

PROCEEDINGS OF SPIE

# ***Health Monitoring of Structural and Biological Systems 2015***

**Tribikram Kundu**  
*Editor*

**9–12 March 2015**  
**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 9438**

Proceedings of SPIE 0277-786X, V. 9438

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

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 2015*, edited by Tribikram Kundu, Proceedings of SPIE Vol. 9438 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628415414

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 © 2015, 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](http://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/15/\$18.00.

Printed in the United States of America Vm7 i ffUb '5gg: WjUH'gž bWZi bXYf'jW'bg' Zca 'GD-9.

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



[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**Paper Numbering:** Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique 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.

# Contents

vii *Authors*  
ix *Conference Committee*

---

## **SESSION 1 GUIDED WAVES FOR PIPE INSPECTION**

---

- 9438 03 **Multi-helical ultrasonic imaging for corrosion monitoring of cylindrical structures** [9438-2]  
9438 04 **Signal processing for determining water height in steam pipes with dynamic surface conditions** [9438-3]  
9438 05 **Guided wave technique for non-destructive testing of StifPipe** [9438-4]

---

## **SESSION 2 NONCONTACT GUIDED WAVE TECHNIQUES**

---

- 9438 06 **Development of an electromagnetic acoustic transducer (EMAT) for the noncontact excitation of guided ultrasonic waves** [9438-5]  
9438 07 **Wavenumber study of guided waves in aluminum honeycomb sandwich structures** [9438-6]  
9438 09 **Laser ultrasonic evaluation of bonding layer in thermal barrier coating** [9438-9]

---

## **SESSION 3 NONLINEAR TECHNIQUES I**

---

- 9438 0A **Uncertainty quantification of relative acoustic nonlinearity parameter of guided waves for damage detection in composite structures** [9438-10]  
9438 0B **Fatigue crack visualization using noncontact laser ultrasonics and state space geometrical changes** [9438-11]  
9438 0C **Enhanced nonlinear crack-wave interactions for structural damage detection based on Lamb waves** [9438-12]  
9438 0D **Monitoring accelerated carbonation on standard Portland cement mortar by nonlinear resonance acoustic test** [9438-13]  
9438 0E **Damage imaging in nonlinear vibro-acoustic modulation tests** [9438-14]  
9438 0F **Coupled vibration of nonlinear breathing cracked rotor in lateral, torsional, and longitudinal DOFs** [9438-15]  
9438 0G **Wavelet based simulation of a piecewise linear SDOF oscillatory system** [9438-16]

---

**SESSION 4    DISTRIBUTED SENSORS**

---

9438 0H    **Applications of matched field processing to damage detection in composite wind turbine blades** [9438-17]

---

**SESSION 5    GUIDED WAVES FOR COMPOSITE MONITORING: MODELING ASPECTS**

---

9438 0J    **Hybrid local FEM/global LISA modeling of guided wave propagation and interaction with damage in composite structures** [9438-19]

9438 0K    **Semi-analytical modelling of guided waves generation on composite structures using circular piezoceramics** [9438-20]

9438 0L    **Dispersion of guided waves in composite laminates and sandwich panels** [9438-21]

9438 0M    **Guided waves based SHM systems for composites structural elements: statistical analyses finalized at probability of detection definition and assessment** [9438-22]

---

**SESSION 6    GUIDED WAVES FOR COMPOSITE MONITORING: EXPERIMENTAL INVESTIGATION**

---

9438 0N    **Design of intelligent composites with life-cycle health management capabilities** [9438-23]

9438 0O    **Analysis of Lamb wave dispersion curve sensitivity to material elastic constants in composites** [9438-24]

9438 0P    **Guided waves for detection of delamination and disbonding in stiffened composite panels** [9438-25]

9438 0Q    **Analysis of guided wave propagation in a tapered composite panel** [9438-26]

9438 0R    **Towards a micro-mechanics based understanding of ultrasonic higher harmonic generation** [9438-83]

---

**SESSION 7    METAMATERIAL AND PERIODIC STRUCTURES I**

---

9438 0T    **Design optimization of layered periodic composites for desired elastodynamic response** [9438-28]

