New perspective: The take-off of solid-state lithium battery with soft packing

Yuqi Jing

2022-06-25

Through chances various, through all vicissitudes, we make our way.

This is the words on the title page of Graham's book Smart Investors, which comes from Virgil's unfinished ancient Roman epic Aeneid.

"It's rare in a thousand years. After the vicissitudes of life, we have gone all the way forward."

After Troy fell, Prince Aeneid of *** led the clan around to try to find a blessed land. After countless trekks and arrivals, they encountered storms and *** tests, and even crossed hell. Their beliefs were still like "the reeds are like silk, and the rocks are not transferred." Finally, as he wished, he began the great cause of the founding of the Roman Empire.

Smart investors, like Aeneid, should be able to keep prosperity and loneliness on the way to the goal of faith.

Value investment is long-term, and business operations are even more important.

It is never easy to maintain the original intention and persevere. External doubts, development changes, and self-doubt are all tests, and they may not be full of success in the end.

But in this process, there is a prerequisite - whether to explore the nature of things. If you do it, it is expected to be open to the moon.

The technological development of lithium batteries is a race to see who runs long and far. Only when you master key technologies can you resist the wind and travel in the waves.

Now, the game is entering the second half. Solid-state batteries have attracted a lot of attention and are expected to lead the next wave of lithium batteries. Soft package batteries are undoubtedly the most matching packaging technology.

The legendary "king of soft bags" Funeng Technology (688567. SH) will usher in a high growth moment.

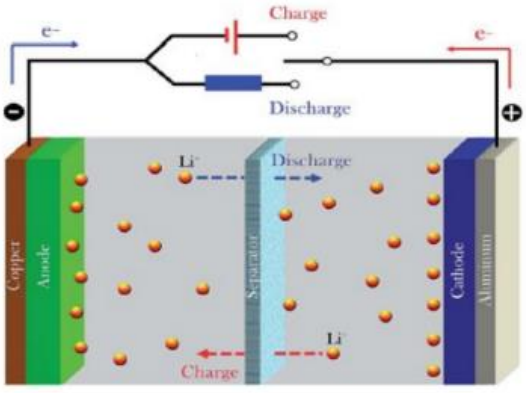
01 Next stop, solid-state battery

When it comes to solid-state batteries, readers may feel a little strange. Strictly speaking, lithium batteries at this stage should be called liquid lithium batteries, because one of their core battery materials is liquid electrolytes (also known as electrolytes).

Then lithium batteries that use solid-state electrolytes are called solid-state lithium batteries, or solid-state batteries for short. Obviously, the structure of the two is different.

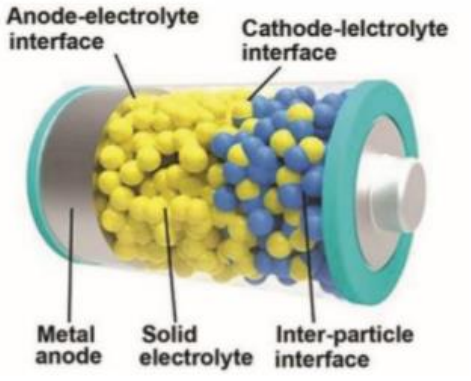
The traditional lithium battery composition includes four materials: positive electrode, negative electrode, electrolyte and diaphragm. Solid-state batteries replace electrolytes and diaphragms with solid-state electrolytes, and the rest are similar.

图1：传统液态锂离子电池



资料来源：Long, Lizhen et al. "Polymer Electrolytes for Lithium Polymer Batteries." 4.26 (2016): 138–169. Web. 天风证券研究所

图2：固态电池电池结构



资料来源：Gao-Long, Zhu, Chen-Zi. Fast Charging Lithium Batteries: Recent Progress and Future Prospects.[J]. Small, 2019. 天风证券研究所

Safety comes first for lithium batteries. However, the safety of traditional liquid lithium batteries has long been questioned by the market.

