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FROM ACADEMIA TO INDUSTRY 2023



# Book of Abstracts

# Plenary Speakers

## Prof. Dmitri Golberg

School of Chemistry & Physics, Faculty of Science  
Queensland University of Technology, Brisbane, Australia

### **"Nanomaterial properties and functions as revealed by *in situ* and *operando* TEM"**

Knowledge of electromechanical, thermal and optoelectronic properties of nanomaterials is of prime importance as far as their integration into modern technologies is concerned. However, typically, such properties are measured using instruments having no direct access to the material atomic structure, its defects and crystallography and spatially resolved chemistry. This drawback largely limits the relevance of data because many structural features of a nanomaterial prior, during and after its testing are hidden. Therefore, the acquired results cannot be linked to a particular material morphology, its atomic structure, and defect network. This disadvantage confuses engineers and leads to many uncertainties with respect to realistic nanomaterials' applications and their commercial potentials. In this presentation I demonstrate the full usefulness of various state-of-the-art *in situ* and *operando* transmission electron microscopy (TEM) techniques (Fig. 1) for property/function studies of frontier materials, *e.g.*, individual carbon,<sup>1</sup> boron nitride and dichalcogenide nanotubes and nanosheets, inorganic nanowires, nanoparticles and nanocomposites. Elasticity, plasticity, fracture strength and toughness, electrical resistivity, thermal gradients, photocurrents,<sup>2</sup> photovoltages and spatially resolved luminescence of a nanomaterial may be unambiguously determined inside TEM, while employing piezo-driven probes, sensors and nanomanipulators and/or optical fibers inserted into the TEM column.<sup>3</sup>

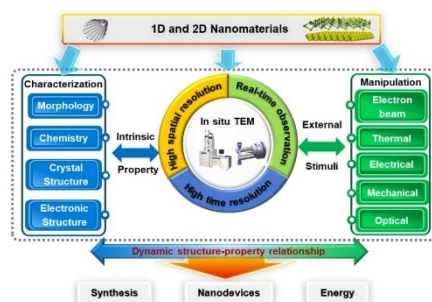


Figure 1. Schematics illustrating utilized techniques of *in situ/operando* TEM for analysis of low-dimensional nanomaterial properties and functions.

[1] D.M. Tang, D. Golberg *et al.*, *Science* 374, 1616 (2021).

[2] C. Zhang, D. Golberg *et al.* *Nano Lett.* 22, 673 (2022).

[3] *In situ* TEM Project is supported through an Australian Research Council (ARC) Laureate fund FL160100089 (2017-2023). The author is grateful to coauthors at QUT, *i.e.*, Drs. J. Fernando, K. Firestein and C. Zhang, and NIMS, *i.e.*, Drs. D.M. Tang, O. Cretu, M.S. Wang, X.L. Wei, X. Zhou, M. Mitome, N. Kawamoto and Y. Bando, for their key contributions to *in situ* TEM projects over the years.



Dmitri Golberg is a Distinguished Professor at Queensland University of Technology (QUT), Brisbane, Australia, a Co-Director of the QUT Centre for Materials Science, and an Australian Research Council (ARC) Laureate Fellow. His research is devoted to the synthesis, structural analysis, and physical property measurements of low-dimensional inorganic nanomaterials. After getting PhD and ten years research career at a Research Institute in Moscow, Russia, in 1995 he joined the National Institute for Materials Science (NIMS) in Tsukuba, Japan. He moved on to QUT in 2017 after more than 20 years of Nanotube Group Leadership at NIMS. Dmitri is an author of 750+ original papers in peer-reviewed international journals cited more than 60,000 times (H-130, *Scopus*). He also registered 130+ Japanese, European and US patents, authored numerous book chapters, and delivered 150+ invited, keynote and plenary lectures during International Scientific Forums. During his career Dmitri received the prestigious Tsukuba Prize (2005), Thomson Reuters Research Front Award (2012), Seto Prize by Japan Microscopy Society (2016), and NIMS President Award (2017). He was also nominated as a Highly Cited Researcher in Materials Science by *Thomson Reuters* during 2014-2022.

## Prof. Ron Naaman

Department of Chemical and Biological Physics

Weizmann Institute of Science, Israel

### **"The chiral induced spin selectivity (CISS) effect - from electron transfer in biology to spintronics"**

Spin based properties, applications, and devices are commonly related to magnetic effects and to magnetic materials. However, we established that chiral organic molecules can act as spin filters for photoelectrons transmission, in electron transfer, and in electron transport. The effect, termed Chiral Induced Spin Selectivity (CISS), has interesting implications for the production of new types of spintronics devices and on the importance of chiral molecules in biological systems. The basic effect, and its mechanism, applications and implications, will be presented.

1. T. K. Das, F. Tassinari, R. Naaman, J. Fransson, The Temperature-Dependent Chiral-Induced Spin Selectivity Effect: Experiments and Theory. *J. Phys. Chem. C*, **126**, 3257–3264 (2022).
2. S.-H. Yang, R. Naaman, Y. Paltiel, S. Parkin, Chiral spintronics, *Nat. Rev. Phys.* **3**, 328–343 (2021).
3. R. Naaman, Y. Paltiel, D. H. Waldeck, Chiral Induced Spin Selectivity and Its Implications for Biological Functions, *Annu. Rev. Biophys.* **51**, 99-114 (2022).



Prof. Ron Naaman earned his BSc in 1973 from Ben-Gurion University of the Negev, and his PhD in 1978 from the Weizmann Institute of Science, Israel. He worked as a postdoctoral researcher at Stanford University in California, and spent a year in the Department of Chemistry at Harvard University. In 1981, Prof. Naaman joined the Weizmann Institute in the Department of Isotope Research (later renamed the Department of Chemical Physics). From 1989-1995, Prof. Naaman chaired the Institute's Chemical Services Unit and from 1995-2000, he headed the Department of Chemical Physics. From

2008-2010, Prof. Naaman was the Chair of the Scientific Council at the Institute. He was awarded the Kolthof Prize from the Technion, the excellent research prize from the Israel Vacuum Society and from the Israel Chemical Society and he is a recipient of the Humboldt-Meitner award. He serves as an associate editor for PCCP. Ron Naaman is a Fellow of the American Physical Society, Fellow of the Royal Society of Chemistry, and Member of Academia Europaea. He published more than 350 scientific papers. Currently his research is focused on the chiral induced spin selectivity (CISS) effect that his group discovered.

# **Keynote Speakers**

## Prof. Kenan Gundogdu

Department of Physics

North Carolina State University, Raleigh, USA

### ***"Room temperature superfluorescence and quantum analog of vibration isolation"***

As the demand for quantum approaches in computing, communication, and cryptology is increasing, the need for discovering new “quantum materials” is unprecedented. While the required quantum properties are known for most applications, the designer's rules for producing these materials are unclear, and quantum materials functioning at room temperature are almost non-existent. One of the significant challenges is the short lifetime of quantum coherent states at practically relevant temperatures. Since the quantum phase is highly fragile due to thermal scattering events, we have the following questions: Are thermal processes a fundamental roadblock for designing quantum materials with extended coherence? Is there a way to protect quantum coherence despite thermal scattering? We recently observed room-temperature superfluorescence in lead-halide perovskites. Superfluorescence (SF) is a collective emission due to the macroscopic quantum state of optically excited dipoles. In the solid state, SF observation is generally limited to low temperatures due to the fast thermal dephasing of electronic excitations. All early observations of SF in the solid state are in two-level systems (discrete transition). Therefore, the observation of SF in hybrid perovskites with extended electronic states (bands) is quite surprising. This observation points to a mechanism protecting a quantum system's quantum phase from thermal disturbances in lead-halide perovskites. In this talk, I will present the Quantum Analog of Vibration Isolation (QAVI) model and its signatures protecting the quantum phase transition of incoherent dipoles into a macroscopically coherent superradiant state in perovskites.



Kenan Gundogdu is a physics professor at NC State University. He received his BSc degree from Bogazici University in 1999. He continued his PhD at the University of Iowa Physics Department, studying spin dynamics in semiconductors and spintronic device applications. He then continued his training in the MIT Chemistry department and developed multidimensional spectroscopy to study excitonic coherences in semiconductor quantum structures. His current research at NC State focuses on understanding quantum coherence and macroscopic quantum effects in solid-state materials at high temperatures.

## Prof. Ernesto Joselevich

Department of Molecular Chemistry and Materials Science, Faculty of Chemistry

Weizmann Institute of Science, Israel

### ***"Polarity and non-linear optics of guided nanowires"***

The large-scale assembly of nanowires (NWs) with controlled orientation on surfaces remains one challenge toward their integration into practical devices. During the last decade, we have reported the growth of perfectly aligned, millimeter-long, horizontal NWs of GaN, ZnO, ZnSe, ZnTe, CdSe, CdS, ZnS, CsPbBr<sub>3</sub> and other materials, with controlled crystallographic orientations on different planes of sapphire, SiC, quartz, and spinel. The growth directions and crystallographic orientation of the NWs are controlled by their epitaxial relationship with the substrate, as well as by a graphoepitaxial effect that guides their growth along surface steps and grooves. We demonstrated the massively parallel self-integration of NWs into circuits via guided growth and the production of optoelectronic nanosystems, including photodetectors, photodiodes and photovoltaic cells. This talk will present systematic studies to map the crystallographic orientations and polarity of epitaxially guided NWs based on their nonlinear optical response under external electric fields [1]. Studies about epitaxially guided ZnO NWs on sapphire by Au-catalyzed vapor-liquid-solid (VLS) growth reveal interesting details about their formation mechanism and the role of the substrate and the catalyst in determining the polarity and morphology of the guided NWs. Studies done with epitaxial CsPbBr<sub>3</sub> perovskite NWs on sapphire by non-catalytic vapor-solid (VS) growth reveal an intriguing memory effect and a strong modulation of their photoluminescence under electric field [2]. These studies reveal the important interplay between epitaxy, polarity and optoelectronic behavior of guided NWs.

[1] Nature Communications **2021**, 12, 3286.

[2] ACS Nano **2021**, 15, 16130.



Ernesto Joselevich is a Professor of Chemistry at the Weizmann Institute of Science. His research focuses on the formation, structure and properties of low-dimensional materials (including carbon and inorganic nanotubes, nanowires and 2D materials), their integration into functional nanosystems, and their characterization by mechanical, electrical and optical measurements at the nanometer scale. He has received numerous prizes and awards, including the Israel Chemical Society Excellent Young Scientist Prize (2007), European Research Council (ERC) Advanced Grant (2014), Tenne Prize for Nanoscale Sciences by the Israel Chemical Society (2016) and Israel Vacuum Society (IVS) Excellence Award for Research (2020).

## Prof. Shlomo Magdassi

Casali Center for Applied Chemistry, the Institute of Chemistry and the Center for Nanoscience and Nanotechnology

Hebrew University of Jerusalem, Israel

### ***"New materials and approaches for 2,3,4D printing"***

Additive manufacturing, which is considered as the next industrial revolution, enables the fabrication of objects and devices through printing processes. It is expected to have a great impact on a variety of industrial applications, for example in the automotive, medical, food and aerospace industries. Our research is focused on the development and investigation of new materials tailored for various printing technologies, and developing new printing approaches. Recent progress made in view of applications will be presented, including: Conductive materials for printed electronics, stretchable materials for soft robotics, 3D printing based on wood waste, new photoinitiator nanoparticles for printing hydrogels in water, compositions for printing of self-healing hydrogels and bio-scaffolds. Also, will be presented bio-inspired, 3D superhydrophobic object and programmable materials.



Shlomo Magdassi is a professor at The Hebrew University of Jerusalem's Institute of Chemistry and serves as the academic director for the university's Center for Functional and 3D Printing. His research centers on micro and nanomaterials, with a focus on their applications in functional 2D and 3D printing. Over the course of his career, he has published more than 340 papers, edited four books, and holds approximately 300 patents and applications. His research outcome also includes creation of numerous commercial activities, including start-up companies, licensing agreements, and worldwide sales. In recognition of his contributions, he was awarded the 2022 Johann Gutenberg Prize by the Society for Imaging Science and Technology, and he is also a Fellow of the National Academy of Inventors.



## Prof. Janice L. Musfeldt

Department of Chemistry

University of Tennessee, Knoxville, USA

### ***"Insulator-metal transition in CrSiTe<sub>3</sub> triggered by structural distortion under pressure"***

van der Waals solids are well known to host remarkable phase diagrams with competing phases, unusual energy transfer processes, and elusive states of matter. Among this class of materials, chalcogenides have emerged as the most flexible and relevant platforms for unravelling charge-structure-function relationships. In order to explore the properties of complex chalcogenides under external stimuli, we measured the far infrared spectroscopic response of CrSiTe<sub>3</sub> under extreme pressure-temperature conditions. Analysis of the 368 cm<sup>-1</sup> Si-Te stretching mode and the manner in which it is screened by the closure of the indirect gap reveals that the insulator-metal transition takes place immediately after the structural phase transition - once the mixed phase aspect of the lattice distortion is resolved. At the same time, the two-phase region associated with the structural transition widens with decreasing temperature, and the slope of the insulator-metal transition under pressure is consistent with increasing entropy. These trends completely revise the character of the temperature-pressure phase diagram as well as the relationship between the structural and insulator-metal transitions, leading to a critical nexus of activity that may hide a quantum critical point and allow superconductivity to emerge.



Prof. Jan Musfeldt is a recognized expert on the spectroscopy of quantum materials. In recent work, she has employed spectroscopy under external stimuli - high magnetic fields, pressure, light, and strain - to reveal the interplay between charge, structure, orbits, and magnetism in novel solids. During her career, Prof. Musfeldt has championed interdisciplinary education in the undergraduate instructional labs as well as in support of emerging fields including nanoscience and the properties of materials away from equilibrium.

## Prof. Daniel Nessim

Bar Ilan Institute for Nanotechnology and Advanced Materials (BINA)

Bar Ilan University, Israel

### **"One-step CVD synthesis of single atom catalysts on nanocarbons using thermal delamination: a new paradigm for high performance, binder-free, electrodes for water splitting"**

We produced single atom catalysts on carbon nanofibers (*SACs@CNFs*) using an innovative one-step CVD synthesis based on temperature-controlled delamination of multilayer mixed metal films from a substrate with concurrent reactions with precursor gases and dopants to obtain a self-standing (no binder), high surface area doped carbon electrode bearing nickel SACs (not-PGM). These electrodes with nickel SACs performed well for water splitting, both in performance (low OER overpotential of 290mV @ 10mAcm<sup>-2</sup>; low HER overpotential of 230mv @ 10mAcm<sup>-2</sup>) and durability (over 20,000 cycles).

