

Materials Science and Engineering of Carbon: Characterization

碳材料科学与工程：表征

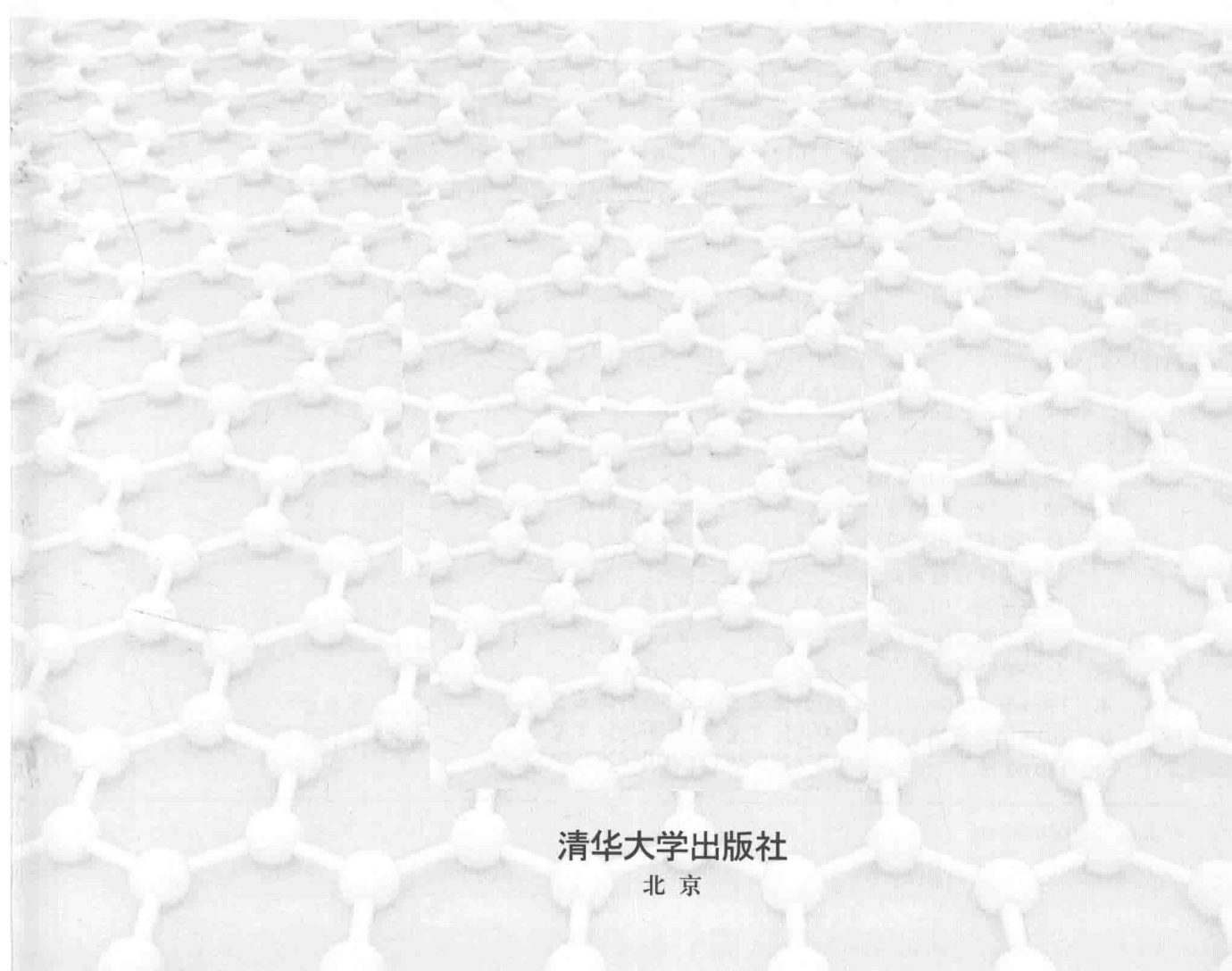
[日] Michio Inagaki [中] Feiyu Kang

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北京

内 容 简 介

碳材料由于其结构多样性,导致其性能多样化,因而应用领域广阔,碳材料研究已受到全球材料科学界、物理学界、化学界的广泛关注。本书系统介绍了碳材料表征技术及应用,包括X射线粉末衍射、小角X射线散射、透射电镜、扫描电子显微镜、图像分析、拉曼光谱、X射线光电子能谱、磁电阻、电化学性能、气体吸附/解吸等温线、热分析、表面官能团滴定测定、程序升温脱附技术。本书读者对象为材料领域的科技人员、研究生和高校教师。本书以英文著述,并与Elsevier出版集团合作已在海外出版。