Recently, the State Administration of Market Supervision issued the Notice on National Recalls of Automobiles and Consumer Goods in 2021. The report shows

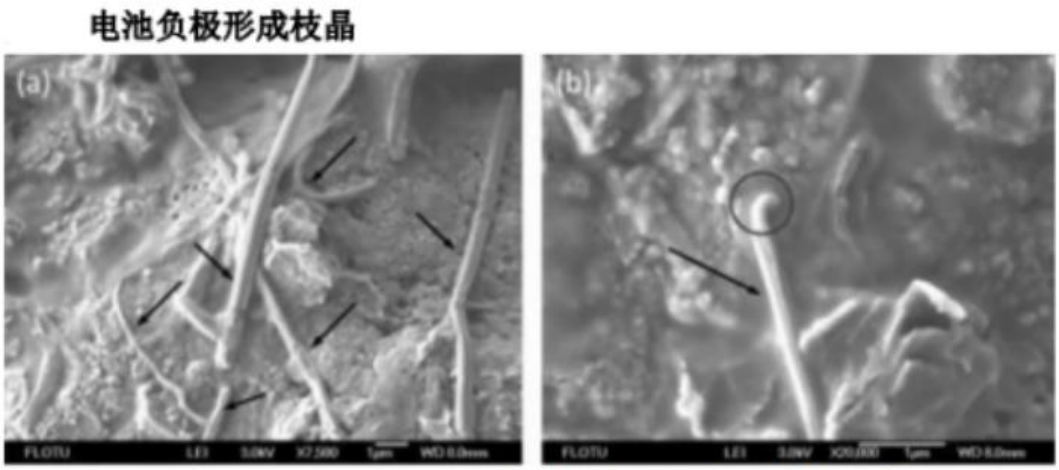
that 59 new energy vehicle recalls were implemented in 2021, involving 830,000 vehicles, accounting for 9.5% of the total number of recalls in the whole year. The number of recalls and the number of new energy vehicles were compared with the same. In the year, it increased by 31.1% and 75.9% respectively.

Among them, 3,033 cases of new energy vehicle defect clues were reported, reflecting power batteries, motors and electronic control systems, accounting for 52.5% of the defect clues of new energy vehicles. Power batteries overheating and fireing and electronic control system failures still account for a large proportion, which is the primary safety hazard of new energy vehicles.

The main cause of lithium batteries is electrolyte. Under the existing technical conditions, the electrolyte provides a place for lithium ions to "swander" in the battery.

However, the electrolyte is very sensitive to temperature. It is very easy to decompose at high temperature, corrosive, flammable and leaky. In particular, the lithium reaction is very easy to cause a short circuit.

Once a short circuit occurs, the local temperature rises sharply to reach the liquid electrolyte burning point inside the lithium battery, and then catches fire or even explodes.



资料来源：D1EV，天风证券研究所

造成电池短路的危险。

Although manufacturers have also tried to solve safety problems by adding flame retardants or using high-temperature-resistant films, they have not been successful. It can be said that liquid battery technology is fundamentally difficult to eliminate potential safety hazards.

In contrast, the most prominent advantage of solid-state batteries is safety. It uses almost non-flammable solid electrolytes as the conduction medium, reduces the sensitivity of the battery pack to temperature, eliminates the short-circuit probability of lithium dendrite increase, and effectively blocks the positive and negative electrodes with good insulation.

In addition to the natural advantages of safety, another highlight of solid-state batteries is performance.

Endurance and fast charging have long been the Achilles' heel of new energy vehicles, and mileage anxiety is an embarrassing "normal". As a result, new energy vehicles have been developing towards a high-endurance path: from 200 kilometers to 500 kilometers, they are about to enter the target range of 1,000 kilometers.

To achieve this goal, lithium batteries with higher energy density are needed. In the industry, the energy density is usually calibrated with Wh/kg.

According to the National Roadmap 2.0 for Energy Saving and New Energy Vehicle Technology released in October 2020, the energy density of power batteries of pure electric vehicles in China is 400Wh/kg in 2025 and 500Wh/kg in 2030.

This is difficult for the current liquid lithium battery technology.

In the field of liquid batteries, ternary soft package is the technology with the highest energy density. According to the Announcement of Voluntary Disclosure of the Progress of New Technology Research and Development in April 2021, the new generation of power batteries successfully developed by Funeng Technology can have an energy density of 330Wh/kg, while other manufacturers are trying to break through 300Wh/kg.

