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Our battery technology delivers a platform for manufacturing efficient, affordable EVs: OneD Battery Sciences

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A Silicon Valley veteran, Vincent Pluvinage is co-founder and chief executive officer of Palo Alto, California-based battery technology company OneD Battery Sciences. In an exclusive interview with S&P Global Mobility Senior Research Analyst Amit Panday, Pluvinage gives a detailed account of how he became an investor and co-founded OneD, its patented SINANODE platform and how its innovative technology has the potential to significantly improve the economics and performance of lithium-ion batteries, General Motors as an investor and customer, pilot production facilities and the road to commercialization. Edited excerpts from the interview:

Source: OneD Battery Sciences

S&P Global Mobility: How was OneD Battery Sciences established? Please tell us about the origin of 'SINANODE' platform.

Vincent Pluvinage: I have lived in the Silicon Valley since 1987, and I have taken a couple of companies public. Since 2001–02, I have been active in Silicon Valley as an investor, mainly focusing on innovative technologies, where I can use my physics and bioengineering background, to bring to market technologies that are well patented.

I am an inventor at heart; I have 100-plus patents in my name, and I have done a lot of licensing transactions amounting to more than a billion dollars over the years.

In 2012, I met our current Chief Technology Officer Yimin Zhu, who at that time was working for well-known Silicon Valley startup Nanosys. It started in 2001 and was a leader in nanotechnologies with quite a large team. It raised about $260 million and had investors such as Venrock, Intel, Samsung, among others. The company had multiple projects, including one called Quantum Dot for display. Today, if you buy a Q LED TV from Samsung, Sony or Panasonic, there is about a 98% chance that the technology has come from that project.

Zhu and his team had also been working on another project called silicon nanowires for lithium-ion batteries since 2007. I was quite intrigued, so I spent a year talking to him and reading all the patent applications they had filed. Then I decided to convince the board of Nanosys to split the company into two. I put together a small investor group with three or four other individuals and we invested our own capital into it. We bought the silicon nanowire project, including the team, facilities, equipment and patents and financed it for the next decade.

Over the years, we enabled Zhu to basically increase the performance and reduce the costs while making the technology scalable. At the same time, we spent many years perfecting the patent portfolio, and we ended up with about 245 granted patents all over the world. So that is how it started.

It was quite interesting at the time to read the scientific literature and realize that the idea of putting silicon in the anode of a lithium battery was not new. I believe that the first research papers that were published on this technology date back to 1995. Then a few more papers were published on the topic in about 2000. So, it was evident that researchers in companies and universities alike had been trying to put silicon in battery anodes in an efficient way, and it has not been easy.

As a matter of fact, some of our competitors are doing things that Zhu did 15 years ago. With his very strong scientific background, he could explain to me the foundational ideas about why he developed the technology the way he did. In addition to that, he had very much a manufacturing mindset and was extremely focused on figuring out how to make it easy to manufacture this technology at exceptionally low cost.

I have seen a lot of innovation and new technology development in my life, and I have rarely found an individual with expertise of these two tracks — new technology development and manufacturing — in the same brain, which was intriguing to me. We started working, and our first licensee was a military battery maker in 2014.

Over the years, we grew increasingly interested in EVs. The turning point was in 2019. At the time, we were working with Hitachi Chemical, which was a supplier of graphite and silicon oxide to Panasonic for the Tesla cells. In 2019, the Tesla Model 3 was the first EV to deploy a little bit of silicon in the battery. We experimented for about a year with Tesla and Hitachi Chemical, which was later acquired by Showa Denko. This exercise convinced us that our technology was vastly superior and more affordable than others.

From 2019 until today, we have decided to focus only on EVs for two reasons — first, the opportunity is so large that a small company needs to be focused. Second, catering to batteries in other sectors such as consumer electronics is quite different from an economic and a technical point of view. I believe working to develop battery solutions for consumer electronics and EVs together to explore synergies is not the best approach.

As you know, initially most EVs were quite expensive. Tesla started with the Model S and the Model X. However, now the Tesla Model 3 and the Model Y sell about 15 times more per quarter than the expensive X and S models. Therefore, the expensive EV market, which is above $60,000-$80,000 per car, is a niche segment that is very crowded. On the contrary, affordable EVs with a price tag under $40,000, remains an undeveloped market because affordable EVs need smaller batteries, which do not offer enough driving range. So, what is necessary is to add EVs that are powered by affordable batteries with a good driving range — a technology that does not yet exist today in commercially produced EVs.

