platform, we developed a nanoparticulate complex with vegetable secondary metabolites, which we call SMNP. This nanoparticulate complex was tested for its efficacy against SARS-CoV-2 infectivity and cytotoxicity in healthy cells. To measure viral infectivity, SARS-CoV-2 was placed in cell cultures and the destructive effect on cultured cells was evaluated. In this system, SMNP demonstrated a significant reduction in viral infectivity *in vitro* by 3 orders of magnitude. Minimal toxicity to healthy cells was observed when compared to other commercially available antiseptics and disinfectants (glutaraldehyde, chlorine, chlorhexidine, ethanol and lysol). Its antifungal activity against important pathogens such as *Aspergillus Niger* and *Candida albicans* was also evaluated, surpassing the activity observed with Amphotericin and Fluconazole. Antibacterial activity has been tested against *Clostridium difficile*, *Clostridium sporogenes*, *Pseudomona aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* and *Enterococcus hirae*. SMNP is named Nbelyax® in its commercial form and has been patented in more than 100 countries. Granted in economies such as: USA, Israel, México, United Arab Emirates, Hong-Kong, South-Africa, Euroasia and Japan.

### Biography:

Mrs. Gabriela León-Gutiérrez leads the research and development of a new nanobiotechnological active ingredient commercially named Nbelyax®. She is a Winner of the Mexico National Health Prize 2016 by COPARMEX, February 2017. Personally selected by Michael Dell to participate in the United Nations Foundation Global Accelerator 2014. She published the most read scientific article in Journal of Nano Research "Secondary Metabolites in Functionalized Titanium Dioxide (TiO<sub>2</sub>) Nanoparticles; A Novel and Safe Virucide against SARS-COV-2," Journal of Nano Research 70.130-145.

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## Molecular Frontiers in Drug Delivery

**Arturo J. Vegas**

*Boston University, MA, USA*

### Abstract:

Therapeutic agents, such as small molecule drugs, are developed to preferentially modulate the function of specific classes of proteins associated with diseased cellular states. These agents are typically not designed to overcome physiological barriers or localize to diseased tissues in the body, and often manifest off-target adverse effects from indiscriminate biodistribution. Formulation of therapeutics with nanocarriers often improves pharmacological properties, but ligands (small molecules, peptides, or proteins) that target unique molecular features of diseased tissue are commonly needed to direct their physiological biodistribution. While there is some success targeting nanocarriers to certain tissues, to date there are few ligands utilized with a limited scope of targeted tissues. Here, we review the new targeting technologies and polymeric delivery systems developed in our lab. We aim to expand the current suite of targeting agents and nanocarriers by establishing new targeting paradigms and novel materials that enable localization of therapeutic payloads to disease microenvironments.

### Biography:

Dr. Arturo J. Vegas is the Peter Paul Career Development Professor at Boston University. He is appointed in the Department of Chemistry and has affiliations with the Department of Biomedical Engineering and the Materials Science and Engineering Division. He is a core faculty member of the BU Center for Molecular Discovery, the BU Nanotechnology Innovation Center, the Biological Design Center, and is Co-Director of the Translational Research in Biomaterials Training Program. He was recently awarded a New Innovator Type 1 Diabetes Pathfinder Award by the NIH and JDRF Innovator award.

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## Battery Electrodes: Nano vs Micro-structuring

**Nikhil Koratkar**

*Rensselaer Polytechnic Institute, NY, USA*

### **Abstract:**

Battery electrodes comprise a current collector onto which a mix of active material particles, conductive carbon and binder additives are deposited. While this basic design has persisted for decades, the desired “size” of the active material particle is a matter of debate. Advances in nanotechnology have spurred interest in deploying nanoparticles as the active material. In this talk, I will compare nano with micro-particle electrodes, and discuss why the battery industry is unlikely to replace micro with nano-size particles. Given this, I will address the question as to whether there is a place for nanomaterials in battery design. I will show that the way forward lies in micro-particles constructed by the assembly of nanoscale building blocks and in micro-particles with engineered or natural nano-porosity. Such "multiscale particles" offer exciting possibilities to develop the next-generation of battery electrodes that are quintessentially both micro and nano with respect to their performance attributes.

### **Biography:**

Nikhil Koratkar is the John A. Clark and Edward T. Crossan Chair Professor at the Rensselaer Polytechnic Institute (RPI). His research has focused on the synthesis, characterization and application of advanced materials. He has published a book on graphene as an additive in composite materials and over 230 archival journal papers. In 2018 and 2021, Clarivate Analytics named him in their highly cited researchers list (top 1% by citations). Prof. Koratkar serves as an Editor of CARBON (Elsevier). He is also a co-founder and serves on the advisory board of a start-up company (Alsym Energy) aimed at commercializing next-generation energy storage solutions.

## Ceramics Nanocomposite Materials for Novel Energy Harvesting and Cooling Technologies

Zdravko Kutnjak<sup>1\*</sup>, Brigita Rožič<sup>1</sup>, Z. Hanani<sup>2</sup>, D. Mezzane<sup>2</sup>, M. El Marssi<sup>3</sup>, H. Ursic<sup>1</sup>, M. Spreitzer<sup>1</sup>

<sup>1</sup>Jozef Stefan Institute, Ljubljana, Slovenia; <sup>2</sup>LMCN, University Cadi Ayyad, Marrakech, Morocco

<sup>3</sup>LPMC, University of Picardie Jules Verne, Amiens, France

### Abstract:

The request for greener energy harvesting and heat-management technologies has recently developed a significant interest in new nanocomposite ceramics with large electromechanical, triboelectric and electrocaloric (EC) effects [1]. Therefore, an overview of experimental and theoretical investigations of the large EC, piezoelectric and triboelectric response in ceramic nanocomposites and ceramics near antiferroelectric transition will be presented in this contribution. Specifically, the significant EC response observed by direct experiments in lead-free BCTZ-based ceramics will be reviewed, including polymer composites' large energy harvesting potential [2]. Besides, it is demonstrated that both negative and positive EC responses can be arbitrarily invoked in antiferroelectric materials by adequately controlling the electric field and temperature, which enables enhancement of the electrocaloric cooling power for up to 100%.

[1] Z. Kutnjak., B. Rožič, R. Pirc., Wiley Encyclopedia of Electrical and Electronics Engineering, 1-19 (2015). [2] Z. Hanani et al., Nano Energy 81, 105661 (2021).

### Biography:

Dr. Kutnjak obtained a PhD degree in physics in 1994 at the University of Ljubljana. After two years of postdoctoral work at MIT, Dr. Kutnjak returned to Jozef Stefan Institute as head of the calorimetry and dielectric spectroscopy laboratory. Today as a Professor at the University of Ljubljana and the Jozef Stefan International Postgraduate School continues research at Jozef Stefan Institute on ordered and disordered systems. Presently, his work is focused on relaxor ferroelectrics, multiferroics, liquid crystal elastomers and various confined nanosystems.

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## Functionalized Nanodiamond Heat Transfer Fluids in Manufacturing Energy Efficiency Improvements

Evidence Akhayere<sup>1,3</sup>, Doga Kavaz<sup>2,3\*</sup>

<sup>1</sup> Department of Environmental Science, Cyprus International University, Nicosia, Mersin 10, Turkey.

<sup>2</sup> Department of Bioengineering, Cyprus International University, Nicosia, Mersin 10, Turkey.

<sup>3</sup> Environmental Research Centre, Cyprus International University, Nicosia, Mersin 10, Nicosia, Turkey.

### Abstract:

The use of concrete for building across tropical and Mediterranean regions can not be overemphasized, although sustainable building materials are being researched daily, concrete will remain in use for some time. It is of great importance for material scientists should work on materials that can improve the strength of concrete and as well increase its sustainable nature. In this study nano silica was synthesized using agricultural waste. The synthesis process of nano silica was done at varying temperatures the study temperatures include 500°C, 600°C, and 700°C respectively, nano silica synthesis was shown to improve as synthesis temperature increases. As seen in the result the synthesis temperature played an important role in the characteristic properties of the nano silica. SEM XRD and XRF characterization were carried out on the nanoparticles at various temperatures to ascertain their properties. The result of the various characterization revealed the presence of elemental Si, C, and O in the synthesized nanoparticles. Nano silica was then used as an enhancer for the mixing of concrete at various mixing ratios. Tensile test, compressive strength, and flexural strength were investigated at 7 and 28 days of curing for the various mixing of the nano silica synthesized at various temperatures. The results showed maximum improvement in the durability of the concrete with the presence of nano silica, also nano silica synthesized at 700°C showed better properties as compared to other temperatures.

**Keywords:** Barley, Concrete, Nano Silica, Temperature, Waste.

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## Functionalized Nanodiamond Heat Transfer Fluids in Manufacturing Energy Efficiency Improvements

**Ethan Languri**

*Tennessee Tech University, TN, USA*

### **Biography:**

Ethan Languri is Director of the Industrial Assessment Center at Tennessee Tech University. He is a registered Professional Engineer (PE) in the State of Tennessee. He received his Mechanical Engineering Ph.D. in 2011 from University of Wisconsin-Milwaukee followed by two Postdoctoral Fellow appointments at the University of Wisconsin-Milwaukee and Texas A&M University. Later, he worked as a Senior Mechanical Engineer at Applied Research Associates for about three years. Dr. Languri has been awarded several times including Kinslow Research Award by TTU and Chancellor's Award by University of Wisconsin.

## In Situ Observation of Electron-Beam-Induced Formation of Nano-Structures in Lead Chalcogenides PbTe, PbSe and PbS

Paul Simon<sup>1\*</sup>, Iryna Zelenina<sup>1</sup>, Igor Veremchuk<sup>1,2</sup>, Yuri Grin<sup>1\*</sup>

<sup>1</sup>Max-Planck-Institut für Chemische Physik Fester Stoffe, Nöthnitzer Str. 40, 01187 Dresden, Germany

<sup>2</sup>Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01314 Dresden

### Abstract:

Nanoparticles are the focus of substantial scientific interest due to their unusual chemical and physical properties. The current interest *e.g.* in PbTe nano-bars arises from their useful thermoelectric properties. It is known that the presence of nano-bar-like formations in spark-plasma sintered PbTe specimens increases the ZT value to approximately 0.45 at 300 K.

In case of PbTe, when the initial single-crystalline particle was exposed to electron irradiation, it partially evaporated. The evaporated material transferred to the colder part of the carbon substrate and produced nano-bars measuring 4–100 nm. The first step of the nano-bar formation is nucleation, which is subsequent to sublimation, where the formation of bars takes place at different times and is indicative of a stochastic process. The growth of isolated nanoparticles after reaching a certain cube size of 10–20 nm follows two possible patterns. The first possibility is that the particle predominantly increases in size along one direction while growing only gradually in the other two directions. The second growth pattern, in which all directions develop equally.

Commonly, coalescence events were observed between nanoparticles known as Ostwald ripening mechanism leading to formation of regular 2D thin films after annealing.

The decomposition of initial particles may be understood by the crystal structure imperfections inherent to lead telluride at temperatures below 450°C. The atomistic depletion mechanism could be revealed at the atomic level by high-resolution TEM, proving that degradation occurs atom-by-atom. The recrystallized nanoparticles in turn exhibit an “ideal” crystal structure.

### Biography:

Paul Simon is permanent scientific employee, Max Planck Institute for Chemical Physics of Solids, Dresden, Germany, Group of Prof. Grin, TEM group. Actual research topic is spherical aberration corrected high-resolution electron microscopy of intermetallics. Former topics include imaging magnetic fields of magnetic nanoparticles and electric fields in biominerals by electron holography.

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## Remediation of Per- and Polyfluorinated Substances (PFAS) from Water via Functionalized Nanoparticles

Victoria Schmidt<sup>1</sup>, Marcus Halik

*Friedrich-Alexander University Erlangen-Nuremberg, Germany*

### Abstract:

A group of more than 4,700 different substances is increasingly attracting the attention of researchers working in the field of sustainability. Some of the per- and polyfluorinated substances (PFAS) have already been declared as persistent organic pollutants (POPs) and banned under the Stockholm Convention. Due to their long-term persistence in the environment, they represent a major challenge for water treatment. Conventional processes are reaching their limits here. An increasingly popular method is the adsorption process for water purification. Here, the various intermolecular interactions are exploited. The use of superparamagnetic iron oxide nanoparticles (SPIONs) for this process allows a simple removal of the nanoparticles after adsorption and a possible recycling of them. The SPIONs are functionalized with self-assembled monolayers (SAMs) to render different interaction motifs for such pollutants. Via the selection of SAM molecules, a customizable shell is created while maintaining the core property. So far, two different SAM molecules have been tested to address the hydrophobic and fluorophilic segments of the fluorinated contaminations. Initial experiments on the adsorption of PFAS showed promising results. The remediation concept is applicable from low molecular weight perfluorooctanesulfonic acid (PFOS) to polymer PTFE.

### Biography:

Victoria Schmidt received her bachelor's and master's degrees at the Friedrich-Alexander University Erlangen-Nuremberg. She completed her master thesis with the topic of selective binding motifs related to functionalized particles to extract residues in water in the "Organic Materials and Devices – OMD" group of Prof. Dr. rer. nat Marcus Halik. Her PhD work within the OMD group started in October 2021 with the research of water purification of per- and polyfluorinated substances through functionalized nanoparticles.



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## Smart Rust to Clean Water from Molecular Pollutants

**Lukas Mueller**, Marcus Halik

*Friedrich-Alexander-University Erlangen-Nuremberg, Organic Materials & Devices, Germany*

### Abstract:

Access to clean water is recognized as a human right by the United Nations. However, anthropogenic molecular pollutants, like herbicides or hormones are present in our ground water and find their way into drinking water due to careless disposal and insufficient remediation. Already at the trace concentration level such compounds have been shown to have severe effects on aquatic flora and fauna, but also to us humans, especially children. Still consequences of long term exposure are often unknown. Therefore, it exists a big demand in affordable and efficient removal of such contaminants from water.

Having this in mind, we are *en route* to develop a promising concept to solve this problem. Superparamagnetic iron oxide nanoparticles (SPIONs) are surface-functionalized with self-assembled monolayers (SAMs) composed of permanently binding phosphonic acid derivates to address certain interaction motifs of selected pollutants (“smart rust”). Such particles attract the pollutants and can be easily remediated from water by an external magnetic field due to the magnetic moment of its cores. We establish the interaction of rationally designed mixed SAMs on SPIONs with dedicated trace organic pollutants (e.g. various steroidal hormone derivates). Therefore, we develop sorbent systems that enable a favorable binding of the whole approached pollutant family in comparison to other organic or inorganic matter by combining multiple interaction motifs. This approach benefits from synergy of experimental materials science and analytical chemistry to tailor hybrid nanoparticles.

