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Design of Hybrid High Voltage High Storage Capacitor with Activated Carbon Medium

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Abstract

In the present day scenario there is energy crisis, a new energy storage device or a system is required irrespective of energy. As we know that electricity is one of the important forms of energy which is a must required necessity of the things or instruments which make our life easier. According to the universal law of charges "charges can neither be created nor destroyed", but the charges once created can be stored in capacitors or other charge storing devices. This paper hence put forth the hybrid high voltage high storage capacitor, with the help of activated carbon as a medium between the two conducting plates. With the unique arrangement of potential plates goal of storing large amount of charges in a single capacitor can be achieved, design and effect analysis of the high voltage high storage capacitor is shown.

Keywords: activated carbon; potential plates; phenolic resin; high electric conductivity; polarization effect; susceptance; minority carrier diffusion; neutral region; diffusion length.

1. Introduction

Speaking with respect to the normal capacitor charging and discharging are the phenomena observed in a capacitor, as it is based on the fact that the potential of the conductor is considerably decreased and its capacity is increased without affecting the electric charge in it. By replacing another earth connected conductor or an oppositely charged conductor in its neighborhood. This arrangement is able to store the electric charges; we have noticed that a special kind of activated carbon made of phenolic resin has following properties.

- It has large specific area (1500-2500) m^2 /g there by it can store large amount of charges.
- It as high electrical conductivity of 60 s cm^{-1}.

A capacitor designed to store large capacity of electric charge without having large dimension and activated carbon as the medium is shown below.

2. Working

When the potential is applied to the circuit, it works as a capacitor by satisfying all the conditions. In the figure it's shown that terminals A and C are shorted and given a positive potential and terminal B and D are shorted and given negative potential. Now the entire capacitor is divided into 4 quarters. The four electrodes individually are made of two thin plates and a small air dielectric in between them this arrangement is to ensure equal distribution of charges among the two quarter of the capacitor, this arrangement is as shown bellow. Use of activated carbon has a large advantage over any other substance because of its high electric conductivity and hence we make effective use of this material to design a high charge storage device. When the applied potential is increased, electrode A and C gets more positive charges deposited on it and plates B and D gets more and more negative charge deposited. When the potential increase positive charge on plate1 A comes in contact with the negative charge on plate2 of B electrode through the activated carbon channel and forms a dipole and now the similar effect is seen between the electrode plates of B - C, C - D and D – A, hence dipoles are formed inside the capacitor due to polarization effect and the charges start accumulating in the free region of the capacitor, as the potential is increased more and more the charges on the electrodes i.e. plate1 and plate2, as they are like charges they start repelling each other hence the effect of susceptance appears. In order to minimize the effect of susceptance a pre designed diodes with required doping levels are introduces as shown in the figure, when there is more potential diodes get forward bias and start to conduct and the other end of the diode is given to the storage channel. Hence the number of charges stored is now increased and the potential between the plates is controlled and ensure the formation of dipole, hence a large storage of the charges is achieved without any damage to the capacitor.

3. Diode design

Assumptions:

- Abrupt pn^+ junction.
- Current is determined by minority carrier diffusion in neutral region by using Shockley equation.
- Length of neutral regions is longer than minority carrier diffusion length.

- Resistance of neutral region in negligible so that the entire forward bias drops across the depletion region.

Calculations: Susceptance is assumed to appear around 40V-60V. Assume 40V as reverse break down voltage.

Current is assume to be I=15mA for V_{be}=0.6V at 300K.

By determining the value of the current (I) and V_{be} area of the diode is calculated and found to be $3.28*10^{-6}m^2$.

The electron drift mobility is at doping concentration is approximately is same as that of the room temperature hence the electron drift mobility = $1350*10^{-4}\,m^2s^{-1}V^{-1}$.

Electron diffusion coefficient = $0.0035*m^2s^{-1}$.

Diffusion length is $3.9*10^{-5}$m.

Area of the diode=$3.28*10^{-6}m^2$.

Hence with the help of above results the doping concentration of the diode is found as follows

P-region= $7.9*10^{15}cm^{-3}$

N-region= >> $7.9*10^{15}cm^{-3}$.

