Springer手册精选系列

电子与光子材料手册

电子与光子材料的制备和特性

【第2册】

Springer
Handbook of
Electronic and Photonic Materials

〔加拿大〕Safa Kasap
〔英　国〕Peter Capper 主编

哈爾濱工業大學出版社
HARBIN INSTITUTE OF TECHNOLOGY PRESS

Springer 手册精选系列

电子与光子材料手册

电子与光子材料的制备和特性

【第2册】

Springer Handbook of *Electronic and Photonic Materials*

〔加拿大〕Safa Kasap
〔英　国〕Peter Capper 主编

（影印版）

哈爾濱工業大學出版社
HARBIN INSTITUTE OF TECHNOLOGY PRESS

黑版贸审字08-2012-031号

图书在版编目（CIP）数据

电子与光子材料手册. 第2册，电子与光子材料的制备和特性=Handbook of Electronic and Photonic Materials Ⅱ Growth and Characterization：英文／（加）卡萨普（Kasap S.），（英）卡珀（Capper P.）主编. 一影印本. 一哈尔滨：哈尔滨工业大学出版社，2013.1
（Springer手册精选系列）
ISBN 978-7-5603-3761-6

Ⅰ. ①电… Ⅱ. ①卡…②卡… Ⅲ. ①电子材料-手册-英文②光学材料-手册-英文 Ⅳ. ①TN04-62②TB34-62

中国版本图书馆CIP数据核字（2012）第189774号

材料科学与工程
图书工作室

责任编辑 杨　桦　张秀华
出版发行 哈尔滨工业大学出版社
社　　址 哈尔滨市南岗区复华四道街10号 邮编 150006
传　　真 0451-86414749
网　　址 http://hitpress.hit.edu.cn
印　　刷 哈尔滨市石桥印务有限公司
开　　本 787mm×960mm 1/16 印张 15.25
版　　次 2013年1月第1版 2013年1月第1次印刷
书　　号 ISBN 978-7-5603-3761-6
定　　价 48.00元

序 言

本书的编辑、作者、出版人都将庆祝这本卓著书籍的出版，这对于电子与光子材料领域的工作者也将是无法衡量的好消息。从以往编辑的系列手册看，我认为本书的出版是值得的，坚持出版这样一本书也是必要的。本书之所以显得特别重要，是因为它在这个领域，内容覆盖范围广泛，涉及的方法也是当今的最新研究进展。在这样一个迅速发展的领域，这是一个相当大的挑战，它已经赢得了人们的敬意。

早期的手册和百科全书也都注重阐述半导体材料的发展趋势，而且必须覆盖半导体材料广泛的研究范围和所涉及的现象。这是可以理解的，原因在于半导体材料在电子领域中的主导地位。但没有多少人有足够的勇气预测未来的发展趋势。1992年，Mahajan和Kimerling在其《简明半导体材料百科全书和相关技术》一书的引言中做了尝试，并且预测未来的挑战将是纳米电子领域、低位错密度的III–V族衬底技术、半绝缘III–V族衬底技术、III–V族图形外延技术、替换电介质和硅接触技术、离子注入和扩散技术的发展。这些预测或多或少地成为了现实，但是这也同样说明做出这样的预测是多么的困难。

十年前没有多少人会想到III族氮化物在这本书中将成为重要的部分。与制备相关的问题是，作为高熔点材料，在受欢迎的能在光谱蓝端作光发射器的材料中它们的熔点并不高。这是一个很有意思的话题，至少与解决早期光谱红端的固体激光器工作寿命短的问题一样有趣。总地说来，光电子学和光子学在前十年中已经呈现出一些令人瞩目的研究进展，这些在本书中得到了体现，范围从可见光发光器件材料到红外线材料。书中Part D的内容范围很宽，包括III–V族和II–VI族光电子材料和能带隙工程，以及光子玻璃、液态晶体、有机光电导体和光子晶体的新领域。整个部分反映了材料的光产生、工艺、光传输和光探测，包括所有用光取代电子的必要内容。

