

Smart Structures +  
Nondestructive Evaluation

2019

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# TECHNICAL PROGRAM

Your complete guide to conferences and special events

**Conferences and Course**

3-7 March 2019

Embassy Suites by Hilton Denver  
Denver, Colorado, USA

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**SPIE.** SMART STRUCTURES+  
NONDESTRUCTIVE  
EVALUATION

CONNECTING MINDS.  
ADVANCING LIGHT.



# SMART STRUCTURES + NONDESTRUCTIVE EVALUATION 2019

Technologies for structural health monitoring,  
advanced materials, and engineered biorobotics.

**3-7 March 2019**  
Embassy Suites by Hilton Denver  
Denver, Colorado, USA



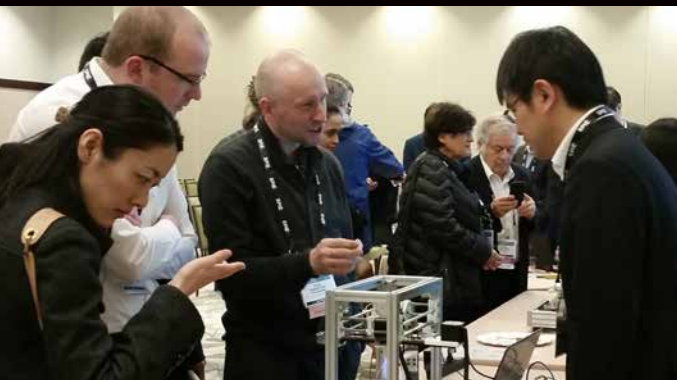
## Welcome to Denver

**CUTTING-EDGE RESEARCH**

**WORLD-CLASS SPEAKERS**

**TRAINING AND EDUCATION**

**FOCUSED TECHNICAL TOPICS**



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## MODERN SOLUTIONS TO A RANGE OF GLOBAL CHALLENGES

SPIE Smart Structures + Nondestructive Evaluation is the largest international meeting on smart materials, sensor networks, nondestructive evaluation and structural health monitoring. Over 700 researchers and engineers from 40+ countries gather to share insights on these emerging technologies and industry developments.

Energy harvesting  
Soft robotics  
Civil infrastructure  
Energy systems  
Damage detection  
Bioinspiration/biomimetics

Wearable sensor systems  
Multifunctional and composite materials  
Shape-memory alloys and polymers  
Smart materials for aerospace and automotive  
3D printing with smart materials  
Electroactive polymers (EAP)

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- Welcome reception
- Coffee breaks
- A choice of online Proceedings

SPIE, the international society for optics and photonics, was founded in 1955 to advance light-based technologies. Serving more than 264,000 constituents from approximately 166 countries, the not-for-profit society advances emerging technologies through interdisciplinary information exchange, continuing education, publications, patent precedent, and career and professional growth. In 2018, SPIE provided \$4 million in support of education and outreach programs.

For more information, visit [www.SPIE.org](http://www.SPIE.org).



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# The leading event for advanced materials and structural health monitoring.



## Plenary Presentations

pages 8-9

Don't miss these world-class speakers discussing the latest directions and most promising breakthroughs.



## Special Events

page 10-11

Join your peers and colleagues at these special events including the Welcome Reception, Student Lunch with the Experts, and the Women in SPIE Networking Dinner.



## Award Announcements


page 13


Don't miss any of the award announcements and presentations at 2019 Smart Structures + Nondestructive Evaluation.

## SPIE. SMART STRUCTURES+ NONDESTRUCTIVE EVALUATION

The latest research from 700 technical presentations in 9 parallel conferences, live demonstrations of EAP-in-Action, as well as Best Student Paper Competition, Poster Session, and Courses.

 **600**  
ATTENDEES

 **9**  
CONFERENCES

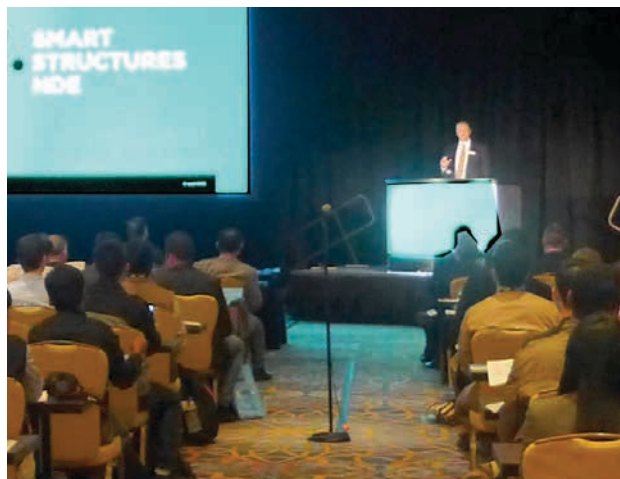
 **700** PAPERS

 **2**  
COURSES

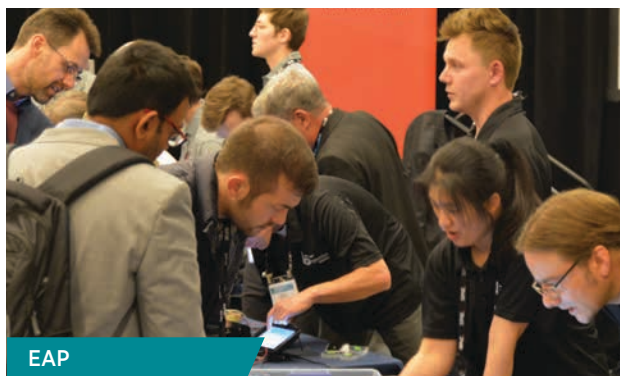
3-7 March 2019  
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**Conferences:** Hear the latest advancements in sensing and measurement science with advanced materials, diagnostics, and smart systems.



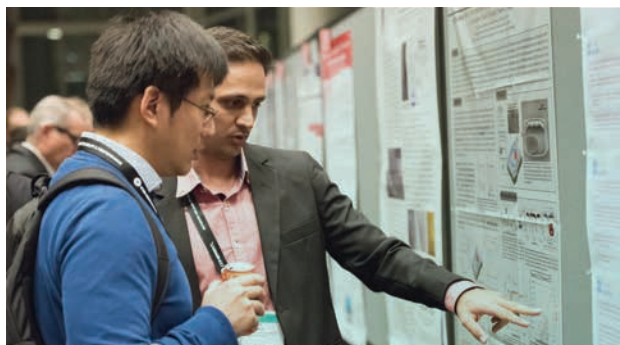
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<b>Electroactive Polymer Actuators and Devices (EAPAD) XXI</b> (Conference 10966) . . . . .	24-56
<b>Active and Passive Smart Structures and Integrated Systems XIII</b> (Conference 10967) . . . . .	24-56
<b>Behavior and Mechanics of Multifunctional Materials XIII</b> (Conference 10968) . . . . .	24-48
<b>Nano-, Bio-, Info-Tech Sensors and 3D Systems</b> (Conference 10969) . . . . .	24-48
<b>Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems</b> (Conference 10970) . . . . .	25-57
<b>Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII</b> (Conference 10971). . . . .	25-55
<b>Health Monitoring of Structural and Biological Systems XIII</b> (Conference 10972). . . . .	25-57
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## EAP-in-Action Demonstrations

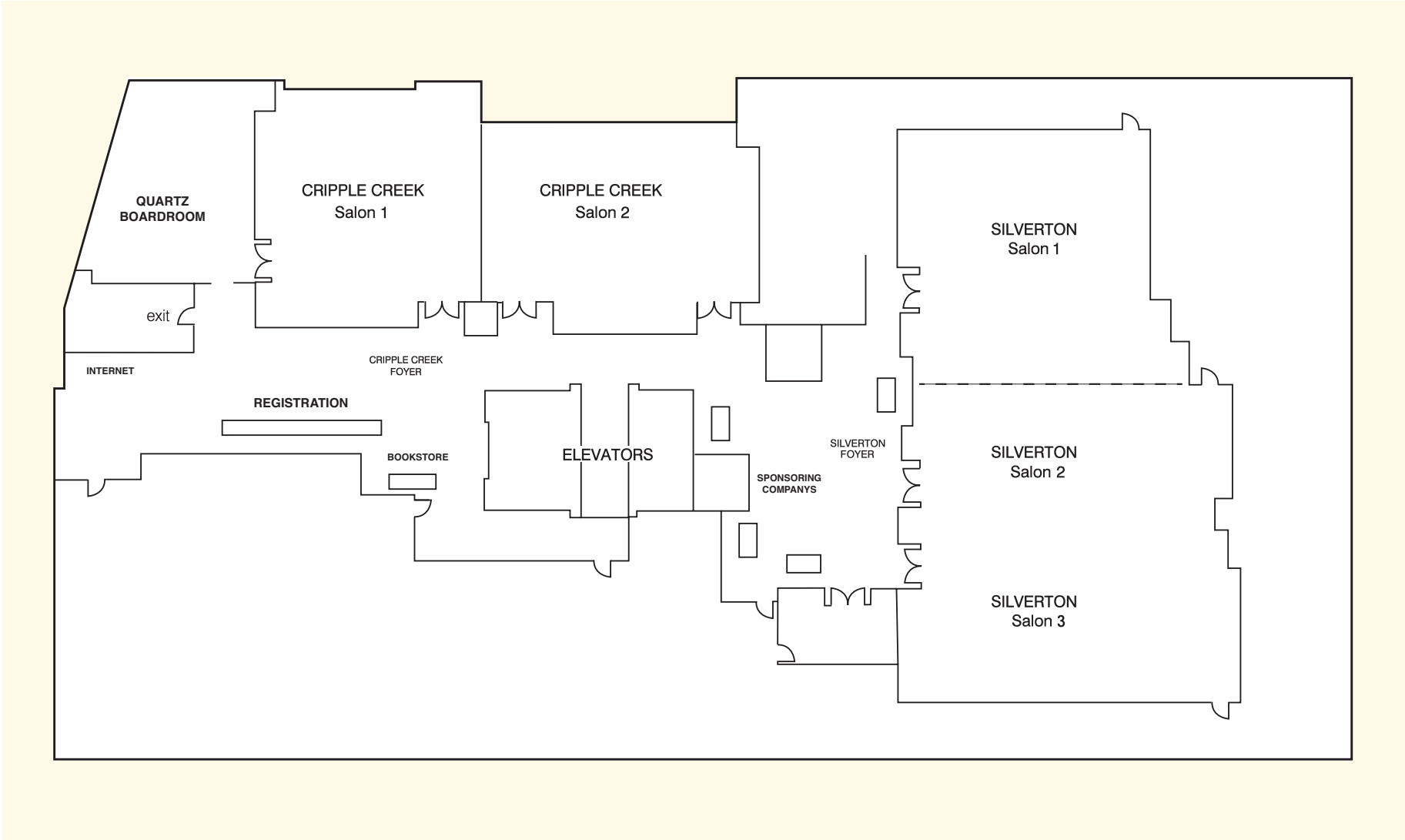
page 14-15

This Session highlights some of the latest capabilities and applications of Electroactive Polymers (EAP) and attendees can view live demonstrations of these materials in action.

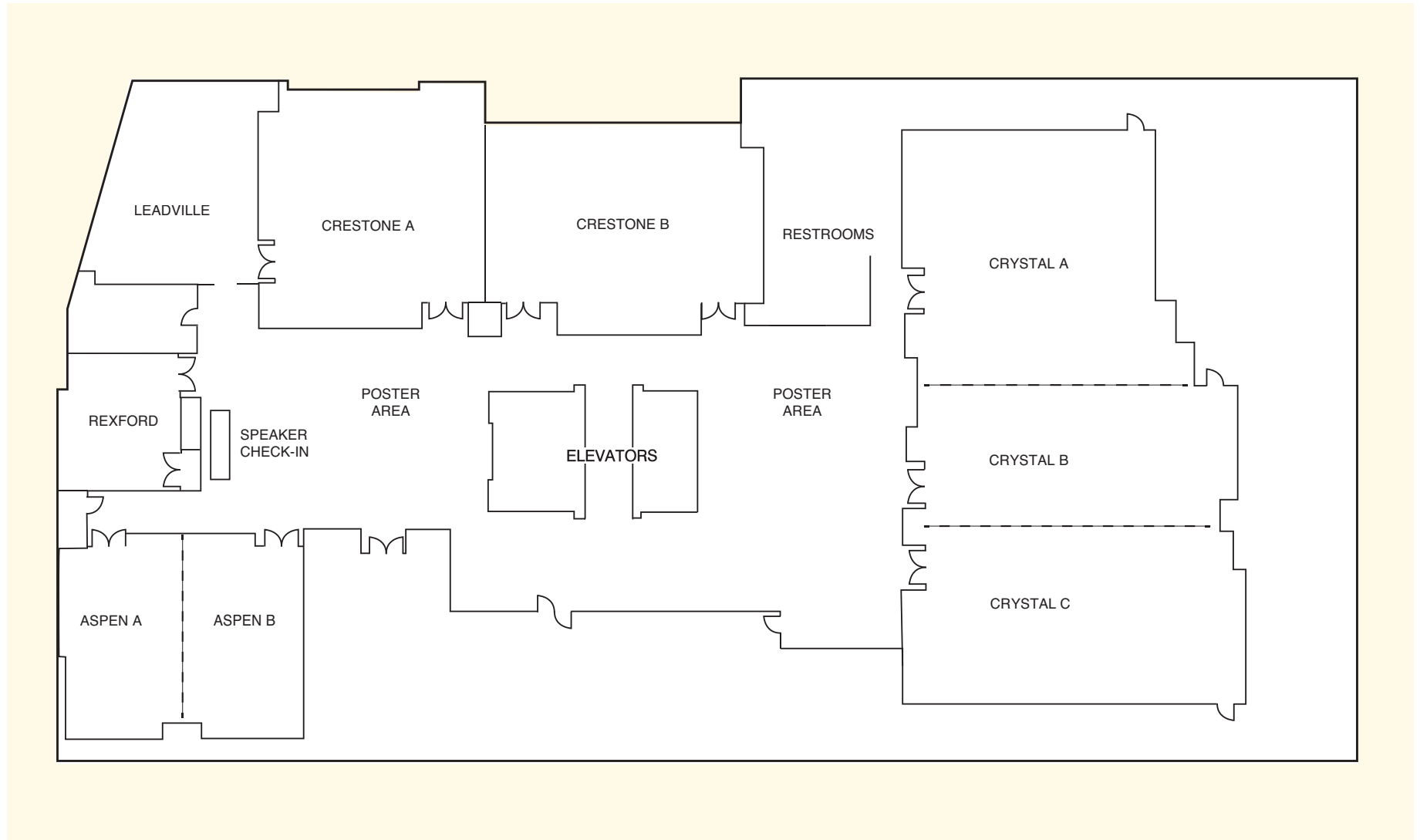


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# FLOOR PLAN EMBASSY SUITES, 2ND FLOOR



# FLOOR PLAN EMBASSY SUITES, 3RD FLOOR



# Welcome

The Organizing Committee of SPIE's 26th Annual International Symposium on Smart Structures and Material Systems + Nondestructive Evaluation welcomes you to this year's meeting. This unique symposium offers many opportunities to network with colleagues from a variety of disciplines in academia, industry, and government from all over the world.

Organized in nine parallel conferences, SS/NDE brings together emerging technologies and advanced research in instrumentation, sensing, and measurement science with advanced materials, diagnostics, and smart systems. Engineers and researchers from government, military, academia, and the commercial sector will discuss the current status and future directions of smart structures and materials, NDE, and health monitoring. Case studies, emerging research agendas, and innovative new technologies will be presented.

The Symposium covers all aspects of the evolving fields of materials, enabling technologies, sensor/actuator design, and applications of these technologies to cover the whole spectrum of life in the 21st century, including commercial, medical, aerospace, and military fields. It also includes several conferences on NDE and structural health monitoring, safety, security, characterization of materials, detection of materials defects and degradation, evaluation of the state of damage enabling reliable component failure prediction, application of micro- and nanomaterial systems, energy systems and infrastructure.

This meeting is a showcase for multidisciplinary research and provides an excellent opportunity to explore new research areas by teaming with new partners from many fields. Welcome to Denver!

## 2019 SYMPOSIUM CHAIRS:



**Tribikram Kundu**  
The Univ. of Arizona (USA)



**Gregory W. Reich**  
Air Force Research Lab. (USA)

## 2019 SYMPOSIUM CO-CHAIRS:



**Zoubeyda Ounaies**  
The Pennsylvania State Univ. (USA)



**Hoon Sohn**  
KAIST (Korea, Republic of)

# SPIE. SMART STRUCTURES+ NONDESTRUCTIVE EVALUATION

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## Cooperating Organizations





# DAILY SCHEDULE

SUNDAY 3 MARCH	MONDAY 4 MARCH	TUESDAY 5 MARCH	WEDNESDAY 6 MARCH	THURSDAY 7 MARCH
<b>SPECIAL EVENTS</b>	<i>In Memoriam: Siegfried Bauer (Kaltenbrunner)</i> , 8:20 to 8:25 AM, p. 6	<i>Plenary Presentaton: Piezoelectric Films for MEMS Applications (Trolier-McKinstry)</i> , 8:30 to 9:15 AM, p. 6	<b>SPIE Best Student Paper Awards, EAP-In-Action Demonstration Awards and Bioinspiration, Biomimetics, and Bioreplication Best Student Paper Awards: In Memory of H. Don Wolpert</b> , 8:15 to 8:30 AM, p. 11	
	<b>2019 NDE Lifetime Achievement Award presentation and 2019 SSM Lifetime Achievement Award presentation</b> , 8:25 to 8:30 AM, p. 11	<i>Plenary Presentaton: Structural Health Monitoring: A View of the Entrepreneur (Uhl)</i> , 9:15 to 10:00 AM, p. 7	<i>Plenary Presentaton: Journey From Energy Harvesting and 4D Printing to Medical Applications (Liao)</i> 8:30 to 9:15 AM, p. 7	
	<i>Plenary Presentaton: Artificial Intelligence-based Structural Health Monitoring (Li)</i> , 8:30 to 9:15 AM, p. 6	<b>Lunch with the Experts - A Student Networking Event</b> , 12:30 to 1:30 PM, p. 9	<i>Plenary Presentaton: Modeling for Research in Ultrasonic NDE (Lowe)</i> 9:15 to 10:00 AM, p. 7	
	<i>Plenary Presentaton: The Emerging Technologies for Future Space Missions (Hadaegh)</i> , 9:15 to 10:00 AM, p. 6	<b>SPIE Best Student Paper Session</b> , 1:30 to 5:00 PM, p. 9	<b>Women in Optics Networking Dinner</b> , 6:00 to 7:30 PM, p. 9	
	<i>EAPAD Keynote Presentation: Sixty Years of Fun in Science and Technology (Baughman)</i> , 10:30 to 11:10 AM, p. 8	<b>Poster Session</b> , 6:00 to 7:30 PM, p. 9		
	<i>Tutorial: Applications of Uncertainty Analysis in Smart Materials and Adaptive Structures (Smith, Oates)</i> , 10:30 am to 3:00 PM, p. 8			
	<i>EAPAD Keynote Presentation: Inflatable Technology: Using Flexible Materials to Make Large Structures (Litteken)</i> , 11:10 to 11:50 AM, p. 8			
	<b>All-Symposium Welcome Reception</b> , 6:00 to 7:30 PM, p. 9			
<b>CONFERENCES</b>	Conf. 10965 <b>Bioinspiration, Biomimetics, and Bioreplication IX</b> ( <i>Martin-Palma</i> ), pp. 24-38			
	Conf. 10966 <b>Electroactive Polymer Actuators and Devices (EAPAD) XXI</b> ( <i>Bar-Cohen</i> ), pp. 24-56			
	Conf. 10967 <b>Active and Passive Smart Structures and Integrated Systems XIII</b> ( <i>Erturk</i> ), pp. 24-56			
	Conf. 10968 <b>Behavior and Mechanics of Multifunctional Materials XIII</b> ( <i>Naguib</i> ), pp. 24-48			
	Conf. 10969 <b>Nano-, Bio-, Info-Tech Sensors and 3D Systems</b> ( <i>Kim</i> ), pp. 24-48			
	Conf. 10970 <b>Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems</b> ( <i>Lynch</i> ), pp. 25-57			
	Conf. 10971 <b>Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII</b> ( <i>Gyekenyesi</i> ), pp. 25-55			
	Conf. 10972 <b>Health Monitoring of Structural and Biological Systems XIII</b> ( <i>Fromme</i> ), pp. 25-57			
Conf. 10973 <b>Smart Structures and NDE for Energy Systems and Industry 4.0</b> ( <i>Meyendorf</i> ), pp. 25-39				
<b>COURSES</b>	SC1265 <b>Industry 4.0: Advanced Materials and NDE in Smart Factory Systems</b> ( <i>Meyendorf</i> ), 8:30 AM to 12:30 PM, p. 17			
	SC634 <b>Electroactive Polymer Actuators and Devices</b> ( <i>Madden, Pei, Spinks</i> ), 1:30 to 5:30 PM, p. 19			

## PLENARY SESSIONS

### Monday Plenary Session

Monday 4 March 2019 · 8:20 AM - 10:00 AM

Location: Silverton Ballroom

Session Chairs: **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

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8:20 AM - 8:25 AM:

Speaker: **Martin Kaltenbrunner**, Johannes Kepler Univ. Linz (Austria)



#### IN MEMORIAM

**Siegfried Bauer** (1961-2018)

Johannes Kepler Univ. Linz (Austria)

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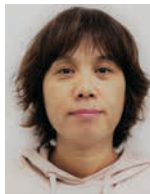
8:25 AM - 8:30 AM:

- 2019 NDE Lifetime Achievement Award presented to **Laurence J. Jacobs**, Georgia Institute of Technology (USA)
- 2019 SSM Lifetime Achievement Award presented to **Diann E. Brei**, Univ. of Michigan (USA)

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8:30 AM - 9:15 AM:

#### ARTIFICIAL INTELLIGENCE-BASED STRUCTURAL HEALTH MONITORING



**Hui Li**

Harbin Institute of Technology (China)

On the one hand, it is well-known that the model-based damage detection and model updating are insensitive to minor damage and is impeded due to ill-condition issues. Artificial intelligence includes machine learning, deep learning, computer vision, virtual and augmented realization (VR/AR), etc. Various

machine learning and deep learning algorithms provide new potential ways to assess the structural conditions by using the big data, which structural health monitoring systems have sampled. In addition, the computer vision and VR/AR aid us to automatically “see” structure damage directly. In this lecture, the recent advances in artificial intelligence-based structural health monitoring are introduced, including the big data driven-based structural condition assessment, big data and model-based structural safety evaluation, and wind and earthquake disaster management.

*Biography:* **Hui Li** is Changjiang Professor in civil engineering and mechanics at Harbin Institute of Technology. Her research interests include artificial intelligence, data science and engineering, structural health monitoring, applied mathematics, fluid dynamics, nonlinear dynamics, and nanomaterials. She is the PI of 15 projects supported by NSFC and the Ministry of Science and Technology, China. She is authors and coauthors of 200 Journal papers and about 80 keynote lectures in conferences.

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9:15 AM - 10:00 AM:

#### THE EMERGING TECHNOLOGIES FOR FUTURE SPACE MISSIONS



**Fred Hadaegh**

Jet Propulsion Lab. (USA)

In an age of proliferating technologies, we must innovate and leverage the right ones for the unique challenges of space exploration. For space, technology carries a specific meaning: the means to enable exciting new missions. We have achieved many new capabilities by leveraging technologies that have seen rapid advances for mission applications. For example, the advantages of rapid 3D printing have been pushed to an additional fourth “dimension,” namely by constructing space systems whose functions evolve over the course of the mission. The use of the smart materials has now made it possible to develop gears that no longer require lubrication and will perform in extreme environment for a long time. Other examples include miniaturization of instruments and systems now flying in JPL’s planetary CubeSats, new robotic systems that can crawl on a wall, and the swarms of thousands of tiny autonomous spacecraft. This presentation will provide an overview of the emerging space missions and the breakthrough technologies that will enable these missions over the next two decades.

*Biography:* **Fred Hadaegh** joined Jet Propulsion Lab in 1984 after receiving his Ph.D. in electrical engineering from University of Southern California, as well as bachelor’s and master’s degrees in the same subject from the University of Texas, Austin. For more than two decades, he supervised Jet Propulsion Lab’s Guidance and Control Analysis Group. He also previously led the development of guidance and control technologies for spacecraft formation flying, autonomous rendezvous and docking for NASA missions and Department of Defense programs. Hadaegh is a Jet Propulsion Lab Fellow and Senior Research Scientist, Fellow of the Institute of Electronics and Electrical Engineers (IEEE) and Fellow of the American Institute of Aeronautics and Astronautics (AIAA). Among his numerous awards are NASA’s Exceptional Service and Exceptional Achievement Medals. His research interests include optimal estimation and control as applied to distributed spacecraft. He has published extensively on mathematical modeling of uncertain systems, parameter identifiability of dynamical systems, identification and control of large space structures, and autonomous control of distributed spacecraft systems.

### Tuesday Plenary Session

Tuesday 5 March 2019 · 8:25 AM - 10:00 AM

Location: Silverton Salons 2-3

Session Chairs: **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

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8:25 AM - 8:30 AM:

SPIE Fellow Awards presented to:

- **Roger M. Groves**, Technische Univ. Delft (Netherlands)
- **Faramarz Gordaninejad**, Univ. of Nevada, Reno (USA)

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8:30 AM - 9:15 AM:

#### PIEZOELECTRIC FILMS FOR MEMS APPLICATIONS



**Susan Trolier-McKinstry**

The Pennsylvania State Univ. (USA)

Piezoelectric thin films are of increasing interest in low voltage microelectromechanical systems (MEMS) for sensing, actuation, and energy harvesting. The key figures of merit for actuators and energy harvesting will be discussed, with emphasis on how to achieve these on practical substrates. For example, control of the domain structure of the ferroelectric material allows the energy harvesting figure of merit for the piezoelectric layer to be increased by factors of 4 – 10. To illustrate the functionality of these films, examples of integration into MEMS structures will also be discussed, including adjustable optics for x-ray telescopes, low frequency, and non-resonant piezoelectric energy harvesting devices, and miniaturized ultrasound transducer arrays.

*Biography:* **Susan Trolier-McKinstry** is the Steward S. Flaschen Professor of Ceramic Science and Engineering, Professor of Electrical Engineering, and Director of the Nanofabrication facility at the Pennsylvania State University. Her main research interests include thin films for dielectric and piezoelectric applications. She currently serves as an associate editor for Applied Physics Letters. She was 2017 President of the Materials Research Society.

9:15 AM - 10:00 AM:

**STRUCTURAL HEALTH MONITORING: A VIEW OF THE ENTREPRENEUR**



**Tadeusz Uhl**

AGH Univ. of Science and Technology (Poland)

Nowadays there is pressure for commercialization of research from founding agencies, but the process of commercialization of research needs time and support to be successful because there are several stages and limits which should be crossed to achieve a market product. Some of them are related to technical

issues but some are related to business problems. One possible path of commercialization is creating new start-up companies. During this presentation, problems of research commercialization will be listed and discussed. Some case studies related to SHM technology will be presented. Particularly, the talk will focus on active thermography and applications, predictive maintenance based on AI algorithms and its application, on sensors design and application, and some UAV-based solutions.

*Biography:* Professor **Tadeusz Uhl** teaches Mechatronics at the University of Science and Technology AGH in Krakow, Poland. His research interest is focused on mechatronics, SHM, predictive maintenance, structural dynamics, and artificial intelligence. He is the coordinator of several international, interdisciplinary research projects with scientific and industrial partners. As an entrepreneur, he created 29 start-up companies in the area of technology with PhD students.

**Wednesday Plenary Session**

Wednesday 6 March 2019 · 8:15 AM - 10:00 AM

Location: Silverton Salons 2-3

*Session Chairs:* **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

8:15 AM - 8:30 AM:

- SPIE Best Student Paper Awards
- EAP-In-Action Demonstration Awards
- Bioinspiration, Biomimetics, and Bioreplication Best Student Paper Awards: In Memory of H. Don Wolpert

8:30 AM - 9:15 AM:

**JOURNEY FROM ENERGY HARVESTING AND 4D PRINTING TO MEDICAL APPLICATIONS**



**Wei-Hsin Liao**

The Chinese Univ. of Hong Kong (Hong Kong, China)

By utilizing adaptive features, smart materials can be built as sensors and actuators. Energy can be harvested from vibration and human motion. Piezoelectric and electromagnetic power generators were used to transform

the mechanical energy from vibration and human motion into electrical energy. On the other hand, robotic exoskeletons that can assist people with impaired mobility have been developed. With the developed device, paralyzed individual can regain the ability to stand up and walk. Smart ankle-foot prostheses with compact cam-spring mechanism have also been implemented to help amputees walk with less effort while having more natural gait. Utilizing additive manufacturing into smart materials has led to 4D printing technology for creating structures that can change their shape and function on-demand and over time. Actuator units were designed and fabricated directly by printing fibers of shape memory polymers in flexible structures. They can serve as tubular stents and grippers for biomedical applications. In this talk, related research projects and key results will be presented.

*Biography:* **Wei-Hsin Liao** received his Ph.D. from The Pennsylvania State University. Since 1997, Dr. Liao has been with The Chinese University of Hong Kong, where he is Professor and Chairman of Department of Mechanical and Automation Engineering. His research has led to publications of over 200 papers in international journals and conference proceedings, 16 granted patents. As the General Chair, he organized the 20th International Conference on Adaptive Structures and Technologies (ICAST 2009). He was the Conference Chair for the Active and Passive Smart Structures and Integrated Systems, SPIE Smart Structures/NDE in 2014 and 2015. He is a recipient of the ASME Best Paper Awards in Structures (2008), Mechanics and Material Systems (2017). He received the SPIE 2018 SSM Lifetime Achievement Award. He is on the editorial boards of the Journal of Intelligent Material Systems and Structures, as well as Smart Materials and Structures. Dr. Liao is a Fellow of ASME, HKIE, and IOP.

9:15 AM - 10:00 AM:

**MODELING FOR RESEARCH IN ULTRASONIC NDE**



**Michael Lowe**

Imperial College London (United Kingdom)

Research in ultrasonic NDE over the past several decades has been supported by a growing use of specialist modeling tools, to calculate wave propagation behavior, the influences of materials, guided waves, and the scattering of waves from features and defects.

Model capabilities are now so good that simulations are being used in a similar manner to experiments, and some important research objectives are not possible at all without them. The NDE research group at Imperial College has worked over many years on the long-term development of some general purpose modeling tools, which have provided essential underpinning to the creation of new capabilities in NDE. This presentation will use some examples of research achievements in NDE to illustrate the vital role of advanced modeling tools in their success.

*Biography:* **Michael Lowe** is Professor of Mechanical Engineering at Imperial College London, UK. His research interests in NDE include guided waves, wave scattering, material structure, and numerical modeling. He was joint founder of spin-out company Guided Ultrasonics Ltd (1999) and the UK Research Centre for NDE (2003), elected Fellow of the Royal Academy of Engineering (2014), and has published about 300 indexed papers.

## SPECIAL EVENTS

### Technical Events

#### EAPAD Keynote Presentations

Monday 4 March 2019 · 10:30 AM - 11:50 AM  
Location: Silverton Ballroom

10:30 AM - 11:10 AM:

#### SIXTY YEARS OF FUN IN SCIENCE AND TECHNOLOGY



**Ray H. Baughman**, The Univ. of Texas at Dallas (USA)

This perspective is on how discoveries have been made during my sixty years as a scientist and engineer, and will include advances up to the present. Many collaborators played star roles. Sometimes research in one area led to the realization of a much more important advance in another area. For instance, our demonstration that cm-size polydiacetylene single crystals can have enormous per-chain strength and can triple the frequency of incoming light has had no commercial importance. However, a desperate search for applications led to the use of topochemical diacetylene polymerization for cheap, printed time-temperature indicators for vaccines, which are saving hundreds of thousands of lives. The scope of described scientific and technological advances will include (1) advances in the early days of conducting polymers; (2) the discovery that many materials are auxetic if you look in the right direction, and some even expand in one or two directions when hydrostatically compressed; (3) early use of photonic crystals to make pretty carpets; (4) the theoretical prediction of many new carbon phases, one of which (a graphyne) has been recently synthesized; (5) weavable yarn fuel cells, batteries, and supercapacitors; (6) strong carbon nanotube yarns and sheets; (7) biscrolling as a way to incorporate up to 95 wt% of function powders into yarns, and resulting superconducting and thermoelectric textiles; (8) carbon nanotube thermoacoustic projectors; (9) thermoelectrochemical energy harvesters; (10) strong, large-stroke thermally, chemically, and electrochemically powered artificial muscles; (11) intelligent textiles; and (12) twistron mechanical energy harvesters.

*Biography:* **Ray Baughman** became the Robert A. Welch Professor of Chemistry and Director of the NanoTech Institute at the University of Texas in Dallas in August 2001, after 31 years in industry. He is a member of the National Academy of Engineering, the Academy of Medicine, Engineering and Science of Texas, the Academia Europaea, and the European Academy of Sciences and Arts; a foreign member of the European Academy of Sciences; a Fellow of the Royal Society of Chemistry, the National Academy of Inventors, and the American Physical Society; an Academician of The Russian Academy of Natural Sciences; and an honorary professor of 7 universities in China.

11:10 AM - 11:50 AM:

#### INFLATABLE TECHNOLOGY: USING FLEXIBLE MATERIALS TO MAKE LARGE STRUCTURES



**Douglas A. Litteken**, NASA Johnson Space Ctr. (USA)

Flexible materials have been investigated and used since the 1960's for a variety of applications including large, expandable space stations and inflatable airlocks. The first ever spacewalk, for example, was performed out of an expandable airlock in 1965. For a long time after that historic spacewalk, however, there was little work performed in the softgoods field until flexible materials were available with enough strength to achieve the vision of those early pioneers. In the late 1990's, NASA developed an inflatable habitat, known as TransHAB, that utilized high strength fabric materials as the primary structure, like Kevlar and Vectran, which could provide a large habitable volume in a small and compact launch package. TransHAB was composed of a metallic core surrounded by softgoods layers that provided a pressure seal, a structural layer, micro-meteorite impact protection, and thermal insulation. The entire softgoods layer stack could be folded and packaged around the core to save significant launch volume. The technology developed during this project led to modern inflatable habitats like the Bigelow Expandable Activities Module (BEAM) on the International Space Station (ISS). Similar technology is also being used to develop new inflatable habitats and airlocks for the lunar Gateway program and a future lunar surface base. These modern softgoods incorporate strain, damage, impact, temperature, pressure, and radiation sensors to build a "smart" structure with integrated structural health monitoring. Future applications could incorporate artificial muscles and other EAPs to better control the deployment and operation of an inflatable. This talk will review the history of inflatable technology at NASA, the science behind designing, building, and testing a large scale habitat, and will discuss the future path for inflatables.

*Biography:* **Douglas Litteken** is a structural engineer at NASA's Johnson Space Center (JSC) in Houston, TX. He is the Lightweight Structures Domain Lead at JSC and a Subject Matter Expert in the agency for softgoods structures. He is also the sub-system manager for the Orion crew cabin primary structure. His interests include inflatable habitats, parachutes, composite structures, flexible electronics, and structural health monitoring. His experience includes the design, analysis and testing of softgoods structures including lunar surface habitats, airlocks, and deep space transit vehicles. He received both his Bachelor's and Master's degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign.