We will discuss the main phenomena are at play, including nucleation, growth, and doping of the nanocarbons; dewetting of thin metal films on the nanocarbons to form the SACs; thermal detachment of selected weak-adhesion thin films; and multiple gas-solid phase reactions in the CVD reactor. Given the inherent scalability of CVD, this technique could be used industrially with large reactors to produce large area electrodes and become a new benchmark for water splitting and other electrocatalytic reactions.



The Nessim laboratory at Bar Ilan University (Israel) focuses on the synthesis of 1D and 2D nanostructures using state-of-the-art chemical vapor deposition (CVD) equipment. The scientific focus is to better understand the complex growth mechanisms of these nanostructures, to possibly functionalize them to tune their properties, and to integrate them into innovative devices. Prof. Nessim joined the faculty of chemistry at Bar Ilan University in 2010 as lecturer, was promoted senior lecturer with tenure

in 2014, and associate professor in 2018. From 2020 to 2023, he was the president of the Israel Vacuum Society. He received the title of "*Cavaliere della Stella d'Italia*" by the President of Italy for his work on research collaborations between Italy and Israel. He holds a PhD in Materials Science and Engineering from the Massachusetts Institute of Technology (MIT), an MBA from INSEAD (France), and Masters in Electrical Engineering from the Politecnico di Milano and from the Ecole Centrale Paris (ECP, within the Erasmus/TIME program). Prior to his PhD Dr. Nessim spent a decade in the high-tech industry and consulting across Europe, USA, and Israel.

## Prof. Boris Rybtchinski

Department Molecular Chemistry and Materials Science, Faculty of Chemistry

Weizmann Institute of Science, Israel

### ***"Solution-processed materials based on carbon nanotubes"***

We will describe our work on carbon nanotube-based materials: porous electrodes, coatings, and polymer composites. Simple dispersion methods and convenient fabrication were employed to create materials used in solar cells, supercapacitors, batteries, artificial muscles, and more.



Born in Kiev, Ukraine, in 1971, Prof. Boris Rybtchinski received his BSc from Kiev State University in 1992. He then immigrated to Israel and in 1993 embarked on graduate studies at the Weizmann Institute. After serving in the medical corps of the Israel Defense Forces, he returned to the Weizmann Institute where he earned his PhD with distinction in 2002. He conducted postgraduate research at Northwestern University, and joined the Weizmann Institute in 2005, holding currently a rank of Full Professor. Prof. Rybtchinski investigates fundamental and applied aspects of organic self-assembly, employing it to create sustainable

materials. To manufacture these systems, he takes his cue from Nature, where self-assembly in water governs the emergence of biological systems, from proteins to living organisms. He exploits the hydrophobic properties of certain organic molecules, manipulating them to self-assemble “molecular plastics”: recyclable adaptive nanomaterials that can potentially replace conventional polymer-based plastics. For example, the Rybtchinski group has created fully recyclable membranes (constructed from organic nanocrystals or self-assembled hydrogels) that can purify water from virtually any pollutant. Another research interest relates to self-assembled sustainable energy materials for solar cells and batteries. The Rybtchinski group also investigates mechanisms of self-assembly, in particular organic and protein crystallization, using state-of-the-art electron microscopy imaging. Prof. Rybtchinski has received a number of prestigious awards, including the Weizmann Institute’s Sir Charles Clore Prize in 2005, and its Scientific Council Prize in Chemistry in 2012. In 2013, he was the Werdelmann-Stiftung Lecturer at the University of Essen, and in 2020 he received the Gutwirth Prize from Technion.

## Prof. Oded Shoseyov

The Robert H Smith Faculty of Agriculture, Food and Environment

Hebrew University of Jerusalem, Israel

### **"The plant age; materials for the future"**

***Bringing together the toughness of cellulose nano-fibers from the plant kingdom, the remarkable elasticity and resilience of resilin that enables fleas to jump as high as 100 times their height from the insect kingdom combined with Human Recombinant Type I collagen produced in tobacco plants; These are the materials of the future; Nature's Gift.***

Resilin is a polymeric rubber-like protein secreted by insects to specialized cuticle regions, in areas where high resilience and low stiffness are required. Plant cell walls also present durable composite structures made of cellulose, other polysaccharides, and structural proteins. Plant cell wall composite exhibit extraordinary strength exemplified by their ability to carry the huge mass of some forest trees. Inspired by the remarkable mechanical properties of insect cuticle and plant cell walls we have developed novel composite materials of resilin and Crystalline Nano-Cellulose (resiline-CNC) that display remarkable mechanical properties combining strength and elasticity. As a central element of the extracellular matrix, collagen is intimately involved in tissue development, remodeling, and repair and confers high tensile strength to tissues. Numerous medical applications, particularly, wound healing, cell therapy, and bone reconstruction, rely on its supportive and healing qualities. Its synthesis and assembly require a multitude of genes and post-translational modifications. Historically, collagen was always extracted from animal and human cadaver sources, but bare risk of contamination and allergenicity and was subjected to harsh purification conditions resulting in irreversible modifications impeding its biofunctionality. A tobacco plant expression platform has been recruited to effectively express human collagen, along with three modifying enzymes, critical to collagen maturation. The plant extracted recombinant human collagen type I forms thermally stable helical structures, fibrillates, and demonstrates bioactivity resembling that of native collagen. Today in greenhouses all over Israel farmers grow transgenic tobacco plants producing human recombinant collagen that is used for the production of medical implants that have already in clinical use. Combining collagen at the nano-scale with resilin to produce fibers resulted in super-performing fibers with mechanical properties which exceed that of natural fibers. We will demonstrate utility of hrCollagen, Cellulose Nano Crystals and resilin using Additive Manufacturing technologies ranging from micron to submicron resolution using 2-photon printing technology.



Professor Oded Shoseyov is a faculty member of the Hebrew University of Jerusalem focusing on plant molecular biology, protein engineering and nano-biotechnology, specifically bio-inspired nano-composite materials. Shoseyov received the Kaye Innovation Award from the Hebrew University in 2010, and an honorable mention from the Israeli Prime Minister for his contributions in entrepreneurship and innovation in 2012. He has authored or co-authored over 300 scientific publications and is the inventor of more than 46 patents. His most recent company, Collplant, produces human recombinant Type I collagen in transgenic plants for medical implants used in tissue repair. Here Oded sheds light on the role

of nanotechnology and the transformation of industries across the world to becoming sustainable.

# Invited Speakers

## Prof. Maya Bar-Sadan

Chemistry Department

Ben Gurion University of the Negev, Israel

### ***"Layered materials as versatile electrocatalysts"***

Layered materials have become one of the most extensively researched systems in nanoscience. Their rich chemistry and simple structure facilitate extensive modeling, making them appealing for correlations of structure and function. Specifically, tuning their composition by doping and alloying and forming complex hybrid structures has been shown to contribute to their catalytic functionality. Here, the formation of various structures of layered materials by wet chemistry will be described, and the impact on catalytic reactions such as hydrogen evolution (HER) and oxygen evolution (OER) will be discussed. I will present work on the commonly known structures of MoS<sub>2</sub> and WS<sub>2</sub>, but also novel structures of VS<sub>2</sub> nanotubes and nanoflowers. The structural features of various hybrids will also be presented, and correlated with the catalytic activity.



Maya Bar-Sadan is a Professor in the Department of Chemistry at Ben-Gurion University, Israel. She received her Ph.D. in Chemistry and Materials Science from the Weizmann Institute of Science in 2007. Before joining Ben-Gurion University in 2011, she held a Minerva Foundation (Max Planck Society) postdoctoral fellowship at the Institute of Solid-State Research, Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Juelich, Germany. She is a recipient of the Charles Roth prize for excellence in teaching from Ben-Gurion University (2014) and the Krill prize for excellence in research from the Wolf Foundation,

Israel (2016). Her research interests are correlating macroscopic features such as catalytic activity and optical properties with the atomic-scale structure, primarily via high-resolution transmission electron microscopy and spectroscopy, and applying this information to design new electrocatalysts and photocatalysts.

## Dr. Doron Burshtain

Israel Cell R&D, Energy Storage Division

SolarEdge Technologies Inc.

### ***"Energy storage: academic research vs. industrial needs"***

Lithium-ion batteries, especially rechargeable lithium-ion batteries, have changed the world in the recent 32 years since the release of the 1st commercial LiBs using the Yoshino design by Sony and Ashei Kasei. It took the world approx. 20 years to move from the early academic research of Lithium-sulfur dioxide (1969) to the successful commercialization of LiBs. Not disregarding the importance and contribution of the academic world to success, the industry sees dissonance in many cases, which are led by trends, the will (and need) to publish, and lack of inter-academic-industry involvement. This includes also insufficient education on industrial approaches and needs. While the academy is led by the inquiry for knowledge, the industry is led by the inquiry of product and profit. In my view, these are merely two faces of the same coin, un-separated, but unfortunately rarely really looking at each other needs. This dissonance results in long training required for brilliant fresh minds who are going out from the academy to the industrial world. In some cases, also a great cause of frustration. By understanding and experiencing the differences between academic essential research tools and tools used in the industry, this gap can be minimized and led to better (and maybe faster) development, and better and more productive collaboration.



Doron Burshtain is Director of Cell R&D at SolarEdge Technologies Inc. Has completed his PhD in Analytical Electrochemistry and Interfaces from The Hebrew University in Jerusalem (Israel) in 2005, and postdoctoral studies at the Weismann Institute of Sciences (Israel). In the past 7 years serves as a consultant at the Weismann institute of science in Rehovot (Israel), at Prof. Jacob Sagiv's group. He has published more than 40 papers and granted patents in reputable journals and major patents offices around the globe (with many other patents pending). In the recent years deeply involved in the cutting-edge R&D and Industrial technologies of Energy Storage devices

## Dr. Ofer Cohen

Department of Molecular Genetics and Biochemistry

Israel Institute for Biological research (IIBR), Israel

### ***"mRNA vaccines: a game-changer in the fight against infectious diseases"***

Messenger RNA (mRNA)-lipid nanoparticle (LNP) vaccines have emerged as a game-changer in the current global fight against COVID-19, due to their efficacy, speed of development, and adaptability to new variants. The mRNA-LNP platform is currently being applied to additional viral pathogens, however, very little information is available regarding its effectiveness against bacterial pathogens. In a recent study we developed an effective mRNA-LNP vaccine against a lethal bacterial pathogen by optimizing the mRNA payload and antigen design. A nucleoside-modified mRNA-LNP vaccine was designed based on the bacterial F1 capsule antigen, a major protective component of *Yersinia pestis*, the etiological agent of plague. Throughout human history, plague has caused millions of deaths due to its rapid deterioration and contagious nature. In light of the global emerging crisis of antibiotic resistance and the lack of effective conventional therapies or vaccine candidates, our results provide new avenues for the development of effective antibacterial vaccines.

Doctor Ofer Cohen is a Principal Investigator at the Israel Institute for Biological Research and specializes in the development of mRNA vaccines against infectious diseases. Dr. Cohen completed his PhD studies at the Weizmann Institute under the supervision of Prof. Adi Kimchi. At the IIBR, Dr. Cohen studied the pathogenesis of bacteria such as *Bacillus anthracis*, *Yersinia pestis*, and *Francisella tularensis* which are considered as threat agents. Dr. Cohen's research group recently completed a long-term study to develop the next generation of anthrax vaccines. Currently, Dr. Cohen and his team are working on the adaptation of mRNA vaccines for the development of vaccines against bacteria.



## Dr. Sébastien Gasc

Spacetek Technology AG, Switzerland

### ***"Novel time-of-flight residual gas analyzer (TOF-RGA) for in situ real-time process monitoring"***

Sensitive gas analyses, in particular in industrial processes, are nowadays performed either via spectroscopy or using quadrupole mass spectrometers; the first method provides a fast but indirect measurement, whereas the second provides in situ measurements of only one species at a time. In this work, we present a novel time-of-flight residual gas analyzer (TOF-RGA) built by the Swiss company Spacetek Technology AG, and show the results of measurements such as the characterization of the FC5311 calibration compound, the detection of naturally abundant noble gases in air, the measurement of a noble gas mixture in the ultra-high vacuum facilities of CERN, and measurements acquired in a X-ray Photoelectron Spectroscopy facility in Germany involving the production of graphene, to demonstrate the capability of this new TOF-RGA to compete with already existing techniques for the monitoring of the composition of gases in real time (10 times per second), at high resolution ( $m/\Delta m = 1200$  measured at  $m/z$  132), and with a high sensitivity at ppb level.



Sébastien Gasc received a MSc in Astronomical and Space-based Systems Engineering in Paris, France, and a PhD in Physics at the University of Bern, Switzerland. He worked on the ROSINA instruments aboard the ESA's Rosetta spacecraft, with focus on the time-of-flight mass spectrometer RTOF. After completing his PhD, he worked as a calibration manager for the CLUPI instrument onboard the ESA's ExoMars Rover. In 2019, he joined Spacetek Technology AG, a spinoff company of the University of Bern, where he has been working on developing commercial time-of-flight mass spectrometers as a R&D engineer and then as Head of Technical Sales.

## Prof. Yao Guo

Beijing Institute of Technology

Haidian, Beijing, China

### ***"Multifield coupling of van der Waals interface: properties, devices, and systems"***

The van der Waals interfaces have drawn intensive attention due to their unique properties. Here, I introduce our studies about the metal-2D material interface and the superlubric incommensurate interface in 1D tungsten disulfide nanotubes, which present parasitic capacitive coupling and in-plane mesoscopic sliding ferroelectricity, respectively. The parasitic capacitive coupling leads to the abnormal current saturation in 2D field effect transistors, and the mesoscopic sliding ferroelectricity results in a programmable photovoltaic effect in the tungsten disulfide nanotube device. We further reveal how these unique properties can be implanted in the preliminary systems that can do inference and achieve the self-powered artificial vision, demonstrating how intelligent materials can push electronic system integration at the material level.



Yao Guo is an Assistant Professor at the School of Physics, Beijing Institute of Technology. He studied at the Department of Electronics, Peking University, and earned his PhD degree in 2015. He then worked as an associate researcher in a joint program between the Hong Kong Polytechnic University and Stanford University. Starting September 2017, he has been an Assistant Professor in the School of Physics at the Beijing Institute of Technology. His primary research interests are experimental research on micro-nano scale materials and devices.