### Biography:

Lukas Mueller obtained his Bachelor’s degree in “Nanotechnology” and Master’s degree in “Advanced Materials and Processes” from Friedrich-Alexander-University Erlangen-Nuremberg (FAU) in Germany, which he concluded with a thesis on antiviral surface coatings at the laboratory of Prof. Francesco Stellacci at École polytechnique fédérale de Lausanne (EPFL) in Switzerland. Currently, he pursues a doctorate back at his alma mater at the laboratory of Prof. Marcus Halik. Lukas works in the field of water remediation making use of mixed shell iron oxide nanoparticles, for which he is supported with a full doctoral scholarship by the Deutsche Bundesstiftung Umwelt (German Federal Environmental Foundation).

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## Waste2: Magnetic Water Remediation of Nano-polyethylene Across Different Length Scales and its Upcycling as an Oil Sorbent

**Henrik Gass**, Marco Sarcletti, Marcus Halik

*Organic Materials & Devices (OMD), Department of Materials Science, Friedrich-Alexander-University Erlangen-Nuremberg, Cauerstraße 3, 91058 Erlangen, Germany*

### Abstract:

The worldwide plastic production is on the highest level ever while recycling is still stagnating. Consequently, the majority of the plastic waste will end up in the aquatic environment. If it is not directly emitted as nanoplastics (NP), several degradation processes will comminute it to the nanoscale. These fragments can easily enter animals or plants and disturb natural processes in organisms. To make matters worse, nanoplastics also act as vehicles for diverse organic and inorganic pollutants due to their huge surface area. However, nowadays NP water remediation research mainly focuses on polystyrene although commodity polymers like polypropylene and polyethylene highly dominate the market.

We have developed a sorbent material consisting of superparamagnetic iron oxide nanoparticles (SPIONs) with a certain surface functionality introduced by self-assembled monolayers. These phosphonic acid based molecules provide an attractive interaction site between NP and SPION that enables a magnetic removal of NP from aqueous solutions. We demonstrated this concept for hydrocarbons across different length scales and molecular weight, ranging from simple alkanes to cross-linked polyethylene. However, this collected “waste” does not have to be disposed or burnt, it can be reused as a sorbent material for liquid hydrocarbons, such as crude oil, boosting the previously stated extraction capacity for only using modified SPIONs.<sup>[1]</sup>

[1] Sarcletti, M. et al. *Adv. Funct. Mater.* 29, 1–7 (2019).

### Biography:

Henrik Gaß studied Nanotechnology for a Bachelor’s degree at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany. He attended a consecutive Master’s program, which he concluded with a thesis about surface functionalization of superparamagnetic iron oxide nanoparticles. Since October 2020, he proceeds his work in the field of water remediation utilizing those particles in the group of Prof. Dr. Marcus Halik at FAU.

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## POSTER PRESENTATIONS

### Biomimetic Nanoparticle-based Host-directed Therapy for the Eradication of *Mycobacterium tuberculosis*

Su-Mari du Plessis<sup>1</sup>, Admire Dube<sup>2</sup>, Josh Reineke<sup>3</sup>, Nelita du Plessis<sup>1</sup> and Samantha L. Sampson<sup>1</sup>

<sup>1</sup>Department of Science and Innovation-National Research Foundation Centre of Excellence for Biomedical Tuberculosis Research, South African Medical Research Council Centre for Tuberculosis Research, Division of Molecular Biology and Human Genetics, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa

<sup>2</sup>Discipline of Pharmaceutics, School of Pharmacy, University of the Western Cape, Cape Town, South Africa.

<sup>3</sup>Department of Pharmaceutical Sciences, College of Pharmacy and Allied Health Professions, South Dakota State University, 1055 Campanile Avenue, Avera Health Science Building, Brookings, SD 57007, United States of America.

#### Abstract:

Current lengthy and unpredictable Tuberculosis (TB) treatment regimens leading to poor adherence and the ongoing emergence of antibiotic resistance desperately calls for alternative strategies. One being host directed therapeutic (HDT) approaches through the use of biomimetic nanoparticles (NPs). We hypothesize that biomimetic NPs will reduce intracellular *M. tuberculosis* (*Mtb*) numbers and instead of targeting the bacilli itself the host cell becomes the target consequently boosting the cells' innate ability to kill invading pathogens. This study aims to assess the antibacterial effects of the NPs on intracellular *M. tuberculosis* and further clarify the stimulated immune pathways that contribute towards NP efficacy.

We will utilize RAW264.7 macrophages as well as bone marrow derived macrophages isolated from C3HeB/FeJ mice as host cell representatives. The NPs to be used will either have a polymer or a metal organic framework core and will be surface functionalized with curdlan or mycolic acid. First, we will assess the safety of the various biomimetic NP formulations at different concentrations, using flow cytometry, on the host cells to determine which non-toxic particle formulations to use for downstream analysis. Afterwards, macrophages will be infected with *Mtb*, containing a *LuxABCDE* gene that will providing luminescent readouts as a proxy for cell number. Up to 10 non-toxic NP formulations will be administered to determine anti-mycobacterial activity over a 72h period. Once anti-mycobacterial activity is detected, cytokine production, intracellular acidification and phagolysosome formation will be investigated as possible antibacterial pathways.

The results will contribute towards the development and successful identification of possible biomimetic NP formulations that could provide an alternative HDT approach towards the treatment and eradication of TB. Furthermore, the results from this study will provide the basis for further *in vivo* studies using mice.

## Nanoparticle-based Host-directed Therapies for Eradication of *Mycobacterium tuberculosis* in the C<sub>3</sub>HeB/FeJ Mouse Model

Zimvo Obasa<sup>1</sup>, Admire Dube<sup>2</sup>, Josh Reineke<sup>3</sup> and Samantha L. Sampson<sup>1</sup>

<sup>1</sup>Department of Science and Innovation-National Research Foundation Centre of Excellence for Biomedical Tuberculosis Research, South African Medical Research Council Centre for Tuberculosis Research, Division of Molecular Biology and Human Genetics, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa

<sup>2</sup>Discipline of Pharmaceutics, School of Pharmacy, University of the Western Cape, Cape Town, South Africa.

<sup>3</sup>Department of Pharmaceutical Sciences, College of Pharmacy and Allied Health Professions, South Dakota State University, 1055 Campanile Avenue, Avera Health Science Building, Brookings, SD 57007, United States of America.

### Abstract:

Although relatively effective Tuberculosis (TB) drug regimens are available, treatment failure remains a roadblock to TB control. One effective TB treatment approach is to boost the host's innate ability to kill invading pathogens – a host-directed approach using engineered bacteriomimetic nanoparticles (NP). We hypothesize that NPs will enhance *in vivo* killing of *Mtb*. Therefore, this study aims to assess *in vivo* response to and efficacy of NPs in the murine infection model. Further, we will determine whether the NP formulations have a synergistic effect with conventional anti-TB drugs.

C<sub>3</sub>HeB/FeJ mice will be infected with *Mtb* (100 CFU) via aerosol inhalation for 2, 4 and 8 weeks. Up to 4 non-cytotoxic nanoparticles with anti-mycobacterial activity will be administered three times a week for four weeks via pharyngeal aspiration. This will be compared to treatment with the first line anti-TB drugs rifampicin and isoniazid. After infection and treatment, groups of mice (n=5) will be euthanized by halothane inhalation, and lungs, liver and spleen will be harvested. A portion of the intact lung and spleen tissue will be reserved for histopathological analysis; stains will include H&E, auramine-rhodamine, Picrosirius red and the pimonidazole hydroxy probe to assess overall pathology, presence of *Mtb*, collagen deposition and regions of hypoxia, respectively. The remainder of the organs will be homogenized, and portions thereof plated for CFU determination. Portions of lung and spleen homogenates will also be reserved for phenotypic characterization using an established flow cytometry protocol. Our results will advance the development of nanoparticle-based, host-directed therapies for TB.

### Biography:

Dr Zimvo Obasa is a postdoctoral researcher at Stellenbosch University. She has a BSc degree in Human Life Sciences (2014), an MSc in Human Physiology (2017) and a PhD in Molecular Biology (2021). Her PhD research focused on understanding the host immune responses elicited by *Mycobacterium tuberculosis* persists in macrophage cultures and she also developed a trackable murine model for the studying of *Mycobacterium* persister formation in Balb/c mice. Her postdoctoral research focuses on assessing *in vivo* response to and efficacy of nanoparticles against *Mycobacterium tuberculosis* in Kramink (C<sub>3</sub>HeB/FeJ) mice.

## Prediction of Self-Assembly Morphology of Amphiphilic Molecules by Combining Molecular Simulation and Machine Learning through Packing Parameters

Yuki Ishiwatari<sup>1</sup>, Takahiro Yokoyama<sup>1</sup>, Taisuke Banno<sup>2</sup>, Noriyoshi Arai<sup>1</sup>

<sup>1</sup>*Department of Mechanical Engineering, Keio University, Japan*

<sup>2</sup>*Department of Applied Chemistry, Keio University, Japan*

### Abstract:

Amphiphilic molecules spontaneously form various self-assembly structures depending on physical conditions such as molecular structure, concentration, and temperature. Self-assembled structures of amphiphilic molecules express various useful functions depending on their morphology. Accordingly, amphiphilic molecules have attracted considerable attention in the fields of materials science, materials chemistry, and medical materials fields owing to their high potential in molecular design and application. However, the current molecular design is mainly done by trial and error. Therefore, it requires significant time and financial costs. The critical packing parameter is a concept that links the self-assembled structure to the chemical structure, but it cannot be calculated and used directly in molecular design unless both the molecular structure as well as the resulting molecular assembly are known.

In this study, we attempt to predict the self-assembled structure of a molecule directly from its chemical structure using machine learning. Dissipative particle dynamics simulations were used to reproduce many self-assembly structures composed of various chemical structures, and their critical packing parameters were estimated. A machine learning model was built using the chemical structures as input data and the critical packing parameters as output data.

By linking the physical and chemical characteristics of surfactant molecules with critical packing parameters, it is possible to predict the shape of molecular assemblies at the molecular design stage. The results of this research will help to further streamline product development in the fields of materials science, materials chemistry, and medical materials.

### Biography:

Yuki Ishiwatari and Takahiro Yokoyama are undergraduate and master's students, respectively, at Keio University, Japan. Noriyoshi Arai is Associate Professor at Keio University. Our laboratory targets to elucidate the self-assembly phenomena of soft matter by molecular simulations. Ishiwatari and Yokoyama are working on a project to use machine learning to predict the self-assembly structure of surfactants. Taisuke Banno is Senior Assistant Professor at Keio University. He focus on the control of dynamics of soft matters, such as vesicles, emulsion droplets, and gels, which are composed of the designed and synthesized amphiphiles.

## Simulation of Physical Properties of Crosslinked Rubber Structures Independent of Semi-empirical Parameters Focusing on the Average Molecular Weight Between Crosslinks

Takumi Sato<sup>1</sup>, Yusei Kobayashi<sup>1</sup>, Noriyoshi Arai<sup>1</sup>, Kenji Yasuoka<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, Keio University, Japan

<sup>2</sup>Department of Applied Chemistry, Keio University, Japan

### Abstract:

Rubber is a polymer with high elasticity and is widely used in the fields of materials science and medical materials. Synthetic rubbers are currently used to improve and control properties such as elasticity, heat resistance, and abrasion resistance by cross-linking, so elucidating their structure and physical properties is an important issue. Therefore, all atomistic molecular dynamics simulation has been used in recent years to develop new materials. Various methods have been proposed to reproduce the crosslinked structure of rubber in simulations, but it is necessary to use semi-empirical parameters to set the crosslinking point.

In this study, we attempt to perform all-atom simulations when the cross-linking point is changed based on the average molecular weight between crosslinks. The simulation results show that if the physical properties of rubber, such as the glass transition temperature, are consistent with experimental values, it is possible to simulate cross-linking based on the molecular weight between cross-linking points.

Furthermore, Average molecular weight between crosslinks is a parameter that can be calculated based on the ratio of cross-linking agents and the degree of polymerization of the rubber, making it possible to create cross-linked structures quantitatively. The results of this research are expected to contribute to the establishment of important simulation models for product development in materials science.

### Biography:

Takumi Sato is Doctor's students, at Keio University, Japan. Noriyoshi Arai is Associate Professor at Keio University. Our laboratory targets to elucidate the self-assembly phenomena of soft matter by molecular simulations. Takumi Sato is working on a project to create a cross-linked structure for rubber based on the average molecular weight between cross-links. Yusei Kobayashi is Associate Professor at Keio University. He focuses on the relationship between self-assembly structure and physical properties of polymers and colloids. Kenji Yasuoka is Professor at Keio University. He focuses on the physical phenomena of soft materials such as clathrate hydrates and proteins.

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## Self-assembly and Mechanical Properties of Polymer Nanocomposites Filled with Patchy Particles

**Yusei Kobayashi**

*Department of Mechanical Engineering, Keio University, Japan*

### **Abstract:**

Janus nanoparticles (JNPs) are unique anisotropic colloids, which typically consist of two distinct surfaces with different properties. To date, many previous studies have used the spontaneous self-assembly of JNPs to generate a variety of self-organized nanostructures such as hexagonal crystals, and Kagome lattices, depending on the surface properties and anisotropy of the JNPs, the particle concentration, and the temperature. In the past decade, some work has been already conducted to study the co-assembly of JNPs and immiscible polymers in the bulk, mainly focusing on the size and shape of the self-assembled structures. However, much less is known on how those self-organized structures impact the mechanical properties of the whole nanocomposite. To shed light onto this question, we investigated the structural as well as the mechanical properties of polymer nanocomposites filled with Janus nanoparticles. We employed coarse-grained molecular simulation and systematically varied the volume fraction of particles and the Janus balance. We found various morphologies, accompanied by unique mechanical properties compared to that of the uniform NPs.

### **Biography:**

Yusei Kobayashi is Assistant Professor at Keio University. My research is to find new insights on the relation between the structural and rheological properties of soft materials (e.g., polymers, colloidal nanoparticles, and surfactants). By utilizing coarse-grained molecular simulations to investigate the self-assembly behavior, I aim to clarify the mechanisms of functional expression of soft materials.

## Curvature Effect of Gold Nanoparticles Alters the Exposure of Amyloid- $\beta^2$ and Modulates its Aggregation Process

Andreas Tapia-Arellano<sup>1,2,3,4</sup>, Eduardo Gallardo-Toledo<sup>4</sup>, Freddy Celis<sup>5</sup>, Italo Moglia<sup>4,6</sup>, Natalia Hassan<sup>1,2</sup>, Marcelo Campos<sup>7</sup>, Natàlia Carulla<sup>3</sup>, Mauricio Baez<sup>4</sup>, Marcelo J. Kogan<sup>4,6</sup>.

