Samsung develops lithium-ion battery with nearly double the life

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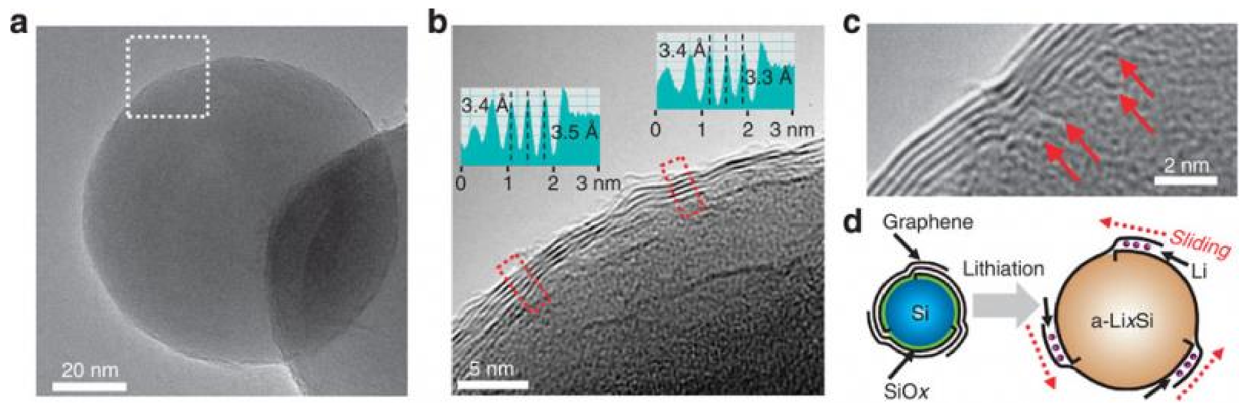

SiC-free graphene growth on Si NPs. (a) A low-magnification TEM image of Gr–Si NP. (b) A higher-magnification TEM image for the same Gr–Si NP from the white box in a. (Insets) The line profiles from the two red boxes indicate that the interlayer spacing between graphene layers is ~3.4 Å, in good agreement with that of typical graphene layers based on van der Waals interaction. (c) A high-magnification TEM image visualizing the origins (red arrows) from which individual graphene layers grow. (d) A schematic illustration showing the sliding process of the graphene coating layers that can buffer the volume expansion of Si. Credit: *Nature Communications* 6, Article number: 7393 doi:10.1038/ncomms8393

(Phys.org)—A team of researches affiliated with Samsung's Advanced Institute of Technology, along with colleagues from other institutions in Korea has found a way to greatly extend lithium-ion battery life. In their paper published in the journal *Nature Communications*, the team describes their new technique and the results they achieved using it.

Consumers want their phone batteries to last longer—that is no secret, and battery life has been extended, but mostly due to improved efficiency of the electronics that depend on it. Researchers at phone companies and elsewhere have been working hard to find a way to get more power out of the same size battery but have to date, not made much progress. In this new effort, the researchers looked to silicon and graphene for a better battery.

The team started by using silicon as the material for their anode, rather than the traditional graphite—it is denser and therefore can hold more charge—and is something other researchers have tried before. The problem has always been that in order to charge it, lithium must be added, which causes the anode to expand, a deal breaker for small electronic devices. To circumvent that problem, the researches grew carbide-free graphene (to keep it from forming they developed a chemical vapor deposition process which included using a mild oxidant) on its surface creating a protective and restrictive coating. In addition to preventing expansion, the graphene also helped prevent the silicon from breaking down over time (which occurs due to constant expanding and contracting).

Testing showed that the arrangement resulted in a battery that had an initial energy density that was 1.8 times that of conventional batteries, and held steady at 1.5 times after repeated use. Translated to the real world that would mean a battery that at least initially, would last nearly twice as long as conventional batteries. That is impressive, of course, but the fly in the ointment is the graphene—despite a lot of time, effort and money invested, scientists still have not figured out a way to manufacture the stuff in bulk, which means, that the new battery design will not be available to consumers until a way can be found to produce the graphene.

More information: Silicon carbide-free graphene growth on silicon for lithium-ion battery with high volumetric energy density, *Nature Communications* 6, Article number: 7393 DOI: 10.1038/ncomms8393

Abstract

Silicon is receiving discernable attention as an active material for next generation lithium-ion battery anodes because of its unparalleled gravimetric capacity. However, the large volume change of silicon over charge–discharge cycles weakens its competitiveness in the volumetric energy density and cycle life. Here we report direct graphene growth over silicon nanoparticles without silicon carbide formation. The graphene layers anchored onto the silicon surface accommodate the volume expansion of silicon via a sliding process between adjacent graphene layers. When paired with a commercial lithium cobalt oxide cathode, the silicon carbide-free graphene coating allows the full cell to reach volumetric energy densities of 972 and 700 Wh l−1 at first and 200th cycle, respectively, 1.8 and 1.5 times higher than those of current commercial lithium-ion batteries. This observation suggests that two-dimensional layered structure of graphene and its silicon carbide-free integration with silicon can serve as a prototype in advancing silicon anodes to commercially viable technology.