## Dr. Amir Handelman

Faculty of Electric and Electronics Engineering,  
Holon Institute of Technology (HIT), Israel

### ***"Amino-acid-based microstructures as versatile organic photonic platforms"***

The increasing interest in implantable medical devices that incorporate photonic components has accelerated the search for new, biocompatible optical materials at nano- and micro-scale. In this lecture, I will introduce the use of the polar amino acid L-Histidine as a candidate for bio-photonic devices. L-Histidine is self-assembled into diverse solid-state crystallized microstructures, one of which, the elongated hexagonal microplates, is shown to have passive waveguiding capability for polarized light. The interaction of polarized light with Histidine microplates having different orientations and thicknesses is studied from Stokes parameters and Mueller matrix. The linear birefringence of Histidine is estimated from the theory of Generalized Jones Matrix for biaxial crystals. Visible fluorescence in heated Histidine microplates is shown and its origin is discussed. Application of optical switching using Histidine microplates is shown. The findings reported in this work may pave the way for utilization of self-assembled amino acids microstructures in biosensors and interconnects in many bio-photonic applications.



Dr. Amir Handelman received his BSc, MSc and PhD degrees in Electrical Engineering in 2008, 2011 and 2014, respectively, all from Tel-Aviv University, Israel. In 2014, Amir joined the faculty of Electrical Engineering in Holon Institute of Technology (HIT) as an electrical engineering faculty member and established there the Applied Optics and Machine Vision Lab. In 2021 he was promoted to a senior member with tenure. In addition to his academic background, Amir has over 10 years' experience in computer vision and optics, which he gained during his works in several Hi-Tech companies, such as Israel Aerospace Industries (IAI), Volume-Elements Ltd., and KLA-Tencor. He's research interests are optic sensors, organic photonics, nanomaterials, metamaterials, photonic topological insulators, nonlinear optics, free-space optical communication, waveguide structures, AI-photonics, medical instruments, computer vision and machine learning. During his PhD studies, Amir received several awards for excellence including SPIE and the Department of Physical-Electronics Award.

## Dr. Noa Lachman

Department of Materials Science and Engineering

Tel Aviv University, Israel

### ***"The unexpected advantages of nanocomposites extrusion-based 3D printing"***

Extrusion-based additive manufacturing (AM), often known as Fused filament fabrication (FFF), or the patented Fused Deposition Modeling (FDM), is one of the oldest and most widely used methods. Being a versatile processing method for thermoplastics makes it useful in the highly complex military and medicinal, but also in the most trivial house-hold consuming. The ability to introduce thermoplastic-matrix nanocomposites, gaining properties as conductivity, mechanical strength, and more, adds another degree-of-freedom to the variety of printable devices. Nevertheless, the addition of nanomaterials to a thermoplastic matrix changes its processing-related properties, most importantly melt viscosity, heat transfer, and stiffness. Furthermore, the printing process itself affects dispersion and orientation of the nanoparticles in the matrix, thereby changing the final product properties. All of these effects should be accounted for in the design to optimize of the process. This talk will demonstrate a few of the governing concepts in extrusion-based process regarding nanocomposites, and highlight the similarity between the result of extrusion-based printing and continuous-fibers composites. We will show that the high-shear extrusion improves dispersion of nanoparticles and increase homogeneity, while the same high shear orients 1D and 2D nanoparticles, inducing anisotropy in the resultant composite. We use these effect to design post print conductivity, capable of making electrically isotropic pre-printed material showing electrical anisotropy. We thus exhibit both the versatility of AM, and extrusion-based AM specifically, in tailoring polymer composites properties. The applications of such smart-materials design can range from mechanical bio-mimicry, to corrosion resistance integrated electrical devices.



Dr. Noa Lachman is a young member in the department of materials science and engineering in Tel Aviv University. She received a BSc (2003) in Chemistry and Physics from the Hebrew University in Jerusalem, Israel, and completed her PhD work (2010) at the Weizmann Institute of Science, in the department of Materials and Interfaces, followed by a post-doc with Prof. Brian Wardle at the department of Aeronautics and Astronautics at MIT. Dr. Lachman's major interests are the effects of nanocomposites micro- and nanostructure, and interfacial characteristics, on the composite behavior, and developing and optimizing real-time visual methods to compliment mechanical testing at various length-scales, including nano-scale. She uses

fabrication techniques such as additive manufacturing and Chemical Vapor Deposition (CVD) to control the composite's nanostructure, which will enable the design of new materials with improved efficiency and performance. Dr. Lachman has authored and co-authored 31 journal articles, which have been cited together more than 1200 times.

## Prof. Andrei Manolescu

Nanophysics Center, School of Technology

Reykjavik University, Iceland

### ***"Electronic properties of semiconductor tubular nanowires"***

With recent technologies thin core-shell nanowires of 100 nm diameter or less, and length up to tens of  $\mu\text{m}$ , can be fabricated with semiconductors. Such a structure is made of a core of one material surrounded by a layer of another material, and can be seen as a radial version of the classical planar heterojunction. With an insulating core and a thin conductive shell, a conductor with tubular geometry is obtained. The cross section of bottom-up grown nanowires based on III-V materials is usually polygonal, most often hexagonal, but possibly triangular. Depending on the doping level of the shell and/or band alignment or bending, the carrier concentration in the shell can be sufficiently low, such that the internal structure of the nanowire is reflected in the transport or optical properties. In this presentation some physical consequences of electronic localization in prismatic tubular shells will be discussed. For example, Aharonov-Bohm oscillations, sign reversal of the thermoelectric current, angular anisotropy of the magnetoresistance, inhomogeneous photoluminescence, or splitting of Majorana zero energy modes.



Prof. Andrei Manolescu was born in Bucharest, Romania. He was graduated in physics engineering at the University of Bucharest between 1978-1983, awarded PhD in condensed matter theory at the Institute of Atomic Physics of Bucharest in 1992. He was employed as a researcher in condensed matter physics at National Institute of Materials Physics, Bucharest until 1999, then statistician at Decode Genetics Inc., Reykjavik (Iceland) between 1999-2007. He is a professor at Reykjavik University since 2008 and director of the Nanophysics Center. His research is in condensed matter physics, mostly theoretical and computational, mainly on low-dimensional electron systems, in particular nanowires, many-body Coulomb effects, transport and electromagnetic absorption in nanoscale systems, electronic properties of nanomaterials, photovoltaics, and related subjects.

## Prof. Doron Naveh

Faculty of Engineering  
Bar-Ilan University, Israel

### ***"From enhanced responsivity to deep sensing: advances in light detection"***

The emergence of 2D layered compounds has ameliorated the field of electronic and optoelectronic devices that are considered as a promising platform for the developments of devices in the quantum era. For example, this progress has included the demonstration of ultrafast photodetectors, room-temperature mid-infrared photodetection, and electrical tunable spectral response by Stark effect. In this talk the recent progress on combined trajectories will be discussed – including fast, room temperature short wave infrared detection of hot photo carriers by intercalated MoS<sub>2</sub> and a few examples on the electrical control of spectral response in photodetectors of 2D materials and heterostructures. Finally, the use of computational resources for the performance of spectral measurements, termed *"Deep Sensing"*, will be shortly reviewed.



Prof. Doron Naveh serves as the head of Nanoelectronics program at the Faculty of Engineering, Bar-Ilan University. Prof. Naveh joined the Faculty of Engineering in 2012 after having completed postdoctoral fellowships at Princeton University and at Carnegie Mellon University. Doron Naveh earned his PhD from the Weizmann Institute of Science and his earlier degrees in Physics and Materials Science from Ben-Gurion University of the Negev. His group investigates electronic devices fabricated from graphene and other 2D materials.

## Prof. Vladimir Osipov

Physics and Applied Mathematics Departments, Faculty of Sciences

Holon Institute of Technology (HIT), Israel

### ***"Polariton luminescence under electron-vibrational interaction"***

The formation of the composite photonic-excitonic particle, known as a polariton, is a phenomenon emerging in materials possessing strong coupling to light. The organic-based materials besides the strong light-matter coupling also demonstrate strong interaction of electronic and vibration degrees of freedom. We present a systematic approach to description of the vibration-assisted polariton wave function evolution. Using the multiconfiguration Hartree approach we derive the equations of motion for the polariton wave function, where the vibration degrees of freedom interact with the polariton quantum field through the mean-field Hartree term. For the conventional quadratic polariton Hamiltonian and the Holstein-type vibration Hamiltonian (Tavis-Cummings-Holstein model), the obtained equations are in one-to-one correspondence with the original Schrödinger equation.

We demonstrate that our theory reproduces the physical properties of the polariton light emission spectrum and, in particular, explains the experimentally observed molecular Stokes shift in the polariton fluorescence spectra. When the photon energy become close to the electron excitation energy we predict formation of an infinite potential barrier of a dynamical origin and a metastable mixed polariton state. In the single-mode microcavity, our theory predicts the Fano resonances in the polariton luminescence and also narrowing of the spectral lines with the increase of the total number of molecules in the case of the intramolecular nature of the low frequency vibrations. We expect that our approach will allow to describe collective behavior in polaritonic and similar systems, for example, mutual synchronization of interacting oscillators, oscillation death, superradiance, etc.



Vladimir Osipov finished the Moscow State Physical Engineering Institute (MEPhI) in 1998 with a diploma of engineer-physicist in nuclear physics. He started a research career at the Semenov Institute of Chemical Physics at the Russian Academy of Sciences in Moscow. There, in 2003, he earned PhD in Theoretical and Mathematical Physics. Osipov's first post-doctoral term was made at HIT-Holon Institute of Technology in Israel. After that, he worked at Duisburg-Essen University and Cologne University in the field of theoretical physics. In the 2015, Osipov moved to the Chemical Physics division of Lund University. In 2018 he was invited to the University of California, Irvine to the group of distinguished

Prof. Shaul Mukamel. In 2019 he returned to HIT. In a short time he will move to the professor position at H.I.T. - Harbin Institute of Technology in China.

## Prof. Ester Segal

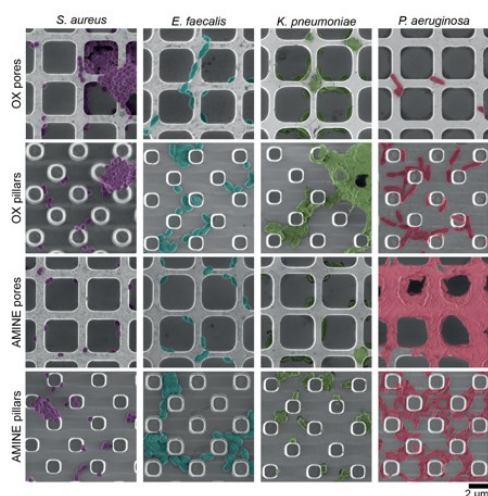
Department of Biotechnology and Food Engineering

Technion – Israel Institute of Technology

### **"Porous silicon-based photonic biosensors for accelerated detection of pathogenic infections and resistant microorganisms"**

The attachment of microorganisms, bacteria and fungi, to abiotic surfaces is of great interest to both the scientific and medical communities and numerous new methods and materials for quantitatively examining bacterial attachment and colony formation on surfaces have recently emerged. Intriguingly, most works have explored micro-/nano-structured substrates as potential antimicrobial surfaces, with an emphasis on antibiofilm properties; whereas, fewer have studied such patterned surfaces as artificial microbial arenas for observing and elucidating the behavior of bacterial communities.

Using engineered porous silicon substrates with carefully designed nano/micro topographies, exhibiting photonic properties, we introduce an optical platform that enables real-time and label-free monitoring of bacterial surface adhesion and colonization. Thus, the porous substrates serve as both a preferable solid-liquid interface for microorganisms networking and a simultaneous transducing element that monitors their response. Such platforms do not require sophisticated microscopy tools or any labels as most of the currently used methods, and it can be conveniently modified with different topographies and surface chemistries, presenting endless study opportunities in a single tool. We demonstrate the application of these platforms to study how different bacterial species, ranging from standard laboratory strains to genetically engineered mutants and clinical isolates, preferentially colonize surfaces with varying topography, wettability and charge and monitor over the formation of a biofilm [1], see Fig. 1. Moreover, we employ these manipulated porous surfaces for solving some critical bottlenecks in clinical microbiology. For example, we have developed a chip-based culture-free method for rapid screening of resistant/susceptible bacteria directly from a clinical sample within only 90 minutes, where current clinical state-of-the-art methods require at least 24 hours.



*Fig. 1: Investigation of pathogenic, clinically relevant bacterial strains (*S. aureus*, *E. faecalis*, *K. pneumoniae*, and *P. aeruginosa*) on oxidized (OX) and amine-terminated silicon pore and pillar microtopologies. Bacteria are false coloured for clarity.*

- [1] Leonard H., Jiang X., Arshavsky-Graham S., Holtzman L., Haimov H., Weizman D., Halachmi S., Segal E., *Nanoscale Horizons*, 7, 729 (2022).



Ester Segal earned her BSc degree in Chemical Engineering from the Technion - Israel Institute of Technology with a cum laude distinction. She completed her PhD in Chemical Engineering from the Technion in 2004 and later trained at the University of California – San Diego, under the direction of Professor Michael J. Sailor as a Rothschild postdoctoral fellow. She began her independent career in the Department of Biotechnology and Food Engineering at the Technion in 2007, where she is now a Full Professor and the Beatrice Sensibar Chair in Engineering. She is the recipient of the 2019 Advances in Measurement Science Lectureship Award by the American Chemical Society, and she serves on the advisory board of ACS Sensors and ACS Measurement Science Au. Her research focuses on the broad interface between materials science and biotechnology to address challenges in medical diagnostics, food safety, and therapy.



## Prof. Pavel Ginzburg

School of Electrical Engineering

Tel Aviv University, Israel

### ***"Optics behind vaterite-based drug delivery"***

Nano-engineered capsules for targeted drug delivery are an essential milestone on pathways to advance precision medicine concepts. As a vast majority of phenomena occur in a liquid environment in vivo, understanding cargo-fluid interaction mechanisms in vitro becomes an important factor, which can control the drug release rates. In this contribution, we will introduce the concept of a metamaterial drug delivery capsule, "golden vaterite", and demonstrate its unambiguous advantages in the future paradigm of light-driven theranostics. In particular, optomechanical drug delivery, bioimaging, drug release, and thermal therapy with the aid of 'golden vaterite' will be shown.



Pavel Ginzburg is an Associate Professor at Tel Aviv University. He is a former EPSRC Research Fellow, International Newton Research Fellow, and Rothschild Fellow at King's College London. He obtained all his degrees in Electrical Engineering at the Technion and took a part in the Technion Excellence Program. He received his PhD from Technion in 2011 on the special "Clare Scholars Programme" course. In his research, he was also involved in the discoveries of several novel phenomena, and he was awarded the "Hershel Rich Innovation Award". His PhD thesis was awarded by QEOD Thesis Prize for Applied Aspects (EPS). Nowadays, Pavel holds a prestigious Alon Fellowship, designated for young faculty members.

