Study on Positive and Negative Materials of High Performance Ion Batteries

Jialong Song, Zijia Sun, Mingfen Sun
Zhuhai College of Jilin University, Guangdong, Zhuhai, 519041, China

Abstract. Study on positive and negative materials of high performance Ion batteries is presented in this manuscript. In recent years, sodium ion batteries have developed rapidly, and a number of key materials with electrochemical activity have emerged. Among them, the transition metal oxide as a core sodium ion battery positive electrode shows considerable sodium-embedded capacity, but the capacity decays severely during continuous cycling. This paper studies the novel findings on the mentioned issues to provide the new perspectives for assisting the future research.

1. Introduction
The structured battery is a unitary body of a battery and a structural material. In order to obtain an efficient structural battery, the battery generally requires a high operating voltage, a long life cycle, and a large specific energy; the material is required to have a high compressive and shear resistance. Its development has experienced hydrogen nickel type, lithium ion battery type and polymer lithium ion battery type, which may be applied in the form of fiber battery or the fully homomorphic thin film battery in the future. Recently, research on lithium ion secondary batteries has continued. Several new systems for improved lithium ion secondary batteries have emerged, such as the polymer lithium ion secondary batteries using in-situ polymerization processes, which simplify the process and improve safety and specific energy; while all-solid-state thin film lithium-ion batteries or fibers Lithium-ion battery is a hot spot at home and abroad. It is a new generation of lithium-ion battery developed on the basis of liquid lithium ion secondary battery. Based on the structure of a common lithium ion battery, it is deposited on the substrate by physical coating.

According to the current research progress, modern sodium ion batteries have three outstanding advantages compared with lithium ion batteries.
- Sodium batteries have relatively stable electrochemical properties and are safer to use. At the same time, sodium-ion batteries also have defects, such as the relative atomic mass of sodium is much higher than that of lithium while also then resulting in a small theoretical specific capacity.
- The raw material resource is rich, the cost is low and the distribution is widespread.
- The half-cell potential of the sodium ion battery is 0.3-0.4v higher than that of lithium ion battery, that is to say, the electrolyte solvent and electrolyte salt with lower decomposition potential can be used, and the selection range of electrolyte is wider.

In recent years, sodium ion batteries have developed rapidly, and a number of key materials with electrochemical activity have emerged. Among them, the transition metal oxide as a core sodium ion battery positive electrode shows considerable sodium-embedded capacity, but the capacity decays severely during continuous cycling. Doping non-transition metals improves the structural stability of
the material, but it will sacrifice the specific capacity of the core material. Therefore, the equilibrium
capacity and cycling performance are the main research bottlenecks of this kind of the materials.

Phosphate compounds have the characteristics of the high voltage and high cycling stability. The
research on these materials is mainly to solve the problem of the poor conductivity. The design and
optimization of carbon content and its structure is an important method to improve the comprehensive
performance of these electrodes. As the sample, figure 1 gives the demonstration.

![Figure 1. The Inner Organization of the High Performance Batteries](image)

2. The Proposed Methodology

2.1. High Performance Batteries Overview

The structure battery is called the multi-purpose structure battery is in order to overcome the present
commercial massive battery quality big, the volume big shortcoming, but unifies an organic entity the
battery and the load-carrying structure which forms.

The structural battery can provide the energy and can be used as a load-bearing structural material,
which can effectively reduce the quality of the system; the fork can save system space and increase its
payload by dispersing the battery in the structure of the system. With the emergence of lithium-ion
batteries, lithium-ion batteries with long service life, high working voltage, large specific energy and
strong load resistance are used as the core of the lightweight honeycomb plate of the structural battery.
In this way, the total mass and volume of the system are further reduced, and the specific energy and
power of the structured battery are greatly improved. Some experts predict that the new technologies,
new methodologies, new materials and new structures will replace the current lead-acid batteries. At
present, the electrode active material used by most lead-acid battery manufacturers is a mixture of fine
particles, that is, lead powder. Lead powder is the starting material for the formation of active
materials in the lead-acid battery. Its properties and the quality control play an important role in the
performance of the entire lead-acid battery. In order to develop high-performance lead-acid batteries
with high energy, long cycle life and high rate discharge performance, domestic and foreign scholars
have carried out a large number of ultra-fine lead powder synthesis and battery performance research.

For each application, each battery has the different performance requirements. Adding additives or
creating a porous environment, or increasing the efficiency of use, or strengthening the strength of the
paste, or improving the conductivity, but the addition of an additive often cannot meet improvement of
multi-faceted performance at the same time. In addition, an all-solid-state thin film lithium ion
secondary battery using a flexible substrate (stainless steel or polyimide) is easily curled into various
shapes and can be combined with a thin film solar cell to form an integral thin film battery.

2.2. Ion Battery

Sodium is abundant in the earth and widely distributed, and it belongs to the same family element as
lithium. Therefore, the development of sodium ion battery technology is of great significance.
However, amount of sodium is larger than that of lithium, and standard electrochemical potential is lower than that of lithium.

