TEL AVIV UNIVERSITY

NANONEWS

The Center for Nanoscience and Nanotechnology • Editor: Dr. Jacob Scheuer

Dear colleagues,

We are proud to present you with the first issue of "Nano-News" – the newsletter of the Center for Nanoscience and Nanotechnology at Tel-Aviv University. This newsletter, published 2-3 times a year, will include news, updates and information regarding the research, people and facilities at the Center. We hope you will find this information interesting and useful and we invite all of you to contribute recent nano-news, suggestions and ideas.

Dr. J. Scheuer – Editor, **Prof. O. Cheshnovsky** – Head of the Nanoscience and Nanotechnology Center

How Hot are Conducting Molecular Junctions?

By: Tamar Shamai and Yoram Selzer

Building electronic devices using molecules is one of the ultimate goals of nanotechnology. While the prospect of applications based on such devices still remains to be seen, they already can be used as wonderful tools to explore fundamental processes, that are also of highest technological importance, at the molecular level. One of these processes is heat generation and dissipation at the nanoscale.

Previous experiments have tried to indirectly determine the effective temperature of nanoscale junctions under bias by measuring attributes such as the breaking rate or the force required to break various junctions, which are temperature dependent.

Yet, the best method to directly determine the effective temperature of junctions under potential bias is to monitor the (non-equilibrium) occupancy of their vibrational levels.

Recently in collaboration with the group of Prof. Ori Cheshnovsky we have demonstrated such a capability in a paper published in Nature Nanotechnology[1]. Using a unique metal/molecular-monolayer/metal junction, we were able to probe the molecular layer by Raman Spectroscopy. Our ability to simultaneously probe the Stokes (S) and Anti-Stokes (AS) components, allowed us to determine the AS/S ratio of each Raman active vibrational mode, ν, which directly represents its steady state nonequilibrium population in the presence of (inelastic) tunneling current. This ratio can be translated into a mode-specific effective temperature, $T_{eff}(\nu)$. Our results demonstrate the power of direct spectroscopic probing of heating and cooling processes in nanostructures.

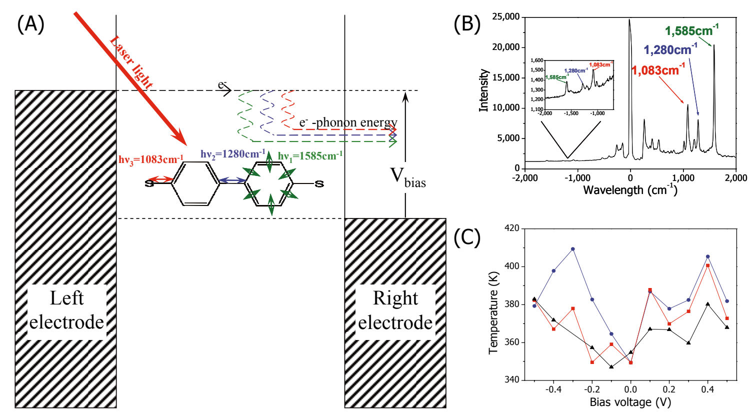


Figure 1: (A) Electrons that tunnel inelastically excite phonons (vibrations) of the molecules residing between the two metal electrodes (three specific vibrational modes are shown). (B) Raman spectrum of a junction showing the Stokes (S) and in the inset the Anti-Stokes (AS) regimes. When current goes through the junction the intensity of the AS increases, as a result of larger occupancy of excited vibrations. (C) The effective temperature of each mode is calculated from the corresponding AS/S ratios at each potential bias value. In this specific junction, all Raman active modes show similar heating (about 30K) as a function of bias at room temperature, suggesting fast internal vibrational relaxation processes.

1 Ioffe, Z.; Shamai, T.; Ophir, A.; Noy, G.; Yutsis, I.; Kfir, K.; Cheshnovsky, O.; Selzer, Y., Nature Nanotechnology, doi 10.1038/nnano2008.304

New Tools and software

LEXT OLS3100 Confocal microscope

Description:
Confocal laser scanning microscopes allow for observations of three-dimensional shapes, such as high-density semiconductors and micro-fabricated MEMS. The LEXT microscope uses a laser scaning head for both direct imaging of the surface and for surface profile measurements.