Prof. Pavel Ginzburg is the head of 'Dynamics of Nanostructures' Laboratory, encompassing theoretical group, optical spectroscopy, and radio waves labs. The Laboratory runs multidisciplinary research in the field of Optics, Biophotonics, Quantum Mechanics, Solid State Physics, Nano-plasmonics and Metamaterials, Optical Forces, and Radio Physics. Pavel Ginzburg has authored 135 journal papers, over 200 conference presentations, and 5 patents. He is a co-founder of 2 start-up companies.

# Poster Presentations

# P1

## Hidden Optical Imaging in Thin Polymer Films with Embedded Fluorescent Peptide Nanodots

P. Rosenbaum<sup>1</sup>, H. Bahrum<sup>2</sup>, A. Inberg<sup>1</sup>, G. Rosenman<sup>2</sup>, B. Apter<sup>1</sup>

<sup>1</sup>Faculty of Engineering, Holon Institute of Technology, Holon, Israel

<sup>2</sup>School of Electrical Engineering, Tel Aviv University, Tel Aviv, Israel

Fluorescent (FL) encoding nano-structures such as quantum dots, carbon dots, organic dyes, lanthanide nanocrystals, DNA and more are effective tool for advanced application in high resolution hidden imaging for tracking, labeling, security printing, anti-counterfeiting drugs technology, and more. Another FL nanostructures, proposed in this work, is recently discovered peptide nanometer scale nanodots. These biocompatible nanodots exhibit strong and tunable FL effect when refolded into particular beta-sheet peptide secondary structure. This biophotonic FL covers a full visible spectrum and makes the peptide dots new nanoscale light sources with 30% of the quantum yield. Our studies showed that these FL biodots also reveal a strong effect of photobleaching which is ascribed to light-induced destruction of noncovalent hydrogen bonds stabilizing the supramolecular refolded beta-sheets FL dots structure. In this work we report on a new approach for optical memory by tailoring hidden images in developed thin PVA polymer films with embedded FL peptide nanodots. A new technology allowed recording different photo-bleached patterns, barcodes, and images of high resolution (Figure). Specific experimental conditions of photo-bleached patterns recording followed by FL hidden images readout are described.

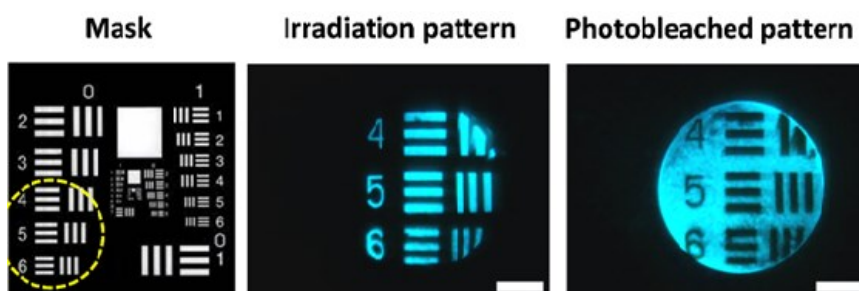


Figure 1. Hidden images (photo-bleached patterns) tailored in thin polymer films with embedded Fluorescent Peptide Nanodots.

## P2

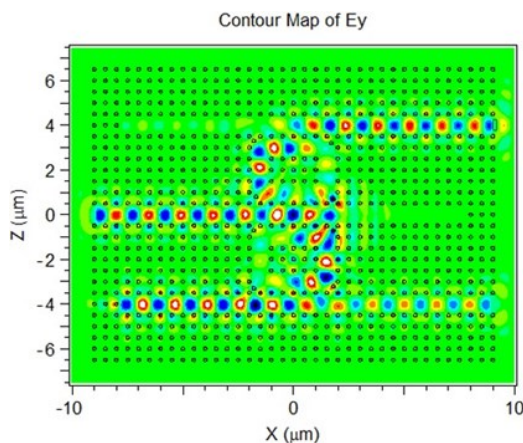
### Design of All-Optical Logic Half-Adder Based on Photonic Crystal Multi-Ring Resonator

Yonatan Pugachov, Moria Gulitski, Omri Mizrahi, Dror Malka\*

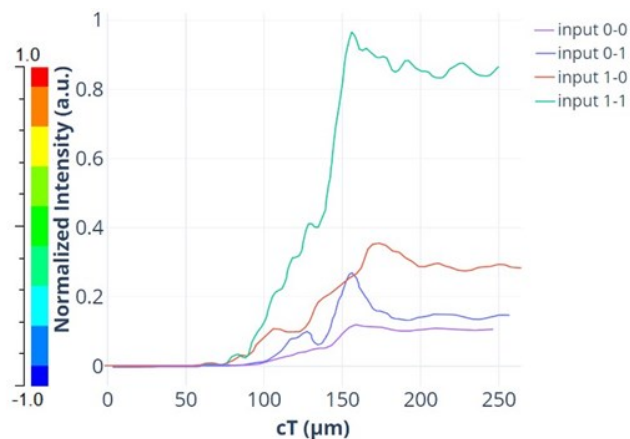
Faculty of Engineering, Holon Institute of Technology (HIT), Holon, Israel

\*Corresponding author [dorm@hit.ac.il](mailto:dorm@hit.ac.il)

In this paper, a novel design of an all-optical half-adder (HA) based on two two-ring resonators in a two-dimensional square-lattice photonic crystal (PC) structure without nonlinear materials is proposed. The all-optical HA comprises AND and XOR gates where each gate is composed of cross-shaped waveguides and two-ring resonators in a 2D square-lattice PC that are filled with silicon (Si) rods in silica ( $\text{SiO}_2$ ). The AND and XOR gates are analyzed and simulated using plane-wave expansion (PWE) and finite-difference time-domain (FDTD) methods. Simulation results show that light guiding inside the device functions as AND and XOR gates. Thus, the proposed device has the potential for use in optical arithmetic logic units for digital computing circuits. The structure comprises an optical AND gate and an optical XOR gate that were designed to work at the C-band spectrum. Results show that there is a clear distinction between logic states 1 and 0 with a narrow power range that leads to a better robust decision on the receiver side for minimized logic errors in the photonic decision circuit. Thus, the proposed HA can be a key component for designing a photonic arithmetic logic unit.



Light intensity propagation profile of the Gaussian pulses at the x-z plane for AND PC gate.



Light intensity diagram for AND gate with inputs: 0-0, 0-1, 1-0, 1-1.

[1] Pugachov, Y.; Gulitski, M.; Mizrahi, O.; Malka, D. Design of All-Optical Logic Half-Adder Based on Photonic Crystal Multi-Ring Resonator. *Symmetry* 2023, 15, 1063. <https://doi.org/10.3390/sym15051063>

## P3

### Engineering of Solid Oxide Fuel Cell's Electrode Containing a Heterogeneous Catalyst for Simultaneous Ammonia Synthesis and Energy Conversion

Or Rahumi<sup>1</sup>, Manasa Kumar Rath, Konstantin Borodianskiy

Department of Chemical Engineering, Ariel University, Ariel, Israel.

Solid oxide fuel cells (SOFC) are prominent electrochemical devices for directly converting chemical energy into electricity due to their fuel flexibility and high conversion efficiency, at a high-operating temperature range of 600–800°C [1]. Alongside the generated electrical power, rarely SOFC's operation can be expanded also to the coproduction of desired chemical components during the cell's operation as a valuable byproduct [2,3].

Ammonia (NH<sub>3</sub>) is one of the most demanded chemicals in the world. Up to these days, ammonia is being produced through the well-known Heber-Bosch process, which requires strict operating conditions and involves high greenhouse gas emissions and high energy consumption [4]. Therefore, the co-production of electricity and ammonia using a SOFC operation is an innovative and cost-efficient approach.

In this study, manganese-nitride modified Ni-ScSZ supported SOFC was fabricated for simultaneous ammonia synthesis and energy conversion. X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) analysis revealed the chemical stability of the nitride catalyst under H<sub>2</sub> and N<sub>2</sub> atmospheres at cell operating conditions, and the nitrogen reduction reaction (NRR) over the Mn<sub>4</sub>N active sites was confirmed. Electrochemical impedance (EIS) analysis revealed improved activity toward hydrogen oxidation reaction and NRR during cell operation. The catalyst-modified cell exhibited peak power densities of 539 and 374 mW·cm<sup>-2</sup> for humidified H<sub>2</sub> and dry N<sub>2</sub>/H<sub>2</sub> (1:1) mixture, respectively. Furthermore, a significantly high rate of ammonia production 1.63×10<sup>-9</sup> mol cm<sup>-2</sup> s<sup>-1</sup> combined with a power density of 348 mW cm<sup>-2</sup> was achieved at 800°C.

- [1] N. Q. Minh, *Solid State Ionics*, **174**, 271–277, 2004.
- [2] K. Panagi, C. J. Laycock, J. P. Reed, and A. J. Guwy, *Appl. Energy*, **255**, 113854, 2019.
- [3] A. Perna, et. al., *Appl. Energy*, **231**, 1216–1229, 2018.
- [4] J. W. Erisman, et. al., *Nat. Geosci.*, **1**, 636–639, 2008.

## P4

### Redox-Sensitive Nanoparticles Based on Trithiocyanuric Acid for Antitumor Drug Delivery

Oleksii O. Peltek, Elena Kopoleva

School of Physics and Engineering, ITMO University, St. Petersburg, Russian Federation

This work introduces a novel methodology for the synthesis of redox-sensitive nanoparticles using trithiocyanuric acid (TTCA) as carriers for low-molecular antitumor drugs. The TTCA-based carriers exhibit commendable adsorption capacity, biocompatibility, and intracellular drug-release capability. We present a synthesis route for TTCA-based nanoparticles, investigate their structure and morphology features, and study drug delivery perspective using doxorubicin as a model drug.

The potential of redox-sensitive nanoparticles as a drug delivery system for biologically active molecules is underscored in this research. Their efficiency heavily relies on their unique therapeutic agent release mechanism, based on the intracellular degradation of the particle material due to inherent redox processes, paving the way for stimulus-sensitive and controlled drug delivery. Compounds comprised of disulfide bonds, mild oxidation products of thiol groups, serve as the material of choice for these particles. TTCA was selected as the polycondensation reaction monomer, representing the novelty of this study in the realm of nanotechnologies for biomedical applications.

Protocols were established for synthesizing TTCA nanoparticles with various size distributions, different ratios of free SH groups to oxidized disulfide bonds, and degrees of modification with polyethylene glycol. Furthermore, the biocompatibility of these materials was investigated using 4T1 and A549 cell lines, and the efficacy of TTCA nanoparticles loaded with doxorubicin was evaluated.

Our results indicate that TTCA is a promising compound for use in the delivery of small therapeutic molecules, demonstrating non-toxicity, biocompatibility, biodegradability, and excellent adsorption capacity. Future studies aim to investigate the efficacy of the developed delivery system *in vivo*.

In a broader context, this research contributes to the burgeoning field of nanotechnology in drug delivery systems. It seeks to simplify and economize the synthesis of redox-sensitive systems, thereby facilitating their potential clinical deployment. The development and study of these systems can improve pharmacokinetics of various antitumor drugs, presenting a step forward towards personalized medicine and high-tech healthcare.

## Synthesis of Pure Phase and Highly Crystalline WS<sub>2</sub> & MoS<sub>2</sub> Inorganic Nanotubes: their Growth Mechanisms

**K. Manjunath, S. Ghosh, P. Chithaiah, A. Zak\***

HIT-Holon Institute of Technology, Holon, Israel

Inorganic nanotubes (INTs) such as WS<sub>2</sub> and MoS<sub>2</sub> with 1D morphology demonstrate unique properties due to their semiconductor nature, mechanical strength, nanosize, closed-cage arrangement of the layers into chiral tubes, and polar structure [1]. WS<sub>2</sub> INTs were first discovered in 1992 [2], but their pure-phase synthesis remained as challenging. However, the WS<sub>2</sub> INTs with the pure, highly crystalline phase and scalable amounts were achieved in 2009 [3] because of the attentive investigation of the reaction parameters, precursor properties, and understanding of WS<sub>2</sub> nanotubes' growth mechanisms. Similarly, MoS<sub>2</sub> INTs were discovered in 1995 [4], and their reproducibility was achieved in 2020 (~25 years after their discovery) but in low yield. Both WS<sub>2</sub> and MoS<sub>2</sub> INTs were synthesized by the catalyst-free, vapor-gas-solid (VGS) method using their respective metal-oxides under H<sub>2</sub>/H<sub>2</sub>S gas flows [5]. Subsequently, several efforts were made to prepare MoS<sub>2</sub> nanotubes in pure and highly crystalline phases successfully. Especially low-temperature synthesis of high-aspect-ratio MoO<sub>3</sub> nanowhiskers and their sulfurization to convert them into hollow MoS<sub>2</sub> NTs in pure (100%) 1D phase. This process could result in perfectly crystalline tubes or tubes with high basal surface defects depending on reaction parameters. The crystalline tubes are perfectly suitable for electronic and optical devices, while defect-rich nanotubes benefit electrocatalytic hydrogen evolution reaction (HER). MoS<sub>2</sub> INTs are 40 % lighter and expected to be 40 % stronger than WS<sub>2</sub> INTs [6] and promise more efficient performance in several applications.

- [1] Sun *et al.*, **Nat Commun.** 2022, 13, 5391.
- [2] Tenne *et al.*, **Nature** 1992, 360, 444.
- [3] Zak *et al.*, **Nano** 2009, 4, 91.
- [4] Feldman *et al.*, **Science** 1995, 267, 222.
- [5] Chithaiah *et al.*, **ACS Nano** 2020, 14, 3004.
- [6] Ashiri *et al.*, **J. Mater. Res.** 2006, 19, 454.

## P6

### **Alloy Nanowire Arrays with Controlled Compositions Templated by Block Copolymers**

**Ofer Burg, Roy Shenhar\***

Institute of Chemistry and the Center for Nanoscience and Nanotechnology, the Hebrew University of  
Jerusalem, Israel

ofer.burg@mail.huji.ac.il; roys@huji.ac.il

Metallic nanowire arrays are promising components for nanotechnology thanks to their directional, continuous, longitudinal structure. Nanowires made from alloys of two or more metals are beneficial for certain applications such as catalysis and magnetism. The alloy composition influences the properties of the nanowires, and certain metal ratios show improved properties compared to those of their individual constituents. Yet, creating these nanowire arrays requires enhanced control over their composition and organization. This requirement may be answered by using block copolymer films, which provide three advantages: (a) they exhibit periodic arrays with typical periodicities of a few tens of nanometers; (b) the domains could be aligned using patterned substrates; (c) selective impregnation of the films with metal precursors and subsequent plasma treatment affords metallic nanowire arrays that are organized in a periodic fashion.

