

# Lithium Solid State Batteries for Electric Vehicles

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**Abstract:-** Recent technologies such as smart phones and electric cars have created an increased demand for highly efficient and large capacity methods of portable energy storage. As commercial producers attempt to reach the predicted maximum capacity of the current lithium-ion batteries, safety risks increase as the heat and lifecycle of the batteries become greater risk factors. Leaders in manufacturing predict that the lithium-ion battery will reach the upper limit of its innovation in 2020. To maintain low weight with high output and safety, engineers are looking towards lithium solid-state batteries. For the electric vehicle market, high energy storage with low weight is crucial. Creating a more energy dense battery holds a two factor benefit for electric vehicles. Not only does a higher capacity increase total charge, but lighter vehicles overall further increase the efficiency and range of an electric vehicle. Compared to the lithium-ion battery, the lithium solid-state battery is much safer. With the application of electric cars, safety serves as a top priority, as crashes have the potential to compromise a battery pack. Solid-state batteries also possess the potential to be sourced from cheaper materials compared to many of the rare earth elements found in lithium ion batteries. Using the example of the electric vehicle, we will be demonstrating the advantages of the development into a safer and less environmentally impactful battery.

**Keywords:** Efficiency, Electric cars, Energy storage, Safety of solid-state batteries, Solid-state lithium ion batteries

## 1. INTRODUCTION

### 1.1. LITHIUM SOLID-STATE BATTERIES ARE THE DIFFERENCE

The need to store energy consistently exists as one of societies' greatest technological issues. Ever-expanding use of electronic devices creates a dire need for an efficient, compact, and safe storage of energy. Currently, the most commonly used battery to fit the needs of the rapidly developing technology industry is the lithium-ion battery. However, this battery type has almost reached its theoretical energy density limit, requiring a new generation to take its place.

The innovation that fills this void is the lithium solid-state battery. Taking advantage of a purely solid composition, the lithium solid-state battery not only possesses a much higher energy capacity, but it also solves many of the environmental and safety issues associated with the other existing battery options. Lithium solid-state batteries outclass their lithium-ion counterpart in almost every way and serve as the next breakthrough in battery technology. Its revolutionary capabilities find applications in every facet of this technologically-advanced modern age [1].

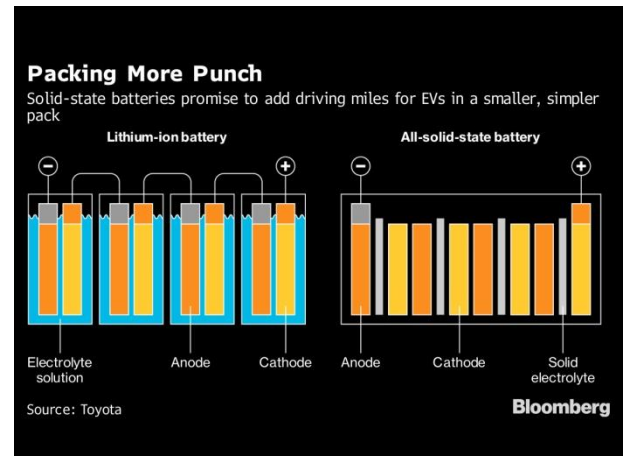


Fig. 1 Packing More Punch Module

Groundbreaking advancements into lithium solid-state technology have the direct effect of accelerating the innovation of electric vehicles. A more compact and energy dense battery allows for the range and efficiency of electric vehicles to be increased significantly. Compared to lithium-ion batteries, the completely solid components of the solid-state battery create a less hazardous environment that is ideal for automobiles. Not only are the components of the lithium solid-state battery safer for use in the automobile industry, but the components themselves require less expensive manufacturing materials when compared to the large use of rare earth elements found in lithium-ion batteries.