<sup>1</sup>Institutional Program for the Promotion of R+D+I (PIDi), Metropolitan Technological University, Chile

<sup>2</sup>Millenium Core of NanobioPhysics, Chile

<sup>3</sup>Institut Européen de Chimie et Biologie, University of Bordeaux, France

<sup>4</sup>Faculty of Chemical Sciences and Pharmacy, University of Chile, Chile

<sup>5</sup>Facultad de Ciencias Naturales y Exactas, Universidad de Playa Ancha, Chile

<sup>6</sup>Advanced Center for Chronic Diseases (ACCDiS), Chile. <sup>7</sup>Faculty of Science, University of Chile.

### Abstract:

Alzheimer's Disease (AD) is one of the main neurodegenerative pathologies characterized by the aggregation process of the amyloid- $\beta$  peptide (A $\beta$ ). This aggregation process produces several toxic intermediate species, and therefore, it becomes an attractive therapeutic target. In this regard, gold nanoparticles (GNP) have emerged as an interesting tool due to their applications in biomedicine, and they are proposed to be used for the detection and treatment of AD inhibiting the A $\beta$  aggregation process. However, there is a lack of knowledge about how the curvature of GNP can modify the A $\beta$  aggregation process. Obtaining this information is relevant to understand how the GNP interact with the A $\beta$  peptide, and how this interaction can alter key molecular steps of the fibril formation. In this study, we analyzed and compared the effect of two GNP: flat gold nanoprisms (GNPr) and curved gold nanospheres (GNS) on *in vitro* A $\beta$ 42 fibril formation kinetics by using the thioflavin-based kinetic assay and global fitting analysis. The results showed GNPr accelerate the aggregation process maintaining the molecular mechanism of aggregation whereas GNS slow down this process and modify the molecular mechanism of aggregation. These results were explained by a differential interaction between the A $\beta$  peptide with each GNP: while GNPr expose key hydrophobic residues involved in the A $\beta$  aggregation, GNS hide them providing a mechanistic insight to improve the rational design of GNP nanomaterials for biomedical applications. This work was funded by Postdoctorado ANID-FONDECYT 3220583 and ANID-Millennium Science Initiative Program NNBPN CN2021\_021, FONDECYT 1211482 and 1191153, FONDAP 15130011.

### Biography:

Andreas Tapia-Arellano, PhD, was born in Santiago, Chile. His PhD was carried out at the University of Chile. Currently, he is a postdoctoral researcher at the Institutional Program for the Promotion of R+D+I (Metropolitan Technological University) and part of the young researchers' staff at Millenium Core of NanobioPhysics. His interest is in the use of nanobiomaterials as tools to study the A $\beta$  aggregation process for the treatment of Alzheimer's Disease. Moreover, his actual postdoctoral research is focused on the generation of a microfluidic simple model for the study of the effect of functionalized gold nanoparticles on the A $\beta$  aggregation process.



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## Trace Atrazine Detection in Drinking Water via Silver Nanoparticles-Enhanced Raman Spectroscopy

Jasmine Zhang<sup>1</sup>, Arthur McCelland<sup>2</sup>, Tingying Helen Zeng<sup>3\*</sup>

<sup>1</sup>Class 2023, Lexington High School, Lexington, MA, U.S.A.

<sup>2</sup>Center for Nanoscale Systems, Harvard University, Cambridge, MA, U.S.A

<sup>3</sup>Tingying Helen Zeng, Academy for Advanced Research and Development (AARD), Cambridge, MA, U.S.A.

### Abstract:

Water contamination has severe implications on public health. As our demand for food increases, the consideration of water quality on humans and animals are getting great attention today. Atrazine is one of the most hazardous and detrimental chemicals that does damage to our health, which as a kind of herbicide existing in our drinking water. In this study, we have developed a nanotechnology-based method to detect traces of atrazine. We used silver nanoparticles to absorb atrazine molecules to achieve Surface Enhanced Raman Spectroscopy (SERS) with high sensitivity. Our experiments established a correlation between atrazine concentration and its Raman spectrum peak enhanced intensity with high confidence. The use of SERS widens the path of monitoring waterborne contaminants, improving overall water quality, and ensures better public health.

### Acknowledgements

Thanks for the Center for Nanoscale Systems at Harvard University to support the SERS characterizations. This project was supported by the Scholarship of Future Scholars from AARD.

**Keywords:** Atrazine, water contamination, public health, Raman Spectroscopy, SERS, silver nanoparticles

## SERS-Based Detection of Alzheimer's Disease Biomarker

Shiqi Min<sup>1</sup>, Arthur McClelland<sup>2</sup>, Tingying Helen Zeng<sup>3\*</sup>

<sup>1</sup>Walnut Hill School for the Arts, Natick, MA.

<sup>2</sup>Center for Nanoscale Systems, Harvard University, Cambridge, MA, U.S.A

<sup>3</sup>Tingying Helen Zeng, Academy for Advanced Research and Development (AARD), Cambridge, MA, U.S.A.

### Abstract:

Alzheimer's disease is the most common form of dementia, affecting an estimated number of 36 million people. The Current detection of AD biomarker is cerebrospinal fluid (CSF)-based, which is invasive and complex to conduct. Diagnosis based on blood measurement has more potential, since it is easier to conduct and less invasive. But diagnosis through blood AD biomarker is challenging due to the low concentration of AD biomarkers in blood, and the interference from other proteins in blood. Thus, It is necessary to find a sensitive and specific detection method for blood-based diagnosis of AD. In the study, surface-enhanced Raman scattering (SERS)-based detection with gold nanoparticles is used to detect Amyloid  $\beta$  42, which is a peptide that is widely found in AD's brain, forming amyloid plaque. The concentration of A $\beta$ 42 is modified to be in between 5-100 pg/ml, simulating its plasma concentration. The use of SERS significantly improves the Raman signal of A $\beta$ 42, achieving enhancement degree of 601%, evidencing its high sensitivity for A $\beta$ 42 detection.

### Acknowledgements:

This project was performed in the Center for Nanoscale Systems, Harvard University. It was supported by the scholarship of the Future Scholars from AARD.

**Keywords:** SERS, gold nanoparticles, Amyloid  $\beta$ , Alzheimer's disease

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## An Early Diagnosis Method for Melanoma Using Tyrosinase as its Biomarker Through SERS With Silver Nanoparticles

Esther Xu<sup>1</sup>, Arthur McClelland<sup>2</sup>, Tingying Helen Zeng<sup>3\*</sup>

<sup>1</sup>Belmont High School, Boston, MA

<sup>2</sup>The Center for Nanoscale Systems (CNS) at Harvard University, Cambridge, MA

<sup>3</sup>Academy for Advanced Research and Development(AARD), Cambridge, MA 02142

### Abstract:

Melanoma is the most common skin cancer diagnosed right now, and is hard to detect because of all the different existing melanomas, which makes the treating process delayed and all the more difficult. Even with the current best diagnosis option (dermoscopy), it can be hard to detect certain melanomas. In 2020, an estimated number of 57,043 people died worldwide from melanoma. It is important to develop a method for the early diagnosis. In our primary research, we found an easier and more efficient way to diagnose melanoma utilizing the benefits of nanotechnology. Our project used biomarker Tyrosinase from mushroom and silver nanoparticles to form conjugated nanoparticles for melanoma detection. Surface-enhanced Raman spectroscopy (SERS) was used for the analysis of the biomarker concentrations. This method is highly sensitive, and shows visible signals even at low concentrations such as  $1.07 \times 10^{-9}$  nmol/ml in our primary study.

**Acknowledgement:** This project was supported by the Scholarship for the Future Scholars of AARD.

**Keywords:** Melanoma, Raman Spectroscopy, Tyrosinase, Silver Nanoparticles, SERS

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## Light or Fiber Touch

### Liqui Wang

*The University of Hong Kong, Hong Kong*

### Biography:

Prof. Wang has over 20 years of university experience in transport phenomena, materials, nanotechnology, biotechnology, energy & environment, thermal & power engineering, and mathematics, and 2 years of industry experience as the Chief Scientist & the Global CTO. Prof. Wang has published 420+ papers, and been ranked amongst the top 1% of most-cited scientists according to Clarivate Analytics' Essential Science Indicator. Prof. Wang's work has been widely featured by local, national and international media, and received recognition through a number of awards, including the 2018 TechConnect Global Innovation Award, the 2018 Silver Medal of the International Exhibition of Inventions of Geneva, and the 2017 OSA Innovation Award.

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## Low-dimensional Nanostructures: Design, Behavior, and Surprises

### David Tomanek

*Physics and Astronomy Dept., Michigan State University, East Lansing, MI 48824, USA*

#### Abstract:

Like in a magic trick, atomically thin layers of specific materials can be mixed and stacked in a well-defined way. Quasi-2D structures with unusual behavior include self-assembled 2D graphitic structures with nanopores, resembling nano-kirigami, which become wider when stretched. Twisted bilayer graphene changes its electronic structure drastically upon changing the relative twist angle. When constrained in the nanosized volume of carbon nanotubes, phosphorus forms previously unknown nanospirals.

#### Biography:

Prof. David Tomanek is emeritus professor of Theoretical Condensed Matter Physics at Michigan State University. He is known for predicting the structure and calculating properties of surfaces, atomic clusters including the C<sub>60</sub> buckminsterfullerene, nanotubes, nanowires and nanohelices, graphene, and two-dimensional materials including phosphorene. Prof. Tomanek's main scientific interest is to understand the formation and the fundamental properties of nanostructured materials using advanced numerical techniques.

## Next Generation Platform for Characterization and Purity Scoring for Nanomaterials

### **Rodney Sappington**

*Epic Advanced Materials, CA*

#### **Abstract:**

This project is focused on machine learning software that ensures consistent quality and volume of nano material production at scale. Quality and high yield nano materials have been the most important barriers to nano production, distribution, and supply chain availability. This project's innovation focuses on a material science platform of artificial intelligence (AI) and machine learning (ML) based nanomanufacturing quality control and process feedback tools that allow for rapid exploration, characterization, generalizability, and optimization of high sensitivity manufacturing processes, such as those required for pharmaceutical and nanomaterial synthesis. The project's novel process for highly crystalline and pure BNNTs utilizes a high-pressure plasma synthesis method that alleviates the shortcomings of many traditional approaches. Currently, this process can be operated in a near-continuous fashion for an increase of over 17x compared to some competitor methods, at a much lower estimated cost per gram of material.

#### **Biography:**

Dr. Rodney Sappington is Chief Executive Officer at Epic Advanced Materials. He is an entrepreneur, clinical data scientist, and researcher based in San Francisco, California. He is focused on building world-class machine learning products, improving clinical outcomes, and growing companies at scale. He is a very well-known speaker both nationally and internationally.

## Nanofluidics in a Transmission Electron Microscope

**Kristian Molhave**

*DTU Nanolab, Technical University of Denmark, Denmark*

### **Abstract:**

Liquid Phase Transmission Electron Microscopy (LPTEM) has over the past twenty years opened up for atomic level imaging of processes in liquids allowing unprecedented insights into complex nanoscale processes and materials in liquids. To achieve high resolution the encapsulation and liquid layer must be well controlled on the 100 nm scale.

Using advanced microfabrication methods to create novel microchip based nanochannel systems that work as miniature laboratories in the TEM that can help getting the needed liquid control to obtain insight to complex nanoscale processes. Applications can be found in physics, chemistry, electrochemistry, materials science, softmatter and biotechnology.

This talk will introduce our nanofluidic LPTEM capabilities. Combining the systems with electron holographic measurements we can also begin to explore directly mapping electric potentials and charge distributions. These microchip-based systems opens up for what could be called 'Nanofluidic Electron Microscopy'.

### **Biography:**

Dr. Kristian S. Mølhave is Professor in Nanotechnology Systems for In-situ Electron Microscopy Applications at DTU Nanolab. He is working on developing novel microchip-based microscopy methods for high resolution imaging especially for electron microscopes in order to provide new insights into physical, chemical and biological processes on the nanoscale.

## Multilayer [60]Fullerenyl Core-Shell $\gamma$ -FeO<sub>x</sub>@Au Nanoparticles on Graphene Nanosheets with Enlarged Photoswitchable Dielectric Properties

He Yin<sup>1,2</sup>, Min Wang<sup>1</sup>, Tzuyang Yu<sup>1</sup>, and Long Y Chiang<sup>1</sup>

<sup>1</sup>University of Massachusetts Lowell, USA

<sup>2</sup>Organix Chemistry Solutions LLC (A Symeres Company), USA

### Abstract:

Novel light-harvesting [60]fullerenyl donor–acceptor conjugates, namely, C<sub>60</sub>(>DPAF-C<sub>9</sub>) monoadduct and a 3D-configured stereoisomer *cis-cup*-tris[C<sub>60</sub>(>DPAF-C<sub>9</sub>)] were designed and synthesized. The later was three C<sub>60</sub>> cages covalently fused into one molecule facing at the same side of the geometrical molecular cup-shape. They both provide excellent binding interaction forces to the plasmonic core-shell  $\gamma$ -FeO<sub>x</sub>@AuNP nanoparticles. When individually coated on the gold surface of core-shell  $\gamma$ -FeO<sub>x</sub>@AuNP nanoparticle, the resulting nanoclusters were found to exhibit reversible photoinduced dielectric property amplification effects at the RF frequency of 1.0 GHz. Moreover, by grafting the nanoclusters on both sides of graphene nanosheets giving the corresponding sandwiched nanostructures was demonstrated up to 10-fold of photoinduced dielectric constant amplification than the ones without graphene nanosheets. The observation was proposed as a phenomenon of enhancing photoinduced intramolecular e<sup>-</sup>-transfer from DPAF to a C<sub>60</sub>> moiety. Since the photoactivation of the Au-layer results in accumulated plasmonic energy at the near-field surface, the negative charges were effectively distributed along the outer [60]fullerenyl shell layer of the nanoclusters. In the combination of a C<sub>60</sub> layer on the surface of exfoliated graphene nanosheets, photoinduced e<sup>-</sup>-transfer at the interface leads to charge recombination. Consequently, the more stable negative charge polarized (C<sub>60</sub>>)<sup>-</sup> results in even larger dielectric constant amplification

### Biography:

Dr. He Yin was a Ph.D. student majoring in Organic Chemistry at University of Massachusetts Lowell between 2015 and 2020. He was doing research on fullerene chemistry in Professor Long Y Chiang's group. In the year of 2021, he was working as a Postdoctoral Research Fellow at Moffitt Cancer Center in Florida. He was engaged in developing anti-cancer drugs during his postdoctoral career. He is now working as a Senior Scientist at Organix Chemistry Solutions LLC (A Symeres Company) in MA. He is mainly focused on the research of lipid chemistry for the delivery of mRNA-based drugs.