Affordable EVs will likely make up about 80% of the global EV market by 2027–28, and every original equipment manufacturer is currently looking at this category. That is where we are focusing, and I will say that it is both a technical challenge as well as an economic challenge. You need to make things cheap enough, otherwise it is impossible.

COVID-19 and the war in Ukraine are the other two important developments in the last few years. These historical events completely changed the approach of global automakers. While vehicle manufacturers were previously looking to source batteries from the big six battery companies — CATL, BYD, LG Energy, Samsung SDI, SK On and Panasonic — for their EVs, they later began looking at creating localized supply chains to decouple and reduce the dependency on external risk factors. Almost 100% of graphite, which is used in developing anodes for the batteries, comes from mainland China, regardless of whether the anode is made and put in EV batteries in the US or in Europe. The creation of a local EV battery supply chain in the US is beneficial for us, and this is the landscape in which we operate. Our work culminated in 2022 with General Motors (GM) investing in our company. GM is collaborating with us to put our technology into EV cells.

Frankly, we are working with other OEMs too and we will be announcing details on this soon. We have set up a subsidiary in Moses Lake, Washington, US, to do pilot production. We have also set up a subsidiary in Germany to do pilot production of our European customers. We are expanding in those two continents right now.

You spoke of developing batteries for the affordable electric car segment. What is your view about the lithium iron phosphate, or LFP, chemistry that is being increasingly considered by the OEMs for making EVs more affordable?

In batteries, we have anodes and cathodes, and LFP is a chemistry for cathodes. There are three types of cathode materials — nickel manganese cobalt (NMC), nickel cobalt aluminum (NCA) and lithium iron phosphate (LFP). In terms of energy density, NCA and NMC are higher, and LFP is lower. This means that for the same amount of energy capacity in the battery, the cathode is thicker in LFP chemistry, which will make the battery significantly heavier.

There is currently an imbalance in supply and demand for NMC and NCA cathode materials, and the price of the materials has increased over the last 24 months, which is abnormal. While there should be a correction in these prices over time, LFP materials are very inexpensive, especially in mainland China. Therefore, companies began using LFP chemistry to make batteries and cut costs; however, LFP makes the battery heavier and bigger. So essentially, using LFP will come with the problem of trying to fit a bigger, heavier battery into a small car.

Now, what we do is extraordinary: while almost all of the other silicon anode solutions make the battery more expensive, our silicon solution actually does the opposite. Our solution aims to combine high energy density and a smaller and thinner cathode (NMC or NCA) with the high-performance silicon anode, while reducing the cost.

What is the SINANODE platform, and how does it work? Also, please differentiate how OneD's SINANODE technology is different than the other innovations on battery anodes developed using silicon?

Let me explain the technical as well as the economic aspects of our solution. On the technical side, there is the law of physics, which is when you alloy lithium ions with silicon atoms, the ratio is on average 3.75 lithium atoms per atom of silicon. Factually, you can put a lot more lithium in silicon than you can put lithium in graphite, where the ratio is 1/6, and that is why silicon is interesting.

However, when you mix lithium ions with silicon atoms, silicon grows in volume. When the lithium leaves during the discharge, it shrinks; the changes in volume create stress.

So, if you have a powder of silicon, with silicon particles in micron size, these particles break, and the anode fails to deliver the expected performance. The way automakers solve this problem today in electric cars like Teslas is by using silicon oxide instead of using pure silicon. Also, they do not use the stable form of silicon oxide (SiO_2), because it does not allow for the alloying of lithium with silicon since all of the silicon chemical bonds are occupied by the oxygen atoms.

However, you can manufacture what is called silicon mono-oxide (SiO), in which there is one atom of silicon for one atom of oxygen. When that happens, half the bonds of silicon are tied to the oxygen atoms and the remaining half are available to store energy by forming a bond with lithium ions; the oxygen atoms act like a rubber band, preventing fracturing of the micron-sized SiO particles.

