SPINOFF SPOTLIGHT

Charging Ahead

A123 Systems makes a new lithium-ion battery with the power to run cordless tools, electric cars, and even military equipment

If the world will beat a path to your door for a better mousetrap, imagine what it would do for a battery that weighs less, lasts longer, and recharges faster. Using technology developed by MIT professor Yet-Ming Chiang, A123 Systems has started selling such a battery and hopes customers from car manufacturers to the military will soon be beating its door down.

Founded in 2001, A123, of Watertown, MA, kept a low profile until November, when it announced a deal to supply toolmaker Black and Decker with 36-volt batteries, which have twice the voltage of the 18-volt batteries most common in cordless tools now. That translates to an increase in peak output power from 600 watts to about 2,500 watts, enough to enable battery-powered versions of tools that until now needed to be plugged in, such as hammer drills and circular saws, and more powerful versions of existing portable power tools. The batteries will hold about five times as much energy as the previous generation of lithium-ion batteries and can be recharged much faster—to 90 percent capacity in five minutes.

These batteries are not made of exactly the same materials as the lithium-ion batteries used in laptops and cell phones. Chiang, the Kyocera Professor of Ceramics in the Department of Materials Science and Engineering and a cofounder of the company, won’t discuss the specifics of the proprietary material in the batteries. But while standard lithium-ion devices use a lithium cobalt oxide for the positive, or cathode, side of the battery, his device uses a different material, lithium metal phosphate.

A major concern in battery design is thermal runaway, in which current flows through a battery too quickly, leading to an explosion. The metal phosphate in A123’s batteries is less prone than cobalt cathodes to thermal runaway, which in turn confers power advantages.

In a lithium-ion battery, the physical movement of lithium particles through the surrounding metal carries the charge. Lithium cobalt batteries use relatively large lithium particles, approximately 5 to 20 micrometers in diameter, whose comparatively slow movement lessens the chances of thermal runaway.

Since the metal phosphate cathode is more stable, however, A123 can use particles of lithium only about 50 nanometers in diameter, at least 50 times smaller. That allows more of the energy-holding material to be packed into the same space, and the shorter distance between particles speeds up charge and discharge rates. The result is a battery that can safely handle bigger bursts of outgoing power, of the type that a saw hitting a knot of wood might need. These batteries can also be recharged several thousand times, compared to a few hundred times for current lithium batteries. And the battery cell has been designed in such a way that it transfers heat better and heats up to only about 40 °C, as opposed to the roughly 50 °C of a laptop battery.

Because of safety concerns, power tools have tended to use nickel-cadmium (NiCad) batteries, says A123 Systems CEO David Vieau. NiCad is better at supplying the high bursts of energy tools require, rather than the steady trickle of lower
energy—maybe 25 watts—that a laptop might need. But even existing lithium batteries hold two to three times as much energy as NiCad batteries, and about four times as much as lead-acid batteries. “The power tool industry had pretty much exhausted the capacity of NiCad,” Vieau says. To deliver even 1,500 watts of power would require about five pounds of NiCad batteries, versus one pound of A125’s.

Vieau says the increased capacity of A125’s batteries may lead to battery-run versions of devices that have traditionally run on either motors or power cords, such as lawn mowers. Because they can supply more power in less space and at less weight than other batteries, they’d be a good choice for starters in helicopters and other aircraft, he says: “There’s a very, very broad set of applications.”

The company is especially interested in developing batteries for hybrid vehicles, a project on which it has worked since its inception, in collaboration with the U.S. Department of Energy. “We think our chemistry and our cell design are really ideally suited for that area,” Chiang says. The A125 battery’s stability lets it handle large bursts of incoming power, as are generated when braking recharges the batteries in a hybrid gasoline-electric car. And the batteries’ higher power-to-weight ratio is important to car manufacturers who want to keep the weight of their vehicles down. It could be three or four years before the company has batteries ready for automakers, though. “There’s a lot of engineering that will need to be done, and a lot of evaluation,” Chiang says.

