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14th annual Spring Symposium

International Invitational Symposium - Nanomaterials & Nanocomposites: Processing, Synthesis & Applications

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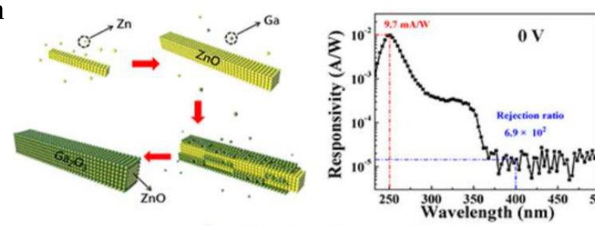
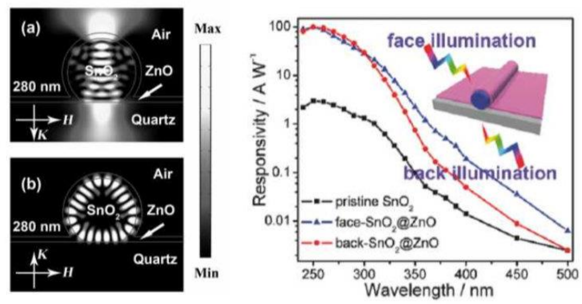
ZnO Micro/Nanostuctures Based Ultraviolet Photodetectors

Prof. Xiaosheng Fang, Fudan University, P. R. China

ZnO micro/nanostructures have received significant attention in ultraviolet photodetectors due to their wide bandgap (3.37 eV), abundant morphologies and ease of preparation. Typically, post-prepared ZnO micro/nanostructures show intrinsic n-type properties, and p-type ZnO is rather difficult to be realized. In this talk, we present various researches of composite structural ultraviolet photodetectors based on composite heterostructures between ZnO and different p-/n- type materials (such as SnO2@ZnO core-shell, ZnO@Ga2O3 core-shell, ZnO/BiOCl heterostructures et al.). The two different semiconductors were artfully chosen to meet the requirement of forming type-II heterojunction (i.e., staggered gap). Therefore, in all of these devices, a self-powered characteristic was shown because the photogenerated electron-hole pairs can be collected by the built-in electric field. Our device design method would provide a new approach to realize the high performance energy saving photodetectors.



▲ $ZnO@Ga_2O_3$ core–shell PD



▲ Ω-shaped SnO_2@ZnO core–shell PD

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Xiaosheng Fang is currently professor in the Department of Materials Science, Fudan University, China. After achieving his PhD degree from the Institute of Solid State Physics, the Chinese Academy of Sciences in 2006, he worked in National Institute for Materials Science (NIMS), Japan as a JSPS postdoctoral fellow, as well as International Center for Young Scientists (ICYS)-International Center for Materials Nanoarchitectonics (MANA) researcher. His research focuses on inorganic semiconductor nanostructure-based photodetectors. 150 articles in peer-reviewed scientific journals, two English monographs, and 4 book chapters have been authored and co-authored. The journal publications have already generated over 12000 citations, and h-index is 63. He was listed as a Highly Cited Researcher (in Materials Science) since 2014.

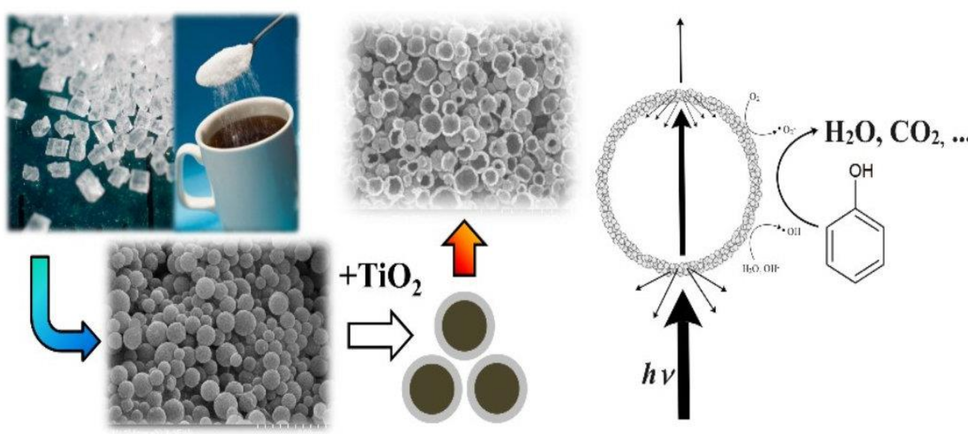
Fabrication of Hollow Nanostructures: CNT Forests and Spherical Semiconductors

