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Principles of Nanotechnology

Molecular-Based Study of Condensed

Matter in Small Systems

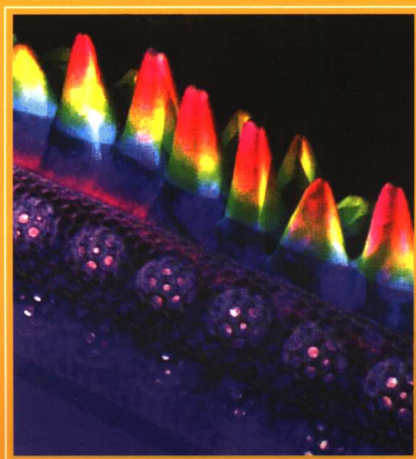
纳米技术原理

——微系统中基于分子的凝聚态研究

(英文影印版)

G. Ali Mansoori

(University of Illinois, USA)



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出版者的话

复旦大学出版社出版英文影印版《研究生前沿教材书系》，主要基于以下几点考虑。

1. (新加坡)世界科技出版公司以出版科技专著闻名于世,同我社已有 10 多年的友好交往。从 20 世纪 90 年代以来,尤其是 1995 年该公司并购了伦敦帝国学院出版社(Imperial College Press) 51% 的股份(近年已完成了 100% 的股份收购)之后,这两大出版机构在潘国驹教授的集中指挥下,充分发挥了编辑学术委员会的职能,使得出书范围不断拓宽,图书层次逐渐丰富,因此从中遴选影印图书的空间就更大了。再加上该公司在上海设有办事机构,相关工作人员工作细致,服务周到,给我们两个单位的合作交流带来极大的便利。

2. 研究生教育是创新人才培养的关键,教材建设直接关系到研究生科学水平和创新能力的培养。从 2003 年开始,我社陆续出版了 *Fudan Series in Graduate Textbooks* 这套丛书,国内的读者反响很好。但限于作者人力,这套丛书涵盖的学科和门类都较为不足。为此,我们想到再借助国外出版力量,引进一批图书作为硕士研究生的补充教材,(新加坡)世界科技出版公司与我社的合作,恰好提供了这样一个良好的机会。我们从该公司提供的大量近期书目中,遴选出 30 多本样书,经过专家审读后,最终确定了其中的 11 种作为首批《研究生前沿教材书系》影印出版。这 11 种图书的作者来自美、英、法、德、加拿大 5 个国家的 10 多所高校或研究部门,他们既是相关学科科研的领军人物,又是高年级本科生和研究生教学的杰出教授(详见各书的作者介绍)。各门教材既考虑到深入浅出的认知规律,又突出了前沿学科的具体应用,每本书都有充实的文献资料,有利于读者和研究人员深入探索。其中 6 本教材配有习题,

还包括一本具有物理背景的人员都需要了解的高级科普读物——《理解宇宙——从夸克到宇宙学》。

3. 为了有利于广大读者和图书管理、图书采购、图书销售人员的使用,特请龚少明编审为每本影印书编写出中文内容介绍和作者概况,并由他将 **preface**(序言)译成中文。序言是一本书的总纲,它涉及写作要旨、逻辑体系、内容特色和研读指导等等,我们将其译成中文至少有利于读者的浏览和选购,避免买书仓促带来的失误,毕竟英语是多数读者的第二种语言。

4. 原版书价格较贵,大大超出读者的购买能力,即使图书馆或大学资料室也会受到经费不足的制约。出版影印本的书价不到原价的十分之一,无疑会给需要这些书的研究生和图书馆带来真正的实惠,这也是(新加坡)世界科技出版公司与我们合作的目的之一。

5. 考虑到物理类图书是(新加坡)世界科技出版公司的第一品牌,我们首次引进的 11 本书,都属大物理的范畴。这一尝试如果得到读者和专家的认可,今后我们将陆续开辟其他学科的影印渠道。

欢迎读者批评指正,并提出有益的建议。

复旦大学出版社
2006 年 9 月

内 容 简 介

纳米技术最先由诺贝尔物理学奖获得者、著名的物理学家理查德·费曼在1959年12月29日的一次报告中提出来的。20世纪80年代,扫描探针显微镜发明之后,纳米技术开始快速发展,现在它已成为物品设计和制作中最活跃的前沿应用领域。本书就是作者根据自己37年的研究工作,在给伊利诺依(Illinois)大学的工程、生物和物理类研究生和读过量子力学、统计力学的高年级大学生讲课的讲稿基础上撰写而成的。全书强调在凝聚态物质的分子研究基础上,重点介绍微系统的有趣课题。全书共分11章,分别讲述原子、分子纳米技术的进展;纳米系统中分子间的作用力和势函数;纳米系统的热力学和统计力学;纳米系统的Monte Carlo模拟法;纳米系统的动力学模拟法;纳米系统的计算机模拟和最优化;纳米系统的相变;原子分子的定位安装;分子自组装;动力学组合化学;分子组装的鸟笼结构等。全书提供了丰富的进一步研究的参考文献。