These expensive materials keep the cost of lithium-ion batteries relatively high, even with a streamlined manufacturing process. Lithium solid-state batteries, on the other hand, consist of inexpensive and abundant materials, relying less on the expensive and hard to obtain earth elements. Even though the cost of producing lithium solid-state batteries is far greater than any of the competition that is currently on the market, the rapid adoption and eventual mass production methods of the solid-state battery have the capability to dramatically decrease its overall cost.

## 2. WHAT ARE LITHIUM SOLID-STATE BATTERIES?

In solid-state batteries, both the electrodes and the electrolytes are solid state. Solid-state electrolyte normally behaves as the separator as well, allowing down-scaling due to the elimination of certain components (e.g. separator and casing). Therefore, they can potentially be made thinner, flexible, and contain more energy per unit weight than conventional Li-ion [7]. In addition, the removal of liquid electrolytes can be an avenue for safer, long-lasting batteries as they are more resistant to changes in

temperature and physical damages occurred during usage. Solid state batteries can handle more charge/discharge cycles before degradation, promising a longer life time [3].

### 3. COMPARING LITHIUM SOLID-STATE TO LITHIUM-ION BATTERIES

The lithium solid-state “revolution” is in full swing today. Due to its enhanced safety features, energy storage, and life-span, there has been a call for a shift from the current lithium-ion batteries towards these innovative, solid-state energy sources [8]. This transition comes at a good time, as many key safety deficiencies in the structure of lithium-ion batteries are beginning to come to light. Of the many advantages that the solid-state battery boasts, perhaps its most impressive property is its feasible solution to the prevalent dangers that lithium-ion batteries possess. Lithium solid-state batteries are paving a path towards a safer and more energy efficient future [4].

#### 3.1 Advantages of Lithium Solid-State Batteries

Lithium solid-state batteries are a complete upgrade from lithium-ions. With crucial safety improvements, a higher energy storage, better cost-effectiveness, and overall advances in durability, these units are shown to be extremely beneficial. When utilized within their most noteworthy application, being electric cars, they demonstrate the value of their extended life-span as rechargeable cells.

In turn, this aids the environmental improvement effort by encouraging the production of more electric vehicles, thereby limiting the amount of air pollutants released into the atmosphere. These batteries are recognized as a step towards universally enhancing the quality of living throughout the world [5].

#### 3.2 Safety Improvements

Conceivably, the most vital attribute of lithium solid-state batteries is that they are considerably less harmful than lithium-ion packs. The interior of the lithium solid-state battery contains a solid electrolyte, which is far less reactive than the liquid or gel electrolytes that form lithium-ions. This helps to prevent chemical destabilization within batteries. It also provides a solid separator that essentially does not allow for the anode and cathode to come in contact with each other [6].

### 4. APPLICATION IN ELECTRIC CARS

The uses for solid-state lithium batteries are pretty extensive, but their explicit use in electric cars is very promising. The industry of electric cars is being redefined in order to attempt to provide the best possible car as it is in competition with fuel-burning cars. Solid-state batteries

provide a means of striving to lower their total costs, improve the general safety, and enhance the full effectiveness of electric cars [2].

### 5. LITHIUM SOLID-STATE BATTERIES: THE FUTURE OF ENERGY STORAGE

In conclusion, the future of energy storage will be held in lithium solid-state batteries. Solid-state batteries are made up of a solid cathode, anode, and electrolyte. In comparison to all other batteries on the market, it is far superior. It is safer, smaller, and has a larger energy density than anything else. Solid-state batteries are an excellent choice for electric cars in the future. With the capacity to outperform other types of electric cars, as well as fuel-burning cars, solid-state electric cars could reshape the entire automobile industry. In addition, it will provide an outlet towards a future of reducing carbon emissions through the reduction of fuel-burning cars. The lithium solid-state battery holds a place as the next breakthrough in battery technology all across the world with its high efficiency, large energy density, greater tolerances to temperature, and overall use. Solid-state batteries have the aptitude to redefine energy storage as we know it. They have a diverse set of applications from phones to cars and beyond. With careful development, solid-state batteries could become the primary power source for everything.

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