Prof. Klara Hernadi, University of Szeged, Hungary

Hollow materials generally show better performance than their solid counterparts thus they are excellent candidates for various applications in the fields of energy, environment, health, or sensing. However, their fabrication can be challenging therefore the scientific community attends to their selective synthesis. In my talk I am going to give a brief summary about the syntheses of both carbon nanotube forests and spherical semiconductors.

Potential applications of carbon nanotubes (CNTs) can be significantly widened, if CNTs can form a forest-like, vertically aligned structure (VACNT). The aim of our experiments was to develop a cheap and easy method for growing carbon nanotubes forests on various substrates (either conductive or non-conductive) with the CCVD (Catalytic Chemical Vapor Deposition) method. However, this growth technique is rather sensitive to synthesis parameters both during catalyst layer formation (substrate; composition; thickness; porosity; etc.) and during CCVD (gas feed – carbon source, carrier, hydrogen, water vapor; reaction temperature; reaction time; etc.). In order to tune the height of vertically aligned carbon nanotube forest several parameters were varied during both catalyst layer fabrication (e.g. ink concentration, ink composition, dipping speed) and CCVD synthesis (e.g. gas feeds, reaction time). It was established that no considerable alignment occurs when CNTs are shorter than 10 μm. The authors are convinced that simple and cheap methods for CNT forest growth can open up novel applications in nanotechnology devices.

Semiconductor hollow structures are of growing interest in the field of photocatalysis. These objects are interesting not just because of their low apparent density but also their unique optical properties. For the synthesis of either carbon-



metal oxide composites or hollow semiconductor structures, nanometer sized carbon spheres (CS) were prepared by mild hydrothermal treatment of ordinary table sugar (sucrose). The size of these spheres can be controlled by the parameters of the hydrothermal treatment (e.g. time and pH). CSs were successfully coated with TiO2 and ZnO via either sol-gel method or atomic layer deposition. Subsequently, burning out the carbon core templates resulted in hollow metal oxide nanospheres. The unique hollow sphere morphology proved to enhance the photocatalytic activity (six times) as well as TOC removal efficiency (twelve times) compared to the sample which was prepared by the same method without the CSs.

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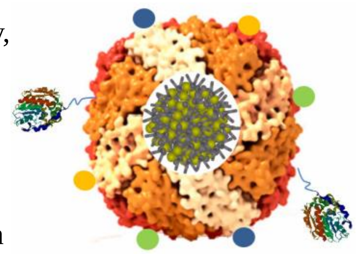
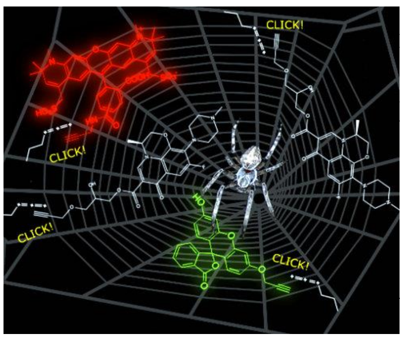
Klara Hernadi received her MSc degree in chemistry from the University of Szeged in 1983, PhD/Candidate of Chemical Science from the Hungarian Sciences in 1993, and Doctor of Chemical Science in 2004 (HAS). She had short-term employments at Texas A&M University, at Facultés Universitaires Notre-Dame de la Paix (Namur Belgium) and at Ecole Polytechnique Federale de Lausanne (Switzerland). Currently she is the leader of Research group of Environmental Chemistry as a full professor at University of Szeged. Her current research interest covers various topics in the field of nanocrystalline materials (carbon nanotubes, hollow semiconductors, nanocomposites, etc.).