在电子材料这一章（Part C）探讨了硅的进展。毋庸置疑地是，硅是占据了电子功能和电子电路整个范围主导地位的材料，包括新电介质和其他关于缩减电路和器件的几何尺寸以实现更高密度的封装方面的内容，以及其他书很少涉及的领域，薄膜、高温电子材料、非晶和微晶材料。增加硅使用寿命的新技术成果（包括硅/锗合金）在书中也有介绍，并且又一次提出了同样问题，即，预测硅过时时间是否过于超前！铁电体——一类与硅非常有效结合的材料同样也出现在书中。

Part E章节中（新型材料和选择性的应用）使用了一些极好的新方法开辟了新领地。我们大都知道且频繁使用信息记录器件，但是很少知道，涉及器件使用的材料或原理，比如说CD、视频、DVD等。本书介绍了磁信息存储材料，同样介绍了相变光记录材料，使我们充分与当前发展步伐保持同步更新。该章也同样介绍了太阳能电池、传感器、光导体和碳纳米管的应用，这样大量的工作也体现出编写内容汲取到了世界范围的广度。本章各节中的分子电子和封装材料从研究到应用都得到了呈现。

本书的突出优点在于它的内容覆盖了从基础科学（Part A）到材料的制备、特性（Part B）再到材料的应用（Part C ~ E）。实际上，书中介绍了涉及的所有材料的广泛应用，这就是本书为什么将会实用的原因之一。就像我之前提及的那样，我们之中没有多少人能够成功地预测未来的发展方向和趋势，在未来十年占领这个领域的主导地位。但是，本书教给我们关于材料的基本性能，可用它们去满足将来的需要。我热切地把这本书推荐给你们。

Prof. Arthur Willoughby
Materials Research Group,
University of Southampton,
UK

前　言

不同学科各种各样的手册，例如电子工程、电子学、生物医学工程、材料科学等手册被广大学生、教师、专业人员很好地使用着，大部分的图书馆也都藏有这些手册。这类手册一般包含许多章（至少50章）内容，在已确定的学科内覆盖广泛的课题；学科选材和论述水平吸引着本科生、研究生、研究员，乃至专业工程人员；最新课题提供广泛的信息，这对该领域所有初学者和研究人员是非常有帮助的；每隔几年，就会有增加新内容的新版本更新之前的版本。

电子和光子材料领域没有类似手册的出版，我们出版这本《电子与光子材料手册》的想法是源自于对手册的需求。它广泛覆盖当今材料领域内的课题，在工程学、材料科学、物理学和化学中都有需要。电子和光子材料真正是一门跨学科的学问，它包含了一些传统的学科，如材料科学、电子工程、化学工程、机械工程、物理学和化学。不难发现，机械工程人员对电子封装实施研究，而电子工程人员对半导体特性进行测量。只有很少的几所大学创建了电子材料或光子材料系。一般来说，电子材料作为一个“学科”是以研究组或跨学科的活动出现在“学院”中。有人可能会对此有异议，因为它事实上是一个跨学科领域，非常需要既包括基础学科又要有最新课题介绍的手册，这就是出版本手册的原因。

本手册是一部关于电子和光子材料的综合论述专著，每一章都是由该领域的专家编写的。本手册针对于大学四年级学生或研究生、研究人员和工作在电子、光电子、光子材料领域的专业人员。书中提供了必要的背景知识和内容广泛的更新知识。每一章都有对内容的一个介绍，并且有许多清晰的说明和大量参考文献。清晰的解释和说明使手册对所有层次的研究者有很大的帮助。所有的章节内容都尽可能独立。既有基础又有前沿的章节内容将吸引不同背景的读者。本手册特别重要的一个特点就是跨学科。例如，将会有这样一些读者，其背景（第一学历）是学化学工程的，工作在半导体工艺线上，而想要学习半导体物理的基础知识；第一学历是物理学的另外一些读者需要尽快更新材料科学的新概念，例如，液相外延等。只要可能，本手册尽量避免采用复杂的数学公式，论述将以半定量的形式给出。手册给出了名词术语表（Glossary of Defining Terms），可为读者提供术语定义的快速查找——这对跨学科工具书来说是必须的。