本书除了可用作相关专业的研究生教材和本科生选修课教材之外,还可作为有关专家了解纳米系统学科概貌的参考读物。本书的细致解释,一定会引起读者的广泛关注。考虑到纳米技术是一门跨学科交叉学科,本书还附上术语解释,包括了缩略语、化学方程式、概念定义、方程和理论等方面,这将为不同学科的读者提供阅读的方便。

G. Ali Mansoori

美国 Illinois 大学生物工程和化学工程系教授、博士。

作者致力于将统计力学和热力学应用于化学工程和生物工程之中, 研究范围涉及重油利用、沥青质特征、天然气净化、超临界流体的提取、生物技术和环境污染等。作者已经取得了以下成果: 确立了可用于工程设计计算的新的分子溶液理论、多组份混合物的相平衡理论, 并将上述两理论用于聚合物溶体、石油贮存流体、煤液化流体以及生物学流体之中; 得到由极化分子或亲水性分子组成的反对称混合物的统计力学混合规则; 提出了超临界流体萃取和反缩聚的可能技术手段, 并将这些技术手段用于天然气的生产和加工过程之中; 得出生物学分离的相平衡理论以及在从生物学流体富集生物大分子(蛋白质)过程中的应用; 从石油原油中提取沥青质的沉淀和分离技术及其在石油生产和加工过程中的应用等。作者采用了色谱法、界面张力计、沸点升高测定法以及微组分集结、胶体化、微胶粒、聚合等实验方法和统计力学理论, 建立了上述的技术设施。

《纳米技术原理》一书是作者近年来对微系统进行分子研究和在凝聚态物理教学工作的基础上编写而成的。

序

《纳米技术原理》是我近年来对纳米系统凝聚态的分子行为的研究工作和教学活动的结晶。书中涉及的纳米系统的特殊观念源于我早先对物质、统计力学、热力学和工程科学的分子研究。以前我曾参与该学科的各种专题讨论、口头交谈、学术讨论和研究论文切磋等活动。

我很感激很多同事、朋友和学生,从他们中间我找到了许多论文的合作伙伴。我特别要感谢的是:J. Anderson, L. Assoufid, R. Bagherian, B. Chehroudi, D. Dziura, T. Ebtekar, A. Eliassi, K. Esfarjani, T. F. George, A. Johnson, L. A. Kennedy, G. L. Klimchitskaya, C. Megaridess, S. Priyanto, H. Rafii-Tabar, H. Ramezani, D. Samaranski, B. Searles, T. A. F. Soelaiman, G. R. Vakili-Nezhaad, M. Shariaty-Niassar, A. Soltani, B. Soltani, A. Suwono, G. Uslenghi, G. Willing 以及 G. Zhang。这些合作者对本书的完成起到极为宝贵的作用。

读者应该牢记在心的是:本书是专为纳米技术这一专题服务的。书中列出的题目和参考文献是有限的,我要对忽视的出版物的作者表示歉意。

G. Ali Mansoori
2004 年 10 月 8 日
于芝加哥

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Chapter 1

Advances in Atomic and Molecular Nanotechnology

“Everything we see around us is made of atoms, the tiny elemental building blocks of matter. From stone, to copper, to bronze, iron, steel, and now silicon, the major technological ages of humankind have been defined by what these atoms can do in huge aggregates, trillions upon trillions of atoms at a time, molded, shaped, and refined as macroscopic objects. Even in our vaunted microelectronics of 1999, in our highest-tech silicon computer chip the smallest feature is a mountain compared to the size of a single atom. The resultant technology of our 20th century is fantastic, but it pales when compared to what will be possible when we learn to build things at the ultimate level of control, one atom at a time.” **Richard E. Smalley**

Introduction

In this chapter, we present an introduction to the advances made in the atomic and molecular nanotechnology, ability to systematically organize and manipulate properties and behavior of matter in the atomic and molecular levels. It is argued that through nanotechnology, it has become possible to create functional devices, materials and systems on the 1 to 100 nanometer (one billionth of a meter) length scale.

The reasons why nanoscale has become so important are presented. Historical aspects of nanotechnology are introduced starting with the famous 1959 lecture by R.P. Feynman. It is suggested to name the nanometer scale the *Feynman* (ϕ nman) *scale* after Feynman's great contributions to nanotechnology ($1 \text{ Feynman } [\phi] \equiv 10^{-9} \text{ meter} = 10^{-3} \text{ Micron } [\mu] = 10 \text{ Angstroms } [\text{\AA}]$). Recent inventions and discoveries in