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Introduction

1.1. Engineering Materials

Materials are substances from which something is composed or made from. Let us consider engineering materials used in building our material world: building construction, roads, bridges, irrigation systems, pipelines, machines, transportation equipment, electricity systems, tools, furniture, communication facilities, instrumentation, and various utilities and appliances both at home and in the office.

Materials are central to the growth, prosperity, security, and quality of human life. Throughout history, the development of human civilisation has been closely tied to materials which have been produced and used in society. The levels of involvement have been designated according to the materials used. In early human civilisation, people used materials existing in nature such as stone, wood and clay. This period became known as the "Stone Age". In time, techniques to produce materials having properties superior to those occurring naturally were discovered. With the Industrial Revolution, modern heavy industries were based largely on iron, steel and other metals, and this became known as the "Metal Age". Only recently have scientists begun to study the relationships between the composition, structure and properties of materials, and the knowledge and understanding gained have enabled us to design and create the numerous materials necessary to meet the needs of an ever evolving technological society.

Material scientists and engineers now have a rapidly evolving ability to tailor materials from the atomic scale upwards to obtain desired properties. A new age in materials, known as the "Tailored (or Designed) Materials Age", has been used to describe the revolutionary changes in materials science and engineering (MSE), as well as their impact on society. For example, advanced composites have been developed to combine the properties of high stiffness, strength, toughness and low density to meet special structural requirements. Surface treatments, including the development of various coatings and surface modification techniques, provide a combination of extreme hardness, wear, corrosion and high temperature oxidation resistance on the top surface, combined with a tough, shock-absorbing body. Artificial layered structures offer limitless possibilities for creating new electronic and semiconductor devices which can be produced using many methods, including molecular beam epitaxy (MBE), chemical vapour deposition (CVD), vacuum evaporation, sputter deposition, ion beam deposition, and solid-phase epitaxy. We now face exciting and dramatic changes in the materials world, giving our industries and society endless developmental opportunities.

1.2. Classification and Properties of Materials

1.2.1. *Classification of Materials*

Engineering materials are classified using different methods. The traditional method is to classify then according to their *nature*:

(i) Metals and alloys are inorganic materials composed of one or more metallic elements. They may also contain a small number of non-metallic elements. Metals usually have a crystalline structure and are good thermal and electrical conductors. Many metals are strong and ductile at room temperature and maintain good strength at high and low temperatures.

(ii) Ceramics are inorganic materials consisting of both metallic and non-metallic elements bonded together chemically. Ceramics can be crystalline, non-crystalline, or a mixture of both. Generally, they have high melting points and high chemical stabilities. They also have high hardness and high temperature strength, but tend to be brittle. Ceramics are usually poor electrical conductors.