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Study of Methods used in Capacitor Manufacturing Process

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Abstract--A capacitor is a passive two terminal electrical component used to store the energy electrostatically in an electric field. A ceramic capacitor is a fixed value capacitor where the ceramic material that act as the dielectric. Manufacturing process of ceramic capacitor, principal ingredient of the ceramic capacitor is ceramic powder, where ceramic material acts as a dielectric. Due to their unique material properties, technical ceramics are considered to be one of the most efficient materials of our time. The different materials used for ceramic capacitors, paraelectric or ferroelectric ceramic capacitors, influences the electrical characteristics of the capacitors. Using mixtures of paraelectric substance based on titanium dioxide results in very stable and linear behavior of the capacitance value within a specified temperature range and low losses at high frequencies. But these mixtures have a relatively low permittivity so that the capacitance values of these capacitors are relatively small. It is constructed of two or more alternating layers of ceramic and metal layer acting as the electrodes. The composition of the ceramic material defines the electrical behavior and therefore applications.

Keywords **– capacitor, Manufacturing process, ceramic powder or material, ceramic capacitor**

I. INTRODUCTION

A Capacitor is a two terminal, electrical component. Along with resistor and inductors, they are one of the most fundamental passive components we use. You would have to look very hard to find a circuit which didn't have a capacitor in it. What makes capacitors special is their ability to store energy; they're like a fully charged electric battery. *Caps*, as we usually refer to them, have all sorts of critical applications in circuits. A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. Its function is to store the electrical energy and give this energy again to the circuit when necessary. In other words, it charges and discharges the electric charge stored in capacitor. The capacitor is made up of two close conductors (usually plates) that are separated by a dielectric material. The plates accumulate electric charge when connected to power source. One plate accumulates positive charge and the other plate accumulates negative charge.

A. How a capacitor is made

The schematic symbol for a capacitor actually closely resembles how it's made. A capacitor is created out of two metal plates and an insulating material called a dielectric. The metal plates are placed very close to each other, in parallel, but the dielectric sits between them to make sure they don't touch.

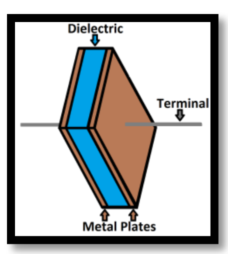

Fig. 1 Standard capacitor sandwich- two metal plates separated by an insulating dielectric

The dielectric can be made out of all sorts of insulating materials: paper, glass, rubber, ceramic, plastic, or may be anything that will obstruct the flow of current. The plates are made of a conductive material: tantalum, aluminium, silver, or other metals. They are connected to a terminal wire, which is eventually connects to the rest of the circuit. The capacitance of a capacitor and how many farads it has is depends on how it is constructed. More capacitance requires a large capacitor; Plates with more overlapping surface area provide more capacitance, while more distance between the plates means less capacitance. The material of the dielectric even has an effect on how many farads a capacitor has.

B. Ceramic Capacitor

The most commonly used and produced capacitor out there is the ceramic capacitor. The name comes from the material from which their dielectric is made. Ceramic capacitors are usually physical wise and capacitance-wise small. It is hard to find a ceramic capacitor much larger than 10 microfarad (µF). A surface-mount ceramic cap is commonly found in a tiny 0402 (0.4mm x 0.2mm), 0603 (0.6mm x 0.3mm) or 0805 package. Through-hole ceramic caps usually look like small (commonly yellow or red) bulbs, with two sticking out terminals. Compared to the equally popular electrolytic caps, ceramics are a more near-ideal capacitor (much lower ESR and leakage currents), but their small capacitance can be limiting. They are usually the least expensive option too. Ceramic capacitors have a high dielectric constant (High-K) and are available so that relatively maximum capacitance can be obtained in a small physical size.

A ceramic capacitor is a fixed value capacitor where the ceramic material acts as dielectric. Ceramic capacitors can also be used as a general purpose capacitor, because of their non-polarity and are available in a large variety of capacitances, voltage ratings, and sizes. Ceramic disc capacitors are used across brush DC motors to minimize RF noise. Compared to the equally popular electrolytic caps, ceramics are a more near-ideal capacitor (much lower ESR and leakage currents), but their small capacitance can be limiting. They are usually the least expensive option too. These caps are well-suited for high-frequency coupling and decoupling applications.

