

Structurally Integrated Composite Cathodes for Lithium-Ion Batteries

Argonne's innovation will enable smaller, more powerful, and safer batteries to be used in diverse applications, including computers, power tools, HEVs, and electric vehicles.

BENEFITS

- Higher capacity and longer life than conventional cathodes, which makes them significantly less expensive to use.
- Can be used in a variety of applications, from HEVs to portable devices.
- Safer than conventional cathodes.
- Proven applicability with worldwide market appeal.

APPLICATIONS

- Hybrid-electric vehicles
- Electric vehicles
- Power tools
- Medical devices
- Laptop computers
- Cell phones
- Cameras
- DVD players

STATUS

- Three patents have been awarded.
- The technology has been licensed to a U.S.-based start-up company.
- Several large battery manufacturers are considering replacing their current NiMH technology with Argonne's cathode material technology.

The Opportunity

Over the last 15 years, lithium-ion technology has become established in the market as a realistic solution to many of the societal needs for portable power. From personal devices (e.g., cell phones and laptop computers) to commercial equipment (e.g., backup-power systems and power tools), lithium-ion battery systems are capable of meeting current mobile energy needs and will likely be applicable, via continued innovation, to future generations of these electronic devices.

As the need for improved, longer-lasting, and smaller electronic devices grows, so will the need for batteries to be used in hybrid electric vehicles (HEVs), "plug-in" hybrid-electric vehicles (PHEVs) (with a longer driving range than HEVs), and even all-electric vehicles. Paramount to this societal shift toward rechargeable-battery-powered devices and automobiles will be the continued development of lithium-ion batteries that are safer, smaller, and more powerful than those we use today.



At Argonne's Advanced Photon Source, researchers load a lithium-ion battery pouch into an insertion device x-ray beamline in order to evaluate the electrode material structure stability during charging and discharging. Shown here are Christopher Johnson (foreground) and Jeremy Kropf (background).—Photo by George Joch.

The Solution

Argonne scientists have invented and patented novel composite cathodes that offer the lithium-ion battery industry increased energy, power, and lifetime — with improved safety at a reduced cost. This technology can be used in the design, packaging, manufacture, and use of lithium-ion rechargeable batteries.

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This technology will also enable a timelier switch from a fossil-fuel economy to an economy that relies on alternative energy sources.

This technology is being licensed to industry, and the attributes and advantages of Argonne's materials promise further improvements in the compositional design and performance of Li_2MnO_3 -stabilized LiMO_2^* electrodes in the next generation of lithium-ion batteries.

The Innovation

Argonne's innovation is based on structurally integrated composite material, which is used as the cathode in high-energy lithium-ion batteries. By using the composite cathode material structure, researchers have been able to develop higher lithium content to substantially improve the performance of lithium-ion batteries over conventional batteries that use LiCoO_2 as the cathode, particularly with respect to battery capacity, power, safety, cost, and calendar life. These improvements will enable smaller, more powerful, and safer batteries to be used in diverse applications, including computers, power tools, HEVs, and electric vehicles.



A plug-in hybrid electric vehicle (PHEV) prototype is prepared for testing.

ABOUT ARGONNE TECHNOLOGY TRANSFER

Argonne National Laboratory is committed to developing and transferring new technologies that meet industry's goals of improving energy efficiency, reducing wastes and pollution, lowering production costs, and improving productivity.

Argonne's industrial research program, comprised of leading-edge materials research, cost-saving modeling, and unique testing and analysis facilities, is providing solutions to the challenges that face U.S. manufacturing and processing industries.

Improved Safety, Performance

Typical positive electrodes used in existing lithium-ion batteries are limited in terms of their capacity, safety, and electrochemical stability — especially at high temperatures. In contrast, an Argonne cathode delivers exceptionally **high capacity** — **almost 80% higher than that provided by conventional lithium cobalt oxide electrodes**, which are widely used in consumer and military applications. Also, Argonne's novel and patented Li_2MnO_3 -stabilized LiMO_2^* composite electrode structures enable the development of lightweight, high-energy-density lithium-ion batteries with enhanced safety, performance, and the ability to withstand an operating environment of -25 – 55°C .

Improved Cost

A further advantage of Argonne's cathode technology is that it should enable the design of compact, but powerful, **high-rate** batteries with a significant cost reduction over state-of-the-art batteries. The per-gram cost of Argonne's composite cathode materials for lithium-ion batteries is less than that of conventional lithium cobalt oxide materials. Because the new Argonne composite cathodes have higher capacity and life, their cost as measured in $\$/\text{kW-h}$, is significantly lower than that of currently used industry standard materials.

* $(\text{M}=\text{Mn, Ni, Co})$

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