Nevertheless, the side effect of this process is that you are using only half the silicon for lithiation. So, essentially, you are wasting half the silicon, and when you do that for a variety of reasons — economical or technical — you can only use a small percentage.

For nearly two decades, it has been understood that reducing the size of silicon powder to particles with radii of 100 nanometers or less results in a higher surface area-to-volume ratio. This means that a significant number of silicon atoms are located near the surface of the particles, while fewer atoms are found within the particle. As a result, when these small silicon particles undergo lithiation, they exhibit improved stability and do not experience significant structural damage.

People say why do we not just use a fine powder of silicon? Well, the problem with this approach is that you increase the surface area. For example, if you have a powder of micron size silicon, which has four square meters per gram, grinded to achieve 100 nanometers — you grind into the particles that are 10 times smaller and the resulting surface area of the powder may be forty square meters per gram or more. As a result, you will run into another problem, which is that the surface of the silicon is so electrochemically active that too much electrolyte is decomposed, and the anode quickly fails.

So, what our competitors are doing is what we did 15 years ago. They say why do we not put the particles of silicon inside a porous carbon framework and then cover all the particles with a shell that prevents the electrolyte from going in and reacting with the silicon but leaves the lithium ion to go in. You can do that and when you do, it can work better.

Nevertheless, there are three problems with this approach — the first one is that you have to manufacture that carbon framework, which costs money. The second problem is that the lithium ions slow down when they migrate from the electrolyte to the silicon, and some of the lithium is trapped in the hard carbon scaffold; this increases the first cycle loss. So, when you first charge the battery, some lithium gets trapped and, therefore, you need an extra amount of cathode (at added cost) material to compensate.

The third problem is that you cannot scale this solution to the very large quantities of EV-grade graphite. So, some of our competitors are using a proprietary process that costs about 10 times more capex than ours. If you look at graphite today, about 400,000 metric tons of graphite is used per year for producing EV battery cells; this number will double in the next four to five years, and there is no way you can replace that. Attempting to replace a significant fraction of the EV-grade graphite is simply technical and an economic lunacy. That is a story that is being told to please some investors, but no one in the EV supply chain believes it possible.

Now, let me explain how we are different from our competitors. First, we start with commercial EV-grade graphite, and this is a particularly important point. We can take graphite that is already produced by some of the suppliers to the EV industry; it is already produced at scale, and it is already qualified with the EV cell factories. This alone saves many years of research and development (R&D) and testing work because these are known powders that have already been evaluated for their chemical characteristics. The slurry recipes for use in large electrode coating machines are already optimized.

Through our inexpensive process, we deposit trillions of very tiny "nano" catalyst copper particles directly onto the graphite surfaces, including inside the pores commonly found in uncoated natural graphite used in EV anodes. The diameter of the catalyst particles is 30 nanometers, which is about 1/2,000th of an eyelash. The catalysts are like little seeds attached to the surface of the graphite. We then inject silane gas (SiH_4) — a gas made of silicon and hydrogen. Because of the catalyst, the gas is very quickly decomposed into pure silicon and hydrogen, with the silicon forming tiny little silicon hairs called "nanowires," which are attached to the graphite. We are the only ones in the world to do that, and we have patented the process, equipment and resulting materials in all key markets.

While the silane decomposition process used by our competitors takes hours to partially decompose silane, in our case it takes less than an hour to completely convert 100% of the silane into silicon, with only hydrogen and nitrogen in the exhaust of the reactor. So, the SINANODE process avoids generating wasted silane; it is much faster, and it costs less.

Natural graphite particles have pores, which can be more than a few microns in length. Our silicon nanowires grow like little hairs inside the pores within the graphite particles. These nanowires have two amazing properties. The first property is that they are plugged into the graphite, just like you plug an extension cord into the wall. So, the root of the nanowire is like the plug of an electrical extension cord: it is electrically connected inside the graphite, providing an excellent electrical path for electrons to flow to the silicon during the charging of the battery and flow out of the silicon and to the motor during the discharging.

Another property that people do not realize is the unique shape. If you make silicon in the form of a nanowire, the surface area is two orders of magnitude smaller than the surface area of nanoparticles of silicon, for the same amount of silicon. So, we aim to avoid the problem of having a lot of ultra-reactivity between the silicon and the electrolyte.