编者非常感激所有作者们卓越的贡献和相互合作，以及在不同阶段对撰写这本手册的奉献。真诚地感谢Springer Boston的Greg Franklin在文献整理以及手册出版的漫长的工作中给予的支持和帮助。Dr.Werner Skolaut在Springer Heidelberg非常熟练地处理了无数个出版问题，涉及审稿、绘图、书稿的编写和校样的修改，我们真诚地感谢他和他所做出的工作——使得手册能够吸引读者。他是我们见过的最有奉献精神和有效率的编者。

感谢Arthur Willoughby教授的诸多建设性意见使得本手册更加完善。他在材料科学杂志（Journal of Materials Science）积累了非常丰富的编辑经验：电子材料这一章在书中起着重要作用，不仅仅是选取章节，而且还要适应读者需要。

最后，编者感谢所有的成员（Marian, Samuel and Tomas; and Nicollette）在全部工作中的支持和付出的特别耐心。

Dr. Peter Capper
Materials Team Leader,
SELEX Sensors and Airborne Systems,
Southampton, UK

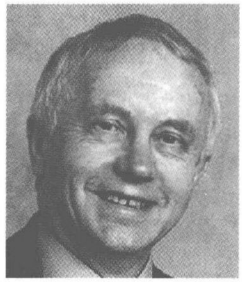
Prof. Safa Kasap
Professor and Canada Research Chair,
Electrical Engineering Department,
University of Saskatchewan,
Canada

Foreword

The Editors, Authors, and Publisher are to be congratulated on this distinguished volume, which will be an invaluable source of information to all workers in the area of electronic and photonic materials. Having made contributions to earlier handbooks, I am well aware of the considerable, and sustained work that is necessary to produce a volume of this kind. This particular handbook, however, is distinguished by its breadth of coverage in the field, and the way in which it discusses the very latest developments. In such a rapidly moving field, this is a considerable challenge, and it has been met admirably.

Previous handbooks and encyclopaedia have tended to concentrate on semiconducting materials, for the understandable reason of their dominance in the electronics field, and the wide range of semiconducting materials and phenomena that must be covered. Few have been courageous enough to predict future trends, but in 1992 Mahajan and Kimerling attempted this in the Introduction to their Concise Encyclopaedia of Semiconducting Materials and Related Technologies (Pergamon), and foresaw future challenges in the areas of nanoelectronics, low dislocation-density III-V substrates, semi-insulating III-V substrates, patterned epitaxy of III-Vs, alternative dielectrics and contacts for silicon technology, and developments in ion-implantation and diffusion. To a greater or lesser extent, all of these have been proved to be true, but it illustrates how difficult it is to make such a prediction.

Not many people would have thought, a decade ago, that the III-nitrides would occupy an important position in this book. As high melting point materials, with the associated growth problems, they were not high on the list of favourites for light emitters at the blue end of the spectrum! The story is a fascinating one – at least as interesting as the solution to the problem of the short working life of early solid-state lasers at the red end of the spectrum. Optoelectronics and photonics, in general, have seen one of the most spectacular advances over the last decade, and this is fully reflected in the book, ranging from visible light emitters, to infra-red materials. The book covers a wide range of work in Part D, including III-V and II-VI optoelectronic materials and band-gap engineering, as well as photonic glasses, liquid crystals, organic photoconductors, and the new area of photonic crystals. The whole Part reflects materials for light generation, processing, transmission and detection – all the essential elements for using light instead of electrons.



Prof. Arthur Willoughby
Materials Research Group,
University of Southampton,
UK

In the Materials for Electronics part (Part C) the book charts the progress in silicon – overwhelmingly the dominant material for a whole range of electronic functions and circuitry – including new dielectrics and other issues associated with shrinking geometry of circuits and devices to produce ever higher packing densities. It also includes areas rarely covered in other books – thick films, high-temperature electronic materials, amorphous and microcrystalline materials. The existing developments that extend the life of silicon technology, including silicon/germanium alloys, appear too, and raise the question again as to whether the predicted timetable for the demise of silicon has again been declared too early!! Ferroelectrics – a class of materials used so effectively in conjunction with silicon – certainly deserve to be here.

