A PROJECT

REPORT ON

"DESIGN AND DEVELOPMENT OF CAPACITORS USING VARIOUS DIELECTRIC MATERIALS"

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF

DIPLOMA IN

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

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GOVERNMENT POLYTECHNIC, NASHIK

(An Academically Autonomous Institute of Govt. Of Maharashtra)

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CERTIFICATE

This is to certify that the project report entitled "DESIGN AND DEVELOPMENT OF CAPACITORS USING VARIOUS DIELECTRIC MATERIALS" was successfully completed by student of sixth semester Diploma in Electronics and Telecommunication Engineering

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In partial fulfilment of the requirements for the award of the Diploma in Electronics and Telecommunication Engineering and submitted to the Department of Electronics and Telecommunication Engineering of GOVERNMENT POLYTECHNIC, NASHIK, work carried out during a period for the academic year 2019-20 as per curriculum.

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ACKNOWLEDGEMENT

The successful completion of this project required a lot of guidance and assistance from many people and I am extremely privileged to have got this all along the completion of my project. I am extremely thankful to my Head of Department, Electronics, **Dr. S. D .Pable** for providing support and encouragement for my project work. I owe my deep gratitude to our project guide, **Mr. Dr. Jayant G. Joshi** who took keen interest in our project work and guided us all along, till the completion of our project work by providing all the necessary information for developing a good system.

I would like to extend our sincere respect to all the teaching and supporting staff in the department for timely support and help in completion of the project.

At last I would like to thank my parents, friends and all those who have helped directly or indirectly towards the completion of my project.

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ABSTRACT

A capacitor is a device that stores electric charge in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. Capacitor means having two metallic plates and a dielectric material in between these two plates. The graphene-based materials are promising for applications in capacitor or capacitor and other energy storage device due to the intriguing properties, i.e., highly tunable Surface area, outstanding electrical conductivity good chemical stability and excellent mechanical behavior. A capacitor works on the principle that the capacitance of a conductor is brought near it. Hence a capacitor has two plates Separated by a distance having equal and opposite changes.

Graphene is a thin layer of pure carbon, lightly packed and bonded together in a hexagonal honeycomb lattice. It is an allotrope of atoms arranged a two-dimensional honeycomb lattice. The graphite allotrope of carbon consists of stacked graphene layers. Each atom in a graphene sheet is connected to its three nearest neighbors, and contributes one electron to a conduction band that extends over the whole sheet.

Polyester capacitors are able to provide a low level of equivalent series resistance. High dV/dt: The construction and dielectric of polyester, PET capacitors means that they are able to be used in applications where sharp, fast rise time spikes are present as they are able to accommodate high dV/dt figures.

While non-polar polymers (PTFE, PP, PE, PS) have symmetrical molecules and are truly covalent. There are no polar dipoles present in them and hence in presence of electric field does not align the dipoles. These polymers have high resistivities and low dielectric constant.

CHAPTER 1

INTRODUCTION

1.1. INTRODUCTION

Basically capacitors are used in almost all electronics devices, right from the home appliances till the major military equipment. It is expected that every component should give accurate measurement and work properly. For this each component in the electronic circuit should be properly fabricated and proper materials should be used for each and every component. Our project was to make capacitors using various dielectric materials especially Graphene. We used three dielectric materials they are Polyester, Polypropylene and Graphene. We concentrated Graphene because its accuracy is greater than other dielectric material. Capacitor is nothing but a passive electronic component with two terminals. And the basic concept of a capacitor is that it has two metal plates (copper, aluminum) and a dielectric material sandwich in between the two metal plates. The graphene is selected as the main dielectric material because it is extremely strong, it is conductive as well as it is flexible.

PHOTOGRAPH NO.1.1.Perfect Partner of Electronics- CAPACITOR

1.2 Objective

To know about the various capacitors and dielectric materials.

To calculate theoretically values of capacitance using various dielectric materials for axial and radial capacitors.

To fabricate different capacitors.

To measure the values of fabricated capacitors.

To analyses theoretically and measured values of capacitors.