The electrolyte can provide the lithium to the nanowires, where the lithium ions can quickly alloy with the silicon. We have also invented a novel thin surface treatment of the graphite-silicon composite particles to stabilize the interface between the active anode materials and the electrolyte. We patented this novel and inexpensive surface treatment, which can double the cycle life of the battery.

So now we have a solution that is inexpensive, for three reasons. First, we use graphite, so we do not have to spend money making a carbon framework. Second, we use catalysts so that we can speed up the reaction. And third, we can have a much longer battery life because of this new surface treatment.

Moreover, the way we grow the nanowire is extraordinarily inexpensive, because we use a Solar chemical vapor deposition (CVD) machine that is normally used to process solar cells in huge quantities. Zhu realized more than a decade ago that such inexpensive machines could process a reactor with catalyzed graphite powders rather than solar cell wafers. A single machine can process up to 1,000 metric tons per year, enough for 3 GWh of anode materials, with a cost of less than $2 million per machine.

This approach offers a significant cost advantage, with capital expenditure (capex) costs at least an order of magnitude lower than the proprietary equipment utilized by our competitors.

So, now we have the last piece of the puzzle, which is large-scale manufacturing, which can be scaled the same way large solar cell factories are scaled today: by adding more CVD machines. This is how it is done in the factories that make solar cells in huge quantities.

We are using this type of CVD machine in our pilot plant, with a small version that can process up to 100 metric tons per year, or about 340 megawatts of graphite-silicon anode material ready for use in current EV cell-coating machines.

We have estimated that with a capex budget of $130 million to $160 million, a SINANODE processing plant can process up to 40,000 metric tons of anode material for 140 GWh, enough for about two million EVs. Those numbers are in an order of magnitude better than our competitors.

Is there an energy density/range that OneD has achieved or has been targeting? This question stems from rivals claiming to have achieved high energy densities; for example, Amprius reportedly achieved 500 Wh/kg recently.

We cannot discuss specifications regarding our customers because of our nondisclosure agreements (NDAs); however, in general, the target for EV cells that OEMs are seeking with the next generation of production ranges from 300 to 350 Wh/kg or 700 to 780 Wh/L at the EV cell level.

In the context of the example you gave, let me say that achieving high energy density based on only a few cycles does not represent EV cell specifications in mass production. Also, the production volumes and costs are at orders of magnitudes different than what is needed in EV cell factories.

In general, OEMs are more interested in a gradual improvement roadmap that is safe and conservative rather than pushing the envelope and taking significant risks. Nothing is more important than safety: a recall because of battery risks can potentially bankrupt even a very large company if millions of EVs are affected.

GM is a strategic investor in OneD. How did you convince GM to come on board? GM executives would have tried to thoroughly understand OneD's silicon anode technology as well as your scale-up plans. What was the brief that you got from the company when you met for the first time, which eventually led it to invest in your company?

The carmakers want to test our technology before making a decision to invest in our company. I think there were three things that convinced them — the first being cost. They knew that generally the silicon anode technology is expensive. One of our competitors claims to offer silicon anode technology at over $20 to $100/kWh. So, they spent a good amount of time with us to understand our technology and how we can save on costs.

They were surprised to learn that our cost is basically less than $2/kWh and graphite costs about $7/kWh. So, adding the silicon nanowires costs less than using graphite (in anode). The more silicon we put (in the anode), the more money we save.

If you are making a 100kWh battery, you need 77 kg of graphite. However, our solution uses only 24 kg of graphite and 6 kg of silicon nanowires to deliver better performance and significantly reduce costs. In addition, the weight and volume of the battery drops, and this means that the number of cells required in the battery are also reduced.

The second factor in the GM investment was performance. We are not cell makers, but we know companies in Germany that make good battery cells. We have two partners in Germany — Customcell and EAS Batteries. We asked our partners to make EV4 batteries in various formats (cylindrical, pouch and prismatic) for OEM customers, and we provide those to GM to assess the cells in their lab. Last year, GM said that if these cells are able to duplicate our results, then they would invest in OneD. That did happen and they acknowledged and verified our test data. So, the proof is in the pudding so to speak.