The chapters in Part E (Novel Materials and Selected Applications), break new ground in a number of admirable ways. Most of us are aware of, and frequently use, information recording devices such as CDs, videos, DVDs etc., but few are aware of the materials, or principles, involved. This book describes magnetic information storage materials, as well as phase-change optical recording, keeping us fully up-to-date with recent developments. The chapters also include applications such as solar cells, sensors, photoconductors, and carbon nanotubes, on which such a huge volume of work is presently being pursued worldwide. Both ends of the spectrum from research to applications are represented in chapters on molecular electronics and packaging materials.

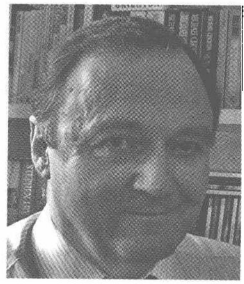
A particular strength of this book is that it ranges from the fundamental science (Part A) through growth and characterisation of the materials (Part B) to applications (Parts C–E). Virtually all the materials covered here have a wide range of applications, which is one of the reasons why this book is going to be so useful. As I indicated before, few of us will be successful in predicting the future direction and trends, occupying the high-ground in this field in the coming decade, but this book teaches us the basic principles of materials, and leaves it to us to adapt these to the needs of tomorrow. I commend it to you most warmly.

Preface

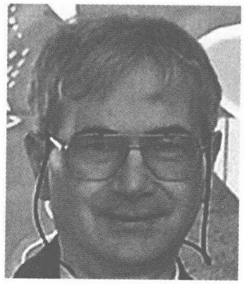
Other handbooks in various disciplines such as electrical engineering, electronics, biomedical engineering, materials science, etc. are currently available and well used by numerous students, instructors and professionals. Most libraries have these handbook sets and each contains numerous (at least 50) chapters that cover a wide spectrum of topics within each well-defined discipline. The subject and the level of coverage appeal to both undergraduate and postgraduate students and researchers as well as to practicing professionals. The advanced topics follow introductory topics and provide ample information that is useful to all, beginners and researchers, in the field. Every few years, a new edition is brought out to update the coverage and include new topics.

There has been no similar handbook in electronic and photonic materials, and the present Springer Handbook of Electronic and Photonic Materials (SHEPM) idea grew out of a need for a handbook that covers a wide spectrum of topics in materials that today's engineers, material scientists, physicists, and chemists need. Electronic and photonic materials is a truly interdisciplinary subject that encompasses a number of traditional disciplines such as materials science, electrical engineering, chemical engineering, mechanical engineering, physics and chemistry. It is not unusual to find a mechanical engineering faculty carrying out research on electronic packaging and electrical engineers carrying out characterization measurements on semiconductors. There are only a few established university departments in electronic or photonic materials. In general, electronic materials as a "discipline" appears as a research group or as an interdisciplinary activity within a "college". One could argue that, because of the very fact that it is such an interdisciplinary field, there is a greater need to have a handbook that covers not only fundamental topics but also advanced topics; hence the present handbook.

This handbook is a comprehensive treatise on electronic and photonic materials with each chapter written by experts in the field. The handbook is aimed at senior undergraduate and graduate students, researchers and professionals working in the area of electronic, optoelectronic and photonic materials. The chapters provide the necessary background and up-to-date knowledge in a wide range of topics. Each chapter has an introduction to the topic, many clear illustrations and numerous references. Clear explanations and illustrations make the handbook useful to all levels of researchers. All chapters are as self-contained as possible. There are both fundamental and advanced chapters to appeal to readers with different backgrounds. This is particularly important for this handbook since the subject matter is highly interdisciplinary. For example, there will be readers with a background (first degree) in chemical engineering and working on semiconductor processing who need to learn the fundamentals of semiconductors physics. Someone with a first degree in physics would need to quickly update himself on materials science concepts such as liquid phase epitaxy and so on. Difficult mathematics has been avoided and, whenever possible, the explanations have been given semiquantitatively. There is a "*Glossary of Defining Terms*" at the end of the handbook, which can serve to quickly find the definition of a term – a very necessary feature in an interdisciplinary handbook.