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## Tutorial: Applications of Uncertainty Analysis in Smart Materials and Adaptive Structures

Monday 4 March 2019 · 10:30 AM - 3:00 PM  
Location: Quartz Boardroom



*Instructors:*  
**Ralph Smith**, North Carolina State Univ. (USA)



**William Oates**, Florida State Univ. (USA)

The purpose of this hands-on tutorial is to expose participants to statistical and numerical techniques that will allow them to quantify the accuracy of multi-physics models and simulation codes for active materials and structures when one accounts for uncertainty or errors in models, parameters, numerical simulation codes, and data.

In the first part of the tutorial, we will provide an overview of Bayesian statistics and numerical algorithms necessary to propagate input uncertainties through simulation codes. We will consider several case studies to illustrate these techniques for a variety of materials and smart structure applications. These include models for piezoelectric macro-fiber composites, shape memory alloys, viscoelastic polymers, graphene thermoacoustics, quantum-informed ferroelectric continuum models, and Rietveld analysis. In this part of the tutorial, we will provide participants with algorithms that quantify the uncertainties in model parameters, such as piezoelectric constants, when they are calibrated from experimental data. To illustrate the uncertainty propagation techniques, we will demonstrate the construction of 95% prediction intervals for PZT models at a given applied field.

As part of the tutorial, participants will have the opportunity to run case studies using MATLAB, if they have a local license on their laptop. These studies will include models and data provided by the instructors, but participants are also encouraged to bring their own models and data for testing during the tutorial, based on their specific problem(s) of interest. All tutorial code will be available online for later use by participants not having a local MATLAB license.

This introductory tutorial is intended for graduate students, industrial practitioners, and academic professionals who are interested in quantifying uncertainty in material and structural models in light of experiments or higher fidelity model predictions.

The tutorial is open to all registered attendees on a first-come first-serve basis. Seating is limited.

**Ralph Smith** is a distinguished professor of Mathematics at North Carolina State University, who has expertise in mathematical modeling, uncertainty and sensitivity analysis, and control of smart materials and structures. He has written books on both smart materials and structures as well as uncertainty quantification and sensitivity analysis. He has investigated the role of uncertainty quantification in the context of macro-fiber composites and shape memory alloys including the use of uncertainty quantification to improve robust control design.

**William Oates** is an associate professor in the Department of Mechanical Engineering at Florida State University. His research includes constitutive model development, structural analysis, and experimental characterization of smart materials and adaptive structures. He has utilized Bayesian statistics to analyze smart materials and systems including quantum informed ferroelectric modeling, graphene thermoacoustics, piezoelectric composites, and multi-functional polymer constitutive model development.

## SPIE Best Student Paper Session

Tuesday 5 March 2019 · 1:30 PM - 5:00 PM  
Location: Quartz Boardroom

Finalists for the SPIE Best Student Paper Award will present their papers in this special session.

## Poster Session

Tuesday 5 March 2019 · 6:00 PM - 7:30 PM  
Location: 3rd Floor - Crestone and Crystal Foyer

Conference attendees are invited to attend the poster session on Tuesday evening. Come view the posters, ask questions, and enjoy the refreshments. Authors of poster papers will be present to answer questions concerning their papers. Attendees are required to wear their conference registration badges to the poster session.

### Poster Set-Up/Viewing:

Tuesday 5 March, 10:00 AM - 4:00 PM

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## Social Events

### All-Symposium Welcome Reception

Monday 4 March 2019 · 6:00 PM - 7:30 PM  
Location: 4th Floor Atrium

All attendees are invited to relax, socialize, and enjoy refreshments. Please remember to wear your conference registration badges. Dress is casual.

### Lunch with the Experts - A Student Networking Event

Tuesday 5 March 2019 · 12:30 PM - 1:30 PM  
Location: 4th Floor Atrium

Open to Student Attendees

Seating is limited. Enjoy a casual meal with colleagues at this engaging networking opportunity. Hosted by SPIE Student Services, this event features experts willing to share their experience and wisdom on career paths in optics and photonics. Seating is limited and will be granted on a first-come, first-served basis.



### Women in SPIE Networking Dinner

Wednesday 6 March 2019 · 6:00 PM - 7:30 PM  
Location: Elements Restaurant and Bar

**To reserve your spot, please come to the SPIE Registration Desk.** Due to limited seating, we will only be able to accommodate the first 20 to RSVP.

Female conference attendees are invited to meet at Elements Restaurant and Bar in Embassy Suites for a delicious dinner and stimulating conversation.

Elements Restaurant and Bar: Embassy Suites, 1420 Stout St., Denver, CO 80202

# AWARD EVENTS



## Award Presentations

Monday through Wednesday 4–6 March 2019  
Location: Silverton Salons 2–3

Monday 4 March · 8:25 AM - 8:30 AM:

## 2019 NDE Lifetime Achievement Award

presented to



**Laurence J. Jacobs**, Georgia Institute of Technology (USA)

Biography: **Laurence J. Jacobs** is Associate Dean for Academic Affairs of the College of Engineering at the Georgia Institute of Technology, and Professor of Civil and Environmental Engineering and Mechanical Engineering. Dr. Jacobs received his PhD in Engineering Mechanics from Columbia University and joined the faculty of Georgia Tech in 1988. Professor Jacobs' research focuses on the application of linear and nonlinear ultrasound for the characterization of fatigue, creep, stress-corrosion, thermal embrittlement and radiation damage in metals. His work in cement-based materials includes the application of ultrasonic techniques to quantify microstructure and progressive micro-cracking in concrete.

## 2019 SSM Lifetime Achievement Award

presented to



**Diann E. Brei**, Univ. of Michigan (USA)

Biography: **Dr. Diann Brei** joined the Mechanical Engineering at the University of Michigan in 1994 after graduating from Arizona State University with her Ph.D (1993) in Mechanical Engineering and her BSE (1988) in Computer Systems Engineering. She served as the Mechanical Engineering Associate Chair for Undergraduate Education and as the Director of the Design Science Program. She was the co-director of the General Motors/University of Michigan Smart Materials and Structures Collaborative Research Laboratory (SMS CRL) with a range of projects focused on smart material maturity, product innovation utilizing smart materials, and mechatronic design tools. She is currently Professor of Mechanical Engineering and recently became chair of the Integrative Systems + Design Division at the University of Michigan. She currently serves as the co-director of the General Motors/University of Michigan Multifunctional Vehicle Systems Collaborative Research Laboratory (MVS CRL) with thrust in Multi-functional Interactive Knits, NeuroTech, Multi-functional Active System Technologies and The Technology Incubator. Dr. Brei's expertise is in multi-domain design with technical interests in smart materials and structures, sensors and actuators, and medical devices. Her research has focused on the underlying design science for device innovation using smart materials. Fundamental to her work is the synthesis and analysis of smart material actuation and device architectures from conventional ratcheting and spooling to cutting edge architectures such as active knits and active Velcro. Her smart material architectural models along with her multi-domain, multi-stage design methods have set the foundation for a successful translational research and development paradigm adopted by industries in the automotive, medical, and aerospace sectors. She has written over 125 referred journal and conference publications. Apart from her publications, she has sixteen patents and 22 pending, with exclusive licenses with General Motors and Lynx. Dr. Brei who is an ASME Fellow and AIAA Associate Fellow, has been an active leader in the smart materials and structures community, co-founding the SMASIS conference, originating the ASME/AIAA Adaptive Structures e-newsletter, and establishing the Adaptive Structures national database. For her research she has been awarded the ASME Best Paper Award in Structures and Structural Dynamics, Hartwell Award, Ted Kennedy Team Excellence Award, and the National Multiple Sclerosis Society Da Vinci Award; for her teaching she has received the Ruth and Joel Spira Outstanding Teaching Award, ASEE Best Paper Award, University of Michigan College of Engineering Outstanding Faculty Award for Mechanical Engineering; for her dedicated service she has been awarded the ASME Distinguished Service Award, Monroe-Brown Foundation Service Excellence Award and was a Willie Hobbs Moore Aspire, Advance, Achieve Mentoring Award Finalist.

Tuesday 5 March · 8:25 AM - 8:30 AM:

## 2019 SPIE Fellow Awards

presented to



**Roger Groves**, Technische Univ. Delft (Netherlands)

Biography: **Dr. Roger M. Groves** is Associate Professor of NDT/SHM & Heritage Diagnostics on the Faculty of Aerospace Engineering at Delft University of Technology in the Netherlands. He has been an active member of the international optics community for 20 years. He was a Senior Scientist at ITO, University of Stuttgart from 2004-2008. Since 2008, he has headed the Aerospace NDT research at TU Delft, leading a team of 20 researchers and students in optical metrology, fibre optic sensors and ultrasonics. He is well known as a leading researcher in shearography, and more recently in hyperspectral imaging for museum conservation and fibre optic sensors for aerospace structural health monitoring. He was Acting Chair of the Structural Integrity and Composites Group from Nov 2016 to May 2017.



**Faramarz Gordaninejad**, Univ. of Nevada, Reno (USA)

Biography: **Dr. Faramarz Gordaninejad** is a Regents and Foundation Professor of Mechanical Engineering at the University of Nevada, Reno. He currently serves as the Director of the Composite and Intelligent Materials Laboratory at UNR. Dr. Gordaninejad's research interests are in the areas of dynamics and control of smart and composite-material structures, with an emphasis on active and passive vibration damping control applied to land vehicles, aerospace and robotic systems. His research is focused on both fundamental and applied research on materials development, understanding magnetorheological-based materials behavior, design and development of semi-active and active systems, and testing and evaluation of composite and smart materials systems. In addition to his academic position, Dr. Gordaninejad is the founder and President of Advanced Materials and Devices, Inc., which is a research, development, and commercialization business located in a 6,000sq-ft facility in Reno, Nevada that designs, develops, tests and evaluates advanced systems for government agencies and leading industry.

## AWARD EVENTS

Wednesday 6 March · 8:15 AM - 8:30 AM:

### SPIE Best Student Paper Awards

SPIE is sponsoring the Best Student Paper contest. Papers will be presented in a special Session on Tuesday afternoon. Entrants will be judged by a committee from SPIE. The committee will then vote to determine the top three finalists. The top three finalist student authors and/or student co-authors will receive certificates and cash awards.

### Bioinspiration, Biomimetics, and Bioreplication Best Student Paper Award: In Memory of H. Don Wolpert

The Bioinspiration, Biomimetics, and Bioreplication VIII conference chairs will choose the Best Student Paper Award from their conference. This award is sponsored by the Optical Society of Southern California. A cash prize will be given to the first, second, and third place winners.

Sponsored by:



### EAP-In-Action Demonstration Awards

As part of the EAPAD conference of the SPIE Smart Structures/NDE symposia, the EAP-in-Action Demonstration Session has been held over the past 19 years. In an effort to encourage excellence in developing the Electroactive Polymers (EAP) demonstrations and accelerate the transition of EAPs to practical and commercial technologies, award certificates will be issued as of the 2018 SPIE Smart Structures/NDE symposium. A judging committee, consisting of leading EAP experts, will select the award winners among the presenters at the EAP-in-Action Demonstration Session. The judges will assess the presenters' performance as well as the quality and content of the demos. The top ranked three will be recognized and will be awarded certificates.



Photo credit: Kallol Mukherjee



## International Day of Light

16 May

**The International Day of Light is a global initiative highlighting to the citizens of the world the importance of light and light-based technologies in their lives, for their futures, and for the development of Society.**

**SPIE supports the International Day of Light and its annual celebration on 16 May.**



#### SPIE IDL GRANTS

SPIE will provide seed funding up to US\$3,000 to organizations creating Day of Light activities.



#### IDL RESOURCES

SPIE encourages communities to plan their own annual celebration on 16 May and provides various resources to help create an event.



#### SPIE PHOTO CONTEST

Amateur and professional photographers alike should submit photos demonstrating the vital role that light plays in our lives for a chance to win US\$2,500.



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**Learn more: [spie.org/idl](http://spie.org/idl)**

# 21ST ANNUAL EAP-IN-ACTION SESSION AND DEMONSTRATIONS

Monday 4 March 2019 · 4:30 PM - 5:45 PM · Location: Silverton Ballroom · Part of conference 10966 on EAPAD.



Session Chair:

**Yoseph Bar-Cohen**  
Jet Propulsion Lab. (USA)

This Session highlights some of the latest capabilities and applications of Electroactive Polymers (EAP) materials where the attendees are shown demonstrations of these materials in action. Also, the attendees interact directly with technology developers and given “hands-on” experience with this emerging technology. The first Human/EAP-Robot Armwrestling Contest was held during this session of the 2005 EAPAD conference.

## EAP Demonstrations

### Novel dielectric elastomer membrane actuator concept for pneumatic valves

**Steffen Hau**, Saarland Univ. (Germany)

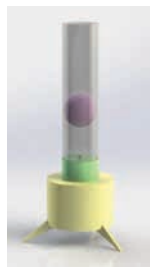
Despite being relatively easy to manufacture and providing large strokes, dielectric elastomer (DE) membrane actuators suffer from low force outputs (for single layer systems). This demo presents a novel design concept that permits to retune the stroke-force trade-off of DE actuators, by allowing increasing force output of the actuator at the expense of a reduced stroke. This is of particular interest for valve applications, which typically need high closing forces and low strokes in the submillimeter regime. By means of the novel design concept, the valve closing force of single DE membranes can be increased by a factor of 3 to 4. The concepts still keeps the general advantages of DEAs, e.g., light weight, and energy efficiency. The use of strip-in-plane DE actuators additionally allows staying within the typical dimension of commercial valves.



### DEA-based pneumatic pump

**Philipp Linnebach**, Saarland Univ. (Germany)

This demonstrator shows the use of circular out-of-plane dielectric elastomer actuators (COP-DEA) in a pneumatic pump application. The presented concept allows building very small and lightweight pumps. It is related to the paper with the title “Design of a dielectric elastomer actuator driven pneumatic pump”.



### A fast 200 mg DEA robot

**X. Ji, B. Aksoy, H. Shea**, EPFL (Switzerland)

We present the DEAnsect: an ultra-light (0.2 g) soft robot driven by stacked dielectric elastomer actuators (DEAs) operating at 450V. The DEAnsect has a flexible silicone body and three legs, each driven independently by a DEA stack. The DEAnsect moves at 4 body lengths per second and can be accurately steered thanks to the independent control of each DEA. It is robust, can climb slopes of 15°, and survives being flattened with a fly swatter.



### Textile exoskeletons

**Edwin W. H. Jager, Jose G. Martinez**, Linköping Univ. (Sweden);  
**Nils-Krister Persson**, Univ. of Borås (Sweden)

Various diseases or aging can cause a reduction in the muscle function of a person. Robotic exoskeletons have been developed to augment or replace the movement of various limbs and thus for instance assist walking or aid rehabilitation. Current exoskeletons are rigid, heavy, stiff and non-compliant. We are developing textile-based exoskeletons that can be worn like items of clothing being light-weight, soft, compliant and comfortable. In this EAP-in-Action, demonstrators of the prototype textile exoskeleton-arm-sleeves developed by Linköping University and University of Borås will be shown. The exoskeleton arm sleeve prototypes use small electrical motors or McKibben actuators and enable lifting the arm, including a weight, of the wearer without using their own muscles.

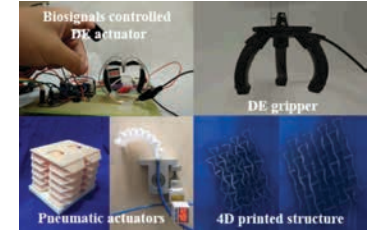


### Smart soft polymers and structures

**Liwu Liu, Qinghua Guan, Jinrong Li, Yanju Liu, Jonsong Leng**, Harbin Institute of Technology (China)

The demonstration will focus on the applications of smart soft polymers, including dielectric elastomer (DE), shape memory polymer (SMP) and other smart soft structures.

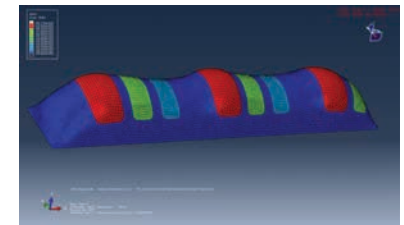
1. Biosignals controlled DE actuators. The biosignals will be acquired, processed and then amplified to drive DE actuators.
2. Smart morphing structures based on DE and SMP: Structures may include deployable gripping devices or lock-release structures, etc.
3. Flexible pneumatic actuators. Multi-degree-of-freedom motions could be realized by combining multiple flexible pneumatic actuators together.
4. SMP based 4D printing technique. The 3D printable filaments with shape memory effect and some representative printed structures, which can change shape along with time, will be demonstrated.



### Inflatable dielectric elastomer conveyor

**Joseph Ashby, E.-F. Markus Henke, Sam Rosset, Iain Anderson**, Biomimetics Lab. (New Zealand)

We present an inflatable robot, created from a sheet of silicone and airbrushed electrodes, which uses out of phase segmented actuation to produce linear conveyance of a light load along its length. Also presented: a finite element simulation of the model. This demonstrates one potential application for inflatable dielectric robotics.

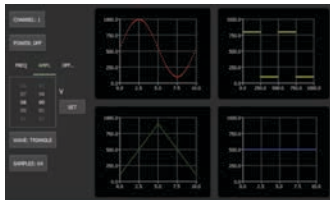




## High voltage EAP controller

**E.-F. Markus Henke**, Biomimetics Lab. (New Zealand) and TU Dresden (Germany); **Patrin Illenberger, Katie Wilson, Sam Rosset, Iain Anderson**, Biomimetics Lab. (New Zealand)

We will showcase a new EAP high voltage controller that is at the  $\alpha$  stage. This new controller will help university labs and other research institutions to easily power their EAP actuators without the need of developing complicated driving electronics. It comes with four channels, a touch screen user interface and is battery powered. The controller provides DC, rectangle, sinusoidal and triangle signals, with an amplitude of up to 5kV @ 1mA per channel. The Channels can be programmed independently.



## Geometric limit switches (gDES) for robotics and automation industry

**E.-F. Markus Henke**, Biomimetics Lab. (New Zealand) and TU Dresden (Germany); **Patrin Illenberger, Katie Wilson, Sam Rosset, Iain Anderson**, Biomimetics Lab. (New Zealand)

Geometric dielectric elastomer switches (gDES) switch both high and low voltages. They only consist of soft materials such as silicones and carbon-doped conductive silicones. Arrays of these switches can be integrated in soft robotic grippers and extend the features of those grippers by touch and shear force detection. Furthermore, gDES can act as limit switches and can be introduced in automation technology. One of the key advantages is that the switches themselves are entirely shielded and not affected by environmental influences.



## From StretchSense Ltd.: the latest in EAP gloves

**Marco Tabor, Iain Anderson**, StretchSense Ltd. (New Zealand)

StretchSense is putting EAP sensors into garments using fabric-backed sensors and combining information from different sensor types. To illustrate the technology we present an EAP glove, that can capture and send in real-time hand-posture (rotation) and fingerbending to a device with an application to visualize the data e.g. game.



## Synthetic Muscle in prosthetics

**Lenore Rasmussen, Damaris Smith**, Ras Labs, Inc. (USA)



Ras Labs Synthetic Muscle™ is an EAP based actuator that contracts, and with reversed electric input polarity, expand. Ras Labs has begun testing their EAP system on amputees to maintain continual perfect prosthetic socket fit and is going to present their prototype. These EAPs serve dual use as sensors, which can be tied in to automatic adjustment and touch biofeedback, and can determine the number of impacts (or steps) and severity of impact/pressure for protective gear and comfortable shoe wear and insoles.



## Versatile dielectric loudspeakers

**Florian Klug**, TU Darmstadt (Germany)

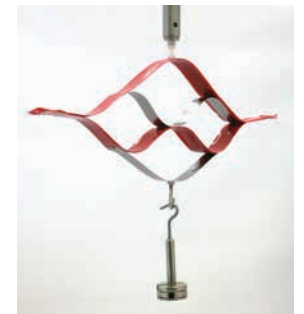
Electronic EAPs, such as the dielectric elastomer transducer, offer higher frequencies up to several kilohertz. Therefore, different kinds of EAP loudspeakers have been presented. Due to their nonlinear behavior and high driving voltages, they suffer from poor audio quality and high costs. Within this demonstration, we are presenting different configurations for low cost, flexible or low distortion loudspeakers. Sound pressure levels higher than 100 dB with >10 kHz bandwidth and distortion < 2 % can be achieved. Depending on the configuration, they can be adaptable to various shapes and produced with large surfaces.



## Electro-ribbon actuators and electro-origami robots

**Tim Helps, Majid Taghavi, Richard Suphapol Diteesawat, Jonathan Rossiter**, Univ. of Bristol (United Kingdom)

Electro-origami is an electrostatic active origami concept, that allows for simple, inexpensive, lightweight, efficient, powerful, and scalable electronic actuators and lightweight and thin robots. The simplest embodiment of electro-origami, electro-ribbon actuators, can be easily fabricated from any combination of conducting and insulating material. Electro-ribbon actuators can lift 1000 times their own weight, contract by 99.8% of their length, and deliver specific energy and specific power equivalent to muscle. Possible morphologies include high-stroke, high-force, multiactuator lattices, 3D-printed and paper actuators, self-twisting spirals, and tensile elements inspired by spider silk. More complex electro-origami devices include solenoids, adaptive grippers, robotic cilia, locomoting robots, self-packing deployable structures, origami artificial muscles, and dynamic origami art.





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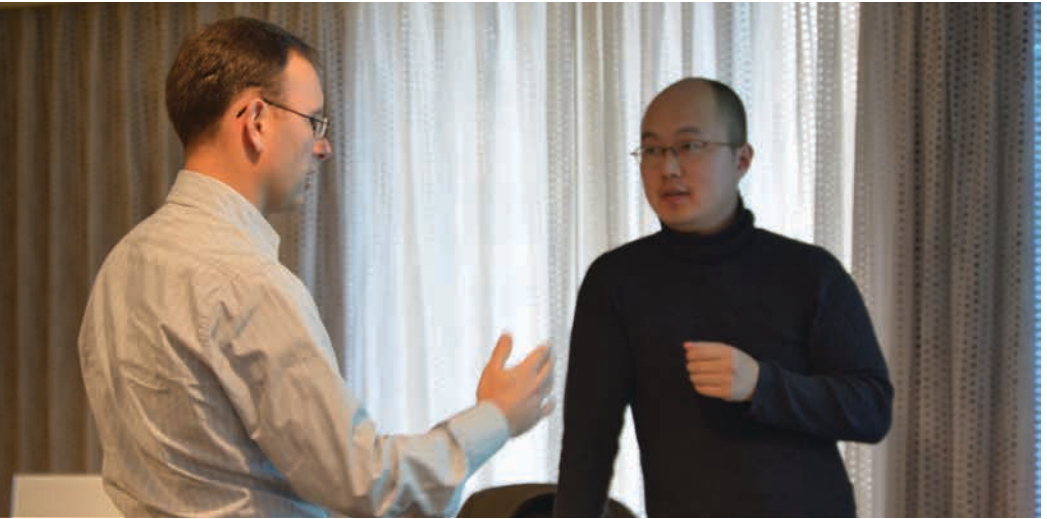
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## Industry 4.0: Advanced Materials and NDE in Smart Factory Systems

### SC1265

Sunday · 8:30 AM - 12:30 PM

Course Level: Introductory · CEU: 0.4

Member: \$390.00 · Non-Member: \$445.00

Student Member: \$253.00

The fourth industrial revolution will change the way we create, apply, and inspect Smart Materials and Systems. Modern manufacturing techniques are characterized by networking of systems in all industrial areas (Industry 4.0) and producing individual components tailored to the needs of individual customers. This course explains how the Internet of Things and the next generation of industrial production encompasses the complete networking of all industrial areas. New production techniques, such as 3D printing, will allow efficient in-time production for low numbers of unique parts. A significant aspect is also quality and maintainability of these sometimes unique structures and components. NDE has to follow these trends, by not only adapting NDE techniques to the new technologies, but also by introducing the capability of cyber systems into the inspection and maintenance processes. This course will introduce present trends in industry such as production

of individual parts by 3D printing, product design and testing by digital twins, 3D volume data creation, component live data files, management of big data, real time monitoring of structural integrity, reliable inspection of individual components, and remote NDE to include competencies not available onsite.

#### LEARNING OUTCOMES

- discuss different aspects of production in a digital world
- explain new terminology used for cyber-physical systems
- create concepts for the next generation of production, where components can be tailored to custom requirements for different materials (metals, ceramic, polymers)
- create databases for product life files, monitoring, and NDE data
- manage big data
- use the internet of things as a tool for real-time product monitoring
- apply modified procedures for quality insurance and NDE for Industry 4.0
- introduce the complete modeling of a structure for product development and testing (digital twin)
- organize remote NDE inspections for a better use of the qualification of your inspectors
- select required hardware and software

*Continued*

[spie.org/education](http://spie.org/education)



## Fight Bias, Embrace Diversity

SPIE seeks to cultivate a culture of openness and inclusivity. Help us eradicate bias and make the world of optics and photonics a shining example of all minds coming together to innovate regardless of gender, race, nationality, culture, educational background, politics, sexuality, body-type and age, for the betterment of life.

Educate yourself on the issues faced by a diverse workforce, challenge your own assumptions, and tap into the rich pool of talent, perspectives, and ideas offered by people different from you.

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SPIE is accredited by the International Association for Continuing Education and Training (IACET) and is authorized to issue the IACET CEU.

## INTENDED AUDIENCE

Scientists, engineers, technicians, managers or students who wish to get an overview of different aspects of Industry 4.0. Undergraduate training in engineering or science is assumed.

## INSTRUCTOR

**Norbert G. Meyendorf** is adjunct faculty at the Iowa State University, the University of Dayton, and the University of Technology in Dresden (Germany). He is recently retired from Fraunhofer Institute for Ceramic Technologies and Systems (IKTS). His expertise ranges from materials science, image and data processing, to NDE and SHM. He is Editor-in-Chief of the Journal of Nondestructive Evaluation and a Fellow of SPIE.

## Electroactive Polymer Actuators and Devices

### SC634

Sunday · 1:30 PM - 5:30 PM

Course Level: Introductory · CEU: 0.4

Member: \$390.00 · Non-Member: \$445.00

Student Member: \$253.00

This course will provide an overview of the field of EAP covering the state of the art, challenges and potential. Three general classes of polymer materials are described, namely those that involve ionic mechanisms (Ionic EAP including gels), field activated materials (Electronic EAP) and torsional actuators (typically thermally or electrothermally driven). The basic mechanisms responsible for the active behavior of EAP materials will be covered and compared with natural muscles. Analytical models, fabrication processes and methods of characterizing these materials will be described. Moreover, the currently considered applications will be reviewed including actuators, robotics, animatronics, energy harvesting, medical, and biologically inspired mechanisms, so called biomimetics. The course begins with an overview of the field, current capabilities, potential and challenges. The course follows with a description of the currently available EAP materials and principles of operating them as actuators and artificial muscles. The course ends with a review of the future prospect of EAP as actuators and sensors in systems, mechanisms and smart structures for industrial and medical applications.



## LEARNING OUTCOMES

- identify EAP based available and emerging actuators/sensors
- learn the fundamentals of electroactive behavior in leading EAP materials
- describe the capabilities, limitations and benefits of electroactive polymers
- become familiar with fabrication processes
- review mechanical analysis and design principles associated with EAP
- assess the applicability of current EAP actuators while accounting for their limitations
- describe the future prospects of EAP materials as actuators and their applications

## INTENDED AUDIENCE

Engineers, scientists and managers who need to understand the basic concepts of EAP, or are interested in learning, applying or engineering mechanisms or devices using EAP materials. Also those who wish to discover the excitement of research and development in EAP materials and their applications - present and future.

## INSTRUCTORS

**John David W. Madden** is a Professor of Electrical & Computer Engineering at the University of British Columbia, Vancouver, Canada. His research areas include the application of EAP materials in active catheters, as well as the development and characterization of molecular, carbon nanotube and anisotropically thermally expanding polymer actuators. <http://mina.ubc.ca/member/john-madden/>  
**Qibing Pei** is professor of materials science and engineering at the University of California, Los Angeles. His research interests cover a wide range of soft materials and span from polymer synthesis, processing, to fabrication of functional devices which include flexible polymer electronics, dielectric elastomer artificial muscles, and Braille electronic readers. <http://www.mse.ucla.edu/faculty/pei/>

**Geoffrey M. Spinks** is a Professor of Materials Engineering at the University of Wollongong, Australia. His research interests focus on new materials and manufacturing methods for artificial muscles, soft robotics and wearable robotics. [https://scholars.uow.edu.au/display/geoff\\_spinks](https://scholars.uow.edu.au/display/geoff_spinks)

# CONFERENCE SESSION SCHEDULE

	<b>CONFERENCE 10965</b> Bioinspiration, Biomimetics, and Bioreplication IX	<b>CONFERENCE 10966</b> Electroactive Polymer Actuators and Devices (EAPAD) XXI	<b>CONFERENCE 10967</b> Active and Passive Smart Structures and Integrated Systems XIII	<b>CONFERENCE 10968</b> Behavior and Mechanics of Multifunctional Materials and Composites XIII	<b>CONFERENCE 10969</b> Nano-, Bio-, Info-Tech Sensors and 3D Systems
Monday 4 March	<p><b>Session 1</b> Mon 10:30 am to 12:10 pm Robotics I <i>(Martín-Palma)</i></p>	<p><b>Session 1</b> Mon 10:30 am to 11:50 am Keynote Session: EAP as Emerging Actuators <i>(Bar-Cohen, Anderson)</i></p>	<p><b>Session 1</b> Mon 10:30 am to 11:50 am Active and Passive Vibration/Noise Attenuation I <i>(Erturk, Han)</i></p>	<p><b>Session 1</b> Mon 10:30 am to 11:50 am New Synthesis and Technologies <i>(Naguib, Ahmed)</i></p>	<p><b>Session 1</b> Mon 10:30 am to 11:15 am Keynote Session I <i>(Kim)</i></p> <p><b>Session 2</b> Mon 11:15 am to 12:25 pm Man-Machine Interface for Healthcare <i>(Song)</i></p>
	<p><b>Session 2</b> Mon 1:10 pm to 2:10 pm Robotics II <i>(Bar-Cohen)</i></p> <p><b>Session 3</b> Mon 2:10 pm to 3:20 pm Environmental Biomimetics <i>(Lakhtakia)</i></p> <p><b>Session 4</b> Mon 3:50 pm to 5:30 pm Biomimetic Optics <i>(Knez)</i></p>	<p><b>Session 2</b> Mon 1:20 pm to 3:20 pm EAP Materials and Devices Fabrication Methods (e.g., 3D Printing): Progress and Challenges <i>(Spinks, Baughman)</i></p> <p>4:30 pm to 5:45 pm EAP-in Action Demonstration Session <i>(Bar-Cohen)</i></p>	<p><b>Session 2</b> Mon 1:00 pm to 3:20 pm Metamaterials and Metastructures <i>(Arrieta, Gibert)</i></p> <p><b>Session 3</b> Mon 3:50 pm to 5:30 pm Energy Harvesting I: Nonlinear/Wideband <i>(Liao, Harne)</i></p>	<p><b>Session 2</b> Mon 1:20 pm to 3:00 pm Modeling of Smart Materials <i>(Harne, Wissa)</i></p> <p><b>Session 3</b> Mon 3:30 pm to 5:30 pm Shape Memory Materials I <i>(Hartl, Abel)</i></p>	<p><b>Session 3</b> Mon 1:35 pm to 3:25 pm Wearable Technology and Healthcare <i>(Yeo)</i></p> <p><b>Session 4</b> Mon 3:55 pm to 5:25 pm Nanosensors and Applications <i>(Oh)</i></p>
Tuesday 5 March	<p><b>Session 5</b> Tue 10:30 am to 12:00 pm Biomimetic Materials and Structures I <i>(Porfiri)</i></p>	<p><b>Session 3</b> Tue 10:30 am to 11:50 am Design Methods of Producing EAP Mechanisms <i>(Alici, Litteken)</i></p>	<p><b>Session 4</b> Tue 10:30 am to 12:10 pm Energy Harvesting II: Nonlinear/Wideband <i>(Tol, Tang)</i></p>	<p><b>Session 4</b> Tue 10:30 am to 12:10 pm Mechanics of Smart Particulate Polymer Composites <i>(Loh, Rizvi)</i></p>	<p><b>Session 5</b> Tue 10:30 am to 11:15 am Keynote Session II <i>(Kim)</i></p> <p><b>Session 6</b> Tue 11:15 am to 12:45 pm 3D Printing and Systems I <i>(Park)</i></p>
	<p><b>Session 6</b> Tue 1:30 pm to 2:30 pm Biomimetic Materials and Structures II <i>(Libonati)</i></p> <p><b>Session 7</b> Tue 2:30 pm to 3:30 pm Biomimetic Actuators <i>(Lenau)</i></p> <p><b>Session 8</b> Tue 4:00 pm to 6:00 pm Sensors <i>(Hölscher)</i></p>	<p><b>Session 4</b> Tue 1:20 pm to 3:00 pm Twisted and Coiled Polymer Actuators <i>(Schlaak, Johnson)</i></p> <p><b>Session 5</b> Tue 3:30 pm to 5:50 pm Modeling <i>(Skov, Zhao)</i></p>	<p><b>Session 5</b> Tue 1:40 pm to 3:00 pm Energy Harvesting III: Fluid/Acoustic-Structure Interaction <i>(Bryant, Danesh-Yazdi)</i></p> <p><b>Session 6</b> Tue 3:30 pm to 5:50 pm Fluid-Structure Interaction <i>(Zuo, Chae)</i></p>	<p><b>Session 5</b> Tue 2:00 pm to 3:00 pm Additive Manufacturing <i>(Ameli, Elahinia)</i></p> <p><b>Session 6</b> Tue 3:30 pm to 5:30 pm Origami Materials <i>(Ounaies, von Lockette)</i></p>	<p><b>Session 7</b> Tue 2:05 pm to 3:25 pm 3D Printing and Systems II <i>(Lin)</i></p> <p><b>Session 8</b> Tue 3:55 pm to 5:45 pm Nanomaterials and Applications I <i>(Kim)</i></p>