1.3 Necessity

Graphene has emerged as one of the most promising nanomaterial's because of its unique combinations of superb properties; it is not only one of the thinnest but also strongest materials; it conducts heat better than all other materials; it is a better conductor of electricity, it is optically transparent.

The polyester is the choice of fiber and fabric for many industries. It can be applied to many useful purposes, they are very important polymers, where they are used in clothing, the food, the packaging, the plastic water bottles, and the carbonated soft drinks bottles. The most important necessity of polyester is that is used in capacitors because it offers high dielectric strength.

Polypropylene (PP) is a thermoplastic "addition polymer" made from the combination of propylene monomers. It is used in a variety of applications to include packaging for consumer products, plastic parts for various industries including the automotive industry, special devices like living hinges, and textiles. As it has low coefficient of friction it is used as a dielectric material in capacitor.

Capacitor is used in almost all electronic devices. A capacitor can store electric energy when it is connected to it charging circuits. And when it is disconnected from its charging circuit, it can dissipate that stored energy, so it can be used as a temporary battery

CHAPTER 2

LITERATURE REVIEW

In October 1745, Ewald Georg von Kleist of Pomerania, Germany, found that charge could be stored by connecting high-voltage electrostatic generator by a wire to a volume of water in hand-held glass. Von Kleist found that touching the wire resulted in a powerful spark, much more painful that the obtained from an electrostatic machine.

Pieter van Musschenbroek invented a similar capacitor which was named the Leyden jar, after the University of Leiden where he worked.

Daniel Galatz was the first to combine several jars in parallel to increase the charge storage capacity

Benjamin Franklin investigated the Leyden jars and come to the conclusion that the charge was stored on the glass, not in water as others had assumed. Ley Dan jars were later made outside by coating the inside and of jars with metal foil, leaving a space at the mouth, to prevent raring between the foils.

Advert from the 28 December 1923 edition of the radio times. For dabbler condensers, for use in wireless receiving sets.

Early capacitors were known as Condensers, a term that is still occasionally used today, particularly in high power application, such as automotive systems. The term was first the wed for this purpose by Alessandro Volta in 1182. The term became deprecated because of the ambiguous meaning of steam condenser with capacitor becoming the recommended with from 1926.

Porcelain was used in the first ceramic capacitors. Mica dielectric capacitors were invented in 190g by William Dubliner. Mica was the most common dielectric for capacitors in the United States.

Charles Pollak the inventor of first electrolytic capacitors. Film capacitors was described in British Patent 587,953 in 1944.

CHAPTER 3

EXPLAIN CAPACITOR AND DIELECTRIC MATERIALS

3.1 Definition Of Capacitor

A capacitor is an indispensable part of electronic equipment and is thus almost invariable used in an electronic circuit. A Capacitor is a passive electronic component with two terminals. It passes alternating current. (Blocks DC current.)It is an electronic component that stores and releases electricity in a circuit. The basic concept of capacitor is that it has a dielectric material sandwich in between two metal plate.
Dielectric Materials can be in any state for i.e. Solid, Liquid and Gaseous state. The various dielectric materials are:

1. Polyester
2. Paper
3. Glass
4. Mineral oil
5. castor oil natural ester
6. Nitrogen
7. Graphene, etc.

3.2 In our project we are using three types of dielectric, they are as follows:

1) Polyester
2) Polypropylene
3) Graphene

1) POLYSTER:-

PHOTOGRAPH NO.3.1. Polyester

Polyester has a high dielectric constant compared to polypropylene, and is one of the most widely used dielectric materials. This high dielectric constant allows construction of capacitors with small physical size.

2) POLYPROPYLENE:-

PHOTOGRAPH NO.3.2.Polyeproperlene

Polypropylene is commonly used in the construction of capacitors for high-frequency AC applications. These properties make polypropylene a dielectric material of choice for a wide range of applications including snubbed circuits, high-frequency AC systems high voltage DC &AC systems, and high current DC applications.