Spider silk and protein nanocages for drug delivery and other healthcare applications

Prof. Neil R. Thomas, University of Nottingham, Centre for Biomolecular Sciences, Nottingham, UK



Nature provides a range of self-assembling protein-based materials that provide architectures and physical properties that lend themselves to applications in drug delivery, in vivo imaging or as scaffolds for new tissue formation. In my talk, I will present our results on the modification of both spider silk and human apoferritin (a 12 nm diameter protein capsule) using a combination of protein engineering and chemical modification and subsequent biological evaluation. We have demonstrated that apoferritin can be used to encapsulate PbS quantum dots that have fluorescent emission in the NIR and have targeted these to the Human epidermal growth factor receptor (HER2), over expressed on the surface of breast, gastric and ovarian cancer cells.



Spider silk including recombinant forms is a biomaterial of significant interest for medical and other applications due to both its mechanical properties (high tensile strength and toughness) and its biocompatibility. We have recently reported the preparation of antibiotic and fluorophore functionalized silk fibres self-assembled from the miniaturized major spidroin protein 4RepCT derived from the dragline silk of the South African nursery web spider, Euprosthenops australis5, through the site-specific incorporation of the un-natural, bio-orthogonally functionalized amino acids L-azido-homoalanine (Aha) and L-homopropargylglycine (Hpg) in the mini spidroins. The Aha residues can be selectively and efficiently modified with ligands bearing alkyne groups using either a range of ‘click’ reactions.

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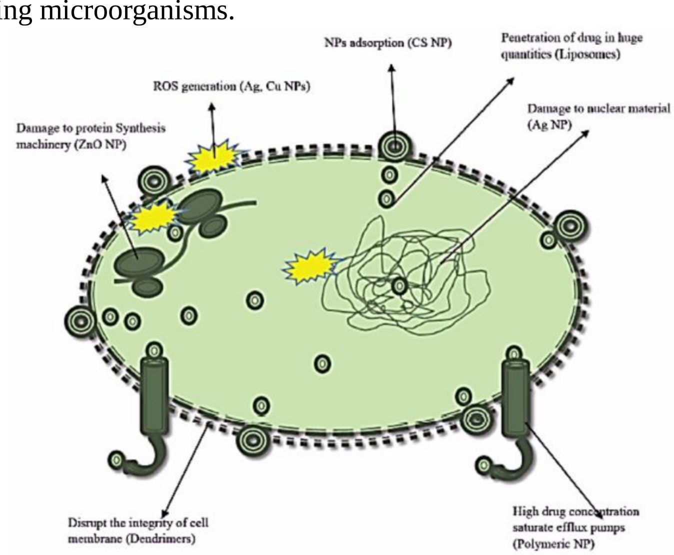
Neil Thomas is currently Professor of Medicinal & Biological Chemistry in the School of Chemistry, University of Nottingham, UK having undertaken his BSc(Hons) Chemistry degree (1987) and PhD (1990) at the University of Southampton, UK. He was then awarded a NATO/SERC postdoctoral research fellowship (1990-92) to work in the group of Stephen J. Benkovic at the Pennsylvania State University, USA on catalytic antibodies. He then took up a Royal Society University Research Fellowship and lectureship in the School of Chemistry at Bath University UK (1992-95) before moving to Nottingham. Research interests: Mechanistic enzymology; bionanotechnology; generating proteins with new functions for healthcare applications; developing new biological probes and enzyme inhibitors.

Imipenem Loaded Chitosan Based Nano-Constructs: A New Paradigm to Cure Multidrug Resistant Clinical Isolates

