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Graphene Batteries over Lithium Ion Batteries

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Abstract

In this technical world mobiles and other electronic gadgets have become most important drivers in our day to day life. We often see new innovations and improvements in tech community. But coming to the batteries we are using lithium ion batteries since 3 decades and there are many disadvantages in these batteries. Graphene batteries would be the best alternative for lithium ion batteries

Keywords : graphene battery, high capacity, fast charging, flexibility, high temperature range

INTRODUCTION

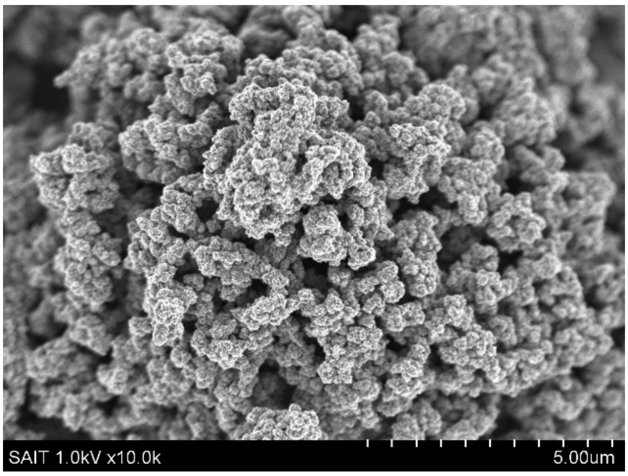
Lithium-ion batteries were first commercialized in 1991, and widely applied to markets for mobile devices and electric vehicles. However, with standard lithium batteries requiring charging times of at least an hour to fully charge, even with quick charging technology, and considered to have reached their limit for capacity expansion, there have been numerous attempts to explore use of new innovative materials. Among the materials looked at, graphene has widely become the primary source of interest as the representative next generation material.

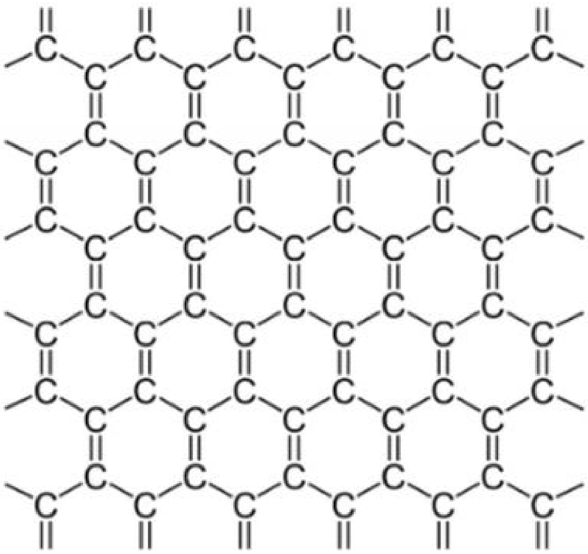
Recently, a team of researchers at the Samsung Advanced Institute of Technology (SAIT) developed a "**graphene*** ball," a unique battery material that enables a 45% increase in capacity, and five times faster charging speeds than standard lithium-ion batteries. The breakthrough provides promise for the next generation secondary battery market, particularly related to mobile devices and electric vehicles. In its research,

SAIT collaborated closely with Samsung SDI as well as a team from Seoul National University's School of Chemical and Biological Engineering. In theory, a battery based on the "graphene ball" material requires only 12 minutes to fully charge. Additionally, the battery can maintain a highly stable 60 degree Celsius temperature, with stable battery temperatures particularly key for electric vehicles.

In its research, SAIT sought for an approach to apply graphene, a material with high strength and conductivity to batteries, and discovered a mechanism to mass synthesize graphene into a 3D form like popcorn using affordable silica (SiO_2). This "graphene ball" was utilized for both the anode protective layer and cathode materials in lithium-ion batteries. This ensured an increase of charging capacity, decrease of charging time as well as stable temperatures.

MATERIAL AND METHODOLOGY





Graphene and batteries

Graphene, a sheet of carbon atoms bound together in a honeycomb lattice pattern, is hugely recognized as a "wonder material" due to the myriad of astonishing attributes it holds. It is a potent conductor of electrical and thermal energy, extremely lightweight chemically inert, and flexible with a large surface area. It is also considered eco-friendly and sustainable, with unlimited possibilities for nmerous applications.

