PROCEEDINGS OF SPIE

Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2010

Peter J. Shull Aaron A. Diaz H. Felix Wu Editors

8–11 March 2010 San Diego, California, United States

Sponsored by SPIF

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 7649

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 Nondestructive Characterization for Composite Materials, Aerospace Engineering, Civil Infrastructure, and Homeland Security 2010, edited by Peter J. Shull, Aaron A. Diaz, H. Felix Wu, Proceedings of SPIE Vol. 7649 (SPIE, Bellingham, WA, 2010) Article CID Number.

ISSN 0277-786X ISBN 9780819480644

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 © 2010, 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/10/\$18.00.

Printed in the United States of America.

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



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

ix

SESSION 1 OPTICAL METHODS FOR COMPOSITE AND CIVIL STRUCTURES I 7649 02 Simultaneous strain and temperature measurement using long-period fiber grating sensors [7649-01] G. Chen, H. Xiao, Y. Huang, Y. Zhang, Z. Zhou, Missouri Univ. of Science and Technology (United States) 7649 03 Impact localization on complex structures using FBG strain amplitude information [7649-02] C. Hiche, C. K. Coelho, A. Chattopadhyay, Arizona State Univ. (United States); M. Seaver, U.S. Naval Research Lab. (United States) 7649 04 A fiber Bragg grating interrogation system for health monitoring of metals and composites A.-D. Nguyen, Los Gatos Research, Inc. (United States); A. S. Rakow, Stanford Univ. (United States) SESSION 2 OPTICAL METHODS FOR COMPOSITE AND CIVIL STRUCTURES II Silicon-based thin film solid oxide fuel cell array [7649-77] 7649 07 P.-C. Su, National Taiwan Univ. (Taiwan); F. B. Prinz, Stanford Univ. (United States) 7649 08 Casing pipe damage detection with optical fiber sensors: a case study in oil well constructions [7649-06] Z. Zhou, Dalian Univ. of Technology (China) and Missouri Univ. of Science and Technology (United States); J. He, M. Huang, J. He, Harbin Institute of Technology (China); J. Ou, Dalian Univ. of Technology (China); G. Chen, Missouri Univ. of Science and Technology (United States) 7649 09 In situ monitoring of curing and ageing effects in FRP plates using embedded FBG sensors G. Xian, C. Wang, H. Li, Harbin Institute of Technology (China) 7649 0A Structural health monitoring of PC structures with novel types of distributed sensors [7649-08] C. Yang, Southeast Univ. (China); Z. Wu, Southeast Univ. (China) and Jiangsu Transportation Research Institute (China); Y. Zhang, Jiangsu Transportation Research Institute (China) SESSION 3 **HEALTH MONITORING OF AEROSPACE COMPOSITES** 7649 OC Fatigue damage prognosis of a cruciform structure under biaxial random and flight profile **loading** [7649-10] S. Mohanty, A. Chattopadhyay, P. Peralta, D. Quech, Arizona State Univ (United States)

