Seminar

Prof Bohuslav Rezek

Faculty of Electronic Engineering, Czech Technical University in Prague, Czechia

Diamond molecular interfaces for solar energy conversion

Tuesday, 25 February 2025, h. 11.00

Wataghin Room, Physics department, via Pietro Giuria 1, Torino

Abstract:

Modern concept and devices for energy conversion including photovoltaic solar cells continue to explore the idea of using molecules, polymers and nanomaterials in key parts of such systems. There are several reasons for this: shorter time to return the energy used for device fabrication, lower production and deployment costs, principally better power output under low-light or diffuse light conditions such as in hazy weather, building integration or indoor applications, and last but not least material and energy independence of Europe. In spite of many advances in the past decades, the technology still need improvements in terms of efficiency, materials cost, and long-term stability for scaling up its production and practical applications. In all these aspects, diamond-based hybrid systems may have an immense potential, which is still mostly underexplored. Diamond as technological material is abundant, inexpensive and non-toxic. Our long term research shows that diamonds can advantageously act as more stable inorganic electron acceptors, light trapping enhancers, interface for more efficient charge separation, transparent electrodes for charge transport, and more. A nanocomposite fabrication technology with polypyrrole (PPy) and nanodiamond (ND) is presented. The formation, pronounced material interaction, and photovoltaic properties of ND-PPy composites are characterized down to nanoscale by atomic force microscopy, optical spectroscopies, Kelvin probe, and electronic transport measurements. NDs with different surface terminations (hydrogenated, oxidized, poly-functional) assemble PPy oligomers in different ways, leading to different optoelectronic properties. Infrared spectroscopy shows a tight nanoscale interaction between ND and PPy in the composites, which explains enhanced optical absorption and more efficient charge generation. Combination of both oxygen and hydrogen functional groups on the nanodiamond surface appears to be the most favorable. Photovoltage shows that NDs act as electron acceptors. Theoretical calculations of the structure and electronic properties show HOMO-LUMO separation in the ND-PPy complex and elucidate mechanism of exciton dissociation. Somewhat counterintuitively, hydrogenated NDs also work best as electron transporting layers instead of ZnO or SnO when combined with polymer solar cells. Analysis of energetic levels of hydrogenated NDs of various origin and their conductivity helps understand these effects.

References

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Biography

Bohuslav Rezek is a professor of Applied physics and the head of Physics dept. at the Faculty of Electrical Engineering of the Czech Technical University in Prague.

He graduated from Physics at the Faculty of Mathematics and Physics at the Charles University in Prague in 1996 and he continued at the Czech Academy of Sciences (CAS) in the group of Dr. Jan Kočka with PhD study on charge transport in amorphous and microcrystalline silicon with high lateral resolution by using scanning probe techniques. During his PhD he also had several research stays in the group of Prof. Martin Stutzmann at the Walter Schottky Institute, Technical University Munich. There he worked with Dr. Christoph Nebel on development of large grain silicon thin films using interference laser crystallization of amorphous silicon layers and on their investigation by laser beam induced currents with a sub-micrometer lateral resolution, with a special view to optical and electronic properties of grain boundaries.

After receiving PhD degree in 2001, he continued in the group of Prof. Stutzmann as a postdoctoral researcher on the project for diamond devices and sensors where he focused on a study and modification of hydrogen terminated diamond surfaces and their electrolytic interfaces. In 2002 he joined the Nanotechnology Group at the Swiss Federal Institute of Technology, where he worked on guided assembly of colloidal nanoparticles at solid state surfaces. Since 2004 he worked at the Diamond Research Center of AIST in Tsukuba, Japan, doing research on surface (bio)-functionalized diamond devices.

In 2006 he became research group leader and Purkyně Fellow at the Institute of Physics CAS in Prague, Czech Republic. In 2013 he habilitated in the field of Applied physics. Since 2015 he became also a head of Physics dept. at the Faculty of Electrical Engineering of the Czech Technical University in Prague. In 2019 he became full professor there. Among other duties he chairs the doctoral study program of Applied Physics and governmental evaluation panel of Natural Sciences.

His research team is focused on nano-interfaces of semiconductors and organic materials towards opto-electronic and bio-electronic applications. His main interests lie in characterization and modification of material, electronic, and chemical properties by local probe techniques as well as in assembly of organic and inorganic nanostructures. Experimental studies are complemented by simulations on atomic and molecular scale.