## Effect of the Geometry of Gold Nanoparticles in the Interaction with Plasma Proteins by Microfluidic Devices

Natalia Hassan<sup>1,2,3</sup>, Nacaroha Orellana<sup>1</sup>, Estefania Torres<sup>1</sup>, Karla Vargas<sup>1</sup>, and Marcelo Kogan<sup>3,4</sup>

<sup>1</sup>*Programa Institucional de Fomento a la I+D+I, Universidad Tecnológica Metropolitana, Santiago, Chile*

<sup>2</sup>*Millenium Nucleous in NanoBioPhysics, N2BP, Chile*

<sup>3</sup>*Advanced Center for Chronic Diseases (ACCDiS), Independencia, Santiago, Chile*

<sup>4</sup>*Departamento de Química Farmacológica y Toxicológica, Facultad de Ciencias Químicas y Farmacéuticas, Laboratorio de Nanobiotecnología, Universidad de Chile, Chile*

### Abstract:

We propose to functionalize different geometries of GNPs with polyethylene glycol (PEG) to prevent PC formation. It is known that PEG reduces NPs uptake in in vivo cultured cells and increases the retention times in blood circulation. Furthermore, GNPs are extensively used in different therapy and diagnosis application because of their potent photothermal effect. For this reason, we will take advantage of them to study in cancer disease. Moreover, folic acid will be used adsorbed onto the GNPs-PEG surface to give directionality and specificity to GNPs. It is because some tumor cells have folate receptors that normal cells do not have.

The major number of the papers are related to the study of protein corona (PC) formation in static conditions, where is far from reality. In this sense, a central aspect that has been poorly studied is the nanoparticle-protein interaction within a dynamic environment caused by a flow. Microfluidic (MF) is a pioneering technique that allows analysing and studying hydrodynamic regimes. Furthermore, it can emulate a natural environment to explore the nanoparticle-protein interaction by simulating a PC formation in the bloodstream. Therefore, for this reason, it is vital to consider the potential information that these experiments could provide to mimic the natural conditions that nanoparticles could face in the bloodstream.

### Biography:

Dr. Natalia Hassan is PhD in Science Materials from Santiago de Compostela University. She works in the synthesis, functionalization, and characterization of inorganic and polymeric NPs. She worked in different projects related to the development of multifunctional NPs, considering magnetic, plasmonic and fluorescent NPs for biological applications. She had two postdoctoral projects related to the synthesis and characterization of NPs and their application in nanomedicine, including microfluidics for nanomedicine (Chile and France).

## Amphiphilic Comb Polymer Additives to Bicontinuous Microemulsions

**Henrich Frielinghaus**

*Research Center Juelich GmbH, Germany*

### **Abstract:**

It has been shown that the thermodynamics of bicontinuous microemulsions can be tailored via the addition of various different amphiphilic polymers. In this manuscript, we now focus on comb-type polymers consisting of hydrophobic backbones and hydrophilic side chains. The distinct philicity of the backbone and side chains leads to a well-defined segregation into the oil and water domains respectively, as confirmed by contrast variation small-angle neutron scattering experiments. This polymer–microemulsion structure leads to well-described conformational entropies of the polymer fragments (backbone and side chains) that exert pressure on the membrane, which influences the thermodynamics of the overall microemulsion. In the context of the different polymer architectures that have been studied by our group with regards to their phase diagrams and small-angle neutron scattering, the microemulsion thermodynamics of comb polymers can be described in terms of a superposition of the backbone and side chain fragments. The denser or longer the side chain, the stronger the grafting and the more visible the brush effect of the side chains becomes. Possible applications of the comb polymers as switchable additives are discussed. Finally, a balanced philicity of polymers also motivates transmembrane migration in biological systems of the polymers themselves or of polymer–DNA complexes.

## Active Reduction of p-nitrophenol by Silver Nanoparticle on Fe<sub>3</sub>O<sub>4</sub>/ATO Nanocomposite

Hem Prakash Karki<sup>1,2</sup>, Laxmi Kafle<sup>2</sup>, and Han Joo Kim<sup>2</sup>

<sup>1</sup>Department of Environmental Engineering, Korea University, Sejong Campus.

<sup>2</sup>Department of Convergence Technology Engineering, Jeonbuk National University, Republic of Korea

### Abstract:

Silver nanoparticles have attracted wide attention as catalyst for pollutant degradation because of their unique reactivity. Direct use of silver nanoparticles in water treatment induces prohibitive challenges due to nanoparticles aggregation and post-treatment separation. Silver loaded magnetic nano-composite Ag-Fe<sub>3</sub>O<sub>4</sub>/ATO (Ag-NC) was successfully synthesized by one pot hydrothermal method. The active Ag-NC was characterized by FE-SEM, HRTEM, EDS, XRD, and FTIR. The catalytic property of Ag-NC for the reduction of p-nitrophenol (PNP) into p-aminophenol (PAP) in the presence of sodium borohydride (NaBH<sub>4</sub>) was monitored by Uv-vis spectroscopy. The reduction of p-nitrophenol with the excess amount of NaBH<sub>4</sub> followed the pseudo-first order kinetics. The antimony doped tin oxide (ATO) surface area was used for the hydrothermal growth of silver and magnetic iron oxide nanoparticles. The in situ growth of these nanoparticles provided an effective bonding of the components over the surface of ATO nanoparticles. The enhanced catalytic activity of Ag-NC catalyst was primarily owing to the large surface area and excellent adsorption of nitrophenols and effective electron transfer from BH<sub>4</sub><sup>-</sup> to nitrophenols, respectively. The Ag-NC exhibited facile synthesis, cost effective, and rapid separation using external magnet. The excellent catalytic activity of the prepared Ag-NC makes it potential nano-catalyst for waste water remediation.

### Biography:

Dr. Hem Prakash Karki received his M. Sc. in Chemistry from Tribhuvan University Kathmandu, Nepal in 2011 where he studied basic organic chemistry. In Sept. 2016, he joined the Department of Convergence Technology Engineering, advisor Prof. Han Joo Kim in Jeonbuk National University, South Korea, as a PhD candidate investigating the water pollution mitigation using nanoparticles and nanofibers. He served Department of Bio-nanotechnology, School of Engineering, Jeonbuk National University as Postdoc from 1 March 2020 to 28 February 2021. From 1 March 2021 to till date, he is working as research professor at Department of Environmental Engineering, Korea University, Sejong Campus.

## Enhancement of Transformer Oil Heat Transfer Characteristics via Functionalized Nanodiamond Additives

Miles Nevills<sup>1</sup>, Ethan Languri<sup>1</sup>, Jim Davidson<sup>2</sup>, Lino Costa<sup>3</sup>, and David Kerns<sup>2</sup>

<sup>1</sup>Tennessee Technological University, USA

<sup>2</sup>International FemtoScience Inc., USA

<sup>3</sup>University of Tennessee Space Institute, USA

### Abstract:

Due to the increasing focus of industry on electrification, the delivery systems of the power grid are encountering new challenges in meeting the demands of shifting electrical needs. A core point of interest in power delivery is the transformer. Necessary for adjusting voltages, these are key systems in maintaining proper power characteristics in machinery as well as reducing line losses across the grid; however, these machines are highly limited by thermal behaviors. As the demand on a transformer increases, greater current is passed through it. This current resistively heats the coils and doubling the current quadruples the resistive heating. Since transformer life is highly negatively correlated to increasing core temperature, improving cooling is paramount in ensuring long lifespan. By using a functionalized nanodiamond additive (~2200 W/m<sup>2</sup>\*K), the comparatively poor heat transfer medium of transformer oil (~0.162 W/m<sup>2</sup>\*K) can be significantly improved while needing only fractions of a weight percent. This study seeks to explore the precise enhancement characteristics with respect to weight percent, as well as measure other factors relevant to the enhanced transformer oil's purpose.

### Biography:

Miles Nevills is mechanical engineering Ph.D. Student at Tennessee Technological University and a research assistant for the TNTech Industrial Assessment Center. He has been a part of 22 assessments, leading 8 of those, assisting manufacturers and industry in reducing energy needs where possible. Of these assessments, there has been roughly \$1.76m in implemented savings.

NOVEMBER  
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# 8<sup>th</sup> NANO BOSTON CONFERENCE

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NOV 02, 2022 | ONLINE | ZOOM

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## Oxide Nanostructures for Electronics and Energy Applications

### Rodrigo Martins

*New University of Lisbon, Portugal*

#### Biography:

Rodrigo Martins is full professor in Materials Science Department of Faculty of Science and Technology of New University of Lisbon, a Fellow of the Portuguese Engineering Academy since 2009 and a member of the European Academy of science since 2016. He was decorated with the gold medal of merit and distinction by the Almada Municipality for his R&D achievements. Currently he is the Director of the Centre of Excellence in Microelectronics and Optoelectronics Processes of the Institute of New Technologies, CEMOP/Uninova; Head of the group of Materials for Electronics, Optoelectronics and Nanotechnologies (MEON) of CENIMAT/I3N; President of the European Academy of Sciences;

## Liquid-crystal Based Caloric Materials for New Heat-management Technologies

Brigita Rožič<sup>1</sup>, Gregor Skačej<sup>2</sup>, Samo Kralj<sup>1,3</sup>, Boštjan Zalar<sup>1</sup>, and Zdravko Kutnjak<sup>1</sup>

<sup>1</sup>*Jozef Stefan Institute, Slovenia*

<sup>2</sup>*Faculty of Mathematics and Physics, University of Ljubljana, Slovenia*

<sup>3</sup>*Faculty of Natural Sciences and Mathematics, University of Maribor, Slovenia*

### Abstract:

With increased environmental awareness, the search for an environmentally friendlier heat-management device has been the topic of many scientific studies. Materials with large caloric effects, such as the electrocaloric (EC) and elastocaloric (eC) effects, have the promise of realizing new solid-state refrigeration techniques. A review of recent direct measurements of the large EC effect in liquid crystals (LCs) and large eC effect in liquid crystal elastomers (LCEs) [1,2] will be given in this contribution, including the application aspect. In particular, in smectic LCs and mixtures of LCs with functionalized nanoparticles, the EC effect exceeds 8 K and the eC in main-chain (MC) LCEs exceeds 1K. However, both soft materials can play a significant role as active cooling elements and parts of thermal diodes or regeneration material in developing new cooling devices.

[1] D. Črešnar et al, *Liq. Cryst.* 48:405-411, 2021. [2] A. Rešetič et al, *Nat Comm* 7:13140,2016.

### Biography:

Dr. Brigita Rožič obtained a Ph.D. degree in physics in 2012 at the Jozef Stefan International Postgraduate School, Ljubljana. After two years of postdoctoral work at Institut des Nano-Sciences de Paris (INSP), Pierre and Marie Curie Université Paris, France, Dr. Rožič returned to Jozef Stefan Institute. As a research associate, she works in the laboratory for calorimetry and dielectric spectroscopy, and she is an Assistant Professor at the Jozef Stefan International Postgraduate School. She continues the soft matter research, including multicalorics, multiferroics, magnetoelectrics, plasmonic systems, liquid crystal elastomers, and topological defects.

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## Current and Future of Red and Black Phosphorus Nanomaterials

### Hai-Feng Ji

*Department of Chemistry, Drexel University, PA*

#### Abstract:

The presentation will summarise some optoelectronic applications of red and black phosphorus nanomaterials. The synthesis, characterization, stability improvement of the materials will also be discussed.

#### Biography:

Dr. Hai-Feng (Frank) Ji is current a professor of Department of Chemistry, Drexel university. His research interests focus on MEMS devices, nanomaterials for energy and environmental applications, drug discovery, nanopillars and phosphene for energy applications, and surface chemistry. He is currently a co-author of 200 peer-viewed journal articles and book chapters. He has an H-index of 40. He is an editorial board member of several chemistry journals.

**VELION – a Novel FIB-SEM Instrument Concept for Nanoscale Science and Engineering****Yang Yu***Raith America, Inc., MA***Abstract:**

Over the last decades, focused ion beam (FIB) technology has evolved into an extremely versatile technique for various application areas. FIB's great success has been accelerated in particular by the combination with scanning electron microscopy (SEM) in FIB-SEM microscopes. Today these FIB tools are found in most microscopy and analysis labs worldwide, where the FIB column is included as an add-on component for supporting sample preparation and basic patterning tasks. However, FIB is also an increasingly valuable tool for nanofabrication and rapid prototyping applications, providing direct resistless three-dimensional patterning and thus complementing other top-down lithography instrumentation. Even though patterning with ions has advanced very quickly to a high-performance level, the SEM prioritized microscope architecture has limited it so far to more sophisticated applications. Based on unique FIB and precision stage technology as well as a novel nanofabrication platform, the Raith VELION FIB-SEM is designed around the FIB as the primary patterning technique, supported by uncompromised SEM and laser interferometer stage capabilities. Such a FIB-centric state-of-the-art nanofabrication system allows scientists to take advantage of the unique capabilities afforded by focused ions. In addition, with VELION's liquid metal alloy ion sources (LMAIS) technology, one can access multiple ion species from a single source, including Au/Si/Ge, or Ga/Bi/Li, for high-resolution, large-area FIB-assisted ion implantation and nanofabrication. This presentation discusses various capabilities and key strengths of the VELION, which have enabled the researchers on the MIT.nano VELION system to manipulate and significantly enhance the scintillation in nanophotonic structures, to integrate large numbers of artificial atoms with photonic architectures to enable large-scale quantum information processing systems, to fabricate complicated optics for focusing X-rays, to facilitate rapid, affordable, and accurate DNA sequencing, etc.



## Manipulating Interlayer Magnetic Orders of 2D Magnets by Stacking Rotation

Liangbo Liang and Xiangru Kong

Center for Nanophase Materials Sciences, Oak Ridge National Laboratory, TN

### Abstract:

Chromium triiodide ( $\text{CrI}_3$ ), a two-dimensional (2D) van der Waals (vdW) magnet, exhibits complex magnetism depending on the number of layers and interlayer stacking patterns. Within each layer spins are ferromagnetically coupled with strong out-of-plane anisotropy, but between layers the magnetic orders can be manipulated between ferromagnetic (FM) and antiferromagnetic (AFM) by numerous ways due to the relatively weak interlayer coupling. In this work [1], we considered three energetically stable stacking patterns  $\overline{R3}$ , C2/m and AA in bilayer  $\text{CrI}_3$ , and the reversed counterparts  $\overline{R3}$ -r, C2/m-r and AA-r through rotating one layer by  $180^\circ$  with respect to the other layer. Our first-principles calculations suggest that the interlayer magnetic ground state can be switched from AFM to FM (or FM to AFM) by reversing the stacking pattern, corroborating prior experimental results in bilayer  $\text{CrBr}_3$ . Detailed microscopic analysis was carried out by magnetic force theory calculations on C2/m stacking which favors AFM and C2/m-r stacking which favors FM. The interlayer magnetic interactions and the origin of the magnetic order change were revealed through specific orbital analysis. Our work demonstrates that stacking rotation, like stacking translation, allows us to control and manipulate the interlayer magnetism of  $\text{CrI}_3$  and possibly other 2D magnetic materials as well.