全球软包电池企业产品性能对比

企业名称	电芯产品序号	电池类型	容量（Ah）	能量密度（Wh/kg）	工作电压范围（V）	循环寿命（次）	工作温度范围（℃）
孚能科技	1	三元软包	30.5	220	2.75-4.20	≥2,000	-30 至 55℃
	2	三元软包	56	255	2.75-4.30	≥2,000	-30 至 55℃
	3	三元软包	63.1	263	2.75-4.30	≥2,000	-30 至 55℃
	4	三元软包	66.5	263	2.75-4.30	≥2,000	-30 至 55℃
	5	三元软包	74.1	285	2.75-4.20	≥1,800	-30 至 55℃
LG 新能源	1	三元软包	未披露	250	未披露	2	未披露
远景 AESC	1	三元软包	未披露	224	未披露	未披露	未披露
	2	三元软包	未披露	300	未披露	未披露	未披露
SKI	1	三元软包	64	260	标称电压 3.6	1,500-2,000	未披露
亿纬锂能	1	三元软包	50	230	标称电压 3.7	未披露	未披露
桑顿新能源	1	三元软包	32	221	标称电压 3.65	2,500	未披露
	2	三元软包	42	220	标称电压 3.65	2.5	未披露
多氟多	1	三元软包	10	≥165	标称电压 3.7	≥800	-10 至 45℃
	2	三元软包	46	≥230	标称电压 3.7	≥2,000	-20 至 60℃
	3	三元软包	55	≥230	标称电压 3.7	≥2,000	-20 至 60℃

资料来源：公司公告，华创证券

The energy density of lithium batteries mainly depends on the operating voltage and the specific capacity of the positive and negative material. That is to say, the higher the voltage, the higher the energy density; the higher the specific capacity, the higher the energy density.

Simply put, when lithium batteries are working, the battery voltage will decrease as the power decreases. Assuming that other conditions remain unchanged, the working time of high voltage is longer than that of low voltage at the same current.

For example, a higher reservoir can hold more water, so it will definitely take longer to drain water with the same faucet.

However, a voltage above 4.3V will aggravate the electrolyte decomposition. Therefore, due to the current material and safety of use of liquid lithium batteries, the operating voltage of lithium batteries is generally less than 4.2V, which is difficult to improve.

The meaning of the specific (g) capacity is how much mAh (mAh) per gram of lithium battery material. From the positive and negative electrode materials of liquid lithium electricity, the negative electrode graphite 365m A·h/g, and the 8 series ternary high nickel positive electrode 220mA·h/g. The specific capacity of existing positive and negative materials is difficult to significantly increase.

Under the inherent bottleneck constraints of liquid lithium power technology, it is difficult to achieve the future energy density goal. Solid-state batteries cannot be regarded as a disruptive technology if they only replace electrolytes to improve safety.

Most critically, the use of solid-state electrolytes can change the existing positive and negative electrode system and adopt higher specific capacity materials as positive and negative electrodes.

By using negative metal lithium and positive high potential materials, the electrochemical window can reach more than 5V. The specific capacity of lithium is as high as 3860mA·h/g, more than 10 times that of graphite and 17.5 times that of the ternary high nickel positive electrode.

不同正极/负极的比容量对比

正极活性物质分子式	缩写	比容量/mAhg-1	平均电压（vs.Li）V
LiCoO2—140	LCO-140	140	3.8
LiCoO2—180	LCO-180	180	4.3
LiCoO2—220	LCO-220	220	4.4
LiMn2O4	LMO	130	4.05
LiFePO4	LFP	160	3.4
LiCoPO4	LCP	130	4.8
LiNi0.33Mn0.33Co0.33O2	NCM333	160	3.7
LiNi0.5Mn0.2Co0.3O2	NCM523	180	3.7
LiNi0.8Mn0.1Co0.1O3	NCM811	220	3.7
负极活性物质分子式	缩写	比容量/mAhg-1	平均电压（vs.Li）V
石墨	/	365	0.1
软碳-250容量	SC-250	250	0.5
软碳-400容量	SC-400	400	0.5
硬碳	HC	250	0.5
SiOx-420容量	SiOx-420	420	0.2
SiOx-1000容量	SiOx-1000	1000	0.4
Si-C-450容量	Si-C-450	450	0.2
Si-C-1000容量	Si-C-1000	1000	0.4
Si-C-2000容量	Si-C-2000	2000	0.4
金属Li	Li	3860	0