	E. D. Swenson, S. R. Soni, Air Force Institute of Technology (United States); H. Kapoor, Virginia Polytechnic Institute and State Univ. (United States)			
7649 OE	Effects of Z-pins on Lamb waves in composite plates [7649-12] E. D. Swenson, Air Force Institute of Technology (United States); H. Kapoor, Virginia Polytechnic Institute and State Univ. (United States); S. R. Soni, Air Force Institute of Technology (United States)			
7649 OF	Characterizing the self-sensing performance of carbon nanotube-enhanced fiber-reinforced polymers [7649-13] B. R. Loyola, V. La Saponara, K. J. Loh, Univ. of California, Davis (United States)			
7649 OG	Analysis techniques for eddy current imaging of carbon fiber materials [7649-14] M. H. Schulze, N. Meyendorf, H. Heuer, Fraunhofer-Institut für Zerstörungsfreie Prüfverfah (Germany)			
SESSION 4	NIST TECHNOLOGY INNOVATION PROGRAM ON CIVIL INFRASTRUCTURE CRITICAL NATIONAL NEED: ADVANCED SENSING TECHNOLOGIES FOR THE INFRASTRUCTURE: BRIDGES, ROADS, HIGHWAYS, AND WATER SYSTEMS I			
7649 OK	A two-tiered self-powered wireless monitoring system architecture for bridge health management [7649-18] M. Kurata, J. P. Lynch, T. Galchev, M. Flynn, Univ. of Michigan (United States); P. Hipley, California Dept. of Transportation (United States); V. Jacob, G. van der Linden, SC Solutions, Inc. (United States); A. Mortazawi, K. Najafi, R. L. Peterson, Univ. of Michigan (United States); LH. Sheng, California Dept. of Transportation (United States); D. Sylvester, Univ. of Michigan (United States); E. Thometz, California Dept. of Transportation (United States)			
7649 OM	Smart antenna technology for structural health monitoring applications [7649-20] T. Özdemir, Monarch Antenna, Inc. (United States); Y. Goykhman, Univ. of Michigan (United States); L. Oberdier, Monarch Antenna, Inc. (United States); J. Lynch, Univ. of Michigan (United States)			
7649 ON	Near-optimal sensor placement for health monitoring of civil structures [7649-21] G. W. van der Linden, A. Emami-Naeini, R. L. Kosut, H. Sederat, SC Solutions, Inc. (United States); J. P. Lynch, Univ. of Michigan (United States)			
SESSION 5	NIST TECHNOLOGY INNOVATION PROGRAM ON CIVIL INFRASTRUCTURE CRITICAL NATIONAL NEED: ADVANCED SENSING TECHNOLOGIES FOR THE INFRASTRUCTURE: BRIDGES, ROADS, HIGHWAYS, AND WATER SYSTEMS II			
7649 OP	Nondestructive monitoring of a pipe network using a MEMS-based wireless network [7649-23] M. Shinozuka, Univ. of California, Irvine (United States); P. H. Chou, Univ. of California, Irvine (United States) and National Tsing Hua Univ. (Taiwan); S. Kim, Univ. of California, Irvine (United States); H. R. Kim, Ctr. for Embedded Software Technology (Korea, Republic of);			

E. Yoon, H. Mustafa, D. Karmakar, Univ. of California, Irvine (United States); S. Pul, Karadeniz

Lamb wave propagation in Z-pin reinforced co-cured composite pi-joints [7649-11]

Technical Univ. (Turkey)

