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Piezoelectricity: Evolution and Future of a Technology

压电

——该技术的发展和未来

(影印版)

〔德〕埃旺 (W. Heywang)

〔德〕卢比茨 (K. Lubitz) 主编

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序 言

物理学是研究物质、能量以及它们之间相互作用的科学。她不仅是化学、生命、材料、信息、能源和环境等相关学科的基础,同时还是许多新兴学科和交叉学科的前沿。在科技发展日新月异和国际竞争日趋激烈的今天,物理学不仅囿于基础科学和技术应用研究的范畴,而且在社会发展与人类进步的历史进程中发挥着越来越关键的作用。

我们欣喜地看到,改革开放三十多年来,随着中国政治、经济、教育、文化等领域各项事业的持续稳定发展,我国物理学取得了跨越式的进步,做出了很多为世界瞩目的研究成果。今日的中国物理正在经历一个历史上少有的黄金时代。

在我国物理学科快速发展的背景下,近年来物理学相关书籍也呈现百花齐放的良好态势,在知识传承、学术交流、人才培养等方面发挥着无可替代的作用。从另一方面看,尽管国内各出版社相继推出了一些质量很高的物理教材和图书,但系统总结物理学各门类知识和发展,深入浅出地介绍其与现代科学技术之间的渊源,并针对不同层次的读者提供有价值的教材和研究参考,仍是我国科学传播与出版界面临的一个极富挑战性的课题。

为有力推动我国物理学研究、加快相关学科的建设与发展,特别是展现近年来中国物理学者的研究水平和成果,北京大学出版社在国家出版基金的支持下推出了《中外物理学精品书系》,试图对以上难题进行大胆的尝试和探索。该书系编委会集结了数十位来自内地和香港顶尖高校及科研院所的知名专家学者。他们都是目前该领域十分活跃的专家,确保了整套丛书的权威性和前瞻性。

这套书系内容丰富,涵盖面广,可读性强,其中既有对我国传统物理学发展的梳理和总结,也有对正在蓬勃发展的物理学前沿的全面展示;既引进和介绍了世界物理学研究的发展动态,也面向国际主流领域传播中国物理的优秀专著。可以说,《中外物理学精品书系》力图完整呈现近现代世界和中国物理

科学发展的全貌,是一部目前国内为数不多的兼具学术价值和阅读乐趣的经典物理丛书。

《中外物理学精品书系》另一个突出特点是,在把西方物理的精华要义“请进来”的同时,也将我国近现代物理的优秀成果“送出去”。物理学科在世界范围内的重要性不言而喻,引进和翻译世界物理的经典著作和前沿动态,可以满足当前国内物理教学和科研工作的迫切需求。另一方面,改革开放几十年来,我国的物理学研究取得了长足发展,一大批具有较高学术价值的著作相继问世。这套丛书首次将一些中国物理学者的优秀论著以英文版的形式直接推向国际相关研究的主流领域,使世界对中国物理学的过去和现状有更多的深入了解,不仅充分展示出中国物理学研究和积累的“硬实力”,也向世界主动传播我国科技文化领域不断创新的“软实力”,对全面提升中国科学、教育和文化领域的国际形象起到重要的促进作用。

值得一提的是,《中外物理学精品书系》还对中国近现代物理学科的经典著作进行了全面收录。20世纪以来,中国物理界诞生了很多经典作品,但当时大都分散出版,如今很多代表性的作品已经淹没在浩瀚的图书海洋中,读者们对这些论著也都是“只闻其声,未见其真”。该书系的编者们在这方面下了很大工夫,对中国物理学科不同时期、不同分支的经典著作进行了系统的整理和收录。这项工作具有非常重要的学术意义和社会价值,不仅可以很好地保护和传承我国物理学的经典文献,充分发挥其应有的传世育人的作用,更能使广大物理学人和青年学子切身体会我国物理学研究的发展脉络和优良传统,真正领悟到老一辈科学家严谨求实、追求卓越、博大精深的治学之美。

温家宝总理在2006年中国科学技术大会上指出,“加强基础研究是提升国家创新能力、积累智力资本的重要途径,是我国跻身世界科技强国的必要条件”。中国的发展在于创新,而基础研究正是一切创新的根本和源泉。我相信,这套《中外物理学精品书系》的出版,不仅可以使所有热爱和研究物理学的人们从中获取思维的启迪、智力的挑战和阅读的乐趣,也将进一步推动其他相关基础科学更好更快地发展,为我国今后的科技创新和社会进步做出应有的贡献。

《中外物理学精品书系》编委会 主任
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王恩哥

2010年5月于燕园

Walter Heywang · Karl Lubitz
Wolfram Wersing

Piezoelectricity

Evolution and Future of a Technology

With 326 Figures

Foreword

Piezoelectricity represents an intriguing property of a dedicated class of materials to directly transform mechanical energy and electrical energy into one another. Despite the fact that the phenomenon of piezoelectricity shows all ingredients to fascinate physicists and engineers alike, it only plays a subordinate role in science education. The reason for this discrepancy is due to the fact that piezoelectricity appears to be a minor physical effect. As a consequence, the revolutionary opportunities and the huge technological development in the recent decades hardly reached the awareness of the public. Nevertheless, just piezoelectric devices comprise an annual turnover of umpteen billion dollars, enabling a system technology that stands for an even larger economical value.

