RESEARCH BRIEF

ELECTROSTATIC NANOCAPACITORS

The challenge

To save money and energy, many people are purchasing hybrid electric cars or installing solar panels on the roofs of their homes. But both have a problem—the technology to store the electrical power and energy is inadequate.

Battery systems that fit in cars don't hold enough energy for driving distances, yet take hours to recharge and don't give much power for acceleration. Renewable sources like solar and wind deliver significant power only part time, but devices to store their energy are expensive and too inefficient to deliver enough power for surge demand.

The potential

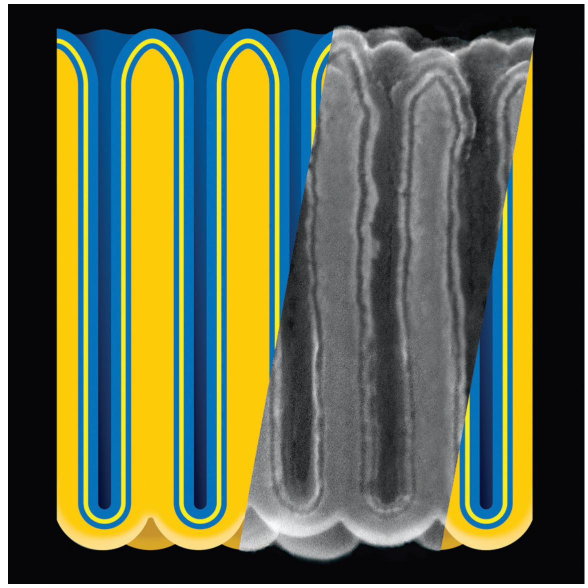
Efficient and affordable batteries are needed for many different applications. Renewable energy sources like solar and wind provide time-varying, somewhat unpredictable energy supply, which must be captured and stored as electrical energy until demanded. Conventional devices to store and deliver electrical energy—batteries and capacitors—cannot achieve the needed combination of high energy density, high power, and fast recharge that are essential for our energy future.

The research

A research team led by Maryland Nanocenter Director and former ISR Direcor **Gary Rubloff** (MSE/ECE/ISR) has developed new processes to significantly enhance the performance of electrical energy storage devices, and new systems for storing electrical energy—including energy derived from solar and wind sources—that are, in some cases, 10 times more efficient than what is commercially available.

The researchers are using the nanotechnology processes of self-assembly, self-limiting reaction, and self-alignment to construct millions—and ultimately billions—of tiny, virtually identical nanostructures to receive, store, and deliver electrical energy.

"These devices exploit unique combinations of materials, processes, and structures to optimize both energy and power density—combinations that, taken together,



Electrostatic nanocapacitors formed in nanoporous anodic aluminum oxide (darker yellow) film by sequential atomic layer deposition of metal (blue), insulator (yellow), and metal. Insert: cross-section of actual structure, represented as rescaled scanning electron micrograph. (Nature Nanotechnology/A. James Clark School of Engineering)

have real promise for building a viable next-generation technology, and around it, a vital new sector of the tech economy," Rubloff said.

The goal for electrical energy storage systems is to simultaneously achieve high power and high energy density to enable the devices to hold large amounts of energy, to deliver that energy at high power, and to recharge rapidly (the complement to high power).

Electrical energy storage devices fall into three categories. Batteries store large amounts of energy but cannot provide high power or fast recharge. Electrochemical capacitors (ECCs), also relying on electrochemical phenomena, offer higher power at the price of relatively lower energy density. In contrast, electrostatic capacitors (ESCs) operate by purely physical means, storing charge on the surfaces of two conductors. This makes them capable of high power and fast recharge, but at the price of lower energy density.

The new devices are electrostatic nanocapacitors which dramatically increase energy storage density of such devices without sacrificing the high power they characteristically offer. The Rubloff team's advance brings electrostatic devices to a performance level competitive with electrochemical capacitors and introduces a new player into next-generation electrical energy storage.

These new nanodevices are being developed for mass production as layers of devices that could look like thin panels, similar to solar panels or flat panel displays, manufactured at low cost. Multiple energy storage panels would be stacked together inside a car battery system or solar panel. These same nanotechnologies could provide new energy capture technology (solar, thermoelectric) that could be fully integrated with storage devices in manufacturing.

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