Specifications Features:
1. Resolution of 0.12µm.
2. The microscope is equipped with a 408 nm violet opto-system. Improved Z measurement repeatability of 3σ=0.05+0.002Lµm with the standard error, where L is the measurement length in µm.
3. Allows for color 3D observations and brightfield, darkfield and differential interference observations.
4. Provides simultaneous observations of darkfield or differential interference contrast observations and laser observations on the same screen.

More details can be found in company website: **http://www.olympus.co.uk/microscopy/26_LEXT.htm**

Lumerical FDTD tool

Lumerical is a Finite Difference Time domain simulation tool capable of solving the temporal evolution of electromagnetic fields and waves in complex structures. In particular the software can simulate dielectric structures such as waveguides, photonic crystals and micro-ring resonators as well as metallic structures – nano-particles and plasmonics. The applications of such structures range for optical processing and communication to sensing, biophotonics and strong light-matter interactions.

More details and examples can be found in company website: **http://www.lumerical.com/fdtd.php**

Accelrys

Accelrys' tools provide modeling and simulation solutions for drug discovery, studying chemicals and materials, crystal structure and crystallization processes, polymer properties, catalysis, and structure-activity relationships.

Materials Studio-materials modeling and simulations software. It offers access to the complete range of computational materials science methods via desktop computing. It is designed for structural and computational researchers in chemicals and materials R&D who need to perform expert-level modeling and simulations tasks in an easy-to-learn yet powerful environment. It provides tools for modeling crystal structure and crystallization processes, for the study of polymer properties, catalysis, and the study of structure-activity relationships.

Discovery Studio 2.0- life science modeling and simulations software. This is a single, easy-to-use, graphical interface for powerful drug design and protein modeling research. Discovery Studio 2.0 contains both established gold-standard applications (e.g., Catalyst, MODELER, CHARMm, etc.) with years of proven results and cutting-edge science to address today's drug discovery challenges. Discovery Studio 2.0 is built on the SciTegic Pipeline Pilot™ open operating platform, allowing seamless integration of protein modeling, pharmacophore analysis, and structure-based design, as well as third-party applications.

More information can be found at the website: **http://accelrys.com/**

Prizes and awards

"**Daniel Szwarcman**, a Ph.D. student at the school of chemistry (supervised by Prof. Gil Markovich and Yossi Lereah) received the Lev Margulis prize which is awarded by the Israel Society for Microscopy to one graduate student every year. Daniel's work focuses on studies of nanoscale ferroelectricity. In his work, Daniel prepared barium titanate nanocubes and imaged their internal ferroelectric polarization fields with nanometric resolution using electron holography performed in a transmission electron microscope. Several interesting findings regarding the dependence of these polarization fields on nanocrystal size and their behavior close to the nanocrystal edges were obtained."

Research news

Quantum Confinement in Self Assembled Bio-Inspired Nanostructures

Nadav Amdursky, Ehud Gazit, Gil Rosenman

We discover pronounced quantum confinement (QC) and photoluminescence (PL) phenomena in self-assembled peptide nanostructures of different origin diphenylalanine (FF) nanotubes deposited by a vapor deposition method, hydrogels self-assembly of short Fmoc (*N*-fluorenylmethoxycarbonyl)-based molecules i nto fibrous formation, nanospheres self-assembled from Fmoc-FF or Boc-(Di-tert-butyl dicarbonate)-FF monomers and natural self assembly of amyloidogenic proteins. Our observation of QC effects is a direct evidence of highly ordered sub-nano-crystalline areas embedded in the structures. The observed PL of the bio-nanotubes opens a new nanotechnology field of bio-inspired materials for optical devices such as biosensors, biolasers and more.

