Energy in the Miniature

As appliances and devices shrink in size, the need for efficient miniature batteries grows. Prof. Emanuel Peled and Prof. Diana Golodnitsky, Raymond and Beverly Sackler School of Chemistry, are developing tiny batteries to be lodged in ingestible capsules for medical use, or in minuscule sensors for security purpose.

Scientists are attempting to develop long-life, high-current micro-batteries needed today for a range of novel applications. "Commonly available batteries are built of layers—cathode, anode, electrolyte, and current collector—which together carry out an electricity-producing electrochemical reaction," explains Prof. Golodnitsky. "When we reduce the quantity of matter to construct a smaller battery, the amount of energy produced drops accordingly, and the battery is inefficient. For medical use inside the body, traditional batteries are unsuitable because of the danger of toxic electrolyte fluid leaking. In addition, small batteries with thin layers of solid electrolyte, which were developed 15 years ago, must be recharged frequently. Prof. Menachem Nathan of the Iby and Aladar Fleischman Faculty of Engineering has come up with a brilliant solution: a perforated silicon chip that carries many nanoscale batteries. Our group is developing miniature batteries based on Prof. Nathan's idea."

Miniature batteries are built into a three-dimensional silicon chip. Its surface area is less than one square centimeter, it is 500 microns thick, and has 20,000–30,000 fine holes measuring 30–50 microns in diameter each, approximately 10 microns apart. Using smart wet chemistry methods—a variety of coating processes in solutions—researchers place thin layers that form independent nano-batteries into each hole. The chip offers 10–40 times more active material for electricity production per surface unit, compared with other micro-batteries.

"We are developing nanomaterial batteries that supply voltage according to need and application," says Prof. Golodnitsky. "For example, solar cells require a voltage of 1.5–2 volts, whereas batteries for medical use usually operate on 3 or more volts." Potential applications range from implants with controlled-release drugs; micro-cameras for internal imaging of the digestive tract (endoscopy); implanted hearing aids, pacemakers, blood-pressure or insulin-level sensors; collection and storage of solar energy with small solar cells; environmental-monitoring sensors and atmospheric-pressure gauges; outdoor sensors for defense purposes; and so forth.

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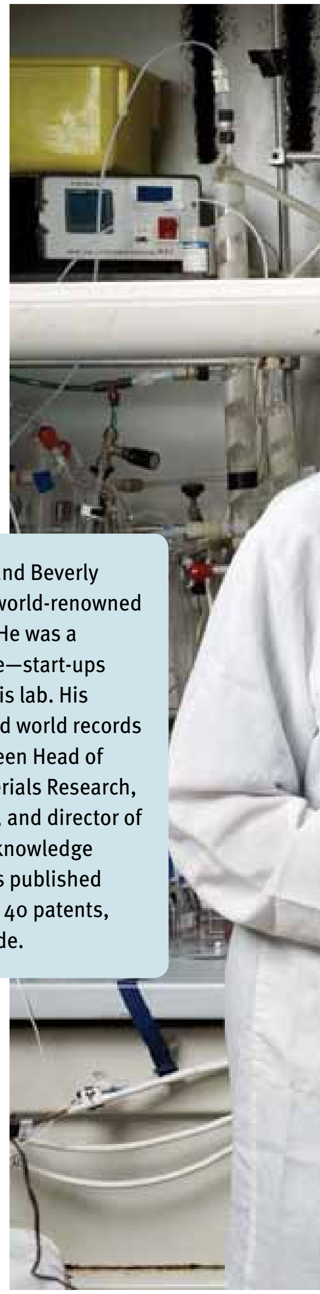
Prof. Emanuel Peled, Raymond and Beverly Sackler School of Chemistry, is world-renowned in the field of fuel cells and batteries. He was a founder of Chemtronics and EnStorage—start-ups based on technologies developed in his lab. His group's unique fuel cells have achieved world records in electricity output. Prof. Peled has been Head of TAU's Wolfson Center for Applied Materials Research, and Gordon Center for Energy Studies, and director of the Ministry of Science & Technology knowledge center for fuel cells & batteries. He has published more than 150 papers, registered over 40 patents, and won awards in Israel and worldwide.

GREEN FUEL CELLS

Researchers create clean, green fuel cells using nanotechnology. "A fuel cell is an electrochemical device that continuously converts chemical energy from a fuel (such as hydrogen) and an oxidant (such as oxygen or air) into electrical energy," explains



Prof. Peled. "Green fuel cells are environmentally friendly because they release only water and heat to the atmosphere. They have garnered interest as a means of producing and storing energy in general, and particularly clean energy. They can store energy produced from wind or sun, and supply energy to the grid, individual homes, or mobile devices; but their most promising application today is powering electric vehicles." Important components of fuel cells are the catalysts—nanometric particles that facilitate redox processes taking place in the fuel cell. Catalysts are made of nanoparticles of platinum—a prohibitively expensive metal. Currently, the cost of the catalysts is approximately half the cost of the entire fuel cell. Prof. Peled's team has developed a new type of catalyst: a nanometric core made of a less costly metal, encased in a thin coat or sub-coat of platinum or platinum alloy.

Prof. Diana Golodnitsky, Raymond and Beverly Sackler School of Chemistry, specializes in electrochemistry, lithium batteries, and electrochemical storage of energy. She has published more than 90 scientific papers and penned three book chapters. She holds 12 patents and was a founder of DEVIS Electroscopy. Prof. Golodnitsky collaborates with leading scientists in the US and Europe, and sits on the editorial board of *The Open Electrochemistry Journal*.

Such catalysts are more easily manufactured by non-electrical deposition, at room temperature. They significantly reduce the cost of fuel cells without compromising their performance, and even improving it. ●