# CONFERENCE SESSION SCHEDULE

<b>CONFERENCE 10970</b> Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems	<b>CONFERENCE 10971</b> Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII	<b>CONFERENCE 10972</b> Health Monitoring of Structural and Biological Systems XIII	<b>CONFERENCE 10973</b> Smart Structures and NDE for Energy Systems and Industry 4.0
<p>Session 1                      Mon 10:30 am to 11:50 am                      Keynote Session  <i>(Lynch, Huang)</i></p>	<p>Session 1                      Mon 10:30 am to 11:50 am                      SHM-NDE of Civil Structures/Infrastructure I  <i>(Yu, Ozevin)</i></p>	<p>Session 1                      Mon 10:30 am to 12:10 pm                      Guided Waves for SHM I  <i>(Fromme, Su)</i></p>	<p>Session 1                      Mon 10:30 am to 11:10 am                      Keynote Session I  <i>(Gath)</i></p> <p>Session 2                      Mon 11:10 am to 11:50 am                      The Internet of Things  <i>(Gath)</i></p>
<p>Session 2                      Mon 1:20 pm to 3:00 pm                      Computer Vision and Augmented Reality Solutions for SHM  <i>(Torbol, Lynch)</i></p> <p>Session 3                      Mon 3:30 pm to 5:30 pm                      Ultrasound/Guided Waves  <i>(Peters, Tol)</i></p>	<p>Session 2                      Mon 1:10 pm to 3:10 pm                      SHM-NDE of Civil Structures/Infrastructure II  <i>(Lau, Omenzetter)</i></p> <p>Session 3                      Mon 3:40 pm to 6:00 pm                      SHM-NDE of Civil Structures/Infrastructure III  <i>(Farhangdoust, Wu)</i></p>	<p>Session 2                      Mon 1:20 pm to 3:00 pm                      Sensors for Real-Time Monitoring I  <i>(Ostachowicz, Uhl)</i></p> <p>Session 3                      Mon 3:30 pm to 5:50 pm                      Elastic and Metamaterials I  <i>(Huang, Semperlotti)</i></p>	<p>Session 3                      Mon 1:20 pm to 3:00 pm                      New Applications for Smart Structures and Materials for Industry 4.0  <i>(Meyendorf)</i></p> <p>Session 4                      Mon 3:30 pm to 5:30 pm                      Industrial and Commercial Application of Smart Structures and Materials  <i>(Meyendorf)</i></p>
<p>Session 4                      Tue 10:30 am to 12:10 pm                      Machine Learning and Data Analysis  <i>(Mehrabi, Kong)</i></p>	<p>Session 4                      Tue 10:30 am to 12:10 pm                      SHM-NDE Science and Theory I  <i>(Gyekenyesi, Chen)</i></p>	<p>Session 4                      Tue 10:30 am to 12:10 pm                      Modeling of Ultrasonic and Guided Waves  <i>(Giurgiutiu, di Scalea)</i></p>	<p>Session 5                      Tue 10:30 am to 11:10 am                      Keynote Session II <i>(Meyendorf)</i></p> <p>Session 6                      Tue 11:10 am to 12:10 pm                      Big Data, Data Management, Data-processing, and Datafusion I  <i>(Liu)</i></p>
<p>Session 5                      Tue 1:40 pm to 3:00 pm                      Smart Materials Integration for Smart Systems  <i>(Tallman, Ryu)</i></p> <p>Session 6                      Tue 3:30 pm to 5:50 pm                      Case Studies of SHM in Civil Infrastructure Systems  <i>(di Scalea, Zonta)</i></p>	<p>Session 5                      Tue 1:40 pm to 3:00 pm                      SHM-NDE of Civil Structures/Infrastructure IV  <i>(Mirsayar, Chen)</i></p> <p>Session 6                      Tue 3:30 pm to 5:50 pm                      SHM-NDE of Civil Structures/Infrastructure V  <i>(Lau, Su)</i></p>	<p>Session 5                      Tue 1:20 pm to 3:00 pm                      Elastic and Metamaterials II  <i>(Yang, Nough)</i></p> <p>Session 6                      Tue 3:30 pm to 5:50 pm                      Monitoring of Aerospace and Composite Structures  <i>(Ricci, Kundu)</i></p>	<p>Session 7                      Tue 1:10 pm to 1:50 pm                      Big Data, Data Management, Dataprocessing, and Datafusion II  <i>(Liu)</i></p> <p>Session 8                      Tue 1:50 pm to 4:40 pm                      NDE and SHM for Energy Systems  <i>(Niezrecki)</i></p> <p>Session 9                      Tue 4:40 pm to 5:40 pm                      Sensors, Actuators, and Monitoring for Energy Systems  <i>(Niezrecki)</i></p>

# CONFERENCE SESSION SCHEDULE

	<b>CONFERENCE 10966</b> Electroactive Polymer Actuators and Devices (EAPAD) XXI		<b>CONFERENCE 10967</b> Active and Passive Smart Structures and Integrated Systems XIII		<b>CONFERENCE 10968</b> Behavior and Mechanics of Multifunctional Materials and Composites XIII	<b>CONFERENCE 10969</b> Nano-, Bio-, Info-Tech Sensors and 3D Systems
Wednesday 6 March	<p>Session 6 Wed 10:30 am to 12:10 pm Testing and Characterization of EAP Materials <i>(Mazurek, Kaltenbrunner)</i></p>		<p>Session 7 Wed 10:30 am to 11:50 am Morphing, Deployable, and Origami Structures <i>(Harne, Tol)</i></p>		<p>Session 7 Wed 10:30 am to 11:50 am Magnetostrictive and Magnetorheological Materials <i>(Dapino, Gallagher)</i></p>	<p>Session 9 Wed 10:30 am to 12:20 pm Smart Optics <i>(Yoon)</i></p>
	<p>Session 7 Wed 1:40 pm to 3:00 pm Manufacturing, Mechanical Properties, and Performance of EAP Materials <i>(Liu, Zhu)</i></p> <p>Session 8 Wed 3:30 pm to 6:10 pm Ionic EAP Materials Including IPMC <i>(Kim, Rasmussen)</i></p>		<p>Session 8 Wed 1:40 pm to 3:00 pm Active and Passive Vibration/Noise Attenuation II <i>(Lee, Zuo)</i></p> <p>Session 9 Wed 3:30 pm to 6:10 pm Energy Harvesting IV: General <i>(Shahab, Towfighian)</i></p>		<p>Session 8 Wed 2:00 pm to 3:00 pm Shape Memory Polymers II <i>(Leng, Meddeb)</i></p> <p>Session 9 Wed 3:30 pm to 5:50 pm Multifunctional Composites Systems <i>(Myers, Ciocanel)</i></p>	<p>Session 10 Wed 1:50 pm to 3:10 pm Nanomaterials and Applications II <i>(Wang)</i></p> <p>Session 11 Wed 3:40 pm to 5:50 pm Nanomaterials and Applications III <i>(Porfiri)</i></p>
Thursday 7 March	<p>Session 9A Thu 8:20 to 10:00 am Application of EAP to Robotics <i>(Rosset, Sundaresan)</i></p>	<p>Session 9B Thu 8:00 to 10:00 am Applications of EAP I <i>(Koh, Park)</i></p> <p>Session 10B Thu 10:30 to 11:50 am Applications of EAP II <i>(Keplinger, Böse)</i></p>	<p>Session 10A Thu 8:00 to 10:00 am Acoustics and Wave Propagation <i>(Nouh, Kauffman)</i></p> <p>Session 11A Thu 10:30 to 11:50 am Modeling and Analysis of Smart Structures <i>(Ozer, Danzi)</i></p>	<p>Session 10B Thu 8:00 to 10:00 am Magnetorheological Devices and Systems <i>(Pekcan, Erturk)</i></p> <p>Session 11B Thu 10:30 to 11:50 am Magnetostrictive, Magnetoelectric, and Magnetorheological Devices <i>(Han, Erturk)</i></p>		
	<p>Session 10A Thu 10:30 to 11:50 am Wearable and Tactile Applications <i>(Madden, Jean-Mistral)</i></p> <p>Session 11A Thu 1:20 to 3:00 pm EAP Actuators <i>(Pei, Su)</i></p> <p>Session 12A Thu 3:30 to 5:50 pm EAP Sensors and Actuators <i>(Christianson, Liu)</i></p>	<p>Session 11B Thu 1:20 to 3:00 pm Applications of EAP III <i>(Henke, Mirvakili)</i></p> <p>Session 12B Thu 3:30 to 5:50 pm Applications of EAP IV <i>(Vertechy, Jager)</i></p>	<p>Session 12A Thu 1:20 to 3:00 pm Shape Memory Alloys <i>(Goo, Shahab)</i></p> <p>Session 13A Thu 3:30 to 5:50 pm Sensing, Actuation, and Diagnostics <i>(Lee, Ozer)</i></p>	<p>Session 12B Thu 1:20 to 3:00 pm Energy Harvesting V: General <i>(Liao, Danzi)</i></p> <p>Session 13B Thu 3:30 to 4:30 pm Energy Harvesting VI: General <i>(Soto, Liao)</i></p>		



# CONFERENCE SESSION SCHEDULE

<b>CONFERENCE 10970</b> Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems		<b>CONFERENCE 10971</b> Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII	<b>CONFERENCE 10972</b> Health Monitoring of Structural and Biological Systems XII	
<p>Session 7 Wed 10:30 am to 12:10 pm Power Harvesting for Self-Powered Sensors (Noh, Su)</p>		<p>Session 7 Wed 10:30 am to 12:10 pm SHM-NDE Science and Theory II (Chiang, Bartlett)</p>	<p>Session 7 Wed 10:30 am to 12:10 pm Sensors for Real-Time Monitoring II (Niezrecki, Krishnaswamy)</p>	
<p>Session 8 Wed 1:40 pm to 3:00 pm Actuators/Adaptive Structures (Badescu, Abdullah)</p> <p>Session 9 Wed 3:30 pm to 6:10 pm Nanocomposites and Flexible Sensors (Kim, Huang)</p>		<p>Session 8 Wed 1:40 pm to 3:00 pm SHM-NDE Ultrasonics I (Shull, Zhang)</p> <p>Session 9 Wed 3:30 pm to 5:50 pm SHM-NDE of Composite Materials I (Bowland, Khodaei)</p>	<p>Session 8 Wed 1:20 pm to 3:00 pm Elastic and Metamaterials III (Semperlotti, Huang)</p> <p>Session 9 Wed 3:30 pm to 5:50 pm Civil Infrastructure Monitoring I (Stepinski, Rizzo)</p>	
<p>Session 10A Thu 8:00 am to 10:00 am Proximity Sensors for IoT Solutions (Wang, Loh)</p> <p>Session 11A Thu 10:30 am to 11:50 am Modeling of Smart Materials and Sensor Performance (Xia, Zhang)</p>	<p>Session 10B Thu 8:00 am to 10:00 am Health Monitoring of Large-Scale and Complex Systems (Sohn, Lynch)</p> <p>Session 11B Thu 10:30 am to 11:50 am Control and Actuation of Dynamic Systems (Peckens, Bridgelall)</p>	<p>Session 10 Thu 8:00 am to 10:00 am SHM-NDE Ultrasonics II (Ostachowicz, Dehghan-Niri)</p> <p>Session 11 Thu 10:30 am to 11:50 am SHM-NDE of Composite Materials II (Giurgiutiu, Koricho)</p>	<p>Session 10A Thu 8:20 am to 10:00 am Nonlinear Ultrasonic Techniques (Su, Croxford)</p> <p>Session 11A Thu 10:30 am to 11:50 am Sensors for Real-Time Monitoring III (Sabato, Wang)</p>	<p>Session 10B Thu 8:20 am to 10:00 am Civil Infrastructure Monitoring II (Fekrmandi)</p> <p>Session 11B Thu 10:30 am to 11:50 am Elastic and Metamaterials IV (Yang, Banerjee)</p>
<p>Session 12A Thu 1:20 pm to 3:00 pm Optical Fiber Sensors (Jenkins, Groves)</p> <p>Session 13A Thu 3:30 pm to 5:50 pm Sensor Development and Applications (Zhang, Liao)</p>	<p>Session 12B Thu 1:20 pm to 3:00 pm SHM Applications to Concrete Structures (Glisic, Huang)</p> <p>Session 13B Thu 3:30 pm to 5:50 pm Skin-based Distributed Sensing for SHM Applications (Loh, Laflamme)</p>	<p>Session 12 Thu 1:20 pm to 3:20 pm SHM-NDE Science and Theory III (Mao, Koshti)</p>	<p>Session 12A Thu 1:20 pm to 3:00 pm Guided Waves for SHM II (Yu, Shen)</p> <p>Session 13 Thu 3:30 pm to 5:10 pm Civil Infrastructure Monitoring III (Su, Reis)</p>	<p>Session 12B Thu 1:20 pm to 3:00 pm Medical / Biomedical Applications (Jiang)</p>

## CONFERENCE 10965

Monday–Tuesday  
4–5 March 2019  
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### Bioinspiration, Biomimetics, and Bioreplication IX

*Conference Chair:* **Raúl J. Martín-Palma**, Univ. Autónoma de Madrid (Spain)

*Conference Co-Chairs:* **Mato Knez**, CIC nanoGUNE Consolider (Spain); **Akhlesh Lakhtakia**, The Pennsylvania State Univ. (USA)

*Program Committee:* **Javaan S. Chahl**, Univ. of South Australia (Australia); **Vincenzo Fiumara**, Univ. degli Studi della Basilicata (Italy); **Laurent A. Francis**, Univ. Catholique de Louvain (Belgium); **Olaf Karthaus**, Chitose Institute of Science and Technology (Japan); **Kwang Jin Kim**, Univ. of Nevada, Las Vegas (USA); **Mathias Kolle**, Massachusetts Institute of Technology (USA); **Bert Müller**, Univ. Basel (Switzerland); **Maurizio Porfiri**, NYU Tandon School of Engineering (USA); **Akira Saito**, Osaka Univ. (Japan); **Cordt Zollfrank**, Technische Univ. München (Germany)

## CONFERENCE 10966

Monday–Thursday  
4–7 March 2019  
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### Electroactive Polymer Actuators and Devices (EAPAD) XXI

*Conference Chair:* **Yoseph Bar-Cohen**, Jet Propulsion Lab. (USA)

*Conference Co-Chairs:* **Iain A. Anderson**, The Univ. of Auckland (New Zealand); **Nancy L. Johnson**, General Motors Co. (USA)

*Program Committee:* **Barbar J. Akle**, Lebanese American Univ. (Lebanon); **Kinji Asaka**, National Institute of Advanced Industrial Science and Technology (Japan); **Pavol Bauer**, Technische Univ. Delft (Netherlands); **Siegfried G. Bauer**, Johannes Kepler Univ. Linz (Austria); **Ray H. Baughman**, The Univ. of Texas at Dallas (USA); **Václav Bouda**, Czech Technical Univ. in Prague (Czech Republic); **Federico Carpi**, Univ. degli Studi di Firenze (Italy); **Suresh Chandra**, Institute of Technology, Banaras Hindu Univ. (India); **Hyook Ryeol Choi**, Sungkyunkwan Univ. (Korea, Republic of); **Gal deBotton**, Ben-Gurion Univ. of the Negev (Israel); **Toribio Fernández Otero**, Univ. Politécnica de Cartagena (Spain); **Yahya A. Ismail**, A'Shargiyah Univ. (Oman); **Edwin W. H. Jager**, Linköping Univ. (Sweden); **Giedrius Janusas**, Kaunas Univ. of Technology (Lithuania); **Kwang Jin Kim**, Univ. of Nevada, Las Vegas (USA); **Gabor M. Kovacs**, EMPA (Switzerland); **Maarja Kruusmaa**, Univ. of Tartu (Estonia); **Jinsong Leng**, Harbin Institute of Technology (China); **John D. W. Madden**, The Univ. of British Columbia (Canada); **Qibing Pei**, Univ. of California, Los Angeles (USA); **Thelge Chaminda Peiris**, MAS Innovation Ltd. (Sri Lanka); **Valentin Radu**, Omicron Plus S.R.L. (Romania); **Mehdi Razzaghi-Kashani**, Tarbiat Modares Univ. (Iran, Islamic Republic of); **Jonathan M. Rossiter**, Univ.

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## CONFERENCE 10967

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### Active and Passive Smart Structures and Integrated Systems XIII

*Conference Chair:* **Alper Erturk**, Georgia Institute of Technology (USA)

*Conference Co-Chair:* **Jae-Hung Han**, KAIST (Korea, Republic of)

*Program Committee:* **Mehdi Ahmadian**, Virginia Polytechnic Institute and State Univ. (USA); **Steven R. Anton**, Tennessee Technological Univ. (USA); **Hiroshi Asanuma**, Chiba Univ. (Japan); **Diann E. Brei**, Univ. of Michigan (USA); **Matthew Bryant**, North Carolina State Univ. (USA); **Gregory P. Carman**, Univ. of California, Los Angeles (USA); **Eun Jung Chae**, California State Univ., Long Beach (USA); **Seung-Bok Choi**, Inha Univ. (Korea, Republic of); **Carlos De Marqui Jr.**, Univ. de São Paulo (Brazil); **Alison B. Flatau**, Univ. of Maryland, College Park (USA); **Mehrdad N. Ghasemi-Nejhad**, Univ. of Hawai'i (USA); **Victor Giurgiutiu**, Univ. of South Carolina (USA); **Nam Seo Goo**, Konkuk Univ. (Korea, Republic of); **Faramarz Gordaninejad**, Univ. of Nevada, Reno (USA); **Nakhiah C. Goulbourne**, Univ. of Michigan (USA); **Ryan L. Harne**, The Ohio State Univ. (USA); **Daniel J. Inman**, Univ. of Michigan (USA); **Hyung-Jo Jung**, KAIST (Korea, Republic of); **M. Amin Karami**, Univ. at Buffalo (USA); **Jung-Ryul Lee**, KAIST (Korea, Republic of); **Soobum Lee**, Univ. of Maryland, Baltimore County (USA); **Junrui Liang**, ShanghaiTech Univ. (China); **Wei-Hsin Liao**, The Chinese Univ. of Hong Kong (Hong Kong, China); **Zhu Mao**, Univ. of Massachusetts Lowell (USA); **David L. Mascareñas**, Los Alamos National Lab. (USA); **Gyuhae Park**, Chonnam National Univ. (Korea, Republic of); **Norbert Schwesinger**, Technische Univ. München (Germany); **Shima Shahab**, Virginia

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## CONFERENCE 10968

Monday–Wednesday  
4–6 March 2019  
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### Behavior and Mechanics of Multifunctional Materials XIII

*Conference Chair:* **Hani E. Naguib**, Univ. of Toronto (Canada)

*Conference Co-Chairs:* **Ryan L. Harne**, The Ohio State Univ. (USA); **Aimy Wissa**, Univ. of Illinois at Urbana-Champaign Chapter (USA)

*Program Committee:* **Amir Ameli**, Washington State Univ. Tri-Cities (USA); **Gregory P. Carman**, Univ. of California, Los Angeles (USA); **Constantin Ciocanel**, Northern Arizona Univ. (USA); **Marcelo J. Dapino**, The Ohio State Univ. (USA); **Mohammad H. Elahinia**, The Univ. of Toledo (USA); **Nakhiah C. Goulbourne**, Univ. of Michigan (USA); **Darren J. Hartl**, Texas A&M Univ. (USA); **Daniel J. Inman**, Univ. of Michigan (USA); **Kwang Jin Kim**, Univ. of Nevada, Las Vegas (USA); **Dimitris C. Lagoudas**, Texas A&M Univ. (USA); **Hyeong Jae Lee**, Jet Propulsion Lab. (USA); **Donald J. Leo**, Virginia Polytechnic Institute and State Univ. (USA); **Jiangyu Li**, Univ. of Washington (USA); **Christopher S. Lynch**, Univ. of California, Los Angeles (USA); **William S. Oates**, Florida State Univ. (USA); **Zoubeida Ounaies**, The Pennsylvania State Univ. (USA); **Reza Rizvi**, The Univ. of Toledo (USA); **Ralph C. Smith**, North Carolina State Univ. (USA); **Vishnu Baba Sundaresan**, The Ohio State Univ. (USA)

## CONFERENCE 10969

Monday–Wednesday  
4–6 March 2019  
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### Nano-, Bio-, Info- Tech Sensors and 3D Systems

*Conference Chair:* **Jaehwan Kim**, Inha Univ. (Korea, Republic of)

*Conference Co-Chairs:* **Kyo D. Song**, Norfolk State Univ. (USA); **Ilkwon Oh**, KAIST (Korea, Republic of); **Ajit Khosla**, Yamagata Univ. (Japan)

*Program Committee:* **Amir Ameli**, Washington State Univ. Tri-Cities (USA); **Kean C. Aw**, The Univ. of Auckland (New Zealand); **Anja Boisen**, Technical Univ. of Denmark (Denmark); **Christina L. Brantley**, U.S. Army Research, Development and Engineering Command (USA); **Wei Chen**, Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO) CAS (China); **Sang H. Choi**, NASA Langley Research Ctr. (USA); **Eugene Edwards**, U.S. Army Research, Development and Engineering Command (USA); **Hidemitsu Furukawa**, Yamagata Univ. (Japan); **Srinivasan Gopalakrishnan**, Indian Institute of Science (India); **Seiich Hata**, Nagoya Univ. (Japan); **Taizo Hayashida**, JSR Corp. (Japan); **Mamoru Kawakami**, Yamagata Univ. (Japan); **Adrian Koh**, National Univ. of Singapore (Singapore); **Kimiya Komurasaki**, The Univ. of Tokyo (Japan); **Hideki Kyogoku**, Kindai Univ. (Japan); **Kam K. Leang**, The Univ. of Utah (USA); **Uhn Lee M.D.**, Gachon Univ. Gil Medical Ctr. (Korea, Republic of); **Yirong Lin**, The Univ. of Texas at El Paso (USA); **Hani E. Naguib**, Univ. of Toronto (Canada); **Hidegori Okuzaki**, Univ. of Yamanashi (Japan); **Simon Park**, Univ. of Calgary (Canada); **Steve Park**, KAIST (Korea, Republic of); **Maurizio Porfiri**, NYU Tandon School of Engineering (USA); **Yongrae Roh**, Kyungpook National Univ. (Korea, Republic of);

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CONFERENCE 10970

Monday–Thursday  
4–7 March 2019  
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**Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems**

*Conference Chair:* **Jerome P. Lynch**, Univ. of Michigan (USA)

*Conference Co-Chairs:* **Haiying Huang**, The Univ. of Texas at Arlington (USA); **Hoon Sohn**, KAIST (Korea, Republic of); **Kon-Well Wang**, Univ. of Michigan (USA)

*Program Committee:* **Hiroshi Asanuma**, Chiba Univ. (Japan); **Chih Chen Chang**, Hong Kong Univ. of Science and Technology (Hong Kong, China); **Genda Chen**, Missouri Univ. of Science and Technology (USA); **Alison B. Flatau**, Univ. of Maryland, College Park (USA); **Branko Glisic**, Princeton Univ. (USA); **Faramarz Gordaninejad**, Univ. of Nevada, Reno (USA); **Benjamin L. Grisso**, Naval Surface Warfare Ctr. Carderock Div. (USA); **Ryan L. Harne**, The Ohio State Univ. (USA); **Jung-Wuk Hong**, KAIST (Korea, Republic of); **Neil A. Houtt**, Queen’s Univ. (Canada); **Ying Huang**, North Dakota State Univ. (USA); **Mohammad Reza Jahanshahi**, Purdue Univ. (USA); **Gi-Woo Kim**, Inha Univ. (Korea, Republic of); **Jeong-Tae Kim**, Pukyong National Univ. (Korea, Republic of); **Simon Laflamme**, Iowa State Univ. (USA); **Hui Li**, Harbin Institute of Technology (China); **Jian Li**, The Univ. of Kansas (USA); **Suyi Li**, Clemson Univ. (USA); **Wei-Hsin Liao**, The Chinese Univ. of Hong Kong (Hong Kong, China); **Chin-Hsiung Loh**, National Taiwan Univ. (Taiwan); **Kenneth J. Loh**, Univ. of California, San Diego (USA); **Bryan R. Loyola**, Sandia National Labs. (USA); **Theodore E. Matikas**, Univ. of Ioannina (Greece); **Norbert G. Meyendorf**, Iowa State Univ. of Science and Technology

*Committee continues page 27*

CONFERENCE 10971

Monday–Thursday  
4–7 March 2019  
Proceedings of SPIE  
Vol. 10971

**Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII**

*Conference Chair:* **Andrew L. Gyekeyesi**, Ohio Aerospace Institute (USA)

*Conference Co-Chairs:* **Tzu-Yang Yu**, Univ. of Massachusetts Lowell (USA); **H. Felix Wu**, U.S. Dept. of Energy (USA); **Peter J. Shull**, The Pennsylvania State Univ. (USA)

*Program Committee:* **Gary Carr**, Federal Railroad Administration (USA); **Chia-Ming Chang**, National Taiwan Univ. (Taiwan); **Genda Chen**, Missouri Univ. of Science and Technology (USA); **Chih-Hung Chiang**, Chaoyang Univ. of Technology (Taiwan); **Dwight A. Clayton**, Oak Ridge National Lab. (USA); **Kaoshan Dai**, Tongji Univ. (China); **Reinhard Ebert**, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung (Germany); **Zhenhua Huang**, Univ. of North Texas (USA); **Dryver R. Huston**, The Univ. of Vermont (USA); **Xiaoning Jiang**, North Carolina State Univ. (USA); **Ajay M. Koshti**, NASA Johnson Space Ctr. (USA); **Denvind Lau**, City Univ. of Hong Kong (Hong Kong, China); **Shiyuan Liu**, Huazhong Univ. of Science and Technology (China); **Kenneth J. Loh**, Univ. of California, San Diego (USA); **Jerome P. Lynch**, Univ. of Michigan (USA); **Oliver J. Myers**, Clemson Univ. (USA); **Piotr Omenzetter**, Univ. of Aberdeen (United Kingdom); **Didem Ozevin**, Univ. of Illinois at Chicago (USA); **Akira Sasamoto**, National Institute of Advanced Industrial Science and

*Committee continues page 27*

CONFERENCE 10972

Monday–Thursday  
4–7 March 2019  
Proceedings of SPIE  
Vol. 10972

**Health Monitoring of Structural and Biological Systems XIII**

*Conference Chair:* **Paul Fromme**, Univ. College London (United Kingdom)

*Conference Co-Chair:* **Zhongqing Su**, The Hong Kong Polytechnic Univ. (Hong Kong, China)

*Program Committee:* **Sourav Banerjee**, Univ. of South Carolina (USA); **Yoseph Bar-Cohen**, Jet Propulsion Lab. (USA); **Fu-Kuo Chang**, Stanford Univ. (USA); **Anthony J. Croxford**, Univ. of Bristol (United Kingdom); **Hadi Fekrmandi**, South Dakota School of Mines and Technology (USA); **Victor Giurgiutiu**, Univ. of South Carolina (USA); **Srinivasan Gopalakrishnan**, Indian Institute of Science (India); **Mohammad Hadi Hafezi**, The Univ. of Arizona (USA); **Guoliang Huang**, Univ. of Missouri (USA); **Xiaoning Jiang**, North Carolina State Univ. (USA); **Ajay M. Koshti**, NASA Johnson Space Ctr. (USA); **Sridhar Krishnaswamy**, Northwestern Univ. (USA); **Tribikram Kundu**, The Univ. of Arizona (USA); **Francesco Lanza di Scalea**, Univ. of California, San Diego (USA); **Zhu Mao**, Univ. of Massachusetts Lowell (USA); **Christopher Niezrecki**, Univ. of Massachusetts Lowell (USA); **Mostafa A. Nough**, Univ. at Buffalo (USA); **Wieslaw M. Ostachowicz**, The Szewalski Institute of Fluid-Flow Machinery (Poland); **Xinlin Qing**, Xiamen Univ. (China); **Henrique L. Reis**, Univ. of Illinois at Urbana-Champaign (USA); **Fabrizio Ricci**, Univ. degli Studi di Napoli Federico II (Italy); **Piervincenzo Rizzo**, Univ. of Pittsburgh (USA); **Alessandro Sabato**, Univ. of Massachusetts Lowell (USA); **Fabio Semperlotti**, Purdue Univ. (USA); **Yanfeng Shen**, Shanghai Jiao Tong Univ. (China); **Hoon Sohn**, KAIST (Korea, Republic

*Committee continues page 27*

CONFERENCE 10973

Monday–Tuesday  
4–5 March 2019  
Proceedings of SPIE  
Vol. 10973

**Smart Structures and NDE for Energy Systems and Industry 4.0**

*Conference Chair:* **Norbert G. Meyendorf**, Iowa State Univ. of Science and Technology (USA)

*Conference Co-Chair:* **Kerrie Gath**, Ford Motor Co. (USA)

*Program Committee:* **Ali Abdul-Aziz**, NASA Glenn Research Ctr. (USA); **Steven R. Anton**, Tennessee Technological Univ. (USA); **Nicolas P. Avdelidis**, Univ. Laval (Canada); **George Y. Baaklini**, NASA Glenn Research Ctr. (USA); **Leonard J. Bond**, Iowa State Univ. of Science and Technology (USA); **Diann E. Brei**, Univ. of Michigan (USA); **Peter C. Chen**, NASA Goddard Space Flight Ctr. (USA); **Michael Dalichow**, Quality Network Inc. (USA); **Marcelo Dapino**, The Ohio State Univ. (USA); **Dimitrios A. Exarchos**, Univ. of Ioannina (Greece); **Kevin M. Farinholt**, Luna Innovations Inc. (USA); **Xiao-Yan Gong**, Medical Implant Mechanics LLC (USA); **Steven F. Griffin**, The Boeing Co. (USA); **Peter Heilmann**, arxes-tolina GmbH (Germany); **Manfred Johannes**, South African Institute for Non-Destructive Testing (South Africa); **Nancy L. Johnson**, General Motors Co. (USA); **Vassilios Kappatos**, Univ. of Southern Denmark (Denmark); **Michael Kroening**, Pontificia Univ. Católica do Rio de Janeiro (Brazil); **Jayanth N. Kudva**, NextGen Aeronautics, Inc. (USA); **Amrita Kumar**, Accellent Technologies, Inc. (USA); **Jay Lee**, Univ. of Cincinnati (USA); **Jung-Ryul Lee**, KAIST (Korea, Republic of); **Donald J. Leo**, The Univ. of Georgia (USA); **Zheng Liu**, The Univ. of British Columbia Okanagan (Canada); **Theodore E. Matikas**, Univ. of Ioannina (Greece); **Geoffrey P. McKnight**,

*Committee continues page 27*

## CONFERENCE 10965

## CONFERENCE 10966

of Bristol (United Kingdom); **Anuvat Sirivat**, Chulalongkorn Univ. (Thailand); **Anne Ladegaard Skov**, Technical Univ. of Denmark (Denmark); **Geoffrey M. Spinks**, Univ. of Wollongong (Australia); **Ji Su**, NASA Langley Research Ctr. (USA); **Minoru Taya**, Univ. of Washington (USA); **I-Hsiang Tseng**, Feng Chia Univ. (Taiwan); **Rocco Vertechy**, Univ. degli Studi di Bologna (Italy); **Frédéric Vidal**, Univ. de Cergy-Pontoise (France); **Thomas Wallmersperger**, Technische Univ. Dresden (Germany); **Qiming M. Zhang**, The Pennsylvania State Univ. (USA); **Jian Zhu**, National Univ. of Singapore (Singapore); **Pawel Zylka**, Wroclaw Univ. of Technology (Poland)

## CONFERENCE 10967

Polytechnic Institute and State Univ. (USA); **Yi-Chung Shu**, National Taiwan Univ. (Taiwan); **Henry A. Sodano**, Univ. of Michigan (USA); **Jiong Tang**, Univ. of Connecticut (USA); **Lihua Tang**, The Univ. of Auckland (New Zealand); **Serife Tol**, Univ. of Michigan (USA); **Dai-Hua Wang**, Chongqing Univ. (China); **Kon-Well Wang**, Univ. of Michigan (USA); **Ya S. Wang**, Stony Brook Univ. (USA); **Norman M. Wereley**, Univ. of Maryland, College Park (USA); **Byeng D. Youn**, Seoul National Univ. (Korea, Republic of); **Lei Zuo**, Virginia Polytechnic Institute and State Univ. (USA)

## CONFERENCE 10968

## CONFERENCE 10969

**Debiprosad Roy Mahapatra**, Indian Institute of Science (India); **Ashok Srivastava**, Louisiana State Univ. (USA); **Hiroya Tanaka**, Keio Univ. (Japan); **Tauno Vaha-Heikkila**, VTT Technical Research Ctr. of Finland (Finland); **Vijay K. Varadan**, The Pennsylvania State Univ. (USA); **Wei-Chih Wang**, Univ. of Washington (USA); **W. Hong Yeo**, Georgia Institute of Technology (USA); **Hargsoon Yoon**, Norfolk State Univ. (USA); **Xuanhe Zhao**, Massachusetts Institute of Technology (USA)

## MONDAY 4 MARCH

PLENARY SESSION · 8:20 AM - 10:00 AM · LOCATION: SILVERTON BALLROOM

Session Chairs: **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

8:20 AM - 8:25 AM:

IN MEMORIAM: **Siegfried Bauer** (1961-2018), Johannes Kepler Univ. Linz (Austria)

8:25 AM - 8:30 AM:

- **2019 NDE Lifetime Achievement Award** presented to **Laurence J. Jacobs**, Georgia Institute of Technology (USA)
- **2019 SSM Lifetime Achievement Award** presented to **Diann E. Brei**, Univ. of Michigan (USA)



8:30 AM - 9:15 AM:

Plenary Presentation

**Artificial intelligence-based structural health monitoring**

**Hui Li**

Harbin Institute of Technology (China)



9:15 AM - 10:00 AM:

Plenary Presentation

**The emerging technologies for future space missions**

**Fred Y. Hadaegh**

Jet Propulsion Lab. (USA)

Coffee Break · 10:00 to 10:30 am

## CONFERENCE 10970

(USA); **Akira Mita**, Keio Univ. (Japan); **Yiqing Ni**, The Hong Kong Polytechnic Univ. (Hong Kong, China); **Haeyoung Noh**, Carnegie Mellon Univ. (USA); **Irving J. Oppenheim**, Carnegie Mellon Univ. (USA); **Wieslaw M. Ostachowicz**, The Szwedzki Institute of Fluid-Flow Machinery (Poland); **Kara J. Peters**, North Carolina State Univ. (USA); **Piervincenzo Rizzo**, Univ. of Pittsburgh (USA); **Donghyeon Ryu**, New Mexico Institute of Mining and Technology (USA); **Liming W. Salvino**, Office of Naval Research Global (USA); **Fabio Semperlotti**, Purdue Univ. (USA); **Wei Song**, The Univ. of Alabama (USA); **Wieslaw J. Staszewski**, AGH Univ. of Science and Technology (Poland); **Zhongqing Su**, The Hong Kong Polytechnic Univ. (Hong Kong, China); **R. Andrew Swartz**, Michigan Technological Univ. (USA); **Tyler N. Tallman**, Purdue Univ. (USA); **Jiong Tang**, Univ. of Connecticut (USA); **Marco Torbol**, Ulsan National Institute of Science and Technology (Korea, Republic of); **Ming L. Wang**, Northeastern Univ. (USA); **Xingwei Wang**, Univ. of Massachusetts Lowell (USA); **Ya Wang**, Texas A&M Univ. (USA); **Yang Wang**, Georgia Institute of Technology (USA); **Rosalind M. Wynne**, Villanova Univ. (USA); **Fuh-Gwo Yuan**, North Carolina State Univ. (USA); **Daniele Zonta**, Univ. degli Studi di Trento (Italy)

## CONFERENCE 10971

Technology (Japan); **Caesar Singh**, U.S. Dept. of Transportation (USA); **Yu-Min Su**, National Kaohsiung Univ. of Applied Sciences (Taiwan); **Yan Wan**, Univ. of Texas at Arlington (USA); **Ming L. Wang**, Northeastern Univ. (USA); **Yang Wang**, Georgia Institute of Technology (USA); **Tian Xia**, The Univ. of Vermont (USA); **Lingyu Yu**, Univ. of South Carolina (USA); **Fuh-Gwo Yuan**, North Carolina State Univ. (USA)

