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Technical Article Release

Beyond Lithium-Ion: Future Battery Concepts

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Mobile technology hinges upon the availability of batteries to support it. This is something most of us know all too well, as we charge up our mobile devices every night. Lightweight, cost-effective, rechargeable, and providing higher energy density by far compared to the next commercial battery chemistry, Lithium (Li)-ion is the workhorse and standard for powering today's mobile devices. Developed in the 1970's, Li-ion battery technology is unfortunately nearing its theoretical limits though, and the lag in its ability to keep pace with advancements in mobile technology is plainly evidenced not only by our nightly charging ritual, but also by the latest product introductions to circumvent the issue and provide improved run-time, including wireless charging and mobile battery cases. The hunt has been ongoing for a better battery since the beginning, but there is urgency now, with battery limitations gating not only consumer electronics, but also the electric car industry and related clean energy initiatives. In November 2013, the U.S. Department of Energy even kicked off a $120M effort to develop a game-changing battery technology in five years that would extend battery life by 5X today's capabilities. The push has spawned a flurry of activity and here are a few of the future battery concepts you will be hearing more and more about.

Tin Nanocrystal Li-Ion Batteries

Batteries convert chemical energy into electrical energy by sharing a common carrier electron. Today's Li-ion batteries generate power by sending Li ions from the negative electrode (anode) to the positive electrode (cathode), and the reverse during charging. The electrodes are typically made of cobalt, graphite, manganese, or nickel and do not absorb all of the Li ions. Tin is a more ideal electrode, but tin crystals can become up to three times bigger when absorbing ions, and shrink when releasing the ions, much like a sponge. To handle the volumetric change, scientists at the Laboratory of Inorganic Chemistry at ETH Zurich and Empa are developing a nanomaterial made of tiny tin crystals which can effectively absorb and release the Li ions, thus doubling the energy capacity of the battery.

Metal-Air Batteries

The metal electrodes of batteries in the metal-air category react with oxygen in the air, instead of a liquid, to produce an electrical current. The most promising materials for the electrode appear to be Li and sodium, but aluminum and zinc have also been researched. In fact, zinc-air batteries, such as Renata's ZA675DP6 are already available on the market for use in hearing aids.

Although development of the Li-air battery is still in its infancy, the technology holds the most promise, with 5 to 10X higher theoretical specific energy than Li-ion batteries, and is particularly attractive to the

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electric car industry. The high specific energy of Li-air batteries translates to 1000 miles of range, compared to the existing average of 125 miles on Li-ion batteries.

Sodium-air batteries have a lower *theoretical* energy capacity than Li-air, but are more stable and easier to build, while still more efficient than today's Li-ion batteries. Tests on sodium-air batteries have also shown that they may present a higher *practical* energy storage capacity than Li-air.

Liquid Metal Batteries

MIT-founded and Bill-Gates backed start-up, Ambri, has developed a battery that uses a molten salt electrolyte sandwiched between two layers of liquid metal. The difference in composition between the liquid-metal electrodes—one low-density negative and the other high-density positive, creates a voltage. Ambri, also the recipient of a $6.9M grant from the U.S Department of Energy's high risk early stage ARPA-E program, is targeting the technology towards storage applications in the power grid to make the energy system more efficient.

More New Battery Concepts

Other new battery concepts including Li-sulpher, which has energy density that is 3 to 5X that of today's Li-ion batteries, and sugar-powered biobatteries which offer green technology in addition to high energy density are among many new battery concepts in development for the next generation of electrochemical batteries. It's a race to see which battery technology will succeed Li-ion, but no matter what, the consumer is sure to benefit.