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Investigation of modern ceramics in bioelectrical engineering with proper thermal and mechanical properties

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Abstract

Today, electronic ceramics make up the largest share of advanced markets. Ceramics are chemically neutral and resistant to high temperatures, so they provide a good environment for circuits. Most ceramics have electronic mobility. Ceramic engineering is one of the attractive trends in the field of materials science and engineering. In ceramic engineering, parts are made of inorganic and non-metallic materials. Like other trends in materials engineering, ceramic engineering is based on the study of the structure, chemical composition and properties of ceramic materials from the atomic dimension of the material to its bulk structure. Ceramic materials have different crystalline, semi-crystalline and amorphous structures. In other classifications, ceramics are divided into two categories such as traditional and advanced ceramics. Therefore, in this we evaluate the mechanical properties and application of the modern ceramics. Nowadays, the study of engineered and advanced ceramics is very widespread. Advanced ceramics are a group of ceramics that have components, complex manufacturing technology and more sensitive applications, and different categories are considered for them in which are in the form of engineering ceramics, glass ceramics, electro ceramics and bioceramics.

Keywords: Ceramic engineering, Electrical component, Electro ceramics, Mechanical performance

1- Introduction

All artifacts made from non-metallic minerals are called ceramic. Ceramic products are very diverse and have different applications. Types of ceramics include sanitary ceramics, electrical ceramics, construction ceramics, glass, porcelain, abrasives, glazes, refractories, monocrystals and advanced ceramics [1-2]. Ceramics are also classified according to their body type, which may be dense or porous. The most important raw materials for ceramics are clay, diopside, hydroxyapatite and silica. Special ceramics, such as electrical ceramics, use talc, sodium, titanium, and metallic elements [3-6].

The most important raw materials for ceramics are clay, alkane feldspar and silica. Special ceramics, such as electrical ceramics, sodium, titanium, and metallic elements. Traditional ceramics were considered for their thermal and mechanical properties, but gradually the electrical, optical and magnetic properties of ceramics were considered in many industries such as telecommunications, energy conversion and storage and electronics, leading to the development of electro ceramics as shown in Fig. 1. In the first application of ceramics in the electrical industry, the advantage of their stability in bad weather conditions or their high electrical resistance, which is a characteristic of most silicate materials, was used. The methods that have been developed in traditional pottery for thousands of years have been modified to produce the body of electrical insulation. These insulators are required for the transmission and separation of electrical conductors in applications ranging from power lines to the strength of winding cores and electrical heating elements [5-8].

Although ceramics were obviously characteristic of electrical applications, chemical stability, and electrical resistance in the first half of the twentieth century, it was clear that their range of properties was very wide [9-14]. For example, the mineral magnetite nanoparticles (MNPs), which early sailors called iron ore, was found to have good electrical conductivity properties in addition to their magnetic properties. This property, along with chemical neutralization, made it usable as an anode in the extraction of halogens from mineral nitrates [15-32].

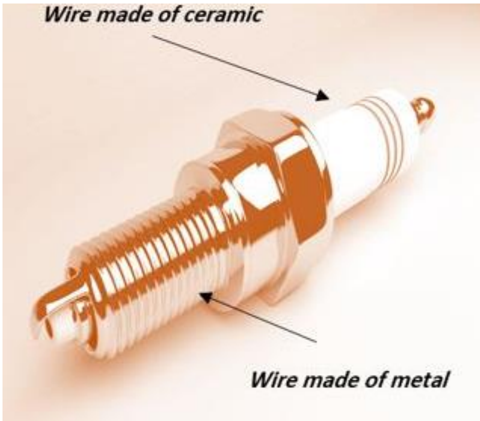

Fig. 1 Modern ceramics used in car candles

Fig. 2 Use of modern ceramics in lamp [4-7]

Zirconia, along with small amounts of lanthanide oxide (rare earths that can reach high temperatures by passing currents and not being filamentous), is an effective source of white light [33-38]. Conduct electricity well, which is why in the last two decades these materials have been considered because of their crucial role in fuel cell technology, batteries and sensors as shown in Figs. 2 and 3.