Dr. Bushra Jamil, National University of Medical Sciences, Rawalpindi, Pakistan

The global emergence of metallo-β-lactamase (MBL) producing bacterial pathogens has rendered the current therapeutic options ineffective. This perturbing situation requires an inventive strategy to stop the dissemination of MBL producers and their associated infections. The present investigation reports the fabrication and evaluation of bio-based nano-carrier system carrying imipenem, a carbapenem representative, as a therapeutic tool against resistant pathogens. Empty chitosan nanoparticles (CSNPs) and drug loaded CSNPs were generated by ionic gelation method. Both nano-dispersions had mean particle size of less than 100 nm as confirmed by Atomic Force Microscopy (AFM) based analyses. The stability of nano-colloidal system was affirmed by positive zeta potential of more than +50 mV. Encapsulation efficiency of imipenem varied from 45-64% as a function of drug concentration at the time of ionic gelation. FTIR studies confirmed that the drug was entrapped inside CSNPs by simple electrostatic interactions between active molecule and polymer. The imipenem loaded CSNPs displayed a significant antimicrobial activity in vitro against the MBL producing microorganisms.



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Dr. Bushra Jamil holds a bachelor degree in pharmacy from University of the Punjab, Lahore; M.Phil in Microbiology from Quaid-i-Azam University, Islamabad; and has a doctorate from COMSATS Institute of Information Technology, Islamabad. Her title of research during PhD was "Nano-antibiotics: Nano Encapsulation of Natural and Synthetic Antimicrobials to Combat Multi Drug Resistant Pathogens". She has over seven years of work experience. She is experienced in pharmaceutical microbiology, medical microbiology and Nano biotechnology.

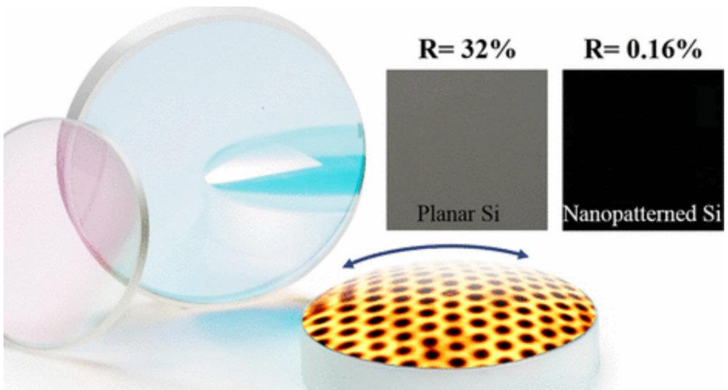
Right now she is serving as assistant Professor at National University of Medical Sciences (NUMS). It is pertinent to mention here that NUMS is a Federal Public Sector University envisioned to grow as a research led institution providing opportunities of undergraduate and post graduate education in Medicine, Dentistry, Nursing, Allied Health and Animal Husbandry.

Dr Bushra has also undertaken several technical writing and review projects. She has written numerous peer reviewed papers and book chapter relating to nanotechnology and microbiology.

Self-Assembly of NanoStructures for Fabrication of AntiReflective Surfaces

Dr. Parvaneh Mokarian, Advanced Materials and BioEngineering Research Centre, Trinity College Dublin, Ireland

Nanostructured surfaces that engineer the interaction between incident light and an object are a topic of both scientific and manufacturing significance. Nature routinely produces nanostructured surfaces with fascinating properties, such as antireflective moth eyes, self-cleaning lotus leaves, colourful butterfly wings, and water harvesting desert beetles. We now understand such properties and can mimic some of these natural structures in the laboratory. However, these synthetic structures are limited in the real industrial world since they are not easily mass produced over large areas due to the limited scalability of current technologies such as UV-lithography, the high cost of infrastructure and the inability to pattern non-planar surfaces. Here, we report a solution process based on high molecular weight block copolymers (BCP) self-assembly that allows the fabrication of sub-wavelength structures on large areas of optical and curved surfaces with feature sizes and spacings designed to efficiently scatter visible light. Si nanopillars (SiNPs) with diameters of ~115±19 nm, periodicity of 180 ± 18 nm and aspect ratio of 2-15 show a reduction in reflectivity by a factor of 100, < 0.16% between 400-900 nm at AOI 30°. Significantly, the reflectivity remains below 1.75% up to incident angles of 75°. The BCP nano-patterning capabilities avoid previous 'inherent' size limitations, make exceptional surfaces for improved transparency, light focusing, antireflection and for tuning photon absorption for a variety of applications on a wide range of surfaces, materials and non-planar substrates. This technique facilitates fabrication of a high density ordered array of nanopillars with tunable height, which are easily scalable and can be formed at low temperature. Compared to nanocones and other 'black' silicon layers, broadband antireflection coatings may now be possible for flexible PVs, solar cell technologies, and for broadband elimination of reflection of high quality glass optics.



