



# 锂电池正在进行静悄悄的革命

## Lithium-ion Batteries Are Under A Quiet Revolution

文/ 俞峻美 Text / Yu Junmei

电动车需要锂动力电池，储能站则需要锂储能电池。电动车的动力电池与储能站的储能电池则可以天然紧密对接。这样，锂电池静悄悄的一场革命即将爆发。

Electric cars need lithium power battery, while energy storage stations need lithium batteries. Electric-car power battery and energy-storage station battery play a key role. In this way, lithium battery is under a quiet revolution.

### 电动汽车与光伏发电共振

Tesla公布的Gigafactory(千兆锂电池工厂)，标志着Musk向储能的布局。锂电池将实现Tesla和Solarcity的无缝对接，实现了电动汽车与光伏发电的共振，新能源将作为一个整体真正挑战传统能源。锂电池将是这一轮电动汽车行情的主轴。

### Electric car and photovoltaic power generation

Gigafactory (gigabit lithium battery factory) announced by Tesla marks that Musk enters the field of energy storage. Lithium battery will seamlessly link Tesla and Solarcity in which the electric car is closely related with photovoltaic generation. New energy will be taken as a whole really challenge for the traditional energy source. The lithium battery will be a hot spot in this round of the development of the electric car market.

电动汽车已经基本确定锂电池技术路线。电动汽车的技术路线(燃料、镍氢、超级电容等)一直有争议，但千兆锂电池工厂的开工，至少说明两件事情：

The electric car has been basically determined to take lithium battery technology route. Electric car technology route (fuel, nickel hydride, super capacitor, and etc.) is always controversial, but the opening of the gigabit lithium battery factory means at least two things:

第一，Tesla对锂电池中期内有信心。Musk原来也说过超级电容可能是未来的方向，但目前用自己的行动表明，至少在2020年之前是最看好锂电池的；

First, Tesla is confident in mid-term lithium battery. Musk also said that the direction of the future was super capacitors. But at present, with their own actions, Musk show that until at least 2020, he is confident in the lithium batteries. Second, followers will drive the industry to accelerate the progress. Although there may be some companies not following the Tesla, more and more countries and enterprises (especially China) will be followers and imitators of Tesla. The progress of the industry is often associated with the number of participants. Basic technical route being determined will accelerate industry clustering. Industrial clustering will accelerate technological progress. The industrial chain of the lithium battery is comparatively mature with a clear division of labor and a large space of cost down. Tesla plans that, in 2020, the cost will

第二，跟随者会带动产业加速进步。尽管可能会有企业跳出Tesla的框架另起炉灶，但不可否认，更多的国家和企业(尤其是中国)会作为跟随者和模仿者参与其中，而产业的进步速度往往与参与者的数量正相关(光伏即是一例，晶硅从薄膜、聚光中脱颖而出)。技术路线基本确定后，会加速产业的集群，产业集群会加速技术进步，并且由于锂电池的产业链已经比较成熟，而且分工明确，成本下降空间大，Tesla规划2020年相比目前成本减少30%以上，这是完全可能的。

锂电池的成本下降不但会带动电动车，也会带动光伏自发自用的需求，可以彻底脱离补贴。对于新兴行业，行业供需都是由需求决定的，需求的波动性远远大于产能。如果行业需求达到较高增速(30-50%)，那么利润表是有可能体现的。并且，目前很多锂电池环节毛利率很低(正微利甚至亏损，负微利)，



毛利率向下的空间很小，而销量上升，费用摊薄的空间很大。因此，锂电池产业链利润表会短期改善，中期甚至将大放异彩。

如同苹果手机崛起，带动的不仅仅是苹果产业链，也不仅仅是智能手机，还带动后来的手游、移动支付等其他领域。Tesla崛起，也不仅仅影响电动汽车产业链，它与Solarcity的紧密对接，带来的将是一场能源革命。