[1]. X. Kong, H. Yoon, M. J. Han, L. Liang, "Switching interlayer magnetic order in bilayer  $\text{CrI}_3$  by stacking reversal", *Nanoscale*, 13, 16172 (2021)

**Acknowledgement:** This work was supported by Center for Nanophase Materials Sciences (CNMS), which is a US Department of Energy, Office of Science User Facility at Oak Ridge National Laboratory.

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## Process Optimization of Rapid Thermal Alloyed Collector Metals Layer in Compound Semiconductor Devices

**Stephanie Y. Chang**, Shibam Tiku, Lam Luu-Henderson, and Nercy Ebrahimi  
*Skyworks Solutions, Inc., USA*

### Abstract:

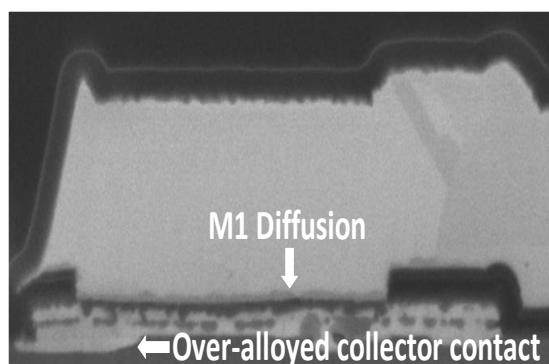
Rapid thermal processing (RTP) is critical within the fabrication flow for alloying an evaporated metal stack (AuGe/Ni/Au) of approximately 200 nm thickness at the eutectic temperature to achieve low contact resistance ( $R_c$ ). While insufficient alloying results in an incompletely formed collector contact, excessively high temperatures during or downstream from the alloy step results in undesirable diffusion, as depicted in Figure 1.

Therefore, it is essential to take into consideration the downstream effects and tuning of alloy process conditions. As shown in Figure 2's temperature profile, greater stabilization of power and steady intervals of lamp illumination were achieved through the implementation of a series of two moderate ramps and stabilization steps. Furthermore, misalignment or topology of patterned wafers may result in uneven heating. The temperature profile of a batch process' first wafer may also slightly vary due to the quartz chamber's heat capacity and initial temperature after extended idle time. The addition of a preheating step and utilization of graphite susceptors for identical backside conditions facilitates a more consistent run-by-run temperature profile and uniform heating distribution, as shown in Figure 3.

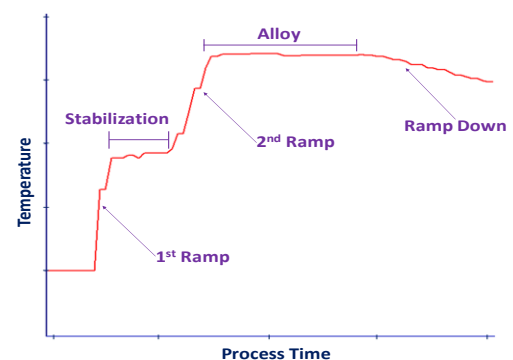
To study the downstream effects on electrical characterization of the collector layer, process control monitor (PCM) structures were measured for  $R_c$  after oxidative and thermal processes, as shown in Figures 4 and 5. With a minimal shift in average  $R_c$  of  $3.24E-3$  Ohm-mm between Poly Via 1 (PV1) and end-of-frontside device process, an earlier electrical characterization of collector-related parameters can be achieved and reduce wafer scrap arising from process drifts.

### Biography:

Stephanie Chang is a process engineer at Skyworks Solutions, Inc.'s Advance Process Technology Group, specializing in thin films and photo processes. She graduated from UC Berkeley and previously worked at Lawrence Berkeley National Laboratory's Molecular Foundry where she researched liquid cell TEM, MEMS/NEMS, and metamaterials.



**Figure 1.** High temperature processes downstream from Metal 1 (M1) deposition resulted in an over-alloyed collector contact metal stack and diffusion into the M1 layer.



**Figure 2.** Temperature profile showing heating ramps, intermediate stabilization step, alloying at eutectic temperature, and cool down ramp.

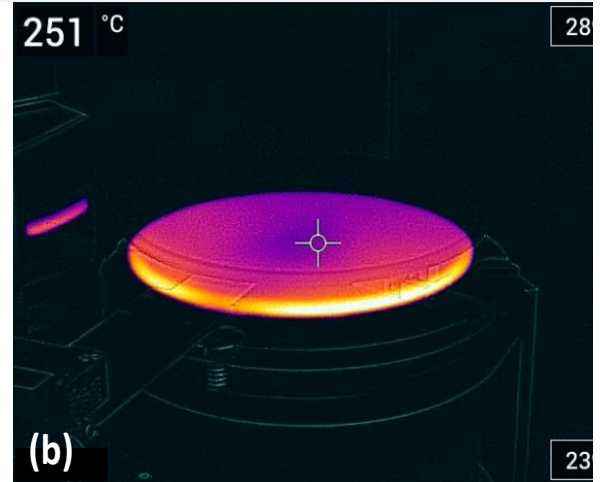
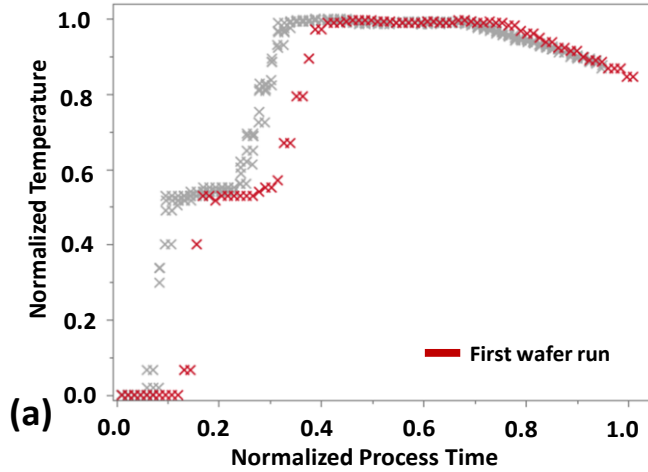


Figure 3. (a) Temperature profile of the first wafer processed through rapid thermal alloying slightly differs from that of the subsequent runs. (b) Temperature distribution map of susceptor with enclosed GaAs product wafer after exiting the quartz furnace for cool down in the ambient environment.

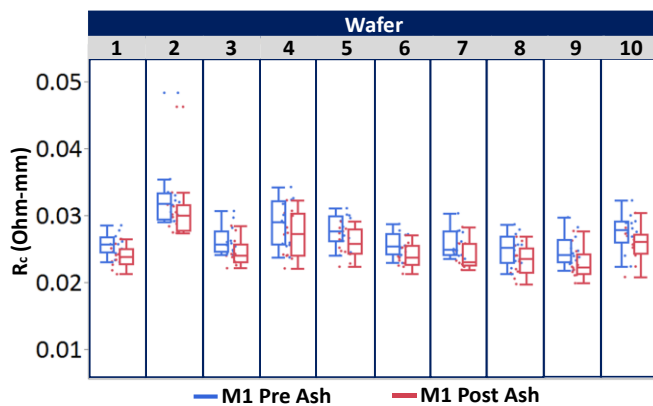


Figure 4. Highly oxidative and thermal ash treatment at M1 stage resulted in a downwards shift in  $R_c$ .

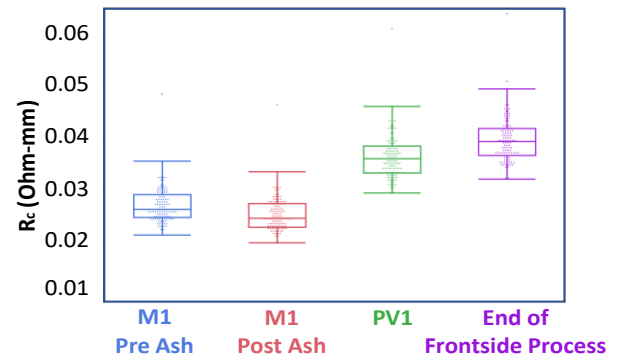


Figure 5. Progression of  $R_c$  measured at several stages downstream from the alloy step: M1, PV1, and end of frontside process.

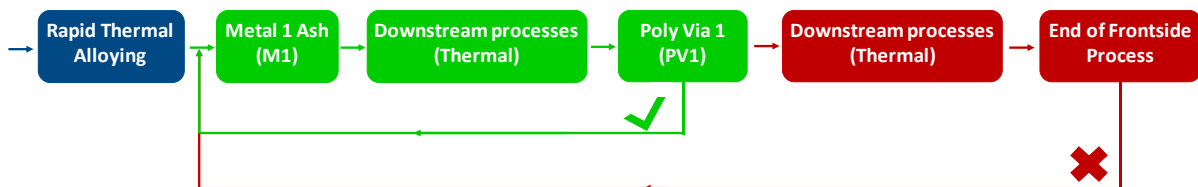


Figure 6. Comparable  $R_c$  measured at PV1 and end of frontside process allowed shortened feedback loop for earlier electrical testing of collector-related parameters.

## Fast Gas Sensing Using Surface Acoustic Wave Based PEDOT: PSS Conductive Polymer

Zakariae Oumekloul<sup>1</sup>, Arnaud Demaître<sup>2</sup>, Sébastien Pecqueur, Kamal Lmimouni<sup>1</sup>, Abdelkrim Talbi<sup>1</sup>, and **Bilel Hafsi**<sup>1,2</sup>

<sup>1</sup>Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France, UMR 8520 – IEMN, France

<sup>2</sup>ICAM site de Lille, France

### Abstract:

Electrochemical biosensors and especially surface acoustic wave sensors (SAWs) are fast, selective, and inexpensive detection tools. They have been successfully used in many different application fields for the detection such as environment, industry, health, public security. Nevertheless, their integration in microsystems is under-exploited in data and smart decision.

In this paper we experimentally demonstrate the design and fabrication of shear wave gas sensors based on bottom-up process. PEDOT: PSS conductive polymer was electro-polymerized on top of structured gold surfaces, acting as sensing layer and allowing a multivariate and fast detection of low gas concentrations. The architecture is made using ST-Quartz piezoelectric substrate with high polymer uniformity over a large area (**Fig.1**). With an operating frequency of 215 MHz and insertion losses of about 33dB our designed sensors combine the recognition properties of molecularly imprinted polymers with micro-squared structured gold layer, thus obtaining an ultra-compact and connected detection platform. The electrical response of our sensors has been investigated by mean of transmission parameter S<sub>21</sub> using MATLAB program for gas exposure process. We observed a clear effect on the working frequency after electro-polymerization process, in fact the presence of the polymer affects the wave propagation by shifting the central frequency response (370 kHz frequency shift) with a small insertion loss, this can be explained by the mass effect due to the polymer's growth above the square patterns. The sensor responses were also tested under acetone (C<sub>3</sub>H<sub>5</sub>OH), methanol (CH<sub>3</sub>OH), Isopropanol (C<sub>3</sub>H<sub>7</sub>OH) and water vapor gases. Phase changes were more pronounced under water vapors gases. These changes depend on the surface conductivity of PEDOT: PSS deposited on the sensor. The double-port SAW gas sensors modified with the PEDOT: PSS presents the highest sensitivity in the case of water vapor, with a maximum phase shift of 0.8° and an insertion loss of about 0.5 dB at room temperature.

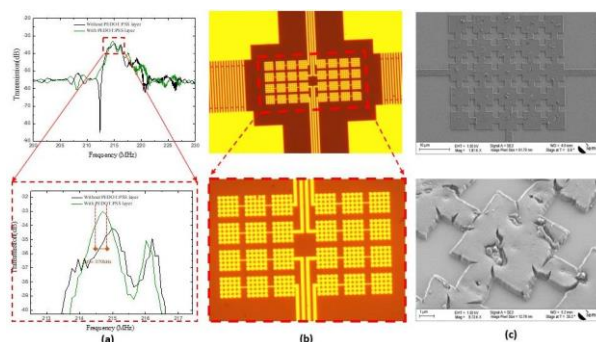


Fig.1. (a) Transmission response of our SAW gas sensors (b) Au-Structured, the squared regions are used to hold PDOT:PSS after electro-polymerization process (c) SEM top view of the PEDOT:PSS/Au/Quartz structure, the thickness of the polymer is about 300 nm.

## Impedance Analyzer Based AD5933: Environment Monitoring Through the Detection of Complex Gas Mixtures with Chemosensors

Louis Routier<sup>1,2</sup>, Kamal Lmimouni<sup>1</sup>, Sébastien Pecqueur<sup>2</sup>, and Bilel Hafsi<sup>1,2</sup>

<sup>1</sup>Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France, UMR 8520 - IEMN, France

<sup>2</sup>ICAM site de Lille, France

### Abstract:

This paper describes the development of a miniaturized, multiplexed and connected impedance spectrometer platform (Fig.1). The platform we developed has been tested and created for the characterization and interfacing of multi-selective chemically sensitive sensors. Designed for portable measurements and adapted to wireless network architectures, the circuitry is designed with low-cost, low-power microelectronic components, allowing for long-term operation without reducing the accuracy and precision of sensor measurements, which is currently below 5%. The AD5933 impedance network analyzer chip (Analog Devices, Norwood, MA, USA) was used. It can measure impedance spectra from 5 Hz to 100 kHz. We used two ADG1608 multiplexers for calibration and feedback in the proposed system. An ATmega328P microcontroller controls the AD5933 via its I2C interface. As a result, our platform is capable of interfacing up to 15 conductivity chemical sensors sequentially. The data is relayed wirelessly for data analysis and storage, in real time conditions. In addition, our platform is designed to prevent degradation of chemical sensors over time by using very low voltages (200mV) at the AD5933's output.

In the paper, we describe the microelectronics design, the impedance response over time, the sensitivity and accuracy of measurements, and how the data are collected and processed using PCA (Principal Component Analysis) method, once the acquisitions are made.

