

PROCEEDINGS OF SPIE

Carbon Nanotubes, Graphene, and Associated Devices VII

**Manijeh Razeghi
Young Hee Lee
Maziar Ghazinejad**
Editors

**20–21 August 2014
San Diego, California, United States**

Sponsored by
SPIE

Cosponsored by
Aldrich Materials Science (United States)

Published by
SPIE

Volume 9168

Proceedings of SPIE 0277-786X, V. 9168

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Carbon Nanotubes, Graphene, and Associated Devices VII, edited by Manijeh Razeghi,
Young Hee Lee, Maziar Ghazinejad, Proc. of SPIE Vol. 9168, 916801 · © 2014 SPIE
CCC code: 0277-786X/14/\$18 · doi: 10.1117/12.2081210

Proc. of SPIE Vol. 9168 916801-1

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Carbon Nanotubes, Graphene, and Associated Devices VII*, edited by Manijeh Razeghi, Young Hee Lee, Maziar Ghazinejad, Proceedings of SPIE Vol. 9168 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628411959

Published by

SPIE

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2014, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/14/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID Number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID Number.

Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>
ix	<i>Introduction</i>

SESSION 1	SYNTHESIS AND CHARACTERIZATION I
9168 04	Optical impedance transformer for transparent conducting electrodes [9168-3]
9168 07	Nonlinear optical and electrical conductivity properties of Carbon Nanotubes (CNT) doped in Sol-Gel matrices [9168-13]
SESSION 2	DEVICES I
9168 09	Femtomolar molecular detection with CNT based SERS substrate (Invited Paper) [9168-7]
9168 0B	Graphene nano-objects tailored by interference lithography [9168-9]
9168 0C	Formation of Fabry-Perot cavity in one-dimensional and two-dimensional GaAs nanostructures [9168-32]
SESSION 3	SYNTHESIS AND CHARACTERIZATION II
9168 0H	Simulation of Maxwell-Dirac equations in graphene nanostructures [9168-15]
SESSION 4	DEVICES II
9168 0M	Pillared graphene and silicon nanocomposite architecture for anodes of lithium ion batteries [9168-20]
SESSION 5	DEVICES III
9168 0O	Cross-linked carbon nanotube heat spreader [9168-21]
9168 0S	A comparative study of the thermal interface materials with graphene and boron nitride fillers [9168-29]
	POSTER SESSION
9168 0T	Separation of the semiconducting and the metallic types of single-wall carbon nanotube by electrophoresis method [9168-10]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Alaie, Seyed Hamidreza, 0B
Altun, Ali Ozhan, 09
Arab, Shermin, 0C
Balandin, A. A., 0S
Bar, Galit, 07
Bond, Tiziana C., 09
Brueck, Steven R. J., 0B
Burshtein, Zeev, 07
Chen, Guan-Jhen, 0T
Chen, Hsi-Chao, 0T
Chi, ChunYung, 0C
Cronin, Stephen B., 0C
Dapkus, P. Daniel, 0C
Dawson, Noel Mayur, 0B
Fan, Shanhui, 04
Ghasemi, Javad, 0B
Gvishi, Raz, 07
Habteyes, Terefe, 0B
He, Xiang, 0B
Hsiao, Tzu-Ti, 0T
Huang, Kuo-Ting, 0T
Kargar, F., 0S
Kazemi, Alireza, 0B
Kiesow, Karissa, 0B
Klein, Brianna, 0B
Konesky, Gregory, 0O
Krishna, Sanjay, 0B
Lee, Hsin-Ta, 0T
Legedza, S., 0S
Ozkan, Cengiz S., 0M
Ozkan, Mihrimah, 0M
Park, Hyung Gyu, 09
Piper, Jessica R., 04
Pokrass, Mariana, 07
Renteria, J., 0S
Ruiz, Isaac, 0M
Salgado, R., 0S
Wang, Ken X., 04
Wang, Wei, 0M
Wozniak, Douglas, 0B
Yang, Wan-Ting, 0T
Yao, Maoqing, 0C
Yen, Chih-Feng, 0T
Zhang, Xuechang, 0H
Zhou, Chongwu, 0C
Zhou, Yang, 0T