## 电动汽车和储能电站联姻

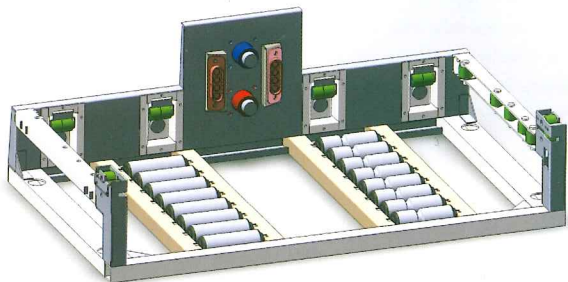
锂电池将实现电动汽车和储能的联姻。在技术路线确定，产业竞争加速、成本下降的过程中，不仅是电动汽车，储能电站的需求也会快速甚至爆发式增长。储能会爆发的原因是：

第一、光伏+储能的分布式系统离用户侧平价紧一步之遥。目前在德国，居民的电价约为2.4元/度，而目前光伏的发电成本约为1.1元/度，如果储能的成本低于1.3元/度，居民使用光伏结合储能的系统将会替代从电网购电，而目前的储能成本正在此临界值(1.2-1.5元/度左右)附近，如果储能成本按照每年10-15%的速度下降，平价在未来一到两年即将实现。一直以来，光伏由于靠补贴维系而饱受诟病，而这个需求完全是经济性驱动的，脱离补贴的需求是具备极大爆发力和空间的，这种用户侧平价也将在意大利、澳大利亚等高电价的国家陆续实现。

第二、电动车的电池与储能天然紧密对接。电动车对锂电池的质量要求高，而储能则不然，待电动汽车市场启动后，可以将置换或者淘汰的车用动力电池第二、待新能源汽车市场启动后，其淘汰的车用动力电池，可作为储能电池用于储能(充电桩或者家用的系统)，这样多次利用，会大幅度摊薄成本。锂电池是电动车价值中最大的部分，也是跟传统燃油车差异最大的部分。一辆电动车中，30-40%的成本构成是锂电池，价值量最大。能摊薄成本，何乐而不为？！

《第三次工业革命》作者的核心观点是新能源和信息技术会带动产业革命，分布式、可再生、储能、电动车、智能电网是五大支柱，Tesla和Solarcity的出现，勾画出这个蓝图。随着锂电成本和光伏成本的不断下降，新能源的使用将会普及，脱离补贴、规模化的应用在未来2-3年就可能兑现。

电动汽车已经启动，围绕着锂电池，电机、电控、充电桩、汽车电子、整车甚至光伏也将被带动起来。



reduce by over 30% when compared with that at present. It is entirely possible. Lithium batteries cost down not only can drive electric vehicles but also the demand for the photovoltaic spontaneous need. This will lead to no need for subsidies. For the emerging industry, the supply and demand plays a role with the demand more volatile than the production capacity. If the industry needs have high growth (30-50%), then the income will be excellent. And, at present many links of the lithium battery have a very low gross profit margin (or loss and so forth). The space of the gross profit margin downward is very narrow. Increased sales and large space of the expenses diluted are expected. Therefore, the income statement will improve in short term and shine brilliantly in mid term.

Like the rise of Apple mobile phone which not only drives Apple industry chain and the other fields such as mobile payments, the rise of Tesla will not only influence the electric car industry chain, and closely cooperate with Solarcity which is expected to bring a revolution of energy.

## Electric vehicle and energy storage power station

Lithium battery will link electric vehicle and energy storage. The technology route determined, industrial competition accelerated, and cost reduced will lead to the rapid or even explosive growth of the demand for not only the electric vehicles but also energy storage power stations. The explosive growth in the energy storage is due to the follows:

First, photovoltaic + energy storage type distributed system is one step away from the user side. In Germany, the current resident-type electricity price is about 2.4 dollars, and the cost of the photovoltaic power generation is about 1.1 dollars. If the energy storage cost is lower than 1.3 dollars in price, then residents will most adopt PV power rather than the electric grid. At present, the energy storage cost is at the critical value (1.2-1.5 dollars or so). The cost drop annual rate is 10-15%, then it will be popular. For a long time, PV needs subsidies leading to being criticized. At present, this demand is economically driven and has a large space of explosive growth. This user side price will be achieved in Italy, Australia, and so forth where the electricity price is high.