7649 0D

7649 OR	Quantification of fatigue cracking in CT specimens with passive and active piezoelectric sensing [7649-25] J. Yu, P. Ziehl, B. Zarate, J. Caicedo, L. Yu, V. Giurgiutiu, Univ. of South Carolina (United States); B. Metrovich, Univ. of Miami (United States); F. Matta, Univ. of South Carolina (United States)				
7649 OW	Finite element analysis of surface wave radiation for pavement debonding [7649-83] Y. Lu, Y. Cao, Northeastern Univ. (United States); J. G. McDaniel, Boston Univ. (United States) M. L. Wang, Northeastern Univ. (United States)				
SESSION 6	ACOUSTIC/ULTRASOUND CHARACTERIZATION I				
7649 OX	Fabrication and characterization of high frequency phased arrays for NDE imaging [7649-30] X. Jiang, North Carolina State Univ. (United States); K. Snook, TRS Technologies, Inc. (United States); R. Liu, X. Geng, Blatek, Inc. (United States); W. S. Hackenberger, TRS Technologies, Inc. (United States)				
7649 OY	Evaluation of bridge cables corrosion using acoustic emission technique [7649-63] D. Li, J. Ou, Dalian Univ. of Technology (China)				
7649 OZ	Ultrasonic inspection technique for NDE of fiber composite materials [7649-32] D. Hentschel, F. Schubert, L. Schubert, B. Frankenstein, Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (Germany)				
7649 10	Structural health monitoring techniques for detecting incipient buckling [7649-33] K. Asamene, B. Ali, M. Sundaresan, North Carolina Agricultural and Technical State Univ. (United States)				
7649 11	Service induced damage in composite laminates: non destructive assessment, quantification and modeling [7649-34] D. G. Aggelis, N. M. Barkoula, T. E. Matikas, A. S. Paipetis, Univ. of Ioannina (Greece)				
7649 12	Acoustic emission characterization of steel fibre reinforced concrete during bending [7649-35] D. G. Aggelis, D. V. Soulioti, N. Sapouridis, N. M. Barkoula, A. S. Paipetis, T. E. Matikas, Univ. of Ioannina (Greece)				
7649 13	Using 2-D arrays for sensing multimodal Lamb waves [7649-36] M. Engholm, T. Stepinski, Uppsala Univ. (Sweden)				
SESSION 7	ACOUSTIC/ULTRASOUND CHARACTERIZATION II				
7649 14	Lamb wave excitation and detection with smart fasteners for structural health monitoring [7649-37] HS. Yoon, R. DeCicco, Tennessee Technological Univ. (United States)				
7649 15	Active learning data selection for adaptive online structural damage estimation [7649-38] D. Chakraborty, N. Kovvali, A. Papandreou-Suppappola, A. Chattopadhyay, Arizona State Univ. (United States)				

thermography [7649-70] Z. Liu, M. Genest, D. Krys, National Research Council Canada (Canada) SESSION 8 THERMOGRAPHIC IMAGING 7649 1A Transient infrared thermography for damage evaluation in aerospace composites [7649-42] S. Pawar, K. Peters, North Carolina State Univ. (United States) 7649 1B Application of line scanning thermography for the detection of interlaminar disbonds in sandwich composite structures [7649-43] O. Ley, Mistras Group (United States); S. Chung, J. Schutte, A. Caiazzo, Materials Sciences Corp. (United States); V. Godinez, Mistras Group (United States); B. Bandos, Naval Surface Warfare Ctr. (United States) 7649 1D Repair integrity monitoring of composite aerostructures using thermographic imaging [7649-45] S. Grammatikos, E. Kordatos, N.-M. Barkoula, T. Matikas, A. Paipetis, Univ. of Ioannina (Greece) SESSION 9 **WIRELESS RADAR NDE TECHNOLOGIES** 7649 1E A tunable impulse ultra-wide-band sensor for civil infrastructure sensing applications [7649-46] J. W. Han, Danam Systems Inc. (Korea, Republic of); C. Nguyen, Texas A&M Univ. (United States) 7649 1F A 35-GHz radar for sensing applications [7649-47] J. S. Park, SAMSUNG Electronics Co. (Korea, Republic of); C. Nguyen, Texas A&M Univ. (United States) 7649 1G Estimation of kernels mass ratio to total in-shell peanuts using low-cost RF impedance meter [7649-48] C. V. Kandala, J. Sundaram, B. Hinson, National Peanut Research Lab. (United States) **SESSION 10** CIVIL INFRASTRUCTURE HEALTH MONITORING I 7649 1H Comprehensive condition assessment of bridge decks by multimodal NDE [7649-49] N. Gucunski, Rutgers, The State Univ. of New Jersey (United States); R. Feldmann, German Federal Institute for Materials Research and Testing (Germany); F. Romero, Rutgers, The State Univ. of New Jersey (United States); S. Kruschwitz, German Federal Institute for Materials Research and Testing (Germany); H. Parvardeh, Rutgers, The State Univ. of New Jersey (United States) 7649 11 A pragmatic and innovative approach for civil infrastructure management: structural behavior monitoring [7649-50] G. Chen, Missouri Univ. of Science and Technology (United States)