I think the third aspect that convinced the GM leadership was our patent portfolio. When you are an OEM that plans to put new technology into its cars, you want freedom to operate. What I mean by this is when you make big investments to build your product and ship millions of cars, you do not want someone to show up at your doorstep claiming any kind of patent infringement.

With over 240 granted patents in the US, Europe, mainland China, South Korea, Australia and Japan, we have an extensive patent portfolio by which we can offer freedom to operate. We have spent several hours with the head of intellectual property at GM to convince her that we can protect the materials, the equipment, the processes, the cells and the batteries. Our patents are battle tested.

OneD offers OEMs the ability to license SINANODE, wherein we will not manufacture the EV batteries and cells themselves but own the technology and innovation, which gives customers the freedom to customize. So, we convinced GM that we would engage in three ways — we do a joint development agreement, where our engineering team will work with their engineering team to develop the EV cell prototype. Then we can produce enough SINANODE cells using the graphite supplier of their choice at our pilot plant in pre-production quantities of tens of metric tons to make 10,000 battery packs to qualify that stage.

Furthermore, when they plan to increase scale, we have large industrial partners that we are licensing our technology to and those companies are publicly traded, with multibillion dollars of sales. They have all the operating knowhow of manufacturing plants, and their cost of capital is 6% to 7%, unlike that of a startup, which is about 30%. So, our business model is much safer.

And we can have nonexclusive licensing, so we can have one partner in Europe and one partner in the US, for example. In my view, OEMs mostly love this model.

When the engineers at GM were testing your SINANODE-enabled battery cells and its feasibility in their Ultium platform, were LG engineers also involved in that exercise? When is OneD's battery technology expected to commercially hit the market in GM EVs?

I cannot share details about GM because it is under an NDA. But let me make a general statement about all of our OEM customers. Most are following the same publicly known strategy of Tesla. Although they have suppliers, they are developing their own (battery) cell. And then they are asking their cell manufacturers to make the cells developed in their own labs.

This approach takes time, but this essentially means that the OEMs want to control the technology roadmap. They do not want to just buy a specific type of cells from one cell maker. An LG cell is different from a Samsung cell. So, automakers are engaging with multiple battery manufacturers to secure cell supplies.

What was clever about Tesla is that the company developed its own capabilities, manufacturing line, cell design and technology roadmap. After this, it told its suppliers to make cells using its (Tesla's) cell design, called 4680. This is what most EV makers are beginning to do.

I understand that you have an NDA with GM, and you cannot divulge more details, but can you give us a tentative timeline on the commercialization of your technology? When will we see electric cars with your technology on the road?

Making and optimizing an EV battery cell prototype takes about 12 to 18 months, and we are doing that today. We will complete this exercise with some customers by the end of this year. Then we expect to add more customers by the middle and end of the next year. This is step one, which is the first item — the joint development agreement (JDA) with the OEMs.

The pilot program follows next, which is when we take the 'design recipe' that we have optimized and the graphite that the OEM has selected and make SINANODE anode materials for 5,000 battery packs for pre-production qualification. This is where we leverage our pilot facilities starting in Q1 2024, and this stage will take about 24 months. So, the earliest is 2024–2025 and the latest is 2025–2026 for the pilot, depending on the customer. After that, we will go into large-scale manufacturing, which is scheduled for 2026–27 for the first customers.

Will OneD's SINANODE technology be seen first in high end or affordable electric cars?

We are developing multiple prototypes of EV cells for premium cars as well as for affordable EVs. I would say that affordable EVs are what will tick the box for us. What the OEMs want is to be able to make a battery that is small enough and light enough to fit into a small car and that is cost effective enough for them to be able to sell the car at $30,000 price range. At the same time, the EV should deliver at least 300 miles of driving range per charge. I estimate that the first companies to hit those milestones will capture the market share of everybody else.

Currently, as you can see, the mainland Chinese companies are exporting EVs to Europe. I was recently in Paris and in Munich; I took an Uber in both the cities, and both times the drivers were driving an EV produced a mainland Chinese company.

Mainland China has begun exporting EVs that are attractive to other global markets and the mainland Chinese companies are already taking away the market share from the US and European companies. This is similar to what happened decades ago when Japanese and Korean carmakers began exporting attractive cars to North America.