资料来源：吴娇杨,刘品,胡勇胜,李泓.锂离子电池和金属锂离子电池的能量密度计算[J].储能科学与技术,2016,5(04):443-453，天风证券研究所

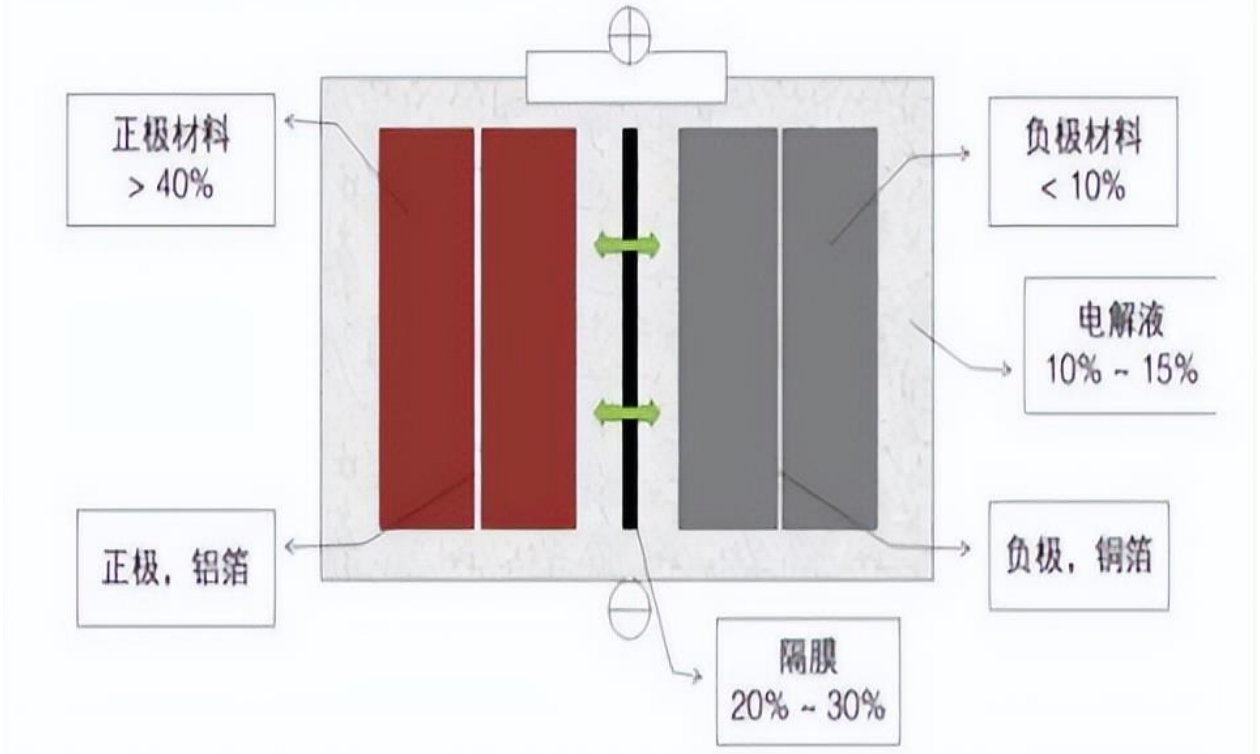
Judging from the future technical development path of high energy density of lithium batteries, solid-state batteries are undoubtedly more suitable for large-scale applications.

One of the most important prerequisites for large-scale technology promotion is cost. Although the cost of solid-state batteries is much higher than that of liquid lithium batteries, the cost reduction path has gradually become clear.

First of all, solid-state batteries use electrolytes to replace electrolytes and diaphragms, accounting for 30-45% of the total cost of lithium batteries.

Solid-state battery electrolytes currently in use or near commercial use include polymers, sulfides and oxides. Recently, the University of Science and Technology of China synthesized a new solid electrolyte, lithium zirconium chloride, reducing the cost by 94%.

图 42 锂电池成本结构（%）



资料来源：赣锋锂业公司官网，信达证券研发中心

In addition to lithium, liquid lithium batteries also use a large amount of scarce metals such as cobalt and nickel, which are expensive. The positive electrodes of solid-state batteries can use common materials such as manganese and sulfur, which objectively ensures the cost competition space for solid-state batteries in the future.