Conference Committee

Symposium Chairs

Satoshi Kawata, Osaka University (Japan)
Manijeh Razeghi, Northwestern University (United States)

Symposium Co-chairs

David L. Andrews, University of East Anglia Norwich (United Kingdom)
James G. Grote, Air Force Research Laboratory (United States)

Conference Chairs

Manijeh Razeghi, Northwestern University (United States)
Young Hee Lee, Sungkyunkwan University (Korea, Republic of)
Maziar Ghazinejad, California State University, Fresno (United States)

Conference Program Committee

Paolo Bondavalli, Thales Research & Technology (France)
Jia Choi, Sigma-Aldrich Company (United States)
Costel-Sorin Cojocaru, Ecole Polytechnique (France)
Kenji Hata, National Institute of Advanced Industrial Science and Technology (Japan)
Mark C. Hersam, Northwestern University (United States)
Seong Chan Jun, Yonsei University (Korea, Republic of)
Horacio Lamela Rivera, Universidad Carlos III de Madrid (Spain)
Seung Hee Lee, Chonbuk National University (Korea, Republic of)
Annick Loiseau, ONERA (France)
Ryan McClintock, Northwestern University (United States)
William I. Milne, University of Cambridge (United Kingdom)
Philip W. T. Pong, The University of Hong Kong (Hong Kong, China)
Seunghyun Baik, Sungkyunkwan University (Korea, Republic of)

Session Chairs

- 1 Synthesis and Characterization I
Maziar Ghazinejad, California State University, Fresno (United States)
- 2 Devices I
Mark C. Hersam, Northwestern University (United States)
- 3 Synthesis and Characterization II
Maziar Ghazinejad, California State University, Fresno (United States)

- 4 Devices II
 Maziar Ghazinejad, California State University, Fresno (United States)
- 5 Devices III
 Maziar Ghazinejad, California State University, Fresno (United States)

Introduction

As industry demands more and more sophisticated solutions from applied sciences, there is an ever-growing need for new materials with promises that are beyond those of the traditional materials. Today, technological breakthroughs are often associated with the development of materials that can revolutionize the very nature of an industrial field. Successful implementation of these materials solution, however, often calls for reliable synthesis, characterization and device application approaches. Carbon Nanotubes and its younger sibling, graphene, are standard examples of such trend. With their versatility and unprecedented electrical, optical, thermal and mechanical attributes, graphene and carbon nanotubes are poised to become materials of choice for a wide range of industrial applications.

With the high level of scientific interest in carbon nanomaterials, we are pleased to provide SPIE members with a platform to connect and share their research across multidisciplinary frontiers that cover all aspects of nano-carbon science and engineering. In this year's conference of Carbon Nanotubes, Graphene, and Associated Devices, we have categorized the paper presentations in two main sections of Synthesis and Characterization, and Devices. In the former category we covered a variety of studies, including optoelectronics of graphene transparent conducting electrodes, industrial scale metrology of graphene materials, optical-electrical characterization of CNT doped Sol-Gel matrices, and rapidly growing subject of transition metal dichalcogenide monolayers. In the *Devices* category, we had stimulating research works with versatile topics that includes, carbon nanomaterial electronics and optoelectronic technologies, CNT-based substrates for surface enhanced Raman spectroscopy, graphene-boron nitride composites for optoelectronic devices, graphene based energy storage systems, and application of graphene materials in thermal interface products.

In our future issues we plan to enhance the scientific scope of SPIE's nano-carbon conference by including more research works from emerging areas of nano-science and engineering. The conference particularly aims to organize special sessions that will focus on contemporary subjects of new 2D materials and systems, and carbon nanomaterials for sustainable energy harvesting. Topics of interest will include current synthesis routes for 2D materials, nano carbon-based energy storage and conversion, and device application of 2D materials.

We would like to thank all of our authors and presenters for their contribution to this issue of SPIE's NanoScience + Engineering proceedings, and hope that the presented studies stimulate further innovations and research on Carbon Nanotube, Graphene and Associated Devices.

Manijeh Razeghi
Young Hee Lee
Maziar Ghazinejad

