



Nanotechnology Research

Small Miracles



Bar-Ilan University

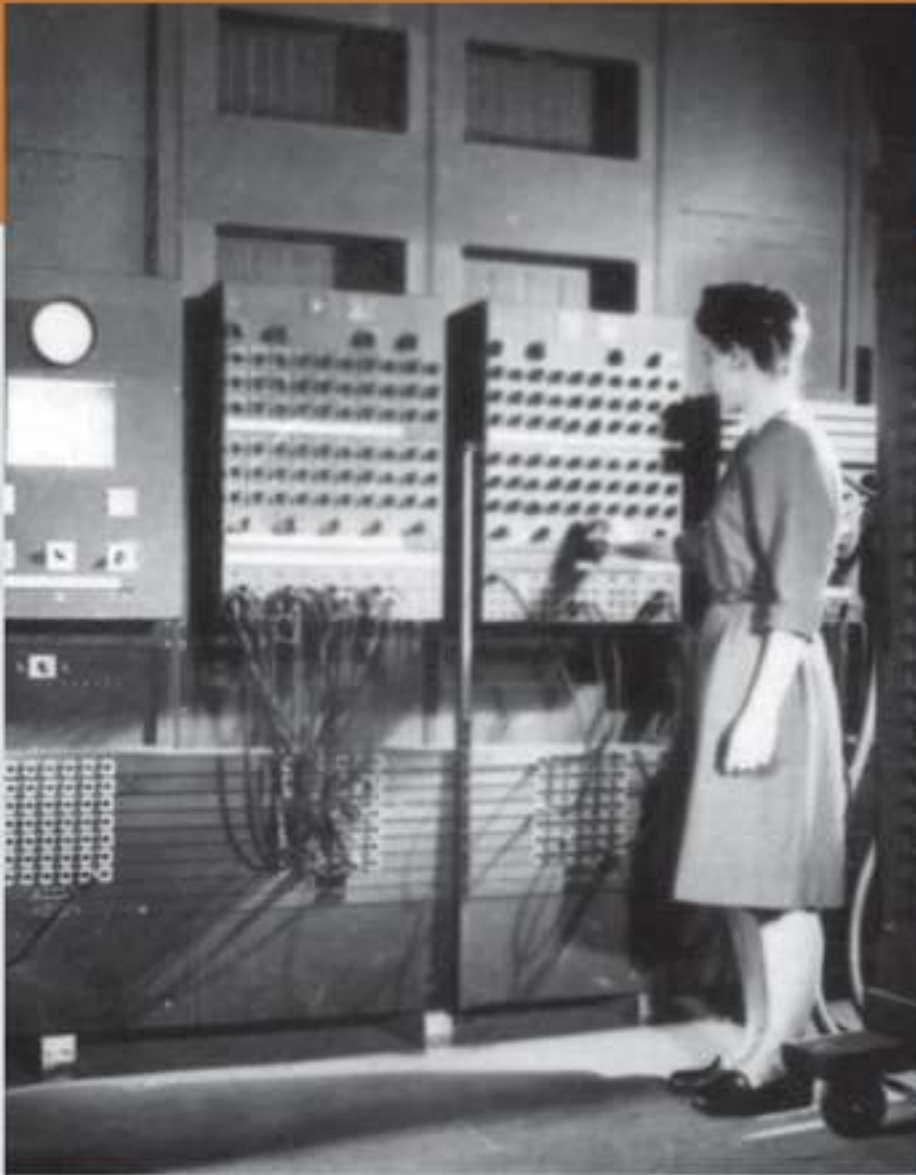
→ → →  Bar-Ilan's Institute for Nanotechnology and Advanced Materials is home to top innovators who publish hundreds of papers a year, collaborate with multi-national corporations and help set the global nano-research agenda.

Pictured from left to right: 
Prof. Arie Zaban
Prof. Aviad Frydman
Dr. Shuki Wolfus
Dr. Avi Zadok

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In 1946, scientists unveiled ENIAC, the world's first computer, which weighed over 27 tons, took up 680 square feet, and consumed 150 kW of power. More than a decade later, in a talk entitled, "There's Plenty of Room at the Bottom," American physicist Richard Feynman claimed that computers – and many other things – could be made much, much smaller. Feynman's prescient predictions became a roadmap for nanotechnology – a science in which man-made variations in the arrangement of atoms result in fabulous new functionalities, and powerful solutions for pressing problems.

Today, Bar-Ilan University is one of Israel's most dynamic nanotechnology research centers. The University's Institute for Nanotechnology and Advanced Materials (BINA) is home to top innovators who publish hundreds of papers a year, collaborate with multi-national corporations and help set the global nano-research agenda.

Bar-Ilan nanoscientists are uncovering fundamental principles that govern the world in which we live, and are creating the technologies of tomorrow.

