Silicon based lithium

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The mainstay material of electronics is now yielding better energy storage

Group14 Technologies is making a nanostructured silicon material that looks just like the graphite powder used to make the anodes in today's lithium-ion batteries but promises to deliver longer-range, faster-charging batteries.

Since lithium-ion batteries" commercial debut three decades ago, this portable and high-density (and Nobel Prize-winning) energy storage technology has revolutionized the fields of consumer electronics, electric vehicles, and large-scale energy storage. And yet even for the technology"s vast advancements--a staggering thirtyfold drop in price between 1991 and 2018, for instance--the biggest improvements have taken place mostly on the lithium-metal-oxide cathode side. Lithium-ion batteries" graphite anodes, by contrast, have largely stayed the same.

Silicon has long held out promise as a medium for anodes, because it can hold 10 times as many lithium ions by weight as graphite. In fact, silicon"s first documented use as a lithium battery anode even predates that of graphite--by seven years. But experiments with that element have been plagued by technical challenges--including volume expansion of the anode when loaded with lithium ions and the resulting material fracture that can happen when an anode expands and contracts.

Now, however, after some 15 years of incremental improvements and dashed hopes, silicon"s time as a mainstay material in batteries has finally arrived.

Some carmakers and silicon anode startups have teamed up to produce longer-range, lower-cost EVs that could be on the road by mid-decade. General Motors and OneD Battery Sciences in Palo Alto, Calif., are putting OneD"s silicon nanotechnology into GM"s Ultium battery cells. Alameda, Calif.-based Sila Nanotechnologies" silicon anode, which has powered the Whoop fitness tracker since 2021, will be in the Mercedes G-Class SUV by 2026. Group14 Technologies, in Woodinville, Wash., should have its silicon battery setup in a Porsche EV by next year.

In late 2022, Group14, Sila, and Amprius Technologies in Fremont, Calif., raised nearly half a billion dollars to commercialize their anode materials, with US $250 million from the U.S. Department of Energy and, for Group14, another $214 million in private investment. All three plan to have domestic gigawatt-scale factories up and running in the next few years. Group14 began construction of a 20-gigawatt plant in Moses Lake, Wash., in April.

"Silicon has transformed the way we store information, and now it"s transforming the way we store energy," says Group14"s chief technology officer, Rick Costantino.

Silicon promises longer-range, faster-charging and more-affordable EVs than those whose batteries feature today"s graphite anodes. It not only soaks up more lithium ions, it also shuttles them across the battery"s membrane faster. And as the most abundant metal in Earth"s crust, it should be cheaper and less susceptible to supply-chain issues. As things stand, nearly all graphite anode material is processed in China.

When researchers first began to explore silicon for lithium battery anodes--as noted above, in 1976, before graphite became the compromise solution--silicon"s drastic swelling and shrinking during charge and discharge quickly disintegrated the anode. And adverse side reactions complicated the process during charging and shortened battery life as well.

Some commercial battery makers, including Tesla, have boosted the lithium-holding capacity of their batteries" anodes by adding a small amount (usually up to 5 percent) of silicon. But silicon anode startups want to go much further.