9438 0U    **Sound insulation and energy harvesting based on acoustic metamaterial plate** [9438-29]

9438 0X    **Design of multi-stopband metamaterial plates for absorption of broadband elastic waves and vibration** [9438-32]

9438 0Y    **Cellular phononic crystals with piezoelectric shunts for tunable directivity** [9438-33]

9438 10    **A wrinkly phononic crystal slab** [9438-35]

---

**SESSION 8 EMERGING AND FUTURISTIC TECHNIQUES**

---

- 9438 13 **Prototype 1.75 MV X-band linear accelerator testing for medical CT and industrial nondestructive testing applications** [9438-84]

---

**SESSION 9 BRIDGE MONITORING**

---

- 9438 16 **Monitoring viscosity in asphalt binders using an ultrasonic guided wave approach** [9438-40]
- 9438 17 **Nondestructive evaluation of piers** [9438-41]
- 9438 18 **Damage identification in rectangular plates using spectral strain energy distribution** [9438-42]

---

**SESSION 10 CIVIL STRUCTURE MONITORING: BUILDING, BRIDGE, AND TOWER**

---

- 9438 19 **Output-only identification of civil structures using nonlinear finite element model updating** [9438-43]
- 9438 1A **Linear and nonlinear ultrasonic characterization of limestone** [9438-44]
- 9438 1B **Kalman filter based data fusion for neutral axis tracking in wind turbine towers** [9438-45]
- 9438 1C **Quantitative evaluation of rejuvenators to restore embrittlement temperatures in oxidized asphalt mixtures using acoustic emission** [9438-46]
- 9438 1D **Phase-shifted helical long-period grating-based temperature-insensitive optical fiber twist sensors** [9438-47]

---

**SESSION 11 METAMATERIAL AND PERIODIC STRUCTURES II**

---

- 9438 1F **GPU accelerated variational methods for fast phononic eigenvalue solutions** [9438-49]
- 9438 1H **Anisotropic mass density by three-dimensional elastic metamaterials** [9438-51]
- 9438 1K **Variational methods in phononics** [9438-54]

---

**SESSION 12B COMPOSITE MONITORING**

---

- 9438 1P **Heat induced damage detection in composite materials by terahertz radiation** [9438-58]

---

**SESSION 13A GUIDED WAVE-BASED SHM I**

---

- 9438 1Q **Monitoring of hidden fatigue crack growth in multi-layer aircraft structures using high frequency guided waves** [9438-59]
- 9438 1R **On propagation of shock waves generated under hypervelocity impact (HVI) and application to characterizing orbital debris-induced damage in space vehicles** [9438-60]
- 9438 1S **Data fusion for compensation of temperature variations in Lamb-wave based SHM systems** [9438-61]
- 9438 1T **Distance-domain based localization techniques for acoustic emission sources: a comparative study** [9438-62]

---

**SESSION 13B NONLINEAR TECHNIQUES II**

---

- 9438 1U **Non-classical dissipative model of nonlinear crack-wave interactions used for damage detection** [9438-63]
- 9438 1V **Perturbation approach to dispersion curves calculation for nonlinear Lamb waves** [9438-64]

---

**SESSION 14A GUIDED WAVE-BASED SHM II**

---

- 9438 1Z **Lamb wave propagation in vibrating structures for effective health monitoring** [9438-68]
- 9438 20 **Semi-analytical modelling of piezoelectric excitation of guided waves** [9438-69]
- 9438 21 **A haptic-inspired audio approach for structural health monitoring decision-making** [9438-70]

---

**SESSION 14B BIOMEDICAL APPLICATIONS: ORGAN AND IMPLANT MONITORING**

---

- 9438 23 **Dual-frequency super harmonic imaging piezoelectric transducers for transrectal ultrasound** [9438-72]
- 9438 26 **Application of structural health monitoring technologies to bio-systems: current status and path forward** [9438-75]
- 9438 27 **On the repeatability of the EMI for the monitoring of bonded joints** [9438-76]

---

**POSTER SESSION**

---

- 9438 29 **A novel low profile wireless flow sensor to monitor hemodynamic changes in cerebral aneurysm** [9438-78]