In this work, we use block copolymer films to create arrays of alloy nanowires with controlled compositions. We achieve this control by studying how different impregnation parameters affect the amount of metal in the nanowires and the metal ratio in alloys. Namely, impregnating with palladium precursors, followed by platinum precursors for different durations, shows how one metal increases over the other, and the rate of metal precursor replacement in the film. Additionally, impregnating with a mixture of palladium and platinum precursors in different ratios gives different Pd-Pt alloys, and elucidates the affinity of each metal to the film. These experiments give an understanding of the interaction between the metal precursors and the polymer film and lay a foundation for fabricating alloy nanowires with controlled compositions.



**Reinforcing Polyetherimide with WS<sub>2</sub> Nanotubes into Highly Oriented Nanocomposite Strings****D. Babai<sup>a, b</sup>, R. Tenne<sup>b</sup>, D. Naveh<sup>a</sup>,**<sup>a</sup>Faculty of Engineering and Bar-Ilan Institute for Nanotechnology and Advanced Materials, Bar-Ilan University, Ramat-Gan, Israel.<sup>b</sup>Department of Molecular Chemistry and Materials Science, Weizmann Institute of Science, Rehovot, Israel

Email: babaido@biu.ac.il

Improving the mechanical properties of advanced polymers is a desirable goal, especially for the high-tech and aerospace industries regarding the toughness to density ratio. This study investigated the potential of reinforcing polyetherimide (PEI), commercially known by the name Ultem, with tungsten disulfide inorganic nanotubes (WS<sub>2</sub> INT). A new method for dispersing the WS<sub>2</sub> INT into a molten PEI solution and pulling long threads from it was successfully demonstrated, resulting in highly oriented nanocomposite strings. The new nanocomposite strings were exhaustively characterized to assess the homogeneity of the nanotubes dispersion in the solid polymer and their orientation, which was found to be mostly in parallel with the string axis. Studying the mechanical behavior of these nanocomposite strings under tensile test emphasizes the contribution of the oriented nanotubes to the string mechanical properties. The embedded WS<sub>2</sub> INT were found to accelerate the PEI intrinsic mechanism of strain hardening. We also found that higher quantities of WS<sub>2</sub> INT led to a shortened range of plastic flow under constant load and an accelerated elastoplastic mode of behavior with steeper linear trend. The elastoplastic behavior is known to involve  $\pi$ - $\pi$  interactions, which occur due to the tensile alignment of the PEI molecular chains in one direction and densification of the chains in the perpendicular direction. XRD measurements of the strained nanocomposite strings revealed a quasi-crystalline structure, which is attributed to the oriented molecular chains owing to strong  $\pi$ - $\pi$  stacking.

Reinforcing PEI with 2 wt % WS<sub>2</sub> INT led to remarkable ultimate tensile stress (UTS) value of around 450 MPa.

Our findings suggest that WS<sub>2</sub> INT-reinforced PEI nanocomposites have the potential to achieve higher mechanical properties with an improved toughness to density ratio, making them ideal for advanced applications in high-tech and aerospace industries.

## P8

### Photochemistry Signature of Xenon-Water Sandwich Film (Xe@H<sub>2</sub>O) on Ruthenium Ru(0001) Substrate in Interstellar Medium upon Electron Bombardment

Ahmad Nawaz\*, Roey Sagi, Hiley Iny, Micha Asscher

Institute of Chemistry, Faculty of Science, the Hebrew University of Jerusalem, Israel

\*Corresponding Email: ahmad.nawaz@mail.huji.ac.il

The desorption kinetics of Xe@H<sub>2</sub>O film deposited on a Ru (0001) surface under ultra-high vacuum (UHV) environment ( $2 \times 10^{-10}$  Torr) has been investigated as a model study for electrons-induced reactivity that takes place in the interstellar medium, using temperature-programmed desorption (TPD) measurements, at substrate temperature of 35K. The TPD spectra of all the prominent product masses were well detected by the QMS, employing a 3D-TPD analysis. The N<sub>2</sub>O molecules, embedded within ASW as the host matrix, decompose upon exposure to electrons at kinetic energies of 10eV and 50 eV. This leads to the formation of new molecular as the primary products. Typical TPD spectra of the parent Xe molecules, while embedded in ASW layer (15 ML) are shown in Figure 1a. Here, the primary Xe TPD peaks appear at ~55K, while some of these molecules are trapped within the water film and desorb together with the main ASW film at ~160K. Decomposition cross sections for the various electron-induced products will be discussed in the main poster.

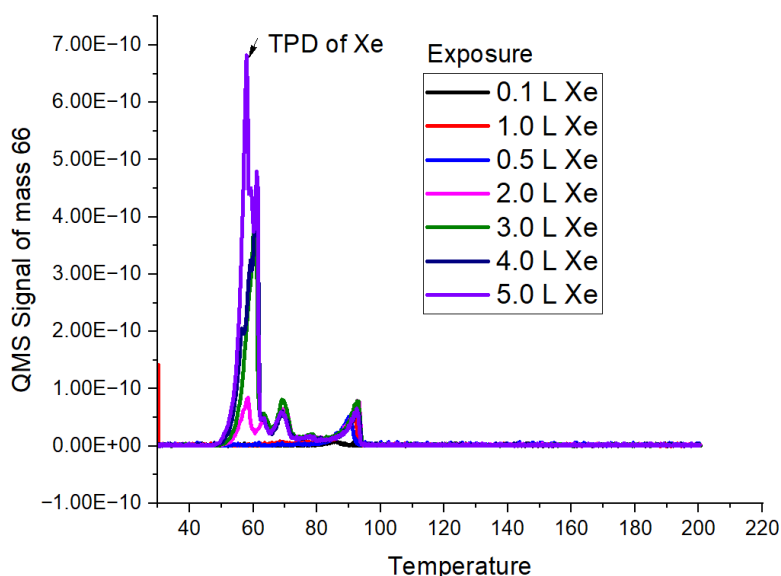


Fig. 1: a) TPD of 15 ML sandwich layer [5ML H<sub>2</sub>O+6ML Xe + 4ML H<sub>2</sub>O] with its multilayer peak at 55K.

[1] G.Toker and M. Asscher, Phys.Rev.Lett., **107**, 167402 (2011).

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## P9

### Nanobubbles for Groundwater Remediation

#### Inspecting the Effects of Solution Chemistry and Porous Media Characteristics on Nanobubbles Transport

Lina Borsky<sup>1</sup>, Yinon Yechezkel<sup>1</sup>, Ines Zucker<sup>1,2</sup>

<sup>1</sup>School of Mechanical Engineering, Faculty of Engineering, Tel Aviv University, Israel

<sup>2</sup>Porter School of Earth and Environmental Studies, Faculty of Exact Sciences, Tel Aviv University, Israel

Nanobubbles are tiny gas-filled cavities smaller than 1000 nm in diameter, stable in liquids due to their negligible buoyancy. They are negatively charged and maintain high internal pressure, making them significant entities with potential applications in various fields - such as advanced oxidation of groundwater.

We hypothesize that usage of nanobubbles can increase the efficiency of groundwater ozonation process. Typical ozonation process in contaminated water is conducted by delivering dissolved ozone, which is ~200 times less stable compared to gaseous ozone. Stabilizing the ozone molecules by keeping them in gaseous phase will lead to faster oxidation and will reduce energy costs. Therefore, by delivering ozone-filled nanobubbles into contaminated groundwaters, we expect to see higher removal rates and larger radius of influence.

The current fundamental scientific knowledge regarding the interactions between nanobubbles and porous media is limited. The interactions between nanobubbles and porous media can be repulsive, attractive, or inert and can involve sorption or destruction mechanisms. Additionally, nanobubbles' size and concentration can be influenced by changes in solution chemistry.

In this study, we investigated how changes in solution chemistry (pH, ionic strength, and valence) and media characteristics (surface roughness, size and wettability) affect size and concentration of nanobubbles (which are measured using NTA – Nanoparticles Tracking Analysis) in dynamic conditions using column experiments. We show that nanobubbles concentration at the outlet of a column (filled with glass beads) decreases with increasing ionic strength and valence, and decreasing pH. No obvious trend of the bubbles' size at the outlet is recognized. This behaviour can be explained by the correlation between solution type and the nanobubbles' and glass-beads'  $\zeta$ -potential, which governed the repulsion and attraction forces between them. Additionally, to isolate the sorption phenomenon, nanobubbles solution is tested using QCMD. Sorption of particles to the quartz sensor changes its resonance frequency, which allows the identification of sorption rate and close inspection of the solution type influences.

Overall, this fundamental study provides valuable insights into the behaviour of nanobubbles in dynamic conditions within porous media, under different chemical and physical conditions. Further research and understanding of the interactions between nanobubbles and porous media will contribute to optimizing the design and application of nanobubbles for enhanced groundwater ozonation and other potential applications.

# P10

## Self-Assembly Based Fabrication of Optical Sub-Wavelength Structures

<sup>1,2</sup>Sivan Tzadka, <sup>1,2</sup> Lotem Kitaroo, <sup>1,2</sup> Mark Schwartzman

<sup>1</sup>Department of Materials Engineering and <sup>2</sup>Ilse Katz Institute for Nanoscale Science & Technology, Ben-Gurion University of the Negev, Beer-Sheva, Israel

Any optical surface reflects light, and this reflection reduces the quality of the image passed through eyeglasses, telescopes, or optics for autonomous driving. This reflection also produces ghosting and glare in the camera and displays. Traditionally, the reflection is addressed by thin antireflective films, which are, however, effective only for a limited range of the spectrum. Furthermore, these films are quickly damaged due to scratching, cracking, and detachment, especially when exposed to harsh environments or sudden temperature changes. The solution comes from nature: It was discovered that the cornea of some insects, such as moths, are covered with nanometric conical bumps. While smaller than the wavelength of light, these bumps produce an optical effect that prevents light reflection for a broad range of light colors and angles, which is unachievable by thin films. The idea of using artificial biomimetic moth-eye structures to reduce reflection from optical surfaces has been extensively discussed over the last two decades. Yet, the realization of this idea was challenged by the lack of scalable methods to produce biomimetic objects sized a few times smaller than the wavelength of light, i.e. down to one hundred nanometers.

In this work, we examine two novel approaches to fabricating moth-eye nanostructures using nanopatterning from the bottom up. In the first approach, polystyrene nanoparticles are assembled on the optical surface using Langmuir-Blodgett technique, following the controlled reduction of the nanoparticle diameter by Oxygen plasma, deposition of a metallic mask, plasma etching of the substrate, and removal of the remained mask by wet etching. In the second approach, the assembly of nanoparticles is done by a novel approach based on the mechanical assembly of nanoparticles onto a surface of elastomer to get a packed particle monolayer and transfer of these nanoparticles onto the optical surface. We first compared between the two approaches in terms of the quality of the particle assembly, using home-made algorithm for image processing of the SEM of the resulting monolayers. We then used both approaches to fabricate broadband antireflective nanostructures on Sapphire, and characterized their optical performance by surface reflection. The experimentally obtained reflection spectra also showed good agreement with those obtained by simulations using Effective Medium Theory. Overall, our work provides a new route for facile and high-throughput nanostructuring of optical surfaces, and paves the way for numerous optical applications.

# P11

## Exploring the Synthesis Mechanisms of Novel CsPbBr<sub>3</sub>@MoS<sub>2</sub> Nanostructures Toward their Implementation in the Field of Renewable Energy

Achiad Goldreic, Lena Yadgarov

Department of Chemical Engineering, Ariel University, Ariel,, Israel

The capacity to capture and convert solar energy into efficient, environmentally friendly, and renewable power sources has wide-ranging implications globally, spanning across scientific and technological domains. Halide perovskites (HPs) exhibit remarkable performance in optoelectronics and photovoltaic devices, making them promising materials for a vast gamut of applications.<sup>[1]</sup> Within the halide perovskites family, the nanocrystals of CsPbBr<sub>3</sub> stand out with their extraordinary photoelectric properties, positioning them as a highly promising option for photovoltaic devices. Nonetheless, their widespread adoption faces obstacles due to their intrinsic instability and toxicity, resulting in detrimental phase changes and decomposition when exposed to environmental factors.<sup>[2]</sup> To surmount these challenges, a well-established and effective approach entails the development of a protective shell surrounding the core perovskite. This shell acts as a physical barrier, providing stability to the perovskite and augmenting the optical characteristics of the core material. Previous studies have demonstrated the potential of transition metal dichalcogenides (TMDs) as agents for surface passivation and exhibiting outstanding optoelectronic properties.<sup>[3]</sup> Moreover, owing to the TMD's semiconductor features, their bandgap and work functions can be modified by various methods, such as doping or induced strain. Indeed, it was shown that MoS<sub>2</sub> doped with sulfur deficiency serves as an additive to solar cells and produces very stable devices. Herein, we developed a new synthetic strategy for stabilizing HPs and boosting their optoelectronic properties by sheeting the NCs with TMDs. We investigate the synthesis mechanism by analyzing each step using a gamut of analytical methods. Namely, we study the mechanism of MoS<sub>2</sub> shell formation around the CsPbBr<sub>3</sub> NCs by examining the impact of the reaction temperature and the concentration of the precursors. Moreover, the analysis of the optical properties of the core-shell nanostructures indicates a charge transfer from the conduction band (CB) of the CsPbBr<sub>3</sub> NCs to the CB of MoS<sub>2</sub>. The findings from our study are anticipated to facilitate the integration of halide perovskites into sustainable energy applications and pave the way to their rapid commercialization.

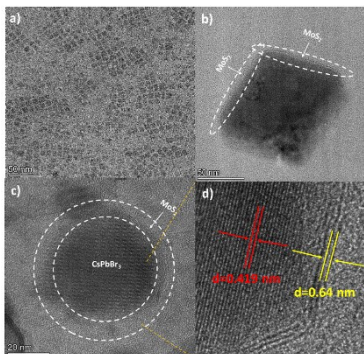


Figure 1. TEM images of (a) CsPbBr<sub>3</sub> NPs, (b) CsPbBr<sub>3</sub> with a MoS<sub>2</sub> partial coating, (c) complete encapsulation of MoS<sub>2</sub> on CsPbBr<sub>3</sub> NPs, (d) HR-TEM images of CsPbBr<sub>3</sub> with a lattice spacing of 0.419 nm (red), and MoS<sub>2</sub> with 0.64 nm (yellow)

- [1] A. Swarnkar, A. R. Marshall, E. M. Sanehira, B. D. Chernomordik, D. T. Moore, J. A. Christians, T. Chakrabarti, J. M. Luther, *Science (New York, N.Y.)* **2016**, *354*, 92-95.
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## P12

### A Novel, Compact and High-Performance Time-Of-Flight Mass Spectrometer for Residual Gas Analysis: The IonTamer™

**Federico Binda, Sébastien Gas**

Spacetek Technology AG; Brüggliweg 18, 3073 Muri bei Bern, Switzerland; [www.spacetek.ch](http://www.spacetek.ch)

[federico.binda@spacetek.ch](mailto:federico.binda@spacetek.ch), [sales@spacetek.ch](mailto:sales@spacetek.ch)

Spacetek Technology AG has developed the IonTamer™, a compact and high-performance mass spectrometer originally designed for space applications. Through meticulous engineering, the IonTamer™ has been optimized to overcome the inherent limitations of space environment, ensuring compactness and long-term reliability even in the harshest conditions.

The IonTamer™ sets a new standard in residual gas analysis, surpassing conventional and widely used quadrupole mass spectrometers. This breakthrough includes the miniaturization of traditionally bulky time-of-flight technology, resulting in a compact design for the first time. The IonTamer™ empowers in-situ, fully quantitative, and highly sensitive analysis of gas composition, along with real-time monitoring capabilities [1]. In a single measurement, it can detect all gas species within the mass-to-charge ( $m/z$ ) range of 1-1200, providing a mass resolution of  $m/\Delta m = 1200$  at  $m/z = 132$  and achieving sensitivity at the parts-per-billion (ppb) level. Continuous and immediate data acquisition is enabled by its capability to acquire measurements every 0.1 second.

The IonTamer™ mass spectrometer finds applications in various fields, including semiconductor manufacturing, OLED display production, optics, solar panel manufacturing, and vacuum-based processes. Its compact design allows seamless integration in space-constrained settings without compromising performance, making it a highly valuable monitoring tool for both academia and industry.

[1] Gasc, Sébastien, and Lukas Hofer. "Novel Time-of-Flight Residual Gas Analyzer (TOF-RGA) for in situ Real-time Process Monitoring." *Chimia* 76.1-2 (2022): 52-52.

## P13

### Laser-Processed Direct Coating of Graphene-Based Films on Plastic Substrates with Anti-Bacterial Properties

Aneena Lal<sup>1</sup>, Rivka Cahan<sup>2</sup>, Arie Borenstein<sup>1\*</sup>

<sup>1</sup>Department of Chemical Sciences, Ariel University, Ariel, Israel

<sup>2</sup>Department of Chemical Engineering, Ariel University, Ariel, Israel

Enormous efforts are devoted to the search for cost-effective, easy, and single-step synthesis techniques for micron-thick coatings. Recently, laser processing emerged as a novel method to form micron-thick films of highly graphitic carbon. Laser processing offers significant advancements including (1) fast, single-step, and waste-free synthesis, (2) allowing direct printing of graphene over any substrate, including thermal-sensitive materials (i.e., polymers), and (c) micron-resolution patterning of the coated materials. In this work, we use an intense laser beam to fabricate graphene-metal-oxide nanoparticles composites films. The metal-oxide nanoparticle films (Cobalt and Copper) are tested for antibacterial activity. Due to the combined formation, the metal-oxide nanoparticles are highly dispersed and strongly adhered to the graphene matrix. Importantly, chemical and physical properties such as the graphitization level can be controlled by tuning the laser parameters. Moreover, the composite coatings demonstrate anti-bacterial activity. Studying substrates coated with different compositions of metal found that 4.5-5% of metal contents have antibacterial activity (% inhibition), by 89%. Moreover, leaching studies demonstrate the fabricated substrates are stable in different pH solutions.

## P14

### Carbon Nanodots Driven Coating of WS<sub>2</sub> Nanotubes Improves Hydrogen Evolution Reaction

Asmita Dutta, Alla Zak, Arie Borenstein

Ariel University, Ariel, Israel

[asmita@ariel.ac.il](mailto:asmita@ariel.ac.il)

Transition metal dichalcogenides have recently been proposed as an excellent catalytic substitute for noble metals for hydrogen evolution reaction (HER). However, these alternatives often suffer from inferior performance. The poor performance of WS<sub>2</sub> nanotubes attributes intrinsically inert basal plane and lack of active edge sites which causes less electron transport and low conductivity. In this work, tungsten disulfide nanotubes (WS<sub>2</sub> NT) are coated with nitrogen-doped graphitic carbon, in three steps. Excess carbon from the sample is removed by CO<sub>2</sub> gas which acts as a mild oxidizer. Finally, recrystallization at 800° C is done by thermal annealing in presence of N<sub>2</sub>. Products from each reaction step are chemically analyzed. The heterostructure with carbon after recrystallization shows significantly improved HER performance showing an onset potential of 172 mV compared to 540 of the uncoated NTs. The improved activity was confirmed in different pH electrolytes. Moreover, stability measurements prove enhanced efficiency of the composites upon prolonged electrochemical reaction. The formation of carbon-coated INT-WS<sub>2</sub> nanostructure provides a promising way to obtain a pH-universal, cost-effective electrocatalyst for energy conversion.

[1] Jinqiang Zhang, Hagit Sade, Yufei Zhao, Adrian T. Murdock, Avi Bendavid, JeanPaul Lellouche, Guoxiu Wang, Zhaojun Han. *Nanotechnology*, 30, 035401

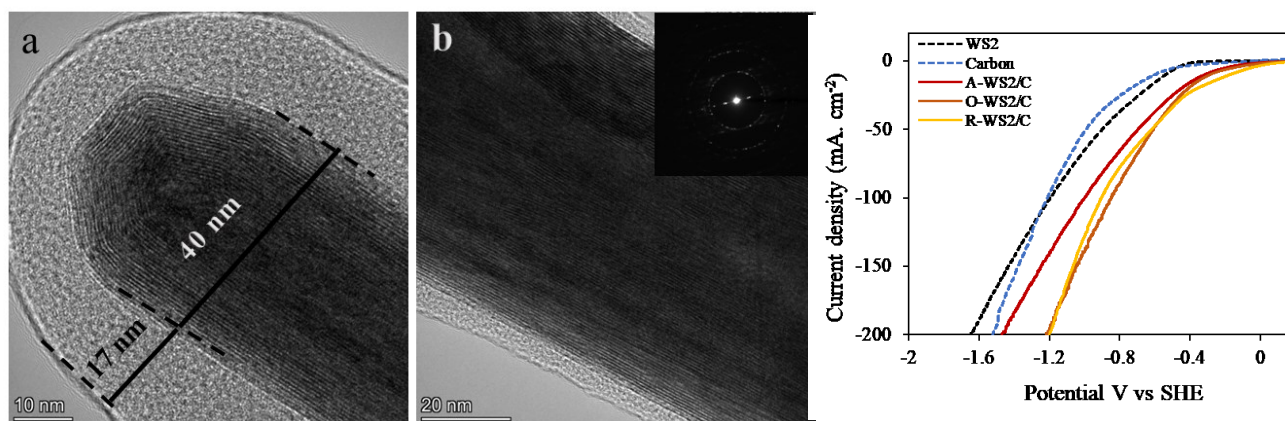


Figure 1. (Left) TEM magnification image of WS<sub>2</sub> nanotube coated by carbon layers. (Right) LSV curves showing H<sub>2</sub> evolution reaction in 0.5 M H<sub>2</sub>SO<sub>4</sub>.



# P15

## Enhancing the Stability of Vertically Aligned CsPbBr<sub>3</sub> Nanowire Arrays through Template-Assisted Growth

Neena Prasad, Lena Yadgarov\*

Department of Chemical Engineering, Ariel University, Ariel, Israel

\*[lenay@ariel.ac.il](mailto:lenay@ariel.ac.il)

Metal halide perovskites (HPs) are being recognized as a novel category of semiconductor nanomaterials because of their fascinating properties and potential applications. However, their instability when exposed to air and light presents a significant challenge, severely limiting their practical applications. In this study, we explore the growth of CsPbBr<sub>3</sub> nanowire arrays within anodized alumina oxide (AAO) templates. Here the AAO has a double purpose: on the one hand, it is a stabilizing media. On the other hand, the ordered honeycomb-like array of the AAO template can be used to enhance and control the light-matter interaction within the HP's nanowires. We use the inverse temperature crystallization (ITC) method to successfully grow the nanowires within the AAO templates. Furthermore, we employ "finite-difference time-domain" (FDTD) simulations to explore the light-matter interaction within the nanowires and the entire AAO/HPs structure. These simulations provide insights into the absorption properties and electric field distributions inside and between the nanowires. Moreover, we use the FDTD simulations to optimize the light-matter interaction by varying the pore diameter and inter-pore distance. The results obtained from the FDTD simulations align well with the experimental findings, affirming the reliability of our approach. Overall, this study is a significant reference for future advancements in developing highly stable halide perovskite nanowire-based devices, opening doors for diverse applications in the field of photonics or renewable energy.

Keywords: Metal halide perovskites, Anodized alumina oxide, Templated growth, Electric filed distribution

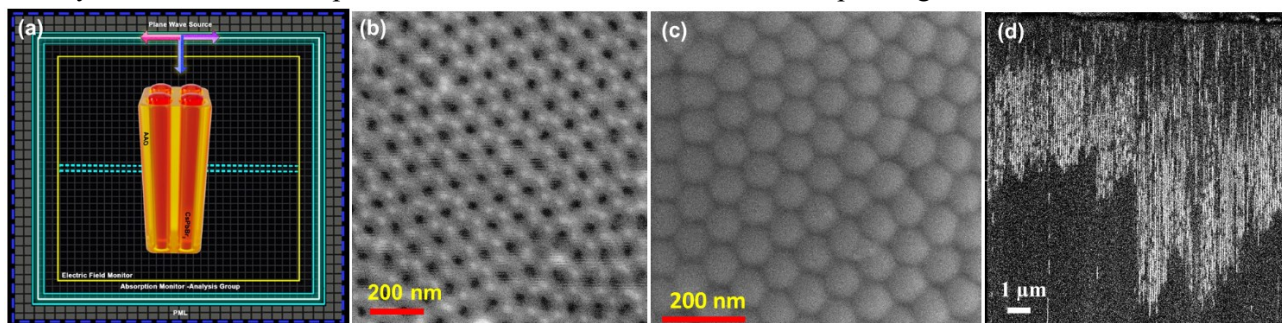


Figure 1 (a) FDTD Simulation setup and layout (b) SEM image of porous AAO (c) SEM top view of AAO/HPs structure (d) cross-sectional view AAO/HPs structure.

# P16

## Novel CsPbBr<sub>3</sub>@MoS<sub>2</sub> Nanostructures: Nanoscale Modeling of the Optical Response Toward their Implementation in the Field of Renewable Energy

Jonathan Prilusky, Lena Yadgarov

Department of Chemical Engineering, Ariel University, Ariel, Israel

The ability to convert solar energy to effective, clean, and renewable energy sources has vast global implications, both scientifically and technologically. Halide perovskites (HPs) exhibit excellent optoelectronic and photovoltaic device performance and have a high potential for use in applications such as solar cells and photocatalysis. Inorganic CsPbBr<sub>3</sub> perovskite is a promising candidate in photovoltaic devices due to its excellent photoelectric property. However, when exposed to ambient conditions, HPs can undergo a phase transformation and decomposition. This instability and toxicity of HPs materials limit their commercialization. Growing a robust shell over the core perovskite is an effective and classical strategy to overcome these obstacles. The shell acts as a physical barrier, stabilizing the HPs and enriching the optical properties of the core. Earlier studies have demonstrated that transition metal dichalcogenides (TMDs) have great potential as surface passivation agents and have shown great promise in various applications. In our study, we use the MoS<sub>2</sub> shell to stabilize the CsPbBr<sub>3</sub> core and enhance its overall optoelectronic properties. We employ Finite difference time domain (FDTD) simulations to explore the core-shell system's optical properties and electric field distribution. We explore the impact of core and shell size by varying the diameter of CsPbBr<sub>3</sub> and the number of MoS<sub>2</sub> layers. By observing both near-field and far-field cross sections, we gain a comprehensive understanding of electromagnetic behavior, including field enhancement, resonant modes, scattering properties, and absorbance of the core-shell system. This study's insights can guide the design and optimization of stable photonic and optoelectronic HPs-based devices. Moreover, it can address the urgent need to develop sustainable and efficient energy technologies and pave the way toward a more sustainable future.

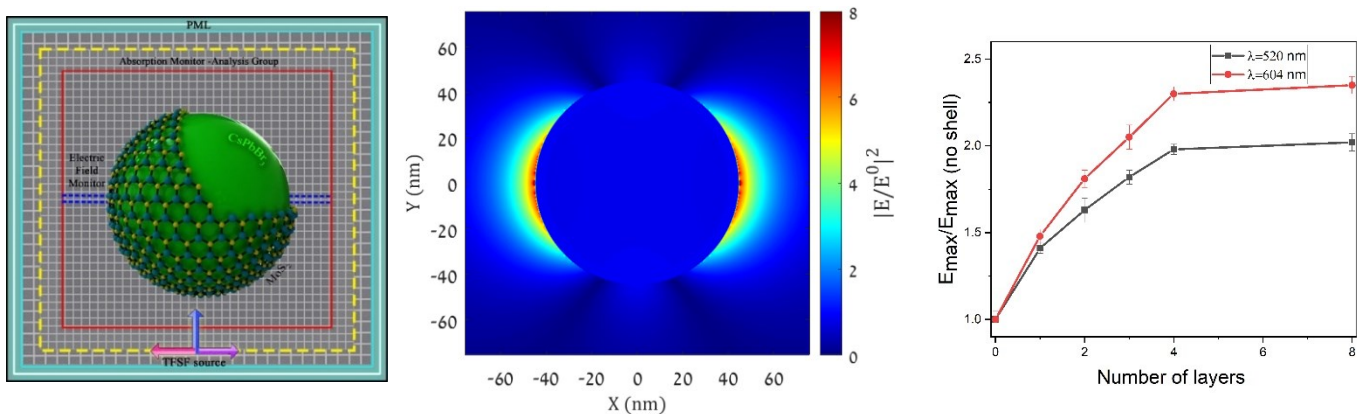


Figure 1-(a) Schematic description of 2D FDTD simulation setup, (b) Simulated Electric field distribution of CsPbBr<sub>3</sub>@MoS<sub>2</sub> at  $\lambda = 604$  nm perpendicular to light source for CsPbBr<sub>3</sub>@4L-MoS<sub>2</sub>, (c) Visualization of the electric field enhancement of the CsPbBr<sub>3</sub>@MoS<sub>2</sub> as a function of MoS<sub>2</sub> layers, for  $\lambda = 604$  nm and  $\lambda = 520$  nm

## **P17**

### **2D SnSe Nanosheets by Simple Solution Chemistry for Pseudocapacitive Electrode Studies**

**Chandradip D. Jadhav, Girish P. Patil, Refael Minnes\***

Department of Physics, Faculty of Natural Sciences, Ariel University, Ariel, Israel

Tin selenide (SnSe) has been thoroughly investigated as an important binary IV-VI compound for a wide variety of energy storage applications in the class typical layered metal chalcogenide family. Solution processed and phase-controlled synthesis of 2D SnSe nanosheets with hexagonal morphology has observed from Scanning electron microscope analysis. We fabricated binder-free active electrode and tested for electrochemical performance. As-prepared SnSe electrode shows specific capacitance of 397 F/g at a scan rate 2 mV/s and good electrochemical stability. The findings show that the suggested simple synthesis technique for the construction of binder-free electrodes has a promising future in the development of high-performance energy storage devices.