Second, electric car batteries are closely related with energy storage batteries. The EV has a high requirement for the lithium battery, while not energy storage. After the electric car market is initiated, the abandoned or replaced power battery can be used for the other purpose. After the new energy car market is initiated, the abandoned power battery can be used as a kind of energy storage battery (charging pile or household system). The repeated use will certainly let the cost greatly diluted. Lithium battery is the largest part of the electric car value and is also the biggest different part with traditional fuel cars. In an electric car, 30-40% of the cost is in lithium battery. Therefore, this cost dilution is very meaningful!

"The Third Industrial Revolution" author's main point of view is that the new energy and information technology will drive the industry revolution. Distributed energy, renewable energy, energy storage, electric vehicle, smart grid are five pillars. The rise of Tesla and Solarcity leads to the fact that the blueprint is outlined. As lithium battery and PV costs fall and the new energy use is popular, the large scale of use will occur in the next 2-3 years. Electric vehicle market has been initiated. The fields including the lithium battery, motor, electric control, charging pile, automotive electronics, vehicles and even PV will be driven up.







# 锂电正极材料 把握电车命运

## Li-ion Battery Anode Material and Electric Car

全国人大十二届二次会议通过的《政府工作报告》中，增加“推广新能源汽车”的内容。这表明以纯电动汽车为代表的新能源汽车前景看好，并将带动锂电池等相关产业发展。随着锂电池产业规模的扩张，作为锂电池重要组成、占其成本30%–40%左右的正极材料产业也将迎来快速发展期。锂电池选用的正极材料主要有锰酸锂、三元材料（镍钴锰酸锂）和磷酸铁锂3种，它们决定锂电池能量密度、寿命和安全性等重要指标，受到业界重视。

### 锂电产业被催热

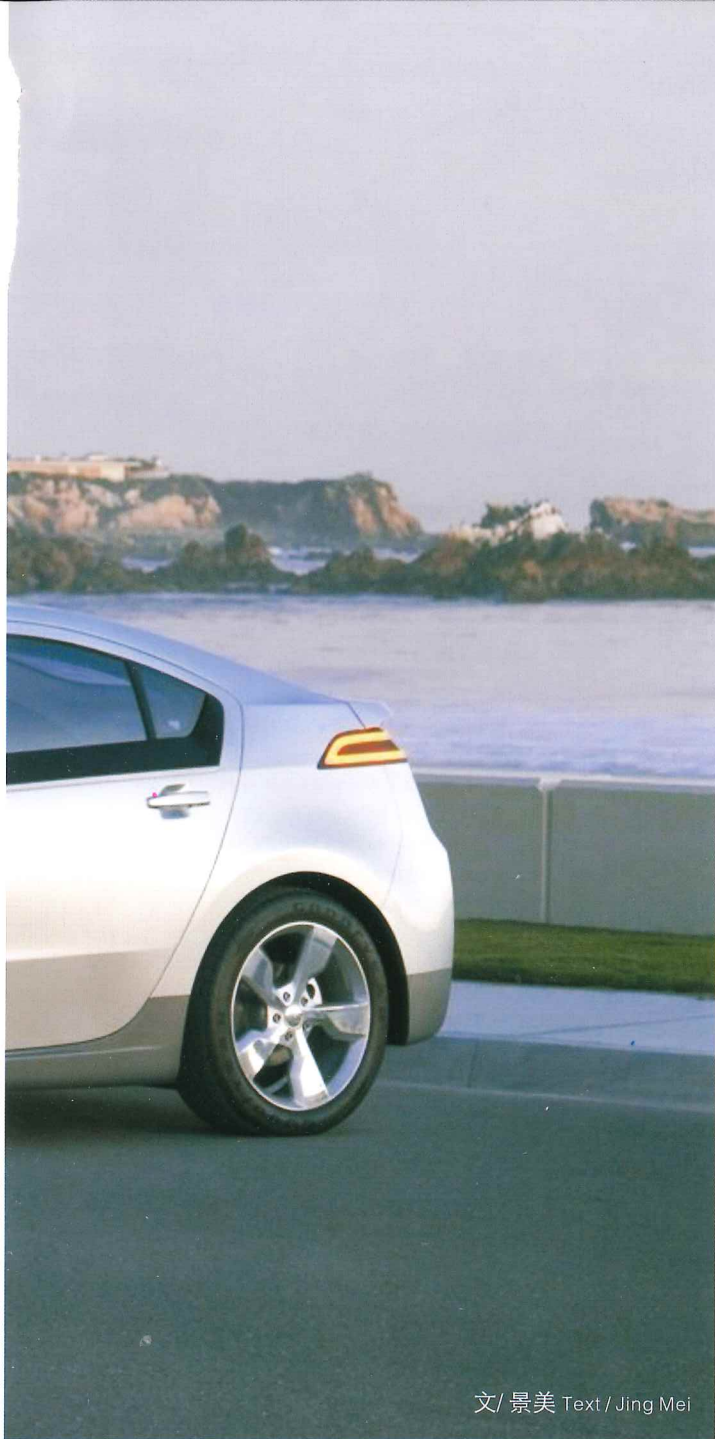
根据《节能与电动汽车产业发展规划（2012–2020年）》，2015年纯电动汽车和插电式混合动力汽车累计产销量

