AN “AAAAAAAAA” BATTERY? UF RESEARCHERS MAKE PROGRESS ON TINY CELL

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GAINESVILLE, Fla. --- It would send and receive faxes and video and have the processing power of a personal computer. The cell phone of the future would be on the market today but for one hitch: the battery.

The technology is available to build cell phones that would make the latest versions -- those that allow users to send pictures and play video games -- seem almost primitive. But the batteries now used in cell phones are not nearly powerful enough to drive all the fancy add-ons, said Charles Martin, a University of Florida chemistry professor. Laptop computers, video cameras and digital cameras also are hobbled by today’s power storage technology. Meanwhile, tiny machines being developed for a variety of purposes -- such as “lab-on-a-chip” devices that sense airborne chemical or biological pathogens -- will require batteries many times smaller and more powerful than today’s smallest batteries.

So Martin and his team are making progress on a new approach: Batteries inspired by the emerging field of nanotechnology. The research could both improve the small batteries used in portable electronics and lead to truly miniscule power packs for so called “microelectromechanical” machines, or MEMS, devices. In the first year of a five-year collaborative effort with three other institutions funded by a $5 million grant from the U.S. Office of Naval Research, the research is showing progress toward its goal of creating a three-dimensional, millimeter-sized battery -- considerably smaller than the centimeter-sized hearing aid batteries that are the smallest batteries on the market today.

All batteries consist of two electrodes, an anode and a cathode, and an electrolyte solution. UF researchers have created both nano-anodes and nano-cathodes, or anodes and cathodes measured on the scale of billionths of a meter. They’ve shown in tests that these electrodes are as much as 100 times more powerful than traditional ones.

The electrodes also have a unique and promising structure.

“The UF progress is very significant,” said Bruce Dunn, a professor of materials science and engineering at the University of California-Los Angeles, the lead institution in the project. “(Martin’s) work, the fabrication and testing of nano-dimensional cathodes and anodes, represents the...”
key elements of his concentric tube battery approach, which represents a novel three-dimensional configuration.”

Martin and his colleagues create the nano-electrodes using a technique he pioneered called template synthesis. This involves filling millions of tiny “nanoscopic” holes in a centimeter-sized plastic or ceramic template with a solution that contains the chemical components that make up the electrode. After the solution hardens, the researchers remove the template, leaving only the electrodes. The next challenge is to find a way to put together the nano-anode and nano-cathode with a nano-electrolyte and other components.

“We’ve proposed a totally new design for a battery where all the components are nanomaterials, and we have succeeded in making nearly all of these components,” Martin said. “We have not yet developed the technologies to assemble these components, and that’s what we’re working on.”

Robbie Sides, a UF doctoral student in chemistry and one of the researchers in Martin’s lab, said UF’s nano-anodes and nano-cathodes are not only more powerful than traditional ones, they’re also hardier. Lithium-ion battery electrodes might sustain an average of 500 charges and discharges before wearing out, he said. In tests done by another UF chemistry doctoral student on Martin’s team, the nano-electrodes sustained as many as 1,400 charges.

The new technology could improve cell phones and other portable electronics, which use lithium-ion batteries. These batteries are made of composites of small particles. Their ability to produce power depends on lithium ions diffusing throughout these particles. While microscopic, the particles are large enough to be measured in microns, or millionths of a meter. The nano-battery approach seeks to replace these particles with particles measured in billionths of a meter, which would enhance power storage and production because the lithium ions would have less distance to travel as they diffuse.

Micro-batteries also could power tiny pumps or presses in MEMS devices. Researchers already have developed or are working on a plethora of uses for such machines, including tiny switches or environmental sensors. As Sides pointed out, however, it doesn’t make much sense to make the device tiny unless there is a power source to match.

“If you have a circuit the size of a pinhead and you need a battery the size of a triple A that you get from the store, then it (the circuit) won’t be useful,” he said.

The U.S. Department of Energy has funded much of the UF basic science research on nanobatteries. Aside from UF and UCLA, the other participants in the Office of Naval Research project are the University of Utah and the Naval Research Laboratory. Each institution is working on a different approach to creating batteries made of nanoscale materials, efforts Martin predicts could result in a prototype device within three years.

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