Characterization of pitting corrosion on small diameter ductile iron pipe using

7649 18

7649 1J	Damage inspection of fiber reinforced polymer-concrete systems using a distant acoustic-laser NDE technique [7649-51] TY. Yu, Univ. of Massachusetts Lowell (United States); R. Haupt, MIT Lincoln Lab. (United States)				
7649 1K	The role of terrestrial 3D LiDAR scan in bridge health monitoring [7649-52] W. Liu, SE. Chen, The Univ. of North Carolina at Charlotte (United States); A. Sajedi, FARO Technologies Inc. (United States); E. Hauser, The Univ. of North Carolina at Charlotte (United States)				
SESSION 11	CIVIL INFRASTRUCTURE HEALTH MONITORING II				
7649 1L	Identification and health monitoring of an instrumented building using earthquake respons data [7649-53] H. S. Ulusoy, M. Q. Feng, Univ. of California, Irvine (United States); P. J. Fanning, Univ. Colleg Dublin (Ireland)				
7649 1M	Structural behavior of a cable stayed bridge through the use of a long-term health monitoring system [7649-54] Y. Cao, M. Wang, Northeastern Univ. (United States)				
7649 1N	Damage assessment of the bridge structures using a hybrid optimization strategy [7649-R. Baghaei, M. Q. Feng, Univ. of California, Irvine (United States)				
7649 1P	Global mechanical behavior of Sutong Bridge under static loads [7649-64] Y. B. Li, Q. W. Zhang, Tongji Univ. (China)				
7649 1Q	Segmentation of laser range image for pipe anomaly detection [7649-57] Z. Liu, D. Krys, National Research Council Canada (Canada)				
7649 1R	Monitoring early age microstructure development of cement paste using bender element [7649-58] J. Zhu, SH. Kee, The Univ. of Texas at Austin (United States)				
7649 1S	Efficient order reduction in vibration analysis of periodic structures with uncertainties [7649-59] Z. Xia, J. Tang, Univ. of Connecticut (United States)				
7649 IT	Damage detection of an in-service condensation pipeline joint [7649-60] J. Briand, D. Rezaei, F. Taheri, Dalhousie Univ. (Canada)				
7649 IV	Ultrasonic wave attenuation measurement for nondestructive evaluation of concrete [7649-76] H. J. Yim, KAIST (Korea, Republic of); J. H. Kim, Northwestern Univ. (United States); HG. Kwak KAIST (Korea, Republic of)				
	POSTER SESSION				
7649 1X	Non-linear material characterisation using the noncollinear method [7649-65] A. J. Croxford, P. D. Wilcox, B. W. Drinkwater, Univ. of Bristol (United Kingdom)				

- Analysis of monitored strain of the National Aquatics Center under snow load [7649-68]
 H. Li, F. Zhou, W. Zhou, Y. Zhu, J. Teng, Harbin Institute of Technology (China); J. Ou, Harbin Institute of Technology (China) and Dalian Univ. of Technology (China)
- 7649 20 The advanced magnetovision system for Smart application [7649-69]
 J. Kaleta, P. Wiewiórski, D. Lewandowski, Wroclaw Univ. of Technology (Poland)
- 7649 22 Measurement of surface resistivity/conductivity of anodized aluminium alloy by optical interferometry techniques [7649-73]

 K. Habib, Kuwait Institute for Scientific Research (Kuwait)

Author Index

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)

Norman M. Wereley, University of Maryland, College Park (United States)

Conference Chair

Peter J. Shull, The Pennsylvania State University (United States)

Conference Cochairs

Aaron A. Diaz, Pacific Northwest National Laboratory (United States)
 H. Felix Wu, National Institute of Standards and Technology (United States)

Program Committee

A. Emin Aktan, Drexel University (United States)
 Farhad Ansari, University of Illinois at Chicago (United States)
 George Y. Baaklini, NASA Glenn Research Center (United States)
 Lawrence Bank, National Science Foundation (United States)
 Yoseph Bar-Cohen, Jet Propulsion Laboratory (United States)
 Oral Buyukozturk, Massachusetts Institute of Technology (United States)