In a meeting held in National People's Congress, the government work report was passed. This report added the content about the promotion of new energy cars. This shows that new energy vehicles represented by pure electric vehicles are promising and that they will drive the development of related industries e.g., lithium-ion batteries. With the expansion of the scale of lithium battery industry, anode materials whose cost accounts for about 30% – 40% will usher in rapid development. Anode materials of lithium-ion batteries are mainly manganese acid lithium, ternary material (nickel-cobalt-manganese acid lithium) and lithium iron phosphate. They are closely related to energy density, life and safety and other important indicators in the lithium battery, so attracting the attention in the industry.

### Lithium electricity industry is a hot spot

According to Energy Saving and Electric Car Industry Development Planning (2012–2020), by 2015, all-electric cars and plug-in hybrids cumulatively produced and sold will reach 500000 in number; by 2020, all-electric cars and





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达到50万辆；到2020年纯电动汽车和插电式混合动力汽车生产能力达200万辆、累计产销量超过500万辆。

那么,电动汽车在未来3-5年将进入快速增长期。作为电动汽车重要组成部分、占其成本50%左右的锂电池产业必将从中受益。

我国锂离子电池原材料来源十分丰富：青海和西藏等地的盐湖中储藏大量锂资源；锰、铁、钒、磷等资源的储量也十分丰富。同时，我国在小功率锂离子电池领域已经形成完整的产业链，锂电池发展十分迅速。国家统计局的数据显示，2013年我国锂电池累计完成产量47.68亿自然只，累计同比增长16.9%；主营业务收入超过740亿元，同比增长17.8%。

然而,与相机、电脑、手机等小型锂电池领域不同，电动汽车的锂电池用量是电子产品应用的几百倍乃至上千倍。以

plug-in hybrid electric vehicles produced 2 million and sold cumulatively more than 5 million.

The electric car in next 3-5 years will enter a rapid growth. As an important part of the electric car, the lithium battery industry will benefit from it.

Lithium ion battery's raw material source is very rich in China. Salty lakes in Qinghai, Tibet and other places have a rich content of lithium, manganese, iron, vanadium, phosphorus and etc. At the same time, our country's small power lithium ion battery has formed a complete industrial chain. Lithium battery development is very rapid. The national bureau's statistics data show that lithium batteries produced cumulatively in our country in 2013 were 4.768 billion in number, increasing 16.9% when compared with the last year; main business income of more than 74 billion yuan, increasing 17.8%.

However, different from other small lithium batteries for camera, computer, mobile phone and so forth, lithium batteries for EV have a very huge capacity. Taking 2015 as an example, if the number of electric cars is 500 thousand in number, then batteries needed will be 15 billion WH (module type) and 3 billion WH (power type). The electric car market once opens, it will bring the lithium battery industry explosive growth.

### The anode material is the key

The expansion of the lithium battery industry will inevitably lead to the development of the anode materials industry. The anode materials chosen for lithium batteries are mainly three types: manganese acid lithium, ternary material (nickel-cobalt-manganese acid lithium) and lithium iron phosphate. The market size of anode materials, as data in 2013 show, was 7.36 billion yuan, up 12% over last year in China. At present, lithium battery cathode material production enterprises in China are 189 in number.