3) GRAPHENE:-

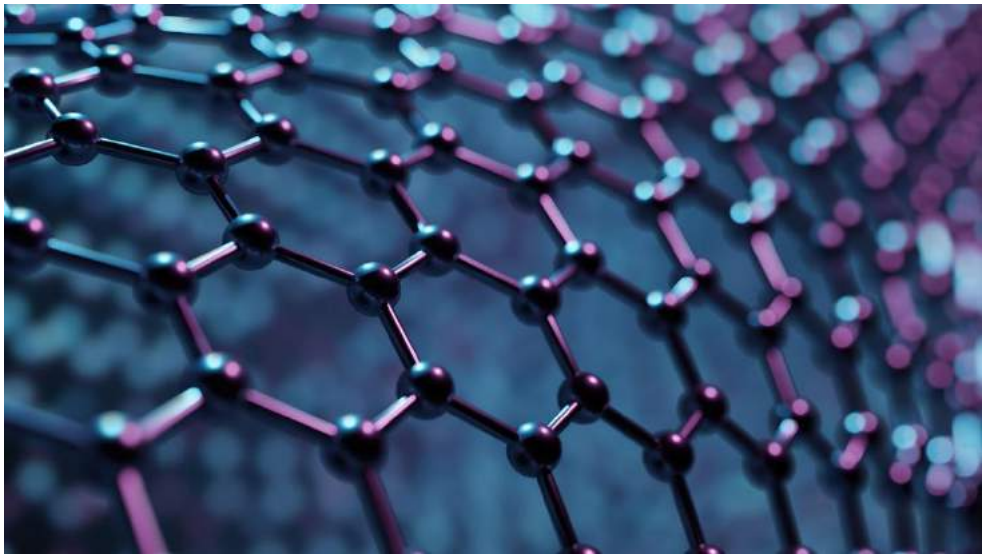
PHOTOGRAPH NO.3.3.Graphene

Graphene is a 2D material with very particular dielectric properties. For different wave ranges and different doping dielectric permittivity (depends on frequency) can be negative or positive with low damp.

CHAPTER 4

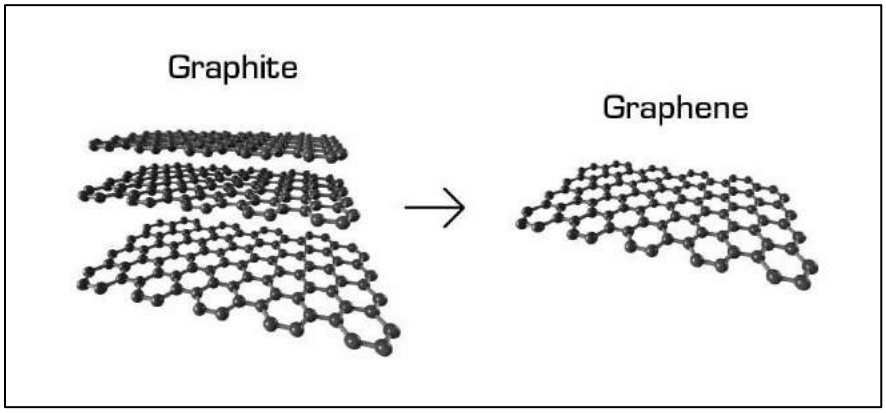
GRAPHENE

Graphene is simply one atomic layer of **Graphite** - A layer of sp2 bonded carbon atoms arranged in a hexagonal or honeycomb lattice. **Graphite** is a commonly found mineral and is composed of many layers of **graphene**. The structural make-up of both **graphene** and **graphite**, and their fabrication methods are slightly different.



PHOTOGRAPH NO.4.1.Developing Sustainable Graphene Technologies

Graphene is made from graphite this involves splitting single layer of graphene from multi-layered graphite. Achieving single layer typically requires multiple exploitation steps, each producing slices with fewer layer, until only one remains. The structural research pulled graphene layer from graphite and transferred them onto this on a silicon wafer in a process called either micromechanical cleavage or the scotch tape technique.