## CONFERENCE 10972

of); **Wieslaw J. Staszewski**, AGH Univ. of Science and Technology (Poland); **Tadeusz Stepinski**, AGH Univ. of Science and Technology (Poland); **Tadeusz Uhl**, AGH Univ. of Science and Technology (Poland); **Wei-Chih Wang**, Univ. of Washington (USA); **Yue-Sheng Wang**, Beijing Jiaotong Univ. (China); **Jinkyu Yang**, Univ. of Washington (USA); **Lingyu Yu**, Univ. of South Carolina (USA); **Andrei N. Zagrai**, New Mexico Institute of Mining and Technology (USA)

## CONFERENCE 10973

HRL Labs., LLC (USA); **Tobias Melz**, Fraunhofer-Institut für Betriebsfestigkeit und Systemzuverlässigkeit (Germany); **Michele Meo**, Univ. of Bath (United Kingdom); **Alexander Michaelis**, Fraunhofer-IKTS (Germany); **Bernd Michel**, Fraunhofer-Institut für Elektronische Nanosysteme (Germany); **Christopher Niezrecki**, Univ. of Massachusetts Lowell (USA); **Piotr Omenzetter**, Univ. of Aberdeen (United Kingdom); **Gyuhae Park**, Chonnam National Univ. (Korea, Republic of); **Kara J. Peters**, North Carolina State Univ. (USA); **W. Lance Richards**, Armstrong Flight Research Ctr. (USA); **Janet M. Sater**, Institute for Defense Analyses (USA); **Stefano Sfarra**, Univ. degli Studi dell'Aquila (Italy); **Tadeusz Stepinski**, AGH Univ. of Science and Technology (Poland); **Mark R. Woike**, NASA Glenn Research Ctr. (USA); **H. Felix Wu**, U.S. Dept. of Energy (USA); **Dong-Jin Yoon**, Korea Research Institute of Standards and Science (Korea, Republic of); **Lingyu Yu**, Univ. of South Carolina (USA); **Christian Wunderlich**, Fraunhofer-IKTS (Germany); **Edward V. White**, The Boeing Co. (USA)

## MONDAY 4 MARCH

PLENARY SESSION · 8:20 AM - 10:00 AM · LOCATION: SILVERTON BALLROOM

Session Chairs: **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

8:20 AM - 8:25 AM:

IN MEMORIAM: **Siegfried Bauer** (1961-2018), Johannes Kepler Univ. Linz (Austria)

8:25 AM - 8:30 AM:

- **2019 NDE Lifetime Achievement Award** presented to **Laurence J. Jacobs**, Georgia Institute of Technology (USA)
- **2019 SSM Lifetime Achievement Award** presented to **Diann E. Brei**, Univ. of Michigan (USA)



8:30 AM - 9:15 AM:

Plenary Presentation

**Artificial intelligence-based structural health monitoring**

**Hui Li**

Harbin Institute of Technology (China)



9:15 AM - 10:00 AM:

Plenary Presentation

**The emerging technologies for future space missions**

**Fred Y. Hadaegh**

Jet Propulsion Lab. (USA)

Coffee Break · 10:00 to 10:30 am

**CONFERENCE 10965  
Bioinspiration,  
Biomimetics, and  
Bioreplication IX**

**SESSION 1**

**ROOM: CRIPPLE CREEK 1  
MON 10:30 AM TO 12:10 PM**

**Robotics I**

Session Chair: **Raúl J. J. Martín-Palma**, Univ. Autónoma de Madrid (Spain)

10:30 am: **Design and modeling of biomimetic soft jellyfish robots with IPMC actuators**, Zakai Olsen, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) . . . . . [10965-1]

10:50 am: **Autonomous robotic jellyfish actuated with shape memory alloy springs**, Mohammad Ali Kazemi Lari, John A. Shaw, Univ. of Michigan (USA) . . . . . [10965-2]

11:10 am: **Study on proper behavior of home robot supporting multiple residents**, Takumi Kimura, Akira Mita, Keio Univ. (Japan) . . . . . [10965-3]

11:30 am: **Variable stiffness soft robotics using pennate muscle architecture**, Tyler E. Jenkins, Matthew Bryant, North Carolina State Univ. (USA) . . . . . [10965-4]

11:50 am: **An information-theoretic approach to study hydrodynamic interactions in schooling fish**, Peng Zhang, Elizabeth Krasner, NYU Tandon School of Engineering (USA); Sean Peterson, Univ. of Waterloo (Canada) and NYU Tandon School of Engineering (USA); Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . . . [10965-5]

Lunch Break . . . Mon 12:10 pm to 1:10 pm

**CONFERENCE 10966  
Electroactive Polymer  
Actuators and Devices  
(EAPAD) XXI**

**SESSION 1**

**LOCATION:  
SILVERTON BALLROOM  
MON 10:30 AM TO 11:50 AM**

**Keynote Session: EAP  
as Emerging Actuators**

Session Chairs: **Yoseph Bar-Cohen**, Jet Propulsion Lab. (USA); **Iain A. Anderson**, The Univ. of Auckland (New Zealand)

The session will start with a brief acknowledgement for the late Dr. Siegfried Bauer by Dr. Martin Kaltenbrunner, Johannes Kepler Univ. Linz (Austria)

10:30 am: **Sixty years of fun in science and technology (Keynote Presentation)**, Ray H. Baughman, Alan G. MacDiarmid, The Univ. of Texas at Dallas (USA) . . . . . [10966-1]

11:10 am: **Inflatable technology: using flexible materials to make large structures (Keynote Presentation)**, Douglas A. Littenken, NASA Johnson Space Ctr. (USA) . . . . . [10966-2]

Lunch Break . . . Mon 11:50 am to 1:20 pm

**CONFERENCE 10967  
Active and Passive  
Smart Structures and  
Integrated Systems  
XIII**

**SESSION 1**

**LOCATION: CRESTONE SALON A  
MON 10:30 AM TO 11:50 AM**

**Active and Passive  
Vibration/Noise  
Attenuation I**

Session Chairs: **Alper Erturk**, Georgia Institute of Technology (USA); **Jae-Hung Han**, KAIST (Korea, Republic of)

10:30 am: **Adaptive damping and stiffness control of composite structures: an experimental illustration**, Benoit Verdin, David Renault, Pauline Butaud, Morvan Ouisse, Emmanuel Foltete, Emeline Sadoulet-Reboul, Gael Chevallier, FEMTO-ST, Univ. Bourgogne Franche-Comté (France) . . . . . [10967-1]

10:50 am: **Panel vibration suppression by using piezoelectric damping system**, Shunji Suzuki, Toshizumi Yamaguchi, Honda R&D Co., Ltd. (Japan) . . . . . [10967-2]

11:10 am: **Sky-ground hook controller design for MR damper of aircraft landing gear**, Byung-Hyuk Kang, Chulhee Han, Seung-Bok Choi, Inha Univ. (Korea, Republic of) . . . . . [10967-3]

11:30 am: **Adaptive control of non-minimum phase smart aerospace structures using linear distributed parameter models**, Mark Balas, The Univ. of Tennessee Space Institute (USA); Susan Frost, NASA Ames Research Ctr. (USA) . . . . . [10967-4]

Lunch Break . . . Mon 11:50 am to 1:00 pm

**CONFERENCE 10968  
Behavior and  
Mechanics of  
Multifunctional  
Materials XIII**

**SESSION 1**

**LOCATION: CRYSTAL C  
MON 10:30 AM TO 11:50 AM**

**New Synthesis and  
Technologies**

Session Chairs: **Hani E. Naguib**, Univ. of Toronto (Canada); **Saad Ahmed**, Intel Corp. (USA)

10:30 am: **Sample containerization and planetary protection using brazing for breaking the chain of contact to Mars (Keynote Presentation)**, Yoseph Bar-Cohen, Mircea Badescu, Stewart Sherrit, Xiaoqi Bao, Hyeong Jae Lee, Erik Bombela, Sukhwinder Sandhu, Jet Propulsion Lab. (USA) . . . . . [10968-1]

11:10 am: **Synthesis and characterization of a photostrictive polymer thread**, John A. Gallagher, Meghan Martin, Alec Nicotra, Sarah Kapelner, Jimmy Franco, Merrimack College (USA) . . . . . [10968-2]

11:30 am: **Targeted mode attenuation and broadband vibration control with optimized elastomeric metamaterials**, Sih-Ling Yeh, Ryan L. Harne, The Ohio State Univ. (USA) . . . . . [10968-3]

Lunch Break . . . Mon 11:50 am to 1:20 pm

**CONFERENCE 10969  
Nano-, Bio-, Info-Tech  
Sensors and 3D Systems**

**SESSION 1**

**LOCATION: CRYSTAL SALON B/C  
MON 10:30 AM TO 11:15 AM**

**Keynote Session I**

Session Chair: **Jaehwan Kim**, Inha Univ. (Korea, Republic of)

10:30 am: **Merging human and machines (Keynote Presentation)**, Xuanhe Zhao, Massachusetts Institute of Technology (USA) . . . . . [10969-1]

**SESSION 2**

**LOCATION: CRYSTAL SALON B/C  
MON 11:15 AM TO 12:25 PM**

**Man-Machine Interface  
for Healthcare**

Session Chair: **Kyo D. Song**, Norfolk State Univ. (USA)

11:15 am: **Robust human-machine interfaces enabled by a skin-like, electromyogram sensing system (Invited Paper)**, Yun-Soung Kim, Musa Mahmood, W. Hong Yeo, Georgia Institute of Technology (USA) . . . . . [10969-2]

11:45 am: **Novel implantable nanoelectrodes for use in brain imaging with electrical impedance tomography**, Hargsoon Yoon, Anton Shimkevitch, Lochan Pai, Seonhye Han, Min Hyuck Kim, Norfolk State Univ. (USA) . . . . . [10969-3]

12:05 pm: **Polydopamine-nanocellulose nanocomposites: physical and electrical properties for biomedical electrodes**, Sunanda Roy, Ruth M. Muthoka, Hyun Chan Kim, Hargsoon Yoon, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-4]

Lunch Break . . . Mon 12:25 pm to 1:35 pm

**CONFERENCE 10970  
Sensors and Smart  
Structures Technologies  
for Civil, Mechanical,  
and Aerospace Systems**

**SESSION 1**

**LOCATION: CRESTONE SALON B  
MON 10:30 AM TO 11:50 AM**

**Keynote Session**

Session Chairs: **Jerome P. Lynch**, Univ. of Michigan (USA); **Haiping Huang**, The Univ. of Texas at Arlington (USA)

10:30 am: **Emerging roles of autonomous systems, structural health monitoring, and nondestructive evaluation in bridge inspection and maintenance** (*Keynote Presentation*), Genda Chen, Missouri Univ. of Science and Technology (USA) . . . . . [10970-1]

11:10 am: **A sound future for acoustic metamaterials** (*Keynote Presentation*), Steven A. Cummer, Duke Univ. (USA) . . . . . [10970-2]

Lunch Break . . . Mon 11:50 am to 1:40 pm

**CONFERENCE 10971  
Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII**

**SESSION 1**

**LOCATION: ASPEN B  
MON 10:30 AM TO 11:50 AM**

**SHM-NDE of  
Civil Structures/  
Infrastructure I**

Session Chairs: **Tzuyang Yu**, Univ. of Massachusetts Lowell (USA); **Didem Ozevin**, Univ. of Illinois at Chicago (USA)

10:30 am: **Risk-based retaining wall management using a long-term wireless monitoring solution**, Kidus Admassu, Jerome Lynch, Adda Athanasopoulos-Zekkos, Dimitrios Zekkos, Univ. of Michigan (USA) [10971-1]

10:50 am: **Optimized spatial placement of structural bolts in connections for effective ultrasonic inspection**, Gorkem Okudan, Lu Zhang, Didem Ozevin, Univ. of Illinois at Chicago (USA) . . . . . [10971-2]

11:10 am: **Electromagnetic sensing of a subsurface metallic object at different depths**, Ahmed Alzeyadi, Tzuyang Yu, Jie Hu, Univ. of Massachusetts Lowell (USA) . . . . . [10971-3]

11:30 am: **Characterization of textile effects on concrete panels using synthetic aperture radar imaging**, Jie Hu, Tzuyang Yu, Qixiang Tang, Univ. of Massachusetts Lowell (USA) . . . [10971-4]

Lunch Break . . . Mon 11:50 am to 1:30 pm

**CONFERENCE 10972  
Health Monitoring of Structural and Biological Systems XIII**

**SESSION 1**

**LOCATION: CRIPPLE CREEK 2  
MON 10:30 AM TO 12:10 PM**

**Guided Waves for SHM I**

Session Chairs: **Paul Fromme**, Univ. College London (United Kingdom); **Zhongqing Su**, The Hong Kong Polytechnic Univ. (Hong Kong, China)

10:30 am: **Guided wave techniques for damage detection and property characterization in composite aerospace structures**, Francesco Lanza di Scalea, Margherita Capriotti, Ranting Cui, Univ. of California, San Diego (USA) . . . . . [10972-1]

10:50 am: **A helical-based ultrasonic imaging algorithm for structural health monitoring of cylindrical structures**, Stylianos Livadiotis, Arvin Ebrahimkhanlou, Salvatore Salamone, The Univ. of Texas at Austin (USA) . . [10972-2]

11:10 am: **High frequency guided wave defect imaging in monocrystalline silicon wafers**, Mathieu Simon, Bernard Masserey, Jean-Luc Robyr, Haute Ecole Spécialisée de Suisse Occidentale (Switzerland); Paul Fromme, Univ. College London (United Kingdom) . . . . . [10972-3]

11:30 am: **Ultrasonic guided wave propagation in a repaired stiffened composite panel**, Shirsendu Sikdar, Pawel Malinowski, Piotr Fiborek, Wieslaw Ostachowicz, The Szewalski Institute of Fluid-Flow Machinery (Poland) . [10972-4]

11:50 am: **Acoustic source localization in non-homogenous plates**, Shenxin Yin, Jilin Univ. (China) and The Univ. of Arizona (USA); Tribikram Kundu, The Univ. of Arizona (USA); Zhiwen Cui, Jilin Univ. (China) . . . . . [10972-5]

Lunch Break . . . Mon 12:10 pm to 1:20 pm

**CONFERENCE 10973  
Smart Structures and NDE for Energy Systems and Industry 4.0**

**SESSION 1**

**LOCATION: CRYSTAL SALON A  
MON 10:30 AM TO 11:10 AM**

**Keynote Session I**

Session Chair: **Kerrie Gath**, Ford Motor Co. (USA)

10:30 am: **NDE for additive manufacturing of metallic components** (*Keynote Presentation*), Leonard J. Bond, Iowa State Univ. of Science and Technology (USA)[10973-1]

**SESSION 2**

**LOCATION: CRYSTAL SALON A  
MON 11:10 AM TO 11:50 AM**

**The Internet of Things**

Session Chair: **Kerrie Gath**, Ford Motor Co. (USA)

11:10 am: **Low-power EM sensing based tensile force monitoring for PSC bridge**, Junkyeong Kim, Sungkyunkwan Univ. (Korea, Republic of) . . . . . [10973-2]

11:30 am: **Piezoelectric pressure harvester for autonomous sensors**, Sherif Keddis, Norbert Schwesinger, Technische Univ. München (Germany) . . . . . [10973-3]

Lunch Break . . . Mon 11:50 am to 1:20 pm



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**CONFERENCE 10965**

**SESSION 2**

**LOCATION: CRIPPLE CREEK 1  
MON 1:10 PM TO 2:10 PM**

**Robotics II**

Session Chair: **Yoseph Bar-Cohen**, Jet Propulsion Lab. (USA)

1:10 pm: **Humanlike robots: the state of the art and the challenges** (*Keynote Presentation*), Yoseph Bar-Cohen, Jet Propulsion Lab. (USA) . . . . . [10965-6]

1:50 pm: **A pipe-crawling robot using bio-inspired peristaltic locomotion and modular actuated non-destructive evaluation mechanism**, Hadi Fekrmandi, Phillip Hillard, South Dakota School of Mines and Technology (USA) . . . [10965-7]

**SESSION 3**

**LOCATION: CRIPPLE CREEK 1  
MON 2:10 PM TO 3:20 PM**

**Environmental Biomimetics**

Session Chair: **Akhlesh Lakhtakia**, The Pennsylvania State Univ. (USA)

2:10 pm: **Evomimetics: the biomimetic design thinking 2.0** (*Invited Paper*), Dominique Adriaens, Univ. Gent (Belgium) [10965-8]

2:40 pm: **Biomimicry of school of fish for community windstorm design**, Brandon Enbody, Amanda Melendez, Mariantonieta Gutierrez Soto, Univ. of Kentucky (USA) . . . . . [10965-9]

3:00 pm: **Can robotic fish help zebrafish learn to open doors?**, Yanpeng Yang, Tianjin Univ. (China) and NYU Tandon School of Engineering (USA); Brandon LeMay, Rana El Khoury, Romain J. G. Clément, NYU Tandon School of Engineering (USA); Stefano Ghirlanda, Brooklyn College (USA) and The Graduate Ctr., CUNY (USA) and Stockholm Univ. (Sweden); Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . [10965-10]

Coffee Break. . . . . Mon 3:20 pm to 3:50 pm

**CONFERENCE 10966**

**SESSION 2**

**LOCATION:  
SILVERTON BALLROOM  
MON 1:20 PM TO 3:20 PM**

**EAP Materials and Devices Fabrication Methods (e.g., 3D Printing): Progress and Challenges**

Session Chairs: **Geoffrey M. Spinks**, Univ. of Wollongong (Australia); **Ray H. Baughman**, The Univ. of Texas at Dallas (USA)

1:20 pm: **3D printing of soft microactuators**, Manav Tyagi, Edwin W. H. Jager, Linköping Univ. (Sweden) and Univ. of Wollongong (Australia); Geoffrey M. Spinks, Univ. of Wollongong (Australia) . . . . . [10966-3]

1:40 pm: **Ink-jet printed conductive and semi-conductive rubber for dielectric elastomer devices**, Katherine E. Wilson, Jared Jordan, The Univ. of Auckland (New Zealand); E.-F. Markus Henke, TU Dresden (Germany) and The Univ. of Auckland (New Zealand); Geoffrey A. Slipper, U.S. Army Research Lab. (USA); Samuel Rosset, The Univ. of Auckland (New Zealand); Iain A. Anderson, The Univ. of Auckland (New Zealand) and Stretchsense Ltd. (New Zealand) . [10966-4]

2:00 pm: **Additive manufacturing of arterial phantoms with integrated electroactive polymer actuators: effect of stenosis and dilation on flow characteristics**, F. Benjamin Holness, Aaron D. Price, Tamie L. Poepping, Western Univ. (Canada) . . . . . [10966-5]

2:20 pm: **Investigation of inkjet and stencil/screen printed silver (Ag) electrodes for Ionic Polymer Metal Composites (IPMCs)**, Eva Ann Sideris, Technische Univ. Eindhoven (Netherlands) . . . . . [10966-6]

2:40 pm: **Optimization and characterization of inkjet-printed ferroelectric capacitor for human body detection**, Yanid Arango, Ecole Nationale Supérieure des Mines de Saint-Étienne (France) and IRLYNX (France); Jean-Fabien Capsal, Institut National des Sciences Appliquées de Lyon (France); Lionel Fritsch, IRLYNX (France); Thierry Djenizian, Xavier Boddart, Mohamed Saadaoui, Ecole Nationale Supérieure des Mines de Saint-Étienne (France) . . . . . [10966-7]

3:00 pm: **Rapid prototyping zipping HASEL actuators for high-speed and versatile artificial muscles**, Shane K. Mitchell, Univ. of Colorado Boulder (USA); Xingrui Wang, Univ. of Colorado Boulder (USA) and Tongji Univ. (China); Eric Acome, Trent Martin, Khoi Ly, Nicholas Kellaris, Christoph Keplinger, Univ. of Colorado Boulder (USA) . . . . . [10966-8]

Coffee Break. . . . . Mon 3:20 pm to 3:50 pm

**CONFERENCE 10967**

**SESSION 2**

**LOCATION: CRESTONE SALON A  
MON 1:00 PM TO 3:20 PM**

**Metamaterials and Metastructures**

Session Chairs: **Andres F. Arrieta**, Purdue Univ. (USA); **James M. Gibert**, Purdue Univ. (USA)

1:00 pm: **Realization of frequency-dependent effective boundary conditions using elastic metamaterials**, Yong Chang Shin, Heonjun Yoon, Soo-Ho Jo, Byeng Dong Youn, Seoul National Univ. (Korea, Republic of) . . . . [10967-10]

1:20 pm: **An analytical framework for Kirchhoff plate-type locally resonant piezoelectric metastructures**, Christopher Sugino, Massimo Ruzzene, Alper Erturk, Georgia Institute of Technology (USA) . . . . . [10967-11]

1:40 pm: **Vibration suppression of metamaterial with local resonators coupled by negative stiffness springs**, Guobiao Hu, Lihua Tang, The Univ. of Auckland (New Zealand); Jiawen Xu, Southeast Univ. (China); Chunbo Lan, Nanjing Univ. of Aeronautics and Astronautics (China); Raj Das, RMIT Univ. (Australia) . . . . . [10967-12]

2:00 pm: **Energy harvesting characteristics in metamaterials based on bistable lattices**, Myungwon Hwang, Andres F. Arrieta, Purdue Univ. (USA) . . . . . [10967-13]

2:20 pm: **Auxetic metamaterials-inspired piezoelectric vibration energy harvesting**, Heonjun Yoon, Byeng Dong Youn, Seoul National Univ. (Korea, Republic of) . . . . . [10967-14]

2:40 pm: **Correlation of elastic metamaterial-based energy harvesting performance with geometric and material properties of piezoelectric ceramic devices**, Miso Kim, Korea Research Institute of Standards and Science (Korea, Republic of); Tae-Gon Lee, Korea Univ. (Korea, Republic of); Choon-Su Park, Korea Research Institute of Standards and Science (Korea, Republic of); Sahn Nahm, Korea Univ. (Korea, Republic of) . . . . . [10967-15]

3:00 pm: **Analytical modeling for defect band splitting of a phononic crystal with double defects**, Soo-Ho Jo, Heonjun Yoon, Yong Chang Shin, Byeng Dong Youn, Seoul National Univ. (Korea, Republic of) . . . . . [10967-16]

Coffee Break. . . . . Mon 3:20 pm to 3:50 pm

**CONFERENCE 10968**

**SESSION 2**

**LOCATION: CRYSTAL C  
MON 1:20 PM TO 3:00 PM**

**Modeling of Smart Materials**

Session Chairs: **Ryan L. Harnes**, The Ohio State Univ. (USA); **Aimy Wissa**, Univ. of Illinois (USA)

1:20 pm: **Parameter dependent surrogate model development for PZT bimorph actuators employed for robobee**, Nikolas Bravo, Ralph C. Smith, North Carolina State Univ. (USA) . . . . . [10968-4]

1:40 pm: **Global sensitivity analysis of fractional-order viscoelasticity models**, Paul R. Miles, Graham Pash, Ralph C. Smith, North Carolina State Univ. (USA); William S. Oates, Florida State Univ. (USA) [10968-5]

2:00 pm: **Strain and damage sensing at the mesoscale in energetic materials in response to low velocity impact and localized thermal loads**, Stefan Povolny, Krishna Talamadupula, Gary D. Seidel, Virginia Polytechnic Institute and State Univ. (USA) . . . [10968-6]

2:20 pm: **Parametric coupling in Lamb wave devices**, Joseph Schneider, Ting Lu, Greg P. Carman, Ethan Wang, Ajit K. Mal, Univ. of California, Los Angeles (USA) . . . . . [10968-7]

2:40 pm: **COMSOL multiphysics based modeling of coiled nylon actuator**, Robert Hunt, Zakai Olsen, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) . . . . . [10968-8]

Coffee Break. Mon 3:00 to 3:30 pm

**CONFERENCE 10969**

**SESSION 3**

**LOCATION: CRYSTAL SALON B/C  
MON 1:35 PM TO 3:25 PM**

**Wearable Technology and Healthcare**

Session Chair: **W. Hong Yeo**, Georgia Institute of Technology (USA)

1:35 pm: **Design of electronic skin for tactile sensing applications** (*Invited Paper*), Steve Park, KAIST (Korea, Republic of) . . . . . [10969-5]

2:05 pm: **Multifunctional wearable biopatch for real-time monitoring of physiological activities**, Yongkuk Lee, Wichita State Univ. (USA); W. Hong Yeo, Georgia Institute of Technology (USA) . . . . . [10969-6]

2:25 pm: **Investigation of electrochemical and mechanical coupling effects of micromotion in neural sensing**, Seonhye Han, Norfolk State Univ. (USA); Jisuk Kang, JunHyun Kim, Myung Yung Jeong, Pusan National Univ. (Korea, Republic of); Hargsoon Yoon, Norfolk State Univ. (USA) . [10969-7]

2:45 pm: **Detection of urine glucose using PCF based sensor in terahertz region: design and analysis**, S. A. M. Matiur Rahman, Bikash Kumar Paul, Sayed Asaduzzaman, Daffodil International Univ. (Bangladesh); Kawsar Ahmed, Mawlana Bhashani Science and Technology Univ. (Bangladesh) . [10969-8]

3:05 pm: **Real time label-free monitoring of plasmonic polymerase chain reaction products**, Gideon Uchehara, Andrew G. Kirk, Miltiadis Paliouras, Padideh Mohammadyousef, Mark Trifiro, McGill Univ. (Canada) . . . . . [10969-9]

Coffee Break. . . . . Mon 3:25 pm to 3:55 pm



CONFERENCE 10970

SESSION 2

LOCATION: CRESTONE SALON B  
MON 1:40 PM TO 3:00 PM

**Computer Vision and Augmented Reality Solutions for SHM**

Session Chairs: **Marco Torbol**, Ulsan National Institute of Science and Technology (Korea, Republic of); **Jerome P. Lynch**, Univ. of Michigan (USA)

1:40 pm: **Non-contact modal parameters identification using a K-cluster algorithm**, Marco Torbol, Ulsan National Institute of Science and Technology (Korea, Republic of); Amir Nasrollahi, Piervincenzo Rizzo, Univ. of Pittsburgh (USA) . . . . . [10970-3]

2:00 pm: **Investigation and mitigation of the distortions in motion magnified videos**, Aral Sarrafi, Zhu Mao, Univ. of Massachusetts Lowell (USA) . . . [10970-4]

2:20 pm: **Virtual tours, augmented reality, and informational modeling for visual inspection and structural health monitoring**, Rebecca Napolitano, Zachary Liu, Carl Sun, Branko Glisic, Princeton Univ. (USA) . . . . . [10970-6]

2:40 pm: **Vision-based precision localization of UAVs in outdoor environments for sensor payload placement and pickup for field monitoring applications**, Hao Zhou, Jerome P. Lynch, Dimitrios Zekkos, Univ. of Michigan (USA) . . . . . [10970-7]

Coffee Break. . . . Mon 3:00 pm to 3:30 pm

CONFERENCE 10971

SESSION 2

LOCATION: ASPEN B  
MON 1:30 PM TO 3:10 PM

**SHM-NDE of Civil Structures/ Infrastructure II**

Session Chairs: **Denvid Lau**, City Univ. of Hong Kong (Hong Kong, China); **Piotr Omenzetter**, Univ. of Aberdeen (United Kingdom)

1:30 pm: **Effect of rebar geometries on ultrasonic waves propagation in reinforced concrete structures using finite element method**, Qixiang Tang, Jie Hu, Tzuyang Yu, Univ. of Massachusetts Lowell (USA) . . . . . [10971-5]

1:50 pm: **Rail track surface irregularity detection and validation using low-cost sensors**, Leonard Chia, Bhavana Bhardwaj, Pan Lu, Raj Bridgelall, Denver Tolliver, Ying Huang, North Dakota State Univ. (USA) . . . . . [10971-6]

2:10 pm: **Autoregressive model based damage detection in an experimental top-tensioned riser**, Bugra Bayik, Piotr Omenzetter, Dominic van der A, Ekateriana Pavlovskaja, Univ. of Aberdeen (United Kingdom) . . . . . [10971-7]

2:30 pm: **Deep learning from vibrational responses for enhanced damage identification in an experimental wind turbine blade**, Simon Hoell, Bauhaus-Univ. Weimar (Germany); Piotr Omenzetter, Univ. of Aberdeen (United Kingdom) . . . . . [10971-8]

2:50 pm: **Multi-frequency excitation based full-field laser scanning for improved depth estimation**, Seong Jin Im, JunYoung Jeon, Gyuhae Park, Chonnam National Univ. (Korea, Republic of); To Kang, Soon Woo Han, Korea Atomic Energy Research Institute (Korea, Republic of) . . . . . [10971-10]

Coffee Break. . . . Mon 3:10 pm to 3:40 pm

CONFERENCE 10972

SESSION 2

LOCATION: CRIPPLE CREEK 2  
MON 1:20 PM TO 3:00 PM

**Sensors for Real-Time Monitoring I**

Session Chairs: **Wieslaw M. Ostachowicz**, The Szewalski Institute of Fluid-Flow Machinery (Poland); **Tadeusz Uhl**, AGH Univ. of Science and Technology (Poland)

1:20 pm: **A deep learning-based framework for two-step localization and characterization of acoustic emission sources in metallic panels using only one sensor**, Arvin Ebrahimkhanlou, Brennan Dubuc, Salvatore Salamone, The Univ. of Texas at Austin (USA) . . . . . [10972-6]

1:40 pm: **PBXs damage monitoring based on acoustic emission system in temperature change environment**, Zhiwei Qiu, Maoping Wen, Tao Fu, China Academy of Engineering Physics (China) . . . . . [10972-7]

2:00 pm: **An innovative decentralised data fusion using electromechanical impedance techniques**, Tomasz Wandowski, Shishir Kumar Singh, Pawel Malinowski, The Szewalski Institute of Fluid-Flow Machinery (Poland) . [10972-8]

2:20 pm: **Finite element evaluation of EMI-based structural health monitoring during impact**, Mohsen Safaei, Eric C. Nolan, Steven R. Anton, Tennessee Technological Univ. (USA) . . . . [10972-9]

2:40 pm: **Application of electromechanical impedance for damage assessment of composite power boat**, Tomasz Wandowski, Rohan N. Soman, Pawel Malinowski, Wieslaw Ostachowicz, The Szewalski Institute of Fluid-Flow Machinery (Poland) [10972-10]

Coffee Break. . . . Mon 3:00 pm to 3:30 pm

CONFERENCE 10973

SESSION 3

LOCATION: CRYSTAL SALON A  
MON 1:20 PM TO 3:00 PM

**New Applications for Smart Structures and Materials for Industry 4.0**

Session Chair: **Norbert G. Meyendorf**, Iowa State Univ. of Science and Technology (USA)

1:20 pm: **Simulation-based sensor network optimal design for detecting fracture in pipeline systems**, Chungwon Kim, Hyunseok Oh, Gwangju Institute of Science and Technology (Korea, Republic of) . . . . . [10973-4]

1:40 pm: **Smart approach to integrated natural risks management for Industry 4.0**, Alessandra Marino D.V.M., Mariano M. Ciucci, Istituto Nazionale Assicurazione contro gli Infortuni sul Lavoro (Italy) . . . . . [10973-5]

2:00 pm: **Design optimization of flexible piezoelectric PVDF unimorphs for surface pressure transducer applications**, Arun Kumar Ramanathan, Leon M. Headings, Marcelo J. Dapino, The Ohio State Univ. (USA) . . . . . [10973-6]

2:20 pm: **Porous bone tissue scaffold based on shape memory polymer**, Wei Zhao, Liwu Liu, Jinsong Leng, Yanju Liu, Harbin Institute of Technology (China) . . . . . [10973-7]

2:40 pm: **Development of smart gear system by conductive-ink print: impedance variation of a gear sensor with loads and data transmission from an antenna**, Shintaro Futagawa, Daisuke Iba, Nanako Miura, Takashi Iizuka, Arata Masuda, Akira Sone, Ichiro Moriwaki, Kyoto Institute of Technology (Japan) . . . . . [10973-8]

Coffee Break. . . . Mon 3:00 pm to 3:30 pm

CONFERENCE 10965

SESSION 4

LOCATION: CRIPPLE CREEK 1  
MON 3:50 PM TO 5:30 PM

**Biomimetic Optics**

Session Chair: **Mato Knez**, CIC nanoGUNE (Spain)

3:50 pm: **Optical changes in coleopteran wings induced by liquids and vapors** (*Invited Paper*), Sébastien R. Mouchet, Univ. of Exeter (United Kingdom) and Univ. de Namur (Belgium); Pete Vukusic, Univ. of Exeter (United Kingdom); Olivier Deparis, Univ. de Namur (Belgium). . . . . [10965-11]

4:20 pm: **On the multi-functionality of colored insect scales** (*Invited Paper*), Hendrik Hölscher, Karlsruher Institut für Technologie (Germany). . . . . [10965-12]

4:50 pm: **Towards biomimetic red solar cells**, Torben A. Lenau, Technical Univ. of Denmark (Denmark); Akhlesh Lakhtakia, The Pennsylvania State Univ. (USA) and Indian Institute of Technology (BHU), Varanasi (India); Faiz Ahmad, The Pennsylvania State Univ. (USA) [10965-13]

5:10 pm: **Underwater solar navigation using the in-water light field**, Samuel B. Powell, N. Justin Marshall, The Univ. of Queensland (Australia) . . . . . [10965-14]

CONFERENCE 10966

LOCATION: SILVERTON BALLROOM  
4:30 PM TO 5:45 PM

**EAP-in Action Demonstration Session**

Moderator : **Yoseph Bar-Cohen**, Jet Propulsion Lab. (USA)

This session highlights some of the latest capabilities and applications of Electroactive Polymers (EAP) materials where the attendees are shown demonstrations of these materials in action. Also, the attendees interact directly with technology developers and given "hands-on" experience with this emerging technology. The first Human/EAP Robot Armwrestling Contest was held during this session of the 2005 EAPAD conference. See the full program and descriptions of EAP presentations.