II. INDUSTRIAL MANUFACTURING PROCESS OF CERAMIC CAPACITOR

In the relatively few years since man first made a sandwich of electrodes and dielectric material, the capacitor industry has grown into a billion dollars worldwide industry and has divided into major product groups for specialist applications. All capacitors are formed with the same basic structure but uses different material or components. The multi – layer ceramic capacitor manufacturing process begins by producing ceramic sheet that is used as the dielectric material in the ceramic capacitor ceramic powders are mixed with dispersing agents to make slurry. The slurry is then milled to string process specifications, the slips is filtered then precisely coated on to carrier film then dried and labelled with a manufacturing lot number to ensure traceability and sent to the screen printing process, the electrode printing process provides the internal electrodes of a multi – layer ceramic capacitor this operation is performed in a class 10,000 clean room environment the electrode ink is used to produce the electrode pattern.

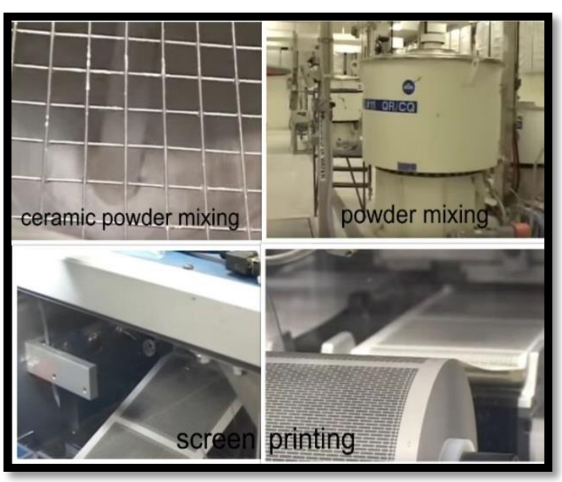

Fig. 2 Methods of Mixing

A bar – coded run sheet is issued to the production floor to ensure that proper material is received, then the internal electrodes are screen- printed on to the ceramic tape, the precisely patterned screen is used on the roll screen printer to print the electrodes on to the ceramic tape, the roll screen printer re-reels the blank ceramic tape prints the electrodes pattern and dries it then re-reels the printed sheet the printed ceramic tape is then stacked in an alternating manner to produce the multi – layer structure.

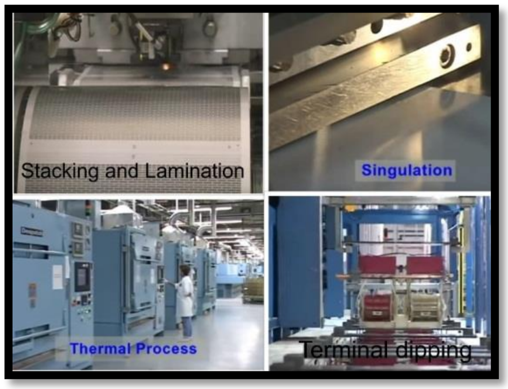

Fig. 3 Methods of Mixing

The chip build up operation is also performed in a clean room environment, reels of blank ceramic tape our first laminated together to provide the bottom cover layer printed tape layer are precisely stacked and laminated to create the active portion of the multi- layer structure then more blank tape layers are added to produce the top cover layer each electrode layer is aligned using an exclusive computer – controlled vision alignment system and each pad contains thousands of individual chips, the batch tickets remains with the batch throughout the process and is tracked using chem it's exclusive manufacturing execution system, the pad cutter cuts the multi – layer pad into thousands individual green ceramic chip capacitors the separated green ceramic capacitor chips are sent through a baked out process to remove organic materials introduces in earlier process steps green ceramic chips are loaded onto centres which are then loaded into a backed out the chips are baked out with a precisely controlled time and temperature profile after baked out the chips are fired in either a batch kiln or a pusher kiln(heating chamber) previously loaded centres are removed from the baked out carts and loaded into the firing kilns during firing densification of the chips occurs the volume of each chips is reduced approximately 50% and the fired chips is now strong and dense, corner rounding process smooths the chips surface and rounds off sharp corners to reduce the possibility of chipping or breaking the corners of the chips. chips are loaded into a bowl with a mixture of water alumina powder and media chips are unloaded from the bowls rinsed and dry the chips are then separated from the media, the external electrode or termination is now applied to allow electrical connection of the device to the circuit corner rounded chips are loaded into carrier plated precisely aligned pins are used to push one end of each chip in the carrier plate out an exact amount to expose it for dipping process the exposed ends are dipped into precisely metered paste with a computer-controlled terminator. The chips and termination plate are then dried in a computer – controlled drying oven then the other end of chip is then exposed dipped and dried, the chips are then removed from the carrier plated load it into mesh firing baskets and fired in a multi zone built furnace, copper termination is used for base metal electrode product and inspired in a controlled nitrogen atmosphere the terminated chips are then electroplated with a nickel barrier layer followed by an electroplating ten layer. Chips are plated using either an automatic barrel plating process or rotary flow through platter the automatic barrel plating line is a continuous operation which is computer – controlled and capable of processing a variety of chip sizes simultaneously, chips are loaded into plating barrels with conductive media and plated in the order line after plating the chips and media are removed dried and separated,[9], for a technical survey of the manufacturing process of capacitors)

Fig:-4 Optical Inspection

Each batch is tested for solder ability to ensure quality the chips are then 100% tested using state of the art computer controlled sorting equipment.

