

# Preface

Materials science and engineering (MSE) combines physics and chemistry principles to solve practical problems associated with major engineering disciplines, such as information technology, energy, manufacturing, nanotechnology, and biotechnology. The experimental teaching of this specialty is particularly prominent because it is an important way to train students to apply multidisciplinary knowledge comprehensively. In order to improve students' ability to solve practical problems in scientific research and engineering development, it is necessary to eliminate obsolete experiments and increase the number of comprehensive experiments that involve multiple principles, skills, and methods.

Besides the essential basic experiments in the first several chapters, most experiments designed in this book are comprehensive. This is why this book is titled *Comprehensive Experiments*. In this book, a comprehensive experiment can be one experiment or divided into several experiments to facilitate teaching implementation. The experiments involve the forefront of scientific research and the materials industry with appropriate modification. It is worth noting that this book does not specifically design experiments on material characterization, although it is an essential basis of MSE. Instead, the principles, methods, and apparatuses for material characterization are integrated into relevant experiments.

This book covers the main contents of experimental courses of MSE. It intends to serve as a textbook for undergraduate students and aims to help teachers find a wide enough variety of experiments to construct an experimental course.

## Organization of the book

In recent years, many universities and colleges have put forward modularized teaching mode. The experimental knowledge and skills can be modularized to form a systematic, independent curriculum system so that students can systematically master the complete experimental knowledge and skills of MSE. Therefore, this book establishes a modularized structure. The experiments in this book are divided into five parts.

Part I is Preliminary Exploration of Materials Science and Engineering, including preliminary experiments of metallographic analysis, material processing,

electronic materials, energy materials, and biomaterials.

Part II is Fundamentals of Chemistry and Crystallography, including basic experiments of physical chemistry, organic chemistry, and crystallography. Chemical synthesis is an important way to obtain materials, and chemical reaction is closely related to a variety of material treatment and processing methods. In contrast, the students majoring in MSE generally lack the knowledge and experiment skills in chemistry, especially in organic chemistry. Therefore, the chemical experiments are strengthened in this part to support the study of subsequent experiments.

Part III is Material Properties, including experiments of mechanical and physical properties of materials.

Part IV is Material Preparation and Treatment, including experiments of forming and heat treatment of metal materials, synthesis of organic and polymeric materials, and synthesis of nanomaterials.

Part V is Material Applications, including experiments of energy materials, electronic materials and devices, bio materials, and materials and environment.

Besides the experiments in the text, the appendices describe the most relevant aspects of experimental safety, error, and data presentation in a general way. The contents and requirements of the experimental report are suggested.

At the end of each chapter, a list of books, journal articles, and websites is provided for extended reading on topics covered in the chapter.

### Organization of the experiments

The main contents of each experiment consist of the following sections:

*Type of the experiment* (cognitive, comprehensive, or designing) and *Recommended credit hours* are first described. These may facilitate teaching implementation. For the experiment that is further divided into several experiments, the type and credit hours for each separated experiment are given.

*Brief introduction* compendiously introduces the main contents of the experiment, the materials used, and the principles involved.

*Objectives* describe the main contents to be completed and the knowledge and experimental skills to be mastered in the experiment.

*Principles* introduce the materials, methods, apparatuses involved in the experiment. It is noted that these principles are in the form of a brief introduction or a summary since we pay more attention to applying the relevant knowledge and the cultivation of experiment skills.

*Experimental* includes two parts. They are the “preparation”, which lists materials, chemicals, apparatuses, tools, and others for the experiment, and the “procedure”, which describes the main steps of the experiment. The manufacturers and models of the main apparatuses are given to facilitate the introduction of the experimental steps.

*Requirements for experimental report* put forward the specific requirements in the report. These include description and explanation of experimental phenomena,

analysis of photographs, and data processing.

*Questions and further thoughts* guide students to expand their thinking or knowledge based on the experiment through several questions.

*Cautions* list key operating points or critical safety matters that should be paid attention to during the experiment.

### Division of the authors

The authors all come from the teaching laboratory of the Department of Materials Science and Engineering at Southern University of Science and Technology (SUSTech). Most experiments were designed or reformed from the classic experiments by the authors during teaching practice.

Professor Fei Ye is the chief editor of the book and is responsible for the compilation and review of the book. He studied at Tsinghua University from 1994 to 2004 and successively received a bachelor's degree, a master's degree, and a Ph.D. degree in materials science and engineering. Then, he worked at National Institute for Materials Science, Japan, and became a regular researcher in 2008. Professor Fei Ye worked at Dalian University of Technology as a full professor from 2010 to 2018. After that, he joined Southern University of Science and Technology in July 2018. Professor Fei Ye has taught the course "Fundamentals of Materials Science and Engineering" for years and has rich teaching experience.

The basic information and division of the other authors are as follows:

Chengzhu Liao received a Ph.D. degree in Materials Science from City University of Hong Kong in 2011. She wrote Experiments 5.1, 14–19, 21.1, 21.3, 22, 23, 27, 34, 37.1, 38, 39, 57. She also participated in the writing of Chapter 12, Biomaterials.

Hua Cheng received a Ph.D. degree in materials science from City University of Hong Kong in 2011. She wrote Experiments 13, 29, 30, 41, 47, 50, 52, 59.

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