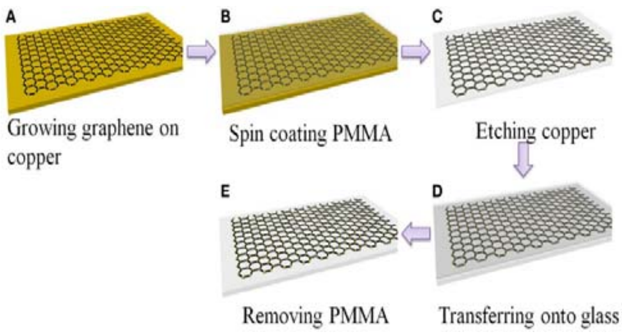
THE ADVANTAGES OF GRAPHENE BATTERIES

In the field of batteries, conventional battery electrode materials (and prospective ones) are significantly improved when enhanced with graphene. A graphene battery can be light, durable and suitable for high capacity energy storage, as well as shorten charging times. It will extend the battery's life, which is negatively linked to the amount of carbon that is coated on the material or added to electrodes to achieve conductivity, and graphene adds conductivity without requiring the amounts of carbon that are used in conventional batteries.

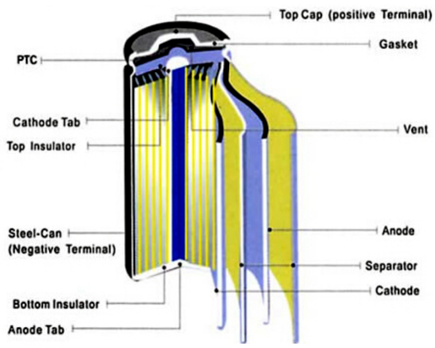
Graphene can improve such battery attributes as energy density and form in various ways. Li-ion batteries (and other types of rechargeable batteries) can be enhanced by introducing graphene to the battery's anode and capitalizing on the material's conductivity and large surface area traits to achieve morphological optimization and performance.

It has also been discovered that creating hybrid materials can also be useful for achieving battery enhancement. A hybrid of Vanadium Oxide (VO^2) and graphene, for example, can be used on Li-ion cathodes and grant quick charge and discharge as well as large charge cycle durability. In this case, VO^2 offers high energy capacity but poor electrical conductivity, which can be solved by using graphene as a sort of a structural "backbone" on which to attach VO^2 - creating a hybrid material that has both heightened capacity and excellent conductivity.

Another example is LFP (Lithium Iron Phosphate) batteries, that is a kind of rechargeable Li-ion battery. It has a lower energy density than other Li-ion batteries but a higher power density (an indicator of of the rate at which energy can be supplied by the battery). Enhancing LFP cathodes with graphene allowed the batteries to be lightweight, charge much faster than Li-ion batteries and have a greater capacity than conventional LFP batteries.



Structure



BATTERY BASICS

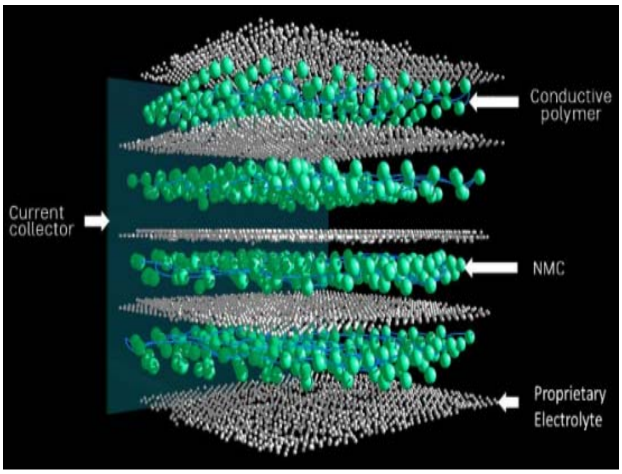
Batteries serve as a mobile source of power, allowing electricity-operated devices to work without being directly plugged into an outlet. While many types of batteries exist, the basic concept by which they function remains similar: one or more electrochemical cells convert stored chemical energy into electrical energy. A battery is usually made of a metal or plastic casing, containing a positive terminal (an anode), a negative terminal (a cathode) and electrolytes that allow ions to move between them. A separator (a permeable polymeric membrane) creates a barrier between the anode and cathode to prevent electrical short circuits while also allowing the transport of ionic charge carriers that are needed to close the circuit during the passage of current. Finally, a collector is used to conduct the charge outside the battery, through the connected device. When the circuit between the two terminals is completed, the battery produces electricity through a series of reactions. The anode experiences an oxidation reaction in which two or more ions from the electrolyte combine with the anode to produce a compound, releasing electrons. At the same time, the cathode goes through a reduction reaction in which the cathode substance, ions and free electrons combine into compounds. Simply put, the anode reaction produces electrons while the reaction in the cathode absorbs them and from that process electricity is produced. The battery will continue to produce electricity until electrodes run out of ecessary substance for creation of reactions.