Other potential markets abound; any application that requires portable power could benefit, says Chiang. In the medical industry, portable monitoring devices could be given more power. The military, which has to be mobile, would appreciate longer-lasting batteries, especially ones powerful enough to run vehicles or power laser weapons. A123 hopes to be able to make more product announcements this year.

One set of gadgets the new batteries will not power is consumer devices such as cell phones and laptops. Chiang said he and A125 are developing another material more suitable for the constant output of lower power that those devices require, but he would not discuss it in detail.

Chiang founded the company with Ric Fulop, a fellow at MIT’s Sloan School of Management who is now vice president of business development and marketing, and Bart Riley, who is vice president of research and development. Chiang took a year’s leave of absence from MIT in 2002 to get the company on its feet and still serves as a consultant. The company licensed the original technology from MIT and with its own development efforts now has about 19 patents pending, says Vieau.

A125 has raised $32 million in venture funding and expects to close a Series C round of financing this month. It currently has 140 employees and will probably add more over the coming year, Vieau says. It owns some manufacturing facilities and also subcontracts with other companies, both in the U.S. and abroad.

Sara Bradford, research manager for the power supplies and batteries group at Frost and Sullivan, says that although the battery market is very competitive, A125’s technology—particularly in terms of improved safety—could give it a leg up. Entering the cordless-power-tool market sounds like a winning proposition, she says, but the hybrid-vehicle market might prove more challenging. Still, she says, “they have a really good technology that could show some new things to this area.”
E = mc^2 passes tough MIT test

Researchers at MIT’s Institute for Soldier Nanotechnologies are working on the waterproof fabrics of the future, materials so resistant to water they’re called superhydrophobic. Unlike current materials, these fabrics would be porous and breathable, so the wearer wouldn’t overheat, and would also be resistant to the oils that can damage waterproof materials.

Researchers from chemical-engineering professor Gregory Rutledge’s group presented their methods at the November meeting of the Materials Research Society. Key to their work is a process called electrospinning, in which a liquid polymer is drawn into a thread by electrical charges. The resulting fibers, with diameters of hundreds of nanometers, are much finer than the 50-micrometer-diameter fibers created by other processes. Fibers that small can be made into a fabric whose surface is smooth to the wearer but very rough on the scale of a water droplet, giving the water little to stick to. To further increase water resistance, researchers either make the fibers out of polymers that reject water or use chemical vapor deposition to coat them with a water-resistant substance.

Silence of the Cells

In a paper published in the December 16 issue of the journal Science, MIT biology professor David Bartel, associate professor Christopher Burge, and their team showed that microRNAs, small stretches of RNA believed just a few years ago to be meaningless, in fact affect the expression or evolution of most genes.

Genes direct the production of proteins via a molecule called messenger RNA (mRNA). MicroRNAs can bind to a short sequence on an mRNA and prevent protein production. Some of these sequences are conserved across species as disparate as chickens and humans, so researchers regard them as typical microRNA “target sequences.”

In the Science study, the team examined non-conserved binding sequences. They found that in some cells, microRNAs used these sequences to regulate gene expression. More frequently, however, if microRNAs for a particular nonconserved sequence were present in a cell, mRNAs containing that sequence were not. This suggests that many mRNAs, to preserve their function, have lost sites that pair up with microRNAs. At the same time, many microRNAs that bind to evolutionarily conserved targets are active in processes such as growth and development, turning the manufacture of certain proteins off at the right time. The researchers say some genes seem to be trying to hold onto beneficial target sequences while others are evolving to avoid harmful ones.

High-Speed Testing

Finding better polymers for use in devices ranging from medical implants to batteries is a difficult affair, slowed by the extensive preliminary testing needed to determine their mechanical properties. MIT scientists have created a technique to speed the process, slashing the time needed to synthesize and test the properties of new polymers from weeks to about two days.

In 2004, Institute Professor Robert S. Langer developed a technique to rapidly deposit 1,728 polymer dots—three copies each of 576 different materials—onto a 25-by-75-millimeter glass slide in order to test how well stem cells grew on them. Materials science professor Krystyn Van Vliet realized that she could use Langer’s slides to test the mechanical properties of materials by pressing a hard probe into each dot and measuring characteristics such as stiffness and toughness, in a process called automated nanoindentation. Combinatorial materials science—a method of optimizing materials’ properties by systematically varying their structure—was proposed in the 1960s but has been held back by slow testing; the new high-throughput assay could make the concept a reality, improving innumerable materials.