Dr. Peter Capper
Materials Team Leader,
SELEX Sensors and Airborne Systems,
Southampton, UK



Prof. Safa Kasap
Professor and Canada Research Chair,
Electrical Engineering Department,
University of Saskatchewan,
Canada

The editors are very grateful to all the authors for their excellent contributions and for their cooperation in delivering their manuscripts and in the various stages of production of this handbook. Sincere thanks go to Greg Franklin at Springer Boston for all his support and help throughout the long period of commissioning, acquiring the contributions and the production of the handbook. Dr. Werner Skolaut at Springer Heidelberg has very skillfully handled the myriad production issues involved in copy-editing, figure redrawing and proof preparation and correction and our sincere thanks go to him also for all his hard work in making the handbook attractive to read. He is the most dedicated and efficient editor we have come across.

It is a pleasure to thank Professor Arthur Willoughby for his many helpful suggestions that made this a better handbook. His wealth of experience as editor of the Journal of Materials Science: Materials in Electronics played an important role not only in selecting chapters but also in finding the right authors.

Finally, the editors wish to thank all the members of our families (Marian, Samuel and Thomas; and Nicollette) for their support and particularly their endurance during the entire project.

Peter Capper and Safa Kasap
Editors

List of Authors

Martin Abkowitz
1198 Gatestone Circle
Webster, NY 14580, USA
e-mail: *mabkowitz@mailaps.org, abkowitz@chem.chem.rochester.edu*

Sadao Adachi
Gunma University
Department of Electronic Engineering, Faculty of Engineering
Kiryu-shi 376-8515
Gunma, Japan
e-mail: *adachi@el.gunma-u.ac.jp*

Alfred Adams
University of Surrey
Advanced Technology Institute
Guildford, Surrey, GU2 7XH,
Surrey, UK
e-mail: *alf.adams@surrey.ac.uk*

Guy J. Adriaenssens
University of Leuven
Laboratorium voor Halfgeleiderfysica
Celestijnenlaan 200D
B-3001 Leuven, Belgium
e-mail: *guy.adri@fys.kuleuven.ac.be*

Wilfried von Ammon
Siltronic AG
Research and Development
Johannes Hess Strasse 24
84489 Burghausen, Germany
e-mail: *wilfried.ammon@siltronic.com*

Peter Ashburn
University of Southampton
School of Electronics and Computer Science
Southampton, SO17 1BJ, UK
e-mail: *pa@ecs.soton.ac.uk*

Mark Auslender
Ben-Gurion University of the Negev Beer Sheva
Department of Electrical and Computer Engineering
P.O.Box 653
Beer Sheva 84105, Israel
e-mail: *marka@ee.bgu.ac.il*

Darren M. Bagnall
University of Southampton
School of Electronics and Computer Science
Southampton, SO17 1BJ, UK
e-mail: *dmb@ecs.soton.ac.uk*

Ian M. Baker
SELEX Sensors and Airborne Systems Infrared Ltd.
Southampton, Hampshire SO15 0EG, UK
e-mail: *ian.m.baker@selex-sas.com*

Sergei Baranovskii
Philipps University Marburg
Department of Physics
Renthof 5
35032 Marburg, Germany
e-mail: *baranovs@staff.uni-marburg.de*

Mark Baxendale
Queen Mary, University of London
Department of Physics
Mile End Road
London, E1 4NS, UK
e-mail: *m.baxendale@qmul.ac.uk*

Mohammed L. Benkhedir
University of Leuven
Laboratorium voor Halfgeleiderfysica
Celestijnenlaan 200D
B-3001 Leuven, Belgium
e-mail: *MohammedLoufti.Benkhedir@fys.kuleuven.ac.be*

Monica Brinza
University of Leuven
Laboratorium voor Halfgeleiderfysica
Celestijnenlaan 200D
B-3001 Leuven, Belgium
e-mail: *monica.brinza@fys.kuleuven.ac.be*

Paul D. Brown
University of Nottingham
School of Mechanical, Materials and Manufacturing Engineering
University Park
Nottingham, NG7 2RD, UK
e-mail: *paul.brown@nottingham.ac.uk*

Mike Brozel
University of Glasgow
Department of Physics and Astronomy
Kelvin Building
Glasgow, G12 8QQ, UK
e-mail: *mikebrozel@beeb.net*