In all kinds of the anode material, lithium iron phosphate is higher than manganese-acid lithium. Internal resistance is small, the battery service life is long, charge / discharge has a low calorific value, and safety is high. However, electric vehicle has dozens or even hundreds of batteries connected together, so the consistency requirement is very high. It is hard for lithium iron phosphate batteries to meet such requirement.

Manganese acid lithium power battery features high REDOX and exothermic stability, capacity retained at more than 90% after more than 300 charge and discharge cycles. In industrial maturity, cost, consistency, it is better than lithium iron phosphate battery, but its stability is poor. To win the market, manganese acid lithium still needs efforts in R and D work in safety.

Ternary material in the lithium battery develops rapidly in recent years and features high capacity, low cost, and excellent safety. On the chemical properties, the ternary material belongs to excessive metal oxide, but it is more active than lithium iron phosphate. Its property of being more active is a risk for safety.

In 2013, one Tesla electric vehicle fired, which was related with battery cathode material. This battery used was aluminum nickel and cobalt type 18650 battery. Ternary material can self heat in more than 180 degrees Celsius. A fire may be difficultly controlled in this case.

At present, for the domestic power battery of electric vehicles, lithium iron phosphate material is mainly used. Lithium iron phosphate material can self heat in more than 250 degrees Celsius. However, lithium iron phosphate battery energy density is 86-120 WH/kg, and the improvement space is not large.

### A test in the battery market

At present, the above three kinds of anode material have been industrialized have their own advantages and disadvantages. A few years ago, the majority of industry experts believed that lithium iron phosphate and manganese acid lithium were the most promising in the field of consumer electronic products. As technology advances, this viewpoint recedes. A few years ago, it was thought that lithium iron phosphate was the safest and many EV makers used it in EV battery. But in recent years, there is a different point of view and





2015年电动汽车50万辆计算, 届时需要能量型动力电池模块150亿瓦时/年、功率型30亿瓦时/年。电动汽车市场一旦开启, 必将给锂电池产业带来爆发式增长。

## 正极材料是重点

锂电池产业规模的扩大, 必将带动正极材料产业的发展。锂电池选用的正极材料主要有锰酸锂、三元材料(镍钴锰酸锂)和磷酸铁锂3种。数据显示, 2013年, 中国正极材料市场规模达到73.6亿元, 同比增长12%。目前, 我国锂电池正极材料生产企业达189家。

在各种正极材料中, 磷酸铁锂的能量密度大于锰酸锂, 其内部阻力比较小, 电池使用寿命则较长, 充放电时发热量小, 安全性高。但是, 电动汽车的动力电池是数十甚至数百个电芯连接起来, 对一致性要求非常高, 这是磷酸铁锂电池很难做到的。

锰酸锂动力电池具有较高的氧化还原放热稳定性, 充放电循环300多次后, 容量保持率可达90%以上; 在工业化成熟度、成本、一致性上, 优于磷酸铁锂, 但其稳定性较差。锰酸锂要想赢得市场, 还需要在安全性领域加大研发。

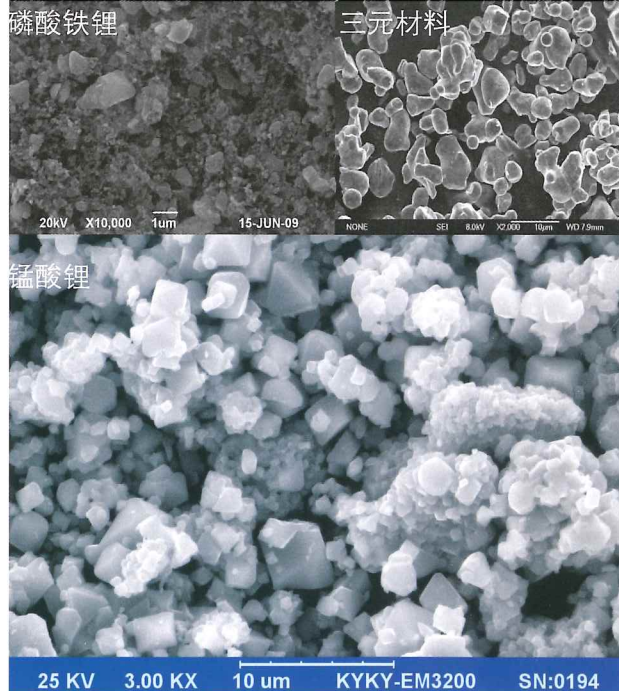
三元材料是近年来发展较快的新型锂电正极材料, 具有容量高、成本低、安全性好等优异特性。从化学性质上说, 三元材料属于过度金属氧化物, 含电量比较高。但是化学性质要比磷酸铁锂活泼, 这就埋下一定的安全隐患。