At this stage, the cost of the ternary battery has exceeded 1,000 yuan per kilowatt-hour.

According to Nissan (7201. T) The plan is that by fiscal year 2028, all solid-state batteries will be able to reduce the cost of battery packs to $75 per kilowatt-hour (about $477), and further reduce the cost to $65 per kilowatt-hour (about 414 yuan) in the future.

Safety, performance and cost are the core three elements of lithium battery promotion. In these three aspects, solid-state batteries have shown great advantages. There is no doubt that the mainstream technical path of lithium batteries in the future belongs to solid-state batteries.

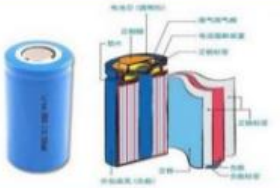
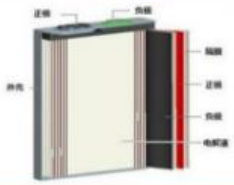
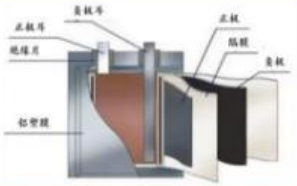
At present, solid-state battery technology is still in a blue sea. Electrolytes, cathode and other materials have no subversive substitution products, and have not formed an industrial foundation. This is the best time for the forerunner to gain an advantage.

However, how to identify enterprises with development prospects and potential is a difficult problem for investors.

02 The future determined belongs to the soft package battery.

At this stage, in the technical cognition of solid-state batteries, one direction is more deterministic, that is, packaging.

Traditional lithium batteries and solid-state battery packaging are available in soft package, square and cylinder.

	圆形锂电池	方形锂电池	软包锂电池
结构			
制造工艺	圆形卷绕	方形卷绕	方形叠片
包装材质	一般钢壳，也有铝壳	铝壳为主	铝塑膜
优点	工艺成熟，一致性高，适宜大批量连续生产;比表面积大，散热效果好（优于方形电池）;外壳耐压高，使用中不出现膨胀现象。	结构强度高，承受机械载荷能力好;重量小，相对能量密度高;可以定制化生产。	可鼓气裂开，安全性能好;较钢壳、铝壳重量轻;同等尺寸下电池容量更高;内阻小，自耗电低;设计灵活，可按照需求定制。
缺点	容量小，大容量需并联连接，工艺复杂、成本更高;爆炸可能性大;体积大，空间利用率低。	工艺复杂，壳体与电芯配合需要考虑;产品良率低，一致性较差。	一致性较差，难批量生产;成本较高;对铝塑膜的质量要求高，不达标产品可能泄液。
代表厂商	松下，江森自控	三星SDI，宁德时代	LG化学，AESC
典型应用	特斯拉	宝马I3	日产聆风
典型正极材料	NCA	LMO/NCM/NCA	LMO/NCM
外壳材料	铝合金、不锈钢	铝合金、不锈钢	铝塑膜
安全性	一般	较高，对电芯的保护作用强	不易爆炸；铝塑膜机械强度低
能量密度	较高	较低	较同等容量硬壳电池有更高能量密度
产品特性	散热性能优，圆柱形便于多种形态组合	容量大	重量轻，散热性能较好
产品标准化/生产自动化	高，生产工艺成熟	低	低
电池一致性	高	较低	较低
产品研发趋向	适当增加圆柱体积以获得更大电池容量，例如特斯拉/松下量产21700（直径21mm，高70mm）电池	封装材料向高硬度，轻质化发展	改进生产工艺，实现全自动生产，提升一致性，电池管理系统研发
现实条件约束	国内技术，电池管理系统和自动化水平低	适合大型汽车使用	铝塑膜依赖进口，国产化进程低下，影响软包电池成本

数据来源：汽车之家，上海证券研究所

The manufacturing process can be divided into three parts: the first, middle and the back. Simply put, the first part is the process of positive and negative production, and the latter part is the detection and assembly.

