Introduction

Materials science involves the development and study of materials' properties for specific purposes. Except in a few special cases, metals are rarely used industrially in their pure state. Generally, alloys consist of two elements (binary alloys), three elements (ternary alloys), and so on. Alloys can be composed of a single phase (single-phase alloys) or multiple phases (polyphase alloys). A phase (solid solution) is defined as a homogeneous part of the material with its own chemical composition and structure. These phases can undergo transformations during material use, driven by diffusion phenomena. Such phase changes are represented by equilibrium diagrams (or phase diagrams). Any phase transformation results in a reduction in the system's free enthalpy, which is the thermodynamic principle for reaching equilibrium, and can only begin from the nuclei of the new phase. These nuclei grow to eventually form an equilibrium phase. Thus, in all phase transformations, we observe both nucleation and growth phenomena.

The phase transformation mechanisms follow Avrami's law, which describes the variation in the nucleation rate as a function of time at a constant temperature. By analyzing different curves, we can construct the T.T.T. (transformation-temperature-time) diagram and describe phase transformations as a function of time.

In these chapters, students will learn the fundamental thermodynamic, crystallographic, and kinetic principles of phase changes in materials. Practical examples illustrate transformations considered essential from an engineering perspective. Each chapter should be thoroughly studied by students to:

- Distinguish between the fundamental types of changes in engineering materials based on thermodynamic, crystallographic, and kinetic features,
- Propose a realistic explanation for the phase changes that might occur under specific conditions during the technological processing of metallic materials,
- Identify the fundamental transformation products of engineering materials.

The books listed in the reference section at the end of this document can be consulted for additional information.

This document is intended for Master I students in the three specialties of Nanophysics, Applied Physics, and Physics of Materials at Frères Mentouri-Constantine 1 University. It is also suitable for students from other fields of study, provided they meet the essential prerequisites for enrolling in this course, which include completion of courses in Material Sciences, Structure and Properties of Solids, and Heat Treatment Essentials. The recommended approach for each chapter is to read the text section attentively and then complete the exercises provided.

At the end of this document, a trilingual glossary is provided as a fundamental tool for Master's students in physics, particularly in materials sciences. Its primary aim is educational; it is designed to alleviate the challenge of finding relevant bibliography in Arabic within the field. The glossary includes the majority of terms used in this manuscript.