2013年特斯拉电动汽车起火事件与动力电池正极材料就有关, 其采用的是镍钴铝三元材料的18650电池, 该三元材料在180摄氏度以上会出现自加热, 起火后很难控制。

目前, 国内电动汽车用动力电池主要为磷酸铁锂材料, 磷酸铁锂材料要到摄氏250度以上才会出现自加热现象。但是, 磷酸铁锂电池的比能量密度在86-120瓦时/千克, 提高的空间不大。

## 电池市场说了算

目前, 磷酸铁锂、锰酸锂和三元材料是3种已经产业化的正极材料, 它们各有优缺点, 各有支持者。几年前, 业内多数人认为, 磷酸铁锂和锰酸锂是最有前途的动力锂电池正极材料, 三元材料比较适用于消费电子产品。随着技术进步, 对锂电池正极材料的观点也在不断发生变化。几年前认为磷酸铁锂最安全, 国内很多生产厂家, 不少电动汽车生产企业都采用磷酸铁锂电池装车试制, 近年来却有不同观点, 并改变技术路线; 以前有人认为锰酸锂不够安全, 但近年来锰酸锂在日本等国发展很快; 以前认为三元材料不适合用作动力电池, 循环寿命相对



the technical route is changed. In previous time, it was thought that manganese acid lithium was not safe, but in recent years, it develops fast in Japan and other countries. In previous time, it was thought that the ternary material was not suitable for power battery due to a short life, but now Tesla's electric vehicle uses it. Although there is a fire, but this seems not to have much negative influence on its development.

From the standpoint of requirement of EV for power battery, the future development trends of the lithium ion battery are high energy density, high safety, long life, high reliability and low cost, etc.

Under the current technical conditions, the above-said three materials have their own market space. Many companies think ternary material will become the mainstream of future market. At present or in the short term, lithium iron phosphate batteries is or will be dominant. How is the future development trend?

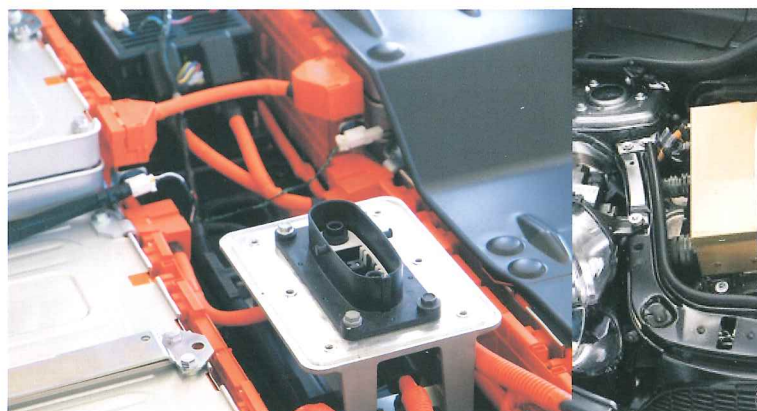
主要正极材料性能参数比较

	钴酸锂	镍酸锂	镍钴酸锂	镍锰酸锂	钴镍锰酸锂	锰酸锂	磷酸铁锂
工作电压	3.6V	3.3V	3.7V	3.7V	3.7V	3.8V	3.4V
电容量	160mAh	200mAh/g	180mAh/g	160mAh/g	190mAh/g	110mAh/g	160mAh/g
循环寿命	>500次	>500次	>500次	>500次	>500次	>500	>2000
价格	高	较高	较高	较高	较高	低	较低
安全性	低	低	低	较低	较低	较好	好
应用领域	小型电池	小型电池	小型电池	小型电池	小型电池	动力电池	动力电池

Which can occupy a larger market share? It depends on market development and the realistic effect of EV popularization. We should follow the choice of the market with "visible hand" and "invisible hand". The market is the final judge.