Fu-Kuo Chang, Stanford University (United States)
Steven Chase, University of Virginia (United States)
Howard Chung, Acellent Technologies, Inc. (United States)
Maria Q. Feng, University of California, Irvine (United States)
Masoud Ghandehari, Polytechnic Institute of New York University (United States)

Hamid Ghasemi, Federal Highway Administration (United States)Nenad Gucunski, Rutgers, The State University of New Jersey (United States)

Andrew L. Gyekenyesi, NASA Glenn Research Center (United States) Xiaoning Jiang, North Carolina State University (United States) Garo K. Kiremidjian, Sensametrics, Inc. (United States)

Amrita Kumar, Florida State University (United States)

Jerome P. Lynch, University of Michigan (United States)

Richard E. Martin, Cleveland State University (United States)

Theodore E. Matikas, University of Ioannina (Greece)

Paul Mlakar, U.S. Army Engineer Research and Development Center (United States)

Aftab A. Mufti, University of Manitoba (Canada)

Didem Ozevin, University of Illinois at Chicago (United States)

Masanobu Shinozuka, University of California, Irvine (United States)

Kurt L. Silvers, Pacific Northwest National Laboratory (United States)

Lizhi Sun, University of California, Irvine (United States)

Bernhard R. Tittmann, The Pennsylvania State University (United States)

Brian J. Tucker, Pacific Northwest National Laboratory (United States)

Dietmar W. Vogel, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)

Ming Wang, Northeastern University (United States)

Yang Wang, Georgia Institute of Technology (United States)

Tzu-Yang Yu, University of Massachusetts Lowell (United States)

Jian Zhang, Drexel University (United States)

Ying Zhang, Georgia Institute of Technology (United States)

Session Chairs

- Optical Methods for Composite and Civil Structures I

 Amrita Kumar, The Florida State University (United States)

 Pei-Chen Su, National Taiwan University (Taiwan)
- Optical Methods for Composite and Civil Structures II Jerome P. Lynch, University of Michigan (United States) Amrita Kumar, Florida State University (United States)
- 3 Health Monitoring of Aerospace Composites Aditi Chattopadhyay, Arizona State University (United States) Pei-Chen Su, National Taiwan University (Taiwan)
- A NIST Technology Innovation Program on Civil Infrastructure Critical National Need: Advanced Sensing Technologies for the Infrastructure: Bridges, Roads, Highways, and Water Systems I
 A. Emin Aktan, Drexel University (United States)
 Nenad Gucunski, Rutgers, The State University of New Jersey (United States)

5 NIST Technology Innovation Program on Civil Infrastructure Critical National Need: Advanced Sensing Technologies for the Infrastructure: Bridges, Roads, Highways, and Water Systems II Nenad Gucunski, Rutgers, The State University of New Jersey (United States)

A. Emin Aktan, Drexel University (United States)

- Acoustic/Ultrasound Characterization I
 Xiaoning Jiang, North Carolina State University (United States)
 Didem Ozevin, University of Illinois at Chicago (United States)
- Acoustic/Ultrasound Characterization II
 Xiaoning Jiang, North Carolina State University (United States)
 Didem Ozevin, University of Illinois at Chicago (United States)
- Thermographic Imaging
 Ying Zhang, Georgia Institute of Technology (United States)
 Genda Chen, Missouri University of Science and Technology (United States)
- 9 Wireless Radar NDE Technologies
 Tzu-Yang Yu, University of Massachusetts Lowell (United States)
 Ying Zhang, Georgia Institute of Technology (United States)
- Civil Infrastructure Health Monitoring I
 Ming L. Wang, Northeastern University (United States)
 Tzu-Yang Yu, University of Massachusetts Lowell (United States)
- 11 Civil Infrastructure Health Monitoring II

 Ming L. Wang, Northeastern University (United States)

 Tzu-Yang Yu, University of Massachusetts Lowell (United States)