4:30 pm: **Demo Title: Novel dielectric elastomer membrane actuator concept for pneumatic valves**, Steffen Hau, Univ. des Saarlandes (Germany) . . . . . [10966-201]

4:35 pm: **Demo Title: DEA-based pneumatic pump**, Philipp Linnebach, Univ. des Saarlandes (Germany) . . . . . [10966-202]

4:40 pm: **Demo Title: A fast 200 mg DEA robot**, Herbert R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland) . . . . . [10966-203]

4:45 pm: **Demo Title: Textile exoskeletons**, Edwin W. H. Jager, Linköping Univ. (Sweden) . . . . . [10966-204]

4:50 pm: **Demo Title: Smart soft polymers and structures**, Liwu Liu, Jinsong Leng, Harbin Institute of Technology (China) . . . . . [10966-205]

4:55 pm: **Demo Title: Inflatable dielectric elastomer conveyor**, Joseph Ashby, The Univ. of Auckland (New Zealand); E.-F. Markus Henke, The Univ. of Auckland (Germany); Samuel Rosset, Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-206]

5:00 pm: **Demo Title: High voltage EAP controller**, E.-F. Markus Henke, The Univ. of Auckland (Germany); Patrin K. Illenberger, Samuel Rosset, Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-207]

5:05 pm: **Demo Title: Geometric limit switches (gDES) for robotics and automation industry**, E.-F. Markus Henke, The Univ. of Auckland (Germany); Katherine E. Wilson, Ross M. Green, The Univ. of Auckland (New Zealand) . . . . . [10966-208]

5:10 pm: **Demo Title: From StretchSense Ltd.: the latest in EAP gloves**, Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-209]

5:15 pm: **Demo Title: Synthetic muscle in prosthetics**, Lenore Rasmussen, Ras Labs., Inc. (USA) [10966-210]

5:20 pm: **Versatile dielectric loudspeakers**, Florian Klug, Technische Univ. Darmstadt (Germany)[10966-211]

5:25 pm: **Demo Title: Electro-ribbon actuators and electro-supragami robots**, Tim Helps, Majid Taghavi, Richard Suphapol Diteesawat, Jonathan M. Rossiter, Univ. of Bristol (United Kingdom) . . . . . [10966-212]

CONFERENCE 10967

SESSION 3

LOCATION: CRESTONE SALON A  
MON 3:50 PM TO 5:30 PM

**Energy Harvesting I: Nonlinear/Wideband**

Session Chairs: **Wei-Hsin Liao**, The Chinese Univ. of Hong Kong (Hong Kong, China); **Ryan L. Harne**, The Ohio State Univ. (USA)

3:50 pm: **An SECE-based piezoelectric power harvesting induced by rotary magnetic plucking**, P. H. Huang, H. C. Chang, Yi-Chung Shu, T. T. Hsieh, National Taiwan Univ. (Taiwan) . . . . . [10967-5]

4:10 pm: **Vibration energy harvesting system with coupled bistable modules**, Patrick Dorin, Univ. of Michigan (USA); Jinki Kim, Georgia Southern Univ. (USA); Kon-Well Wang, Univ. of Michigan (USA) . . . . . [10967-6]

4:30 pm: **Extension of cross-well bandwidth for a bistable oscillator**, Andrew Lee, Daniel Inman, Univ. of Michigan (USA) . . . . . [10967-7]

4:50 pm: **Moderate to high field nonlinearities in resonant dynamics of piezoelectric macro-fiber composite cantilevers**, David Tan, Alexander K. Kremenov, Alper Erturk, Georgia Institute of Technology (USA) . . . . . [10967-8]

5:10 pm: **Controllable orbit jumps in bistable energy harvesters by using a bidirectional energy conversion circuit**, Bao Zhao, Junrui Liang, ShanghaiTech Univ. (China) . . . . . [10967-9]

CONFERENCE 10968

SESSION 3

LOCATION: CRYSTAL C  
MON 3:30 PM TO 5:30 PM

**Shape Memory Materials I**

Session Chairs: **Darren J. Hartl**, Texas A&M Univ. (USA); **Julianna M. Abel**, Univ. of Minnesota, Twin Cities (USA)

3:30 pm: **Crack growth in shape memory alloys under thermo-mechanical loading**, Behrouz Haghgouyan, Sameer Jape, Texas A&M Univ. (USA); Theocharis Baxevanis, Univ. of Houston (USA); Ibrahim Karaman, Dimitric C. Lagoudas, Texas A&M Univ. (USA) . . . . . [10968-9]

3:50 pm: **Exploration of static equilibrium in elastically biased shape memory alloy components**, Trent D. White, Darren J. Hartl, Texas A&M Univ. (USA) . . . . . [10968-10]

4:10 pm: **Experimental investigation of hybrid shape memory alloy pneumatic actuators**, Makella Daley, Julianna Abel, Univ. of Minnesota, Twin Cities (USA) . . . . . [10968-11]

4:30 pm: **Exploration of the partial transformation behaviour of shape memory alloys and its effect on actuation performance**, Anargyros A. Karakalas, Theodoros T. Machairas, Dimitris Saravanos, Univ. of Patras (Greece) . . . . . [10968-12]

4:50 pm: **A micro indentation approach for fracture toughness evaluation of a Ni2MnGa alloy**, Constantin Ciocanel, Northern Arizona Univ. (USA); Viorel Goanta, "Gheorghe Asachi" Technical Univ. of Iasi (Romania) . . . . . [10968-13]

5:10 pm: **Finite element modeling and simulation of a robotic finger actuated by Ni-Ti shape memory alloy wires**, Filomena Simone, Zentrum für Mechatronik und Automatisierungstechnik gGmbH (Germany); Daniele Melli, Politecnico di Bari (Italy); Gianluca Rizzello, Univ. des Saarlandes (Germany); Paul Motzki, Zentrum für Mechatronik und Automatisierungstechnik gGmbH (Germany); David Naso, Politecnico di Bari (Italy); Stefan Seelecke, Univ. des Saarlandes (Germany) . . . . . [10968-14]

CONFERENCE 10969

SESSION 4

LOCATION: CRYSTAL SALON B/C  
MON 3:55 PM TO 5:25 PM

**Nanosensors and Applications**

Session Chair: **Il-Kwon Oh**, KAIST (Korea, Republic of)

3:55 pm: **Stretchable sensors for real-time condition monitoring of railway tracks** (*Invited Paper*), Adrian Koh, National Univ. of Singapore (Singapore) . . . . . [10969-10]

4:25 pm: **Modeling surface acoustic wave coupled surface plasmon resonance in layered structures**, Thomas Coleman, Baldwin Varner, Doyle A. Temple, Norfolk State Univ. (USA) . . . . . [10969-11]

4:45 pm: **Design of an underwater vector hydrophobe using a miniature shear mode accelerometer**, Yongrae Roh, Kyungpook National Univ. (Korea, Republic of) . . . . . [10969-13]

5:05 pm: **Evaluation of signal onset detection algorithms using Delta-T acoustic emission source location**, Wee Hoe Ng, Chan Ghee Koh, National Univ. of Singapore (Singapore) . . . . . [10969-14]

CONFERENCE 10970

SESSION 3

LOCATION: CRESTONE SALON B  
MON 3:30 PM TO 5:30 PM

Ultrasound/Guided Waves

Session Chairs: **Kara J. Peters**, North Carolina State Univ. (USA); **Serife Tol**, Univ. of Michigan (USA)

3:30 pm: **Ultrasonic Lamb wave mode conversion to optical fiber guided mode with varying input conditions**, Junghyun Wee, Drew Hackney, Kara Peters, North Carolina State Univ. (USA) . . . . . [10970-8]

3:50 pm: **Waveguide sensing for structural health monitoring and process characterization at elevated temperatures**, Sayantan Ghosh, Krishnan Balasubramaniam, Indian Institute of Technology Madras (India) . . . . [10970-9]

4:10 pm: **Industrial applications of electro-mechanical impedance technique in novel non-bonded configurations**, Jayalakshmi Raju, Suresh Bhalla, Indian Institute of Technology Delhi (India); Visalakshi Talakokula, Bennett Univ. (India); Supriya Thakur, Indian Institute of Technology Delhi (India) . . . . . [10970-11]

4:30 pm: **Improved damage isolation using guided waves based on optimized sensor placement**, Rohan N. Soman, Pawel Kudela, Kaleeswaran Balasubramaniam, Shishir Singh, Pawel Malinowski, The Szewalski Institute of Fluid-Flow Machinery (Poland) [10970-12]

4:50 pm: **Analysis of a piezoelectric d15 shear-mode sensor in parallel and series connections**, Pelin Berik, Middle East Technical Univ. (Turkey) . . [10970-14]

5:10 pm: **Wave focusing in pipe-like structures via gradient-index metamaterial lens toward damage detection and localization**, Serife Tol, Univ. of Michigan (USA); Minoo Kabir, Gorkem Okudan, Didem Ozevin, Univ. of Illinois at Chicago (USA) . . . . . [10970-15]

CONFERENCE 10971

SESSION 3

LOCATION: ASPEN B  
MON 3:40 PM TO 6:00 PM

SHM-NDE of Civil Structures/Infrastructure III

Session Chairs: **Saman Farhangdoust**, Florida International Univ. (USA); **H. Felix Wu**, U.S. Dept. of Energy (USA)

3:40 pm: **Wind-induced vibration energy harvesting for the bridge health monitoring applications**, Saman Farhangdoust, Armin Mehrabi, Florida International Univ. (USA); Davood Younesian, Iran Univ. of Science and Technology (Iran, Islamic Republic of). [10971-11]

4:00 pm: **Detecting damages and stress changes in concrete structures using Coda wave interferometry**, Hanyu Zhan, New Mexico State Univ. (USA); Hanwan Jiang, Univ. of Wisconsin-Platteville (USA); Chenxu Zhuang, New Mexico State Univ. (USA); Jinquan Zhang, Research Institute of Highway (China); Ruinian Jiang, New Mexico State Univ. (USA) . [10971-12]

4:20 pm: **3D InspectionNet: a deep 3D convolutional neural networks based approach for 3D crack detection on concrete columns**, Mehrdad Shafiei Dizaji, Devin Harris, Univ. of Virginia (USA) . . . . . [10971-13]

4:40 pm: **The assessment of temperatures dissipation during the hot mix asphalt concrete construction in conjunction with a multilayered pavement temperature monitoring stations**, Yu-Min Su, National Kaohsiung Univ. of Science and Technology (Taiwan); Tsung-Chin Hou, National Cheng Kung Univ. (Taiwan); Jia-Lin Chen, Huang-Hsin Pan, National Kaohsiung Univ. of Science and Technology (Taiwan); Ming-Gin Lee, Chaoyang Univ. of Technology (Taiwan) . . . . . [10971-14]

5:00 pm: **Stress measurement of a pressurized vessel using candle soot nanocomposite based photoacoustic excitation**, Ho-Wuk Kim, Wei-Yi Chang, Taeyang Kim, Shujin Huang, Xiaoning Jiang, North Carolina State Univ. (USA) . . . . . [10971-15]

5:20 pm: **Acoustic emission monitoring of post-installed shear connectors in strengthened steel bridges**, Arvin Ebrahimkhanlou, The Univ. of Texas at Austin (USA); Amir Reza Ghiami Azad, Arash Ebrahimkhanlou, Univ. of Tehran (Iran, Islamic Republic of); Salvatore Salamone, Michael Engelhardt, The Univ. of Texas at Austin (USA) . . . . . [10971-16]

5:40 pm: **Concrete performance prediction using boosting smooth transition regression trees (BooST)**, Uchenna Anyaoha, Xiang Peng, Zheng Liu, The Univ. of British Columbia Okanagan (Canada) . . . . . [10971-17]

CONFERENCE 10972

SESSION 3

LOCATION: CRIPPLE CREEK 2  
MON 3:30 PM TO 5:50 PM

Elastic and Metamaterials I

Session Chairs: **Guoliang Huang**, Univ. of Missouri (USA); **Fabio Semperlotti**, Purdue Univ. (USA)

3:30 pm: **Dynamics of topological metastructures: nonlinearities and quasi-periodicity (Keynote Presentation)**, Massimo Ruzzene, Georgia Institute of Technology (USA) . . . . . [10972-11]

4:10 pm: **Space-time modulated programmable metamaterial beam for nonreciprocal control of flexural waves**, Yangyang Chen, Xiaopeng Li, Hussein Nassar, Guoliang Huang, Univ. of Missouri (USA) . . . . . [10972-12]

4:30 pm: **Non-reciprocity in time-periodic phononic materials with a non-zero moving velocity**, Mohammad A. Attarzadeh, Mostafa A. Nouh, Univ. at Buffalo (USA) . . . . . [10972-13]

4:50 pm: **Achieving structural vibration isolation via a total-internal-reflection elastic metasurface**, Hongfei Zhu, Fabio Semperlotti, Purdue Univ. (USA); Timothy F. Walsh, Sandia National Labs. (USA) . . . . . [10972-14]

5:10 pm: **Viscoelastic effects on the frequency response of elastomeric metastructures**, Connor Pierce, Univ. of Illinois (USA); Vincent Chen, James Hardin, Carson Willey, John Berrigan, Abigail Juhl, Air Force Research Lab. (USA); Kathryn H. Matlack, Univ. of Illinois (USA) . . . . . [10972-15]

5:30 pm: **Isolating vibrations with different polarizations via lightweight embedded metastructure**, Weijia Zhao, Yitian Wang, Beijing Institute of Technology (China); Guoliang Huang, Univ. of Missouri (USA); Rui Zhu, Beijing Institute of Technology (China). [10972-16]

CONFERENCE 10973

SESSION 4

LOCATION: CRYSTAL SALON A  
MON 3:30 PM TO 5:50 PM

Industrial and Commercial Application of Smart Structures and Materials

Session Chair: **Norbert G. Meyendorf**, Iowa State Univ. of Science and Technology (USA)

3:30 pm: **Guided wave based detection and analysis of defects in integrated circuit packages using dispersion dependent matching pursuit decomposition**, Javaid Ikram, Arizona State Univ. (USA) . . . . . [10973-9]

3:50 pm: **A highly flexible non-destructive quality inspection device for glue joints by active thermography for Industry 4.0**, Marc Hill, Zentrum für Mechatronik und Automatisierungstechnik gGmbH (Germany); Benedikt Faupel, Hochschule für Technik und Wirtschaft des Saarlandes (Germany) . . . [10973-10]

4:10 pm: **Utilization of Scanning Acoustic Microscope (SAM) to prove the existence of stress relaxation in woven composite**, Mohammad Sadegh Saadatzi, Hossain Ahmed, Subir Patra, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10973-36]

4:30 pm: **Determination of the size of representative volume element involving shape memory alloy composites with randomly arranged ellipsoid precipitates**, Jobin K. Joy, Aitor Cruzado, Alexandros Solomou, Ahmed A. Benzerga, Dimitris C. Lagoudas, Texas A&M Univ. (USA) . . . . . [10973-13]

4:50 pm: **MFL sensing and pattern recognition based automated damage detection for steel chain NDE**, Ju-Won Kim, Byoungjoon Yu, Minsoo Park, Seunghee Park, Sungkyunkwan Univ. (Korea, Republic of) . . . . . [10973-14]

5:10 pm: **Experimentally verified models to predict the voltage coefficient of a piezoelectric nanogenerator**, Alireza Nafari, Henry A. Sodano, Univ. of Michigan (USA) . . . . . [10973-34]

**CONFERENCE 10965  
Bioinspiration,  
Biomimetics, and  
Bioreplication IX**

**CONFERENCE 10966  
Electroactive  
Polymer Actuators  
and Devices  
(EAPAD) XXI**

**CONFERENCE 10967  
Active and Passive  
Smart Structures and  
Integrated Systems  
XIII**

**CONFERENCE 10968  
Behavior and Mechanics  
of Multifunctional  
Materials XIII**

**CONFERENCE 10969  
Nano-, Bio-, Info-Tech  
Sensors and 3D Systems**

**PLENARY SESSION · 8:25 AM to 10:00 AM · LOCATION: SILVERTON SALONS 2-3**

Session Chairs: **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

**8:25 AM - 8:30 AM:**

• **SPIE Fellows Awards** presented to:  
**Roger M. Groves**, Technische Univ. Delft  
(Netherlands) and **Faramarz Gordaninejad**,  
Univ. of Nevada, Reno (USA)



**8:30 AM - 9:15 AM · Plenary Presentation**  
**Piezoelectric films for MEMS applications**  
**Susan Trolier-McKinstry**  
The Pennsylvania State Univ. (USA)



**9:15 AM - 10:00 AM · Plenary Presentation**  
**Structural health monitoring: a view of the  
entrepreneur**  
**Tadeusz Uhl**  
AGH Univ. of Science and Technology (Poland)

Coffee Break · Tues 10:00 am to 10:30 am

**SESSION 5**

**LOCATION: CRIPPLE CREEK 1  
TUE 10:30 AM TO 12:00 PM**

**Biomimetic Materials  
and Structures I**

Session Chair: **Maurizio Porfiri**,  
NYU Tandon School of Engineering  
(USA)

10:30 am: **Bone-inspired solutions  
for novel strong and tough  
composites** (*Invited Paper*), Flavia  
Libonati, Politecnico di Milano  
(Italy) ..... [10965-15]

11:00 am: **Development of a  
conceptual demonstrator of an  
SMA-based rotorcraft blade twist  
system**, Salvatore Ameduri, Antonio  
Concilio, Ctr. Italiano Ricerche  
Aerospaziali (Italy). .... [10965-16]

11:20 am: **Biomimetic  
nanostructures on various  
polymer surfaces by plasma  
nanotexturing**, Y.P. Li, X.Y. Li, M.K.  
Lei, Dalian Univ. of Technology  
(China); Akhlesh Lakhtakia, The  
Pennsylvania State Univ.  
(USA)..... [10965-17]

11:40 am: **Adaptive and compliant  
wing tip devices enabled by  
additive manufacturing and  
multi-stable structures**, Kimberly  
Gustafson, Luis Urrutia, Univ. of  
Illinois (USA); Alexander Pankonien,  
Gregory Reich, Air Force Research  
Lab. (USA); Aimy Wissa, Univ. of  
Illinois (USA) ..... [10965-18]

Lunch Break Tue 12:00 pm to 1:30 pm

**SESSION 3**

**LOCATION: SILVERTON  
SALONS 2-3  
TUE 10:30 TO 11:50 AM**

**Design Methods  
of Producing EAP  
Mechanisms**

Session Chairs: **Gursel  
Alici**, Univ. of Wollongong  
(Australia); **Douglas A.  
Litteken**, NASA Johnson  
Space Ctr. (USA)

10:30 am: **Design of reliable  
silicone elastomers for  
dielectric elastomers and  
stretchable electronics**  
(*Invited Paper*), Piotr Mazurek,  
Liyun Yu, Anne Ladegaard Skov,  
Technical Univ. of Denmark  
(Denmark) ..... [10966-9]

11:10 am: **A novel design  
concept to boost the force  
output of dielectric elastomer  
membrane actuators**, Steffen  
Hau, Gianluca Rizzello, Univ.  
des Saarlandes (Germany);  
Stefan Seelecke, Univ. des  
Saarlandes (Germany) and  
Zentrum für Mechatronik und  
Automatisierungstechnik  
gGmbH (Germany) . [10966-10]

11:30 am: **A technique for  
creating planar tension  
in DEAs using fiber-  
reinforcement**, Austin Moss,  
Kamran Mohseni, Univ. of  
Florida (USA) . . . . . [10966-11]

Lunch Break 11:50 am to 1:20 pm

**SESSION 4**

**LOCATION: CRESTONE SALON A  
TUE 10:30 AM TO 12:10 PM**

**Energy Harvesting II:  
Nonlinear/Wideband**

Session Chairs: **Serife Tol**, Univ. of  
Michigan (USA); **Lihua Tang**, The Univ.  
of Auckland (New Zealand)

10:30 am: **A passive self-tuning  
nonlinear resonator with beam-slider  
structure**, Liuding Yu, Harbin Engineering  
Univ. (China) and The Univ. of Auckland  
(New Zealand); Lihua Tang, Liuyang  
Xiong, The Univ. of Auckland (New  
Zealand); Tiejun Yang, Harbin Engineering  
Univ. (China); Brian R. Mace, The Univ. of  
Auckland (New Zealand) . . . . . [10967-17]

10:50 am: **Nonlinear dynamic analysis  
of 1:2 internal resonant V-shaped  
harvester**, Francesco Danzi, Politecnico  
di Torino (Italy); Amin Joodaki, James M.  
Gibert, Purdue Univ. (USA). . . . . [10967-18]

11:10 am: **Optimized piezoelectric  
energy harvesters for performance  
robust operation in periodic vibration  
environments**, Wen Cai, Ryan L. Harne,  
The Ohio State Univ. (USA) . . . . [10967-19]

11:30 am: **Wideband operation of a  
nonlinear vibration energy harvester  
with asymmetric restoring force**, Arata  
Masuda, Yusuke Miyata, Sou Ushiki,  
Zhao Feng, Kyoto Institute of Technology  
(Japan). . . . . [10967-20]

11:50 am: **Magnetically coupled multi-  
frequency hybrid energy harvester  
with dual-directional bandwidth  
broadening**, Zhenlong Xu, Hangzhou  
Dianzi Univ. (China); Hong Yang, Zhejiang  
Univ. (China); Wen Wang, Hangzhou  
Dianzi Univ. (China). . . . . [10967-21]

Lunch Break . . . . Tue 12:10 pm to 1:40 pm

**SESSION 4**

**LOCATION: CRYSTAL C  
TUE 10:30 AM TO 12:30 PM**

**Mechanics of Smart Particulate  
Polymer Composites**

Session Chairs: **Ken J. Loh**, Univ. of California,  
San Diego (USA); **Reza Rizvi**, The Univ. of Toledo  
(USA)

10:30 am: **Towards complex microarchitectural  
nanocomposites using non-uniform multi-  
field processing**, Md Al Masud, Anil Erol, The  
Pennsylvania State Univ. (USA); Saad Ahmed, Intel  
Corp. (USA); Zoubeida Ounaies, Paris vonLockette,  
The Pennsylvania State Univ. (USA) . . . . [10968-15]

10:50 am: **Development and characterization  
of graphene oxide based electronics and  
actuators**, Reza Rizvi, Omkar Bhatkar, Sheikh  
Rasel, The Univ. of Toledo (USA) . . . . . [10968-16]

11:10 am: **On the effects of nanoparticles on the  
electrical, mechanical, and electromechanical  
behavior of elastomer nanocomposites**, Amira  
Meddeb, Zoubeida Ounaies, The Pennsylvania  
State Univ. (USA); Oscar Lopez-Pamies, Univ. of  
Illinois (USA) . . . . . [10968-17]

11:30 am: **Modeling damage during cyclic loading  
in smart particulate polymer composites**, Vishnu  
Baba Sundaresan, Srivatsava Krishnan, The Ohio  
State Univ. (USA) . . . . . [10968-18]

11:50 am: **Topological design of graphene  
nanocomposites for strain sensing**, Long Wang,  
Gianmarco Vella, Kenneth J. Loh, Univ. of California,  
San Diego (USA) . . . . . [10968-19]

12:10 pm: **On high velocity impact on carbon  
fiber reinforced polymers**, Rade Vignjevic, Nenad  
Djordjevic, Tom De Vuyst, Brunel Univ. London  
(United Kingdom); Gareth Appleby-Thomas,  
Cranfield Univ. (United Kingdom); Agata Wasilczuk,  
Brunel Univ. London (United Kingdom) . [10968-45]

Lunch Break . . . . . Tue 12:10 pm to 2:20 pm

**SESSION 5**

**LOCATION: CRYSTAL SALON B/C  
TUE 10:30 AM TO 11:15 AM**

**Keynote Session II**

Session Chair: **Jaehwan Kim**, Inha Univ. (Korea,  
Republic of)

10:30 am: **Mechanically guided assembly  
of functional 3D mesostructures** (*Keynote  
Presentation*), John A. Rogers, Northwestern Univ.  
(USA) . . . . . [10969-15]

**SESSION 6**

**LOCATION: CRYSTAL SALON B/C  
TUE 11:15 AM TO 12:45 PM**

**3D Printing and Systems I**

Session Chair: **Simon Park**, Univ. of Calgary  
(Canada)

11:15 am: **3D printing of functional ceramics for  
multifunctional materials** (*Invited Paper*), Yirong  
Lin, Luis Chavez, Ryan Wicker, Jaime Regis,  
Hoejin Kim, The Univ. of Texas at El Paso  
(USA) . . . . . [10969-16]

11:45 am: **Smart additive manufacturing  
empowered by a closed-loop machine learning  
algorithm**, Yaser Mohammadi Banadaki, Southern  
Univ. and A&M College (USA) . . . . . [10969-17]

12:05 pm: **Wavelength dependence of two-  
photon polymerization and photoreduction  
in silver nitrate doped SU-8**, Quincy Williams,  
Thomas Coleman, Baldwin Varner, Doyle A.  
Temple, Norfolk State Univ. (USA) . . . . [10969-18]

12:25 pm: **Kirigami-inspired 2D flexible and  
3D deformable structural layouts for flexible  
electronic applications**, Srinivas Gandla, Hyeok  
Ju Chae, Muhammad Naqi Siddiqi, Sunkook Kim,  
Sungkyunkwan Univ. (Korea, Republic  
of) . . . . . [10969-19]

Lunch Break . . . . . Tue 12:45 pm to 2:05 pm

**CONFERENCE 10970  
Sensors and Smart  
Structures Technologies  
for Civil, Mechanical,  
and Aerospace Systems**

**CONFERENCE 10971  
Nondestructive  
Characterization and  
Monitoring of Advanced  
Materials, Aerospace,  
Civil Infrastructure, and  
Transportation XIII**

**CONFERENCE 10972  
Health Monitoring  
of Structural and  
Biological Systems XIII**

**CONFERENCE 10973  
Smart Structures and NDE  
for Energy Systems and  
Industry 4.0**

**PLENARY SESSION · 8:25 AM to 10:00 AM · LOCATION: SILVERTON SALONS 2-3**

*Session Chairs: Tribikram Kundu, The Univ. of Arizona (USA) and Gregory W. Reich, Air Force Research Lab. (USA)*

**8:25 AM - 8:30 AM:**

• **SPIE Fellows Awards** presented to:  
**Roger M. Groves**, Technische Univ. Delft  
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Univ. of Nevada, Reno (USA)



**8:30 AM - 9:15 AM · Plenary Presentation**  
**Piezoelectric films for MEMS applications**  
**Susan Trolier-McKinstry**  
The Pennsylvania State Univ. (USA)



**9:15 AM - 10:00 AM · Plenary Presentation**  
**Structural health monitoring: a view of the  
entrepreneur**  
**Tadeusz Uhl**  
AGH Univ. of Science and Technology (Poland)

Coffee Break · Tues 10:00 am to 10:30 am

**SESSION 4**

**LOCATION: CRESTONE SALON B  
TUE 10:30 AM TO 12:10 PM**

**Machine Learning and  
Data Analysis**

Session Chairs: **Armin B. Mehrabi**,  
Florida International Univ. (USA); **Xuan  
Kong**, Hunan Univ. of Technology  
(China)

10:30 am: **Acoustic emission pattern  
recognition to identify failure modes  
of GFRP laminate coupons**, Xuan Kong,  
Hunan Univ. (China); C. S. S. Cai, Archana  
Nair, Louisiana State Univ. (USA) [10970-16]

10:50 am: **Addressing sensor drift in a  
propreroceptive optical foam system**, Ilse  
M. Van Meerbeek, Christopher M. De Sa,  
Robert F. Shepherd, Cornell Univ.  
(USA) . . . . . [10970-17]

11:10 am: **An autoencoder and recurrent  
neural network based approach for  
estimation of dynamic bending and  
twisting loads using depth images**,  
Diyar Khalis Bilal, Mustafa Ünel, Sabanci  
Univ. (Turkey) . . . . . [10970-18]

11:30 am: **DeepSHM: a deep learning  
approach for structural health  
monitoring based on guided lamb wave  
technique**, Vincentius Ewald, Roger M.  
Groves, Rinze Benedictus, Technische  
Univ. Delft (Netherlands) . . . . . [10970-19]

11:50 am: **Prediction of damage location  
in composite plates using artificial  
neural network modeling**, Saman  
Farhangdoust, Shervin Tashakori, Amin  
Baghalian, Armin Mehrabi, Ibrahim N.  
Tansel, Florida International Univ.  
(USA) . . . . . [10970-20]

Lunch Break . . . . Tue 12:10 pm to 1:40 pm

**SESSION 4**

**LOCATION: ASPEN B  
TUE 10:30 AM TO 12:10 PM**

**SHM-NDE Science and  
Theory I**

Session Chairs: **Andrew L. Gyekenyesi**,  
Ohio Aerospace Institute (USA); **Tzikang  
John Chen**, U.S. Army Research Lab.  
(USA)

10:30 am: **Verification of probabilistic  
risk assessment method AMETA  
(Aircraft Maintenance Event Tree  
Analysis) for aircraft fatigue life  
management**, Tzikang J. Chen, Michael  
Shiao, Mulugeta Haile, U.S. Army  
Research Lab. (USA) . . . . . [10971-18]

10:50 am: **Exploring the feasibility of  
crack detection in plate weldments  
through an interposed layer of  
viscoelastic material**, Karl A. Fisher,  
Owen Mays, David Obenauf, John  
T. Chang, Peter Haugen, Lawrence  
Livermore National Lab. (USA). [10971-19]

11:10 am: **Assessing reliability of NDE  
flaw detection using smaller number  
of demonstration data points**, Ajay M.  
Koshti, NASA Johnson Space Ctr.  
(USA) . . . . . [10971-20]

11:30 am: **NDE flaw detectability  
validation using smaller number of  
signal response data-points**, Ajay M.  
Koshti, NASA Johnson Space Ctr.  
(USA) . . . . . [10971-21]

11:50 am: **In-line quality control using  
dimensional metrology of 3D metal  
parts printed by laser beam melting**,  
Michael Kalms, Ralf B. Bergmann, Bremer  
Institut für angewandte Strahltechnik  
GmbH (Germany) . . . . . [10971-22]

Lunch Break . . . . Tue 12:10 pm to 1:40 pm

**SESSION 4**

**LOCATION: CRIPPLE CREEK 2  
TUE 10:30 AM TO 12:10 PM**

**Modeling of Ultrasonic  
and Guided Waves**

Session Chairs: **Victor Giurgiutiu**, Univ. of  
South Carolina (USA); **Francesco Lanza di  
Scalea**, Univ. of California, San Diego (USA)

10:30 am: **Prediction of the amplitude of  
ultrasound reflection from rough defects**,  
Michael Lowe, Fan Shi, Stewart Haslinger,  
Peter Huthwaite, Richard Craster, Imperial  
College London (United Kingdom). [10972-17]

10:50 am: **Convergence issues in guided  
wave prediction using global matrix,  
transfer matrix, and stiffness matrix  
methods in anisotropic materials**,  
Mohammad Faisal Haider, Victor Giurgiutiu,  
Univ. of South Carolina (USA) . . . . [10972-18]

11:10 am: **Improved global-local model to  
predict guided-wave scattering patterns  
from discontinuities in complex parts**,  
Francesco Lanza di Scalea, Univ. of California,  
San Diego (USA); Antonino Spada, Univ. degli  
Studi di Palermo (Italy); Margherita Capriotti,  
Ranting Cui, Univ. of California, San Diego  
(USA) . . . . . [10972-19]

11:30 am: **Guided wave mode conversion  
phenomenon in composite materials:  
numerical and experimental study**, Tomasz  
Wandowski, Pawel Kudela, Pawel Malinowski,  
Wieslaw Ostachowicz, The Szwalski Institute  
of Fluid-Flow Machinery (Poland) . [10972-20]

11:50 am: **Wave damage interaction in  
metals and composites**, Hanfei Mei, Victor  
Giurgiutiu, Univ. of South Carolina  
(USA) . . . . . [10972-21]

Lunch Break . . . . . Tue 12:10 pm to 1:20 pm

**SESSION 5**

**LOCATION: CRYSTAL SALON A  
TUE 10:30 AM TO 11:10 AM**

**Keynote Session II**

Session Chair: **Norbert G. Meyendorf**, Iowa  
State Univ. of Science and Technology (USA)

10:30 am: **NDE of ceramic components  
manufactured by additive technologies  
(Keynote Presentation)**, Christian Wunderlich,  
Fraunhofer-IKTS (Germany); Jörg L. Opitz,  
Fraunhofer IKTS-MD (Germany); Uwe Scheithauer,  
Fraunhofer-IKTS (Germany) . . . . . [10973-16]

**SESSION 6**

**LOCATION: CRYSTAL SALON A  
TUE 11:10 AM TO 12:10 PM**

**Big Data, Data Management,  
Dataprocessing, and  
Datafusion I**

Session Chair: **Zheng Liu**, The Univ. of British  
Columbia Okanagan (Canada)

10:30 am: **Delamination detection of integrated  
circuit package using a multivariate Gaussian  
mixture model**, Guoyi Li, Javaid Ikram, Aditi  
Chattopadhyay, Arizona State Univ. (USA); Rajesh  
Kumar Neerukatti, Kuang C. Liu, Intel Corp.  
(USA) . . . . . [10973-15]

10:50 am: **FRP tank NDT (Non Destructive  
Test) using PAUT C-scan**, Dugi An, Jauk Gu,  
SAMSUNG Electronics Co., Ltd. (Korea, Republic  
of) . . . . . [10973-17]

11:10 am: **Direct structural element recognition  
from scattered point cloud data**, Tsung-Chin  
Hou, National Cheng Kung Univ. (Taiwan); Yu-Min  
Su, National Kaohsiung Univ. of Science and  
Technology (Taiwan); Cheng-Yan Wu, National  
Cheng Kung Univ. (Taiwan) . . . . . [10973-18]

Lunch Break . . . . . Tue 12:10 pm to 1:10 pm

CONFERENCE 10965

SESSION 6

LOCATION: CRIPPLE CREEK 1  
TUE 1:30 PM TO 2:30 PM

**Biomimetic Materials and Structures II**

Session Chair: **Flavia Libonati**, Politecnico di Milano (Italy)

1:30 pm: **Hybrid materials by mimicking mineralization from the vapor phase**, Mato Knez, CIC nanoGUNE (Spain) . . . . . [10965-19]

1:50 pm: **Morphogenesis of compliant thin shells mechanisms: bioinspiration and transformation of geometric surfaces**, Victor Charpentier, Sigrid Adriaenssens, Princeton Univ. (USA) . . . . . [10965-20]

2:10 pm: **Time-lapse imaging of bactericidal effect on nanostructural surface**, Takeshi Ito, Kazuki Nakade, Keisuke Jindai, Kansai Univ. (Japan); Takashi Sagawa, Hiroaki Kojima, National Institute of Information and Communications Technology (Japan); Tomohiro Shimizu, Shoso Shingubara, Kansai Univ. (Japan) . . . . . [10965-21]

SESSION 7

LOCATION: CRIPPLE CREEK 1  
TUE 2:30 PM TO 3:30 PM

**Biomimetic Actuators**

Session Chair: **Torben A. Lenau**, Technical Univ. of Denmark (Denmark)

2:30 pm: **Actuation simplification for grippers based on bioinspired spring origami**, Salvador Rojas, David M. Boston, Andres F. Arrieta, Purdue Univ. (USA) . . . . . [10965-22]

2:50 pm: **Bio-inspired orderly recruitment valve for fluidic artificial muscles**, Dheeraj Vemula, Matthew Bryant, North Carolina State Univ. (USA) . . . . . [10965-23]

CONFERENCE 10966

SESSION 4

LOCATION: SILVERTON SALONS 2-3  
TUE 1:20 PM TO 3:00 PM

**Twisted and Coiled Polymer Actuators**

Session Chairs: **Helmut F. Schlaak**, Technische Univ. Darmstadt (Germany); **Nancy L. Johnson**, General Motors Co. (USA)

1:20 pm: **Controllable and three-dimensional shape-morphing link actuated by twisted-and-coiled actuators**, Jiefeng Sun, Ben Pawlowski, Jianguo Zhao, Colorado State Univ. (USA) . . . . . [10966-12]