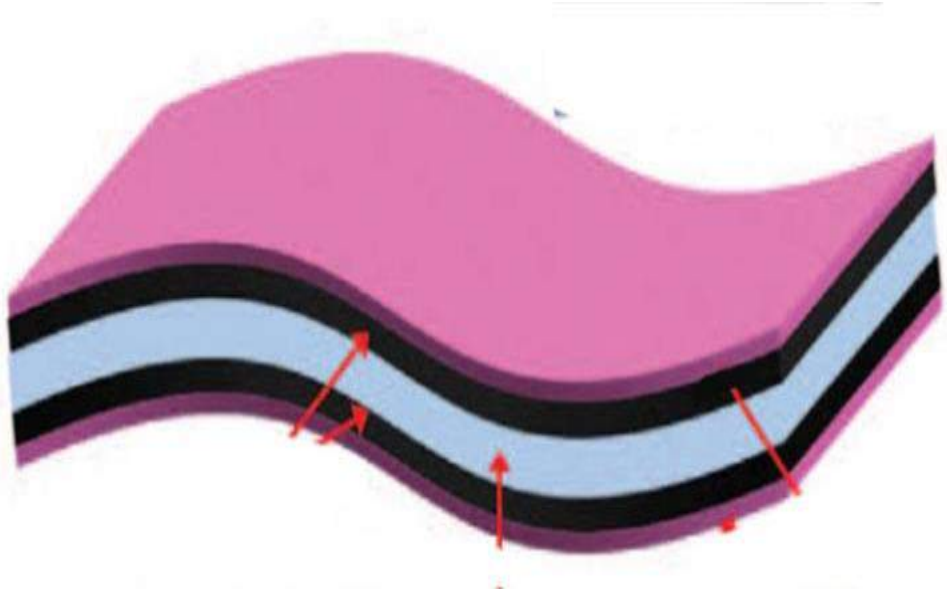
PHOTOGRAPH NO.4.2. Graphite to Graphene

Graphene is an allotrope of carbon consisting of a single layer of atoms arranged in a two dimensional honeyed lattice. The graphite allotrope of carbon consists of stacked -graphene layers. Each atom in a graphene sheet is connected to it's their nearest neighbors, and contributes one electron to a conduction band that extends over the whole sheet.

This conduction bands make graphene a semi metal with unusual electronic properties that are best described by theories for massless relativistic particles. Charge carriers in graphene show linear, rather than quadratic dependence of energy on momentum, and field effect transistors with graphene can be made that show bipolar conduction. Change transport is ballistic over long distance; the material exhibits large quantum oscillations and large and non-linear diamagnetism.

Graphene conducts heat and electricity very efficiently along its plane. The material strongly absorbs light of all visible wavelength, which accounts for the black color of graphite; yet a single graphene shut is nearly transparent because of its extreme thinness. The material is also about 100 times stronger than would be the strongest steel of the same thickness. Scientists have theorized about graphene for decades. It has likely been unknowingly produced in small quantities for centuries, through the use of pencils and other similar applications of graphite. It was originally deserved in electron microscopes in 1962, but only studied.

The material was later rediscovered isolated and characterized in 2004 by Andre Grim and Konstantin Novoselvo at the University of Manchester who were awarded the Nobel Prize in Physics in 2010 for their research on their Material. High-quality graphene proved to be surprisingly easy to isolate. The IUPAC (International Union for Pure and applied Chemistry.) recommends use of the name "graphite" for the three-dimensional material, and "graphite "only when the reaction, structural relations or other properties of individual layers are discussed. A narrow definition, of isolated or free-standing of graphene" requires that the layer be sufficiently isolated from its environment but would include layers suspended or transferred to Silicon dioxide or silicon carbide. As we are using the graphene is used with capacitor so the surface is one of the limitations of capacitance and higher surface area means a better electrostatic charge storage. A graphene capacitor is said to store almost as much energy as a lithium-ion battery, charge and discharge in seconds and maintain all these over tens of thousands of charging cycles.



PHOTOGRAPH NO.4.3. Graphene

Graphene possess other amazing characteristics that are like it has electron mobility, faster than silicon, it conducts heat better than diamond, its electric conductivity is better than copper, it absorbs only 2.3% of reflecting light, it is impervious so that even the smallest atom (helium) can't pass through a defect-free monolayer graphene sheet. Graphene has emerged as one of the most promising nanomaterial's because of its unique combinations of superb properties: it is not only one of the thinnest but also strongest materials; it is a greater conductor of electricity, it is optically transparent. The term "graphene" was first used in 1987 to describe single sheet of graphite and it was also used in early description of carbon nanotubes. In the early 1970s chemist figured out how to deposit carbon in graphene monolayers onto other materials. Perfectly stacked and aligned graphene sheets have a density close to that of crystalline graphite $2.267 g/cm^3$. The main problem is that, when you exfoliate graphene mechanically through force or by taking a chemical-based approach, you can introduce defects into the structure of the material, says Koziol". With the CVD technique, harmful acids might be used to dissolve the substrate and separate it from the grapheme

CHAPTER 5

FABRICATION AND IMPLEMENTATION

(FABRICATION PROCESS OF POLYPROPERLENE)

As to make capacitors we needed to first calculate the values of the capacitors that we were going to fabricate so for the theoretical we used the formula $C = \varepsilon_0 \varepsilon r A/d$.

After working theoretical we started to fabricate the material as we know that capacitor is nothing but t it has a dielectric material sandwich in between two metal plate (copper, aluminum). First we started with the fabrication of polypropylene.

1) First we had cut the polypropylene in a proper measurement, than we took the measurement and cut the metal plate it was of copper (self-adhesive).

PHOTOGRAPH NO.5.1.Cutted Copper Tape and Polypropylene

2) After cutting polypropylene (as dielectric material) and copper foil (as metal plate) the polypropylene was pasted between the two metal plates.

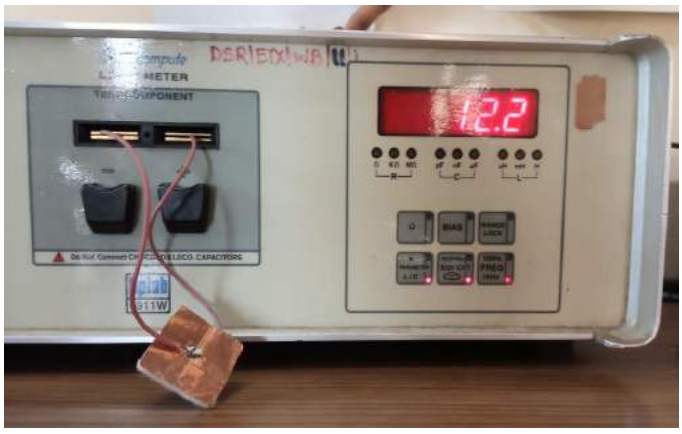
PHOTOGRAPH NO.5.2 Polypropylene Was Pasted Between the Two Metal Plates

3) After that we had soldered two terminals in two different ways they were axial and radial.

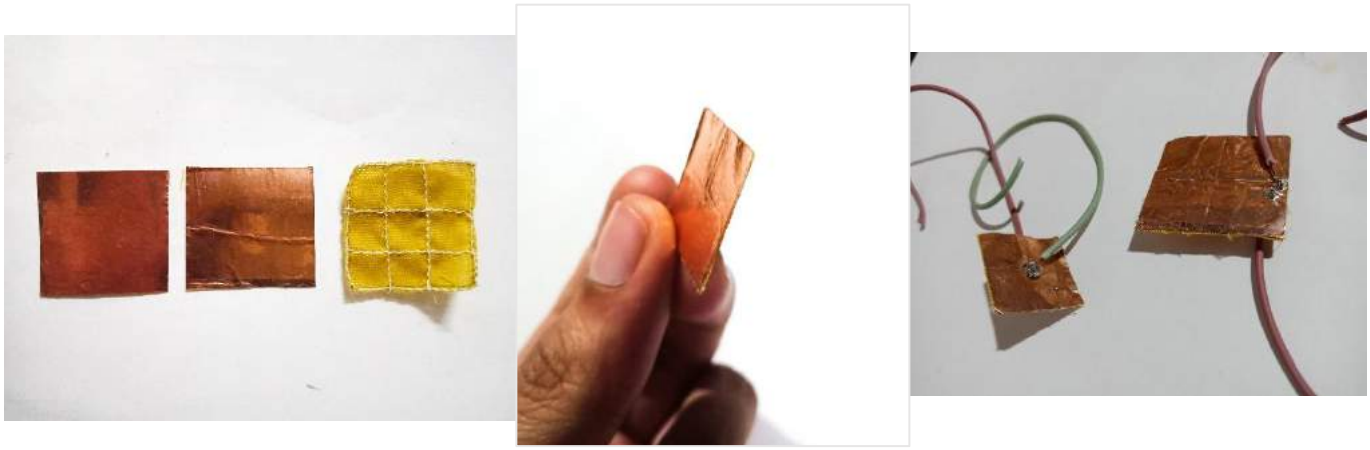
PHOTOGRAPH NO.5.3.Material for Soldering

