PROCEEDINGS OF SPIE

Industrial and Commercial Applications of Smart Structures Technologies 2013

Kevin M. Farinholt
Steven F. Griffin
Editors

10–14 March 2013
San Diego, California, United States

Sponsored by
SPIE

Cosponsored by
American Society of Mechanical Engineers (United States)

Cooperating Organizations
Intelligent Materials Forum (Japan)
Jet Propulsion Laboratory (United States)
National Science Foundation (United States)

Published by
SPIE

Volume 8690

Proceedings of SPIE 0277-786X, V. 8690

Industrial and Commercial Applications of Smart Structures Technologies 2013,
edited by Kevin M. Farinholt, Steven F. Griffin, Proc. of SPIE Vol. 8690, 86900P

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 *Industrial and Commercial Applications of Smart Structures Technologies 2013*, edited by Kevin M. Farinholt, Steven F. Griffin, Proceedings of SPIE Vol. 8690 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819494733

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 Chairs

Norbert G. Meyendorf, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany) and University of Dayton (United States)
Norman Wereley, University of Maryland, College Park (United States)

Symposium Cochairs

Victor Giurgiutiu, University of South Carolina (United States)
Christopher S. Lynch, University of California, Los Angeles (United States)

Conference Chair

Kevin M. Farinholt, Commonwealth Center for Advanced Manufacturing (United States)

Conference Cochair

Steven F. Griffin, Boeing LTS Inc. (United States)

Conference Program Committee

Eric H. Anderson, CSA Engineering, Inc. (United States)
Emil V. Ardelean, Schafer Corppration (United States)
Brandon J. Arritt, Air Force Research Laboratory (United States)
Christian Boller, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany)
Diann E. Brei, University of Michigan (United States)
Alan L. Browne, General Motors Corporation (United States)
Peter C. Chen, NASA Goddard Space Flight Center (United States)
Marcelo J. Dapino, The Ohio State University (United States)
L. Porter Davis, Honeywell Defense and Space Electronic Systems (United States)
Xiao-Yan Gong, Medical Implant Mechanics LLC (United States)
Holger Hanselka, Fraunhofer-Institut für Betriebsfestigkeit und Systemzuverlässigkeit (Germany)
Ernie Havens, Cornerstone Research Group, Inc. (United States)
Nancy L. Johnson, General Motors Corporation (United States)
Chad H. Joshi, Energen, Inc. (United States)
Jayanth N. Kudva, NextGen Aeronautics, Inc. (United States)
Amrita Kumar, Acellent Technologies, Inc. (United States)

Ou Ma, New Mexico State University (United States)
Geoffrey P. McKnight, HRL Laboratories, LLC (United States)
Christopher Niezrecki, University of Massachusetts Lowell (United States)
Gyuhae Park, Chonnam National University (Korea, Republic of)
Marc E. Regelbrugge, Rhombus Consultants Group (United States)
W. Lance Richards, NASA Dryden Flight Research Center (United States)
Eric J. Ruggiero, GE Global Research (United States)
Janet M. Sater, Institute for Defense Analyses (United States)
Henry Sodano, University of Florida (United States)
Edward V. White, The Boeing Company (United States)

Session Chairs

1 Smart Structures Technologies for Control
Gyuhae Park, Chonnam National University (Korea, Republic of)

2 Enabling Technologies for Embedded Sensing
Kevin M. Farinholt, Commonwealth Center for Advanced Manufacturing (United States)

3 Aerospace Applications
Steven F. Griffin, Boeing LTS Inc. (United States)

4 Automotive Applications
Diann E. Brei, University of Michigan (United States)
Marcelo J. Dapino, The Ohio State University (United States)