1:40 pm: **Investigation of manufacturing parameters for copper-braided super coiled polymer actuators**, Matthew Padgett, Stephen Mascaro, The Univ. of Utah (USA) . . . . . [10966-13]

2:00 pm: **A modular twisted and coiled polymer actuator unit for emerging soft robotics**, Lianjun Wu, Xuemin Wang, Georgia Southern Univ. (USA) . [10966-14]

2:20 pm: **Double helix artificial muscles**, Geoffrey M. Spinks, David Shepherd, Univ. of Wollongong (Australia) [10966-15]

2:40 pm: **Experimental investigation of temperature-dependent hysteresis of fishing-line artificial muscle (twisted and coiled polymer fiber) actuator**, Hoshito Tanizaki, Kentaro Takagi, Chihaya Oiwa, Nagoya Univ. (Japan); Ken Masuya, Tokyo Institute of Technology (Japan); Kenji Tahara, Kyushu Univ. (Japan); Toshihira Irisawa, Nagoya Univ. (Japan); Masatoshi Shioya, Tokyo Institute of Technology (Japan); Kinji Asaka, National Institute of Advanced Industrial Science and Technology (Japan) . . . . . [10966-16]

Coffee Break . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10967

SESSION 5

LOCATION: CRESTONE SALON A  
TUE 1:40 PM TO 3:00 PM

**Energy Harvesting III: Fluid/Acoustic-Structure Interaction**

Session Chairs: **Matthew J. Bryant**, North Carolina State Univ. (USA); **Amir H. Danesh-Yazdi**, Rose-Hulman Institute of Technology (USA)

1:40 pm: **Power output comparison of side-by-side fluidic harvesters in different types of fractal grid-generated turbulence**, Amir H. Danesh-Yazdi, Rose-Hulman Institute of Technology (USA); Kevin Ferko, Nick Chiappazzi, Penn State Behrend (USA); George Lesieutre, The Pennsylvania State Univ. (USA) . . . . . [10967-22]

2:00 pm: **Aspect ratio effects in wind energy harvesting using piezoelectric inverted flags**, Oluwafemi Ojo, Florida State Univ. (USA); David Tan, Yu-Cheng Wang, Georgia Institute of Technology (USA); Kourosh Shoele, Florida State Univ. (USA); Alper Erturk, Georgia Institute of Technology (USA) . . . . . [10967-23]

2:20 pm: **Toward synergistic performance of integrated solar-wind hybrid energy harvesting structures**, Nicholas Mazzoleni, Matthew Bryant, North Carolina State Univ. (USA) [10967-24]

2:40 pm: **Comparison of various models for piezoelectric receivers in wireless acoustic power transfer**, Ahmed Allam, Karim Sabra, Alper Erturk, Georgia Institute of Technology (USA) . . [10967-25]

Coffee Break . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10968

SESSION 5

LOCATION: CRYSTAL C  
TUE 2:20 PM TO 3:00 PM

**Additive Manufacturing**

Session Chairs: **Amir Ameli**, Washington State Univ. Tri-Cities (USA); **Mohammad H. Elahinia**, The Univ. of Toledo (USA)

2:20 pm: **Temperature-compensation of 3D-printed polymer-based strain gauge**, Demetris Coleman, Mohammed Khalid, Xiaobo Tan, Michigan State Univ. (USA) . . . . . [10968-20]

2:40 pm: **Ultrasonic microparticle alignment and direct-ink-writing using glass capillaries**, Erin R. Dauson, Kelvin B. Gregory, Robert A. Heard, Irving J. Oppenheim, Stephanie W. Wong, Cheyney (Chiheng) Zhou, Carnegie Mellon Univ. (USA) . . . . . [10968-21]

Coffee Break . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10969

SESSION 7

LOCATION: CRYSTAL SALON B/C  
TUE 2:05 PM TO 3:25 PM

**3D Printing and Systems II**

Session Chair: **Yirong Lin**, The Univ. of Texas at El Paso (USA)

2:05 pm: **Near field electrospinning of nanowires for multi-modal hydrogen sensing**, Danny Wong, Allen Sandwell, Simon Park, Univ. of Calgary (Canada) . . . . . [10969-20]

2:25 pm: **Neural recordings and machine learning techniques for the analysis of brain function and impact from stressors associated with space exploration**, Shao-Hui Chuang, Norfolk State Univ. (USA); Larry D. Sanford, Richard A. Britten, Eastern Virginia Medical School (USA); Hargsoon Yoon, Norfolk State Univ. (USA) . . . . [10969-55]

2:45 pm: **Micro-CLIP magnetic resin high-resolution fabrication and potential applications**, Guangbin Shao, Harbin Institute of Technology (China) and Northwestern Univ. (USA); Henry Oliver T. Ware, Xiangfan Chen, Northwestern Univ. (USA); Longqiu Li, Harbin Institute of Technology (China); Cheng Sun, Northwestern Univ. (USA) . . . . [10969-22]

3:05 pm: **Fabrication and characterization of 3D printing flexible capacitive pressure sensor for wearable device and biomechanical applications**, Gwang-Wook Hong, Sunkon Lee, Joo-Hyung Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-23]

Coffee Break . . . . Tue 3:25 pm to 3:55 pm

CONFERENCE 10970

SESSION 5

LOCATION: CRESTONE SALON B  
TUE 1:40 PM TO 3:00 PM

**Smart Materials  
Integration for Smart  
Systems**

Session Chairs: **Tyler N. Tallman**, Purdue Univ. (USA); **Donghyeon Ryu**, New Mexico Institute of Mining and Technology (USA)

1:40 pm: **Multifunctional Beta cloth: development of aerospace-grade fabric with woven sensory fibers for damage detection**, Juliana Cherston, Joseph A. Paradiso, MIT Media Lab. (USA)[10970-21]

2:00 pm: **Performance of a water level sensor using magnetostrictive materials**, Jin Yoo, Nicholas J. Jones, Naval Surface Warfare Ctr. Carderock Div. (USA); Kyle J. Flynn, Virginia Polytechnic Institute and State Univ. (USA); Rachel Jacobs, Naval Surface Warfare Ctr. Carderock Div. (USA) . . . . . [10970-22]

2:20 pm: **A baseline free approach for multiple damage detection in beams**, Jashanjeet Randhawa, Suresh Bhalla, Indian Institute of Technology Delhi (India). . . . . [10970-23]

2:40 pm: **An analytical model for a shape memory alloy beam accounting for tension-compression stress asymmetry effect**, Nguyen V. Viet, Wael Zaki, Khalifa Univ. of Science, Technology and Research (United Arab Emirates) . . . . . [10970-24]

Coffee Break. . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10971

SESSION 5

LOCATION: ASPEN B  
TUE 1:40 PM TO 3:00 PM

**SHM-NDE of  
Civil Structures/  
Infrastructure IV**

Session Chairs: **Mirmilad Mirsayar**, Texas A&M Univ. (USA); **Jun Chen**, Beihang Univ. (China)

1:40 pm: **Structural health monitoring using embedded magnetic shape memory alloys for magnetic sensing**, Allen Davis, Mirmilad Mirsayar, Brady Edmiston, Darren J. Hartl, Texas A&M Univ. (USA) . . . . . [10971-23]

2:00 pm: **Control of thermal deflection in concrete structures through implementation of prestained shape memory alloy rods**, Brady Edmiston, Mirmilad Mirsayar, Allen Davis, Darren J. Hartl, Texas A&M Univ. (USA) . [10971-24]

2:20 pm: **High-speed passive-only rail track integrity evaluation using deep learning-based anomaly detection**, Xuan Zhu, The Univ. of Utah (USA); Francesco Lanza di Scalea, Margherita Capriotti, Albert Liang, Simone Sternini, Univ. of California, San Diego (USA) . . . . . [10971-25]

2:40 pm: **Non-contact assessment of thermal damage of concrete using a nonlinear wave modulation technique**, Jun Chen, Yuning Wu, Beihang Univ. (China) . . . . . [10971-26]

Coffee Break. . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10972

SESSION 5

LOCATION: CRIPPLE CREEK 2  
TUE 1:20 PM TO 3:00 PM

**Elastic and  
Metamaterials II**

Session Chairs: **Jinkyu Yang**, Univ. of Washington (USA); **Mostafa A. Nouh**, Univ. at Buffalo (USA)

1:20 pm: **A tunable two-way, one-dimensional acoustic diode**, Weiqiu Chen, Zhejiang Univ. (China) . . [10972-22]

1:40 pm: **Flexural wave control via origami-based elastic metamaterials**, Mingkai Zhang, Beijing Institute of Technology (China); Jinkyu Yang, Univ. of Washington (USA); Rui Zhu, Beijing Institute of Technology (China). [10972-23]

2:00 pm: **Manipulating elastic waves in real time with programmable metasurfaces**, Yangyang Chen, Xiaopeng Li, Hussein Nassar, Guoliang Huang, Univ. of Missouri (USA) . . . . . [10972-24]

2:20 pm: **The critical point's control of parity-time symmetric beam structure**, Zheng Li, Jianlin Yi, Peking Univ. (China) . . . . . [10972-25]

2:40 pm: **Tunable reflected acoustic wave front modulated with adaptive acoustic metasurfaces**, Shilong Li, Yixin Yao, Jiong Tang, Univ. of Connecticut (USA) . . . . . [10972-26]

Coffee Break. . . . . Tue 3:00 pm to 3:30 pm

CONFERENCE 10973

SESSION 7

LOCATION: CRYSTAL SALON A  
TUE 1:10 PM TO 1:50 PM

**Big Data, Data  
Management,  
Dataprocessing, and  
Datafusion II**

Session Chair: **Zheng Liu**, The Univ. of British Columbia Okanagan (Canada)

1:10 pm: **Possibilities and limitations of passive and active thermography methods for investigation of composite materials using NDT simulations**, Vitalij Popow, Martin Gurka, Institut fuer Verbundwerkstoff (Germany) . . . . . [10973-19]

1:30 pm: **Acoustic emission monitoring of rate of damage growth in composite structures**, Duy Q. Tran, Mannur Sundaresan, North Carolina A&T State Univ. (USA)[10973-20]

SESSION 8

LOCATION: CRYSTAL SALON A  
TUE 1:50 PM TO 4:40 PM  
**NDE and SHM for Energy  
Systems**

Session Chair: **Christopher Niezrecki**, Univ. of Massachusetts Lowell (USA)

1:50 pm: **Non-invasive pressure measurement in microfluidic chips using optical interferometry**, Asm Kamruzzaman, Hossein Kazemi, Xiaolong Yin, Erdal Ozkan, Colorado School of Mines (USA); Umit U. Kaya, Yusuf A. Koksal, Kaia Corp. (USA) . . [10973-21]

2:10 pm: **A review on corrosion sensors for structural health monitoring of oil and natural gas infrastructure**, Ruishu F. Wright, Ping Lu, Jagannath Devkota, Fei Lu, Margaret Ziomek-Moroz, Paul R. Ohodnicki Jr., National Energy Technology Lab. (USA) . . . . [10973-22]

2:30 pm: **Use of infrared imaging for structure from motion assessment of heat loss in buildings via unmanned aerial inspection**, Alessandro Sabato, Christopher Niezrecki, Univ. of Massachusetts Lowell (USA) . . . . [10973-23]

2:50 pm: **Detection and monitoring of damages in large diameter underground waterworks pipelines**, Dong-Jin Yoon, Sun-Ho Lee, Choon-Su Park, Korea Research Institute of Standards and Science (Korea, Republic of) . . . . . [10973-24]

Coffee Break. . . . . Tue 3:10 pm to 3:40 pm

CONFERENCE 10965

3:10 pm: **Flow- and temperature-induced structural changes of liposomes**, Bert Müller, Marzia Buscema, Sofiya Matviyukiv, Hans Deyhle, Univ. Basel (Switzerland) . . . . . [10965-24]

Coffee Break . . . . Tue 3:30 pm to 4:00 pm

SESSION 8

LOCATION: CRIPPLE CREEK 1  
TUE 4:00 PM TO 6:00 PM

Sensors

Session Chair: **Hendrik Hölscher**, Karlsruhe Institut für Technologie (Germany)

4:00 pm: **Digitization of biomimetic vision sensor based on the common housefly**, Sakshi Agrawal, Brian Dean, Oakland Univ. (USA) . . . . . [10965-25]

4:20 pm: **Finite element analysis of structural implications of Basilar membrane measurements**, Mohammad Sadegh Saadatzi, Vahid Tavaf, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10965-26]

4:40 pm: **Liquid metal-based bio-inspired capacitive flow sensor**, James P. Wissman, Kaushik Sampath, Charles A. Rohde, U.S. Naval Research Lab. ( USA) . . . . . [10965-27]

5:00 pm: **Behavior prediction for several seconds using human body model and non-contact sensor**, Yosuke Kimura, Keio Univ. (Japan) . . . . . [10965-28]

5:20 pm: **The structural colors of the blue butterflies: from sexual signaling to chemically selective vapor sensing**, Gábor Piszter, Krisztián Kertész, Hungarian Academy of Sciences Ctr. for Energy Research (Hungary); Zsolt Bálint, Hungarian Natural History Museum (Hungary); László P. Biró, Hungarian Academy of Sciences Ctr. for Energy Research (Hungary) . . . . . [10965-29]

5:40 pm: **Breathing skins workshop: a hands-on investigation of bio-inspired foldable structures for temperature and humidity control in buildings**, Ariana Rupp, Thibaut Houette, The Univ. of Akron (USA); Lorenzo Guiducci, Humboldt-Univ. zu Berlin (Germany); Petra Gruber, The Univ. of Akron (USA) . . . . . [10965-34]

Conference End.

CONFERENCE 10966

SESSION 5

LOCATION: SILVERTON  
SALONS 2-3  
TUE 3:30 PM TO 5:50 PM

Modeling

Session Chairs: **Anne Ladegaard Skov**, Technical Univ. of Denmark (Denmark); **Xuanhe Zhao**, Massachusetts Institute of Technology (USA)

3:30 pm: **Numerical studies on origami dielectric elastomer actuator using Kresling pattern**, Jang Ho Park, Stanislav Sikulskyi, Daewon Kim, Eduardo Divo, Embry-Riddle Aeronautical Univ. (USA) . . . . . [10966-17]

3:50 pm: **Finite-elements simulation of electro-mechanically coupled elastomer and electrode layered dielectric elastomer membrane actuators for large deformations**, Philipp Loew, Gianluca Rizzello, Univ. des Saarlandes (Germany); Fiomena Simone, Zentrum für Mechatronik und Automatisierungstechnik gGmbH (Germany); Stefan Seelecke, Univ. des Saarlandes (Germany) . . . . . [10966-18]

4:10 pm: **Effects of variation of permittivity and the actuating voltage on the dynamic response of dielectric elastomer actuator**, Zezhou Li, Henry Y.K. Lau, Xiaoyu Chen, The Univ. of Hong Kong (Hong Kong, China) . . . . [10966-19]

4:30 pm: **Continuum electro-mechanical damage modeling of dielectric elastomer**, Lorenzo Agostini, Scuola Superiore Sant'Anna (Italy); Gianluca Rizzello, Univ. des Saarlandes (Germany); Marco Fontana, Univ. degli Studi di Trento (Italy); Rocco Vertechy, Univ. degli Studi di Bologna (Italy); Stefan Seelecke, Univ. des Saarlandes (Germany) . . . . . [10966-20]

4:50 pm: **A dynamic model of helical dielectric elastomer actuator**, Abdullah El Atrache, Daewon Kim, Eduardo Divo, Sergey Drakunov, Embry-Riddle Aeronautical Univ. (USA) . . . . [10966-21]

5:10 pm: **Electromechanical hysteresis model and identification for a soft DEA**, Lili Meng, Fucai Li, Hongguang Li, Shanghai Jiao Tong Univ. (China) . . . . . [10966-22]

5:30 pm: **A finite element model for investigating the thermo-electro-mechanical response of dielectric elastomer actuators**, Atul Sharma, Manish M. Joglekar, Indian Institute of Technology Roorkee (India) . . . [10966-23]

CONFERENCE 10967

SESSION 6

LOCATION: CRESTONE SALON A  
TUE 3:30 PM TO 5:50 PM

Fluid-Structure Interaction

Session Chairs: **Lei Zuo**, Virginia Polytechnic Institute and State Univ. (USA); **Eun Jung Chae**, California State Univ., Long Beach (USA)

3:30 pm: **Development of a variable-incidence-angle vortex generator for surface contaminated wind-turbine blades**, Ho-Hyun Kim, Ho-Young Kim, Jong-Seob Han, Jae-Hung Han, KAIST (Korea, Republic of) . . . . . [10967-26]

3:50 pm: **Dynamics of a hybrid ocean wave-current energy converter with mechanical motion rectifier**, Boxi Jiang, Xiaofan Li, Robert Parker, Lei Zuo, Virginia Polytechnic Institute and State Univ. (USA); Bangfuh Chen, National Sun Yat-sen Univ. (Taiwan) . . . . . [10967-27]

4:10 pm: **Design of bat inspired compliant dielectric membrane wings**, Gurmeet Singh, Nakhiah C. Goulbourne, Univ. of Michigan (USA) . . . . . [10967-28]

4:30 pm: **Aerodynamic characteristic of the continuous morphing trailing edge**, Pyae Su, Eun Jung Chae, California State Univ., Long Beach (USA) . . . . [10967-29]

4:50 pm: **Characterization of a bio-inspired piezoelectric swimmer in a quiescent water and under imposed flow**, David Tan, Yan-Alan Le Dault, Alper Erturk, Georgia Institute of Technology (USA) . . . . . [10967-30]

5:10 pm: **Flutter analysis of a large civil aircraft in case of free-plays and internal failures of morphing wing flaps mechanical systems**, Rosario Pecora, Francesco Amoroso, Univ. degli Studi di Napoli Federico II (Italy); Ignazio Dimino, Antonio Concilio, Ctr. Italiano Ricerche Aerospaziali (Italy) . . . . . [10967-31]

5:30 pm: **Turbulent kinetic energy, power output, and the power law: identifying trends in the behavior of fluidic harvesters in grid turbulence**, Kevin Ferko, Nick Chiappazzi, Penn State Behrend (USA); Amir H. Danesh-Yazdi, Rose-Hulman Institute of Technology (USA) . . . . . [10967-32]

CONFERENCE 10968

SESSION 6

LOCATION: CRYSTAL C  
TUE 3:30 PM TO 5:30 PM

Origami Materials

Session Chairs: **Zoubeida Ounaies**, The Pennsylvania State Univ. (USA); **Paris von Lockette**, The Pennsylvania State Univ. (USA)

3:30 pm: **Optimal design approaches for adaptive structures: self-folding origami and metamaterials** (*Keynote Presentation*), Mary I. Frecker, The Pennsylvania State Univ. (USA) [10968-23]

4:10 pm: **Towards the design of electric field driven self-folding gripper**, Saad Ahmed, Intel Corp. (USA); Anil Erol, Wei Zhang, Jonathan Hong, Zoubeida Ounaies, Paris vonLockette, Mary I. Frecker, The Pennsylvania State Univ. (USA) . . . . . [10968-24]

4:30 pm: **Numerical and experimental investigation of 3D printed origami unit cells and cores for load resistance**, Mohamed Ali E. Kshad, Hani E. Naguib, Univ. of Toronto (Canada) . . . . [10968-25]

4:50 pm: **Self-folding origami surfaces of non-zero Gaussian curvature**, Milton R. Garza, Texas A&M Univ. (USA); Edwin A. Peraza-Hernandez, Univ. of California, Irvine (USA); Darren J. Hartl, Texas A&M Univ. (USA) . . . . . [10968-26]

5:10 pm: **Analyzing the bi-directional dynamic morphing of a bi-stable water-bomb base origami**, Sahand Sadeghi, Suyi Li, Clemson Univ. (USA) . [10968-27]

CONFERENCE 10969

SESSION 8

LOCATION: CRYSTAL SALON B/C  
TUE 3:55 PM TO 5:45 PM

Nanomaterials and Applications I

Session Chair: **Joo-Hyung Kim**, Inha Univ. (Korea, Republic of)

3:55 pm: **Cellulose nanoporous foam for improving THz gas sensing** (*Invited Paper*), Wei-Chih Wang, National Tsing Hua Univ. (Taiwan) and Univ. of Washington (USA); Yen-Tse Cheng, National Tsing Hua Univ. (Taiwan) . . . . . [10969-24]

4:25 pm: **Novel superhydrophobic cellulose coating and its multifunctional applications**, Sunanda Roy, Hyun Chan Kim, Jung Woong Kim, Le Van Hai, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-25]

4:45 pm: **Fabrication of nanocellulose-based long and strong fiber via aligning processes of cellulose nanofibers**, Hyun Chan Kim, Lindong Zhai, Debora Kim, Jiyun Lee, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-26]

5:05 pm: **Feasibility of renewable bulk materials made with nanocellulose**, Jung Woong Kim, Lindong Zhai, Hyun Chan Kim, Young-Min Yun, Jaehwan Kim, Inha Univ. (Korea, Republic of) . [10969-27]

5:25 pm: **Cellulose nanoporous foam filled multi-layered split ring THz sensor**, Wei-Chih Wang, National Tsing Hua Univ. (Taiwan) and Univ. of Washington (USA); Han-Hsiang Chen, Chu-yun Kao, Yen-Tse Cheng, Yu-hsin Chiang, National Tsing Hua Univ. (Taiwan) . . . . . [10969-28]



CONFERENCE 10970

SESSION 6

LOCATION: CRESTONE SALON B  
TUE 3:30 PM TO 5:50 PM

Case Studies of SHM  
in Civil Infrastructure  
Systems

Session Chairs: **Francesco Lanza di Scalea**, Univ. of California, San Diego (USA); **Daniele Zonta**, Univ. degli Studi di Trento (Italy)

3:30 pm: **Sensor data reconstruction using the optimal subset of sensors based on bidirectional long short-term memory recurrent neural network**, Seongwoon Jeong, Max Ferguson, Kincho H. Law, Stanford Univ. (USA) . . . [10970-25]

3:50 pm: **Road vehicle classification using machine learning techniques**, Mu'ath Al-Tarawneh, Ying Huang, North Dakota State Univ. (USA) . . . . . [10970-26]

4:10 pm: **Reidentification of truck loads in highway corridors using convolutional neural networks to link measured truck weights to bridge responses**, Rui Hou, Univ. of Michigan (USA); Seongwoon Jeong, Stanford Univ. (USA); Jerome P. Lynch, Univ. of Michigan (USA); Kincho H. Law, Stanford Univ. (USA) . . . . . [10970-27]

4:30 pm: **Instrumentation plan verification for damage detection of a vertical lift steel truss bridge**, Milad Mehrkash, Vahid Shahsavari, Erin Bell, The Univ. of New Hampshire (USA) [10970-28]

4:50 pm: **Passive extraction of Green's function of solids and application to high-speed rail inspection**, Francesco Lanza di Scalea, Albert Liang, Simone Sternini, Margherita Capriotti, Univ. of California, San Diego (USA); Xuan Zhu, The Univ. of Utah (USA) . . . . . [10970-29]

5:10 pm: **Securing critical infrastructures with location based authentication blockchain**, Michael Noble, Zhaohong Wang, California State Univ., Chico (USA) . . . . . [10970-30]

5:30 pm: **Large-scale monitoring of retaining structures: new approaches on the safety assessment of retaining structures using mobile mapping**, Slaven Kalenjuc, Werner Lienhart, Matthias Rebhan, Roman Marte, Technische Univ. Graz (Austria) . . . . . [10970-31]

CONFERENCE 10971

SESSION 6

LOCATION: ASPEN B  
TUE 3:30 PM TO 5:50 PM

SHM-NDE of  
Civil Structures/  
Infrastructure V

Session Chairs: **Denvid Lau**, City Univ. of Hong Kong (Hong Kong, China); **Yu-Min Su**, National Kaohsiung Univ. of Science and Technology (Taiwan)

3:30 pm: **Characterization of dielectric constant of masonry wall using synthetic aperture radar imaging**, Jie Hu, Tzuyang Yu, Qixiang Tang, Univ. of Massachusetts Lowell (USA) . . [10971-27]

3:50 pm: **Automated construction of bridge condition inventory using natural language processing and historical inspection reports**, Tianshu Li, Devin Harris, Univ. of Virginia (USA) . . . . . [10971-28]

4:10 pm: **Detection of grain angle in wood specimens using synthetic aperture radar imaging**, Christopher M. Ingemi, Tzuyang Yu, Univ. of Massachusetts Lowell (USA) . . [10971-29]

4:30 pm: **IoT-powered remote sensing and handy real-time evaluation of strain imaging sheets installed on aged outdoor structures**, Shin-ichi Todoroki, Hiroshi Fudouzi, Koichi Tsuchiya, National Institute for Materials Science Japan) . . . . . [10971-30]

4:50 pm: **Machine vision-based concrete crack pattern identification and structural assessment**, Kaoshan Dai, Desheng Li, Sichuan Univ. (China); Mingyan Luo, Tongji Univ. (China); Yuanfeng Shi, Songhan Zhang, Sichuan Univ. (China); Zhenhua Huang, Univ. of North Texas (USA) . . . . . [10971-31]

5:10 pm: **Grain effect on the accuracy of defect detection in wood structure by using acoustic-laser technique**, Qiwen Qiu, Denvid Lau, City Univ. of Hong Kong (Hong Kong, China) . . . . . [10971-32]

5:30 pm: **Piezoelectric cement sensor and impedance analysis for concrete health monitoring**, Huang-Hsin Pan, Yu-Min Su, National Kaohsiung Univ. of Science and Technology (Taiwan) . . . . . [10971-33]

CONFERENCE 10972

SESSION 6

LOCATION: CRIPPLE CREEK 2  
TUE 3:30 PM TO 5:50 PM

Monitoring of Aerospace and  
Composite Structures

Session Chairs: **Fabrizio Ricci**, Univ. degli Studi di Napoli Federico II (Italy); **Tribikram Kundu**, The Univ. of Arizona (USA)

3:30 pm: **Hybrid structural health monitoring of a composite plate manufactured with automatic fibers placement including embedded fiber Bragg gratings and bonded piezoelectric patches**, Fabrizio Ricci, Ernesto Monaco, Vittorio Memmolo, Natalino D. Boffa, Univ. degli Studi di Napoli Federico II (Italy); Marco Barile, Novotech srl (Italy); Leonardo Lecce, Univ. degli Studi di Napoli Federico II (Italy) and Novotech srl (Italy) [10972-27]

3:50 pm: **Preliminary characterization of bonding defects in multi-element spars**, Antonio Concilio, Monica Ciminello, Ctr. Italiano Ricerche Aerospaziali (Italy); Gianvito Apuleo, Piaggio Aero Industries S.p.A. (Italy); Iddo Kressel, Shay Shoham, David Bardenstein, Israel Aerospace Industries Ltd. (Israel) . . . . . [10972-28]

4:10 pm: **Guided wave damage detection for alpine skis**, Matthew B. Obenchain, Matthew P. Snyder, Andrew C. DeNicola, Mikaela D. Dimaapi, Ryan J. Howe, U.S. Air Force Academy (USA) . . . . . [10972-29]

4:30 pm: **Linear and non-linear analysis of composite plates using guided acoustic waves**, Hamad Alnuaimi, Umar Amjad, The Univ. of Arizona (USA); Pietro Russo, Istituto per i Polimeri, Compositi e Biomateriali (Italy); Valentina Lopresto, Univ. degli Studi di Napoli Federico II (Italy); Tribikram Kundu, The Univ. of Arizona (USA) . . . . . [10972-30]

4:50 pm: **Investigation of manufacturing effects by strength assessment, NDI and guided waves based SHM in composite plates reinforced with bonded stringers**, Ernesto Monaco, Natalino D. Boffa, Vittorio Memmolo, Fabrizio Ricci, Univ. degli Studi di Napoli Federico II (Italy) . . . . . [10972-31]

5:10 pm: **THz spectroscopy application for analyzes of internal structure damage due to moisture influence**, Magdalena Mieloszyk, Katarzyna Majewska, Wieslaw Ostachowicz, Polish Academy of Sciences (Poland) . . . . . [10972-32]

5:30 pm: **Infrared thermography application for analyzes of internal structure damage due to moisture and temperature influence**, Katarzyna Majewska, Magdalena Mieloszyk, Wieslaw Ostachowicz, The Szewalski Institute of Fluid-Flow Machinery (Poland) . . . . . [10972-33]

CONFERENCE 10973

3:40 pm: **Propulsion health monitoring assessed by microwave sensor performance and blade tip timing**, Ali Abdul-Aziz, Kent State Univ. (USA); Mark R. Woike, Robert C. Anderson, NASA Glenn Research Ctr. (USA); Khaled Aboumerhis, Johns Hopkins Univ. (USA) . . . . . [10973-25]

4:00 pm: **Optimal monitoring schedules and lifecycle cost optimization for wind turbines using a neuro-fuzzy system**, Anu Hanish Nithin, Piotr Omenzetter, Univ. of Aberdeen (United Kingdom) [10973-26]

4:20 pm: **High fidelity ultrasound imaging of concrete structures**, Nora Dianne Ezell, Singanallur Venkatakrisnan, Oak Ridge National Lab. (USA); Hani Almansouri, Purdue Univ. (USA); Hector Santos-Villalobos, Oak Ridge National Lab. (USA); Dan Floyd, The Univ. of Tennessee Knoxville (USA); Dwight Clayton, Oak Ridge National Lab. (USA) . . . . . [10973-27]

SESSION 9

LOCATION: CRYSTAL SALON A  
TUE 4:40 PM TO 5:40 PM

Sensors, Actuators, and  
Monitoring for Energy  
Systems

Session Chair: **Christopher Niezrecki**, Univ. of Massachusetts Lowell (USA)

4:40 pm: **Feasibility of piezoelectric energy harvesting from real-life city flyover: a case study**, Sumit Balgavhar, Suresh Bhalla, Pramod Dalal, Indian Institute of Technology Delhi (India) . . . . . [10973-28]

5:00 pm: **Balancing battery and thermal storage for raised renewable energy penetration for microgrid**, Ibrahim Aldaouab, Abdulmajid A. Mrebit, Univ. of Dayton (USA); Abdulmunim Guwaeder, Oklahoma State Univ. (USA) . . [10973-29]

5:20 pm: **Investigation of wave propagation at the Dirac cone near  $k \rightarrow = 0$  for a high symmetry interlocking micro-structure composite metamaterial**, Hossain Ahmed, Mohammad Sadegh Saadatzi, Indaleeb M. Dipro, Univ. of South Carolina (USA); Trisha Sain, Susanta Ghosh, Michigan Technological Univ. (USA); Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10973-30]

Conference End.

# POSTER SESSION

Tuesday 5 March | 6:00 to 7:30 pm

Conference attendees are invited to attend the poster session to network, enjoy light refreshments, and view the poster papers. Attendees are required to wear their conference registration badge. Authors of poster papers will be present to answer questions concerning their papers. Poster authors must set up their poster between 10 am and 4 pm on Tuesday 5 March.