Building Better Materials

Prof. Aharon Gedanken is a pioneer of sonochemistry – a discipline in which reactions are accelerated through the application of ultrasonic sound waves. An expert in the fabrication of nanostructures with special catalytic properties, Gedanken's discoveries include a process for coating textiles with nanoparticles, resulting in antibacterial activity that persists after 65 hospital laundry cycles. Using a domestic microwave oven and aquatic plants, Gedanken also developed a technique for removing useful metals from polluted water. He also invented a ten-second, microwave-based method for converting cooked oils to biodiesel fuel. Gedanken's recent publication on nanocomposite textiles became one of the most-accessed papers on a listing of the American Chemical Society.

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A thin-film deposition technique developed by Prof. Chaim Sukenik – already used to create anti-bacterial coatings for medical devices – is now being applied to the space program. Prof. Sukenik has demonstrated how an inorganic thin film can protect satellite surfaces from the erosion that occurs in low earth orbit. Prof. Sukenik's work provides a potential boost to the "small satellite" industry – a field in which Israeli companies are particularly prominent.

BIU- and Harvard-trained crystallization expert Dr. Eli Sloutskin has created a new "colloidal" material that may help scientists understand the physics of glass formation. He also used a colloid-based model to study the behavior of Random Close Packed materials. Because RCP materials bear many similarities to the disordered, rigid structures created when nano-sized particles are "shot" toward a substrate, Sloutskin's discovery provides valuable data for the development of tomorrow's nano-electronic devices.



Carbon nanotubes are structures that many scientists believe may one day serve as “wires” for nanoelectronics. Dr. Joseph Frey – an expert in the design and synthesis of functional polymers – has created a mechanism for the procurement of individual, isolated carbon nanotubes, an advance that helps overcome the fact that such nanotubes usually appear as part of inseparable bundles.

New Energy Sources

To promote the use of renewable energy sources, they must first be made both efficient and affordable. Prof. Arie Zaban recently reduced costs by finding a new way to produce highly photoactive quantum dots for solar cells. In previous work, Zaban demonstrated how metallic wires mounted on conductive glass can form the basis of cheap and efficient photovoltaic solar cells. He also created a low-cost technology in which dye-activated semiconductor nanoparticles are arranged in a sponge-like array on flexible plastic sheets.

Also in photovoltaics, Dr. David Zitoun has created a method for producing amorphous silicon nanoparticles that may form the basis of a new, “ink-jet” based method for printing solar cells. Zitoun also creates contaminant-free surfaces for thin films, powders and other manufactured nanomaterials used in energy conversion and storage applications.

BIU alumnus Prof. Doron Aurbach – best known for the primary role he played in the development of the rechargeable lithium batteries used in cellphones and computers – is developing advanced Li ion batteries for electric vehicles. He is also working on several electrochemical technologies for the storage and conversion of sustainable energy – applications called “load leveling”.

Prof. Moshe Deutsch recently became the first in the world to reach atomic-scale resolution in examining the interface between liquid electrolytes and mercury electrodes – an achievement that has revealed important new insights relevant to many renewable energy and battery applications. Prof. Deutsch was also the first to determine the atomic-level structure of how a metal in liquid phase orders itself near a solid surface.

Green Nanoscience

In addition to devising new materials and methods for energy production, BIU researchers are spearheading research that will safeguard our natural environment. Prof. Aurbach is advancing promising discoveries related to water desalination – an area of research crucial to ensuring the availability of clean drinking water. Dr. Ehud Banin is creating new “anti-fouling” methodologies that can prevent the formation of biofilms – resistant bacterial “communities” that thrive in moist environments, contaminate surfaces, and are responsible for billions of dollars in lost industrial productivity and equipment damage every year. Prof. Gedanken has developed a number of processes in which inexpensive waste materials are transformed into useable bio-diesel – cleaning up our environment while providing a new source of energy at the same time.

A New “Spin”

Physical phenomena related to the charge carried by electrons have been responsible for decades of amazing progress in the electronics industry. However, this industry is approaching a fundamental limit, as technologists attempt to surmount barriers to greater computational power and speed. One of the most promising ideas is to take advantage of the magnetic moment of the electron, known as “spin.” This idea is the basis for the emerging field of “spintronics.” BIU nanomagnetism experts are pursuing spintronic science, and are also examining the basic characteristics of magnetic materials – paving the way toward a variety of magnetism-based applications.

Prof. Lior Klein – together with colleagues from Yale – recently proposed a Magnetic Random Access Memory, or MRAM – a device that may eventually replace the volatile and non-volatile memory devices in computers. Unlike today’s multi-layer and expensive MRAMs, Klein’s single-layer device is expected to be relatively simple and inexpensive to produce. In another project, Klein has fabricated magnetoresistive magnetic sensors with sub-nanotesla resolution. Such devices may drive new applications in basic and applied science, from nanomagnetism research to chip diagnostics.