BATTERY TYPES AND CHARACTERISTICS

Batteries are divided into two main types: primary and secondary. Primary batteries (disposable), are used once and rendered useless as the electrode materials in them irreversibly change during charging. Common examples are the zinc-carbon battery as well as the alkaline battery used in toys, flashlights and a multitude of portable devices. Secondary batteries (rechargeable), can be discharged and recharged multiple times as the original composition of the electrodes is able to regain functionality. Examples include lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics.

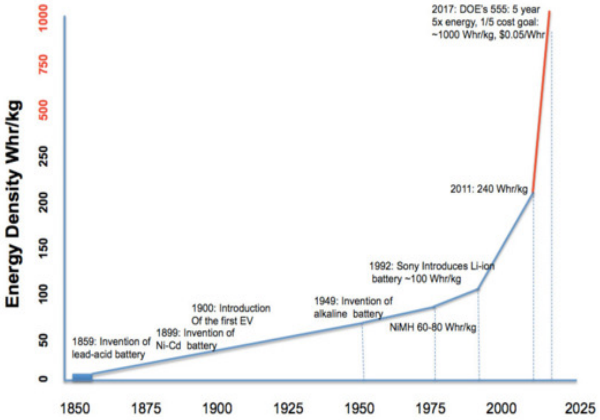
Batteries come in various shapes and sizes for countless different purposes. Different kinds of batteries display varied advantages and disadvantages. Nickel-Cadmium (NiCd) batteries are relatively low in energy density and are used where long life, high discharge rate and economical price are key. They can be found in video cameras and power tools, among other uses. NiCd batteries contain toxic metals and are environmentally unfriendly. Nickel-Metal hydride batteries have a higher energy density than NiCd ones, but also a shorter cycle-life. Applications include mobile phones and laptops. Lead-Acid batteries are heavy and play an important role in large power applications, where weight is not of the essence but economic price is. They are prevalent in uses like hospital equipment and emergency lighting.

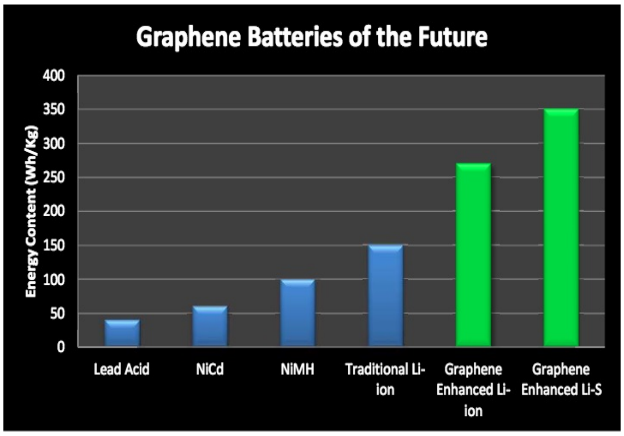
Lithium-Ion (Li-ion) batteries are used where high-energy and minimal weight are important, but the technology is fragile and a protection circuit is required to assure safety. Applications include cell phones and various kinds of computers. Lithium Ion Polymer (Li-ion polymer) batteries are mostly found in mobile phones. They are lightweight and enjoy a slimmer form than that of Li-ion batteries. They are also usually safer and have longer lives. However, they seem to be less prevalent since Li-ion batteries are cheaper to manufacture and have higher energy density.



RESULTS AND TABLES

Energy density and energy content of different types of batteries are as given below.





The lead-acid batteries was introduced in 1850's with energy density of 30-40wh/kg and charge discharge efficiency of 50-95%.

The NiCd batteries was introduced in 1899 with energy density of 40-60wh/kg and charge and discharge density of 70-90%.Specific power is 150wh/kg.

The NiMH batteries was introduced in 1949 with energy density of 60-120wh/kg and charge and discharge density of 66-92%.Specific power is 250-1000wh/kg.

The li-ion batteries was introduced in 1992 with energy density of 100-265wh/kg and charge and discharge density of 80-90%.Specific power is 340wh/kg.

The NiMH batteries was introduced in 1949 with energy density of 60-120wh/kg and charge and discharge density of 66-92%.Specific power is 250-1000wh/kg

The graphene batteries are yet to be introduced and has energy density of 240wh/kg and charge discharge density of 90-95%.

CONCLUSION

Charge time is 5x more than li-ion batteries capacity is 45x more than li-ion batteries. eg: To charge li-ion battery of capacity of 3000mah takes 1 hour whereas graphene battery of same capacity takes 12 mins to charge graphene batteries can withstand temperature upto 65-75 Celsius.were li-ion batteries can withstand temperature upto 50 celsius graphene can be used in automotive industries to make automobile body parts, it helps in improving the strength when it is used along with the carbon fibre.

graphene batteries have stable temperature stability factor. Which is the main factor in manufacture of electric cars.

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