4. Design of Electrode

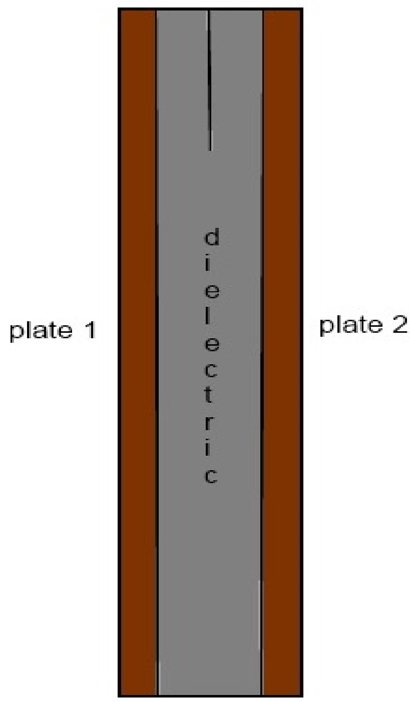
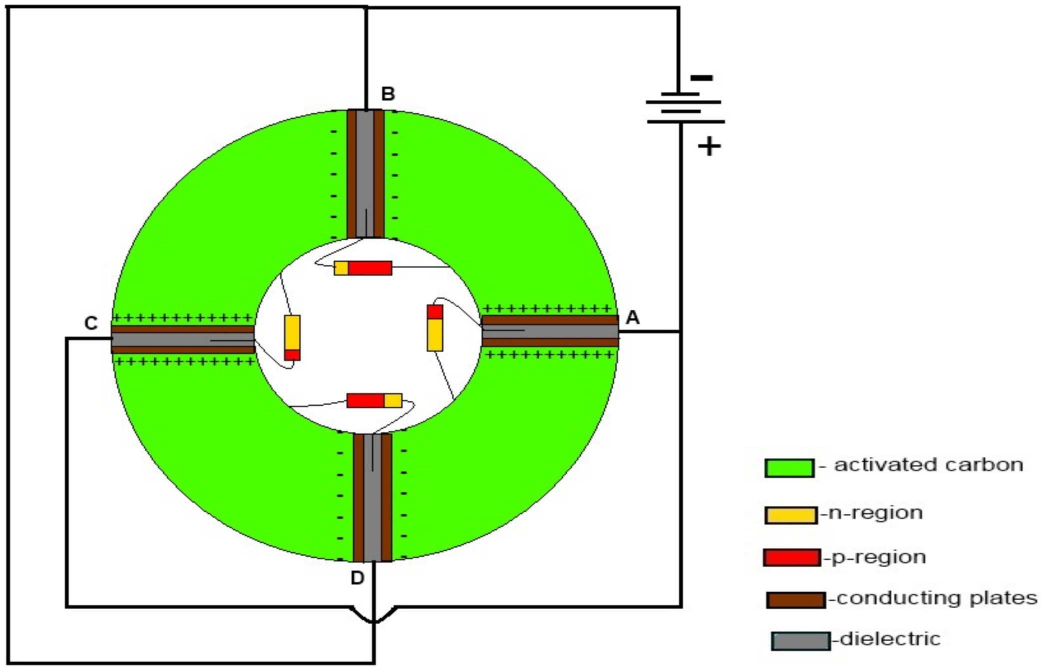


Plate 1 and plate 2 is copper plate
Dielectric is air.

5. Schematic Representation of High Storage Capacitor



6. Results

Considering the conductivity of the activated carbon is

60 s cm^{-1}

Force exerted by charges of B on A:

F_{BA}=3.5985*10^{-4} N

Similarly F_{BA}=F_{BC}=3.5985*10^{-4} N

F_{AD}=F_{DC}=3.5985*10^{-4} N

Potential at all the electrodes are same.

Electric field intensity created inside the Capacitor is 359.85 V/m

Susceptance is found to happen at 50V

Hence total force =2.399*10^{-5} N

Therefore calculating total electric field

Intensity E=23.99*10^{3} V/m

Hence with the above obtained values capacitance of the capacitor is calculated, i.e. C= 1 farad.

7. Analysis

From the obtain results and analyzing the design, it is clearly shown that the capacitor is able to store large amount of charge in it and the time required to charge the capacitor is reduced, which indicates that capacitor gets charged up very fast. Now when the capacitor is discharged it is seen that it discharges slowly, during this process we can observe that the capacitor discharges completely.

8. Application

- It can be used to store large amount of charges for industrial purpose.
- It can be use in mobile application.
- It can be used in batteries.
- It can be use in tracking device which require quite large amount of current to track.

9. Conclusion

In this paper we have designed a capacitor which can hold large amount of charges in a considerably small area with the use of activated carbon as the channel or medium. The phenomenon of storing large amount of charges is achieved the design shows enhancement in terms of charge storage. Future works includes refining the proposed design to ultra high capacitors with reduced size. And to enable its usage in electronic gadgets or equipments so that they can be used for very long duration if there is a crisis of electrical energy.

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