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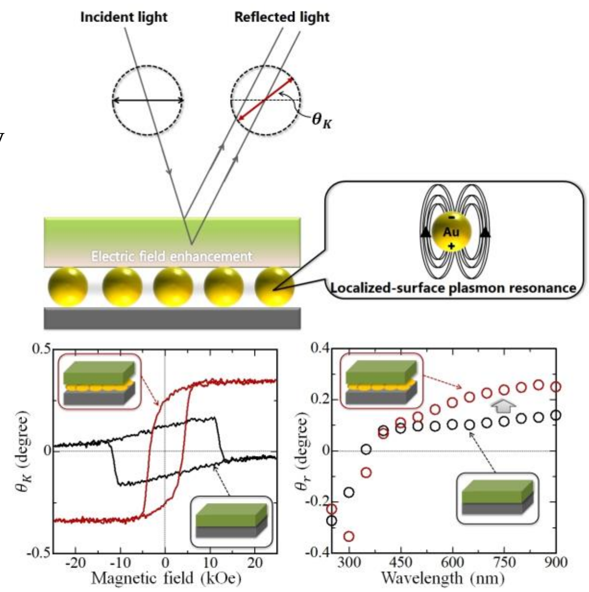
Parvaneh Mokarian is a Principal Investigator at Science Foundation Ireland (SFI) Advanced Materials and BioEngineering Research Centre (AMBER) in Trinity College Dublin, Ireland. She is the coordinator of European Horizon2020 project called SUN-PILOT: Subwavelength Nanostructure Pilot Line (2018-2021). She earned her PhD in 2009 from the University of Sheffield, UK and was recipient of Dorothy Hodgkin's Scholarship. Since then she worked as a Research Fellow in University College Cork in collaboration with Tyndall National Institute and Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), before joining TCD in 2016. Her research interests are in polymer thin films, polymers at surfaces and interfaces, light-nanostructure interaction, cell-nanosurface interaction and soft nanotechnology. Her research team (Intelligent Nano Surfaces Group) is focused on using block copolymers as templates for sub-wavelength nanostructures for nanofabrication, photonics applications, antireflective surfaces and functional/smart surfaces. Dr. Mokarian's team has won the 1st prize for the "Best Innovation Award" by a multilateral project or technology in SPIE, Europe's biggest optics conference held in Brussels in April 2016. The technology is called Zeroptica.

Modification of Magnetic Properties in Nanomagnetic Materials Through Metal Particles

Dr. Yukiko Yasukawa, Chiba Institute of Technology, Japan

TbFeCo, the transition metal-rare earth amorphous alloy magnetic thin film, is known to be one of the superior magneto-optical (MO) materials. In order to apply the magnetic thin films to functional MO electronic devices, an enhancement of the MO properties is essential. So far, MO cavity effects and magnetic photonic crystals have been widely studied to improve the MO properties, and their effective roles have been reported. MO enhancement has also been expected through the effects of plasmons generated by metal particles for materials consisting of MO thin film/metal particles. The plasmon effects on the MO properties, however, have not been systematically investigated.



The aim in this research is an improvement of large polar Kerr rotation angles of TbFeCo magnetic thin films though the plasmon effects induced by self-organized Au nanoparticles. Owing to the localized-surface plasmon resonance of electrons in the Au particles, the enhancements of electric field in the vicinity of Au particles can be expected. As a consequence, enhanced-polar Kerr rotation angles of TbFeCo magnetic thin films could be realized. The polar Kerr rotation angles of TbFeCo magnetic thin film/self-organized Au nanoparticles exhibited two times larger than that of reference sample, i.e., TbFeCo magnetic thin film, at zero magnetic field. We consider that this result could be achieved by the plasmon effects of Au nanoparticles.