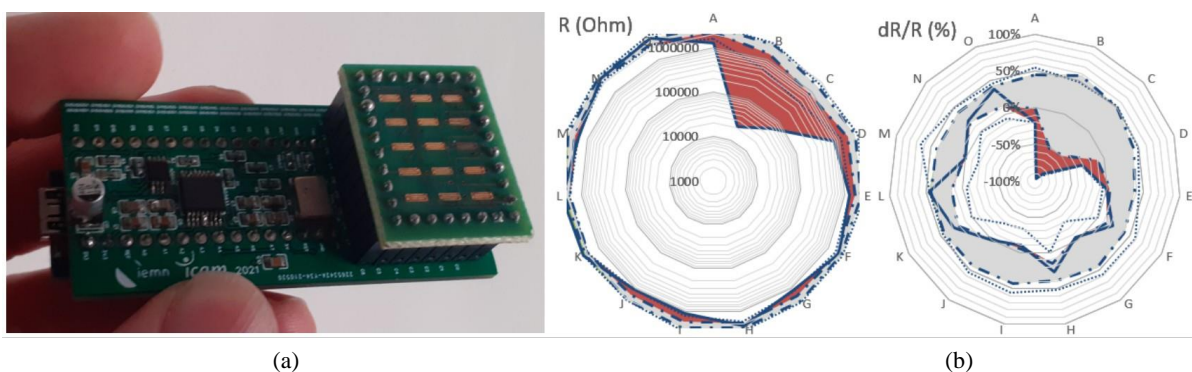


Fig.1. (a) Printed circuit board of our compact sensing Platform based AD5933 Impedance analyzer, (b) Impedance values polar representation of our sensors

1. Abbasi MA, Kim H, Chinnadayala SR, Park KD, Cho S. "Real-Time Impedance Detection of Intra-Articular Space in a Porcine Model Using a Monopolar Injection Needle" *Sensors* **20**(16), 4625 (2020) | doi:10.3390/s20164625
2. Boujnah A., Boubaker A., Kalboussi A., Lmimouni K., Pecqueur S., "Mildly-doped polythiophene with triflates for molecular recognition" *Synth. Met.* **280**, 116890 (2021). | doi:10.1016/j.synthmet.2021.116890.
3. P. Ibba *et al.*, "Design and Validation of a Portable AD5933-Based Impedance Analyzer for Smart Agriculture," in *IEEE Access*, vol. 9, pp. 63656-63675, 2021, doi: 10.1109/ACCESS.2021.3074269.

## Identification of Semiconducting Nanomaterials Using Energy-resolved Distribution of Their Electron Traps: A Novel Concept for True Design of Materials

**Bunsho Ohtani**

*Hokkaido University, Japan*

### Abstract:

How can we design functional solid materials, such as catalysts and photocatalysts? What are the decisive structural parameters controlling their activities, performance or properties? What is obtained as structural properties by popular conventional analytical methods, such as X-ray diffraction (XRD) or nitrogen-adsorption measurement, is limited to bulk crystalline structure and specific surface area, i.e., no structural characterization on amorphous phases, if present, and surface structure has been made so far. This is because there have been no macroscopic analytical methods to give surface structural information including possibly-present amorphous phases. Recently, we have developed reversed double-beam photoacoustic spectroscopy (RDB-PAS) which enables measuring energy-resolved distribution of electron traps (ERDT) for semiconducting materials such as metal oxides [1,2]. Those detected electron traps (ETs) seem to be predominantly located on the surface for almost all the metal oxide particles, and therefore they reflect macroscopic surface structure, including amorphous phases, in ERDT patterns. Using an ERDT pattern with the data of CB bottom position (CBB), i.e., an ERDT/CBB pattern, it has been shown that metal oxide powders, and the other semiconducting materials such as carbon nitride, can be identified without using the other analytical data such as XRD patterns or specific surface area, and similarity/differentness of a pair of metal-oxide samples can be quantitatively evaluated as degree of coincidence of ERDT/CBB patterns. In this talk, an approach of material design based on the ERDT/CBB-pattern analyses is introduced [3].

[1] *Chem. Commun.*, **2016**, 52, 12096–12099. [2] *Electrochim. Acta*, **2018**, 264, 83–90. [3] *Catal. Today*, **2019**, 321–322, 2–8.

## Synthesis and Characterization of Metal (Cu, Mn and Fe) -Doped ZIF-8 Metal Organic Framework for Supercapacitor Applications

Fulya Kumbetlioglu and **Ayten Ates**

*Sivas Cumhuriyet University, Department of Chemical Engineering, Sivas, Turkey*

### Abstract:

In this study, the synthesis of zeolitic-imidazole cages (ZIF-8) for supercapacitors and their modification with three different metals (Cu, Mn and Fe) were carried out. ZIF-8 consists of tetrahedral coordinated zinc ions associated with 2-methylimidazole, resulting in a sodalite zeolite structure. ZIF-8 crystals have become attractive for a wide variety of applications due to a high specific surface area (2100 cm<sup>2</sup>/g) and high porosity. Synthesis method, solvent used, concentrations of reactants are important factors affecting the properties of ZIF-8. Due to the low conductivity of ZIF-8 for supercapacitor applications, one or more different metals can be loaded into the ZIF-8 to eliminate this disadvantage in order to increase its usability in the supercapacitor. For this purpose, single and binary mixtures of Mn, Cu and Fe were loaded into the ZIF-8 crystal structure at different ratios and analysed with a three-electrode and two-electrode systems. ZIF-8 and metal doped-ZIF-8 samples were characterized by SEM, TEM, FT-IR, XRD, N<sub>2</sub> adsorption-desorption, XPS and Raman. The loading of Mn together with Fe and Cu to ZIF-8 increased its capacitance. The highest capacitance was found to be 40 F/g in ZIF-8 containing 2.5 (wt) % Cu and 2.5 (wt)% Mn in 0.1 M Na<sub>2</sub>SO<sub>4</sub> solution.

## Molecular Engineering to Manipulate Cellular Uptake of Rhodamine for High-contrast Discrimination of Cancer Cells

**Lin Yuan** and Gangwei Jiang

*State Key Laboratory of Chemo/Biosensing and Chemometrics, College of Chemistry and Chemical Engineering, Hunan University, Changsha 410082, China*

### Abstract:

Small-molecule fluorescent probes have widely been used in the detection of intracellular molecules to study the development of cancers. 1 However, low-contrast discrimination of cancer cells from normal ones and short residence time after activation hindered their applications in early diagnosis and treatment of cancers. Herein, starting from regulation of cellular uptake of asymmetric rhodamines through structural modification,<sup>2</sup> we constructed a class of fluorescent dyes and probes for distinguishing cancer cells with high-contrast. Introduction of protonated alkylamino to asymmetric rhodamine in the presence of carboxyl group substantially reduces the cellular uptake of dyes, which is yet recovers accompanied by amino-amidation or carboxyl-esterification. Notably, the amidation allows more dyes to be taken up by cancer cells over normal ones (16-fold). The fluorescence contrast (56-fold) between the two types of cells can be further improved through constructing acetamido-responsive probes. What's more, the activated probes can remain in cancer cells, enabling long-term cells and tumors imaging. The superior properties of novel dyes and probes make them potential tools for early diagnosis of cancers.

### References:

1. Liu, H. W.; Chen, L.; Xu, C.; Li, Z.; Zhang, H.; Zhang, X. B.; Tan, W., Recent progresses in small-molecule enzymatic fluorescent probes for cancer imaging. *Chem. Soc. Rev.* **2018**, *47*, 7140-7180.
2. Jiang, G.; Ren, T. B.; D'Este, E.; Xiong, M.; Xiong, B.; Johnsson, K.; Zhang, X. B.; Wang, L.; Yuan, L., A synergistic strategy to develop photostable and bright dyes with long Stokes shift for nanoscopy. *Nat. Commun.* 2022, *13*, 2264.

### Biography:

Dr. Lin Yuan is currently a Professor of College of Chemistry & Chemical Engineering at Hunan University. His current research interests focus on the developing functional dyes and probes for biomedical application.



## Enhanced Penetration Efficacy of Ferromagnetic Nanoparticles Loading Minocycline Against Periodontal Biofilms

Hongmeng Cheng<sup>1,2</sup>, Fei Tong<sup>1,2</sup>, Junchao Wei<sup>1,2</sup>, **Zhihua Li<sup>1,2\*</sup>**

<sup>1</sup>Department of Orthodontics, Affiliated Stomatological Hospital of Nanchang University, China

<sup>2</sup>The Key Laboratory of Oral Biomedicine, Jiangxi Province, China

### Abstract:

**Objectives:** The key factor for the periodontitis therapy is to thoroughly eliminate the dental plaque biofilm especially including the deep periodontal tissue. Antibiotics can penetrate deep periodontal tissue, but bacterial biofilms are difficult to penetrate because of their polysaccharide matrix, often requiring doses up to 1,000 times higher than those of suspended bacteria. In order to effectively penetrate the biofilm, we constructed a Fe<sub>3</sub>O<sub>4</sub> magnetic nanoparticle loading minocycline (FPM NPs) to physically penetrate the biofilm under the magnetic force for effectively eliminating dental plaque biofilm.

**Methods:** The ferromagnetic nanoparticles were prepared by reducing Fe<sup>3+</sup> under the protection of nitrogen, and then loaded with minocycline. The particle size and dispersion of the nanoparticles were characterized by transmission electron microscope, scanning electron microscope and dynamic light scattering, and the drug loading efficiency was determined. In order to verify the magnetic targeting of FPM NPs, the antibacterial effects under magnetic field and non-magnetic field were tested. Furthermore, the therapeutic effect of FPM NPs on periodontitis in rats was also investigated.

**Results:** The results indicated that FPM NPs exhibited good chemical stability and biocompatibility. The multifunctional nanoparticles exerted strong anti-biofilm activity against *Streptococcus Sanguis*, *Porphyromonas Gingivalis* and *Fusobacterium Nucleatus* under magnetic field. The inflammation recovered well in rats after treatment. It also has real-time monitoring function and magnetic targeting capability.

**Conclusions:** The ferromagnetic nanoparticles provide a new idea for the treatment of clinical periodontitis and provides theoretical basis and experimental support for the clinical application of magnetic targeted nanoparticle.

## Ethosomal Formulations Enriched with Skin Permeation Enhancers for Transdermal Delivery

Kristýna Dvořáková<sup>1\*</sup>, Doreen Pritts<sup>1</sup>, Jarmila Zbytovská<sup>1</sup>

<sup>1</sup>University of Chemistry and Technology Prague, Technická 5 Prague 166 22, Czech Republic

### Abstract:

Transdermal application is an ideal non-invasive option for drug delivery providing many benefits over other conventional methods. However, the main limitation for drug transport is the unique skin barrier – *stratum corneum*. Due to this limitation, great attention is paid to the study of transdermal absorption enhancers, that help to improve the drug passage into the blood circulation. In addition, in recent years, nanoparticulate formulations have been increasingly used in the field of transdermal administration. Traditional liposomes, lipid or polymeric nanoparticles show a strong potential in dermal administration, eg. targeting the drug to the skin but not further to the blood system. In contrast, newly described ethosomes may rather promote transdermal drug penetration into the systemic circulation. In the sense of increasing efficiency of this system, the combination with transdermal permeation enhancers, that will be incorporated into the ethosomes, appears to be interesting. Therefore, in this work, we developed a stable ethosomal system capable of incorporating selected drugs with different physicochemical properties (hydrophilic vs. lipophilic, larger vs. smaller molecule). In order to increase the efficiency, we combined this system with transdermal permeation enhancer, which will further promote the penetration of lipophilic drugs through the skin. The efficacy of the nanoformulation was tested by *in vitro* permeation experiments on porcine skin.

### Biography:

Kristýna Dvořáková is a PhD candidate at Laboratory of dermal and transdermal drug delivery at University of Chemistry and Technology Prague studying in Drugs and Biomaterials programme. She focuses on skin barrier characterization and her topics also include the study of molecules as permeation enhancers for topical application, regarding the mechanism influencing skin barrier properties. She has experience in the design and optimization of topically applied nanoformulations and transdermal patches. She currently studies the combination of enhancers with different nanoparticle systems to support their effectivity with the idea of subsequent use in transdermal patches.

## Innovative Cerosomes as Carriers for an Enhanced Dermatoses' Therapy

Aneta Vovesna-Kalvodova<sup>1\*</sup>, Tereza Muzikova, Jarmila Zbytovska<sup>2</sup>

<sup>1</sup>University of Chemistry and Technology Prague, Czech Republic

<sup>2</sup>Faculty of Chemical Technology, Department of Organic Technology, Technická 5, 166 28 Prague, Czech Republic

### Abstract:

Dermatoses are skin diseases caused by lowered level of lipids in the intercellular lipid matrix of skin's uppermost layer stratum corneum. A promising therapy for such cases is the application of liposomally formulated skin lipids (ceramides, cholesterol, fatty acids) that replenish the lipids lost due to the skin condition. These so called cerosomes proved very effective in disrupted skin barrier repair; however, they aim primarily on a mechanical surface restoration. For this reason, an interesting idea is to combine the application of cerosomes and anti-inflammatory drugs (such as hydrocortisone and its derivatives) used for the treatment of pathophysiological processes of the skin diseases. Unfortunately, liposomes generally show low drug encapsulation rates, hence they would not be very effective carriers. On the other hand, great encapsulation effectivity and drug load can be found in another formulation - lipid nanocapsules (LNCs). We therefore aimed to create a combined nanosystem cerosomes-LNCs that would ensure the skin barrier restoration thanks to the ceramides and simultaneously effectively deliver hydrocortisone as a representative of anti-inflammatory drugs into lower layers of the skin. In this work, we characterized the prepared formulations by dynamic light scattering and transmission electron microscopy to assess the size and morphology of the prepared particles. The encapsulation rates for hydrocortisone and its derivatives were measured and ultimately, the efficacy of our formulation in skin repair and drug delivery was studied in vitro.

### Biography:

Aneta Vovesna-Kalvodova is a PhD student at University of Chemistry and Technology in Prague. She is part of a Laboratory of dermal and transdermal drug delivery led by assoc. prof. Jarmila Zbytovská. Aneta's field of research is skin barrier function, its changes by skin diseases and ways to treat and restore skin's protective function. Aneta focuses on formulations containing skin lipids in order to create an effective treatment for disrupted skin barrier. Another field she works on is development of tailored nanocarriers for various APIs for their enhanced topical application.

## Evaluation of Direct Grafting Strategies in Expansion Microscopy

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<sup>1</sup>Department of Chemistry, KU Leuven, Leuven, 3001, Belgium

<sup>2</sup>Chrometra, Kortenaak 3470, Belgium

<sup>3</sup>Max Planck Institute for Polymer Research, 55128 Mainz, Germany

### Abstract:

Expansion microscopy (ExM), a relatively new super-resolution imaging method, enables visualization of biological targets at nanoscale resolution on diffraction limited microscopes. Since its invention in 2015, ExM has aroused a tremendous attention and various ExM variants have been developed to simplify its usage or increase the imaging resolution. However, in commonly used biomolecule-grafting methods, ExM is limited to some biomolecules, such as proteins and nucleic acids. In addition, fluorescence loss is inevitable during radical-induced polymerization and digestion due to the incomplete anchoring of fluorescent labels. To solve these limitations, we design and synthesize novel multifunctional molecules (known as TRITON), allowing direct grafting of labels to the polymer matrix in ExM.