He is the author or co-author of over 200 scientific articles in international peer-reviewed journals that were cited more than 4000 times as well as of book chapters (10) and patents applications (6). More details can be found at https://scholar.google.cz/citations?user=mb1IXcUAAAAJ.

Seminar

Prof Silvia Giordani

School of Chemical Sciences, Dublin City University, Dublin, Ireland

Carbon nano-onions for targeted drug delivery

Tuesday, 26 February 2025, h. 10.00

Wataghin Room, Physics department, via Pietro Giuria 1, Torino

Abstract:

In this presentation, carbon nano-onions (CNOs) will be discussed as a potential vesicle for nanocarrier-type drug delivery systems.1 CNOs, or multi-layer fullerenes, consist of multiple concentric layers of sp2 hybridized carbon and are emerging as platforms for biomedical applications because of their ability to be internalized by cells and low toxicity.2 In my research group we have developed methodology for the synthesis of pure, monodispersed CNOs and various chemical functionalization strategies for the introduction of different functionalities (receptor targeting unit and imaging unit) onto the surface of the CNOs. The modified CNOs display high brightness and photostability in aqueous solutions and are selectively taken up by different cancer cell lines without significant cytotoxicity. Supramolecular functionalization with biocompatible polymers is an effective strategy to develop engineered drug carriers for targeted delivery applications. Non-covalently functionalized CNOs with hyaluronic acid-phospholipid (HA-DMPE) conjugate show excellent in vitro cell viability in human breast carcinoma cells overexpressing CD44 and are uptaken to a greater extent compared to human ovarian carcinoma cells with an undetectable amount of CD44. In addition, they possess high in vivo biocompatibility in zebrafish during the different stages of development.3 We have successfully loaded the CNO-based nanocarrier with chemotherapeutic prodrugs derived from gemcitabine, and showed remarkable efficacy in killing pancreatic ductal adenocarcinoma (PDAC) cells, which are typically resistant to gemcitabine.4 These findings highlight the potential of CNOs as a promising scaffold for advanced targeted drug delivery systems and underscore their translational potential in cancer therapy as they have shown capacity in improving PDAC outcomes over conventional therapy.

References

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3. d'Amora M. et al. Colloids and Surfaces B: Biointerfaces 2020, 110779.
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Biography

Silvia Giordani is full Professor Chair of Nanomaterials at the School of Chemical Sciences at Dublin City University (DCU) since 2018 and she acted as Head of School from 2020 to 2023.

Previously she received a PhD in Chemistry from the University of Miami, USA and carried out postdoctoral research at Trinity College Dublin (TCD), Ireland and at the University of Trieste, Italy. In 2007 she received the prestigious President of Ireland Young Researcher Award and was a Research Assistant Professor at TCD from 2007 to 2013. In September 2013 she founded the new "Nano Carbon Materials" research lab at the Istituto Italiano di Tecnologia (IIT) and in December 2016 she was appointed Associate Professor in Organic Chemistry at the University of Turin, Italy.

Her main research interests are in the design, synthesis, and characterization of a wide range of nanomaterials for applications in smart and responsive bio-related nanotechnologies. She has authored over 160 peer-reviewed publications in International journals from 2001 to date, including Chemical Society Reviews, Nature Nanotechnology, PNAS, Advanced Materials, ACS Nano, Carbon and J. Am. Chem. Soc. that collectively have received over 10,000 citations and her results have been highlighted in journals such as Science, Nature, and New Scientist. Prof. Giordani has also presented her work at numerous conferences around the world e.g. in United States, Canada, Japan, New Zealand, India, Saudi Arabia, Argentina, Brazil, Chile and across most of Europe. She has served as the thesis/dissertation advisor or mentor to over 60 undergraduate, postgraduate and postdoctoral fellows in Ireland and Italy.

In 2012 she was awarded the L'Oréal UK & Ireland Fellowship For Women in Science and in 2014 she has been invited to give a "Women in Science" Masterclass at the Royal Irish Academy. In 2018 she was awarded the William Evans Fellowship from the University of Otago (New Zealand) and was a Visiting Scientist to the Bio-Nano Institute at Toyo University (Japan). In 2024 she was awarded the Montpellier Advanced Knowledge Institute on Transitions (MAK'IT) visiting scientist Fellowship from the University of Montpellier (France).

She is Associate Editor for Beilstein Journal of Nanotechnology.

Prof Giordani's full profile including publications may be found at:

https://www.dcu.ie/chemistry/people/silvia-giordani

and

https://www.giordanigroup.com/