**1.1 INTRODUCTION:**

The word ceramic is derived from the greek term *keramos*, which means “potter’s clay” and *keramikos* means “clay products”. The most important types of ceramics were the traditional clays, made into pottery, bricks, tiles etc. Ceramic artefacts play an important role in historical understanding of the technology and culture of the people who lived many years ago. A ceramic material is an inorganic, non-metallic material and is often crystalline. Traditional ceramics are basically clays.

*Ceramics* are usually associated with “mixed” bonding—a combination of covalent, ionic, and sometimes metallic. They consist of arrays of interconnected atoms; there are no discrete molecules. This characteristic distinguishes ceramics from molecular solids such as iodine crystals (composed of discrete I2 molecules) and paraffin wax (composed of long-chain alkane molecules). It also excludes ice, which is composed of discrete H2O molecules and often behaves just like many ceramics. The majority of ceramics are compounds of metals or metalloids and nonmetals. Most they are oxides, nitrides, and carbides. However, we also classify diamond and graphite as ceramics. These forms of carbon are inorganic in the most basic meaning of the term: they were not prepared from the living organism.

A comparative analysis of ceramics with other engineering materials is shown in table (1). The purpose of presenting this comparative analysis is to show importance of ceramics among different engineering metals and polymers.

***Table 1 Comparison of ceramics with metals and polymers***

**1.2 CLASSIFICATION OF CERAMICS MATERIALS**

Ceramics can be classified in diverse ways i.e. there are number of ways to classify the ceramic materials. Ceramics can divided according to their properties and applications that it is common to class them as *traditional* or *advanced*.

*Traditional ceramics* are usually based on clay and silica. There is sometimes a tendency to equate traditional ceramics with low technology; however, advanced manufacturing techniques are often used. Competition among producers has caused processing to become more efficient and cost effective. Complex tooling and machinery is often used and may be coupled with computer-assisted process control. Traditional ceramics include high-volume items such bricks and tiles, toilet bowls (white wares), and pottery.

*Advanced ceramics* are also referred to as “special,” “technical,” or “engineering” ceramics. They exhibit superior mechanical properties, corrosion/oxidation resistance, or electrical, optical, and/or magnetic properties. Advanced ceramics include newer materials such as laser host materials, piezoelectric ceramics; ceramics for dynamic random access memories (DRAMs), etc., often produced in small quantities with higher prices.Figure 1.1 Classification of ceramics: traditional and advanced ceramics.



***Figure 1.1 Classification of ceramics traditional and advanced ceramics.***

Most commonly, the ceramics can be classified on the following basis:

- Classification based on composition

- Classification based on applications

The detailed classification is shown in figure (1.2).

***Figure 1.2 Classification of ceramics materials***

***1.2-2 Classification based on composition***

***(i) Silicate ceramics***

Silicates are materials generally having composition of silicon and oxygen (figure 1.3a). Four large oxygen (o) atoms surround each smaller silicon (Si) atom as shown in figure 1.3b. The main types of silicate ceramics are based either on alumosilicates or on magnesium silicates. Out of these two, the former include clay-based ceramics such as porcelain, earthenware, stoneware, bricks etc. while the latter consists of talc-based technical ceramics such as steatite, cordierite and forsterite ceramics. Silicate ceramics are traditionally categorized into coarse or fine and, according to water absorption, into dense (< 2 % for fine and < 6 % for coarse) or porous ceramics (> 2% and > 6 %, respectively).



a b

***Figure 1.3 (a) Silicate ceramics (b) Structure of silicate ceramics***

***(ii) Oxide ceramics***

Oxide ceramics include alumina, zirconia, silica, aluminium silicate, magnesia and other metal oxide based materials. These are non-metallic and inorganic compounds by nature that include oxygen, carbon, or nitrogen. Oxide ceramics possess the following properties:

(a) High melting points

(b) Low wear resistance

(c) An extensive collection of electrical properties

These types of ceramics are available with a variety of special features. For example, glazes and protective coatings seal porosity, improved water or chemical resistance, and enhanced joining to metals or other materials.

Oxide ceramics are used in a wide range of applications, which include materials and chemical processing, radio frequency and microwave applications, electrical and high voltage power applications and foundry and metal processing. Aluminum oxide (Al2O3) is the most important technical oxide ceramic material. This synthetically manufactured material consists of aluminum oxide ranging from 80 % to more than 99 %. (Figure 1.4 a and b).



a b

***Figure 1.4 (a) Aluminum oxide, (b) Structure of aluminum oxide***

***(iii) Non-Oxide ceramics***

The use of non-oxide ceramics has enabled extreme wear and corrosion problems to be overcome, even at high temperature and severe thermal shock conditions. These types of ceramics find its application in different spheres such as pharmaceuticals, oil and gas industry, valves, seals, rotating parts, wear plates, location pins for projection welding, cutting tool tips, abrasive powder blast nozzles, metal forming tooling etc.

***(iv) Glass ceramics***

These are basically polycrystalline material manufactured through the controlled crystallization of base glass. Glass-ceramic materials share many common characteristics with both glasses and ceramics. Glass-ceramics possess an amorphous phase and more than one crystalline phases. These are produced by a controlled crystallization procedure.

Glass-ceramics holds the processing advantage of glass and has special characteristics of ceramics. Glass-ceramics yield an array of materials with interesting properties like zero porosity, fluorescence, high strength, toughness, low or even negative thermal expansion, opacity, pigmentation, high temperature stability, low dielectric constant, machinability, high chemical durability, biocompatibility, superconductivity, isolation capabilities and high resistivity. These properties can be altered by controlling composition and by controlled heat treatment of the base glass.