PHASE DIAGRAMS

UNDERSTANDING THE BASICS

Edited
by
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Preface

Phase diagrams are graphical maps that show the behavior of metal alloys during heating and cooling. In addition, they show the solid phases that are present after an alloy freezes. They are a primary tool in metallurgy because they provide the basis for predicting or interpreting the changes in the internal structure of a material. When an alloy undergoes heating and cooling, it undergoes phase transitions or transformations, in both the liquid and solid state. Therefore, an appreciable amount of this book is devoted to understanding these transformations.

In keeping with ASM's goal in the *Understanding the Basics* series of technical books, many of the mathematical formulations that underlie the theory of phase diagrams have been omitted. There are many excellent texts on chemical thermodynamic that provide this theory. The material in this book can be comprehended by anyone with some degree of a technical background. For those lacking knowledge of basic metallurgical principles, I have included two appendices that are helpful. Appendix A covers the basics of metallic structure, while Appendix B is an introduction to the principles of solidification. This book is helpful to engineers, technicians, production personnel and students with no previous exposure to metallurgy. It is also helpful to metallurgical engineers who have forgotten many of the principles of phase diagrams and need a refresher.

Chapter 1 is a brief introduction to phase diagrams. The next two chapters offer basic information that is helpful in reading subsequent chapters. Chapter 2 is an introduction to solid solutions and phase transformations. While I have attempted to avoid the detailed development of the thermodynamic formulation behind phase diagrams, Chapter 3 gives a somewhat cursory overview of the importance of Gibbs free energy and how it is used to construct and interpret phase diagrams.

The two types of alloy phase diagrams that receive the most emphasis are binary (two metals) and ternary (three metals). While a few quaternary (four metals) diagrams can be found in the literature, computer modeling based on thermodynamic principles (described in Chapter 13) are now almost exclusively used to analyze this degree of complexity.

Important binary phase diagrams involving liquid and solid reactions are covered in Chapter 4 (isomorphous), Chapter 5 (eutectic), Chapter 6 (peritectic), and Chapter 7 (monotectic). Solid-state transformations are covered in Chapter 8 and include the important eutectoid and peritectoid reactions.

Gas-metal reactions are important in metals processing and in-service corrosion; therefore, Chapter 11 covers the basics of these systems where pressure becomes an important variable.

The construction of a phase diagram is a tedious and exacting process. In Chapter 12, some of the important methods that are used in phase diagram determination and construction errors are discussed.

While many of the uses of phase diagrams will become apparent as you progress through the book, Chapter 14 summarizes their usage and gives some real world industrial examples of how phase diagrams were used to solve problems.

While phase diagrams are constructed under as close as possible to equilibrium conditions, many important phase transformations in alloys occur under highly nonequilibrium conditions. There are two chapters that cover these types of transformations. Chapter 15 covers the nonequilibrium cooling ferrous alloys that form the basics for the strengthening of steel by heat treatment. Chapter 16 covers the precipitation hardening process that is important in strengthening ferrous and nonferrous alloys, particularly aluminum and nickel-based alloys.

A first course in materials science would be helpful in understanding the material in this book; however, most of the material is easy to understand and builds as you progress through the book. The purpose of this book is to introduce the basics and not to replace handbooks on engineering alloys.

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Phase diagram is a graphical representation of the physical states of a substance under different conditions of temperature and pressure. A typical phase diagram has pressure on the y-axis and â€¦Â Phase diagram is a graphical representation of the physical states of a substance under different conditions of temperature and pressure. A typical phase diagram has pressure on the y-axis and temperature on the x-axis. As we cross the lines or curves on the phase diagram, a phase change occurs. A phase diagram in physical chemistry, engineering, mineralogy, and materials science is a type of chart used to show conditions (pressure, temperature, volume, etc.) at which thermodynamically distinct phases (such as solid, liquid or gaseous states) occur and coexist at equilibrium. Common components of a phase diagram are lines of equilibrium or phase boundaries, which refer to lines that mark conditions under which multiple phases can coexist at equilibrium. Phase transitions occur along lines of