LITHIUM BATTERIES

Hot Commodity

Several large recalls of lithium-ion batteries used in notebook computers have raised questions about how these power packs could overheat enough to erupt in flames. Equally valid is the question of why accidents don't happen more often, given that very few occur among hundreds of millions of batteries sold annually.

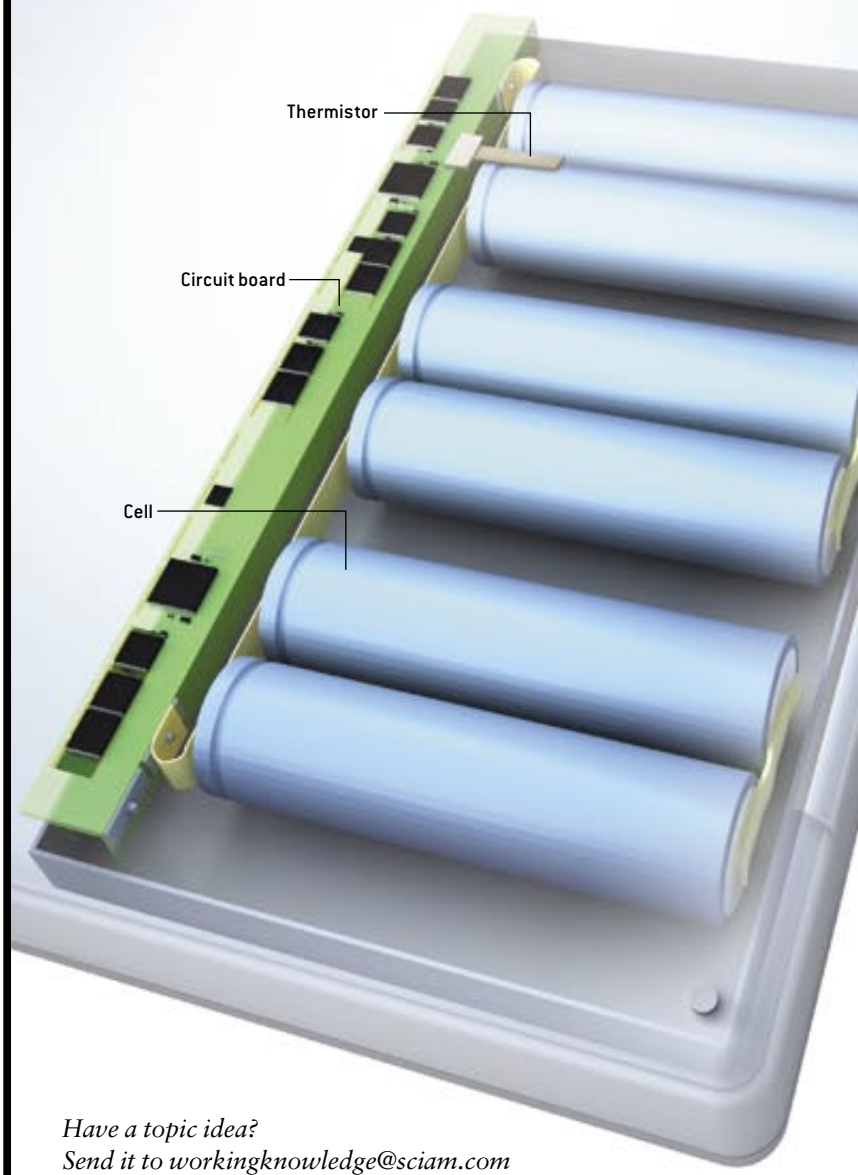
Lithium-ion cells exploit various chemistries, but virtually all rechargeable varieties, including those in cameras and in cell phones, use lithium cobalt oxide in the cathode and graphite in the anode [*see illustrations*]. Although this formulation is "inherently somewhat unsafe," according to Gerbrand Ceder, professor of materials science at the Massachusetts Institute of Technology, careful manufacturing and built-in safety devices have limited accidents to a handful. Still, Ceder explains, "battery makers have been pushing the state of charge" in a given cell because of electronics makers' demands for longer running time, so "there is now less margin for error." By stuffing more ions into the package, manufacturers have quadrupled energy capacity since commercial introduction in 1991.