By applying our TRITON, the first example of lipid membrane and actin filament staining is demonstrated in ExM. Our TRITON linkers are compatible with different labeling strategies, e.g., a direct conjugation of biomolecules with dyes or a post-digestion labeling strategy using a click reaction. With the optimized conditions, we validate and demonstrate that our labeling strategies are compatible with different ExM modalities, e.g.,  $\times 4$  and  $\times 10$  ExM. Furthermore, through covalent grafting of oligonucleotides to the hydrogel, we also show the post-labeling strategy, in which fluorescence signal is introduced via hybridization of readout probes after expansion, making it possible to perform multiplexed imaging in ExM.

### Biography:

Gang Wen obtained his M.Sc. degree in Medicinal Chemistry at Peking Union Medical University, Tsinghua University in 2018. Now he is pursuing his Ph.D. degree under the supervision of Prof. Johan Hofkens at KU Leuven. He focuses on chemical probe synthesis and method development in biological imaging using expansion microscopy.

## Metasurface Bandpass Filter Array for Visible and Near-infrared Spectral Imaging

Yeonsang Park<sup>1,2\*</sup>, Jae-soong Lee<sup>3</sup>, Hyochul Kim<sup>3</sup>, and Young-Geun Roh<sup>3</sup>

<sup>1</sup>Chungnam National University, Korea

<sup>2</sup>Institute of Quantum Systems, Korea

<sup>3</sup>Samsung Advanced Institute of Technology, Korea

### Abstract:

We proposed and demonstrated a metasurface bandpass filter array for spectral imaging in the visible and near-infrared range. The narrow bandpass filter was made by sandwiching a single TiO<sub>2</sub> layer between two distributed Bragg reflectors (DBRs) composed of a SiO<sub>2</sub> and a TiO<sub>2</sub> layer. We could change the central wavelength of transmission by patterning the central TiO<sub>2</sub> layer into nanostructures called as metasurfaces. Owing to the large refractive index contrast between the SiO<sub>2</sub> and TiO<sub>2</sub> materials constituting metasurfaces, we could change the transmission peak wavelength of the metasurface bandpass filter by about 200 nm bandwidth, which corresponds to the range from 500 nm to 700 nm. The proposed metasurface filter array has the advantage of easy fabrication because it does not require multiple depositions to change the central wavelength. Therefore, it is expected that this filter array will be integrated with CMOS image sensors naturally, and the meta-spectral image sensor will be fabricated by integrating the metasurface bandpass filter array directly on the top of the CMOS image sensor. As a result, the meta-spectral image sensor will be introduced into mobile devices in the future, creating new and diverse applications.

### Biography:

Yeonsang Park received his B.S.(1996) degree in Astronomy, M.S.(2001), and Ph.D.(2007) degrees in Physics at Seoul National University. From 2007 to 2009, he was a Postdoctoral Researcher in Institut des Nanotechnologies de Lyon (INL, CNRS 5270), France. In 2010, he joined Samsung Advanced Institute of Technology (SAIT) and worked as a researcher with projects on metasurface and their application to photonic devices. Since 2020, he has been an Associate Professor in Physics at Chungnam National University (CNU), Korea. His current research is focused on developing novel nanophotonic devices based on fundamental physics and nanofabrication technology and their applications.

## Nonvolatile Control of Physical Properties in Correlated Oxides by Electric Field

Ming Zheng

*China University of Mining and Technology, China*

### Abstract:

Correlated electronic oxides have received continuing attention because of various striking discoveries, typified by the occurrence of colossal magnetoresistance effect, high-temperature superconductivity, multiferroicity, exchange bias, vertical hysteretic shift, topologically anomalous Hall effect, etc. Tuning the physical properties of these correlated oxides by an external perturbation, such as a magnetic field, electric field, light illumination, or stress field, enables the investigation of exotic quantum and topological states, and the development of low-energy dissipation electronic and spintronic devices. In this work, we demonstrate the multi-field control of physical properties for perovskite complex oxide (e.g.,  $\text{Nd}_{0.5}\text{Sr}_{0.5}\text{MnO}_3$ ,  $\text{LaVO}_3$ ,  $\text{SrVO}_3$ ) thin films deposited onto ferroelectric  $0.7\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3$ - $0.3\text{PbTiO}_3$  single-crystal substrates. Using the piezoelectric response of the substrate, the quantitative determination of the resistance change and the lateral strain of the film can be obtained. Multiple nonvolatile and reversible resistance evolution can be realized by adjusting the magnitude of ferroelastic strain. These findings demonstrate that lattice strain and physical properties of functional thin films epitaxially grown on PMN-PT substrates can be in situ, in real time, dynamically and continuously modulated via ferroelectric poling, converse piezoelectric effect, polarization rotation, and ferroelastic effect. This method can be further extended to study the intrinsic strain effects of other functional thin films. Moreover, we also found that the strain-excited effect and photo-generated (or magnetic field-generated) effect strongly correlated with each other, which is mediated by the lattice-charge-orbital coupling. Our work points to an effective strategy for realizing the coupled straintronic-optoelectronic effect in hybrid correlated oxide/ferroelectric systems and delivering multi-field tunable low-dissipation versatile electronic and photonic devices.

### Biography:

Prof. Ming Zheng obtained his PhD degree from Shanghai Institute of Ceramics, Chinese Academy of Sciences in 2015. He was awarded JSPS Fellowship in 2018. In 2021, he was honored with IAAM Young Scientist Medal in recognition for his contribution to “Hybrid Electronic, Magnetic & Optical Materials”. In 2022, he was honored with VEBLEO Fellow. His current research interests include functional (multiferroic, ferroelectric, magnetic and luminescent) thin-film materials and device physics. He has authored or co-authored more than 40 papers published in international reputed journals including NPG Asia Mater. (2), Adv. Mater., Adv. Funct. Mater., Nano Energy, Appl. Phys. Lett. (9), Phys. Rev. Applied (3).

## Metrology of Bimodal Gaussian Sample of Cylindrical Nanoparticles Using Translationalrotational Ultrafast Image-based Dynamic Light Scattering

**Paul Briard**

*Xidian University, China*

### **Abstract:**

In a translational-rotational ultrafast image-based dynamic light scattering (TR-UIDLS) experiment, nanoparticles in Brownian motion in a solvent are illuminated by a focused Gaussian beam and scatter the light toward a polarization camera, which records two polarization geometries: vertical-vertical (VV) and vertical-horizontal (VH). The incident laser beam is vertically polarized in respect to the scattering plane, and the pixels of the camera record the horizontal and the vertical electric field components of the scattered light. The cross-correlation coefficients between pairs of pictures recorded in VV and VH geometries permit to determine a distribution of equivalent cylindrical particles, which are the mono-disperse cylindrical particles that scatter the same light fluctuations as the polydisperse particles in the measurement volume. A previous work has permitted to show that the scatter plot of the cross-correlation coefficients in VV and VH polarization geometries has the potential to determine the average lengths and diameters of each Gaussian mode in the sample, assuming the cylindrical particles have a bimodal Gaussian distribution (for both length and diameter). However, this method cannot be used if the VV and VH polarization geometries are not recorded at the same time. Our next efforts are then focused in the measurement of information about a bimodal Gaussian distribution in a sample, in a TR-UIDLS experiment where the VV and VH polarization geometries are recorded at different times, using a conventional ultrafast camera instead of a polarization camera. To reach this purpose, the distribution of characteristic relaxation decays measured from the cross-correlation coefficients recorded by the camera have been investigated, using numerical simulations of the TR-UIDLS experiment.

### **Biography:**

Paul Briard is assistant professor at Xidian university since 2018. His major research interests are the numerical simulation of the light scattering by particles illuminated by a laser beam and how to measure information about particles size and shape by analyzing their light scattering. He focuses his actual efforts on the measurement of size and shape of nanoparticles, using methods derived from conventional dynamic light scattering.

## On the Tunable Hysteresis Loop and Oscillations of Magnetization in Weakly Disordered Antiferromagnetic–ferromagnetic Bilayers

Svetislav Mijatović<sup>1,\*</sup>, Stefan Graovac<sup>1</sup>, Djordje Spasojević<sup>1</sup>, Bosiljka Tadić<sup>2,3</sup>

<sup>1</sup> Faculty of Physics, University of Belgrade, POB 44, 11001 Belgrade, Serbia

<sup>2</sup> Department for Theoretical Physics, Jožef Stefan Institute, POB 3000, SI-1001, Ljubljana, Slovenia

<sup>3</sup> Complexity Science Hub, Vienna, Austria

### Abstract:

We present a study of tunable hysteresis loop and multifractal oscillations of magnetization observed in simulations of the field-driven Ising spin reversal dynamics in weakly disordered antiferromagnetic–ferromagnetic bilayers of varied thicknesses. The hysteresis loop of such heterostructures exhibits the fractional-magnetization plateaus, whose number, height, and width of the central loop, and the structure of side sub-loops, depend on the system parameters. Concomitantly, the coercive field values, which are dominantly determined by the interlayer coupling, are modified by the magnetic disorder, the thickness of the ferromagnetic layer, and the system size in agreement with the proposed theoretical prediction. The magnetization fluctuations, modulated with peaks at the transitions between successive plateaus, reflect the interplay of antiferromagnetic sublattices and disorder caused by the presence of the active groups of spins with different levels of (anti)ferromagnetic couplings. The foregoing findings should be relevant not only to Ising spin systems but also to other antiferromagnetic materials with complex morphology like the novel low-dimensional memory and spintronic materials<sup>1</sup>.

### Biography:

Dr. Svetislav Mijatović works as an assistant professor at the Faculty of Physics, University of Belgrade. He graduated in 2013, finished his master's studies in 2014, and Ph.D. studies in 2019, all at the Faculty of Physics, University of Belgrade, Serbia. The main objective of his research is the theoretical and numerical investigation of the physics of nonequilibrium systems. Besides Physics, he attended studies in Quantitative Finance and worked in 2014/2015 as a quantitative analyst in an oil and gas company MOL, Hungary.



## Ultrahigh Energy Storage Density of $(\text{Bi}_{0.5}\text{Na}_{0.5})_{0.65}\text{Sr}_{0.35}\text{TiO}_3$ -based Lead-free Relaxor Ceramics with Excellent Temperature Stability

Xiaojie Lou<sup>\*1</sup>, Xiaopei Zhu<sup>1</sup>, Yangfei Gao<sup>1</sup>, Peng Shi<sup>1</sup>, Ruirui Kang<sup>1</sup>, Fang Kang<sup>1</sup>, Wenjing Qiao<sup>1</sup>, Jinyan Zhao<sup>2</sup>, Zhe Wang<sup>2</sup>, and Ye Yuan<sup>1</sup>

<sup>1</sup>Frontier Institute of Science and Technology, State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, Xi'an 710049, China

<sup>2</sup>Electronic Materials Research Laboratory, Key Laboratory of the Ministry of Education & International Center for Dielectric Research, Xi'an Jiaotong University, Xi'an 710049, China

### Abstract:

High-performance dielectric ceramic capacitors are a promising technology for addressing the energy crisis and reducing environmental pollution. However, the low energy storage density severely limits their further development. Herein, an ultrahigh recoverable energy density ( $W_{rec}$ ) of  $8.46 \text{ J/cm}^3$  with excellent efficiency of 85.9% under  $522 \text{ kV/cm}$  is obtained in  $0.90(\text{Bi}_{0.5}\text{Na}_{0.5})_{0.65}\text{Sr}_{0.35}\text{TiO}_3$ - $0.10\text{Bi}(\text{Mg}_{0.5}\text{Zr}_{0.5})\text{O}_3$  ceramic by the synergistic effect of delayed polarization saturation and an improved breakdown field ( $E_b$ ). The addition of  $\text{Bi}(\text{Mg}_{0.5}\text{Zr}_{0.5})\text{O}_3$  creates a quenched random field, which increases the number of high dynamic polar nanodomains. This inhibits the formation of long-range polar order and suppresses early polarization saturation. Additionally, the refined grains and compact structure lower the concentration of oxygen vacancies and increase the activation energy, leading to a higher  $E_b$ . Furthermore, the ceramic with  $x = 0.10$  also exhibits impressive thermal stability in the range of  $0$ - $200 \text{ }^\circ\text{C}$ . The  $W_{rec}$  value is  $4.74 \text{ J/cm}^3$  at  $200 \text{ }^\circ\text{C}$ , and the variation is only around 12.4%. This is due to the stable local structure and temperature-insensitive dielectric constant. Our research demonstrates that  $0.90(\text{Bi}_{0.5}\text{Na}_{0.5})_{0.65}\text{Sr}_{0.35}\text{TiO}_3$ - $0.10\text{Bi}(\text{Mg}_{0.5}\text{Zr}_{0.5})\text{O}_3$  is a promising material for next-generation energy storage applications and high temperature dielectric ceramic capacitors.

### Biography:

Prof Xiaojie Lou is the director of the Center for Advanced Electronics at Xi'an Jiaotong University, the research of his group focuses on ferroelectric and piezoelectric materials and devices. After graduating from the University of Cambridge in 2007, he was selected as a Lee Kuan Yew Postdoctoral Fellow in Singapore. To date, he has published over 190 papers in renowned journals such as Phys Rev Lett, Adv Mater, Adv Fun Mater, Nano Lett, Phy Rev B, Appl Phys Lett, Acta Mater; his work has been cited over 7000 times.

## Dispersant-free Colloidal Dispersion of Single-walled Carbon Nanotubes for and its Electrochemical Applications

Joong Tark Han<sup>\*,1,2</sup>

<sup>1</sup>Nano Hybrid Technology Research Center, Electrical Materials Research Division, Korea Electrotechnology Research Institute, South Korea

<sup>2</sup>Department of Electro-Functionality Materials, University of Science and Technology, South Korea

### Abstract:

Surface functionalization of carbon materials such as carbon nanotubes (CNTs) and graphene nanosheets facilitates their dispersion in solution, without using a dispersant, by overcoming the van der Waals interactions between the nanoscale carbon materials. In particular, single-walled CNTs (SWCNTs) tend to be shortened and damaged under harsh oxidation conditions because their curved surfaces have higher reactivity than the graphene basal plane. In this talk, we present the rational oxidation method of SWCNTs via acid treatment by minimizing defect formation on the surface. Importantly, the structure of the oxidized SWCNTs (Ox-SWCNTs) could be recovered by chemical, thermal, photothermal, or solvothermal reduction, enhancing the electrical conductivity of the Ox-SWCNT films from  $\sim 100$  to  $\sim 1000 \text{ S cm}^{-1}$ . The electrical conductivity, Raman analysis, and XPS data all demonstrate the structural recovery of highly oxidized SWCNTs without compromising their electrical or electrochemical performances. Our results demonstrate that remarkable electrical or electrochemical performances were obtained after deposition of SWCNT inks or pastes that were dispersed in water and various organic solvents (without additional dispersant). Supercapacitors and LIB cathode electrodes using Ox-SWCNTs and reduced Ox-SWCNTs showed high electrochemical performances compared to those employing pristine SWCNTs. The high solution dispersibility and structural recovery of oxidized carbon materials are expected to facilitate their application as electrical or electrochemical components in next-generation devices.

