PROCEEDINGS OF SPIE

Reliability, Packaging, Testing, and Characterization of MEMS/MOEMS and Nanodevices VIII

Richard C. Kullberg
Rajeshuni Ramesham
Editors

28–29 January 2009
San Jose, California, United States

Sponsored by
SPIE

Symposium Cosponsors
Texas Instruments Inc. (United States)
NanoInk, Inc. (United States)
The Photonics Center at Boston University (United States)
Ozen Engineering, Inc. (United States)

Published by
SPIE

Volume 7206

Proceedings of SPIE, 0277-786X, v. 7206

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 *Reliability, Packaging, Testing, and Characterization of MEMS/MOEMS and Nanodevices VIII*, edited by Richard C. Kullberg, Rajeshuni Ramesham, Proceedings of SPIE Vol. 7206 (SPIE, Bellingham, WA, 2009) Article CID Number.

ISSN 0277-786X
ISBN 9780819474520

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

Printed in the United States of America.

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

SPIE Digital Library

SPIEDigitalLibrary.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 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

Conference Committee

Symposium Chair

Albert K. Henning, NanoInk, Inc. (United States)

Symposium Cochair

Thomas J. Suleski, The University of North Carolina at Charlotte (United States)

Conference Chairs

Richard C. Kullberg, Arthur Jonath Associates (United States)
Rajeshuni Ramesham, Jet Propulsion Laboratory (United States)

Conference Cochairs

Allyson L. Hartzell, Boston Micromachines Corporation (United States)
James L. Zunino III, U.S. Army Armament Research, Development and Engineering Center (United States)

Program Committee

Enakshi Bhattacharya, Indian Institute of Technology Madras (India)
Jason O. Clevenger, Exponent Inc. (United States)
Colin K. Drummond, ASM International (United States)
Sonia García-Blanco, Institut National d'Optique (Canada)
Christopher K. Harrison, Schlumberger Ltd. (United States)
Albert K. Henning, NanoInk, Inc. (United States)
Maurice S. Karpman, Charles Stark Draper Laboratory, Inc. (United States)
Olivier N. Pierron, Georgia Institute of Technology (United States)
Herbert R. Shea, École Polytechnique Fédérale de Lausanne (Switzerland)
Danelle M. Tanner, Sandia National Laboratories (United States)

Session Chairs

1 MEMS Packing: Assembly and Reliability
Sonia García-Blanco, Institut National d'Optique (Canada)

2 MEMS/MOEMS Reliability
Richard C. Kullberg, Arthur Jonath Associates (United States)

Introduction

The reliability, packaging, testing, and characterization of MEMS/MOEMS are of paramount importance to the commercialization of these advanced and useful emerging technologies. This is the International Reliability Conference and the contributors at this conference attend from around the world. The main objective of this one and only premier reliability conference is to provide a technical forum for in-depth investigations and interdisciplinary discussions involving reliability, packaging, testing, and characterization of MEMS/MOEMS. The response to the call for papers has been awesome and technically rewarding to the MEMS/MOEMS and other community.

The Reliability, Packaging, Testing, and Characterization of MEMS/MOEMS and Nanodevices VIII conference is sponsored by SPIE, and is a part of Photonics West 2009. The conference is a part of the MOEMS-MEMS 2009 Devices/ Applications/Reliability symposium and education program on MOEMS-MEMS, which was held 24–29 January 2009 in the San Jose Convention Center, San Jose, California, USA. SPIE is the premier international forum for presentation of the latest developments associated with MEMS and MOEMS including reliability, testing, packaging, materials, surfaces, and characterization. This conference on the topic of Reliability, Packaging, Testing, and Characterization has been held for over 10 consecutive years.

In preparing for the conference, 20 high-quality papers were received from various countries. This year four sessions covered MEMS Packaging: Assembly and Reliability, MEMS/MOEMS Reliability, and Testing, Characterization, and Failure Analysis of MEMS/MOEMS.

We had a technical program that has three plenary speakers and four invited/keynote speakers from various reputed laboratories around the country and the globe.

We would like to personally thank Dr. Danelle Tanner, Dr. Sonia García-Blanco, Dr. Herbert Shea, as well as Dr. Al Henning and Dr. Thomas Suleski (symposium chair and cochair), and the SPIE staff for their unstinted timely support and encouragement. Finally, we would like to thank the session chairs, conference cochairs, and the program committee members for their support in organizing this conference successfully. We thank all the participants and everyone who participated in this conference.

Richard C. Kullberg
Rajeshuni Ramesham