Indeed, what was once a boutique product is now a commodity. The drive to raise capacity yet lower cost "encouraged manufacturers to take more risks," says Christina Lampe-Onnerud, co-founder of Boston-Power in Westborough, Mass., begun in 2005 to produce new lithium-ion battery types. "The safety mechanisms of five years ago were adequate for the level of energy in those cells," she adds, "but the push for capacity will outpace those mechanisms."

New safety devices and formulations that produce more current with less heat are being prototyped. Brisk work in the burgeoning electric and hybrid vehicle industry in particular "will create much safer cathode materials that will penetrate the consumer electronics industry," Ceder says. New metal oxides may appear in cathodes, and anodes may move from a carbon base to a silicon base. Yet until these materials prove out in testing, Lampe-Onnerud points out, more creative system design is the key to safe operation. "The industry has been pushing a single chemistry harder and harder for a wide range of applications," she says. "It's time to tailor-make different battery systems for different applications."

—Mark Fischetti

LAPTOP battery typically contains pairs of lithium-ion cells connected in series. Circuitry controls current flow and recharging; a thermistor measures temperature to indicate overheating.



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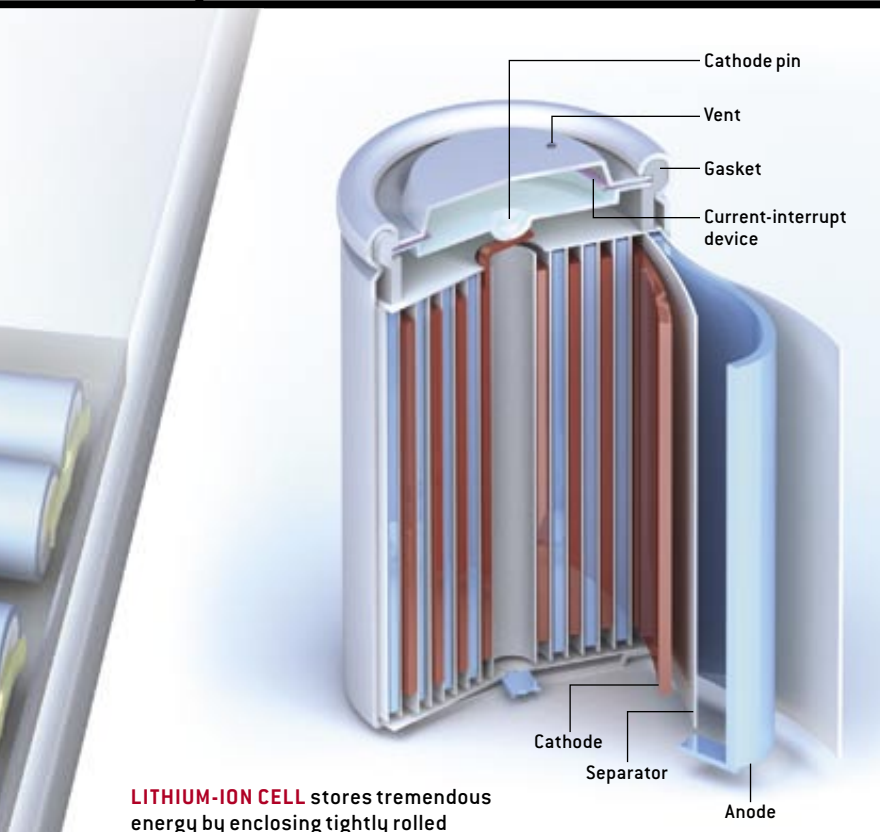
DID YOU KNOW...

