Front Matter: Volume 7982
Smart Sensor Phenomena, Technology, Networks, and Systems 2011

Wolfgang Ecke
Kara J. Peters
Theodore E. Matikas
Editors

7–9 March 2011
San Diego, California, United States

Sponsored by
SPIE

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

Published by
SPIE

Volume 7982
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:


ISSN 0277-786X
ISBN 9780819485441

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 © 2011, 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/11/$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the 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

vii Conference Committee

ix The upcoming revolution in ultrasonic guided waves (Plenary Paper) [798302]
J. L. Rose, The Pennsylvania State Univ. (United States) and FBS Inc. (United States)

<table>
<thead>
<tr>
<th>SESSION 1</th>
<th>FIBER BRAGG GRATING SENSORS I</th>
</tr>
</thead>
<tbody>
<tr>
<td>7982 02</td>
<td>Fibre optic sensors in smart structures: achievements, challenges, and prospects (Invited Paper) [7982-01]</td>
</tr>
<tr>
<td></td>
<td>B. Culshaw, Univ. of Strathclyde (United Kingdom)</td>
</tr>
<tr>
<td>7982 04</td>
<td>Memorization and detection of an arrested crack in a foam-core sandwich structure using a crack arrester with embedded metal wires and FBG sensors [7982-04]</td>
</tr>
<tr>
<td></td>
<td>S. Minakuchi, N. Takeda, I. Yamauchi, The Univ. of Tokyo (Japan); Y. Hirose, Kawasaki Heavy Industries, Ltd. (Japan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 2</th>
<th>DISTRIBUTED SENSORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7982 06</td>
<td>High performance BOTDA for long range sensing (Invited Paper) [7982-06]</td>
</tr>
<tr>
<td></td>
<td>X. Bao, L. Chen, Univ. of Ottawa (Canada)</td>
</tr>
<tr>
<td>7982 07</td>
<td>Distributed fiber optic sensor development, testing, and evaluation for geotechnical monitoring applications [7982-07]</td>
</tr>
<tr>
<td></td>
<td>M. Iten, D. Hauswirth, A. M. Puzrin, ETH Zurich (Switzerland)</td>
</tr>
<tr>
<td>7982 08</td>
<td>Research on the theory of valid sampling points in BOTDR technique [7982-08]</td>
</tr>
<tr>
<td></td>
<td>P. Gong, Dalian Univ. of Technology (China); J. Guo, Dalian Univ. of Technology (China) and Construction Headquarters of Zhoushan Liuheng Sea-cross Bridge (China); Y. Liu, J. Lu, X. Zhao, Dalian Univ. of Technology (China)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION 3</th>
<th>FIBER BRAGG GRATING SENSORS II</th>
</tr>
</thead>
<tbody>
<tr>
<td>7982 09</td>
<td>Analysis of fiber Bragg grating spectral features for in-situ assessment of composites (Invited Paper) [7982-09]</td>
</tr>
<tr>
<td></td>
<td>K. Peters, North Carolina State Univ. (United States)</td>
</tr>
<tr>
<td>7982 0A</td>
<td>Noise propagation in a 3x3 optical demodulation scheme used for fiber Bragg grating interrogation (Invited Paper) [7982-10]</td>
</tr>
<tr>
<td></td>
<td>M. Todd, Univ. of California, San Diego (United States)</td>
</tr>
<tr>
<td>7982 0B</td>
<td>Evaluation of the internal strains and stresses produced in a plate by propagating Lamb waves through the use of fibre optic sensors [7982-11]</td>
</tr>
<tr>
<td></td>
<td>G. Thursby, B. Culshaw, Univ. of Strathclyde (United Kingdom)</td>
</tr>
</tbody>
</table>
Full spectral interrogation of fiber Bragg grating sensors for damage identification [7982-12]
S. Webb, A. Noevere, K. Peters, M. A. Zirky, North Carolina State Univ. (United States); T. Vella, S. Chadderdon, R. Selfridge, S. Schultz, Brigham Young Univ. (United States)

Damage detection in FRP structures using fiber Bragg grating dynamic strain sensing systems [7982-14]
Y. Zhu, Y. Zhu, Ctr. for Quality Engineering and Failure Prevention (United States); L. Hui, Harbin Institute of Technology (China); S. Krishnaswamy, Ctr. for Quality Engineering and Failure Prevention (United States)

SESSION 4 SENSORS FOR SHM I

25 years of structural monitoring using fiber optic sensors (Invited Paper) [7982-15]
E. Udd, Columbia Gorge Research, LLC (United States)

Condition assessment of a bridge superstructure using diagnostic performance indicators [7982-16]
M. V. Gangone, Clarkson Univ. (United States); M. J. Whelan, The Univ. of North Carolina at Charlotte (United States); K. D. Janoyan, Clarkson Univ. (United States)