数据来源：高工锂电、天风证券研究所

The middle section is the process of battery production, including five processes such as laminated/winding, shelling, welding, drying, liquid injection, etc. The core link is the laminated/winding process, which is the highest value in the whole mid-section process, accounting for about 70%.

Different packaging processes are also different. Cylindrical batteries mainly use the winding process (which can be imagined as a burrito made of a variety of ingredients), square batteries are mostly winding, and soft package batteries use the stacking process (which can be imagined as making sandwiches).

Due to the weak flexibility of oxides and sulfide electrolytes, soft package batteries with laminated processes are the most suitable. Not only that, compared with cylindrical batteries and square batteries, soft package batteries also have significant advantages in energy density.

Soft package batteries produced by lamining process have a low probability of internal deformation, bending or fracture. In addition, the aluminum plastic film housing of the soft package battery is not hard. Once the battery loses thermal control, it will generally burst through the aluminum plastic film package first, taking away a large amount of heat, and avoiding the explosion of the battery.

The lighter aluminum-plastic film shell makes the whole battery 40% lighter than that of steel case lithium battery and 20% lighter than aluminum shell lithium battery under the same capacity. Therefore, the energy density of soft-pack batteries will be 40% higher than that of steel shell ternary lithium batteries.

Soft package batteries have won the favor of downstream car manufacturers. Volkswagen, Mercedes-Benz, General Motors, Hyundai, Ford and other car companies have used many mainstream models.

Among the best-selling top 20 new energy passenger cars in Europe in 2020, 15 are equipped with soft package batteries. High-end configuration new energy vehicles also use soft battery technology.

Compared with overseas, domestic soft package batteries are relatively lonely. Domestic car factories prefer square batteries with complete industrial chains and sufficient supply. At present, the foundation of soft package battery-related industries is weak, and in the historical process of promoting new energy vehicles, it temporarily lags behind square and cylindrical batteries.

Domestic substitution has always been a difficult problem for domestic soft package batteries. Soft package battery enterprises represented by Funeng Technology have been deeply engaged for many years. They have broken various technical bottlenecks, and their product quality has reached international advanced standards, and successfully entered the Daimler A supply system.

In 2021, Funeng Technology ranked seventh in the installed power battery power ranking in China. In terms of the installed capacity of domestic soft package batteries and ternary soft package batteries, Funeng continues to maintain the first place.

In terms of production, the first phase of Zhenjiang Factory has completed the climbing of production capacity, and the second phase has been put into production one after another. The construction of the third phase has been accelerated again, and the Wuhu project is ready to start. By the end of 2023, the company will achieve the capacity of 26Gwh soft package battery.

In the process of gradually landing solid-state battery technology, Funeng Technology is expected to gain a first-mover advantage and usher in a high growth moment.

03 Conclusion

In the promotion of solid-state battery technology at home and abroad, no effort has been spared from the government to enterprises.

Overseas companies have made large investments. Thomas Schmall, a board member of Volkswagen Group, said that the company plans to spend up to 30 billion euros (about 22.62 billion yuan) on European cell factories and ensure the supply of important raw materials.

Automotive groups, including BMW, Mercedes-Benz, Volkswagen, Hyundai, Toyota, Honda, Nissan, etc., take solid-state lithium batteries as the technical direction of their next-generation electric vehicle batteries.

At the government level, EU countries jointly contributed 3.2 billion euros and raised 5 billion euros from private investors to develop solid-state batteries. The United States, Japan and South Korea have also announced support policies and subsidies for the development of solid-state lithium batteries.

China's New Energy Vehicle Industry Development Plan puts forward the requirements for strengthening the research and development and industrialization of solid-state batteries. The first batch of 50 Dongfeng-Ganfeng high-profile solid-state battery vehicles jointly developed by Dongfeng Automobile and Ganfeng Lithium Industry were delivered in Xinyu City, Jiangxi Province.

Against this background, there is no doubt about the certainty of the future of solid-state batteries, and even begun to speed up.

China's lithium power technology has gradually grown from the role of imitator and catcher to a guide and innovator. The sea flows across, showing the true nature of heroes.

In the competition for solid-state batteries, in the Ningde era (300750. SZ), BYD (002594. SZ) and Funeng Technology, the Chinese Lithium Power Legion, will

show its ambitions on this stage, show their skills, and compete for the voice in the second half of lithium batteries.