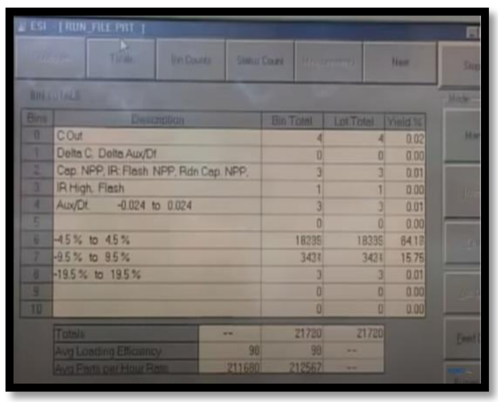

Fig:-5 Testing Average Efficiency of Capacitor

Each chip is tested to ensure that capacitance dissipation factor insulation resistance and dielectric with standing voltage are within stringent specifications any chip not meeting these limits is removed from the batch, the capacitors are now ready for packaging during the packaging process an additional capacitance (fig.6) and dissipation factor test is performed to further

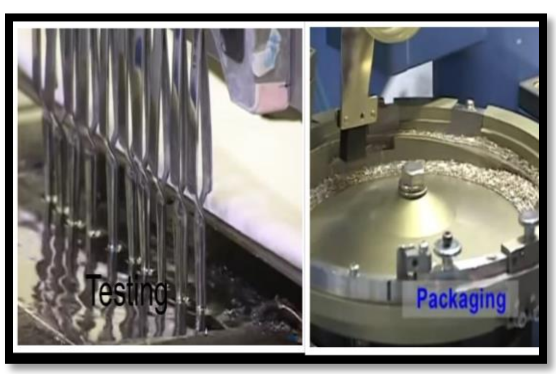

Fig:-6 Methods of Packaging & Testing

Ensure quality as well error – free packing. The packaged product is then sent to our state of the art distribution centre for shipment to customers around the globe.

III. APPLICATIONS OF CAPACITOR

The devices which store electrical charge are known as Capacitors. Energy storage is the most common use for capacitors. Power conditioning, signal coupling or decoupling, electronic noise filtering, and remote sensing are the additional uses of capacitor. Due to its varied applications, capacitors are used in a wide range of industries and have become a necessary or essential item of everyday life. Capacitors have many uses in electronics and electrical systems.

A. Capacitors for energy storage

Capacitors are used to store electrical energy, Individual capacitors generally do not hold a great deal of energy, providing only enough power for electronic devices to use during temporary power outages or when they need additional power.

B. Capacitors for Power conditioning

One important application of capacitors is the conditioning of power supplies. Capacitors allow AC signals to pass but block DC signals when they are charged. They can effectively split these two signal types, cleaning the supply of power.

C. Capacitors as Sensors

Capacitors are used as sensors to measure a variety of things, including air humidity, fuel levels and mechanical strain. The capacitance of a device is dependent on its structure. Changes in the structure can be measured as a loss or gain of capacitance.

D. Capacitors for Signal Processing

Capacitors have found increasingly advanced applications in information technology. Dynamic Random Access Memory (DRAM) devices use capacitors to represent binary information as bits. The device reads one value when the capacitor is charged and another when discharged. For example: Most probably if you are using a smartphone, the touchscreen is capacitive, means it uses several capacitors which you actuate with fingers. In many modern capacitive touchscreens, the position of a touch is detected using an array of capacitors. All memory systems, including these phones and all computers use capacitors for binary memory systems. All fans, water pumps, fluorescent lights use capacitors. You use radio and TV, which use then in large numbers. Selection of stations / channels on these TV/ radios (tuning) is based on capacitors.

IV. CONCLUSION

Capacitors are the important electrical components used in electronic circuits. World capacitor industry and its development trends, manufacturing and development philosophies have been discussed and the areas of polarisation with in the industry highlighted. With these changes it is expected that the industry will continue to experience healthy growth for the foreseeable or predicted future.

V. FUTURE SCOPE

As with all industrial processes, the capacitor industry is shaped and directed by the pressures placed upon it by its customers.

i. Using next level of capacitors, it will be possible to invent paper – thin electronic devices

ii. Charing a devices will be completed in a few seconds.
iii. Energy can be stored for a long period of time

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