Lukasz Brzozowski
University of Toronto
Sunnybrook and Women's Research Institute, Imaging Research/
Department of Medical Biophysics
Research Building, 2075 Bayview Avenue
Toronto, ON, M4N 3M5, Canada
e-mail: *lukbroz@sten.sunnybrook.utoronto.ca*

Peter Capper
SELEX Sensors and Airborne Systems Infrared Ltd.
Materials Team Leader
Millbrook Industrial Estate, PO Box 217
Southampton, Hampshire SO15 0EG, UK
e-mail: *pete.capper@selex-sas.com*

Larry Comstock
San Jose State University
6574 Crystal Springs Drive
San Jose, CA 95120, USA
e-mail: *Comstock@email.sjsu.edu*

Ray DeCorby
University of Alberta
Department of Electrical and Computer Engineering
7th Floor, 9107-116 Street N.W.
Edmonton, Alberta T6G 2V4, Canada
e-mail: *rdecorby@trlabs.ca*

M. Jamal Deen
McMaster University
Department of Electrical and Computer Engineering (CRL 226)
1280 Main Street West
Hamilton, ON L8S 4K1, Canada
e-mail: *jamal@mcmaster.ca*

Leonard Dissado
The University of Leicester
Department of Engineering
University Road
Leicester, LE1 7RH, UK
e-mail: *lad4@le.ac.uk*

David Dunmur
University of Southampton
School of Chemistry
Southampton, SO17 1BJ, UK
e-mail: *d.a.dunmur@soton.ac.uk*

Lester F. Eastman
Cornell University
Department of Electrical and Computer Engineering
425 Phillips Hall
Ithaca, NY 14853, USA
e-mail: *lfe2@cornell.edu*

Andy Edgar
Victoria University
School of Chemical and Physical Sciences SCPS
Kelburn Parade/PO Box 600
Wellington, New Zealand
e-mail: *Andy.Edgar@vuw.ac.nz*

Brian E. Foutz
Cadence Design Systems
1701 North Street, Bldg 257-3
Endicott, NY 13760, USA
e-mail: *foutz@cadence.com*

Mark Fox
University of Sheffield
Department of Physics and Astronomy
Hicks Building, Hounsefield Road
Sheffield, S3 7RH, UK
e-mail: *mark.fox@shef.ac.uk*

Darrel Frear
RF and Power Packaging Technology Development,
Freescale Semiconductor
2100 East Elliot Road
Tempe, AZ 85284, USA
e-mail: *darrel.frear@freescale.com*

Milan Friesel
Chalmers University of Technology
Department of Physics
Fysikgränd 3
41296 Göteborg, Sweden
e-mail: *friesel@chalmers.se*

Jacek Gieraltowski
Université de Bretagne Occidentale
6 Avenue Le Gorgeu, BP: 809
29285 Brest Cedex, France
e-mail: *Jacek.Gieraltowski@univ-brest.fr*

Yinyan Gong
Columbia University
Department of Applied Physics
and Applied Mathematics
500 W. 120th St.
New York, NY 10027, USA
e-mail: *yg2002@columbia.edu*

Robert D. Gould[†]
Keele University
Thin Films Laboratory, Department of Physics,
School of Chemistry and Physics
Keele, Staffordshire ST5 5BG, UK

Shlomo Hava
Ben-Gurion University of the Negev Beer Sheva
Department of Electrical
and Computer Engineering
P.O. Box 653
Beer Sheva 84105, Israel
e-mail: *hava@ee.bgu.ac.il*

Colin Humphreys
University of Cambridge
Department of Materials Science and Metallurgy
Pembroke Street
Cambridge, CB2 3!Z, UK
e-mail: *colin.Humphreys@msm.cam.ac.uk*

Stuart Irvine
University of Wales, Bangor
Department of Chemistry
Gwynedd, LL57 2UW, UK
e-mail: *sjc.irvine@bangor.ac.uk*

Minoru Isshiki
Tohoku University
Institute of Multidisciplinary Research
for Advanced Materials
1-1, Katahira, 2 chome, Aobaku
Sendai, 980-8577, Japan
e-mail: *isshiki@tagen.tohoku.ac.jp*

