PROCEEDINGS OF SPIE

Health Monitoring of Structural and Biological Systems 2007

Tribikram Kundu
Editor

19–22 March 2007
San Diego, California, USA

Sponsored and Published by
SPIE—The International Society for Optical Engineering

Cosponsored by
American Society of Mechanical Engineers (USA)

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

Volume 6532

The International Society for Optical Engineering

Proceedings of SPIE—The International Society for Optical Engineering, 9780819466532, v. 6532

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 *Health Monitoring of Structural and Biological Systems 2007*, edited by Tribikram Kundu, Proceedings of SPIE Vol. 6532 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819466532

Published by
SPIE—The International Society for Optical Engineering
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone 1 360/676-3290 (Pacific Time) · Fax 1 360/647-1445
http://www.spie.org

Printed in the United States of America.

Contents

Pagination: 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.

Symposium Committee

Symposium Chairs

Yoseph Bar-Cohen, Jet Propulsion Laboratory (USA)
Alison B. Flatau, University of Maryland, College Park (USA)
Norbert G. Meyendorf, University of Dayton (USA) and Fraunhofer Institute of Non-Destructive Testing (Germany)
George Y. Baaklini, NASA Glenn Research Center (USA)

Executive Committee

Mehdi Ahmadian, Virginia Polytechnic Institute and State University (USA)
George Y. Baaklini, NASA Glenn Research Center (USA)
Yoseph Bar-Cohen, Jet Propulsion Laboratory (USA)
Marcelo J. Dapino, The Ohio State University (USA)
L. Porter Davis, Honeywell, Inc. (USA)
Michael A. Demetriou, Worcester Polytechnic Institute (USA)
Aaron A. Diaz, Pacific Northwest National Laboratory (USA)
Alison B. Flatau, University of Maryland, College Park (USA)
Victor Giurgiutiu, University of South Carolina (USA)
B. K. Henderson, Air Force Research Laboratory (USA)
Kumar Jata, Air Force Research Laboratory (USA)
Gabor M., Kovacs, EMPA (Switzerland)
Tribikram Kundu, The University of Arizona (USA)
Donald J. Leo, DARPA (USA) and Virginia Polytechnic Institute and State University (USA)
Douglas K. Lindner, Virginia Polytechnic Institute and State University (USA)
Ajit K. Mal, University of California, Los Angeles (USA)
Yuji Matsuzaki, Nagoya University (Japan)
M. Brett McMickell, Honeywell, Inc. (USA)
Norbert G. Meyendorf, University of Dayton (USA)
Zoubeida Ounaies, Texas A&M University (USA)
Kara J. Peters, North Carolina State University (USA)
Peter J. Shull, The Pennsylvania State University (USA)
Masayoshi Tomizuka, University of California, Berkeley (USA)
Eric Udd, Columbia Gorge Research (USA)
Vijay K. Varadan, University of Arkansas (USA)
Dietmar W. Vogel, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)
H. Felix Wu, National Institute of Standards and Technology (USA)
Chung-Bang Yun, Korea Advanced Institute of Science and Technology (South Korea)

Conference Committee

Conference Chair

Tribikram Kundu, The University of Arizona (USA)

Conference Cochairs

Ajit K. Mal, University of California, Los Angeles (USA)
Kumar V. Jata, Air Force Research Laboratory (USA)

Program Committee

Douglas E. Adams, Purdue University (USA)
Yoseph Bar-Cohen, Jet Propulsion Laboratory (USA)
Jürgen Bereiter-Hahn, Johann Wolfgang Goethe-Universität (Germany)
Fu-Kuo Chang, Stanford University (USA)
Olivier Giraudo, ONERA (France)
Victor Giurgiutiu, University of South Carolina (USA)
Wolfgang Grill, Universität Leipzig (Germany)
Shivan Haran, Arkansas State University (USA)
Sridhar Krishnaswamy, Northwestern University (USA)
Francesco Lanza di Scalea, University of California, San Diego (USA)
Shih-Chi Liu, National Science Foundation (USA)
Jerome P. Lynch, University of Michigan (USA)
Won-Bae Na, Pukyong National University (South Korea)
P. Frank Pai, University of Missouri, Columbia (USA)
Paul D. Panetta, Luna Innovations, Inc. (USA)
Dominique Placko, Ecole Normale Supérieure de Cachan (France)
Amit Shukla, Miami University (USA)
Hoon Sohn, Carnegie Mellon University (USA)
Michael D. Todd, University of California, San Diego (USA)
Wei-Chih Wang, University of Washington (USA) and Southern Taiwan University of Technology (Taiwan)
Hwai-Chung Wu, Wayne State University (USA)
George Zentai, Varian Medical Systems, Inc. (USA)