Supercapacitors Based on Peptide Nanotubes-Engineered Electrodes

Peter Beker, Prof. Gil Rosenman, Ehud Gazit

A new peptide nanotubes (PNT)-based on patented technology has been applied to development of "green" energy storage devices-Supercapacitors. Deposition of PNT arrays on carbon electrodes strongly increases efficiency of these electrochemical units. In the developed electrostatic supercapacitors aromatic vertically oriented dipeptide nanotubes have been used for modification of carbon electrodes of supercapacitors. The conducted studies show that PNT-modified electrodes demonstrate pronounced rectangular shape voltammograms and possess a high double-layer capacitance exceeding that parameter for carbon nanotubes-coated electrodes.

Coupled cavity rotation sensors: A new generation of rotation sensors

Jacob Scheuer and Ben Steinberg

A novel concept for rotation sensing (optical Gyro) based on coupled-cavity "slow-light" structure was proposed and analyzed theoretically. The study shows that the new concept provides enhanced sensitivity compared to conventional gyros, thus **breaking a 100 year old limit** on the ability to detect and measure rotation. The new concept facilitates the realization of nanometer scale, yet sensitive, optical gyros which can be used in diverse applications such as navigation, control and more.

Nano antennae on a chip

Yael Hanein, Jacob Scheuer and Amir Boag

Solid state devices for light detection and energy harvesting are widely used and are intensively researched to lower their cost, increase their sensitivity, and improve their efficiency. Despite the apparent success of these efforts solid state technology suffer from several inherent deficiencies which hamper rapid progress towards these stated goals. A new concept, currently investigated at the school of electrical engineering, attempts to achieve light detection through an entirely new scheme based on a classical construct named rectenna. Rectifying antennae (rectennas) are simple electrical devices which facilitate the conversion of micro-wave and radio frequency, AC radiation into DC electrical power. The conversion takes place by a rectifying diode which is incorporated into the antenna. While rectennas for the visible light range were so far technologically infeasible, recent advances in nanotechnology may, in fact, offer the opportunity to finally realize such devices. Arrays of antennae, approximately 500 nm long, have been already demonstrated by the group. Despite their miniscule dimensions, these antennae demonstrate similar performances to their macroscopic counterparts. Fast responding diodes are also developed based on carbon nanotube technology. Nano rectifying antennae will also offer a wide range of advantages with exciting possibilities in sensors, wireless communication, energy harvesting, and smart dust applications, to name few.

Nano electro mechanical systems: Old and new technologies meet

Gabriel Karp, Assaf Yaakobovitz, Slava Krylov and Yael Hanein

Silicon technology is the most prominent in the realm of micro-electro mechanical systems (MEMS). The tiny accelerometers embedded in our cars to alert in case of a collision are a prime example. Despite the relative small dimensions of these devices, in the range of several tens of microns, they are still too big to sense very small movements and therefore their sensitivity is limited. A novel concept, based on carbon nanotube (CNT) technology, is now developed at TAU through collaboration between mechanical and electrical engineers. The novel approach is based on the incorporation of CNTs into functional silicon based MEMS devices. The integration is based on self-assembly of the CNTs to their target position so the overall process is compatible with scalable manufacturing methods. New sensor designs, based on this new technology, promise to achieve sensitivities surpassing contemporary devices.

Make your recent discoveries known by sending a short description to **nanonews@eng.tau.ac.il**

New faces in the Center

Dan Peer, Faculty of Life Sciences

Selective targeting and reprogramming of leukocytes using fully degradable nanomedicines Our lab at the Dept. of Cell Research and Immunology, the Faculty of life Sciences and the Center for Nanoscience and Nanotechnology, is studying how to manipulate cells' functions in order to generate novel therapeutic strategies to treat inflammatory diseases and cancers. We are combining a multidisciplinary approach to develop innovative strategies to target specific cells within the immune system and to bring drugs into these cells in an efficient, selective, and safe manner. We are also harnessing the use of novel class of molecules, termed small interfering RNAs (siRNAs) for drug discovery and therapeutic applications. The siRNAs, while small, are still much larger than conventional drugs, made from RNA, and subject to degradation in the bloodstream. In addition, most cells do not take up siRNAs. The challenge is to direct intact siRNAs to the appropriate tissues in the body and then usher them into cells. In order to address these challenges, we currently develop platforms based on nanoparticles from naturally occurring biopolymers. These nanoparticles are equipped with directing moieties that specifically recognize receptors that undergo conformational changes only in pathological conditions, thus has intrinsic abilities to distinguish between healthy and diseased cells in vivo. Currently, we focus on the following projects:

1. Developing methods to selectively target hematopoietic stem cells in order to comprehensively manipulate the function of these cells and improve bone marrow transplantation.