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Preface

There are few books that offer fundamental knowledge on carbon materials and those that are available must be handy and easy to buy. Therefore, we (M. I. and F. K.) published the book from Tsinghua University Press, China, entitled “Carbon Materials Science and Engineering: From Fundamentals to Applications” in 2006. The book aimed to give comprehensive information firstly on the fundamental science of preparation and characterization of various carbon materials, and secondly on engineering and applications of various carbon materials. Many copies have been sold, mostly in China. However, the progress in carbon materials science research and engineering was rapid not only on nanocarbons, represented by carbon nanotubes and graphenes, but also on classic carbons, such as porous carbons and their application to electric double-layer capacitors, so that we believed it was necessary to revise our 2006 book, even though we added some descriptions on newly developed carbons in 2011. We strongly felt that the revision of the previous book was not enough, mainly because it has to contain the fundamentals of carbon materials. Therefore, we decided to publish the advances in carbon materials science as a new book, with the collaboration of two more authors, H. Konno and M. Toyoda. It was published in September 2013 as “Advanced Science and Engineering of Carbon” from two publishers, Tsinghua University Press and Elsevier. At the same time, we revised and updated the previous book and in 2014 published the second edition of the book entitled “Materials Science and Engineering of Carbon: Fundamentals” from Tsinghua University Press and Elsevier.

During the preparation of these two books, Fundamentals and Advanced, we found that we did not have enough space for the descriptions on the characterization techniques for carbon materials, and also that we could not cover all of the techniques by ourselves. In addition, we found out that special considerations on the preparation of specimens and the conditions applied were required for the characterization of carbon materials, particularly for fundamental techniques of characterization. We found that some of papers that were published in well-respected journals did not employ the proper procedures for specimen preparation and the optimum conditions for the measurements. For our new book, we selected 13 techniques that were commonly used in the research work on carbon materials: X-ray powder diffraction, small-angle X-ray scattering, transmission electron microscopy, scanning electron microscopy, image analysis technique, Raman spectroscopy, X-ray photoelectron spectroscopy, magnetoresistance measurement, electrochemical performance determination, gas adsorption/desorption for pore structure analysis, thermal analysis, titration method for identification of surface

functional groups and temperature programmed desorption. We asked the experts who had been working on carbon materials by using these respective techniques to focus on writing about the practical applications of the techniques on carbon materials.

Michio Inagaki
Feiyu Kang
Editors

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Introduction

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1.1 CARBON MATERIALS

A variety of carbon materials have been developed and have provided distinguished contributions to the development of science and engineering, particularly of modern science and engineering [1,2]. In Fig. 1.1 carbon materials are classified on the basis of carbon-carbon bonds of the hybrid orbitals of sp^3 , planar $sp^2 + \pi$, curved $sp^2 + \pi$ and $sp + 2\pi$.

Carbon materials composed principally of one of these hybrid orbitals are represented by diamond, graphite, fullerenes and carbynes, respectively, and called carbon families [1]. Each family has its own variety, as written in Fig. 1.1. In the diamond family, there are highly crystalline diamonds with cubic and hexagonal crystal symmetries, but also there are noncrystalline (amorphous) materials that have almost the same properties as crystalline diamond, which are called diamond-like carbons (DLCs). Carbon materials belonging to the carbyne family are composed of either double or triple carbon-carbon bonds, cumulene or polyyne type, using $sp + 2\pi$ hybrid orbitals. Carbon materials in the fullerene family contain pentagons together with hexagons of carbon atoms using electronic orbitals of curved $sp^2 + \pi$, which leads to closed cages, the smallest cage being C_{60} . Diversity observed in the fullerene family occurs in the size of the cage, C_{60} , C_{70} , ..., and also in the thickness of the cage wall, single- and multi-walled.