Printed resistive strain sensors for monitoring of light-weight structures [7982-17]
J. Rausch, L. Salun, S. Griesheimer, M. Ibis, R. Werthschützky, Technische Univ. Darmstadt (Germany)

SESSION 5 SENSORS FOR SHM II

Robust diagnostics for Bayesian compressive sensing with applications to structural health monitoring [7982-19]
Y. Huang, Harbin Institute of Technology (China) and California Institute of Technology (United States); J. L. Beck, California Institute of Technology (United States); H. Li, Harbin Institute of Technology (China); S. Wu, California Institute of Technology (United States)

Monitoring strain and damage in multi-phase composite materials using electrical resistance methods [7982-20]
S. A. Grammatikos, G. Gkikas, A. Paipetis, Univ. of Ioannina (Greece)

SESSION 6 WIRELESS SENSORS

Effect of sensor placement on operational modal analysis of steel girder bridges (Invited Paper) [7982-22]
M. J. Whelan, The Univ. of North Carolina at Charlotte (United States); M. V. Gangone, K. D. Janoyan, Clarkson Univ. (United States)

Node cooperation based support vector machine localization algorithm in mobile wireless sensor networks [7982-24]
Q. Guo, T. Tang, Harbin Institute of Technology (China)
SESSION 7  FIBER OPTIC SENSORS

7982 0O  FOS standards and testing method to validate fibre optic strain measurements (Invited Paper) [7982-25]
W. R. Habel, V. G. Schukar, BAM Federal Institute for Materials Research and Testing (Germany)

7982 0P  Multi-use D-fiber sensors (Invited Paper) [7982-26]
R. H. Selfridge, S. Schultz, J. Kvavle, T. Lowder, R. Gibson, Brigham Young Univ. (United States)

7982 0Q  Electro-optic polymer electric field sensor [7982-27]
D. Perry, S. Chadderdon, R. Gibson, B. Shreeve, R. H. Selfridge, S. M. Schultz, Brigham Young Univ. (United States); W. C. Wang, R. Forber, IPITEK, Inc. (United States); J. Luo, Univ. of Washington (United States)

7982 0R  Interrogation systems for slab coupled optical fiber sensors [7982-28]
J. Noren, R. Selfridge, S. Schultz, Brigham Young Univ. (United States)

7982 0S  Experimental verification of a model describing the intensity distribution from a single mode optical fiber [7982-29]
E. A. Moro, Univ. of California, San Diego (United States) and Los Alamos National Lab. (United States); M. D. Todd, Univ. of California, San Diego (United States); A. D. Puckett, Los Alamos National Lab. (United States)

7982 0T  Advanced image processing and artificial intelligence based approaches to fiber optic statistical mode sensor design [7982-30]
H. S. Efendioglu, Fatih Univ. (Turkey); T. Yildirim, Yildiz Technical Univ. (Turkey); O. Toker, Fatih Univ. (Turkey)

SESSION 8  THERMOGRAPHY SENSORS

7982 0U  Developing damage metrics for metallic structures undergoing fatigue using real-time thermographic evaluation [7982-31]
E. Z. Kordatos, T. E. Matikas, Univ. of Ioannina (Greece)

7982 0V  Monitoring of fatigue damage in metal plates by acoustic emission and thermography [7982-32]
E. Z. Kordatos, D. G. Aggelis, T. E. Matikas, Univ. of Ioannina (Greece)

7982 0W  Combined NDT methods for characterization of subsurface cracks in concrete [7982-33]
E. Z. Kordatos, M. Strantza, D. V. Soulioti, T. E. Matikas, D. G. Aggelis, Univ. of Ioannina (Greece)

SESSION 9  ACOUSTICS SENSORS

7982 0X  Linear damage location using fiber optic acoustic emission sensors for structure health monitoring [7982-34]
T. Fu, Z. Zhang, Harbin Institute of Technology (China); Z. Lin, Harbin Institute of Technology (China) and Harbin FRP Research Institute (China); Z. Yao, Harbin FRP Research Institute (China); J. Leng, Harbin Institute of Technology (China)
Acoustic emission felicity ratio measurements in carbon composites laminates using fiber Bragg grating sensors [7982-35]
N. Mabry, The Univ. of Alabama in Huntsville (United States); C. Banks, NASA Marshall Space Flight Ctr. (United States); H. Toutanji, The Univ. of Alabama in Huntsville (United States); M. Seif, Alabama A&M Univ. (United States)

Structural health monitoring of shear waves in aluminum plates [7982-36]
M. J. Sundaresan, W. B. Williams, North Carolina A&T State Univ. (United States)

Monitoring system for windmill rotor blades based on optical connections [7982-48]
L. Schubert, E. Schulze, B. Frankensteiin, D. Fischer, B. Weihnacht, Fraunhofer Institute for Non-Destructive Testing Dresden (Germany); R. Rieske, Technische Univ. Dresden (Germany)

