Translated from Forbes China Magazine, March 2014

技术 | TECHNOLOGY
创新蓄电

锂电先锋

黄百海带领的创新蓄电公司的锂电池能量密度可以比现有锂电池提升30%以上，他还将半导体行业的“轻工厂”策略引入到了电池生产行业。

文 ADA QIN

美国创新蓄电公司（Enevate Corporation）CEO、美籍华人黄百海（Brian Wong）时常穿梭于美国加州和中国东南沿海各城市的电池制造产业群。虽已在职场打拼 32 年，成功领导过两家创业公司，他仍然显得像现在所处的锂电池行业那样“能量充沛”——这已经是他第 3 次加入创业公司。“我喜欢新鲜事物，喜欢做东西，喜欢把最新的技术变成产品带给消费者，并且改变人们的生活。”黄百海言语中的热情犹如他满头的黑卷发，让你无法分辨他真实的年龄。

作为一家专注锂电池创新的创业公司，创新蓄电的锂电池能量密度（energy density）比市场上现有锂电池产品高出 30% 以上，能量密度是检验电池品质的核心指标之一，改善的目标是在重量越轻、体积越小的电池包中存储越来越多的能量，以我们熟悉的广藏比亚迪的锂电池为例，其目前按照重量和体积分别可达到的实际比能量为 100-125 瓦时 / 公斤和 240-300 瓦时 / 升，马头正驰的特斯拉电动汽车 Model S 所使用的松下 18650 钴酸锂电池的能量密度为 170 瓦时 / 公斤，而创新蓄电的新型锂电池能量密度可以达到 250-350 瓦时 / 公斤和 600-800 瓦时 / 升。

A Pioneer in Lithium-Ion Batteries

Enevate, a startup company led by Brian Wong has increased the energy density of lithium-ion batteries by more than 30%. Meanwhile, Brian has applied the fab-light concept from the semiconductor industry to lithium-ion batteries

By Ada Qin

USA innovative energy storage company Enevate Corporation’s CEO is Brian Wong, a Chinese American who frequently travels between California USA and the coastal areas in southeast China to engage battery manufacturers. Even though he has been in the profession for 32 years, and successfully lead two startup companies, he has now joined his third startup company. His energy is very abundant, mentally and physically very optimistic, filled with energy just like Li-ion batteries. “I like new things, I like to take the latest technologies and make them into products for consumers that can change people’s lives. Brian speaks with enthusiasm, his optimism and energy level is just like his full head of black wavy hair, and it’s difficult to guess his real age.

As for his startup company that is developing new forms of Li-ion batteries, the energy density is about 30% higher than existing Li-ion battery products. The energy density is

one of the indicators for battery performance and quality, whether good or bad. The goal for improvement should be emphasized, the lighter the better, the less volume the better, the more energy the better. According to what we know about another company called BYD, the current energy density is 100-125 Wh/Kg or 240-300 Wh/L. The contemporary Tesla Model S vehicle using Panasonic's 18650 LCO battery has an energy density of 170 Wh/kg. For Enevate's new Li-ion battery, energy density can reach 250-350 Wh/kg, or 600-800 Wh/L.

"For smartphones, consumer electronics, and electric cars, the development is very fast. The market driven energy density demand increases an average of 15% per year. However in the past few years, Li-ion battery energy density increases annually only 3-5% per year. According to estimations from the current Enevate development, when it reaches the market, it will deliver about 8 years of improvement, leading by 8 years," says Brian Wong confidently. Currently, Enevate already has supplied product samples to smartphone and notebook PC companies. They estimate this year they will have large-scale but limited production. "Our revolutionary technology not only pushes the energy density very high, but also can make the batteries very thin. This is what the market demands," said Brian Wong.

Enevate's technology originally came from laboratories at the University of California. In 2005, led by Dr. Benjamin Park, they were researching nano-carbon MEMS wafers. The technology he was involved in has a wide impact in the energy storage area. At that time, he established a company called Carbon Micro Battery, the predecessor to Enevate. With the support of some seed funding for research, Dr. Park obtained a series of breakthrough research results. In 2008, CMB obtained it's first Venture Capital funding from DFJ (Draper Fisher Jurvetson) and Mission Ventures for about USD$5M. This of course was a very risky investment. However, this amount of money was enough for scientists as a major driving force to create a team of people to do more research. At that time, they become independent and came out from the University of California to develop commercial applications of the product.

The Li-ion battery was developed as a rechargeable battery in the 20th century during the 1990's and became a new type of practical secondary rechargeable battery. This is comparable with the lead acid battery, NMH battery, etc. The distinguishing advantages of Li-ion batteries are the working voltage is very high, the energy density ratio (per kg or per L) is large, no memory effect, and environmentally friendly. In smartphones, they want faster ICs performance, anything with a display they want bigger displays, in electric cars they want more horsepower and longer cruise range, but the bottleneck still depends on energy density. Just for this, Li-ion batteries in the recent 10 years of new technology development has attracted a lot of attention by the market and being pursued by new investors.