Robert Johanson
University of Saskatchewan
Department of Electrical Engineering
57 Campus Drive
Saskatoon, SK S7N 5A9, Canada
e-mail: *johanson@engr.usask.ca*

Tim Joyce
University of Liverpool
Functional Materials Research Centre,
Department of Engineering
Brownlow Hill
Liverpool, L69 3BX, UK
e-mail: *t.joyce@liv.ac.uk*

M. Zahangir Kabir
Concordia University
Department of Electrical and Computer Engineering
Montreal, Quebec S7N5A9, Canada
e-mail: *kabir@encs.concordia.ca*

Safa Kasap
University of Saskatchewan
Department of Electrical Engineering
57 Campus Drive
Saskatoon, SK S7N 5A9, Canada
e-mail: *safa.kasap@usask.ca*

Alexander Kolobov
National Institute of Advanced Industrial Science and Technology
Center for Applied Near-Field Optics Research
1-1-1 Higashi, Tsukuba
Ibaraki, 305-8562, Japan
e-mail: *a.kolobov@aist.go.jp*

Cyril Koughia
University of Saskatchewan
Department of Electrical Engineering
57 Campus Drive
Saskatoon, SK S7N 5A9, Canada
e-mail: *kik486@mail.usask.ca*

Igor L. Kuskovsky
Queens College, City University of New York (CUNY)
Department of Physics
65-30 Kissena Blvd.
Flushing, NY 11367, USA
e-mail: *igor_kuskovsky@qc.edu*

Geoffrey Luckhurst
University of Southampton
School of Chemistry
Southampton, SO17 1BJ, UK
e-mail: *g.r.luckhurst@soton.ac.uk*

Akihisa Matsuda
Tokyo University of Science
Research Institute for Science and Technology
2641 Yamazaki, Noda-shi
Chiba, 278-8510, Japan
e-mail: *amatsuda@rs.noda.tus.ac.jp*, *a.matsuda@aist.go.jp*

Naomi Matsuura
Sunnybrook Health Sciences Centre
Department of Medical Biophysics, Imaging Research
2075 Bayview Avenue
Toronto, ON M4N 3M5, Canada
e-mail: *matsuura@sri.utoronto.ca*

Kazuo Morigaki
University of Tokyo
C-305, Wakabadai 2-12, Inagi
Tokyo, 206-0824, Japan
e-mail: *k.morigaki@yacht.ocn.ne.jp*

Hadis Morkoç
Virginia Commonwealth University
Department of Electrical and Computer Engineering
601 W. Main St., Box 843072
Richmond, VA 23284-3068, USA
e-mail: *hmorkoc@vcu.edu*

Winfried Mönch
Universität Duisburg-Essen
Lotharstraße 1
47048 Duisburg, Germany
e-mail: *w.moench@uni-duisburg.de*

Arokia Nathan
University of Waterloo
Department of Electrical and Computer Engineering
200 University Avenue W.
Waterloo, Ontario N2L 3G1, Canada
e-mail: *anathan@uwaterloo.ca*

Gertrude F. Neumark
Columbia University
Department of Applied Physics
and Applied Mathematics
500W 120th St., MC 4701
New York, NY 10027, USA
e-mail: *gfn1@columbia.edu*

Stephen K. O'Leary
University of Regina
Faculty of Engineering
3737 Wascana Parkway
Regina, SK S4S 0A2, Canada
e-mail: *stephen.oleary@uregina.ca*

Chisato Ogihara
Yamaguchi University
Department of Applied Science
2-16-1 Tokiwadai
Ube, 755-8611, Japan
e-mail: *ogihara@yamaguchi-u.ac.jp*

Fabien Pascal
Université Montpellier 2/CEM2-cc084
Centre d'Electronique
et de Microoptoélectronique de Montpellier
Place E. Bataillon
34095 Montpellier, France
e-mail: *pascal@cem2.univ-montp2.fr*

Michael Petty
University of Durham
Department School of Engineering
South Road
Durham, DH1 3LE, UK
e-mail: *m.c.petty@durham.ac.uk*

Asim Kumar Ray
Queen Mary, University of London
Department of Materials
Mile End Road
London, E1 4NS, UK
e-mail: *a.k.ray@qmul.ac.uk*