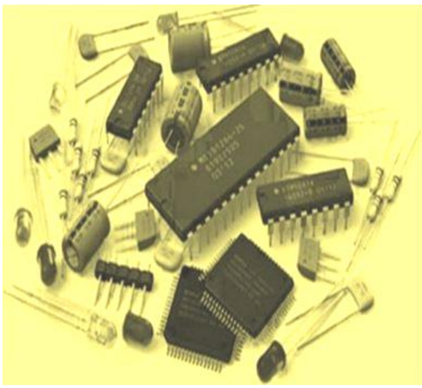

Fig. 3 Usage of modern ceramics in electronic elements

The electrical resistance of silicon carbide-based ceramics and, more recently, zinc oxide can be sensitized to the applied field. This expands the components that absorb unstable oscillations from the power lines and prevent sparks between the relay connections. The nonlinear behavior of these resistors is now attributed to the presence of potential barriers between crystals in ceramics. Ceramics used as dielectrics for capacitors have the disadvantage that they cannot be easily made into thin sheets, or the sheets made of them are very fragile. In the late 1940s, this situation changed with the advent of barium titanium-based high-pass dielectrics (εr≈1000-2000), so that for a wide range of applications, small sheets or tubes with a thickness of 0.2 to 1 mm, they provided a useful combination of size and electrical capacity [30-34]. The development of transistors and integrated circuits has increased the need for higher electrical capacities and smaller sizes created by integrated multilayer structures. In these cases, thin polymer layers containing ceramic powders are made. Patterns of metal ink are inserted as electrodes, and various layers are stacked and pressed together to form pieces that are perfectly glued together. After burning and leaving the organic matter and sinter, strong multilayer parts with dielectrics less than 5 microns thick are obtained [15-21]. These components perform bypass, coupling, and decoupling of semiconductor integrated circuits in thick-layer semiconductor circuits. This single-layer multilayer structure can be used to make any ceramic dielectric. Efforts are underway to develop multilayer structures that have a variety of applications. In particular, low temperature co-fired ceramic technology is widely used for electronic packaging, especially for large computers and communication systems [22-29].


Fig. 4 Schematic of lamps made in which modern ceramics are used [9-10]

The advent of ferromagntic, ferroelectric and conductive ceramics has required the manufacture of compounds often free of natural plasticizers such as clays and magnetite nanoparticles as Fig. 4. These compounds require organic plasticizers to allow them to be formed before sintering. Unlike silicate porcelains, compaction does not depend on the presence of a large amount of melting phases, but on a small amount of liquid phase to improve the sinter in the presence of the liquid phase or the solid-state penetration sinter or a combination of these mechanisms [34-42]. The crystal size and the very small amounts of secondary phases present at the grain boundaries may have a large effect on the properties. Therefore, precise control of raw materials and preparation conditions is essential. This has led to important research into the development of so-called more chemical methods for making primary powders. Ceramics are made up of crystals that may differ in structure, perfection, composition, and size, shape, and internal stresses [37-39]. In addition, commonalities between crystals are areas where changes in lattice directions occur, often accompanied by changes in composition and related electrical effects. As a result, it is very difficult, if not impossible, to justify the behavior of ceramics accurately. The study of the properties of important electro ceramic single crystals has led to an understanding of the behavior of ceramics. However, the growth of monocrystals is usually a difficult and lengthy task, and at the same time, the complexity of ceramic microstructures makes it uncertain to predict their properties from similar monocrystals. Thus, empirical observations have often led to the construction of new ceramic instruments, often before there was a partial understanding of the basic physical mechanisms.

3- The role of materials in ceramics

Zirconium: Increases mechanical strength and increases coefficient of thermal expansion. This type of advanced ceramics in cutting tools, cutting discs, hot press and bearing cover are used. Carbides: Used for high hardness. The resulting ceramics are used in abrasives, drilling rigs, coatings for nuclear power plants, gas turbine components and polishing of hard metals

Nitrides: These materials are hard, brittle and have excellent electrical insulation even at high temperatures. This type of ceramic is used in jet exhaust, metal smelting plants and aircraft radar antenna coating. Boron: This material has very good performance at high temperatures

Aluminum: This material increases the electrical resistance, constant volume and dimensions at very high temperatures, reduces the thermal conductivity with increasing temperature, high hardness and high compressive strength. This type of ceramics is used in cutting tools, parts of textile machines and metal smelting plants.

4- Ferrites (magnetic ceramics)

They are used for a variety of applications, including hard (permanent) magnets in high-reliability speakers and small electric motors, magnetic field detectors, audio and video tapes, computer disks, generators and video recorders. Examples of hard magnetic materials are magnetic plumbites such as $BaFe_{12}O$ and $PbFe_{12}O_{10}$. Soft magnets in telecommunication equipment (TV, radio, single-circuit telephones, filters for telecommunications, submarines), high-frequency welding, low-power transformers, recording heads and magnetic recording agents. Commonly used soft magnets include Mn-Z or ($MnZnO_4$) and Ni-Zn or ($NiZn_2O_4$) spinel ferrites.

