PROCEEDINGS OF SPIE

# *Reliability, Packaging, Testing, and Characterization of MOEMS/MEMS, Nanodevices, and Nanomaterials XIII*

**Herbert R. Shea**
**Rajeshuni Ramesham**
*Editors*

**3–4 February 2014**
**San Francisco, California, United States**

*Sponsored by*
SPIE

*Cosponsored by*
Samsung Advanced Institute of Technology (Korea, Republic of)

*Published by*
SPIE

**Volume 8975**

Proceedings of SPIE 0277-786-786X, V.8975



Reliability, Packaging, Testing, and Characterization of MOEMS/MEMS, Nanodevices, and Nanomaterials XIII, edited by Herbert R. Shea, Rajeshuni Ramesham, Proc. of SPIE Vol. 8975, 897501

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 MOEMS/MEMS, Nanodevices, and Nanomaterials XIII*, edited by Herbert R. Shea, Rajeshuni Ramesham, Proceedings of SPIE Vol. 8975 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819498885

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 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

# Conference Committee

*Symposium Chair*

**David L. Dickensheets**, Montana State University (United States)

*Symposium Co-chair*

**Holger Becker**, microfluidic ChipShop GmbH (Germany)

*Conference Chairs*

**Herbert R. Shea**, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
**Rajeshuni Ramesham**, Jet Propulsion Laboratory (United States)

*Conference Program Committee*

**Cheryl G. Asbury**, Jet Propulsion Laboratory (United States)
**Paul A. Bierden**, Boston Micromachines Corporation (United States)
**Sonia M. García-Blanco**, Universiteit Twente (Netherlands)
**Christopher K. Harrison**, Schlumberger-Doll Research Center (United States)
**Allyson Hartzell**, Qualcomm Inc. (United States) and Pixtronix, Inc. (United States)
**Albert K. Henning**, Aquarian Microsystems (United States)
**Maurice S. Karpman**, Draper Laboratory (United States)
**Richard C. Kullberg**, Vacuum Energy, Inc. (United States)
**Kee-Keun Lee**, Ajou University (Korea, Republic of)
**Jose M. Pozo**, TNO (Netherlands)
**Tolga Tekin**, Technische Universität Berlin (Germany)
**Joyce H. Wu**, Qualcomm Inc. (United States) and Pixtronix, Inc. (United States)
**Yanzhu Zhao**, Medtronic, Inc. (United States)

*Session Chairs*

1 **Joyce H. Wu**, Qualcomm Inc. (United States) and Pixtronix, Inc. (United States)
2 **Rajeshuni Ramesham**, Jet Propulsion Laboratory (United States)
3 **Herbert R. Shea**, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
4 **Cheryl G. Asbury**, Jet Propulsion Laboratory (United States)

# Introduction

A successful MOEMS-MEMS device is built on more than the physical sensor or actuator and the associated electronics. Packaging plays a key role in device performance, lifetime, and cost. Given the strong interaction between the environment and MOEMS-MEMS sensors, and given the multiphysics nature of all MOEMS-MEMS devices, novel testing and characterization methods are required to understand MOEMS-MEMS failure modes. Novel assembly, integration, and packaging approaches are being developed, all posing qualification challenges.

This MOEMS-MEMS symposium brought together experts in a broad range of fields to discuss the latest advances in the fields of MOEMS-MEMS testing, packaging, reliability, and characterization.

The widespread use of MOEMS and MEMS in consumer electronics, the medical field, communications, optical communications, and even spacecraft, and the associated increased maturity of many microfabrication and packaging technologies and processes, has resulted in a marked increase in the performance of commercially available tools for characterizing MOEMS-MEMS. The increased maturity of MOEMS-MEMS has created a need for improved, higher throughput, more sensitive testing techniques for materials properties and device performance. Several exciting new approaches were presented at this symposium as well as the Reliability conference.

The use of MOEMS-MEMS in ever-harsher environments (high temperature, high radiation, high shocks, and vibration, etc.) is enabled by the use of new materials, such as GaN, which in turn require novel processing techniques, new testing techniques, and test equipment. One accelerated testing approach adapted from the standard microelectronics field is HALT (Highly Accelerated Lifetime Testing) that was shown to be applicable to assess the reliability electronic packaging.

This symposium also included novel integration technologies, and the use of non-conventional materials for new applications. Examples of complete MOEMS and MEMS systems were also presented, with the associated reliability challenges.

We invite you to explore these proceedings and we look forward to seeing you next year for another lively symposium.

**Herbert R. Shea**
**Rajeshuni Ramesham**