## P18

### Synthesis of Copper-Based Nanomaterials for CO<sub>2</sub> Electroreduction into Commodity Chemicals

**Manish Yadav Kumar\***, Arie Borenstein

Department of Chemical Sciences, Ariel University, Ariel, Israel

*Email- [manish@ariel.ac.il](mailto:manish@ariel.ac.il)*

The greenhouse gas CO<sub>2</sub> concentration is increasing in the atmosphere and raises concerns for our society. In the last 60 years atmospheric CO<sub>2</sub> concentration increased by 35%. An appealing approach is electrochemical CO<sub>2</sub> reduction reaction to reduce the greenhouse gas in terms of cost, feasibility, energy consumption. Incorporating the electrocatalysts into carbon supports, especially graphene, improves their electric conductivity and accessibility. Our main focus is to fabricate highly dispersed sub nano level catalysts of high surface area in graphene matrix by laser irradiation of copper doped carbon nanodots (CNDs) for CO<sub>2</sub>RR. Laser carbonization offers a simple, cost-effective, and scalable process that results in micron thick films of highly graphitic structure. Synthesizing sufficiently effective carbon-catalyst composites, sub-nano dispersion of the copper-based material is necessary for providing new insights and critical evaluation to this research field. High-quality 3D graphitic films of (111) and (200) facets of copper obtained with the help of laser-graphitization technique, demonstrate high electrical conductivity and surface area. The laser-processed materials was thoroughly characterized by various techniques including XPS, XRD, TEM, SEM, ICP. Electrochemical reaction experiments were carried out in a two-compartment electrochemical by using bicarbonate (HCO<sub>3</sub><sup>-</sup>) as the electrolyte anion to study activity and selectivity of Cu and understand the complex reaction networks for CO<sub>2</sub> reduction on Cu metal. However, low selectivity, HER of copper-based catalyst and poor stability are still the challenges for many researchers. Our goal for the future is development of suitable catalysts by achieving atomic dispersion of metals to study the CO<sub>2</sub> conversion pathways.

## **P19**

### **Vertically Aligned 2D Klockmannite CuSe Nanosheets: as High Capacitive Electrode**

**Girish P. Patil, Chandradip D. Jadhav, Refael Minnes\***

Department of Physics, Faculty of Natural Sciences, Ariel University, Ariel, Israel

Aligned and highly oriented Klockmannite Copper (II) Selenide (CuSe) nanosheets were synthesized by electrodeposition over 304-stainless steel foil. The as-synthesized product was further characterized by XRD and SEM. Aligned CuSe nanosheets possess average thickness 25 nm. Electrochemical capacitive studies of the aligned CuSe nanosheet electrode were carried out in three electrode system. The specific capacitance defined for a scan rate 2 mV/s was found to be 848.2 F/g and 335.6 F/g was obtained at a current density of 0.59 A/g. High surface area of CuSe nanosheets may find the superior applications in other field also like, Solar cells, Sensor and Battery etc.

\*Dr. Refael Minnes (refaelm@ariel.ac.il), Department of Physics, Faculty of Natural Sciences, Ariel University, Ariel, Israel.

### **Metal-Organic Frameworks (MOFs) for Enhanced Stability of Halide Perovskites in Renewable Energy Applications**

**Alen sam Thomas, Lena Yadgarov\***

Department of Chemical Engineering, Ariel University, Ariel, Israel

*[\\*lenay@ariel.ac.il](mailto:lenay@ariel.ac.il)*

Perovskite nanocrystals (NCs) have emerged as promising optical materials holding significant potential for diverse optoelectronic applications. However, their inferior stability against moisture, oxygen, light, and heat limits their practical applications. Incorporating metal-organic frameworks (MOFs) with halide perovskites (HP) has emerged as a promising approach for enhancing their stability. Our study uses the hot-injection method to synthesize CsPbBr<sub>3</sub> NCs, followed by the composite formation with Zn-based MOFs known as zeolitic imidazolate frameworks (ZIFs). Specifically, we use Zeolitic imidazole framework-8 (ZIF-8) with 25% copper doping and without copper doping. The encapsulation matrix created by these MOFs effectively isolates CsPbBr<sub>3</sub> from the surrounding and prevents the perovskite from decomposing or oxidizing in ambient conditions. Structural and optoelectronic studies of these composites indicate the successful formation and extraordinary stability of the CsPbBr<sub>3</sub>/ZIF-8 and CsPbBr<sub>3</sub>/Cu-ZIF-8. The study of the photoluminescence properties of these composites suggests a charge transfer from CsPbBr<sub>3</sub> to Cu-ZIF-8. Interestingly, we did not observe a similar charge transfer for the CsPbBr<sub>3</sub>/ZIF-8. Our findings offer a potential avenue for a wide range of applications in renewable energy, offering promising opportunities for further advancements. Moreover, this work will provide valuable insight into stabilizing halide perovskite materials via facile and cost-effective methods.

**Keywords:** Halide perovskite, CsPbBr<sub>3</sub>, metal-organic framework, nanocrystals

## **P21**

### **Guided 1D Nanostructures of 2D Materials: from Synthesis to Functional Devices**

**Yarden Danieli, Ernesto Joselevich\***

Department of Molecular Chemistry and Materials Science, Weizmann Institute of Science, Rehovot, Israel

2D materials are a versatile platform for optoelectronics, memory and energy-harvesting devices owing to their atomic or nanoscopic thickness, high-carrier mobility and strong light-matter interaction. One can tailor the physical properties of these materials by gaining control over their dimensionality which leads in turn to a dramatic change of physical behavior. However, efficient synthetic methods for the creation of aligned single crystal 1D nanostructures, other than nanotubes, with well-defined edges are still lacking.

In this work, we aim to implement the guided growth approach via different guiding modes to induce the 1D nanostructures of layered materials growth with controlled direction and orientation. Such growth of 1D nanostructures extends Moor's law to next-generation solid-state devices and will hopefully give rise to new and fascinating physical properties, and enhancement to existing ones.

## P22

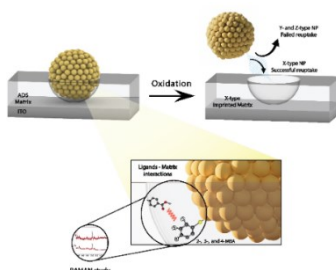
### High Recognition of Nanoparticles Stabilized by Different Structural Isomers through Matrix Imprinting

Din Zelikovich, Daniel Mandler\*

Institute of Chemistry, the Hebrew University of Jerusalem, Jerusalem, Israel

In the last years, nontoxicity has become at the forefront of research due to its relevance and importance to the environment and human health. Although the exposure risk to engineered nanomaterials depends on their physicochemical properties including their surface chemistry, the regulations are based mainly on the particle size. Since the use of NPs is unavoidable, there is an urgent need for small, easy-to-use, and field-available sensors for the detection of NPs. There is a wide range of laboratory techniques to characterize NPs spanning from electron microscopy to light scattering; however, most if not all of these are complex, cost-effective, and require skilled operators. Electrochemical detection methods would provide a cheap and easy tool to help characterize NPs based on their surface chemistry.

Recently, we introduced a different approach, termed nanoparticle-imprinted matrices (NAIM) that enables targeting the NP-matrix interactions<sup>2</sup>. In the NAIM approach, nanocavities with specific sizes, shapes, and chemical compositions are formed through the removal of imprinted NPs in thin matrices. These cavities are used to reuptake NPs very selectively based on their size, shape, and surface properties. The selectivity originates from both physical, i.e., size and shape of the NP, and chemical matching, i.e., proper interactions, between the NPs and the nanocavities. We have shown that such chemical and physical matching made it possible, on one hand, to differentiate between AuNPs of different sizes and, on the other hand, between NPs stabilized by different capping agents. Whereas the NAIM concept has resulted in an incredible selectivity, which is partially due to NP-matrix interactions, it does not disclose the physicochemical nature of these interactions that should be investigated by spectroscopy. Here, we describe a NAIM-Raman combined study where we examined the imprinting and recognition of AuNPs stabilized by the three isomers of mercaptobenzoic acid (MBA) in an aryldiazonium electropolymerized based matrix. Specifically, identical 10 nm diameter AuNPs stabilized by the 2,3, and 4-MBA isomers were formed by a ligand exchange reaction. Their adsorption on an indium tin oxide (ITO) surface modified by a positively charged polymer, e.g., polyethylenimine (PEI), was followed by the controlled electrografting of a thin 4-carboxyphenyl diazonium (ADS-COOH) film. The AuNPs were electrochemically dissolved and the reuptake of the different isomer stabilized AuNPs was studied by electrochemistry, Raman spectroscopy, and other techniques. We found a remarkable selectivity that must be attributed to chemical pairing, namely, to the specific interactions between the stabilizing isomer of the NP and the matrix. Specifically, the highest reuptake percentage was found for those NAIM systems that were imprinted and reuptaken with the same AuNPs isomer capping agent. In particular, the reuptake percentage of the originally imprinted AuNPs ranges from 60 to 80%, whereas the reuptake of AuNPs bearing different MBA isomer capping agents than those imprinted was substantially lower. The interactions between the MBA stabilizing the AuNPs and the aryldiazonium matrix were thoroughly studied by Raman spectroscopy and provided a molecular-level explanation for the performance of these NAIM systems.



1. High Recognition of Nanoparticles Stabilized by Different Structural Isomers through Matrix Imprinting. Din Zelikovich, Pavel Savchenko, and Daniel Mandler. Submitted  
Shell-Matrix Interaction in Nanoparticle-Imprinted Matrices: Implications for Selective Nanoparticle Detection and Separation. Din Zelikovich, and Daniel Mandler. *ACS Applied Nano Materials* 2021



## $\mu$ Reactor: an Emerging Technology for the *In-Situ* and *Ex-Situ* Investigations of High-Temperature Heterogeneous Reactions in the Electron Microscope

Vojtech Kundrat,<sup>1,2</sup> Libor Novak,<sup>2</sup> Reshef Tenne<sup>1</sup>

<sup>1</sup>Weizmann Institute of Science, Rehovot, Israel

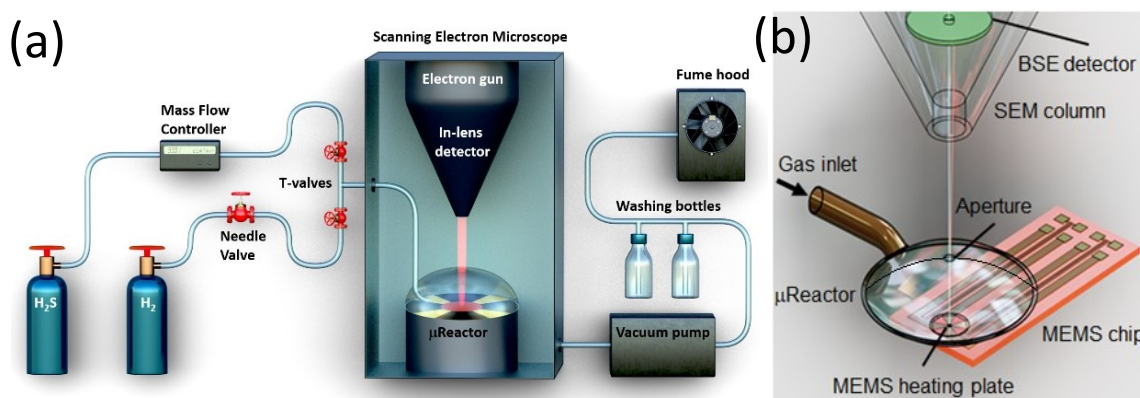
<sup>2</sup>Thermo Fisher Scientific, Brno, Czech Republic

Scanning electron microscopy (SEM) is an essential tool used widely in material science, the semiconductor industry, and countless other fields. *In-situ* observation of high-temperature processes under vacuum or in the low-pressure gaseous atmosphere (environmental SEM) can help understand reaction mechanisms, test variable reaction conditions, or even help to develop of new approaches for reaching desirable high-end materials. The main capabilities of this emerging technology are demonstrated using the  $\mu$ Reactor<sup>1</sup> in conjunction with microelectromechanical system (MEMS) chips as the sample heating stage.

First, the SEM- $\mu$ Reactor is employed as a precise development tool to identify and optimize reaction conditions for the reductive growth of  $W_{18}O_{49}$  nanowhiskers from  $WO_3/SiO_2$  nanofibers. Such direct investigation enables a straightforward transfer of reaction conditions to a low-pressure flow reactor, facilitating multigram synthesis.

In another implementation of the  $\mu$ Reactor within SEM, an  $H_2S$  gas inlet was developed, along with  $H_2$ , to study the mechanisms of the high-temperature sulfidation of  $W_{18}O_{49}$  nanowhiskers towards  $WS_2$  nanotubes under low pressure. The *ex-situ* analytical methodology for studying kinetically frozen states of the reaction at selected times was also developed, utilizing high-resolution transmission electron microscopy (HRTEM). The methodology demonstrates the synergy between *in-situ* SEM and *ex-situ* TEM jointly with sample transfer and analysis on specific locations on the MEMS chip.

The poster introduces the wide scope for utilization of the new  $\mu$ Reactor for applications in material science, as well as in fundamental research focused on reaction mechanisms.



Schemes of the SEM (a) with the fitted  $\mu$ Reactor (b) for *in-situ* studying of sulfidation reactions

<sup>1</sup>L. Novák, J. Stárek, T. Vystavěl, L. Mele, *Microsc Microanal* **2016** 22, 184.

<sup>2</sup>L. Mele, S. Konings, P. Dona, F. Evertz, C. Mitterbauer, P. Faber, R. Schampers, J. R. Jinschek, *Microsc. Res. Tech.* **2016** 79, 239.