When the twentieth century began, ordinary people could hardly understand how cars and airplanes worked. The use of atomic energy was only theoretical, and perhaps even now it is very difficult for some at the beginning of the 21st century to believe that humans would build microscopic robots and have a microscopic assembly line. The production of such extraordinary products is the result of a piece of human knowledge called nanotechnology. The discussion of nanotechnology is one of the most common topics in the scientific community and countries that cannot get a good position in this technology. On the other hand, nanotechnology, due to improving the quality of tools, lower consumption of raw materials, less energy consumption, reducing waste production and increasing production speed in developed countries is the most important method of production and manufacturing of these tools. Also, with the help of this technology, effective steps have been taken to reduce the environmental pollution caused by fossil fuels. Therefore, the most important applications of nanotechnology in the construction and production of new energy converters (such as solar cells and fuel cells), reducing environmental pollutants in gas-fired power plants (using combustion catalysts) and increasing the efficiency of these power plants (using nanocoating's).

5- Advances in Nanotechnology (Metallurgy)

Materials technology is a fundamental technology in the field of information technology, environmental protection, consumption optimization and energy production. On the other hand, nanotechnology has a high ability to modify the properties of materials used and invent new applications for materials by controlling their microstructure in very small dimensions, and therefore its emergence can be considered a great revolution at the beginning of the first century.

6-Advances in manufacturing and production

In the field of manufacturing and production, today the most important work done in the field of production of nanoparticles and nanopowder. Nanopowder are materials that are used in a special type of production called "bottom-up production" due to their unique properties. In low-rise production, instead of making the desired material by turning the bulk material, they make it from the particles and molecules that make it up. This method is very different from conventional method (top-down production) because in normal production, a large amount of waste from the lathe is discarded, but in bottom-up production, in addition to not having such a problem, the strength of the production material due to Reduction of microstructural defects.

7-Advances in improving the properties of materials with nano structure

Researchers and scientists in materials science and physics believe that many of the physical properties of materials are closely related to the microstructure of matter (atomic arrangement, chemical composition, and homogeneity of solid crystalline arrangement in one, two, or three dimensions). Obviously, by accepting such a principle, we can expect the physical properties of a solid to change due to a change in one of the above parameters. In relation to nanomaterials, several reports have been presented about the changes in properties due to these developments, which due to their very interesting applications, many efforts are being made to understand the emerging phenomena created. Changes in the atomic structure of materials play a decisive role in controlling the properties of nanostructured materials.

Fig. 5 Electronic components with different dimensions used in the electrical and electronics industry

8-Advanced ceramics

Due to strong ionic or covalent bonding and high shear strength, ceramic materials have low ductility and high compressive strength. Theoretically, ceramics can also have high tensile strength. However, due to the high melting temperature and lack of ductility, most ceramics are processed in the solid state, and the products are made of powdered materials. After several stages of compaction, the cavities remain between the powder particles and some of these cavities remain stable during the sintering process. Particle surfaces may become contaminated and then become part of the internal structure of the final product. As a result, full theoretical density is very difficult to achieve, and small cracks, pores, and impurity components tend to be an integral part of most ceramic materials. These act as concentrators of mechanical stresses. By applying forces, the effect of these defects cannot be reduced by moving the dough, and the result is generally brittle failure. Using the principles of fracture mechanics, we find that ceramics are also sensitive to very small defects. Advanced ceramics (also called construction ceramics or engineering ceramics) is an emerging technology that has a wide range of current and potential applications. Current base materials include: silicon nitride, silicon carbide, semi-stable zirconia, hardened conversion zirconia, alumina, sialon, boron carbide, boron nitride, titanium diboride, and ceramic composites (such as glass, ceramic, or ceramic fibers). Alumina ceramics (or aluminum oxide) are the most common ceramics in industrial applications. They are relatively inexpensive and have high wear resistance, low density and high electrical resistance. Alumina is under strong compressive loads and retains its useful properties even at 1900°C, but with limited toughness, low tensile strength and sensitivity to heat shock and attack by highly corrosive environments is limited. Due to its high melting temperature, it is generally processed as a powder.

Fig. 6 Ceramic used in dental materials application

Alumina can be bonded to other ceramics or metals by metallization or by hard soldering.

9-Application of nanotechnology in coating hot parts of gas turbines

Ground gas turbine components are made of expensive alloys with relatively high creep durability. The cost of raw materials on the one hand and the complexity of production methods, machining and quality control on the other hand has caused such parts to have high-cost prices. In the last three decades, many efforts have been made to increase the strength of these alloys, thus increasing the strength and resistance to oxidation and corrosion, and the possibility of raising the temperature to increase the efficiency of the turbine, and also to use more impure and cheaper fuels for combustion. Increasing the corrosion resistance of the alloy is achieved by improving the chemical composition, modifying the microstructure, controlling the working temperature and reducing the corrosive factors in the working environment.

Adding a number of elements such as chromium and aluminum also increases corrosion and oxidation resistance. But the addition of these elements greatly reduces the other properties of the alloy, such as strength and impact resistance. On the other hand, reducing the operating temperature of turbines will reduce efficiency and will not be cost-effective.

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