Regeneration Insights

Microscopic flatworms called planarians provide a vivid demonstration of the power of stem cells: cut one into as many as 279 pieces, and each segment will grow into a whole worm. Scientists who hope to use human stem cells to create new tissues and organs believe understanding planarian regeneration may help them in their quest.

Peter Reddien, assistant professor of biology, has identified a gene key to regeneration in adult planarians. Called smedwi-2, this gene controls the cells produced by stem cells. When a stem cell divides, one of its daughter cells is a stem cell, and the other can migrate through the body and replace specific damaged or missing cells. When Reddien and colleagues blocked the activity of smedwi-2, planarians could not regenerate; the second group of daughter cells could migrate throughout the body but could not replace damaged tissue.

A gene related to smedwi-2 is expressed in human bone marrow by adult stem cells that make blood and regenerate the immune system; understanding the planarian gene could yield insights into the operation of these cells, Reddien says.
A Flood of Information

Rafael Bras’s group uses data-intensive computations to better predict flooding and erosion.

As anyone who watched television coverage of the disaster in New Orleans well knows, flooding can devastate land and homes. While some computer models to predict flooding exist, they’re relatively crude and provide limited information. But Rafael Bras, the Edward A. Abdun-Nur Professor in MIT’s Department of Civil and Environmental Engineering, is developing software designed to give detailed information that can be used to predict floods or sketch out the evolution of a landscape.

When National Weather Service meteorologists issue flood warnings, they use what Bras calls a “lumped model.” In essence, they take an area, maybe as large as 1,000 square kilometers, and look at what has historically happened at a particular point within it under specific conditions. The model might say, for instance, that with X amount of rainfall in Y amount of time, Hartford often experiences floods. But the same model might not include enough data for other cities in the same area, such as New Haven, limiting its utility.

Bras’s group, part of the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, takes a different approach. Generally consisting of eight to twelve people, mostly graduate students and one or two postdocs, the group has developed a model that is spatially distributed, meaning that when it looks at a large area, it takes into account how what happens on a particular part of the map might affect what goes on elsewhere. What the model’s data-intensive computations actually depict, Bras says, is how a landscape behaves. “We now have models to predict the evolution of the landscape, for example due to erosion,” he says.

Bras’s model includes information about topography—the rises and dips in the landscape—at a resolution of tens of meters. The data comes from a variety of sources, including commercially available digital elevation maps, photographs from air surveillance, and radar measurements made by the space shuttle, which has mapped 80 percent of the world’s surface.

While most of the data comes mapped onto rectangular grids, Bras remaps it onto triangles of different sizes for processing. He says it’s mathematically easier to vary the position and resolution of triangles as the program is running. He uses an algorithm, which he has patented, to figure out which triangles have characteristics—slope, soil density, and the like—that make them better predictors of climatic events. By omitting less-critical data, he processes more information in less computer time, reducing the overall burden on the computer by a factor of 10.

Bras’s model also includes information on seasonal variations in vegetation and on the quality and moisture of the soil. A series of computational tests looks for errors that might creep into the measurements and corrects for them, yielding a pretty accurate model of a particular area. Just add information on a storm system from standard Doppler radar, and the computer can offer real-time predictions of floods or reveal where previously solid land has turned into truck-trapping mud.

Bras is negotiating with a company interested in licensing the software and working to develop a user-friendly interface. He hopes to have something ready in six months to a year. Besides the National Weather Service, consultants who market geographic information systems to help companies and governments make decisions about resource management might also be interested in the software.

Short-term predictions of the evolution of a landscape could be helpful to the military, which often, when it builds training areas, clears out vegetation and changes slopes, which can lead to rapid erosion and create gullies. “Some of these gullies are very big. They will swallow a tank,” Bras says.