This anthology is intended to contribute to narrowing this gap between high technical and economical importance and low coverage in text book area. In the first part, the fundamentals of piezoelectricity and related phenomena as well as the crystallographic structure of piezoelectric materials are introduced. Prototypical as well as economically relevant classes of piezoelectric materials are described. In the second part, the main part of the book, a broad selection of device applications is presented, which reflects the huge spectrum of functionalities covered by piezoelectric in our world today. The third part deals with the most frequently used characterization methods specifically used for piezoelectric materials and devices. In the fourth part, modeling approaches are covered ranging from empirical thermodynamic theory, via first principles theories of piezoelectric materials, to finite element modeling of devices. The book concludes with a fascinating anticipation of the future evolution of the field.

The volumes address graduate students in material science, solid-state physics, and inorganic chemistry, as well as professional scientists and engineers who are interested in material-based innovations. It also may serve as a reference book for managers who are interested in the economical side of innovations and in potential future markets.

The publishers succeeded in compiling an anthology that creates a bridge between a generic view on piezoelectricity on the one hand and a specific

VI Foreword

treatise of many exciting examples on the other. In all parts, the book has been written by the internationally leading experts in the specific areas of piezoelectricity and in material science. In addition to the aforementioned aspects this constitutes a high value on its own.

August 2008

Jülich
Rainer Waser

Foreword

When starting the European Materials Research Society (E-MRS) 25 years ago, the founders wanted to reestablish the famous tradition of the European materials community. The E-MRS conferences in Strasbourg and Warsaw, which attract annually about 3,000 scientists from everywhere in the world, give proof of this successful initiative.

But in our global world it is not sufficient to be a top-player in science, market success must also be included: besides the well-known traditional pillars of Helmholtz, being research and education, innovation has to be included as a third column. Having this in mind, E-MRS has started “evolution and future of a technology” as a new book series, which is to describe exemplary cases of materials-based innovations.

After “Silicon,” “Piezoelectricity” is the second volume of this series. Piezoelectricity itself is an excellent and instructive example: it was discovered as physical phenomenon by the Curie brothers in 1880, but has required new adapted materials and technologies. It was a long and sometimes troublesome way to go for making this initially minor effect a real and sometimes even superior competitor to the electro-dynamic respectively magnetic principal, which for a long time was the only way to transform electrical energy or signals into mechanical ones or vice versa effectively. Novel piezoelectric devices and novel design will open up means which avoid this roundabout in many cases.

The book “Piezoelectricity” is interesting not only for students, scientists, and engineers involved in this field, it is informative also for the entire innovation management in industry and politics. I hope that many books of this kind will follow in the new E-MRS series.

August 2008

Strasbourg
Paul Siffert

Preface

The volume as presented has originated from discussions with the European Materials Research Society. It is to fill a gap concerning the scientific and technical importance of piezoelectricity. We have to thank all who have supported this project, especially the publisher and all our authors for their excellent cooperation. We hope that we were able to meet the mentioned goal in spite of the broad diversity of the whole field.

München
August, 2008

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Contents

1 Introduction

L.E. Cross and W. Heywang 1

Part I Basics and Materials

2 Basic Material Quartz and Related Innovations

A. Ballato 9

3 The Role of Ferroelectricity for Piezoelectric Materials

W. Wersing, W. Heywang, H. Beige, and H. Thomann 37

4 Piezoelectric PZT Ceramics

G. Helke and K. Lubitz 89

5 Relaxor Ferroelectrics

L.E. Cross 131

6 Piezoelectric Polymers and Their Applications

S. Bauer and F. Bauer 157

Part II Applications and Innovations

7 Electromechanical Frequency Filters

W. Wersing and K. Lubitz 181

8 Ultrasonic Imaging

W. Wersing and R. Lerch 199

9 High Effective Lead Perovskite Ceramics and Single Crystals for Ultrasonic Imaging

Y.(J.) Yamashita and Y. Hosono 223

10 High-Power Ultrasound Transducers for Therapeutic Applications	
<i>D. Cathignol</i>	245
11 Piezoelectric Motors and Transformers	
<i>K. Uchino</i>	257
12 Piezoelectric Positioning	
<i>S. Arnold, P. Pertsch, and K. Spanner</i>	279
13 Piezoelectric Injection Systems	
<i>R. Mock and K. Lubitz</i>	299
14 Advanced RF Signal Processing with Surface Acoustic Waves on Piezoelectric Single Crystal Substrates	
<i>R. Veith, K. Wagner, and F. Seifert</i>	311
15 Piezoelectric Films for Innovations in the Field of MEMS and Biosensors	
<i>P. Muralt</i>	351
16 Piezoelectric Composites by Solid Freeform Fabrication: A Nature-Inspired Approach	
<i>A. Safari and E.K. Akdoğan</i>	377

Part III Characterisation Methods

17 Microstructural Analysis Based on Microscopy and X-Ray Diffraction	
<i>M.J. Hoffmann, H. Kungl, R. Theissmann, and S. Wagner</i>	403
18 Small Signal Resonance Methods	
<i>W. Wersing</i>	423
19 Large Signal Resonance and Laser Dilatometer Methods	
<i>A. Wolff</i>	445
20 Ferroelastic Characterization of Piezoelectrics	
<i>T. Fett</i>	457

Part IV Multiscale Modelling

21 First-Principles Theories of Piezoelectric Materials	
<i>R.E. Cohen</i>	471
22 Thermodynamic Theory	
<i>G.A. Rossetti, Jr.</i>	493