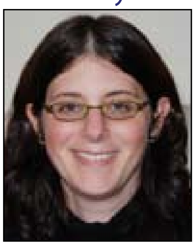
2. Investigating novel nanocarriers and selective targeting moieties that target cancer stem cells (which are highly chemo-resistance tumors) and developing new therapies based on targeted nanoparticles delivering siRNAs to blood cancers.

3. Understanding the role of cell cycle regulators in inflammatory bowel diseases (such as Crohn's Disease and Ulcerative Colitis) for developing future therapies.

4. Creating new approaches for in vivo validation of novel drug targets using siRNAs and miRNAs mimetic.

Dan Peer received his Ph.D. in Biochemistry and Biophysics from Tel Aviv University under the supervision of Prof. Rimona Margalit. He then moved to Harvard Medical School and did his postdoctoral training in the laboratory of Prof. Motomu Shimaoka where he developed two major nano-platforms for siRNA delivery to leukocytes. Both have been successfully licensed and are in clinical development. He is the inventor and co-inventor of more than 25 patents (both granted and pending).

Yael Roichman, School of Chemistry



Soft Matter research concentrates on studying materials made of mesoscopic components. These materials respond readily to mechanical perturbations, are easily imaged in a conventional microscope and can usually be manipulated with laser light. These traits render them ideal as model systems for the study of organization processes both in the fundamental scientific aspect and for practical applications such as assembling new materials and devices. In order to study self assembly processes we use a two way approach: we study dynamics of assembly in out of equilibrium conditions, and we test model systems which are assembled directly. To this end we use holographic optical tweezers (HOTs) to trap, drive, and manipulate colloidal particles.

HOTs afford an elegant method to create simple model driven dissipative systems that can be characterized in the single particle level and in the balk behavior simultaneously. We have studied such a system of particles propelled along the perimeter of a ring trap and found that the dynamics are unusual, since the particle diffuse anomalously. Moreover, the collective mode of these particles seems to verge on chaotic. We are currently studying ordering in sheared crystals and the response of two dimensional crystals to mechanical perturbations. Recent studies show that quasi-periodic structures may have the best symmetry for producing photonic bandgap materials. In the past we have used HOTs to create a prototype for a quasicrystalline photonic bandgap material. We assembled almost three hundred silica particles into an icosahedral quasicrystal and fixed them in three dimensions in a dilute hydrogel. We also demonstrated the ability to produce these materials with predesigned defects in order to create devices such as waveguides. We intend to continue this line of work characterizing the quality of these directly assembled materials.

Dr. Roichman received her PhD from the physics department at the Technion. After that she was a postdoctoral researcher at the department of physics, NYU working with David Grier.

Oded Hod, School of Chemistry

Nanoscience and nanotechnology open a unique opportunity for the application of highly accurate theories to realistic material science problems. The research in my group focuses on the theoretical study of the mechanical, electronic, magnetic, and transport properties of systems at the nanoscale. Using first-principles computational methods, we aim to characterize both ground state and dynamical properties of such systems. A combination of codes developed within our group and commercial computational chemistry packages, operating on a highly parallelizable high-performance computer cluster, allows us to address the properties and functionality of a variety of systems ranging from carefully tailored molecular structures up to bulk systems. On top of basic science questions, the design of technologically applicable nanoscale material properties for future applications in fields such as nano-electronics, nano-spintronics, accurate and sensitive chemical sensing, and nano-mechanical devices, is being pursued.

Dr. Hod received his PhD from the school of Chemistry of Tel Aviv University. After that he was a postdoctoral researcher at Rice University, Houston, Texas where he worked with Gustavo E. Scuesria.

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