A Review of Flexible Energy Storage Devices

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Abstract : This paper reviews the rapid advancements being made in the development of flexible energy storage devices such as a lithium-ion batteries and flexible super capacitors. Flexible energy storage devices like flexible super capacitors and lithium-ion batteries, finds applications in wearable, flexible and portable electronic equipment such as roll-up displays, foldable mobile phones, integrated system and soft electronic products. This work also discusses the technology innovations and difficulties and challenges in flexible lithium-ion batteries and super-capacitors.

***IndexTerms*- Charge storage density, Flexible, Lithium ion batteries, Super capacitors, Wearable.**

I. INTRODUCTION

The energy storage devices, such as super -capacitors and lithium ion batteries are widely used in various electronic applications such as Portable/Flexible/bendable electronic equipment's such as roll-up displays, bendable mobile phones, wearable electronic watches, printable electronics and integrated systems [1-3]. Today's lithium ion batteries have the limitations such as too heavy, rigid and bulky. Moreover, the future energy storage devices should be of flexible, light weight, shape diversity, aesthetic diversity and outstanding mechanical strength.

The critical issue in obtaining flexible energy storage devices are the design of flexible bendable current collectors with excellent mechanism strength their selection and manufacturing of flexible anode and cathode materials with high energy storage capacity and outstanding conductivity [47]. The traditional lithium-ion batteries use lithiated-transition metal oxide compound as cathode material and these oxides store and release energy when the lithium ion are extracted and inserted with charge compensated by redox chemical reaction [8-15].

II. REVIEW OF ANODE/CATHODE MATERIALS OF LITHIUM ION BATTERIES

(A) Lithium cobalt oxide (LiCoO2)

The design of flexible storage devices requires anode and cathode materials having high specific energy and these materials must possess bendability, high load capacity and thermal stability. lithium cobalt oxide (LiCoO2) batteries uses lithium cobalt oxide as cathode and graphite carbon as anode. These have low charging capacities and thermal runaway of 150°C.Though most of the specifications of this battery looks satisfying, It's short lifespan, low specific power and low thermal stability will still remain as the drawbacks of this battery [16]. Cycles: 500-1000

(B) Lithium Nickel Cobalt Aluminium Oxide(LiNiCoAlO2)

On comparing Lithium cobalt oxide(LiNiCoAlO2) with lithium nickel cobalt aluminium oxide(LiNiCoAlO2), it not only requires high specific energy and good specific power but it also requires long life span. Lithium Nickel Cobalt Aluminium oxide, Graphite are used as cathode and anode in lithium nickel cobalt aluminium oxide(LiNiCoAlO2) will provide the charging capacity of 300wh/kg and thermal runaway of 150°C.The only drawback of this battery is high cost [17]. Cycles:500

(C) Lithium Nickel Manganese Cobalt Oxide(LiNiMnCoO2)

The combination of nickel-manganese-cobalt made these batteries successful. As nickel provides high specific energy and manganese provides Low internal resistance. Lithium Nickel Manganese Cobalt Oxide(LiNiMnCoO2) batteries uses Lithium nickel manganese Cobalt Oxide as cathode and graphite as anode which provides the capacity of 2,800mAh and thermal runaway of 210°C.But it is used for electric vehicle [18].

(D) Lithium Manganese Oxide (LiMn2O2)

Lithium Manganese Oxide(LiMn2O2) are preferred for their low internal resistance and high stability. These batteries use Lithium Manganese Oxide as a cathode and graphite as anode. These provides the charging capacity of 1,100mAh-1,500mAh and thermal runaway of 250°C.These batteries are no longer but used for specific application [19].

(E) Lithium Iron Phosphate (LiFePO4)

Lithium iron phosphate(LiFePO4) are used for its good electrochemical performance with low internal resistance, long cycle life and enhanced safety. The cathode used in Lithium iron phosphate(LiFePO4) are lithium iron phosphate and anode used is graphite. this provides the charging capacity of 90-120Wh/Kg and thermal runaway of 270°C.The only drawback of this batteries are moderate specific energy and elevated self-discharge [20].

(F) Lithium Titanate (Li4Ti5O12)

Lithium titanate(Li4Ti5O12) are well known for its safety and excellent low temperature discharge characteristics and obtaining maximum capacity. the Lithium Titanate(Li4Ti5O12) uses Lithium manganese oxide as cathode and titanate as anode. These batteries provide the charging capacity of 50-80 wh/Kg and its thermal runaway is at safest zone and it is considered as the one of the best li-ion batteries. It has the fast charging capability but its major drawback is high expensive[18].

III. FLEXIBLE SUPER CAPACITORS

In Affordable flexible, lightweight, stable, super capacitors metal oxides provide high charge storage capacity but poor cyclic stability due to structural damage occurring during redox process. Super capacitors are electrochemical energy storage devices primarily attractive for their fast charging and discharging capability long lasting stability and safe handling.

Super capacitors are used for regenerative breaking in cars static random access memory and motor starter. In super capacitor devices electrode materials are separated by an ion transport layer through which electrolyte ions shuttle to an electrode surfaces during the discharging process. Energy storage devices are judged on three properties such as

- Power density
- Cycling stability
- Energy density

Newly discovered 2D materials known a transition-metal di chalcogenides (TMDs) only a few atoms thick to coat ID Nano-wires. We just need to establish the optimal layer thickness that provides good conductivity while minimizing the use of the nanoparticles to optimize the tradeoff between cost and performance. The maximum power and energy, density of the metallic paperbased super capacitors are estimated to be 15.1 mw/cm^2 and 267.3-uw/cm^2 respectively, substantially out performing conventional paper on textile super capacitor.

Manganese oxide (MnO_2) has long been investigated as a pseudo-capacitive material for fabricating fiber-shaped super capacitor but its poor electrical-conductivity and its brittleness are clear drawbacks. The wearable energy density should not exceed $10.97x10^{-6}$wh/cm which will be a concern when it comes to wearable gadgets as it might affect the human nervous system. This design has Ni/CNT/MnO_2 as its coaxial electrodes which holds the cathode and anode together with 1.0M $Na_2\ SO_4$ aqueous solution as its electrolyte.

IV. CONCLUSION

In this paper we have reviewed about the advancements that can be brought in the field of mobile electronics. The idea of foldable electronics has already fetched many investors which include big mobile manufacturers like samsung and Motorola have already launched their concept phones which is a big success and they are yet to commercialize

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