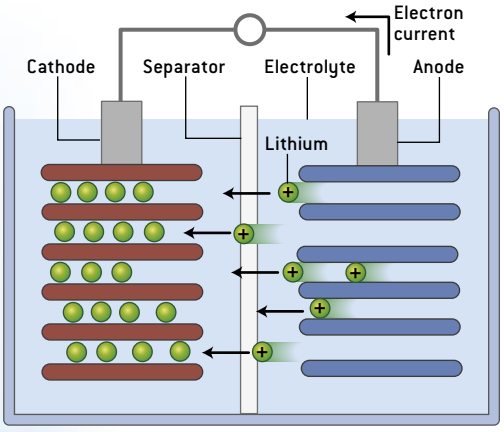
➤ PROTECT YOURSELF: Lithium burns violently when exposed to even traces of moisture—as little as the humidity in air—so never try to pry open a battery. Do not douse a battery fire with water, which will incite flames; use a chemical-based extinguisher. A cell's housing can become dangerously hot or catch fire if the cell greatly overheats (which is more likely if it is fully charged); therefore, do not leave products on hot surfaces (windowsill heater) or in the sun, especially inside a car. Also, avoid shunting the battery's leads.

➤ TESLA'S RIDE: Silicon Valley entrepreneur Martin Eberhard started Tesla Motors two years ago and this past summer unveiled the Tesla Roadster. The souped-up prototype is the first all-electric vehicle to use lithium-ion batteries: 6,831 of them. The car leaps from zero to 60 miles per hour in four seconds; its range between charges is reportedly 250 miles. The company says controllers that monitor each cell can shut down the entire pack in an instant, even if a cell catches fire. Other makers are experimenting with lithium nickel manganese oxide.

➤ LIFE SPAN: All batteries degrade, but lithium-ion cells erode faster when highly charged and warm; an average notebook battery kept at full charge at 25 degrees Celsius will irreversibly lose about 20 percent of its capacity a year, according to studies. Keeping a cell at half-charge in the refrigerator could extend its life.

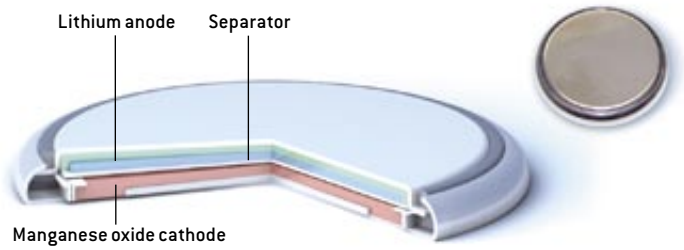


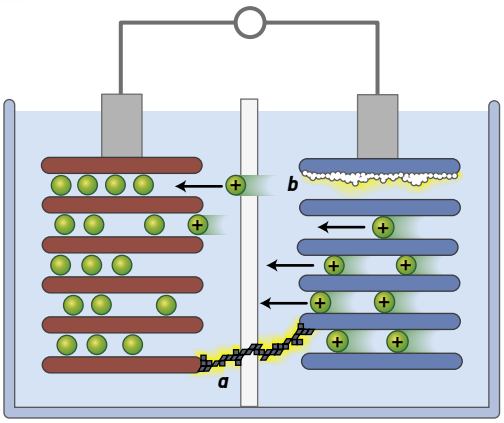
LITHIUM-ION CELL stores tremendous energy by enclosing tightly rolled sheets of cathode and anode, isolated by a separator, all soaked in an electrolyte. To prevent overheating, a vent allows gas from an errant chemical reaction to escape; the gasket blows if gas builds too fast, disabling the cell. If the cell is shorted externally, the rapid discharge triggers the current-interrupt device, which disconnects the cell.



CHEMICAL REACTION creates battery power. Lithium held in the anode ionizes in the electrolyte (a lithium salt) and migrates through the porous plastic separator to the cathode. The reaction frees electrons, which flow as external current. Applying an external voltage to the cathode drives ions back to the anode, recharging the cell.

BUTTON CELL creates current by moving lithium ions across an electrolyte separator. The flow cannot be reversed; the cell cannot be recharged.





OVERHEATING can result if metallic particles from defective manufacturing (the prime suspect in recent battery recalls) link the cathode and anode through the separator (*a*); this connection will shunt current, creating excessive heat. That heat can degrade materials enough to initiate a runaway reaction that becomes so hot that components begin to burn. A short can also occur if lithium metal from undesired chemical reactions accumulates (*b*).

BRYAN CHRISTIE DESIGN (*cutaways*); JEN CHRISTIANSEN (*schematics*); EMILY HARRISON (*photograph*)