John Rowlands
University of Toronto
Department of Medical Biophysics
Sunnybrook and Women's College
Health Sciences Centre
S656-2075 Bayview Avenue
Toronto, ON M4N 3M5, Canada
e-mail: *john.rowlands@sri.utoronto.ca*

Oleg Rubel
Philipps University Marburg
Department of Physics
and Material Sciences Center
Renthof 5
35032 Marburg, Germany
e-mail: *oleg.rubel@physik.uni-marburg.de*

Harry Ruda
University of Toronto
Materials Science and Engineering,
Electrical and Computer Engineering
170 College Street
Toronto, M5S 3E4, Canada
e-mail: *ruda@ecf.utoronto.ca*

Edward Sargent
University of Toronto
Department of Electrical
and Computer Engineering
ECE, 10 King's College Road
Toronto, M5S 3G4, Canada
e-mail: *ted.sargent@utoronto.ca*

Peyman Servati
Ignis Innovation Inc.
55 Culpepper Dr.
Waterloo, Ontario N2L 5K8, Canada
e-mail: *pservati@uwaterloo.ca*

Derek Shaw
Hull University
Hull, HU6 7RX, UK
e-mail: *DerekShaw1@compuserve.com*

Fumio Shimura
Shizuoka Institute of Science and Technology
Department of Materials and Life Science
2200-2 Toyosawa
Fukuroi, Shizuoka 437-8555, Japan
e-mail: *shimura@ms.sist.ac.jp*

Michael Shur
Rensselaer Polytechnic Institute
Department of Electrical, Computer, and Systems Engineering
CII 9017, RPI, 110 8th Street
Troy, NY 12180, USA
e-mail: *shurm@rpi.edu*

Jai Singh
Charles Darwin University
School of Engineering and Logistics, Faculty of Technology, B-41
Ellengowan Drive
Darwin, NT 0909, Australia
e-mail: *jai.singh@cdu.edu.au*

Tim Smeeton
Sharp Laboratories of Europe
Edmund Halley Road, Oxford Science Park
Oxford, OX4 4GB, UK
e-mail: *tim.smeeton@sharp.co.uk*

Boris Straumal
Russian Academy of Sciences
Institute of Sold State Physics
Institutskii prospect 15
Chernogolovka, 142432, Russia
e-mail: *straumal@issp.ac.ru*

Stephen Sweeney
University of Surrey
Advanced Technology Institute
Guildford, Surrey GU2 7XH, UK
e-mail: *s.sweeney@surrey.ac.uk*

David Sykes
Loughborough Surface Analysis Ltd.
PO Box 5016, Unit FC, Holywell Park, Ashby Road
Loughborough, LE11 3WS, UK
e-mail: *d.e.sykes@lsaltd.co.uk*

Keiji Tanaka
Hokkaido University
Department of Applied Physics, Graduate School of Engineering
Kita-ku, N13 W8
Sapporo, 060-8628, Japan
e-mail: *keiji@eng.hokudai.ac.jp*

Charbel Tannous
Université de Bretagne Occidentale
LMB, CNRS FRE 2697
6 Avenue Le Gorgeu, BP: 809
29285 Brest Cedex, France
e-mail: *tannous@univ-brest.fr*

Ali Teke
Balikesir University
Department of Physics, Faculty of Art and Science
Balikesir, 10100, Turkey
e-mail: *ateke@balikesir.edu.tr*

Junji Tominaga
National Institute of Advanced Industrial Science and Technology, AIST
Center for Applied Near-Field Optics Research, CAN-FOR
Tsukuba Central 4 1-1-1 Higashi
Tsukuba, 3.5-8562, Japan
e-mail: *j-tomonaga@aist.go.jp*

Dan Tonchev
University of Saskatchewan
Department of Electrical Engineering
57 Campus Drive
Saskatoon, SK S7N 5A9, Canada
e-mail: *dan.tonchev@usask.ca*

Harry L. Tuller
Massachusetts Institute of Technology
Department of Materials Science and Engineering, Crystal Physics and Electroceramics Laboratory
77 Massachusetts Avenue
Cambridge, MA 02139, USA
e-mail: *tuller@mit.edu*