### Selective Area Growth of Aligned Organic Semiconductor Nanowires

Xingyu Wang<sup>1,2</sup>, Yuhao Luo<sup>3</sup>, Jihui Liao<sup>1</sup>, Jiaxun Song<sup>1</sup>, Ernesto Joselevich<sup>2</sup>, Jinyou Xu<sup>1</sup>

<sup>1</sup>Guangdong Provincial Key Laboratory of Optical Information Materials and Technology & Institute of Electronic Paper Displays. South China Academy of Advanced Optoelectronics. South China Normal University. Guangzhou, People's Republic of China. <sup>2</sup>Department of Materials and Interfaces. Weizmann Institute of Science. Rehovot, Israel. <sup>3</sup>Key Lab of Heat Transfer Enhancement and Energy Conservation of Ministry of Education. School of Chemistry and Chemical Engineering. South China University of Technology. Guangzhou, People's Republic of China

We proposed a facile protocol to enable the one-step wafer-scale growth of addressable self-oriented catalyst-free organic nanowires. The catalyst-free Alq<sub>3</sub> nanowires can be grown with a consistent orientation across the entire sapphire surface by tuning the interaction between the organic molecules and the substrate. The growth position of catalyst-free Alq<sub>3</sub> nanowires can be controlled by tailoring the mass-transport process with microholes. We then investigated the underlying mechanism by a Computational Fluid Dynamics (CFD) simulation. Furthermore, addressable oriented nanowires with modulated number, length, and density were achieved using this facile mass-transport-controlled graphoepitaxial growth. Last, we have confirmed that arrays of nanowire-based devices can be integrated directly on their growth substrate using these addressable oriented organic nanowires.

## P25

### 3D Printed Water Purification Device Based on PLA-0.5 Wt% WS<sub>2</sub>-INT

**Nicole Gorohovsky, Shani Marchini**

Supervised by: Dr. Noa Lachman-Senesh and Mr. Ofek Golan

A collaboration with Prof. Hadas Maman.

Department of Materials Science and Engineering and School of Mechanical Engineering, Tel Aviv University, Israel

Water purification has been a large interest among researchers, scientists, and environmental companies. Many 2D versions of compound materials such as WS<sub>2</sub>, and TiO<sub>2</sub> become optional candidates for the task due to their photocatalytic activity under a wide spectrum of electromagnetic irradiation. Inorganic nanotubes (INTs) structures of such materials serve as additional, desired candidates due to their improved mechanical properties and chemical stability; but alas, INTs are usually incapable of photocatalytic activity because of their pristine structure. Thankfully, studies have showed that incorporating nanoparticles of transition metal into the INTs activates the desired photocatalytic effect.

In this project, WS<sub>2</sub>-INTs were incorporated in a biodegradable polymer matrix, to create a prototype of a water purification device. Thus, a polylactic acid (PLA) matrix containing 0.5 wt% of WS<sub>2</sub>-INTs filament was used to 3D print what will be referred to as a filter. This filter contains a complex infill 3D structure, that was achieved because of the 3D printing process. After printing several filters with various infill percentages, the optimal percentage was chosen according to flux experiments. The filters underwent a surface treatment to expose more INTs to the surface and silver coating to activate the photocatalytic effect. The filters' photocatalytic reaction towards methylene blue was then tested under sunlamp irradiation. The results presented in this work proved that the silver coating does, in fact, activate the photocatalytic activity. Furthermore, filters where more INTs were exposed prior to receiving a silver coating showed the highest photocatalytic activity.

We thus proved the possibility of 3D printing a nanocomposite water filter and activate its photocatalytic abilities by simple surface treatments. This filter is a prototype for a simple water purifying device that ultimately could be distributed in poverty-stricken regions with lacking clean water resources.

Homotopy Asymptotic Method for Study of Radiative Convective Nanofluid Flow

Nicolina Pop<sup>1,\*</sup>, Remus Daniel Ene<sup>2</sup>, Rodica Badarau<sup>3</sup>

\*Corresponding author e-mail: [nicolina.pop@upt.ro](mailto:nicolina.pop@upt.ro)

<sup>1</sup>Department of Physical Foundations of Engineering, Politehnica University of Timisoara, Timisoara, Romania

<sup>2</sup>Department of Mathematics, Politehnica University of Timisoara, Timisoara, Romania

The aim of using nanofluids is to significantly improve heat transfer by increasing the thermal conductivity of base fluids (ethylene glycol, water, motor oil, acetone, etc.). Solving the equations that characterize nanofluids is important because they govern a very important class of common physical processes. Computational techniques and new approximation methods have made it possible to solve these equations with increasing accuracy, confirming experimental results in broad engineering fields.

The partial slip effects for radiative convective flow of a nanofluid over a stretching sheet in porous medium are analytically explored in this work. The Navier-Stokes equations, the momentum and the energy equations are transformed into a set of nonlinear ordinary differential equations by the similarity transformation. Using the modified Optimal Homotopy Asymptotic Method (OHAM), the resulting nonlinear ODEs are analytically approximate solved. The behaviour of the mass and heat transfer depends of the many physical parameters: velocity slip parameter, thermal slip parameter, velocity power's index parameter, wall thickness parameter, the Prandtl number and the radiation parameter. The influence of these parameters are tabular and graphically presented. An excellent agreement between the analytic approximate solution and the corresponding numerical solution is highlighted. The results obtained confirm that the modified OHAM is usefully and competitive mathematical tool for explore a large class of nonlinear problems with applications in different fields of science and engineering.

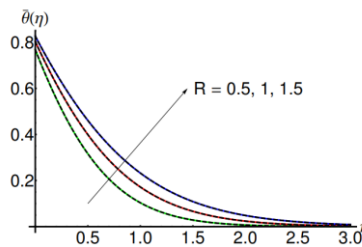


Fig.1. Profile of the temperature  $\bar{\theta}(\eta)$  with increasing of the radiation parameter  $R$  for fixed others physical parameters:  $n = 0.5$ ,  $Pr = 6$ ,  $\delta_2 = 0.2$ ,  $\gamma = 0.25$ ,  $\delta_1 = 0.5$

Keywords

fluid flow; radiation heat transfer; nanofluid; ordinary differential equations; Optimal Homotopy Asymptotic Method (OHAM).

**References**

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 Ene R.D., Pop N.,Badarau R. 2023.. Mathematics. 11 (7) 1648.

## **P27**

### **Usage of Bacterial Conjugation System for Detection of Gram-Positive Pathogens**

**Yonatan Cohen**

Hebrew University of Jerusalem, Israel

Gram positive bacteria are a major player in many infections, capable of infecting virtually any system in the human body, with the raise of antimicrobial resistance strains mortality from bacterial infection expected to surpass cancer as the leading cause of death by the year 2050. The gold standard for detecting such infections is isolating the infection on inductive agar plates require long incubation and growth time. We propose to use a bacterial conjugation system named Xport to transfer an engineered DNA payload that will integrate into the chromosome the bacterial pathogen, resulting in an easy to read signal. Such method will shorten the incubation time dramatically and will provide fast and precise way to detect a wide array of pathogens.

## P28

### In-Vitro Degradation Study of 3D Printed PLA-0.5 Wt% INT-WS<sub>2</sub> Bone Scaffold

**Noa Granada, Lin Lemesh**

Supervised by: Dr. Noa Lachman-Senesh and Mr. Ofek Golan

Department of Materials Science and Engineering,

Tel Aviv University, Israel

Poly(lactic acid) (PLA) is a biocompatible and biodegradable aliphatic polyester with potential application for medical use and food packaging. Reinforcing the PLA with inorganic nanotubes of tungsten disulfide (INT-WS<sub>2</sub>) lead to an improved material with potential to be used as a bone scaffold due to the INT-WS<sub>2</sub> chemical stability, biocompatibility, non-toxicity, and good mechanical properties. The purpose of this project was to evaluate the effects of hydrolytic degradation on the properties of PLA reinforced with 0.5wt% INT-WS<sub>2</sub> as a concept for a 3D printed femur bone (hip) scaffold. A successful artificial bone scaffold requires good biocompatibility, equivalent or better mechanical properties than those of natural bone and suited to the size and shape required by each patient. In addition, an ideal scaffold supports bone regeneration, therefore its degradation rate must match the regeneration rate of bone tissue.

To test the effect of degradation on this material properties, PLA/INT-WS<sub>2</sub> composite tensile specimens were printed and subjected to a degradation process at different time periods – from one hour up to three months, at 37 °C in phosphate buffer saline (PBS) at 7.4 pH to simulate the human body physiological conditions. The degradation was evaluated by weight loss, tensile strength and hardness, and the sample morphology was examined with SEM.

Ultimately, there was no significant change in weight loss, morphology, and hardness of the 3D printed samples. The initial tensile strength of the scaffold was 45MPa and after three-month reduced to 35MPa, still higher than the average stress on femur bone during normal walking which is 9.5MPa.

Although a longer experiment will be necessary to understand the degradation rate, this project demonstrates that PLA reinforced with 0.5wt% INT-WS<sub>2</sub> would be a good candidate for a new 3D printed bone scaffold which can be customized for each patient.

## P29

### MoS<sub>2</sub>-Based Nanoadsorbent for Heavy Metal Removal

**Yasmin Nassar**

Tel Aviv University, Israel

Water contamination by various contaminants including heavy metals poses a significant environmental challenge. The major source of heavy metal contamination is industrial wastes which eventually reach municipal wastewater plants. Therefore, a potential solution to this issue is the selective adsorption of various metals from industrial wastes. While adsorption of heavy metals is limited using conventional adsorbents, other materials may allow their selective removal. Molybdenum disulfide (MoS<sub>2</sub>)-a 2D nanomaterial with a layered structure of molybdenum (Mo) atoms bonded with sulfur (S) atoms—is one of the promising materials for adsorption through soft-soft Lewis acid-base interactions.

Our research aims to optimize MoS<sub>2</sub> for treating non-potable water, specifically industrial wastewater and groundwater. We use MoS<sub>2</sub> in a supported form, where activated carbon (AC) is acting as an active platform, allowing elevated surface area and multifunctional adsorption capabilities. Our approach has been proven effective by characterizing the adsorption and recovery efficiency of mercury (Hg) and silver (Ag).

In the current research effort, we focus on developing MoS<sub>2</sub>-based water treatment solutions that are scalable, cost-effective, and designed for non-potable water sources. Specifically, we are optimizing and upscaling the synthesis procedure, striving to produce high-quality MoS<sub>2</sub> nanocomposites on a larger scale and at affordable costs. Additionally, we test the developed nanoadsorbents activity under real contaminated waters and assess its stability and function over long time periods. By doing this, we hope to contribute to advancing efficient and sustainable treatment technologies for non-potable water while meeting the growing demand for practical solutions.

## P30

### **Influence of Annealing Media on the Structure, Morphology, and Optical Properties of Spin-Coated ZnO Thin Films**

**Maryna Butenko, Viktor Danchuk, Lena Yadgarov**

Department of Chemical Engineering, Ariel University, Ariel, Israel

Renewable energy is of paramount importance in mitigating climate change and reducing our dependence on fossil fuels. Solar cells play a crucial role in this endeavor by harnessing the sun's power and converting it into clean electricity. In this aspect, solar cells based on halide perovskites (HPs) thin films are very promising. However, commercializing these solar cells is still challenging due to the instability of the HPs and the poor durability of active layers, i.e., electron transport layers (ETL) and hole transport layers (HTL) [1]. Due to its semiconductor nature, zinc oxide is one of the leading candidates for improved ETL performance in HPs-based solar cells. [2] In our work, we explore the influence of annealing media (oxygen, air, vacuum) on the crystal structure, morphology, and optical properties of the ZnO films. Using the spin coating technique, we successfully create ultra-thin films of 35-60 nm. We find that the annealing media affects the lattice parameters and crystallinity of the deposited ZnO films. The scanning electron microscopy (SEM) analysis indicates that the ZnO films have a fine-grained structure with a highly developed uniform surface. Regardless of the annealing conditions, increasing the number of layers improves surface uniformity. Annealing of ZnO films in vacuum leads to pronounced healing, smoothing, and bigger grains. Moreover, the films we annealed in a vacuum showed a higher optical transmission in the UV region due to less scattering. Interestingly, while the band gap of the films annealed in air and oxygen is  $\sim 3.26$  eV, the film annealed in a vacuum had a band gap of 4.9 eV.

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## P31

### Anisotropic Van Der Waals Epitaxy and Sliding of CsPbBr<sub>3</sub> Microplatelets on ReSe<sub>2</sub>

Noya Ruth Itzhak<sup>1</sup>, Ifat-Kaplan Ashiri<sup>2</sup>, Katya Rechav<sup>2</sup>, Olga Brontvein<sup>2</sup>, Hagai Cohen<sup>2</sup>, Irit Goldian<sup>2</sup>, Ernesto Joselevich<sup>1,\*</sup>

<sup>1</sup>Department of Molecular Chemistry and Materials Science, <sup>2</sup>Chemical Research Support, Weizmann Institute of Science, Rehovot, Israel

\*Ernesto Joselevich, Ernesto.joselevich@weizmann.ac.il

The growth of highly crystalline semiconductor nanostructures with low defect concentration is essential for realizing their optoelectronic properties and for their efficient integration into functional nanodevices. Our group has shown that nanowires can grow on a single crystal or amorphous substrates using covalent epitaxy and graphoepitaxy to generate well-aligned and guided nanowires with controlled crystallographic orientation. However, covalent epitaxial relations often induce strain and stress in the nanocrystals, leading to dislocations and other defects, which affect the physical properties of semiconductor nanostructures. Substituting covalent substrates with 2D van der Waals (vdW) layered materials could relieve stress and strain issues, as weaker interactions are formed between the top layer of the vdW material and the formed nanostructure. Therefore, we suggest extending the guided growth approach by using vdW epitaxy on 2D materials. Here we present the vapor-solid growth of micro- and nano-platelets of well-ordered cubic CsPbBr<sub>3</sub> on 2D layered triclinic ReSe<sub>2</sub> substrate. X-ray photoelectron spectroscopy (XPS) and cathodoluminescence (CL) measurements revealed type I band alignment, with energy transfer from the CsPbBr<sub>3</sub> platelets to the ReSe<sub>2</sub> substrate. Such heterostructure could be integrated into an enhanced photodetector compared to ReSe<sub>2</sub> based photodetector. To further investigate the vdW epitaxial nature of the heterostructure, we characterized the heterostructure interface by applying lateral force and sliding the CsPbBr<sub>3</sub> platelets on the ReSe<sub>2</sub> using atomic force microscopy (AFM). Our results indicate that some sliding directions are preferable to others, which could be attributed to the in-plane anisotropy of the ReSe<sub>2</sub> surface. These results open a route for the ordered design of heterostructure devices with interesting energy transfer mechanisms and improved optical and electrical properties owing to the lower miss-match stresses induced by vdW vs covalent epitaxy.