## CONFERENCE 10965

### Bioinspiration, Biomimetics, and Bioreplication IX

**Prolonging lifetime of pneumatic artificial muscle using strain-induced crystallization**, Akihiro Kojima, Manabu Okui, Yasuyuki Yamada, Taro Nakamura, Chuo Univ. (Japan) . . . . . [10965-30]

**Lighting control using natural gestures of resident**, Toshiki Minagawa, Akira Mita, Keio Univ. (Japan) . . . . . [10965-31]

**Repel high-speed waterdrops for polyethylene nanowire bundles by plasma nanotexturing**, X.Y. Li, Y.P. Li, I. Muzammil, X. Liu, M.K. Lei, Dalian Univ. of Technology (China); Akhlesh Lakhtakia, The Pennsylvania State Univ. (USA) . . . . . [10965-32]

**Fabrication of bioinspired micro/nanotextured surfaces by femtosecond laser processing**, Miguel Martínez-Calderon, Ainara Rodríguez, CEIT-IK4 (Spain) and Univ. de Navarra (Spain); Vicente Torres-Costa, Miguel Manso-Silván, Univ. Autónoma de Madrid (Spain); Santiago M. Olaizola, CEIT-IK4 (Spain) and Univ. de Navarra (Spain); Raúl J. J. Martín-Palma, Univ. Autónoma de Madrid (Spain) . . . . . [10965-33]

## CONFERENCE 10966

### Electroactive Polymer Actuators and Devices (EAPAD) XXI

**A soft-robotic snake platform using EAP**, Alexandra Washington, Justin Neubauer, Krishna C. Solasa, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) . . . . . [10966-40]

**Dielectric actuators based on block copolymer and lignin**, Rogerio Sousa Jr., Guilherme Garcia, Joana Sacramento, Demetrio Santos, Danilo Carastan, Univ. Federal do ABC (Brazil) . . . . . [10966-78]

**A feasibility study in the use of ionic polymer-metal composites in rectangular cantilever form as flow sensor devices**, Nazanin Minaian, Tyler Stalbaum, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) . . . . . [10966-79]

**Green solvents used in piezo sensors production**, Alessio Marrani, Solvay Solexis S.p.A (Italy) . . . . . [10966-80]

**Improved lifetime of dielectric elastomer actuators in cell culture conditions**, Alexandre Poulin, Herbert R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland) . . . . . [10966-82]

**Small temperature coefficient of resistance of graphene-carbon black-silicone rubber hybrid composite films**, Agee Kurian, The Univ. of Auckland (New Zealand) . . . . . [10966-83]

**Drop-on-demand lift-off patterning of compliant electrodes**, Sahan Jayatissa, Jared Pickery-Jordan, Iain A. Anderson, Samuel Rosset, The Univ. of Auckland (New Zealand) . . . . . [10966-84]

**Abatement of high-voltage leakage current in electrostrictive fluorinated polymers through electro-annealing**, Francesco Pedroli, Jean-Fabien Capsal, Pierre-Jean Cottinet, Institut National des Sciences Appliquées de Lyon (France); Alessio Marrani, Solvay Specialty Polymers (Italy) . . . . . [10966-85]

**Live-mirror shape correction technology operated through modified electroactive polymer actuators**, Kriksadi Thetraphi, INSAVALOR (France); Jean-Fabien Causal, Institut National des Sciences Appliquées de Lyon (France); Gil Moretto, CRAL CNRS Lyon1 (France); Jeff Kuhn, University of Hawaii (USA); David Audigier, LGEF-INSA Lyon (France); Pierre-Jean Cottinet, Institut National des Sciences Appliquées de Lyon (France); Lionel Petit, LGEF-INSA Lyon (France) . . . . . [10966-87]

**Plane-strain deformations of ionic polymer-metal composites**, Alain Boldini, Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . [10966-88]

**Ionically active manipulator for in situ probing of soft samples under scanning electron microscope**, Indrek Johanson, Pille Rinne, Friedrich Kaasik, Urmas Johanson, Alvo Aabloo, Univ. of Tartu (Estonia) . . . . . [10966-91]

**Force optimization and numerical validation of helical dielectric elastomer actuator**, Stanislav Sikulskyi, Daewon Kim, Embry-Riddle Aeronautical Univ. (USA) . . . . . [10966-92]

**Comprehensive figures of merit for dielectric elastomer actuators**, Abdulla El Atrache, Jang Ho Park, Daewon Kim, Eduardo Divo, Embry-Riddle Aeronautical Univ. (USA) . . . . . [10966-93]

**Bioinspired bistable soft actuators**, Susan Wei, Huiqi Shao, North Carolina State Univ. (USA) . . . . . [10966-95]

**Contactless coupling of DEA membranes with magnetic repulsion**, Chongjing Cao, Xing Gao, Andrew T. Conn, Univ. of Bristol (United Kingdom) and Bristol Robotics Lab. (United Kingdom) . . . . . [10966-96]

**The evolution of the dielectric constant in various polymers subjected to an electric field**, Nir Alboteanu, Gal deBotton, Ben-Gurion Univ. of the Negev (Israel) . . . . . [10966-97]

**Denovo Ru-poly of redox active tridentate Schiff's base ligand: study of optical and i-V properties for memristive devices**, Deepa Oberoi, Indian Institute of Technology Roorkee (India) . . . . . [10966-98]

## CONFERENCE 10967

### Active and Passive Smart Structures and Integrated Systems XIII

**Modeling and active control aiming at enhancing the sound transmission loss of thin partition panels**, Francesco Ripamonti, Simone Baro, Fabio Takeshi Okina, Politecnico di Milano (Italy); Flávio Buiochi, Eduardo A. Tannuri, Univ. de São Paulo (Brazil) . . . . . [10967-89]

**Sensitivity enhancing feedback control based damage detection in delaminated smart composite plates**, Bin Huang, Ningbo Univ. (China) [10967-90]

**Shape optimizations for negative Poisson's ratio structures represented by B-spline curves**, Sinwook Jeong, Hong Hee Yoo, Hanyang Univ. (Korea, Republic of) . . . . . [10967-91]

**Study of fluid-structure interactions over different bluff body orientations using a novel smart composite structure for energy harvesting applications in aquatic autonomous observatory**, Pawandeep Singh Matharu, Rupal Srivastava, Bishakh Bhattacharya, Indian Institute of Technology Kanpur (India) . . . . . [10967-92]

**A self-powered nonlinear wideband vibration energy harvester with high-energy response stabilization control**, Sou Ushiki, Arata Masuda, Kyoto Institute of Technology (Japan) . . . . . [10967-93]

**Active mass damper using phase and amplitude of mean field of oscillators**, Junichi Hongu, Tottori Univ. (Japan); Daisuke Iba, Kyoto Institute of Technology (Japan); Takuya Wada, Tottori Univ. (Japan) . . . . . [10967-94]

**Design and development of a miniaturized mechanically and magnetically sprung electromagnetic nonlinear energy harvester**, Zhao Feng, Yusuke Miyata, Sou Ushiki, Arata Masuda, Kyoto Institute of Technology (Japan) . . . . . [10967-95]

**An active ultrasonic multi-sensor method for continuous monitoring of plate-like structures using neural networks**, Yunseok Gwon, Michael Yoon, Hadi Fekrmandi, South Dakota School of Mines and Technology (USA) . . [10967-96]

**Capturing magnetic bead-based arrays using Perpendicular Magnetic Anisotropy (PMA)**, Yu-Ching Hsiao, Univ. of California, Los Angeles (USA) [10967-98]



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**Behavior and Mechanics of Multifunctional Materials XIII**

**Principle design of a testing system for magnetorheological fluids in valve mode**, Jian Chen, Xian-Xu Bai, Li-Jun Qian, Hefei Univ. of Technology (China) . . . . . [10968-30]

**Nonlinear modeling of a giant magnetostrictive material-based actuator**, Zhi-Yuan Si, Hefei Univ. of Technology (China) and Anhui Univ. of Science and Technology (China); Xian-Xu Bai, Li-Jun Qian, Hefei Univ. of Technology (China) . . . . . [10968-42]

**Giant actuation strain over 0.5% in periodically orthogonal poled PZT ceramics and multilayer actuators via reversible domain switching**, Faxin Li, Peking Univ. (China) . . . . . [10968-43]

**CONFERENCE 10969**

**Nano-, Bio-, Info-Tech Sensors and 3D Systems**

**Nanoparticles controlling the interaction between VCAM-1 and VLA-4**, Rawan Jawarneh, Univ. of Jordan (Jordan) . . . . . [10969-44]

**Electrospinning of cellulose nanofiber and poly(vinyl alcohol) blend: experiment and simulation**, Eun Sik Choi, Sunanda Roy, Hyun Chan Kim, Inha Univ. (Korea, Republic of); K. C. Park, Inha Univ. (Korea, Republic of) and Univ. of Colorado Boulder (USA); Jaehwan Kim, Inha Univ. (Korea, Republic of). [10969-45]

**Molecular dynamic simulation of cellulose nanofiber to determine its nano-mechanical properties**, Ruth M. Muthoka, Hyun Chan Kim, Jung Woong Kim, Jaehwan Kim, Inha Univ. (Korea, Republic of). . . . . [10969-46]

**High-performance triboelectric nanogenerator with a hierarchically nanostructured electrode**, Qitao Zhou, Jongnam Kim, Kwan Woo Han, Saewoong Oh, Sima Umrao, Il-Kwon Oh, KAIST (Korea, Republic of) . . . [10969-47]

**Effect of type of aging voltage on the residual breakdown strength of polypropylene films with natural and synthetic nanofillers**, Prathap Basappa, Norfolk State Univ. (USA) . . . . [10969-48]

**A spring mass network as a numerical model for a peridynamic bar: an elastic wave motion study**, Venkata S. Mutnuri, Srinivasan Gopalakrishnan, Indian Institute of Science (India) . . . . [10969-49]

**Modeling laser direct write fabrication in polymeric materials: generalized approach**, Quincy Williams, Thomas Coleman, Baldwin Varner, Doyle A. Temple, Norfolk State Univ. (USA) . . . . . [10969-50]

**Detection of defect in crops using infrared thermography**, Jun Su Lee, Eun-Hyun Kim, Joo-Hyung Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-51]

**Comparison of convective heat transfer of mixed refrigerant and real time monitoring of ORC cycle efficiency according to GTD characteristics**, Kyeong Ho Shin, Joo-Hyung Kim, Da-min Shim, Inha Univ. (Korea, Republic of) . . . . . [10969-52]

**Development of a simple robust method for fabricating nanofiber yarn**, Wei-Chih Wang, Univ. of Washington (USA); Yen-Tse Cheng, National Tsing Hua Univ. (Taiwan) . . . . . [10969-53]

**A feasibility study of multimodal sensing and machine learning techniques to monitor construction workers' mental and physical states and predict unsafe actions**, Younghan E. Jung, Yaohang Li, Old Dominion Univ. (USA); Kevin Han, Edgar Lobaton, North Carolina State Univ. (USA); Hargsoon Yoon, Norfolk State Univ. (USA)[10969-54]

**On frequency spectrum and group speeds in bond-based peridynamics Timoshenko beam**, Venkata S. Mutnuri, Srinivasan Gopalakrishnan, Indian Institute of Science (India) . . . . [10969-56]

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**Train speed estimation using low-cost GPS receivers**, Leonard Chia, Bhavana Bhardwaj, Raj Bridgelall, Pan Lu, Denver D. Tolliver, North Dakota State Univ. (USA) . . . . . [10970-94]

**Design and analysis of flexible skin based on zero Poisson's ratio hybrid honeycomb**, Chang Zhao, Li Zhou, Tao Qiu, Nanjing Univ. of Aeronautics and Astronautics (China) . . . . . [10970-95]

**Active self-tuned mass damper for vibration control and continuous monitoring of civil structures**, Francesco Ripamonti, Alberto Bussini, Ferruccio Resta, Politecnico di Milano (Italy) . . . . . [10970-96]

**Design of a new magneto-rheological pressure seal for rotary shaft**, Xuan Phu Do, Bui Quoc Long Mai, Vietnamese-German Univ. (Viet Nam); Byung Hyuk Kang, Seung-Bok Choi, Inha Univ. (Korea, Republic of). . . . . [10970-97]

**A new magneto-rheological skin for controlling pressure of haptic devices**, Xuan Phu Do, Tran Huy Thang Le, Vietnamese-German Univ. (Viet Nam); Byung Hyuk Kang, Seung-Bok Choi, Inha Univ. (Korea, Republic of) . . . . [10970-98]

**Design of a new magneto-rheological damper featuring a square type of the piston for lower limb exoskeleton**, Xuan Phu Do, Vietnamese-German Univ. (Viet Nam); Seung-Bok Choi, Inha Univ. (Korea, Republic of). . . . . [10970-99]

**Finite element model updating technique oriented to the bearing capacity improvement of bridges**, Zhicheng Tan, Huan Provincial Communications Planning, Survey & Design Institute Co., Ltd. (China); Yunquan Chen, Shandong Qianjian Engineering Test Co., Ltd. (China); Yang Liu, Harbin Institute of Technology (China)[10970-100]

**1 MHz high-sensitivity FBG sensor system to measure low energy impact in droplet experiment**, Lun-Kai Cheng, Ronald Hagen, Davy van Megen, Freek Molkenboer, Rob Jansen, TNO (Netherlands) . . . . . [10970-101]

**Optimal design of electrodes for an electrical impedance tomography based flexible sensor**, Xiaojie Wang, Hefei Institutes of Physical Science (China); Rui Li, Zhiliang Hao, Wenjun Mu, Chongqing Univ. of Posts and Telecommunications (China) . [10970-102]

**Fluid-structure interaction analysis for dynamic intraocular pressure monitoring in the human eye**, Gi-Woo Kim, Yooil Kim, Inha Univ. (Korea, Republic of) . . . . . [10970-103]

**Fiber-ring laser sensor system using a fiber Fabry-Pérot filter for ultrasound detection**, Chuanyi Tao, Liming Mao, Xuhai Jiang, Junhua Cheng, Jing Zhang, Chongqing Univ. of Technology (China) . . . . . [10970-104]

**An approach of identifying the parameters of IMFs based on PLF**, Yuan Shi, Li Zhou, Nanjing Univ. of Aeronautics and Astronautics (China) . . . . [10970-105]

**Envelope analysis for bearing defects detection**, Bandar Alghamdi, Univ. of Southampton (United Kingdom) . . . . . [10970-106]

**Detecting underground metallic objects of different sizes using synthetic aperture radar**, Ahmed Alzeyadi, Tzuyang Yu, Jie Hu, Univ. of Massachusetts Lowell (USA) . [10970-107]

**Seam tracking system sensor system research basing on image identify**, Hongwei Sun, Tao Ma, Zhangru Zheng, Jiangsu Automation Research Institute (China) . . . . . [10970-108]

**Fabrication of Biased-Magnetorheological Elastomers (B-MRE) based on magnetized ferromagnetic particles**, Choonghan Lee, Woosoon Yim, Univ. of Nevada, Las Vegas (USA) . . . . . [10970-109]

**Green's function reconstruction via random decrement technique on damage localization**, YuSheng Chang, North Carolina State Univ. (USA) . . . . . [10970-110]

**A novel special optical waveguide structure with magneto-optic nonreciprocal phase shift under transversely applied magnetic field**, Dengwei Zhang, Zhejiang Univ. (China) and Northwestern Univ. (USA); Cui Liang, Zhejiang Univ. (China); Heming Wei, Abhishek Kottaram Amrithanath, Sridhar Krishnaswamy, Northwestern Univ. (USA); Xiaowu Shu, Zhejiang Univ. (China) . . . . . [10970-112]

**A new type of electromagnetic system for magnetorheological elastomer (MRE)-based base isolation system**, Hyung-Jo Jung, Yongmoon Hwang, Seung-Kyung Kye, Junghoon Lee, KAIST (Korea, Republic of) . . . . . [10970-113]

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**Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII**

**Acoustic emission characterization of PVC pipe for various joining types**, Jauk Gu, SAMSUNG Electronics Co., Ltd. (Korea, Republic of) . . . . . [10971-64]

**Numerical analysis of temperature induced structural strains and stresses for long-span suspension bridge**, Linren Zhou, South China Univ. of Technology (China) . . . . . [10971-65]

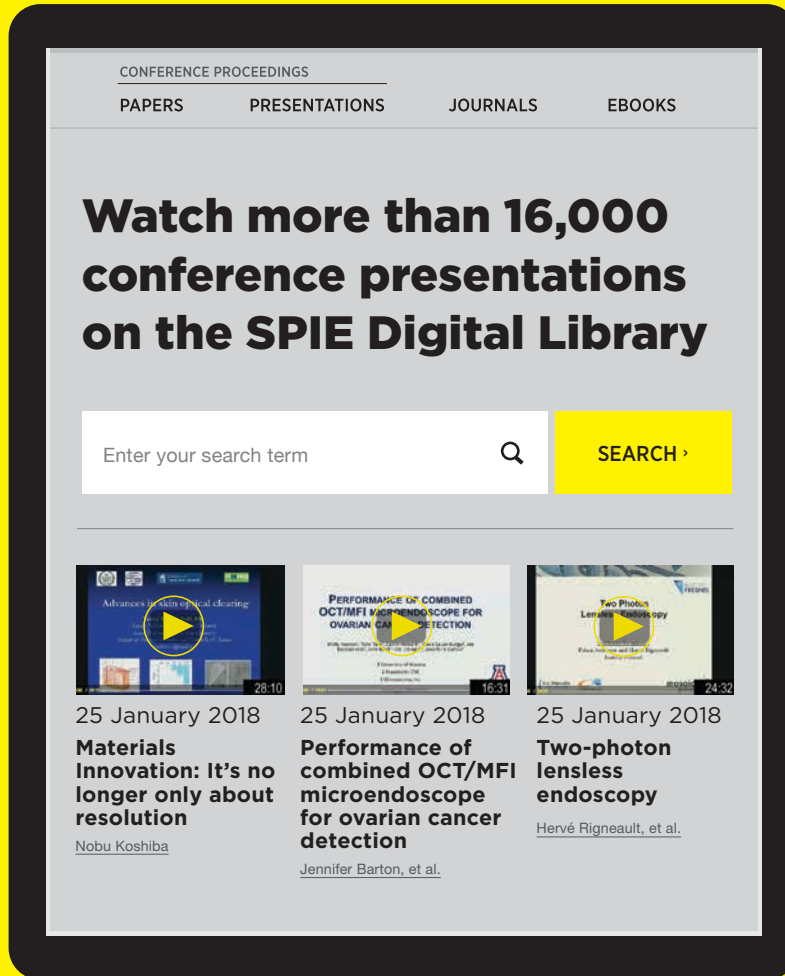
**High gain DC-DC converter with coupled inductor**, Hongwei Sun, Jiangsu Automation Research Institute (China) . . . . . [10971-66]

**Ultrasonic determination of the elastic and shear modulus on aged wood**, Hector G. Carreon, Mayra Carrillo, Jose Cruz, Univ. Michoacana de San Nicolás de Hidalgo (Mexico) . . . . . [10971-67]

**Estimating the density of wood specimens using synthetic aperture radar imaging**, Christopher M. Ingemi, Tzuyang Yu, Univ. of Massachusetts Lowell (USA) . . . . . [10971-69]

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**Measurement of in-plane thermal conductivity of composite structures**, Manoj Rijal, North Carolina A&T State Univ. (USA); Letchuman Sripragash, Siemens Energy, Inc. (USA); Manisha Banker, Mannur J. Sundaresan, North Carolina A&T State Univ. (USA) [10971-70]

**Identifying the stiffness reduction in the supporting tower of wind turbines: a numerical approach**, Yung-Chiang Lin, Chih-Hung Chiang, Chaoyang Univ. of Technology (Taiwan); Chih-Peng Yu, National Chung Hsing Univ. (Taiwan); Keng-Tsang Hsu, Chaoyang Univ. of Technology (Taiwan) . . . . . [10971-71]

## CONFERENCE 10972 Health Monitoring of Structural and Biological Systems XIII

**Fiber-optic sensor for volatile organic compound gas with cholesteric liquid crystal film**, Yuansong Zhan, Zhe Chen, Jianhui Yu, Jieyuan Tang, YunHan Luo, Wenguo Zhu, Heyuan Guan, Jiangli Dong, Huihui Lu, Jun Zhang, Wentao Qiu, Yunchun Zhong, Jinan Univ. (China) . . . . . [10972-84]

**Load and temperature assessment in sandwich structured composite using embedded optical sensors**, Magdalena Mieloszyk, Polish Academy of Sciences (Poland); Michal Jurek, Rzeszów Univ. of Technology (Poland) and Polish Academy of Sciences (Poland); Katarzyna Majewska, Wieslaw Ostachowicz, Polish Academy of Sciences (Poland) [10972-85]

**Recursive hybrid GA and moving window to parameter identification of structural systems with added-damping-and-stiffness devices**, Grace Wang, Yi-Hsing Chen, Chaoyang Univ. of Technology (Taiwan); Fu-Kuo Huang, Tamkang Univ. (Taiwan) . . . . . [10972-86]

**Experimental study on the time-dependent change characteristics of corrosion-induced cracks in the process of electrochemical realkalization**, Ji Zhang, Tongji Univ. (China) . . . . . [10972-87]

**Effect of void sizes with different shapes on effective material properties**, Vahid Tavaf, Mohammad Sadegh Saadatzi, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10972-89]

**Small database fault identification based on separable convolutional network**, Mingxuan Liang, Pei Cao, Jiong Tang, Univ. of Connecticut (USA) . . . . . [10972-90]

**A deep learning approach for data-driven health monitoring using Deep Auto Encoders (DAE)**, Hadi Fekrmandi, South Dakota School of Mines and Technology (USA); Haniyeh Fekrmandi, Institute for Advanced Studies in Basic Sciences (Iran, Islamic Republic of); Michael Yoon, South Dakota School of Mines and Technology (USA) . . [10972-91]

**Fast interpolation algorithm for displaying the sectored image**, Olivier Rukundo, Aalborg Univ. (Denmark) . . . . . [10972-92]

**Variable Kernel based interpolation algorithm for the sectored image**, Olivier Rukundo, Aalborg Univ. (Denmark) . . . . . [10972-93]

**Advances in laser therapy for human 'bone repair'**, Mohammad Nazrul Islam, Shaheed Suhrawardy Medical College and Hospital (Bangladesh) . . . . . [10972-94]

**Frequency analysis of surface response to excitation method for composites bond inspection using COMSOL multiphysics**, Shervin Tashakori, Saman Farhangdoust, Amin Baghalian, Armin Mehrabi, Ibrahim N. Tansel, Florida International Univ. (USA) . . . . . [10972-95]

**Noninvasive assessment of vertebral strength and fracture risk using QCT images and computational modeling**, Asra Askari, Univ. of Michigan Health System (USA); Zahra khoz, Islamic Azad Univ. (Iran, Islamic Republic of); Mohammad Nikkhoo, Islamic Azad Univ. (Qatar); Tribikram Kundu, The Univ. of Arizona (USA) . . . . . [10972-96]

**Simulation and experimental measurement of acoustic wave reflectometry for leak detection in pipes**, Mustapha Abdullahi, S. Olutunde Oyadiji, The Univ. of Manchester (United Kingdom) . . . . . [10972-97]

## CONFERENCE 10973 Smart Structures and NDE for Energy Systems and Industry 4.0

**RUSH: Realtime ultrasonic scanning using submersible hydraulic robotic arms for mechanical properties testing**, Mohammad Sadegh Saadatzi, Hossain Ahmed, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10973-12]

**Vibration analysis of a meshing gear pair by neural network: visualization of meshing vibration and detection of a crack at tooth root by VGG16 with transfer learning**, Daisuke Iba, Yunosuke Ishii, Yusuke Tsutsui, Nanako Miura, Takashi Iizuka, Arata Masuda, Akira Sone, Ichiro Moriawaki, Kyoto Institute of Technology (Japan) . . . . . [10973-32]

**Cyber-enabled distributed machine learning networks for smart manufacturing systems**, Yaser M. Banadaki, Southern Univ. and A&M College (USA) . . . . . [10973-33]

**High-velocity impact response on advanced hybrid composite structures**, Francesco Rizzo, Fulvio Pinto, Michele Meo, Univ. of Bath (United Kingdom) . . . . . [10973-35]

**CONFERENCE 10966**  
**Electroactive Polymer Actuators and Devices (EAPAD) XXI**

**CONFERENCE 10967**  
**Active and Passive Smart Structures and Integrated Systems XIII**

**CONFERENCE 10968**  
**Behavior and Mechanics of Multifunctional Materials XIII**

**CONFERENCE 10969**  
**Nano-, Bio-, Info-Tech Sensors and 3D Systems**

**Plenary Session · 8:15 to 10:00 am · Location: Silverton Salons 2-3**

*Session Chairs:* **Tribikram Kundu**, The Univ. of Arizona (USA) and **Gregory W. Reich**, Air Force Research Lab. (USA)

8:15 to 8:30 am:

- **SPIE Best Student Paper Awards**
- **EAP-In-Action Demonstration Awards**
- **Bioinspiration, Biomimetics, and Bioreplication Best Student Paper Awards: In Memory of H. Don Wolpert**



8:30 to 9:15 am · *Plenary Presentation*  
**Journey from energy harvesting and 4D printing to medical applications**

**Wei-Hsin Liao**  
 The Chinese Univ. of Hong Kong (Hong Kong, China)



9:15 to 10:00 am · *Plenary Presentation*

**Modeling for research in ultrasonic NDE**

**Michael Lowe**  
 Imperial College London (United Kingdom)  
 Coffee Break. .Wed 10:00 am to 10:30 am

**SESSION 6**

**LOCATION: SILVERTON SALONS 2-3**  
**WED 10:30 AM TO 12:10 PM**

**Testing and Characterization of EAP Materials**

*Session Chairs:* **Piotr Mazurek**, Technical Univ. of Denmark (Denmark); **Martin Kaltenbrunner**, Johannes Kepler Univ. Linz (Austria)

10:30 am: **A standard testing method for tensile actuators**, Geoffrey M. Spinks, Shannon Bakarich, Shazed Aziz, Bidita Salahuddin, Hai Xin, Univ. of Wollongong (Australia) . . . . . [10966-24]

10:50 am: **Taming the viscoelastic creep of dielectric elastomer actuators**, Samuel Rosset, The Univ. of Auckland (New Zealand); Alexandre Poulin, Herbert R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland); Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-25]

11:10 am: **Instability and dynamic performance of dielectric elastomers**, Liwu Liu, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China) . . . . . [10966-26]

11:30 am: **Fatigue life performances of silicone elastomer membranes for dielectric elastomer transducers: preliminary results**, Rocco Vertechy, Yi Chen, Univ. degli Studi di Bologna (Italy); Lorenzo Agostini, Giacomo Moretti, Scuola Superiore Sant'Anna (Italy); Marco Fontana, Univ. degli Studi di Trento (Italy) . . . . . [10966-27]

11:50 am: **Characterization of dielectric elastomer actuators made of slide ring materials**, Jun Shintake, The Univ. of Electro-Communications (Japan); Koya Matsuno, Shohei Kumegawa, Kazumasa Baba, Hiromitsu Takeuchi, Toyoda Gosei Co., Ltd. (Japan) . . . . . [10966-28]

Lunch Break . . . . . Wed 12:10 pm to 1:40 pm

**SESSION 7**

**LOCATION: CRESTONE SALON A**  
**WED 10:30 AM TO 11:50 PM**

**Morphing, Deployable, and Origami Structures**

*Session Chairs:* **Ryan L. Harnie**, The Ohio State Univ. (USA); **Serife Tol**, Univ. of Michigan (USA)

10:30 am: **Morphing spacecraft structures: modular optical telescope system performance study**, Austin A. Phoenix, U.S. Naval Research Lab. (USA) . . . . . [10967-33]

10:50 am: **Effect of hinge elasticity on morphing winglet mechanical systems**, Antonio Concilio, Ignazio Dimino, Ctr. Italiano Ricerche Aerospaziali (Italy); Rosario Pecora, Maurizio Arena, Univ. degli Studi di Napoli Federico II (Italy) . . . . . [10967-35]

11:10 am: **Dynamic modeling of origami structures: inverse approaches**, Hongbin Fang, Fudan Univ. (China) and Univ. of Michigan (USA); Zuolin Liu, Tongji Univ. (China); Jian Xu, Fudan Univ. (China); Kon-Well Wang, Univ. of Michigan (USA) . . . . . [10967-36]

11:30 am: **Towards resilient adaptive origami-inspired diagrid building envelope**, Mariantonieta Gutierrez Soto, Amanda B. Bellamy, Univ. of Kentucky (USA) . . . . . [10967-37]

Lunch Break . . . . . Wed 11:50 pm to 1:40 pm

**SESSION 7**

**LOCATION: CRYSTAL C**  
**WED 10:30 AM TO 11:50 AM**

**Magnetostrictive and Magnetorheological Materials**

*Session Chairs:* **Marcelo J. Dapino**, The Ohio State Univ. (USA); **John A. Gallagher**, Merrimack College (USA)

10:30 am: **Overview of magnetostrictive materials and their use in devices (Keynote Presentation)**, Alison B. Flatau, Univ. of Maryland, College Park (USA) . . . . . [10968-28]

11:10 am: **Mechanical control of resonance and relaxation in magnetoelastic composites and MR fluids near microwave frequencies**, John P. Domann, Virginia Polytechnic Institute and State Univ. (USA) . . . . . [10968-29]

11:30 am: **Phase transforming auxetic material with embedding magnets**, Tiegang Chen, Xiaoyong Zhang, Xiaojun Yan, Dawei Huang, Mingjing Qi, Beihang Univ. (China); Bin Zhang, Jun Jiang, Beijing Institute of Control Engineering (China) . . . . . [10968-31]

Lunch Break . . . . . Wed 11:50 am to 2:00 pm

**SESSION 9**

**LOCATION: CRYSTAL SALON B/C**  
**WED 10:30 AM TO 12:20 PM**

**Smart Optics**

*Session Chair:* **Hargsoon Yoon**, Norfolk State Univ. (USA)

10:30 am: **Dielectric elastomer actuator based active-lens module for dynamically controllable optical zoom (Invited Paper)**, Sungryul Yun, Dongbum Pyo, Suntak Park, Electronics and Telecommunications Research Institute (Korea, Republic of) . . . . . [10969-29]

11:00 am: **Refractive index change of cellulose nanocrystal based transparent electroactive polyurethane**, Hyun-U Ko, Hyun Chan Kim, Jung Woong Kim, Ruth M. Muthoka, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-30]

11:20 am: **ZnO-based optical modulators**, Brandon Walker, Kyo Song, Norfolk State Univ. (USA) . . . . . [10969-31]

11:40 am: **Development of G-Fresnel lens-based mu-spectrometer**, Gi-Woo Kim, Sun-Woo Kang, Inha Univ. (Korea, Republic of); Hargsoon Yoon, Norfolk State Univ. (USA) . . . . . [10969-32]

12:00 pm: **Thin film formation of cellulose nanofiber and its physical properties**, Lindong Zhai, Hyun Chan Kim, Jung Ho Park, Qin Yu Zhu, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-33]

Lunch Break . . . . . Wed 12:20 pm to 1:50 pm

**CONFERENCE 10970**  
**Sensors and Smart Structures**  
**Technologies for Civil, Mechanical,**  
**and Aerospace Systems**

**CONFERENCE 10971**  
**Nondestructive Characterization and**  
**Monitoring of Advanced Materials,**  
**Aerospace, Civil Infrastructure, and**  
**Transportation XIII**

**CONFERENCE 10972**  
**Health Monitoring of**  
**Structural and Biological**  
**Systems XIII**

**Plenary Session · 8:15 to 10:00 am · Location: Silverton Salons 2-3**

*Session Chairs: Tribikram Kundu, The Univ. of Arizona (USA) and Gregory W. Reich, Air Force Research Lab. (USA)*

8:15 to 8:30 am:

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8:30 to 9:15 am · *Plenary Presentation*  
**Journey from energy harvesting and**  
**4D printing to medical applications**  
**Wei-Hsin Liao**  
 The Chinese Univ. of Hong Kong  
 (Hong Kong, China)



9:15 to 10:00 am · *Plenary Presentation*  
**Modeling for research in**  
**ultrasonic NDE**  
**Michael Lowe**  
 Imperial College London (United Kingdom)  
 Coffee Break. .Wed 10:00 am to 10:30 am

**SESSION 7**

**LOCATION: CRESTONE SALON B**  
**WED 10:30 AM TO 12:10 PM**

**Power Harvesting for Self-Powered**  
**Sensors**

*Session Chairs: Hae Young Noh, Carnegie Mellon Univ. (USA); Zhongqing Su, The Hong Kong Polytechnic Univ. (Hong Kong, China)*

10:30 am: **Modeling contact electrification in triboelectric impact oscillators as energy harvesters**, Hongcheng Tao, James Gibert, Purdue Univ. (USA); Gregory Batt, Clemson Univ. (USA) ..... [10970-32]

10:50 am: **Self-powering wireless sensors for temperature sensing and monitoring in power generation applications**, Ran Wei, Case Western Reserve Univ. (USA); Andrew Boggs, FirstEnergy Corp. (USA); Susan Maley, Electric Power Research Institute, Inc. (USA); Philip Feng, Case Western Reserve Univ. (USA) ..... [10970-33]

11:10 am: **Self-charging and self-monitoring smart civil infrastructure systems: current practice and future trends**, Amir H. Alavi, Univ. of Missouri (USA); Pengcheng Jiao, Zhejiang Univ. (China); Hassene Hasni, Michigan State Univ. (USA); Kenji Aono, Washington Univ. in St. Louis (USA); Nizar Lajnef, Michigan State Univ. (USA); Shantanu Chakrabarty, Washington Univ. in St. Louis (USA) [10970-34]

11:30 am: **Vibration-based energy harvesting circuit using feed-forward control**, Qinlin Cai, Song-ye ZHU, The Hong Kong Polytechnic Univ. (Hong Kong, China) ..... [10970-35]

11:50 am: **A multistable energy harvesting-based mechanism to detect thermally induced deformation in prestress concrete bridge**, Pengcheng Jiao, Zhejiang Univ. (China); Hassene Hasni, Michigan State Univ. (USA); Amir H. Alavi, Univ. of Missouri (USA); Adam Al-Ansari, Nizar Lajnef, Michigan State Univ. (USA) ..... [10970-36]

Lunch Break ..... Wed 12:10 pm to 1:40 pm

**SESSION 7**

**LOCATION: ASPEN B**  
**WED 10:30 AM TO 12:10 PM**

**SHM-NDE Science and Theory II**

*Session Chairs: Chih-Hung Chiang, Chaoyang Univ. of Technology (Taiwan); Michael Bartlett, Iowa State Univ. of Science and Technology (USA)*

10:30 am: **Bayesian estimation of damage pattern using through-thickness dielectric measurement**, Mushuang Liu, Yan Wan, Vamsee Vadlamudi, Frank Lewis, Kenneth Reifsnider, The Univ. of Texas at Arlington (USA); H. Felix Wu, U.S. Dept. of Energy (USA) ..... [10971-34]

10:50 am: **Towards deep convolutional neural network-based transfer learning for structural health monitoring with partial wavefield scans**, Xinyao Tang, Case Western Reserve Univ. (USA); Pei Cao, Univ. of Connecticut (USA); Joseph Melville, K. Supreet Alguri, Joel Harley, The Univ. of Utah (USA); Soumyajit Mandal, Case Western Reserve Univ. (USA) ..... [10971-35]

11:10 am: **Electrical properties of stainless steel and copper powder in a silicone matrix**, Jenny Wang, Allan S. Chang, Lawrence Livermore National Lab. (USA); Sarai N. Sheffield, Georgia Institute of Technology (USA); Steven L. Hunter, Manyalibo J. Matthews, Lawrence Livermore National Lab. (USA) ..... [10971-36]

11:30 am: **Soft-matter damage detection systems for electronics and structures**, Michael D. Bartlett, Iowa State Univ. of Science and Technology (USA); Eric J. Markvicka, Univ. of Nebraska-Lincoln (USA); Ravi Tutika, Iowa State Univ. of Science and Technology (USA); Carmel Majidi, Carnegie Mellon Univ. (USA) ..... [10971-37]

11:50 am: **Evaluating the shadow or glare effects in thermography for non-destructive testing and evaluation**, Yishuo Huang, Chih-Hung Chiang, Keng-Tsang Hsu, Chaoyang Univ. of Technology (Taiwan) ..... [10971-38]

Lunch Break ..... Wed 12:10 pm to 1:40 pm

**SESSION 7**

**LOCATION: CRIPPLE CREEK 2**  
**WED 10:30 AM TO 12:10 PM**

**Sensors for Real-Time**  
**Monitoring II**

*Session Chairs: Christopher Nizrecki, Univ. of Massachusetts Lowell (USA); Sridhar Krishnaswamy, Northwestern Univ. (USA)*

10:30 am: **A high-resolution structural health monitoring system for plates based on phased array SH wave**, Qiang Huan, Faxin Li, Peking Univ. (China) ..... [10972-34]

10:50 am: **Comparison of coverage areas of two different sensor network arrangements for structural health monitoring of plate-like structures**, Ehsan Dehghan-Niri, Mehrdad Ghyabi, New Mexico State Univ. (USA) ..... [10972-35]

11:10 am: **A study on asymmetric sensor array for robust improvement of beamforming based source localization technique**, Hwee Kwon Jung, Gyuhae Park, Chonnam National Univ. (Korea, Republic of) ..... [10972-36]

11:30 am: **Application of Kalman filter based neutral axis tracking for crack length quantification in beam structures**, Rohan N. Soman, The Szwalski Institute of Fluid-Flow Machinery (Poland); Martin Schagerl, Christoph Kralovec, Johannes Kepler Univ. Linz (Austria); Kai U. Schröder, Andreas Preisler, RWTH Aachen Univ. (Germany); Wieslaw Ostachowicz, The Szwalski Institute of Fluid-Flow Machinery (Poland) ..... [10972-37]

11:50 am: **Femtosecond laser fabricated optical fiber microsensor for ultrasound detection**, Heming Wei, Abhishek Amrithanath, Sridhar Krishnaswamy, Northwestern Univ. (USA) ..... [10972-38]

Lunch Break ..... Wed 12:10 pm to 1:20 pm

CONFERENCE 10966

SESSION 7

LOCATION: SILVERTON SALONS 2-3  
WED 1:40 PM TO 3:00 PM

**Manufacturing, Mechanical Properties, and Performance of EAP Materials**

Session Chairs: **Yanju Liu**, Harbin Institute of Technology (China); **Jian Zhu**, National Univ. of Singapore (Singapore)

1:40 pm: **Manufacturing dielectric elastomer stack actuators: challenges and applications for industrialization** (*Invited Paper*), Helmut F. Schlaak, Technische Univ. Darmstadt (Germany) . . . [10966-29]

2:20 pm: **Mechanical properties of slide-ring elastomers for polymer actuators**, Koichi Mayumi, Chang Liu, The Univ. of Tokyo (Japan); Takanori Nakai, Makoto Ishida, Hiromitsu Takeuchi, Toyoda Gosei Co., Ltd. (Japan); Katsunari Inoue, Advanced Softmaterials Inc. (Japan); Kenji Urayama, Kyoto Institute of Technology (Japan); Hideaki Yokoyama, Kohzo Ito, The Univ. of Tokyo (Japan) . . . [10966-30]