In order to improve Li-ion battery energy density there are 2 principle ways: 1) design the

battery to increase the energy density, try to cut down the materials which does not contributing to storing energy. For example, decrease the thickness of the anode and cathode and separator, adhesive, and conductive materials. However, all this has limitations as you can only do so much; 2) increase the anode and cathode active materials by unit weight or unit volume. The Li-ion battery chemistry principle is during charging, Li-ions has to come out of the cathode crystal lattice, then pass through the electrolyte, and then deposit into the anode material crystal lattice. Therefore the anode will be rich in Li, cathode will be deficient in Li. During discharging the process is reversed. Therefore the main long term focus is developing the anode and cathode materials, for example the cathode material has Co, Mg, Phosphate, all these types of materials are quite well developed and have reached the limit. The major play is in the anode material which gives you a wider area to explore.

The new technology, the first high density battery product to the market by Enevate, is a new type of silicon-carbon anode material. For a long time, the anode in Li-ion batteries is mainly graphite. The graphite anode battery has reached the theoretical limit in capacity. The recent research discovered that using Silicon as a anode has great potential. The theoretical capacity is more than 10 times greater than graphite. While the present technology and engineering cannot use just silicon as an anode material, one of the direction is the technology development to use silicon-carbon as an anode material.

"There are many research organizations using silicon anodes, but they are only able to use silicon as an additive to the high powered graphite electrode. This way, greatly limits the activity of silicon as an anode," explained Brian Wong. Brian continued, "We at Enevate have been developing a silicon-carbon composite material with a unique structure. The material exhibits 100% activity with a very high conductivity. Furthermore, it is highly compatible with the cathode material, the electrolyte, the additives, etc. used in the current Li-ion battery system. Additionally, we will be able to use the current industrial know-how and processes in the production line. We will also be able to use future cathode materials. Therefore, we think we have developed a revolutionary technology in the field of Li-ion batteries."

Before formally joining Enevate in 2010, Brian Wong's career was never involved with batteries. His experience was mainly focused in the field of computers, semiconductors, aeronautics, etc. In the early 80's, soon after obtaining his MSEE from USC, Brian joined TRW, mainly with research responsibilities in aeronautic communications. "During that time, the smartest people were going to the aeronautic field," said Brian Wong humorously. He worked there for 17 years at TRW starting as an engineer, and was then promoted to a senior manager leading a team with almost a 100 people, also helping Nokia to develop a wireless communications station. "I hope to do more work related to the field the common people are able to use. However, TRW cannot provide such opportunities. So I elected to leave and join a startup company," said Brian Wong.

In 2000, he joined Primarion, a fabless semiconductor company, as a VP of Business Development. "During that period of time, we were facing the internet bubble and an economic crisis. The greatest lesson I have learned during this crisis is to focus, more focus, and further focus. In a small startup company, you must be very clear what you can do and what you cannot do, where you can get financial resources to help you accomplish what you want to do. You must have a daily, weekly, and annual plan," said Brian Wong decisively. Primarion safely lived through the internet crisis and Brian Wong was promoted to CEO. In 2008, Primarion was acquired by the semiconductor giant Infineon.

Brian is always enthusiastic about new things. In 2005, he left Primarion and joined another startup company called D2Audio as CEO. This company was focused in the development of digital amplifier ICs for audio applications, and also providing a solution proposal. "During that time, large screen digital flat TVs were in its initial stage. I was very much interested in digital media," said Brian. D2Audio was the only global developer in smart digital amplifiers. Its customers are concentrated in the Asia-Pacific region. "Since joining startup companies since 2000, I have frequently been traveling between US and Taiwan, Japan, China, Korea, etc. Our customers and collaborators consist of Changhong, Konka, Acer, and others. We collaborated with Foxconn earlier than Apple," Brian Wong recounts. In July 2008, D2Audio was acquired by Intersil, a public semiconductor company.

After D2Audio was acquired, Brian as CEO was asked to stay with the company for 1 year. During that time, he also actively planned what he is going to do next. He was still very interested in startup companies. "I had looked at many startup companies previously and I was always involved in the semiconductor area. Now I wanted to do something different," said Brian Wong. He met John Goodenough, a leading scholar in the field of Li-ion batteries (and inventor of lithium cobalt oxide and lithium iron phosphate cathode materials in Li-ion batteries), who later became one of the technical consultants for Enevate. Brian Wong looked into the Li-ion battery field. In 2010, Brian accepted the offer to be CEO of Enevate.