PHOTOGRAPH NO.5.4.Axial and Radial Capacitor

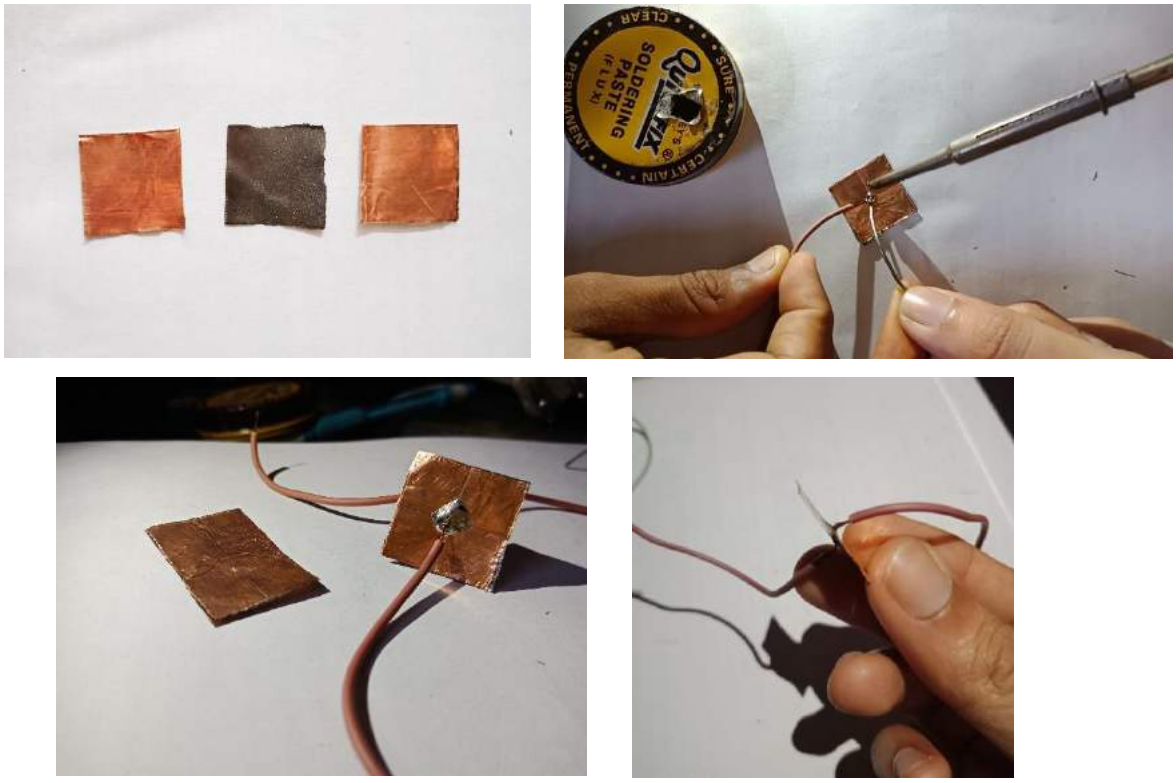
4) After fabricating the capacitors we measured the values to compare with our theoretical values on the LCR meter. This procedure of fabrication was same for other two dielectric materials also. These capacitors are completely designed, developed, fabricated and tested within the four walls of the department. A due care has been taken during fabrication and testing procedure. This is how we fabricate over various capacitors.