Session Chairs

1 SHM for Aerospace Applications
Tribikram Kundu, The University of Arizona (USA)
Wolfgang Grill, Universität Leipzig (Germany)

2 Guided Waves for SHM I
Francesco Lanza di Scalea, University of California, San Diego (USA)
Hoon Sohn, Carnegie Mellon University (USA)

3 Guided Waves for SHM II
Hoon Sohn, Carnegie Mellon University (USA)
Francesco Lanza di Scalea, University of California, San Diego (USA)

4 Guided Waves for SHM of Pipes and Rods
Victor Giurgiutiu, University of South Carolina (USA)
Paul D. Panetta, Luna Innovations, Inc. (USA)

5 Guided Waves for SHM III
Francesco Lanza di Scalea, University of California, San Diego (USA)
Won-Bae Na, Pukyong National University (South Korea)

6 Damage Detection
Wolfgang Grill, Universität Leipzig (Germany)
Kumar V. Jata, Air Force Research Laboratory (USA)

7 Nonlinear Methods in SHM
Michael D. Todd, University of California, San Diego (USA)
Douglas E. Adams, Purdue University (USA)

8 Novel Instrumentation and Sensing I
Sridhar Krishnaswamy, Northwestern University (USA)
Won-Bae Na, Pukyong National University (South Korea)

9 Novel Instrumentation and Sensing II
Kumar V. Jata, Air Force Research Laboratory (USA)
Hwai-Chung Wu, Wayne State University (USA)

10 Civil Infrastructure Applications
Shivan Haran, Arkansas State University (USA)

11 Damage Detection and Prediction
Jerome P. Lynch, University of Michigan (USA)
Goutham R. Kirikera, Northwestern University (USA)

12 Biological and Medical Applications I
George Zentai, Varian Medical Systems, Inc. (USA)
Masoud Ghandehari, Polytechnic University (USA)

13 Biological and Medical Applications II
Wei-Chih Wang, University of Washington (USA) and Southern Taiwan University of Technology (Taiwan)
Olivier Giraudo, ONERA (France)

14 Guided Waves and Vibration Based Techniques for SHM
Sauvik Banerjee, Saint Louis University (USA)
Hoon Sohn, Carnegie Mellon University (USA)

Introduction

In the year 2001 the SPIE conference on Health Monitoring of Structural and Biological Systems (SPIE Vol. 4335) brought engineers, materials scientists, medical doctors, and biologists together to exchange their ideas on this important issue. After having a positive experience at that conference, yearly conferences were organized on the same topic (SPIE Vol. 4702 (2002), SPIE Vol. 5047 (2003), SPIE Vol. 5394 (2004), SPIE Vol. 5768 (2005), and SPIE Vol. 6177 (2006)) and the next one has been planned for the year 2008. These proceedings, SPIE Vol. 6532, contain papers presented at the 2007 conference.

The emphasis of this conference is to recognize that nondestructive evaluation is an integral part of health monitoring of both structural and biological systems. It is my hope that biological and physical science communities are learning from each other by coming to this conference and exchanging ideas. Some of the recent advances in the science and technology of health monitoring techniques that go beyond the traditional nondestructive imaging of internal defects are presented in these proceedings. New diagnosis, prognosis, and rehabilitation techniques applied to engineering structures made of metal, concrete, and composites, as well as biological systems, such as animal and human body parts are presented. The papers published here cover a wide range of technologies. It is hoped that this conference will stimulate further interactions between physical and life science communities resulting in new developments of more innovative techniques for health monitoring applications.

I am thankful to the conference cochairs, program committee members, authors, session chairs, and the SPIE staff for putting together this excellent conference.

Tribikram Kundu