Pedro Restrepo, senior scientist in the National Weather Service’s Office of Hydrologic Development, says Bras’s model is useful both in showing what happens in a small area of a larger watershed and in depicting dynamic changes in vegetation and the like. “It does have very important practical applications,” Restrepo says. If a forest fire occurs in a particular area, for instance, current models have to be recalibrated to reflect it; but the lack of a historical record means new data has to be accumulated over months and years. Bras’s model can adapt to such changes immediately.
Cash in Hand
A company started by three MIT undergraduates and a lecturer has won a $750,000 contract with the army’s Natick Soldier Center. RallyPoint, of Cambridge, MA, is developing a glove that provides computer and weapons control to soldiers.

The Handwear Computer Input Device feels like a normal glove, but it is studded with sensors that can recognize the position and orientation of the hand and translate gestures into computer or weapons commands. It could allow a soldier to manipulate the view in a helmet-mounted display without letting go of a weapon or vehicle handgrip; to control a weapon remotely; or to operate a small, unmanned ground vehicle.

The company was founded by Byron Hus, Forrest Liau, and David Lin, all seniors in the materials science and engineering department, and Tony Eng ’92, a lecturer in the Department of Electrical Engineering and Computer Science. The three won a $3,000 second prize in the 2003 Soldier Design Competition sponsored by MIT’s Institute for Soldier Nanotechnologies.

www.rallypoint.info

Defect Effect
An MIT spinoff trying to make speedier computer chips has found a way to limit the number of defects in its novel semiconductor—defects that can render a chip useless. AmberWave Systems of Salem, NH, calls its new system for making strained-silicon-on-insulator devices a breakthrough.

Strained silicon is silicon that has had its crystalline structure stretched, allowing electrons to move through it more easily. Strained-silicon chips run faster and use less power than ordinary silicon chips. Silicon-on-insulator chips also work up to 50 percent faster than ordinary chips, so combining the two technologies could dramatically increase efficiency. Such combined chips, however, typically suffer large numbers of destructive defects.

AmberWave found that it could reduce the frequency of the most significant defects by introducing less-destructive defects early in the manufacturing process. So-called threading defects, which run from one layer to another in silicon, are acceptable in limited numbers. By starting with a substrate that already had some threading defects, the company reduced a more destructive type of defect by three orders of magnitude and also cut down the final count of threading defects.

Eugene Fitzgerald, an MIT professor of materials science and engineering, and Mayank Bulsara, a student in his lab, founded AmberWave in 1998.

www.amberwave.com

Material Growth
Cambrios, which uses biological particles to “grow” nanocrystals and thin films of inorganic materials such as metals and semiconductors, has licensed six patents from MIT. All the patents list company cofounder Angela Belcher, the John Chipman Career Development Professor of Materials Science, and several other researchers as inventors.

The patents cover various aspects of Cambrios’s technology, such as how to make biological scaffolding for electronic, optical, magnetic, and semiconductor applications, or a viral scaffold for a self-assembled lithium battery. One patent covers a set of biomolecular functions that don’t occur in nature but which Belcher engineered.

Belcher uses directed evolution to grow viruses that tend to stick to a particular material. Over several generations, she binds viruses to the material and washes away the ones that stick only weakly. She ends up with organisms that selectively bind to the materials she wants to use. One of her viruses, for instance, might take raw materials and create crystals of a particular semiconductor. The technology could allow electronics manufacturers to better control the structures of circuit components on the nanometer scale. They could, say, make magnetic materials whose crystals are much more uniform than those created by other processes.

Belcher founded Cambrios in 2001 with Evelyn Hu of the University of California, Santa Barbara.

www.cambrios.com

Job Seeking
Trovix, of Mountain View, CA, has raised $5.25 million in Series A financing from U.S. Venture Partners, 3i, and Stanford University. The company makes intelligent search software to evaluate résumés, a difficult automation challenge, since résumés don’t come in a standard format. Called the Applicant Tracking System, the software can assess the relevance of a job applicant’s experience and determine whether he or she has hopped from one job to another. It is designed to use contextual clues to determine the meaning of words—differentiating, say, familiarity with Oracle software from past employment at the company Oracle.