PHOTOGRAPH NO.5.5.Measurement of Capacitor on LCR Meter



PHOTOGRAPH NO.5.6.Fabrication Process of Polyester



PHOTOGRAPH NO.5.7.Fabrication Process of Graphene

CHAPTER 6
MEASURED RESULTS

We measured the Practical values to compare with our theoretical values on the LCR meter.

1) Polyester

AREA	THEROTICAL VALUE	PRACTICAL VALUE
2cm*2cm	25.9 pF	28.7pF
3cm*3cm	58.2pF	37.9pF

2) Polypropylene

AREA	THEROTICAL VALUE	PRACTICAL VALUE
2cm*2cm	4.1pF	2.0pF
2cm*3cm	6.1pF	5.5pF
3cm*3cm	9.2pF	7.0pF

3) Graphene

AREA	THEROTICAL VALUE	PRACTICAL VALUE
2cm*2cm		
2cm*3cm		

CHAPTER 7
ADVANTAGES, DISADVANTAGES AND APPLICATIONS

A] POLYESTER

1. ADVANTAGES:-
   - Low moisture absorption.
   - Operating temperature up to 125°C
   - Offers high dielectric strength
   - They are acceptable for DC use up to 6okV

2. DISADVANTAGES:-

   They cannot provide a high level of tolerance & and accuracy. They are not used for high frequency or high current applications.

3. APPLICATIONS
   - Circuits where the capacitor needs to handle high peak current levels.
   - Filtering, where high tolerance levels are not required.
   - General coupling and decoupling applications and DC blocking.

B] POLYPROPYLENE

1. ADVANTAGES:-
   - It is a relatively inexpensive material.
   - It possesses high flexural strength because of its semi-crystalline nature.
   - It has a low coefficient of friction
   - It is very resistant to moisture.
   - It has good chemical resistance over a wide range of bases and acids.

2. DISADVANTAGE:-
    - It has a high thermal expansion coefficient which limits its high temperature applications.
    - It is susceptible to UV degradation
    - It has poor resistance to chlorinated solvents and aromatics.
    - It is known to be difficult to paint as it has poor bonding properties.
    - It has a high flammability.

3. APPLICATIONS:-

    PP film capacitors are used for high-frequency high-power applications such as induction heating, for pulsed power energy discharge applications, and as AC capacitors for electrical distribution. The AC voltage ratings of these capacitors can range up to 400 kV.

C] GRAPHENE

1. ADVANTAGES:-
    - High heat conductivity, greater than copper and silver.
    - No heat loss or it gives 100% output.
    - It is transparent and lighter material.
    - Stronger than diamond and steel
    - Can make very light weight parts for auto bodies.
    - Used to make batteries that recharge faster as compared to lithium - ion battery.

2. DISADVANTAGES:-
    - Being a great conductor of electricity, although it doesn’t have a band gap (can't be switched off). Scientists are working on rectifying this.
    - The main disadvantages of graphene as a catalyst is its susceptibility to oxidative environments.
    - Research has proven that graphene exhibits some toxic qualities.

- Scientists discovered that graphene features jagged edges that can easily pierce cell membranes, allowing it to enter into the cell and disrupt normal functions.

3. APPLICATIONS:-
    - Sensors
    - Automobile components
    - Conductive links
    - Biomedicine
    - Solar cells
    - Membranes

CHAPTER 8
ACHIEVEMENTS

Under the guidance of Dr. Jayant G. Joshi we had appeared for the 5th National Level IEEE Project Competition-2021 on 26th off June that was Saturday, we had presented the presentation on our project topic i.e., Design and development of Capacitors using various dielectric materials. And we had received the participation certificates.

PHOTOGRAPH NO.8. Certificates of Group Members

CHAPTER 9

CONCLUSION

This project help us to know the detailed information about various dielectric materials especially about Graphene and its capacitors. As we know that capacitor is a passive electronic component that stores electric energy so in this project the main importance was given to the dielectric material that is graphene because of its extra ordinary advantages and applications. By using this dielectric material we got better accuracy than other two dielectric materials. Polyester also has very better advantages as dielectric material like it has low absorption etc. Theoretical and experimental results are in agreement hence, suitable to fabricate the circuit need based capacitors.

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