### Biography:

Joong Tark Han received his Ph.D. in Chemical Engineering from Pohang University of Science and Technology (POSTECH) in 2005. He is currently a principal researcher in the Nano-Hybrid Technology Research center at Korea Electrotechnology Research Institute (KERI). His research interests are in exploring nanostructures and electronic structures of electrical nano-materials such as nanocarbon materials (carbon nanotube, graphene, etc.), nano-metal, metal oxide nanoparticles, for future smart electric devices.

### Complex-amplitude Hologram by Dielectric Metasurface

Qiang Jiang<sup>\*a</sup>, Liangcai Cao<sup>b</sup>, Lingling Huang<sup>a</sup>, Zehao He<sup>b</sup> and Guofan Jin<sup>b</sup>

<sup>a</sup>School of Optics and Photonics, Beijing Institute of Technology, Beijing 100081, China

<sup>b</sup>State Key Laboratory of Precision Measurement Technology and Instruments, Department of Precision Instruments, Tsinghua University, Beijing 10084, China

#### Abstract:

Metasurfaces have been widely studied for arbitrary manipulation of the amplitude, phase and polarization of a field at the subwavelength scale. Holographic images with high resolution and large viewing angle can be reconstructed from phase-only holograms encoded in metasurface. The quality of a holographic image can be greatly improved when using complex-amplitude holograms. However, realizing a high efficiency metasurface with simultaneous and independent control of the amplitude and phase remains a great challenge. In this work, an ultrathin dielectric metasurface which can modulate complex amplitude in transmission mode is proposed for metasurface hologram. The amplitude is controlled by adjusting the dipoles and quadrupoles by tuning the geometric size. The phase value from 0 to  $2\pi$  is manipulated based on the Pancharatnam–Berry phase (also called geometric phase) by rotating the meta-atom. The experimental results show that a three-dimensional image reconstructed from a complex-amplitude hologram presents better quality than that from a phase-only hologram. The proposed metasurface shows great potential for applications that require complex amplitude modulation.

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**Exchange Coupled Magnetic Nano-heterostructures with Enhanced Energy Product**

**Claudio Sangregorio**

*CNR-ISTM, Italy*

## In-situ Nanofluid Dispersion Monitoring by Liquid-Solid Triboelectric Nanogenerator Based on Tuning the Structure of the Electric Double Layer

Hao Luo<sup>1\*</sup>, Hanqing Wang<sup>1</sup>, Lijun Yang<sup>1</sup>, Jiyu Wang<sup>1</sup>

<sup>1</sup>State Key Laboratory of Power Transmission Equipment and System Security and New Technology, Chongqing University, China

### Abstract:

Agglomeration phenomenon characterized by the nanoparticle dispersion is a decisive factor that reflects the degree of the maintained overall performance of nanofluids and other nanocomposites. However, quantitative and non-destructive measurements of nanofluid dispersion are still stagnant. Herein, an in-situ nanofluid dispersion measurement system based on a variable frequency liquid-solid triboelectric nanogenerator (VFLS-TENG) has been developed. This work proposes an equivalent capacitive circuit model to characterize the nanofluid dispersion utilizing the VFLS-TENG as a detection device, which is supported by the liquid-solid interface electrical double layer theory. In the circuit model, quantitative calculation of nanoparticle size and spacing was achieved by quantum genetic and Levenberg-Marquardt hybrid algorithm (QLHA) and Runge-Kutta algorithm (RKA). The results obtained from the calculations are in good agreement with existing methods. Referring to the statistical results of scanning electron microscopy (SEM), the calculated equivalent capacitive particle size is 28.6% more accurate than the hydrodynamic diameter of dynamic light scattering (DLS), with a sensitivity of up to 1667 nm/nF. This work is possible to measure the effective charge on the nanoparticle surface in situ and obtain both particle size and spacing for online monitoring of nanofluid dispersion, which further facilitates the controlled preparation of nanocomposite modification processes and the quantitative optimization of nanofluid design properties under multi-physics fields.

### Biography:

Hao Luo is currently a PhD candidate at Chongqing University. His interests include energy harvesting and sensing application of liquid-solid Triboelectric Nanogenerator. He has published 3 peer-reviewed journal and conference papers, and 4 Chinese patents as a header. In addition, as a chief researcher, he participated in the science and technology projects of China Southern Power Grid and the national Key R&D Plan.

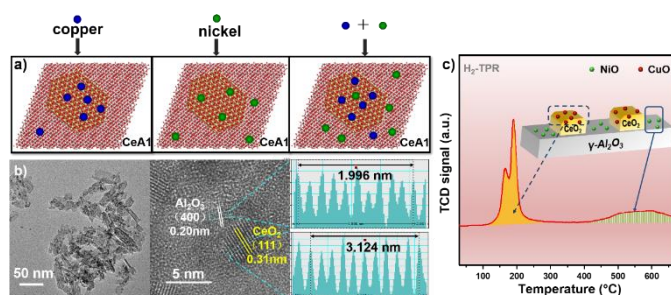
## Selectively Supported Catalysts of Copper and Nickel on Hybrid Ceria-Alumina Nanoparticles

Gu Rongtian, Ding Weiping  
NanJing University, China

### Abstract:

Precise regulation of each component in complex catalysts is the key to improve their catalytic performance <sup>[1,2]</sup>. Herein we present a model catalyst of regioselective distribution of Cu and Ni on hybrid ceria-alumina nanosupport.

We found that the intimate inhomogeneity among loaded species and supports can be used to prepare catalysts with selective spatial distribution, thus enabling the precise introduction of complex components. As shown in Figure 1, CeO<sub>2</sub> particles with a particle size of ~5 nm was uniformly mixed with  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> nanotubes with a length of 10-100+ nm. The spontaneous distribution of nickel and copper species on the hybrid CeO<sub>2</sub>- $\gamma$ -Al<sub>2</sub>O<sub>3</sub> (denoted as CeAl) nanosupport can be determined as: (i) the tendency of copper species impregnated independently on CeAl to prefer ceria over alumina surfaces, (ii) independent nickel species showed no selective tendency for both oxides in CeAl, and (iii) when nickel and copper species are co-impregnated on hybrid CeAl nanosupport, copper mainly distributed on ceria, and nickel distributed on alumina. The H<sub>2</sub>-TPR test provides a good characterization of this distribution: the Ni-Cu/CeAl catalyst only shows distinct two groups peaks, which could be attributed to the copper species interacting with CeO<sub>2</sub> and the nickel species interacting with  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>, respectively.



**Figure 1** Catalysts with selectively spatial distributed of copper and/or nickel species on the hybrid CeO<sub>2</sub>- $\gamma$ -Al<sub>2</sub>O<sub>3</sub> support: (a) schematic diagram, where the blue balls represent copper species and the green balls represent nickel species; (b) morphology, HRTEM image and fringe grayscale distribution maps; (c) H<sub>2</sub>-TPR curves. (CeAl means 30 wt.% CeO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub>{111}.)

This strategy of synthesizing spatially selective distributed catalysts based on intimate inhomogeneity between different components will be further applied to the design of efficient catalysts involving abundant components and specific sites and provide new directions for the study of synergistic interactions between multiple components.

### Biography:

Gu Rongtian, a PhD candidate at the School of Chemistry and Chemical Engineering in Nanjing University (NJU), China. Her areas of interests include precise control of catalysts structure and improvement of catalyst performance.

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**Modeling of the Multi-layered Nanoparticles as Nano-sources of Heat for Photothermal Therapy**

**Joshua Fernandes**

*Dong-A University, South Korea*

## Preparation and Antibacterial Properties of Nano-zinc Oxide Particles/ $\epsilon$ -polylysine Containing PETG Foils

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### Abstract:

**Objectives:** Orthodontic treatment requires retention and a maintenance phase to prevent teeth from returning to pretreatment positions. Nowadays, the most commonly used retention devices are clear thermoplastic retainers made from polyethylene terephthalate glycol (PETG). However, orthodontic retainers frequently cause gingivitis, periodontitis and increase the risk of carious lesions because of surrounding plaque accumulation. In order to effectively clear bacterial biofilm, we constructed a PETG foil loaded with nano-ZnO particles and  $\epsilon$ -polylysine ( $\epsilon$ -PLL) with sustained release properties for long-term controlled biofilm development.

**Methods:** The nano-ZnO particles and  $\epsilon$ -polylysine were layer-by-layer assembled on the surface of PETG foils under the protection of inert gas. The morphology of nanoparticles were characterized by scanning electron microscopy and X-ray photoelectron spectroscopy (XPS). Chemical interactions and stabilities of the nano-ZnO/ $\epsilon$ -polylysine/PETG foils were determined using an FTIR spectrometer. In order to verify the activity of control biofilm development in the oral environment, the mechanical properties, antibacterial effects and ion sustained release properties were tested in an artificial saliva environment.

**Results:** The results indicated that nano-ZnO particles/  $\epsilon$ -PLL PETG exhibited good mechanical properties, chemical stability and biocompatibility. The material showed strong anti-biofilm activity against *Streptococcus mutans* and *Porphyromonas Gingivalis*. It also continuously releases nano-zinc ions function and continues to inhibit the development of plaque biofilm.

**Conclusions:** The layer-by-layer assembly of nano-zinc oxide and  $\epsilon$ -polylysine PETG material improves the existing transparent orthodontic retainers. Provides a new idea and experimental support for the application of nanoparticle antibacterial and ion sustained release in the maintenance phase after orthodontic treatment.



## Synthesis of Ceramide-coated Gold Nanoparticles to Study Skin Barrier Arrangement

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### Abstract:

Ceramides (Cer) are essential for the correct skin barrier function. They are one of the main components of *stratum corneum* (SC) extracellular matrix where they make up around half of the lipids by weight. Apart from free lipids, Cer is also covalently anchored to the surface of corneocytes forming a corneocyte lipid envelope, a structure required for proper arrangement of free lipids in SC. In this study, we synthesized a thiol-terminated Cer which was attached to gold nanoparticles (GNPs) to mimic the corneocyte lipid envelope in SC. The resulting coated GNPs were purified and characterized by UV-visible spectroscopy, and dynamic light scattering.

Modified Cer was prepared by an attachment of a 3-sulfanylpropionic acid linker to their  $\omega$ -hydroxyl group followed by self-assembly with GNPs in different ratios. Modified GNPs showed a high level of particle size uniformity, and the Cer attachment prevented an aggregation. The UV-Vis spectra showed a peak around 570 nm which is in good agreement with the size result and confirmed the attachment of Cer to GNPs. In the future, Cer-coated GNPs will be used in model lipid membranes as a scaffold for the orientation and arrangement of free lipids and to study the effect of GNPs on the lipid matrix nanostructure and permeability. The importance of this study is to shed more light on lipid organization in SC and to improve current models used for SC investigation.

## A New Early Diagnostic Method for Pancreatic Cancer by Nano Sensing through Surface Enhanced Raman Spectroscopy (SERS)

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### Abstract:

Pancreatic Cancer is one of the deadliest forms of cancer and is projected to become the second leading cause of cancer deaths, mainly attributed to late diagnosis. Surgical resection remains the only plausible form of treatment for curing patients of this cancer. However, this is only possible when the cancer is localized making early detection vital. The most common early diagnostic method is the tri-phasic pancreatic-protocol CT scan. This method however has a low accuracy and specificity making it an ineffective early diagnostic tool. The aim of this study was to develop a non-invasive, fast and highly sensitive early diagnostic method for pancreatic cancer through the applications of nanotechnology. This project uses Leucine as a biomarker due to recent studies that have linked its overexpression with pancreatic cancer diagnosis. Studies have found a specificity of 100% with the use of Leucine and early diagnosis 2 to 5 years earlier than current diagnostic methods for pancreatic cancer. Surface Enhanced Raman Spectroscopy (SERS) is innovatively applied as an early diagnostic tool for detecting trace concentrations of Leucine as it's a highly specific and accurate analytical method. The parameters for SERS enhancement were optimized for the detection of Leucine using 20 nm Ag NPs. Predictive curves with linear fits were generated from an analysis of feature peaks giving the highest sensitivity for trace concentrations. This research study shows the promising development of an early diagnostic method that is non-invasive, efficient and highly accurate for pancreatic cancer.

### Acknowledgements:

We are so grateful to the Center for Nanoscale Systems at Harvard University for the SERS characterizations. This project was supported by the scholarship of Future Scholarship from AARD.

**Keywords:** Pancreatic cancer, SERS, Nanotechnology, Leucine, Early Diagnosis

## A Potentially Early Diagnosis of Bronchial Asthma by SERS Nano Detection

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### Abstract:

Bronchial Asthma, or simply asthma, is a chronic disease that affects the airways in the lungs. Every year, it possibly affects more than 350 million people worldwide, and can last for years or be lifelong, requiring ongoing medical attention and limiting daily activities. Common asthma detection methods include spirometry, peak flow test, and FeNO test. Both spirometry and peak flow tests are based on measurement and observation, while FeNo tests measure the level of nitric oxide, a sign of inflammation, in the breath. In this primary student, we aimed to develop a fast, non-invasive, and sensitive method for detecting bronchial asthma at an early stage. We used Interleukin-8(IL-8) as a biomarker as it signals inflammation. Surface Enhanced Raman Spectroscopy (SERS) was used as the nano detection method with gold nanoparticles' enhancements for the feature peaks of IL-8. The SERS is an ultra-sensitive analytical technique for biomolecular detection. A Horiba Raman Spectrometer Confocal Raman Microscope was used to collect all samples' Raman Spectra. Our finding is that the feature peak of IL-8 protein can be seen at its concentration goes as low as 10ng/L. This study shows a potential for the development of a rapid, non-invasive nano method for the early detection of bronchial asthma from a patient's saliva.

### Acknowledgements:

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**Keywords:** Asthma, Surface-Enhanced Raman Spectroscopy, Interleukin-8(IL-8), Gold Nanoparticles, Nano Detection.