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Yukiko Yasukawa, Doctor of Engineering, now is an Associate professor in the Department of Electrical and Electronic Engineering, Faculty of Engineering, Chiba Institute of Technology, Japan. She is a member of The Magnetic Society of Japan, The Japan Society of Applied Physics, Japan Society of Powder and Powder Metallurgy, The Institute of Electrical Engineers of Japan, and The Society of Japanese Women Scientists. For some of the Conferences/Societies mentioned above, she is actively working as one of the committee members. She received her Bachelor of Engineering in magnetic materials, and got a Master of Engineering in high-Tc superconductors. In 2006, she got a Doctor's degree in functional-oxide materials including magnetic materials and superconducting materials from Tokyo Institute of Technology, Japan. While she was a Ph.D. student she worked as a JSPS (Japan Society for the Promotion of Science) researcher.

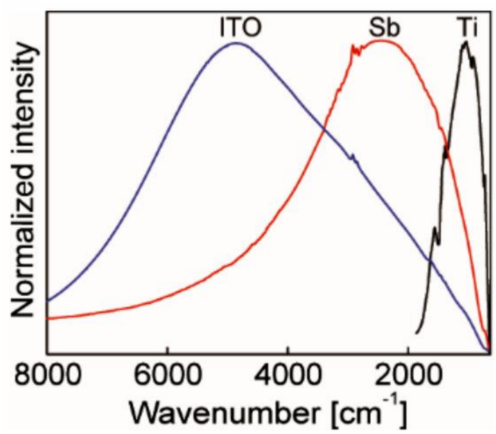
After she received the Ph.D. degree, she was a Postdoctoral student at Kogakuin University and worked on fabrication of self-organized nanomaterials. She joined Shinshu University as an Assistant Professor in 2010. In Shinshu University, she focused on the investigations of nanostructural self-organized magnetic materials.

She established her own laboratory as a PI in 2014 in Chiba Institute of Technology. Her current research topics are based on all the experiences she had. Her present interest is "designing/manipulating" the magnetic properties in nanomagnetic materials. Her group is growing up year by year with active collaboration with The National Institute of Advanced Industrial Science and Technology (AIST) and other Universities.

Plasmonic Semiconductor Nanocrystals as Intrinsically Multifunctional Materials

Prof. Pavel V. Radovanovic, University of Waterloo, Canada

Synthesis, properties, and applications of gold and silver nanostructures with tunable localized surface plasmon resonances (LSPRs) have been a subject of intense investigation over the past decade. The focus on these noble-metal plasmonic nanomaterials stems from their facile synthesis, relative stability, and strong absorption in the visible part of the spectrum. However, among other drawbacks, these nanostructures are also costly for large-scale applications, exhibiting a high degree of optical losses due to electronic transitions, and lack the mechanism to tune the type and concentration of charge carriers. Consequently, doped semiconductor and metal oxide nanostructures have emerged as a new class of unconventional plasmonic materials. In this talk I will present the results of our recent work on colloidal indium oxide-based plasmonic nanocrystals, including structure- and composition-dependent plasmonic properties. I will also discuss colloidal synthesis and spectroscopic properties of several new transparent plasmonic semiconductor nanocrystal systems and comparative investigation of their electronic structure using a combined Drude-Lorenz model and density functional theory. Application of these near-to-mid-infrared plasmonic semiconductor nanocrystals will also be discussed. I will specifically focus on our recent results on robust electron polarization in degenerately-doped In2O3 nanocrystals, enabled by non-resonant coupling of cyclotron magnetoplasmonic modes with the nanocrystal excitonic states.



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Pavle Radovanovic received his Ph.D. degree from the University of Washington, Seattle. Following his postdoctoral appointment at Harvard University, he started his independent research career at the University of Waterloo in 2006. At Waterloo he initiated a new research program in physical-inorganic chemistry focusing on the design, synthesis, and fundamental physical and chemical properties of multifunctional low-dimensional materials. His work has been recognized by number of honors and awards, including Canada Research Chair (NSERC), Early Researcher Award (Ontario Ministry of Research and Innovation), Mobility Award (French Ministry of Foreign Affairs), and CNC-IUPAC Award.

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