A “fault current limiter” technology created by the group of Prof. Yosef Yeshurun and Dr. Shuki Wolfus was named one of the top five technological breakthroughs of 2010 by General Electric Corporation. The self-regulating system – which protects the electricity distribution grid from power surges by taking advantage of superconductors’ special magnetic properties – is being commercially developed by an Israeli company. In another recent achievement, Yeshurun fabricated the world’s smallest nano-ring arrays made from high temperature superconductors.

➔ **Bar-Ilan nano experts are making important advances in energy production, environmental protection and spintronics.**

As anyone who has struggled to recall the name of an acquaintance can attest, it can take time to dredge up and use information stored in memory. The same is true for computers. Dr. Amos Sharoni, an expert on the magnetic behavior of materials on the nano-scale, is developing materials that may someday form the basis of devices in which “logic” and “memory” work seamlessly together, within a single structure. Based on a thin-film deposition process that creates a multi-layer material characterized by stability in terms of its electron spin, Sharoni’s work is moving us closer to the development of practical spintronic devices.

Another BIU magnetism experimentalist working in thin films is Prof. Aviad Frydman. An expert on low-dimensional magnetism and magneto-transport, Frydman is examining the relationship between deposition thickness and the emergence of magnetic properties.

A BIU theorist who is advancing our fundamental understanding of magnetic materials on the nano-scale is Prof. Richard Berkovits. Berkovits uses methods of statistical mechanics to study quantum dots – artificially designed and controlled “super-atoms” made of semiconductors.



Medical Milestones

Prof. Shlomo Margel is an expert in the fabrication of nanoparticles for medical use. His work – together with that of Prof. Chaya Brodie – forms the basis of a new start-up company that is testing specially designed magnetic nanoparticles that target brain cancer.

Another BIU scientist working on cancer – this time from the perspective of molecular imaging – is Dr. Rachela Popovtzer. Popovtzer synthesizes gold nanoparticles that target and attach to malignant cells, creating a “golden” signal on a CT scan that reveals the location of cancer within the body, even at a very early stage of the disease. Popovtzer has also fabricated cancer-killing gold nanorods that attach themselves to malignant cells and can be activated non-invasively by light from the skin surface.

Prof. Jean-Paul Lellouche has engineered a nanoparticle that delivers bacteria-killing medication. In collaboration with Prof. Shulamit Michaeli, Lellouche has also designed nanoparticles for delivering “silencing RNA” – genetic material that prevents the expression of specific genes.

Understanding the dynamics of biological materials is the key to medical nanotechnology. Prof. Yitzhak Rabin has characterized the way DNA molecules move through nanopores – natural or man-made holes in electrically insulating membranes. Using computer simulations, he has also calculated the distribution of “twist” and “writhe” seen in circular double-stranded DNA molecules of various lengths.

The Power of Light

BIU experts in nanophotonics – a scientific discipline that uses the interaction between light and matter to manipulate, transfer and store information – are developing ultra-fast components as well as basic research tools.

Prof. Michael Rosenbluh employs ultra-short laser pulses to manipulate materials on an atomic scale, and has successfully fabricated “nano-wires” for use in photonic applications. In another project, he created an ultra-fast optical random bit generator – a device with great significance for cryptology and secure communication. Rosenbluh has also shown how data derived from scattered light can be amplified, and has created new technologies for efficiently harvesting the power of the sun.

Prof. Zeev Zalevsky focuses on the generation and manipulation of light for use in high-speed information processing, detection and biological sensing. His next-generation optical fibers are being applied to everything from remote sensing to clinical ophthalmology to biomedicine.

“Silicon photonics” aims to create hybrid components that integrate traditional electronics with the data-encoding power of light. Dr. Avi Zadok designs hybrid components that run fast while staying cool – overcoming a major bottleneck in the development of high-speed, multi-processor systems.

Dr. Yaakov Tischler is using organic materials to create next-generation nanolasers for applications including ultra-fast sensors, high-resolution devices for medical imaging, and improved photovoltaic solar cells.

The BIU Nano-Revolution

Situated at the microscopic meeting point between chemistry, biology, engineering and physics, nanotechnology is one of the world's most exciting fields of endeavor. By committing itself to cracking the tiniest of mysteries, Bar-Ilan is opening up wider vistas of the possible – for the good of humankind.



For more about the research of BIU faculty listed in this brochure go to: www.biu.ac.il and click Research.



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BIU's Leslie and Susan Gonda (Goldschmied) Nanotechnology Triplex

Bar-Ilan University Science and Technology

Bar-Ilan University stands at the forefront of cutting-edge research. Bar-Ilan researchers are making breakthroughs that improve life around the globe in areas such as drug-development, nanotechnology, medical research, bio-engineering, microscopy, optics, communications, energy, security, and more. As part of a national program to combat Israel's brain drain, BIU has taken the lead by committing to absorb dozens of returning experimental scientists within its world-class research infrastructure, and has added state-of-the-art physical facilities in engineering, brain sciences and nanotechnology to house these innovative initiatives. The Science and Technology Series highlights some of the University's most exciting research endeavors.



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