Therefore, the energy density of sodium ion batteries is difficult to match that of the lithium ion batteries. However, when large-scale energy storage applications require large amounts of the alkali metals, the cost advantage of the sodium-ion batteries is revealed. Sodium ion battery and lithium ion battery are essentially the same that are a rocking chair battery. Based on the research experience of lithium ion battery, sodium ion battery has made significant progress in electrochemical activity of its key material after some rapid development in recent years. A lithium ion battery using an organic electrolyte has a wide electrochemical window of 3V or more, and thus has a higher energy density than a water ion battery. However, organic electrolytes are flammable and toxic. If they are not used properly, they will bring serious safety and environmental problems, which restricts the application of the lithium-ion batteries in large-scale energy storage.

In the battery structure, aluminum foil or the foamed nickel is usually used as a gasket between the negative electrode and the battery case to reduce the gap to reduce the battery resistance; the negative electrode usually uses the core battery-grade lithium metal plate; PC (Li2O); GC and PC (BN) are Li2O-loaded polymer film, glass-ceramic separator and the boron nitride-loaded polymer film. These three films form a battery separator for the easy ion exchange. The solvent is dimethyl Sulfoxide or the Tetraethylene glycol dimethyl ether, solute is electrolyte of lithium Bistrifluoromethanesulfonimide battery positive electrode is a catalyst-supported glassy carbon electrode, usually using foamed nickel or the like between the battery case and the positive electrode to enhance conductivity feature. In the Li-CO2 battery that has been reported so far, a glass carbon fiber membrane is often used as a battery separator to ensure rapid ion exchange. Figure 2 demonstrates the mentioned ideas.

![Figure 2. The Performance Simulation of the Ion Battery](image)

2.3. Ion Battery Positive and Negative Materials

In order to obtain a sodium ion battery electrode material with high specific capacity and good battery stability, it is particularly important to analyze the mechanism of insertion and removal of sodium ions, the structure of the electrode material and electrochemical performance during charge and discharge. At this stage, the electrode materials of the sodium ion batteries are mainly inorganic compounds based on transition metal elements such as Fe, Co, Ni, Mn, etc., which are limited in resources, expensive, and difficult to recycle. In addition, the lattice size of inorganic metal compounds is fixed while making large-scale sodium ion insertion and extraction are limited, so capacity is limited, and there are not many types of inorganic compounds that can be used as electrode materials for sodium ion batteries.

Therefore, we present the samples as the follows.

(1) Positive Materials list

The earliest research on the polyanionic cathode materials was applied to the positive electrode of lithium ion batteries, which was later applied to the sodium ion batteries. The research of such materials is relatively early, mainly representing a class of olivine crystals such as...
NaMnPO₄ and NaFePO₄. This electrode material has good rate performance and cycle stability as a positive electrode for sodium ion batteries.

The rise of two-dimensional materials came after the discovery of graphene, which showed for the first time that two-dimensional structures could be stable as crystals. Since then, the two-dimensional materials have been developed. Among them, a series of transition metal two-dimensional materials such as general molybdenum disulfide, transition metal bimetal hydroxide, transition metal sulfide have been then gradually synthesized and applied to the positive electrode of sodium ion battery with good results.

Transition metal phosphate is also a positive electrode material used in general lithium ion batteries. It has crystal structures and mature synthesis process. Therefore, hydrothermal synthesis has become a new way to then synthesize sodium iron phosphate. Currently, the research of layered cathode materials mainly focuses on the P2 phase and 03 phase and the specific capacity of P2 phase is generally higher and the stability is better. This is mainly because the coordination space of the triangular prism occupied by Na⁺ in the P2 phase is larger than the octahedral coordination space in the 03 phase, which is favorable for the diffusion of Na⁺.

(2) Negative Materials list

Graphite anode materials have been used in applications in lithium-ion batteries, and also experimental and theoretical studies have shown sodium ions are difficult to intercalate between graphite layers, limiting the application of the graphite in sodium-ion batteries. Interpretation of Na can be explained by first-principles calculations. The mechanism of the extraction, and then find ways to improve the performance of graphite storage.

As the cathode of sodium ion battery, metal compounds are mainly two-dimensional metal carbide and nitride. In addition to the excellent properties of two-dimensional materials, these materials can not only store sodium ions by means of adsorption and intercalation, but also combine with sodium ions to store energy through pseudo-capacitance generated by chemical reactions, thus greatly enhancing the energy storage effect.

![Figure 3. The Ion Battery Positive and Negative Materials](image)

3. Conclusion

Study on the positive and negative materials of high performance Ion batteries is presented in this manuscript. The structured battery is a unitary body of a battery and a structural material. In order to obtain an efficient structural battery, the battery generally requires a high operating voltage, a long life cycle, and a large specific energy; the material is required to have a high compressive and shear
resistance. This paper proposes the novel perspectives on the future advancement of the related work. The ideas are novel and in the next research, we will conduct the experimental analysis.

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