To answer your question, let me say that what is the most interesting about our technology and what attracts our customers is the scope of developing efficient and affordable EVs.

Very impressive. So, this substantiates what GM CEO Mary Barra had said last year about giving a tough competition to Tesla by developing affordable EVs under its JV with Honda. Nevertheless, what is your view of the premium electric car segment? There are already a lot of players in this space.

As you know, Porsche Taycan, which is a brilliant electric car, is witnessing a decline in its annual sales in the US. There are many expensive EVs sold in the market such as the Tesla Model X, Tesla Model S, Mercedes-Benz EQS, Lucid EV models and many more. They are all very nice cars, but the companies will not sell enough to justify the volumes needed for achieving economies of scale on the batteries. GM, on the contrary, is looking to sell millions of EVs. So, in my view, it is a matter of survival. If you cannot sell a million EVs, you will disappear just like Nokia, Motorola and Blackberry exited the cell phone business.

You are talking to a lot of customers. You were in Europe recently. Can you please give us an understanding on how those conversations are going?

Our ongoing conversations with other customers are exactly the same as with GM. Basically, we are working on agreement(s) to develop prototype cells and negotiating on our capacity during the pilot program as well as for the large-scale licensing.

You are talking to Europe's largest carmaker as a potential customer?

Well, I will not categorize it like that, but I can say that we are working with more than one European carmaker.

Are you also working with customers in Asia and Japan?

Yes, but right now we have our hands full with US and European customers. Without disclosing details, I can say that one of the companies that I respect a great deal is Hyundai. I think they make fantastic electric cars.

In Japan, it is very well-known that Toyota is now finally waking up to EVs. It has been terribly slow. However, they are a formidable company with a lot of skills, and we just simply cannot rule them out.

Please tell us about your partnerships with the cell manufacturing companies and how that can help in getting new customers on board?

What gave Tesla the leverage to tell its cell suppliers such as Panasonic, LG and CATL to make 4,680 format cells is that it developed its own design. This is what some of the other EV makers are doing currently. One of the ways in which we can help them is through our partnerships with companies such as Customcells and EAS, which can supply up to 1GWh or 2GWh of batteries.

To really prove a design, you need to make about 10,000 battery packs. To do that, you need at least a gigawatt hour factory line. So, we have established agreements with companies such as Customcells and EAS where we can make up to a 1,000 battery cells per quarter for initial prototyping. That is providing the OEMs with the quantities necessary to prove to themselves and to their suppliers, that their design has the right yield, and then use the SINANODE program to increase the quantities as required.

If you can make a few cells that work well, it means nothing. You need to be able to prove that you can make it in large enough quantities where the cells consistently deliver a high yield. Also, those cells must be safe.

The OEMs want to avoid recall exercises at all costs. It costs billions of dollars. When you talk to the R&D folks, they are always pushing the envelope — we want more silicon (in the anode) for more performance. When you talk to production engineering folks, it is the other way around — how to improve stepwise and safely. I expect that the progress on battery technology will be like a crawl-walk-run. That is to say, the OEMs will put an increasing amount of silicon (in anodes), but they will move up from the current level in baby steps. Nobody wants to take a huge step because it is too dangerous and risky.

What is OneD's current production capacity at its pilot facility in Moses Lake?

In Palo Alto, we have a machine that we have been using since 2018. If we are using it 24X7, it can produce about 25 metric tons of anode material per year, which is about 80 or 90 MWh. However, we are using it to a lesser degree because the City of Palo Alto limits the amount of manufacturing work we can do in that facility; it is an R&D facility.

We are installing another larger machine at our Moses Lake, WA, facility, which can produce up to 100 metric tons of anode materials or about 340 MWh of anode active material. It will be operational by the end of 2023 / early 2024. We will start shipping to customers in the first quarter of 2024.

We have another machine like that in Germany, which will also be operational by the end of Q2 2024. By end of 2024, we will reach a total capacity of about 1GWh.

All this capacity will basically be about pilot production at your facilities?

That is correct.

What about the scale up of cell production?

It is happening with our licensees. So, we are negotiating with large companies, and they will build the plant over the next 36 months. That is basically how long it takes.

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