The software is based on work done at MIT’s Media Lab. Trovix was founded in 2002 by Earl Rennison, who earned an MS in media arts and science from MIT and is now the company’s chairman and chief technology officer, and Jeff Benrey, now CEO. Pattie Maes, an associate professor in the program in Media Arts and Sciences, sits on the company’s advisory board.

www.trovix.com
$1K Warm-Up Awards

The annual MIT $50K Entrepreneurship Competition, designed to encourage students to start businesses, has fostered the growth of Akamai, Virtual Ink, and more than 80 other companies since 1990. Every fall the program kicks off with the $1K Warm-Up competition, which provides MIT students with feedback on their business plans ahead of the main competition. This year’s 10 winning groups—chosen from a pool of 124 teams—received $1,000 each and encouragement to participate in the more competitive $50K.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>COMPANY</th>
<th>CONTACT</th>
<th>PROJECT</th>
</tr>
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<tbody>
<tr>
<td>Tiny tech</td>
<td>Advanced Conductors</td>
<td>John Lock, <a href="mailto:info@avconductors.com">info@avconductors.com</a></td>
<td>Advanced Conductors is developing flexible ceramic films to replace the brittle glass in display devices and solar cells.</td>
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<tr>
<td>Materials</td>
<td>Avanti Metallurgy Research Corp.</td>
<td>Jeffrey Sabados, <a href="mailto:jsabados@mit.edu">jsabados@mit.edu</a></td>
<td>Donald Sadoway, professor of materials science and engineering, has developed a technique to produce titanium at a cost of less than $1.50 per pound, five times cheaper than current methods.</td>
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<tr>
<td>Global</td>
<td>House in a Box</td>
<td>Luis Canizo, <a href="mailto:luis.canizo@sloan.mit.edu">luis.canizo@sloan.mit.edu</a></td>
<td>Canizo’s company, House in a Box, has developed a compact, $1,500 house-in-a-box to provide permanent shelter for people whose homes have been destroyed by natural disasters.</td>
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<tr>
<td>Information technology</td>
<td>Interactive Edutainment</td>
<td>Joanne Metzger, <a href="mailto:jmetzger@sloan.mit.edu">jmetzger@sloan.mit.edu</a></td>
<td>Interactive Edutainment develops educational Web-based video games for “tweens,” or 9- to 14-year-olds.</td>
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<tr>
<td>Services</td>
<td>Izi Interactive</td>
<td>Billy Lo, <a href="mailto:billylo@sloan.mit.edu">billylo@sloan.mit.edu</a></td>
<td>Izi Interactive is filing a patent for an online, interactive language-learning system for children.</td>
</tr>
<tr>
<td>Energy</td>
<td>MicrobeFuel</td>
<td>Nina Kshetry, <a href="mailto:ninak@mit.edu">ninak@mit.edu</a></td>
<td>MicrobeFuel has developed a technique for producing fuel ethanol from agricultural waste, lowering costs.</td>
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<tr>
<td>Social/developmental</td>
<td>OneWorld Medical Devices</td>
<td>Serena Cheng, <a href="mailto:serena@sloan.mit.edu">serena@sloan.mit.edu</a></td>
<td>OneWorld has a patent pending for a portable vaccine storage unit that can weather natural disasters and temperature changes, potentially saving millions of lives each year.</td>
</tr>
<tr>
<td>Hardware</td>
<td>Robopsy</td>
<td>Conor Walsh, <a href="mailto:walshcj@mit.edu">walshcj@mit.edu</a></td>
<td>Robopsy scientists are developing a telerobotic biopsy needle that radiologists can guide toward suspicious lesions during a CT scan, making for quicker, more accurate biopsies.</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>SteriCoat</td>
<td>Christopher Loose, <a href="mailto:crloose@mit.edu">crloose@mit.edu</a></td>
<td>SteriCoat is developing a coating for human implants and medical devices that will prevent infections by disrupting the formation of bacterial films and actively killing bacteria.</td>
</tr>
<tr>
<td>Consumer products</td>
<td>Terrafugia</td>
<td>Carl Dietrich, <a href="mailto:chipd@mit.edu">chipd@mit.edu</a></td>
<td>Terrafugia is developing a vehicle that can drive on roads and fly in the air, economical for trips of between 200 and 500 miles.</td>
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