A Brief Review on Supercapacitor

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Abstract

Supercapacitor is a device different from the original capacitors. It also known as ultracapacitors. The brief review focuses on principle, types, material and the applications of supercapacitor. There are different materials that are used to make the supercapacitor likre grapheme, carbon black, charcoal. But the material should be conductive. Supercapacitor become the important device to solve the problem regarding power suppression in renewable energies and storage of electrical energy. It also used in hybrid power supplies, energy recovery, short charging time. In electrochemical double layer capacitor, the capacitance get reduced with the timescale of months and resistance increases.

Keywords:

Renewable energy source, hybrid power supplies, energy density, storage capacity.

Introduction:

Supercapacitors are centred on the physical principle as same as in conventional capacitors, but the supercapacitors has lesser area of electrode. This is the main fact that gives the large capacitance. Supercapacitors store charge in a analogous method to conventional capacitors, but the charge does not gather in two conductors, but it collect in the interface between the surface of a conductor and an electrolytic solution[1,2]. Supercapacitors, also called ultracapacitors or electrochemical capacitors, store electrical charge on high-surface-area conducting materials. Their widespread use is limited by their low energy storage density and relatively high effective series resistance[3]. Supercapacitors store energy by forming a double layer of electrolyte ions on the surface of conductive electrodes. Supercapacitors are not limited by the electrochemical charge transfer kinetics of batteries and thus can operate at very high charge and discharge rates and can have lifetimes of over a million cycles[4]. . Research has thus been focused on increasing energy density without sacrificing cycle life or high power density [5]. The supercapacitor has developed and appeared to solve energy storage problems[6]. Electrochemical double layer capacitors are consist of two electrodes separated by the separator. Electrolyte should be conductive that is used to polarize the charges that are given on the electrodes and also in the electrolyte itself. In the case of conventional capacitors, the capacitance is depends upon the area and the distance between the electrode. If ‘A’ is the area and ‘D’ is the distance then the capacitance C is given as

$$C = \varepsilon A/D$$

Here

C is the capacitance, D is the distance, A is the area and ε is the permittivity in dielectric medium.

Two-electrode supercapacitor cells constructed with the carbon yielded high values of gravimetric capacitance and energy density with organic and ionic liquid electrolytes. The processes used to make this carbon are readily scalable to industrial levels[3]. Supercapacitor shares the same fundamental equations as conventional capacitors; to attain higher capacitances supercapacitor uses electrodes having high specific surface area and thinner dielectrics. With these properties it makes them have power densities greater than those of batteries and energy density greater than those of conventional capacitors[7].

Supercapacitor:

Supercapacitor is a device similar to the capacitor with some different capabilities. The principle of the supercapacitor is based on the same principle of the capacitor. Supercapacitor can store charge in very short period of time as compared to the ordinary capacitors. It can store energy in two ways that is faradaic and non-faradaic. It consist of two electrodes, electrolyte and separator. The electrodes are made of same material and the electrolyte should be conductive. The charges get separated when the voltage is applied on it.

There are three types of supercapacitor: Electrochemical double layer, hybrid and pseudocapacitors.

Electrochemical Double layer capacitors(EDLCs)
EDLCs are created using two carbon centred materials as electrodes, an electrolyte and a separator. EDLCs can store charge with two processes i.e electrostatically or non- faradic process, which contains no transmission of charge between electrode and the electrolyte [8, 9].

Hybrid capacitors

EDLCs offer good cyclic stability, good power performance while in the case of pseudo capacitance it offers greater exact capacitance. In the case of hybrid system it is a combination of both, that is by joining the energy source of battery-like electrode, with a power source of capacitor-like electrode in the same cell [10, 11].

Pseudocapacitors
Pseudocapacitors can store charge via faradic process. The transfer of charge between electrode and electrolyte is present in these capacitors. The faradic process involved in pseudocapacitors permits them to attain more exact capacitance and energy densities compared to EDLCs[12].

Electrode material:

Different material used in the fabrication of the supercapacitor like grapheme, carbon black, activated carbon.

Graphene

Graphene is a thick layer 2D structure has appeared as an exclusive carbon material that has potential for energy storage device applications, this is because of its excellent features of high electrical conductivity, chemical stability, and large surface area [13-15]. Recently, it was suggested that graphene can be used as a material for supercapacitor applications, because when graphene is used as supercapacitor electrode material it doesn't depend on the distribution of pores in solid state[16, 17]. There are many different methods presently being researched for the fabrication of different types of graphene such as chemical vapour deposition, micromechanical exfoliation, arch discharge method, unzipping of CNTs, epitaxial growth, electrochemical and chemical methods and intercalation methods in graphite [18-21].

Carbon material

Carbon material is the best material used in the fabrication of the supercapacitors used in the electrodes. This is due to the best characteristics like high surface area, low cost, high capacitance. Main factors which effect electrochemical presentation are specific surface area, pore shape and structure, pore size distribution, surface functionality and electrical conductivity [22-24].

Activated carbon

The most widely used electrode material is activated carbon and that is due to its large surface area, good electrical properties and moderate cost [25]. Activated carbon can be produced by either physical or chemical activation from various types of carbonaceous materials [7]. Activated carbon utilises as activated ingredient in the supercapactitor for capacitance because of its large surface area, low cost or cheap and light weight[26]. Activated carbon can be obtained from wide variety of natural sources[26].

Energy Storage Systems:

The energy storage system considered for medium scale applications are classified by their power and energy densities [27].

a. **CAES (Compressed Air Energy Storage)**: CAES uses the heights of energy produced by renewable energy plants to run a compressor that compresses the air into a closed underground tank. The compressed air is used, combined with a variety of fuels in a combustion turbine to produce electric energy. The energy storage capacity depends on deposit volume and maximum storage pressure of the compressed air. Start up time is usually high. [28-36]. CAES is used for large and medium scale systems.

b. **Superconducting Magnets**: A Superconducting Magnetic Energy Storage system stores the energy as magnetic energy. The superconducting magnet can exist two different shapes: toroid or solenoid [37].

c. **Batteries:** These systems could be located in any place and be rapidly installed. Battery energy storage system uses a PCM to convert the battery DC energy into AC grid-compatible energy[37]. Depending on how the battery and cycle are, the battery energy

storage system can require multiple charges and discharges per day. The battery cycles will be normal while the discharge depth is small, but if the discharge depth is high the battery cycle duration could be degraded.[37]

Applications:

Supercapacitor is a type of device which is very useful to store energy, charging capability. It has many features over the normal capacitors. The main application of supercapacitor is used as storage system in hybrid or electrical automobile. Due to advances in technology and the increase in the energy storage capacity, these Systems are beginning to be considered for energy storage systems in renewable energy generation plants [38-41]. For instance, small size supercapacitors can be widely used as maintenance-free power sources for IC memories and microcomputers [42]. Current supercapacitors in the market can be used for applications that require a combination of high power delivery for a short time, high cycling stability, short charging time and long shelf life[7]. Supercapacitors can used in hybrid vehicles, UPS, starter, toy applications, GSM.

Conclusion:

Supercapacitor used to store electrical energy. It can be used in many applications. It improves the efficiency, storage power, life time, if it can combine with the batteries. Due to the large surface area the capacitance increases. This is because the capacitance is directly proportional to the area of the electrode. Different material is used to form an electrodes like grapheme, activated carbon. There are many energy storage system which are used to store the energy or power. Supercapacitor become the interesting device that can solve many problems related to energy storage, charging time.

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