Based on his accumulated experience in the semiconductor field, Brian wanted to impact the new prosperous Li-ion battery field. First, he established the "focused" strategy. At that time, the Li-ion battery industry was at a chaotic sensitive developing stage (the wind blows and you can see the water ripple). No matter it is cell phone or consumer electronics or electric cars or even energy storage industry, the Li-ion battery has its broad market opportunities. "We have very good technology, but we also faced many choices of what we could do. It is impossible to do them all," said Brian Wong.

Under careful investigation and research, Enevate decided to use their breakthrough for cellphone and tablets, Android devices, etc. "In 2009, smartphones were only 16% of the entire cellphone market. However, we confidently felt that the growth potential in this

market was very high because people's use of cellphones will become more and more like computers. Also, the tablet computer will become thinner and thinner. This matches with the advantages of our battery technology. At that time, we estimated the future demand can reach USD$10-12B in these two markets. Even if we get 5% of the total, it is still a significant amount," said Brian Wong. "In addition, my previously accumulated experience in the consumer electronics area can be used effectively."

As matter of fact, the market growth has exceeded the company's expectations, said Brian Wong. According to a 3rd party independent consulting organization in Europe called Avicenne, who's published global Li-ion battery statistics report shows, the global Li-ion battery, the biggest application market is in cellphones and mobile PCs (mainly in the notebook PCs). According to the sales volume, the two areas roughly is USD$3.1B and USD$2.1B, with 29% and 22% of the total market respectively. From the Li-ion battery sales volume (kWh), according to this estimate, the cellphone battery market since 2010 has kept double-digits growth, but the mobile PC battery market in 2012 appeared to be decreasing. The fastest volume increase is in the area of tablets. Starting in 2008, it was zero, but by 2012 it has increased to USD$1B, which is about 10% of the total global Li-ion battery market.

Another new thing Brian Wong has done is to try and use a fab-light model, used in the semiconductor industry, and introduce it into the Li-ion battery industry. For most of Li-ion battery companies, their development process is to first research and develop, then build and establish a factory, then production, then sell. However, Brian considers this kind of model not only needs large amounts of capital investment, but also needs a long period of time to do it. "We estimated if we invested to establish a Li-ion battery factory, we would need at least USD$500M investment. However, in China, Li-ion production in material, facility, production, supply chain is very complete to making products. Why not consider this fab-light model for manufacturing of Li-ion batteries?" said Brian. More importantly, the way Enevate's material is created, there are minimal changes needed in current cell production facilities. And this is completely connected to the current production chain. This is Brian's thinking that it would lay a good foundation to use fab-light.

According to Brian's arrangement, Enevate only establishes a small scale material production factory in the US to use the newly developed silicon-composite anode material. Other parts of production will be carried out in China in existing facilities. Another advantage for this model, Enevate changed the entire process from cell production for the battery. "At present, we are sampling prototypes to our customers, and this way we can directly involve our customer early in the product design. We are not just selling a battery, we are working with our customers during the early product design phases to enable them to develop a new type of product, early in their product development when you can assist them," said Brian Wong.

In December 2012, Enevate completed their USD$24M Series-B funding. The investors consisted of two sources from China venture funds. One is China Electronics Foundation Management Group (CEC), second one is Tsing Capital. And also included is Japan's Sumitomo subsidiary Presidio Ventures. From the angle of business development of Li-ion batteries, research and development is mainly in the US. Commercialization or developing into a product is best still in Japan, and the manufacturing is however in China. From this point of view, Enevate's idea involving a multinational approach is an important advantage. "In April last year, we recruited a highly experienced vice president in supply chain integration and production, and he is very familiar with China. He lived in Suzhou for 3 years," Brian Wong emphasized.

"In 2014, it is definitely a significantly development year for the Li-ion battery business," said Ian Zhu, partner from Tsing Capital. "Besides cellphone, tablets, the future electric car market Li battery demand will need the sum of all capacity." According to the Avicenne forecasts, by 2015 the global consumption of Li-ion batteries will be increased to 4110 MWh, compared to 2012 it increases by 27%; by 2020, it will double compared to 2012. By 2025 it will be 3 times.

In January of this year, SAIF Partners invested in another anode material Li-ion battery company called Amprius with USD$30M, that company declared a nano-silicon anode with a breakthrough discovery. However, a third-party said that technology is not used in the present Amprius product. That new capital spending is very high. The possibility for commercialization for high-volume production at the present time is still in doubt.

"In our company's future development, we have a complete blueprint and plan. The company's strong Board has strong support for us to march on to many future developments. Presently, we must have a jumping start," Brian Wong pointed out meaningfully. He expressed the company already established a collaborative relationship with some large well-known companies. However, at present time, he cannot disclose those companies' names.

END