Evaluation of signal processing tools for improving phased array ultrasonic weld inspection [7982-38]
P. Ramuhalli, A. D. Cinson, S. L. Crawford, R. V. Harris, A. A. Diaz, M. T. Anderson, Pacific Northwest National Lab. (United States)

Simulation on photoacoustic conversion efficiency of optical fiber-based ultrasound generator using different absorbing film materials [7982-39]
K. Sun, N. Wu, Y. Tian, X. Wang, Univ. of Massachusetts Lowell (United States)

Vibration suppression and damage detection in smart composite laminate using high precision finite element [7982-41]
A. Kumar, Harcourt Butler Technological Institute, Kanpur (India); P. J. Fleming, Univ. of Shieffield (United Kingdom); B. Bhattacharyya, Indian Institute of Technology, Kanpur (India)

Characterization and compaction of Lamb wave data using a combination of S and wavelet transformations [7982-42]
I. N. Tansel, G. Singh, G. Singh, S. Korla, Florida International Univ. (United States); B. L. Grisso, L. W. Salvino, Naval Surface Warfare Ctr., Carderock Div. (United States)

Study on theoretic model of metallic pseudo-rubber based on contact microbeams theory and finite element simulation [7982-43]
S. Li, H. Li, Harbin Institute of Technology (China); C. Mao, China Earthquake Administration (China); W. Wang, Harbin Institute of Technology (China); Y. Zhao, Jilin Univ. (China)

Linear phased array of piezoelectric transducers for delamination monitoring in a composite laminate using Lamb waves [7982-44]
V. T. Rathod, N. Chakraborty, D. R. Mahapatra, Indian Institute of Science (India)

Design of hetero-core microbend stress sensors and comparative analysis of various hetero-core sensor architectures [7982-47]
A. K. Sahin, Univ. of Missouri-Columbia (United States); H. S. Efendioglu, K. Fidanboylu, Fatih Univ. (Turkey)
Conference Committee

Symposium Chairs

Donald J. Leo, Virginia Polytechnic Institute and State University (United States)
Kara J. Peters, North Carolina State University (United States)

Symposium Cochairs

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

Conference Chair

Wolfgang Ecke, IPHT Jena (Germany)

Conference Cochairs

Kara J. Peters, North Carolina State University (United States)
Theodore E. Matikas, University of Ioannina (Greece)

Program Committee

Farhad Ansari, University of Illinois at Chicago (United States)
George Y. Baaklini, NASA Glenn Research Center (United States)
Horst J. Baier, Technische Universität München (Germany)
Curtis E. Banks, NASA Marshall Space Flight Center (United States)
Xiaoyi Bao, Université d’Ottawa (Canada)
Hartmut Bartelt, IPHT Jena (Germany)
Brian Culshaw, University of Strathclyde (United Kingdom)
Wolfgang R. Habel, Bundesanstalt für Materialforschung und -prüfung (Germany)
Daniele Inaudi, Smartec S.A. (Switzerland)
Michael Iten, Swiss Federal Institute of Technology (Switzerland)
Kerop D. Janoyan, Clarkson University (United States)
YeonWan Koh, FIBERPRO, Inc. (Korea, Republic of)
Silvio E. Kruger, National Research Council Canada (Canada)
Jinsong Leng, Harbin Institute of Technology (China)
Alexis Mendez, MCH Engineering LLC (United States)
Norbert G. Meyendorf, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (United States)
Bernd Michel, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)
Jeff W. Miller, Micron Optics, Inc. (United States)
Marc Nikles, Omnisens S.A. (Switzerland)
Richard H. Selfridge, Brigham Young University (United States)
Nobuo Takeda, The University of Tokyo (Japan)
Michael D. Todd, University of California, San Diego (United States)
Eric Udd, Columbia Gorge Research (United States)
Zhishen Wu, Ibaraki University (Japan)
Chung-Bang Yun, KAIST (Korea, Republic of)
Zhi Zhou, Dalian University of Technology (China)

Session Chairs

1  Fiber Bragg Grating Sensors I
   Wolfgang Ecke, IPHT Jena (Germany)

2  Distributed Sensors
   Kara J. Peters, North Carolina State University (United States)

3  Fiber Bragg Grating Sensors II
   Theodore E. Matikas, University of Ioannina (Greece)

4  Sensors for SHM I
   Kerop D. Janoyan, Clarkson University (United States)

5  Sensors for SHM II
   Eric Udd, Columbia Gorge Research (United States)

6  Wireless Sensors
   Alexis Mendez, MCH Engineering LLC (United States)

7  Fiber Optic Sensors
   Michael D. Todd, University of California, San Diego (United States)

8  Thermography Sensors
   Hua-Xin Peng, University of Bristol (United Kingdom)

9  Acoustics Sensors
   Norbert G. Meyendorf, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany)