Titan Silicon can completely replace graphite from battery anode: Sila Nanotechnologies

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Amit Panday
S&P Global
Supply Chain and Technology, Automotive

Gene Berdichevsky, co-founder and CEO of upcoming battery-materials company Sila Nanotechnologies (Sila), spoke to S&P Global Mobility Senior Research Analyst Amit Panday in an exclusive interview.

Source: Sila Nanotechnologies

- Sila's anode material plant in Moses Lake, Washington, will produce enough material to serve up to 200,000 electric vehicles in its first phase.
- With Mercedes-Benz as its first official customer, Sila is working through an early qualification process with other potential customers.
- Sila's innovative silicon materials can entirely replace graphite from battery anode.

Berdichevsky gives a detailed account of how Sila was formed, the advantages of breakthrough silicon anodes in EV batteries, Sila's relationship with its first official customer Mercedes-Benz, the implementation of the US Inflation Reduction Act (IRA) and more. The following are edited excerpts from the interview:

S&P Global Mobility: Please give us a backstory on how Sila Nanotechnologies happened. You have been doing research and development (R&D) on batteries for the past 12 years, you have done about 70,000 iterations of the silicon-anode chemistry, and you claim that graphite anodes mixed with some simple silicon compounds have reached their peak performance. Please tell us how you concluded that.

Gene Berdichevsky: I started my career at Tesla. I was the seventh employee there back in 2004. I was the technology lead for the Roadster battery system. We put that into production and even in those days, in about four years from start to finish, we noticed that in the performance of lithium ion (Li-ion) batteries, the improvements were dramatically slowing down, so the energy densities were not improving significantly. The costs were not coming down as much as they had in the previous 15 years. It was sort of these very rapid curves that slowed down.

So, I left (Tesla) in order to understand the science of energy, spent a couple of years studying battery chemistry, science, materials and physics, and in parallel, I was looking to start a business in this area. In 2011, I met Professor Gleb Yushin at Georgia Tech. He had a lot of innovative ideas around next-generation battery technology. He really had developed new methods of making new classes of materials. One of the things that he was working on was this nano-composite silicon class of materials. He understood batteries, and I understood the problems of batteries quite well. We looked at all the opportunities there were in the landscape and we concluded the same thing — that silicon anode was the biggest opportunity for improving battery performance.

Improving performance is critical because it is how you reduce costs. If you can store twice as much energy in every cell, then you need half as many cells to build a battery pack of a certain capacity. If you do that, your cost will drop roughly in half.

We teamed up in 2011 and spent the first five to six years trying to crack the code on making silicon anodes work. The problems with silicon anodes are all well-known, and people had been at it even then for quite a while. It took a long time to understand how to make anodes of nano-composite silicon materials in a way that they would perform. You can get simple silicon materials to cycle maybe 100 times if you replace all the graphite (from anode). However, you cannot get it to cycle 1,000 times, which is what you need for electric cars. That was really the problem.

We engineered these materials, and we iterated through lots of different recipes until we came to this structure. We got over 200 patents along the way on this technology and the implementation of it. We invented this class of materials, and we selected a specific configuration of them in this class of materials to commercialize. Around seven years ago, we started scaling up our technology, along with continuing to iterate it. We went from lab scale to the pilot, which was 100 times bigger, and then we went from that pilot up another 100 times to our commercial line in Alameda (California). It was a roughly $30 million investment that allowed us to produce enough material for tens of millions of small consumer electronics. In 2021, we became the first company with this next-generation battery technology to ship commercially.

What is interesting about silicon materials, as I mentioned — if you replace graphite entirely, you could only get 100 cycles with conventional silicone materials. What people did, as far back as 2012, was they added a small percent of silicon into a graphite anode to get a few percentage-point increase in energy density. That was it if you added more than 5% of silicon in the graphite anode. If you tried to go to 10%, your cycle life would dramatically deteriorate.

The first car on the road that had silicon technology (battery anode) was the Tesla Model S. The cells came from Panasonic, and that technology in 11 years has not really changed. People kept thinking that the manufacturer would keep increasing the silicon content and replacing the graphite little by little. However, that technology is really limited. Here we are 11 years from its commercialization, and it has not happened.

We went out and developed a set of materials that could entirely replace graphite and commercialized that. We have taken these 200 times scale-up steps, and now we are taking another 100 times scale-up steps to build out the facility in Moses Lake, Washington. In the first phase, the facility will be able to deliver enough material for up to 200,000 EVs and have full graphite replacement when it comes online; we plan to expand later. It will probably be a few billion-dollar expansion to get that to a few million vehicles worth of production capacity.

That is the name of the game for us now — to scale the technology. As we have been scaling it up, we have also been tweaking the properties and we have finally gotten the recipes to the place where they are fully scalable. This coincides with us launching and giving this product a name — Titan silicon, which is our version of this nano-composite silicon material.

The material you call Titan silicon can have varying proportions of silicon used in the anode, is it?

Yes, so you replace all the graphite with our technology, or you can replace a part of it. It is up to the customer. The reason you do a partial replacement is, let us say, you are trying to develop a vehicle and you are getting 270 miles of range and you really want a range of 300 miles. You can replace a part of the graphite with our silicon and achieve that range target.

If you replace all the graphite, we currently deliver a 20% increase in energy density over the world's best cells. It depends on your starting point a little bit, and then over time, we will get to 30% or 40% improvements in new product versions.

Please tell us more about your breakthrough material — how does it work in the battery?

In the battery, you have two main components — cathode and anode, and a little separator between them. Our material is dramatically lighter than the graphite, about five times lighter, and it takes up about half the space when it is fully charged. We get to shrink that part quite a lot. Then, you have to fill in the empty space with both anode and cathode. You rebalance the cell and you essentially need more cathode in the cell. If you are removing all the graphite and you are replacing it with silicon, this will create some space, and then you are filling that space with more anode and cathode to store more energy in the same device.

We have been hearing of a lot of innovations on the cathode side but not so much on the anode side. There are a couple of emerging companies with new developments on the anode side. How do you see more players stepping into this new domain of silicon anode? How are you particularly different from those companies?

This is a category shift wherein all graphite (in batteries) will get replaced with silicon anodes. One of our differentiations is that we are the only ones who can entirely replace the graphite and still achieve the level of performance needed for automotive and consumer electronics. As far as I know, nobody else can do that.

However, as a class, these nano-composite silica materials are going to exist and replace graphite over time, and that is really the competition. It is going to be a large market; there will be more than 30 million electric cars sold globally every year by 2030. I think regardless of how many players we end up with, only a fraction of the anode market will be silicon anodes, which will still be replacing graphite.

Displacing the incumbent is a much harder job. When you look at our scaling plans and all the scaling plans across the industry by 2030, it is not enough to replace graphite. It is just not. I think at the earliest, we are probably looking at 2035 before there is an option of which silicon technology versus a choice between graphite or silicon.

As far as how do we differentiate our technology from others, we invented this class of technology, where we were first to market, we are first in production, and we are aiming to be the first in EVs as well. Also, we are the only ones who can replace the graphite (from the batteries) entirely, which is a big deal.

Sila's silicon-anode technology used in the batteries powering Mercedes-Benz's electric G-Class wagon will be a very expensive technology. Do you see this chemistry becoming affordable in the future? If yes, can you give us an estimate of how many years it would be before silicon anodes can be used in batteries powering more affordable electric cars?

The silicon-anode technology will definitely become more affordable in the future. It will 100% come to replace all graphite from the batteries. One of the biggest advantages of this technology is that it is five or six times more effective than graphite. For every metric ton of our material, we displace five or six metric tons of graphite. As we get to economies of scale and get to a million-vehicle scale, we can make batteries with our technology cheaper than batteries using graphite.

Also, we touched upon this point at the very beginning — that if you want higher performance, you can use fewer cells, and that drives cost efficiencies at the cell level.

If you are the owner of a 50 GWh gigafactory and you stop buying graphite and start buying Sila technology, the capacity would increase to 60 or 70 GWh without making any additional investment in capex or labor, and without changing anything about the manufacturing process in the gigafactory. This can translate into dramatically reducing the per-kilowatt-hour cost of that factory, the per-kilowatt-hour cost of labor and the per-kilowatt-hour cost of capex.

In addition, with silicon anode, you can shrink the battery pack — so you need less modules, it has less weight, it needs less cooling, and you need less capacity to go the same distance. It is a no brainer. Silicon anodes will displace all graphite anodes when they get to scale because the batteries made with silicon will (eventually) become cheaper than the batteries made with graphite and they will perform better.

Can you please elaborate on Sila's relationship with Mercedes-Benz? They have invested in your company and they are officially your first customer. Is it a typical customer-vendor relationship or have they teamed up with you in the cell development?

They led our series-E funding round in 2019 and we have worked very closely with them. We develop the material but at the cell level of how our material integrates into the battery that they want to develop; we have worked very closely with them and with their (battery) cell partner as well. The three parties work closely to make the best (battery) cell using the best data and material in order to be able to make the best EV.

It is important to understand for which vehicle you are developing the battery cell. Mercedes-Benz selected the G-Class wagon as the initial platform. The plan is to expand from there and select the right cell-maker to deliver the required cells. That is all part of the process, which entails how we go from a powder to a much better electric car. This process takes a couple of years, and we are in that process in parallel, which includes building our factory.

Essentially, Sila acts as a tier 2 supplier in this engagement?

Yes, we will physically ship our powder to the cell manufacturer, which integrates it in the battery cell. It ships the cell back to Mercedes-Benz.

How are your talks going with customers other than Mercedes-Benz? Please give us some insight on this.

I would not be able to name any company other than Mercedes-Benz right now. However, we are working through an early qualification process with other customers to be able to sign a specific program involving a specific vehicle and a specific timeline that will come.

Can you tell us a bit more in detail about the chemistry that Mercedes-Benz has finalized? Have they opted for a 100% graphite replacement in the anode in their battery?

I cannot comment on this. It will be for them to announce this.

Please give us your perspective on how you think the US IRA would impact an upcoming company such as Sila Nanotechnologies. It is known that besides localization of EV battery components, the IRA mandates local sourcing of battery-critical minerals to the tune of 40% in 2023, rising to 80% from 2027 onward, for EVs to qualify for tax incentives in the US. Do you think a move such as the IRA is a big plus for Sila?

Over 95% of graphite is mined and refined in mainland China and having even as much as a gram of graphite mined or refined in mainland China in your vehicle disqualifies it from the full tax credit. From that perspective, I understand that it is currently a big challenge for original equipment manufacturers to have vendors in place and have a local battery material ecosystem in place.

However, we are here to solve that, and we are going to produce (battery materials) in North America. We will absolutely help our customers qualify for the IRA tax credits.

We also have another interesting side benefit beyond the $7,500 tax credit under the US IRA that we can help the OEMs qualify for. We deliver more value to the battery-cell maker as well. For example, if you are an owner of a 50 GWh gigafactory and you expect a certain amount of tax relief on that, when you adopt Sila's patented material without having to make any new investment, you can add 20% more capacity, which will make you qualify for more incentives accordingly. Just by buying a different anode material from us, you are going to deliver a much bigger bottom-line profit.

Do you see increased traction, especially as all major carmakers are looking to localize their supply chains in North America after the US IRA was announced?

Yes, there is a lot of interest. However, there is very limited capacity. The challenge is that this will not be the solution for everybody all at once. It is going to take time to build out this capacity. We are being very thoughtful with making sure that we have the right vehicle platforms and the right partners to get started. However, you know the supply is going to be limited and I think those OEMs that wait too long are going to end up being left out in the cold.

While building capacity will take some time, are you also looking at other international markets beyond the US in the future, such as Europe?

We are really focused on our first plan. We certainly have ambitions to move internationally. However, we first have to deliver for the US market. That has always been our plan, even before the IRA. The IRA makes that a lot more compelling. We are not going to take our eye off the ball for now.

One of the best things about this technology is that you get to localize production wherever the customers need it. You do not rely on a natural resource such as graphite; you are not mining graphite, which can only be done in certain conditions such as having the availability and meeting environmental standards, among others.

You can produce this as a technology anywhere in the world. We are producing it in the US but you could produce this in Europe; you need a low cost of energy to produce this technology. That is really the key. We absolutely will be able to localize supply in Europe over time, in South America one day, and Asia, or wherever it is needed.

How do you view the concept of battery passports? Material suppliers' and vendors' information are generally seen as business secrets in the automotive industry. However, once the concept of the battery passport is implemented, disclosing these details will probably be part of the mandate. Some companies are already working on such prototype battery passports currently.

I think it is a good direction to go. I think as an industry, we are here to ultimately transform energy and transportation into a cleaner world. It matters that we do not do it by using highly polluting energy sources. It is one of the main drivers of why we are in Moses Lake, Washington. We have great availability of hydropower up there to have a very clean process.

We have done preliminary analysis that our materials emit about 50% to 75% lower CO_2 emissions per kilowatt hour than graphite. Therefore, we dramatically reduce the CO_2 footprint relative to graphite. We do not source our input materials from places that would disqualify our technology from the IRA, for example.

Over time, I think the industry will also insist on 100% recyclability of battery materials. That would be the right thing since we do not want to be landfilling these batteries at the end of life. We are also going to increase the duration of longevity for these battery packs.

On disclosing vendor names, I think there are ways to do it without necessarily needing to disclose your entire supply chain. You could do it with third-party audits wherein you do not need to have the whole world know about it.

I do not think it would be necessary to disclose all vendor names. However, I think it would be necessary that we track the environmental footprint of the batteries and other components.

CONTACTS

The Americas
+1 877 863 1306

Europe, Middle East & Africa
+44 20 7176 1234

Asia-Pacific
+852 2533 3565

www.spglobal.com/mobility