## The electric car has a good fate

At present, the domestic lithium battery industry development has made great progress with advantages e.g. great market potential, low production cost and so forth. It has also obvious shortcomings. At the early stage, the enterprise is





短，但是特斯拉电动汽车却采用三元正极材料，虽然曾出现过起火事件，但似乎并没有对其发展产生过大的负面影响。

从电动汽车对动力电池的要求来看，未来锂离子电池的发展趋势是朝高能量密度、高安全性、长寿命、高可靠性及低成本等方向发展。

目前的技术条件，磷酸铁锂、锰酸锂和三元材料都具有一定的市场空间。不少企业认为三元材料将成为未来市场的主流；现阶段或短期内，磷酸铁锂电池会占据市场主导地位。到底未来发展走向如何？谁能占据更大市场份额？这要看市场发展，看电动汽车推广应用的实际效果，需要遵循“有形的手”与“无形的手”的选择。最后由市场优胜劣汰。

## 电动汽车好命运

目前，国内锂电池产业发展取得了长足进步，具有市场潜力大、生产成本低等优势，但是也存在着明显的不足。企业规模较小，前期研究薄弱，知识产权受困等等。今后需要全方位整合，多方面提升我国锂电池材料的产品品质，做强做大整个产业；特别是与整车企业整合，做强做大电动汽车。

其一、技术创新，加强基础研究，占据知识产权的制高点。研发新一代的正极材料。那些处于中试、处于前期研究阶段的电池正极材料值得业界关注。富锂锰基材料比能量可达250-400瓦时/千克；石墨烯-硫复合物正极材料比能量可超过2000瓦时/千克。这些材料性能出众，目前距离产业化还有距离，但很有可能成为未来的发展方向，在未来动力锂电池大规模应用时才能出奇制胜。

其二、合资合作或收购兼并，改变电池企业规模小、数量多的现状。要在正极材料、负极材料、电解液、隔膜、电池单体和系统等方面要培育出具有世界品牌影响力、国际产品竞争力和盈利能力的大型企业。

其三、深度整合产业链上下游优势，分散风险，降低成本，形成协同效应，谋求电动汽车产业链的整体发展，锂电池产业链各方共同发展动力锂电池产业，为做强做大电动汽车奠定基础。

其四、要促进锂电池企业与整车企业的深度合作，在应用层面创新商业模式，研制出适用于各种纯电动汽车的锂电池系统，促进纯电动汽车的推广和电池的发展。可供选择的典型模式有二：

“汽车整车厂+锂离子电池厂商”

“汽车零部件厂商+锂离子电池厂商”

果然如此，电动汽车必将会有好命运。

small in size, weak in R and D force, and intellectual property issues etc. In the future, we need the integration in many aspects to improve the quality of the lithium battery materials and let the industry stronger. Especially, it should be integrated with the EV makers.

First, technological innovation and strengthening the basic research to occupy the high ground of the intellectual property rights. Develop a new generation of positive electrode materials. Anode materials in test attract attention. Rich lithium manganese base material has specific energy up to 250-400 WH/kg. Graphene - sulfur compound anode material has specific energy of more than 2000 WH/kg. They have excellent performance but are still far away from the industrialization. They are likely to be the future development direction. In the future, power lithium-ion batteries are likely to be used in a large scale.

Second, joint venture or acquisition. It is necessary to change the current situation where the enterprise is small in size and high in number. We should build large enterprises having good profitability, competitiveness and impact in the world in the cathode materials, anode materials, electrolytes, diaphragms, battery monomers and systems etc.

Third, the depth integration is needed in the upstream and downstream of the industry chain so as to reduce the risk and cost and form a synergistic effect and obtain the overall development in the EV industry. The lithium battery is closely related with the population of the electric cars. It deserves our attention.

Fourth, it is necessary to promote the in-depth cooperation of the lithium battery enterprises and vehicle enterprises. In the application, we need to innovate the commercial model and develop a variety of lithium battery systems for pure EVs, promote the development of the pure EVs and batteries.

The typical modes can be selectable as follows:

"Automotive manufacture + lithium-ion battery manufacturer"

"Auto parts manufacturer + lithium-ion battery manufacturer"

As such, the electric car will have a good fate.