2:40 pm: **Measurement of strain distribution of dielectric actuator with several pairs of electrodes by the image correlation method for object transportation**, Takunori Hayashi, Manabu Okui, Chuo Univ. (Japan); Yuji Yonehara, Toyoda Gosei Co., Ltd. (Japan); Taro Nakamura, Chuo Univ. (Japan) . . . [10966-31]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm

CONFERENCE 10967

SESSION 8

LOCATION: CRESTONE SALON A  
WED 1:40 PM TO 3:00 PM

**Active and Passive Vibration/ Noise Attenuation II**

Session Chairs: **Jung-Ryul Lee**, KAIST (Korea, Republic of); **Lei Zuo**, Virginia Polytechnic Institute and State Univ. (USA)

1:40 pm: **Piezoelectric based dither control for automobile squeal noise suppression and prevention**, Ji Sang Kang, Hwee Kwon Jung, Gyuhae Park, Chonnam National Univ. (Korea, Republic of); Jeongkyu Kim, Hyundai Motor Co. (Korea, Republic of) . . . [10967-38]

2:00 pm: **Performance enhancement of a base-isolation structure using optimal tuned inerter dampers**, Feng Qian, Virginia Polytechnic Institute and State Univ. (USA); Wei Che Tai, Michigan State Univ. (USA); Lei Zuo, Virginia Polytechnic Institute and State Univ. (USA) . . . [10967-39]

2:20 pm: **Minimizing deceleration for drop-induced shock systems using magnetorheological energy absorber**, Xian-Xu Bai, Sen Yang, Hefei Univ. of Technology (China) . . . [10967-40]

2:40 pm: **Quantifying the value of control systems for active smart structures**, Piotr Omenzetter, Univ. of Aberdeen (United Kingdom) . . . [10967-41]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm

CONFERENCE 10968

SESSION 8

LOCATION: CRYSTAL C  
WED 2:00 PM TO 3:00 PM

**Shape Memory Polymers II**

Session Chairs: **Jinsong Leng**, Harbin Institute of Technology (China); **Amira Meddeb**, The Pennsylvania State Univ. (USA)

2:00 pm: **Porous materials with stress and temperature activated porosity**, Reza Rizvi, The Univ. of Toledo (USA) . . . [10968-32]

2:20 pm: **Fluorine-containing colorless shape memory polyimide films with high transmittance and high transition temperature**, Xinzuo Huang, Fenghua Zhang, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China) . . . [10968-33]

2:40 pm: **Shape memory alloy-based flexible manipulator for miniature submersible robots**, Prashanth Reddy Sheri, Prabhu Rajagopal, Indian Institute of Technology Madras (India) . . . [10968-35]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm

CONFERENCE 10969

SESSION 10

LOCATION: CRYSTAL SALON B/C  
WED 1:50 PM TO 3:10 PM

**Nanomaterials and Applications II**

Session Chair: **Wei-Chih Wang**, Tsinghua Univ. (USA)

1:50 pm: **Structural supercapacitor based on bicontinuous solid electrolyte with conductive nanowire-carbon fiber electrodes**, Seok-Hu Bae, Choongseop Jeon, Saewoong Oh, Il-Kwon Oh, KAIST (Korea, Republic of) . . . [10969-34]

2:10 pm: **Carbon nanostructures-based soft electro-ionic artificial muscles**, Jaehwan Kim, Il-Kwon Oh, KAIST (Korea, Republic of) . . . [10969-35]

2:30 pm: **Electrostatic actuation in ionic polymer-metal composites**, Alain Boldini, Kevin Jose, NYU Tandon School of Engineering (USA); Youngsu Cha, Korea Institute of Science and Technology (Korea, Republic of); Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . [10969-36]

2:50 pm: **Self-deformable varifocal lens based on electroactive gel**, Dong-Soo Choi, Eun-Jae Shin, Sang-Youn Kim, Korea Univ. of Technology and Education (Korea, Republic of) . . . [10969-37]

Coffee Break. . . . . Wed 3:10 pm to 3:40 pm



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CONFERENCE 10970

SESSION 8

LOCATION: CRESTONE SALON B  
WED 1:40 PM TO 3:00 PM

**Actuators/Adaptive Structures**

Session Chairs: **Mircea Badescu**, Jet Propulsion Lab. (USA); **Ermira Abdullah**, Univ. Putra Malaysia (Malaysia)

1:40 pm: **Auto-Gopher-II: an autonomous wireline rotary-hammer ultrasonic drill test results**, Mircea Badescu, Yoseph Bar-Cohen, Stewart Sherrit, Xiaoqi Bao, Hyeong J. Lee, Shannon P. Jackson, Brandon C. Metz, Zachary C. Valles, Jet Propulsion Lab. (USA); Kris Zacny, Boleslaw Mellerowicz, Daniel Kim, Gale Paulsen, Honeybee Robotics (USA) . . . . . [10970-37]

2:00 pm: **Development of synthetic jet actuator array for vortex-flow generation**, Mathias Lipowski, Dennis Bäcker, Fraunhofer-Institut für Elektronische Nanosysteme (Germany) . . . . . [10970-38]

2:20 pm: **Development of a novel actuator for the application of a reconfigurable reflectarray antenna**, Shui-Dong Jiang, Houfei Fang, Shanghai YS Information Technology Co., Ltd. (China) . . . . . [10970-39]

2:40 pm: **Aerodynamics and structure measurement subsystem for a shape memory alloy actuated adaptive airfoil**, Ermira Abdullah, Nuramira Azid, Suzana Abidin, Wi Tet Ng, Dayang Laila Abd Majid, Azmin Shakrine Mohd Rafie, Univ. Putra Malaysia (Malaysia). . . . . [10970-40]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm

CONFERENCE 10971

SESSION 8

LOCATION: ASPEN B  
WED 1:40 PM TO 3:00 PM

**SHM-NDE Ultrasonics I**

Session Chairs: **Peter J. Shull**, The Pennsylvania State Univ. (USA); **Lu Zhang**, Univ. of Illinois at Chicago (USA)

1:40 pm: **The identification of accurate and computationally efficient arrival time pick-up method for acoustic tomography**, Lu Zhang, Univ. of Illinois at Chicago (USA); Jason Dong, Valery Godinez-Azcuaa, Obdulia Ley, Ed Lowenhar, Hossein Saboonchi, MISTRAS Group, Inc. (USA); Didem Ozevin, Univ. of Illinois at Chicago (USA) . [10971-39]

2:00 pm: **An experimental evaluation of Helmholtz potentials as a source of acoustic emission due to fatigue crack**, Mohammad Faisal Haider, Roshan Joseph, Victor Giurgiutiu, Univ. of South Carolina (USA) . . . . . [10971-40]

2:20 pm: **Nonlinear phased array imaging of flaws: a modulation technique**, Gian Piero M. Malfense Fierro, Michele Meo, Univ. of Bath (United Kingdom)[10971-41]

2:40 pm: **Development of nonlinear acoustic and air-coupled techniques for non-destructive testing**, Marco Boccaccio, Gian Piero M. Malfense Fierro, Michele Meo, Univ. of Bath (United Kingdom). . . . . [10971-42]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm

CONFERENCE 10972

SESSION 8

LOCATION: CRIPPLE CREEK 2  
WED 1:20 PM TO 3:00 PM

**Elastic and Metamaterials III**

Session Chairs: **Fabio Semperlotti**, Purdue Univ. (USA); **Guoliang Huang**, Univ. of Missouri (USA)

1:20 pm: **Experimental validation of acoustic valley Hall edge states in a nonresonant topological elastic waveguide**, Ting-Wei Liu, Fabio Semperlotti, Purdue Univ. (USA) . . . . . [10972-39]

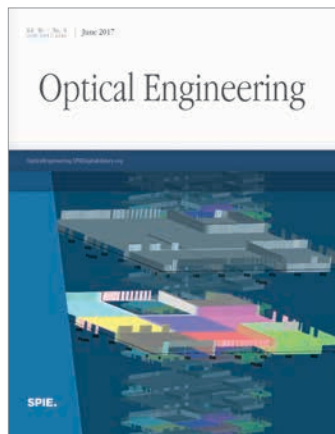
1:40 pm: **Parametric study of asymmetric wave transport in topological lattices at finite frequencies**, Jihong Ma, Univ. of Minnesota, Twin Cities (USA); Di Zhou, Kai Sun, Xiaoming Mao, Univ. of Michigan (USA); Stefano Gonella, Univ. of Minnesota, Twin Cities (USA) . . . . . [10972-40]

2:00 pm: **Multiple Helmholtz resonator based acoustic liner**, Huy Nguyen, Guoliang Huang, Univ. of Missouri (USA) . . . . . [10972-41]

2:20 pm: **Elastic waves in Floquet topological insulators**, Hui Chen, Hussein Nassar, Guoliang Huang, Univ. of Missouri (USA) . . . . . [10972-42]

2:40 pm: **Convenient tunable metasurface for acoustic wave manipulation**, Zhong Chen, Peking Univ. (China) . . . . . [10972-88]

Coffee Break. . . . . Wed 3:00 pm to 3:30 pm



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CONFERENCE 10966

SESSION 8

LOCATION: SILVERTON SALONS 2-3  
WED 3:30 PM TO 6:10 PM

**Ionic EAP Materials Including IPMC**

Session Chairs: **Kwang Jin Kim**, Univ. of Nevada, Las Vegas (USA); **Lenore Rasmussen**, Ras Labs., LLC (USA)

3:30 pm: **From soft microrobotics to macroscopic wearables** (*Invited Paper*), Edwin W. H. Jager, Linköping Univ. (Sweden) . . . . . [10966-32]

4:10 pm: **Modeling and control of self-sensing ionic electroactive polymer actuator**, Sunjai Nakshatharan Shanmugam, Andres Punning, Urmas Johanson, Alvo Aabloo, Univ. of Tartu (Estonia) . . . . . [10966-33]

4:30 pm: **Physics-based electromechanical model of PVC gel actuators**, Zachary Frank, Zakai Olsen, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) . . . . . [10966-34]

4:50 pm: **Ionic buoyancy engines: finite element modeling and experimental validation**, Fadi Alladkani, James Akl, Barbar J. Akle, Lebanese American Univ. (Lebanon) . . . . . [10966-35]

5:10 pm: **Effect of electromechanical cycling and aging on the performance stability of IPMCs**, Allison M. Arnold, Edward M. Sabolsky, Kevin M. Tennant, Kavin Sivaneri Varadharajan Idhaim, West Virginia Univ. (USA); Ji Su, NASA Langley Research Ctr. (USA) . . . . . [10966-36]

5:30 pm: **Development of ionic polymer-metal nanocomposites based polymer transducer**, Varij Panwar, Graphic Era Univ. (India) . . . . . [10966-37]

5:50 pm: **Finite difference method and finite element method for modeling IPMC sensor voltage**, Kota Kondo, Kentaro Takagi, Nagoya Univ. (Japan); Zicai Zhu, Xi'an Jiaotong Univ. (China); Kinji Asaka, National Institute of Advanced Industrial Science and Technology (Japan) . . . . . [10966-38]

CONFERENCE 10967

SESSION 9

LOCATION: CRESTONE SALON A  
WED 3:30 PM TO 5:50 PM

**Energy Harvesting IV: General**

Session Chairs: **Shima Shahab**, Virginia Polytechnic Institute and State Univ. (USA); **Shahzad Towfighian**, Binghamton Univ. (USA)

3:30 pm: **High-voltage output from triboelectric nanogenerator: challenges and opportunities**, Yunlong Zi, The Chinese Univ. of Hong Kong (Hong Kong, China) . . . . . [10967-42]

3:50 pm: **Investigation of various cantilever configurations for piezoelectric energy harvesting under rotational motion**, T. T. Hsieh, S. A. Chen, Yi-Chung Shu, National Taiwan Univ. (Taiwan) . . . . . [10967-43]

4:10 pm: **Ring shaped energy harvester using cylinder volume change**, Yeunhee Kim, Youngsu Cha, Korea Institute of Science and Technology (Korea, Republic of) . . . . . [10967-44]

4:30 pm: **Theoretical study and experimental verification of a piezoelectric energy harvester with dual frequency up-converting mechanisms**, Zhenlong Xu, Maoying Zhou, Wen Wang, Aihua Meng, Hangzhou Dianzi Univ. (China) . . . . . [10967-45]

4:50 pm: **Possibilities of using flexoelectric effect for energy harvesting applications**, Lars Seyfert, Alexander Henneberg, Norbert Schwesinger, Technische Univ. München (Germany) . . . . [10967-46]

5:10 pm: **Analysis of a triboelectric energy harvester for total knee replacements under gait loading**, Alwathiqbellah Ibrahim, Binghamton Univ. (USA); Geoffrey Yamomo, Ryan Willing, Western Univ. (Canada); Shahzad Towfighian, Binghamton Univ. (USA) . . . . . [10967-47]

5:30 pm: **Analytical solutions for a broadband concurrent aeroelastic and base vibratory energy harvester**, Liya Zhao, Univ. of Technology, Sydney (Australia) . . . . . [10967-49]

CONFERENCE 10968

SESSION 9

LOCATION: CRYSTAL C  
WED 3:30 PM TO 5:50 PM

**Multifunctional Composites Systems**

Session Chairs: **Oliver J. Myers**, Clemson Univ. (USA); **Constantin Ciocanel**, Northern Arizona Univ. (USA)

3:30 pm: **Fabrication of non-traditional shapes from bistable carbon fiber reinforced polymer laminates**, Oliver J. Myers, Jonathan Figueroa, Clemson Univ. (USA) . . . . . [10968-36]

3:50 pm: **Tailored bistability in mechanically prestressed laminated composites through planform design**, Venkata Siva Chillara, Marcelo Dapino, The Ohio State Univ. (USA) . . . . . [10968-37]

4:10 pm: **Development of high electrically conductive polymer nanocomposites via plasticizing effect within immiscible polymer blends**, Yu-Chen Sun, Hani E. Naguib, Univ. of Toronto (Canada) . . . . . [10968-38]

4:30 pm: **Parylene C as a multifunctional insulator for all-organic flexible electronics**, Ibrahim Khawaji, Osama O. Awadelkarim, Akhlesh Lakhtakia, The Pennsylvania State Univ. (USA) . . . . [10968-39]

4:50 pm: **Thermal conductivity of GNPs/PDMS composites: a molecular dynamics study**, Xiaojie Wang, Hefei Institutes of Physical Science (China); Chuang Luo, Univ. of Science and Technology of China (China); Douxing Pan, Hefei Institutes of Physical Science (China) . . . . . [10968-40]

5:10 pm: **Active hydrogel composite membranes for the analysis of cell size distributions**, Adrian Ehrenhofer, Thomas Wallmersperger, TU Dresden (Germany) . . . . . [10968-41]

5:30 pm: **Ferroelectric AlN ultrathin films prepared by atomic layer epitaxy**, Bo-Ting Lin, Wei-Hao Lee, Jay Shieh, Miin-Jang Chen, National Taiwan Univ. (Taiwan) . . . . . [10968-44]

Conference End.

CONFERENCE 10969

SESSION 11

LOCATION: CRYSTAL SALON B/C  
WED 3:40 PM TO 5:50 PM

**Nanomaterials and Applications III**

Session Chair: **Maurizio Porfiri**, NYU Tandon School of Engineering (USA)

3:40 pm: **Graphene oxide-based sound absorber** (*Invited Paper*), Junghwan Oh, Ji-Seok Kim, Il-Kwon Oh, KAIST (Korea, Republic of) . . . . . [10969-38]

4:10 pm: **Simultaneous air pressure and velocity measurement using pressure-sensitive flow tracers**, Peng Zhang, NYU Tandon School of Engineering (USA); Sean D. Peterson, Univ. of Waterloo (Canada) and NYU Tandon School of Engineering (USA); Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . . . [10969-39]

4:30 pm: **Rechargeable power management system (RPMS) using active balancing**, Lochan Pai, Nived Mukundan, Aslam Khan, Hargsoon Yoon, Norfolk State Univ. (USA) . . . . . [10969-40]

4:50 pm: **Feedforward control with rate-dependent hysteresis compensator for piezoelectric micro stage**, Jongnam Kim, Hyeong Geon Kim, Il-Kwon Oh, KAIST (Korea, Republic of) . . . . . [10969-41]

5:10 pm: **Partial discharge characteristics and residual breakdown strength of natural nanofilled polypropylene films when aged with different voltage profiles**, Prathap Basappa, Norfolk State Univ. (USA) . . . . . [10969-42]

5:30 pm: **Feasibility of PVA-lignin as resin for nanocellulose future composites**, Hyun-U Ko, Hyun Chan Kim, Jung Woong Kim, Eun Sik Choi, Jaehwan Kim, Inha Univ. (Korea, Republic of) . . . . . [10969-43]

Conference End.

CONFERENCE 10970

SESSION 9

LOCATION: CRESTONE SALON B  
WED 3:30 PM TO 6:10 PM

**Nanocomposites and Flexible Sensors**

Session Chairs: **Daewon Kim**, Embry-Riddle Aeronautical Univ. (USA); **Haiying Huang**, The Univ. of Texas at Arlington (USA)

3:30 pm: **On the transient piezoresistive response of impacted nanofiber-modified epoxy**, Julio Hernandez, Tyler N. Tallman, Purdue Univ. (USA) ..... [10970-41]

3:50 pm: **Stochastic modeling of composite strain and fatigue sensing elements**, Tyler Albright, Jared D. Hobeck, Kansas State Univ. (USA) . . . . [10970-42]

4:10 pm: **Autonomous structural composites for self-powered strain sensing-enabled damage detection**, Alfred Mongare, Aaron Miska, New Mexico Institute of Mining and Technology (USA); Jordan Ulibarri-Sanchez, New Mexico State Univ. (USA); Donghyeon Ryu, Andrei Zagrai, New Mexico Institute of Mining and Technology (USA); Young Ho Park, New Mexico State Univ. (USA) ..... [10970-43]

4:30 pm: **Weatherability improvement of strain imaging sheet in smart photonic coating**, Hiroshi Fudouzi, Koichi Tsuchiya, Shin-ichi Todoroki, National Institute for Materials Science (Japan); Tsuyoshi Hyakutake, Hiroyuki Nitta, Public Works Research Institute (Japan); Yoshikazu Tanaka, Hiroshima Univ. (Japan); Takao Ohya, National Institute for Materials Science (Japan) and SHO-BOND Holdings Co. (Japan); Michiharu Arifuku, National Institute for Materials Science (Japan) and Nippon Kayaku Co., Ltd. (Japan) ..... [10970-44]

4:50 pm: **Evaluation of interfacial and micro-damage sensing of composites via Pencil Lead Drawing Paper Sensor (PLDPS) and Electrical Resistance (ER) mapping**, Joung Man Park, Gyeongsang National Univ. (Korea, Republic of) and The Univ. of Utah (USA); Pyeong-Su Shin, John-Hyun Kim, Ha-Seung Park, Yeong-Min Baek, Gyeongsang National Univ. (Korea, Republic of); Lawrence K. DeVries, The Univ. of Utah (USA) ..... [10970-45]

5:10 pm: **Development of a flexible piezocomposites surface acoustic wave sensor**, Neha V. Ramachandran, Daewon Kim, Eduardo Rojas-Nastrucci, Embry-Riddle Aeronautical Univ. (USA) ..... [10970-46]

5:30 pm: **Implementing antenna sensor on flexible textile substrate**, Haiying Huang, James Skilskyj, The Univ. of Texas at Arlington (USA) ..... [10970-47]

5:50 pm: **Experimental identification of stress concentrations in piezoresistive nanocomposites via electrical impedance tomography**, Hashim Hassan, Tyler N. Tallman, Purdue Univ. (USA) ..... [10970-48]

CONFERENCE 10971

SESSION 9

LOCATION: ASPEN B  
WED 3:30 PM TO 6:10 PM

**SHM-NDE of Composite Materials I**

Session Chairs: **Christopher C. Bowland**, Oak Ridge National Lab. (USA); **Zahra Sharif Khodaei**, Imperial College London (United Kingdom)

3:30 pm: **Structured illumination fiber probe for high-resolution surface feature imaging of 3D printed and composite samples**, Aswin Haridas, Rolls-Royce@NTU Corporate Lab. (Singapore); Murukeshan V.M., Nanyang Technological Univ. (Singapore) ..... [10971-43]

3:50 pm: **Synchro-squeezed adaptive wavelet transform: impact echo signal characterization for delamination identification**, Hongya Qu, Tiantian Li, Genda Chen, Missouri Univ. of Science and Technology (USA) ..... [10971-44]

4:10 pm: **Enhanced piezoresistive sensing of fiber-reinforced composites via embedded nanoparticles**, Christopher C. Bowland, Eric M. Burgeson, Amit K. Naskar, Oak Ridge National Lab. (USA) ..... [10971-45]

4:30 pm: **An energy efficient wireless module for impact detection of aerospace composite structures**, Zahra Sharif Khodaei, Hailing Fu, M.H. Aliabadi, Imperial College London (United Kingdom) ..... [10971-46]

4:50 pm: **Image analysis for classification of damaged and undamaged areas on composite structures**, Pratik Shrestha, Roger M. Groves, Technische Univ. Delft (Netherlands) ..... [10971-47]

5:10 pm: **Detection of disbonds using electromechanical admittance of piezoelectric transducers**, Mahindra Rautela, C.R. Biju, Indian Institute of Space Science and Technology (India) ..... [10971-48]

5:30 pm: **Development of a small-scale and low-cost SHM system for thin-walled CFRP structures based on acoustic emission analysis and neural networks**, Martin Gurka, Benjamin Kelkel, Philipp Argus, Institut fuer Verbundwerkstoff (Germany) ..... [10971-49]

5:50 pm: **Electromagnetic radiation detection in cement mortar: fly ash composite under impact loading**, Amit Kumar, Birla Institute of Technology (India); Kamal Prasad, Tilka Manjhi Bhagalpur Univ. (India) ..... [10971-74]

CONFERENCE 10972

SESSION 9

LOCATION: CRIPPLE CREEK 2  
WED 3:30 PM TO 5:50 PM

**Civil Infrastructure Monitoring I**

Session Chairs: **Tadeusz Stepinski**, AGH Univ. of Science and Technology (Poland); **Piervincenzo Rizzo**, Univ. of Pittsburgh (USA)

3:30 pm: **Self-healing degradation of asphalt concrete materials due to cooling cycles**, Bahzad Behnia, Clarkson Univ. (USA); Henrique L. Reis, Univ. of Illinois (USA) ..... [10972-43]

3:50 pm: **Rock bolt monitoring by means of guided waves**, Tadeusz Stepinski, Ireneusz Dominik, AGH Univ. of Science and Technology (Poland) [10972-44]

4:10 pm: **Data fusion approach for characterization of corrosion-induced stress change in prestressing strands using modulated higher-order guided ultrasonic waves**, Brennan Dubuc, Arvin Ebrahimkhanlou, Salvatore Salamone, The Univ. of Texas at Austin (USA) ..... [10972-45]

4:30 pm: **Measuring axial stress in thick structures using highly nonlinear solitary waves**, Amir Nasrollahi, Piervincenzo Rizzo, Univ. of Pittsburgh (USA) ..... [10972-46]

4:50 pm: **An assessment of in-field non-destructive testing methods for detection of internal defects in standing live tree**, Mohammad Sadegh Taskhiri, Univ. of Tasmania (Australia); Mohammad Hadi Hafezi, The Univ. of Arizona (USA); Damien Holloway, Paul Turner, Univ. of Tasmania (Australia) ..... [10972-49]

5:10 pm: **Diffusion coefficients estimated from Coda wave measurements for nondestructive evaluation of real-size concrete structures**, Hanyu Zhan, New Mexico State Univ. (USA); Hanwan Jiang, Univ. of Wisconsin-Platteville (USA); Jin Quan Zhang, Research Institute of Highway (China); Ruinian Jiang, New Mexico State Univ. (USA) ..... [10972-47]

5:30 pm: **Damage detection capabilities of strain-based displacement methods in beam-like structures**, Kaitlyn S. Klierer, Branko Glisic, Princeton Univ. (USA) ..... [10972-48]

**CONFERENCE 10966**  
**Electroactive Polymer Actuators and Devices (EAPAD) XXI**

Sessions 9A and 9B run concurrently.

**SESSION 9A**

**LOCATION: SILVERTON SALONS 2-3**  
**THU 8:20 AM TO 10:00 AM**

**Application of EAP to Robotics**

Session Chairs: **Samuel Rosset**, The Univ. of Auckland (New Zealand); **Vishnu Baba Sundaresan**, The Ohio State Univ. (USA)

8:20 am: **Soft electronic and robotic systems from biocompatible and degradable materials** (*Invited Paper*), Martin Kaltenbrunner, Johannes Kepler Univ. Linz (Austria) . . . . . [10966-39]

9:00 am: **Searching for clues about Maxwell stress in the back-relaxation of ionic polymer-metal composites**, Alain Boldini, Maxwell Rosen, NYU Tandon School of Engineering (USA); Youngsu Cha, Korea Institute of Science and Technology (Korea, Republic of); Maurizio Porfiri, NYU Tandon School of Engineering (USA) . . . . . [10966-89]

9:20 am: **Inflatable dielectric elastomer robots for space**, Joseph Ashby, Samuel Rosset, E.-F. Markus Henke, Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-41]

9:40 am: **Soft geometric dielectric elastomer switches for soft robotics**, E.-F. Markus Henke, TU Dresden (Germany); Katherine E. Wilson, Iain A. Anderson, The Univ. of Auckland (New Zealand) . . . . . [10966-43]

Coffee Break. . . . . Thu 10:00 am to 10:30 am

**SESSION 9B**

**LOCATION: CRIPPLE CREEK 1**  
**THU 8:00 AM TO 10:00 AM**

**Applications of EAP I**

Session Chairs: **Adrian Koh**, National Univ. of Singapore (Singapore); **Jang Ho Park**, Embry-Riddle Aeronautical Univ. (USA)

8:00 am: **Self-contained liquid filler-polymer composites as active layer for DEAs**, Ankit Ankit, Fanny Ho, Naveen Tiwari, Chien Anh Nguyen, Nanyang Technological Univ. (Singapore); Soo Jin Adrian Koh, National Univ. of Singapore (Singapore); Nripan Mathews, Nanyang Technological Univ. (Singapore) . . . . . [10966-49]

8:20 am: **Experimental determination of material parameters for an enhanced modeling of polyelectrolyte gels**, Beatrice Mau, Jan Erfkamp, Margarita Günther, Thomas Wallmersperger, TU Dresden (Germany) . . . . . [10966-81]

8:40 am: **Monolithic and active soft structures capable of self-actuation and self-adhesion**, Jianglong Guo, Chaoqun Xiang, Jonathan Rossiter, Univ. of Bristol (United Kingdom) . . . . . [10966-45]

9:00 am: **Soft gripper actuated by electro-hydraulic force**, Tongil Park, Youngsu Cha, Korea Institute of Science and Technology (Korea, Republic of) . . . . . [10966-46]

9:20 am: **Glove with versatile operation tools based on dielectric elastomer sensors**, Holger Böse, Stefan Muth, Simon Stier, Fraunhofer-Institut für Silicatforschung ISC (Germany) . . . . . [10966-47]

9:40 am: **Design of a dielectric elastomer actuator driven pneumatic pump**, Philipp Linnebach, Gianluca Rizzello, Steffen Hau, Stefan Seelecke, Univ. des Saarlandes (Germany) . . . . . [10966-48]

Coffee Break. . . . . Thu 10:00 am to 10:30 am

**CONFERENCE 10967**  
**Active and Passive Smart Structures and Integrated Systems XIII**

Sessions 10A and 10B run concurrently.

**SESSION 10A**

**LOCATION: CRESTONE SALON A**  
**THU 8:00 AM TO 10:00 AM**

**Acoustics and Wave Propagation**

Session Chairs: **Mostafa A. Nough**, Univ. at Buffalo (USA); **Jeffrey L. Kauffman**, Univ. of Central Florida (USA)

8:00 am: **One way sound: an acoustic diode based on programmable smart metamaterials**, Sami Karkar, Manuel Collet, Lab. de Tribologie et Dynamique des Systèmes (France) and CNRS (France) . . . . . [10967-49]

8:20 am: **Standing-to-traveling wave transition in piezoelectric thermoacoustic energy harvesters**, Jesse Callanan, Mostafa A. Nough, Univ. at Buffalo (USA) . . . . . [10967-50]

8:40 am: **Nonreciprocal propagation of acoustic waves in a granular chain coupled with asymmetric intruders**, Hoda J. Jalali Najafabadi, Piervincenzo Rizzo, Univ. of Pittsburgh (USA) . . . . . [10967-51]

9:00 am: **Overview of low to high-power contactless ultrasonic energy transfer technology**, Shima Shahab, Virginia Polytechnic Institute and State Univ. (USA); Muhammad Hajj, Stevens Institute of Technology (USA); Marjan Bakhtiar Nejad, Vamsi Meesala, Ahmed Elnahas, Aarushi Bhargava, Omidreza Sadeghi, Thomas Winnard, Ben Ailinger, Virginia Polytechnic Institute and State Univ. (USA) . . . . . [10967-52]

9:20 am: **A computational study of vibration delocalization in cyclic structures using adaptive stiffness elements**, Andres M. Rodriguez, Jeffrey L. Kauffman, Univ. of Central Florida (USA) . . . . . [10967-53]

9:40 am: **Wave propagation in auxetic mechanical metamaterial: Bloch formalism for various boundary conditions**, Vivek Gupta, Indian Institute of Technology Kanpur (India) . . . . . [10967-54]

Coffee Break. . . . . Thu 10:00 am to 10:30 am

**SESSION 10B**

**LOCATION: CRYSTAL SALON A**  
**THU 8:00 AM TO 10:00 AM**

**Magnetorheological Devices and Systems**

Session Chairs: **Gokhan Pekcan**, Univ. of Nevada, Reno (USA); **Alper Erturk**, Georgia Institute of Technology (USA)

8:00 am: **Magnetorheological bypass valve design for a semi-active inerter**, Matthew Tipuric, Neil D. Sims, David Wagg, The Univ. of Sheffield (United Kingdom) . . . . . [10967-55]

8:20 am: **Effect of carbon nanofiber on natural rubber based isotropic magnetorheological elastomers**, Siddaiah Yarra, Gokhan Pekcan, Faramarz Gordaninejad, Univ. of Nevada, Reno (USA) . . . . . [10967-56]

8:40 am: **Speed control of rotary shaft at different loading torque using MR clutch**, Quoc Hung Nguyen, Duc Thang Le, Vietnamese-German Univ. (Viet Nam); Thuy Duy Truong, Vietnamese German Univ. (Viet Nam); Dai Hiep Q. Le, Vietnamese-German Univ. (Viet Nam) . . . . . [10967-57]

9:00 am: **Theoretical and experimental investigation of axial shear gap arrangements for the enhancement of the torque capacity of energy efficient MR-actuators**, Christian Hegger, Jürgen Maas, Technische Univ. Berlin (Germany) . . . . . [10967-58]

9:20 am: **Modeling the behavior of magnetorheological elastomers under different loading conditions**, Siddaiah Yarra, Gokhan Pekcan, Faramarz Gordaninejad, Univ. of Nevada, Reno (USA) . . . . . [10967-59]

9:40 am: **Development of a 3D haptic spherical master manipulator based on MRF actuators**, Quoc Hung Nguyen, Vietnamese-German Univ. (Viet Nam); Ngoc Diep Nguyen, Industrial Univ. of Ho Chi Minh City (Viet Nam); Duc Thang Le, Thuy Duy Truong, Vietnamese-German Univ. (Viet Nam) . . . . . [10967-60]

Coffee Break. . . . . Thu 10:00 am to 10:30 am

CONFERENCE 10970

Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems

Sessions 10A and 10B run concurrently.

SESSION 10A

LOCATION: CRESTONE SALON B  
THU 8:00 AM TO 10:00 AM

Proximity Sensors for IoT Solutions

Session Chairs: **Ya S. Wang**, Texas A&M Univ. (USA); **Kenneth J. Loh**, Univ. of California, San Diego (USA)

8:00 am: **Variational autoencoder for detecting anomalies in longitude elevation of track geometry using the dynamic response of an in-service train**, Jingxiao Liu, Yujie Wei, Mario Bergés, Jacobo Bielak, James H. Garrett Jr., Hae Young Noh, Carnegie Mellon Univ. (USA) . . . . . [10970-49]

8:20 am: **Incentivizing large-scale vehicular crowdsensing system for smart city applications**, Susu Xu, Xinlei Chen, Carlee Joe-Wong, Pei Zhang, Hae Young Noh, Carnegie Mellon Univ. (USA) . . . . . [10970-51]

8:40 am: **A remote sleep monitoring system using an infrared thermal array sensor**, Ya S. Wang, Zhangjie Chen, Texas A&M Univ. (USA) . . . . . [10970-53]

9:00 am: **Monitoring induced floor vibrations: dance performance and bridge engineering**, Dilendra Maharjan, The Univ. of New Mexico (USA); Elijah Wyckoff, Arizona State Univ. (USA); Marlon Agüero, The Univ. of New Mexico (USA); Selene D. Martinez, Menaul School (USA); Lucas Zhou, La Cueva High School (USA); Fernando Moreu, The Univ. of New Mexico (USA) . . . . . [10970-55]

9:20 am: **Enhancing the imaging performance of electrical capacitance tomography for monitoring ossesointegrated prostheses**, Sumit Gupta, Kenneth J. Loh, Univ. of California, San Diego (USA) . . . . . [10970-57]

9:40 am: **VR based strabismus diagnosis using image processing**, Yinan Miao, Hweekwon Jung, Gyuhae Park, Chonnam National Univ. (Korea, Republic of); Hwan Heo, Chonnam National Univ. Medical School (Korea, Republic of) . . . [10970-59]

Coffee Break. . Thu 10:00 am to 10:30 am

SESSION 10B

LOCATION: CRYSTAL SALON B  
THU 8:00 AM TO 10:00 AM

Health Monitoring of Large-Scale and Complex Systems

Session Chairs: **Hoon Sohn**, KAIST (Korea, Republic of); **Jerome P. Lynch**, Univ. of Michigan (USA)

8:00 am: **Online prognosis of fatigue crack at welded joints using nonlinear ultrasonic modulation**, Hyung Jin Lim, Hoon Sohn, KAIST (Korea, Republic of) . . . . . [10970-50]

8:20 am: **On the negative value of information of structural health monitoring**, Denise Bolognani, Univ. degli Studi di Trento (Italy) . . . . . [10970-52]

8:40 am: **Stress distribution monitoring of ground anchor using optical fiber-embedded strand**, Michio Imai, Kazumasa Okubo, Naoki Sogabe, Hayato Tobe, Kajima Technical Research Institute (Japan); Masashi Oikawa, Shinji Nakae, Sumitomo (SEI) Steel Wire Corp. (Japan); Michihiro Hayakawa, SE Corp. (Japan) . . . . . [10970-54]

9:00 am: **Use of bank of Kalman estimators for damage detection of buildings**, Jau-Yu Chou, Chia-Ming Chang, National Taiwan Univ. (Taiwan) . . . . . [10970-56]

9:20 am: **Advanced sensor for in situ, NDE monitoring of nuclear reactors components integrity**, George E. Dovgalenko, Stratford Univ. (USA) and Advanced Sensor Technologies Inc. (USA); Kadir Altintepe, Advanced Sensor Technologies Inc. (USA) and Thomas Nelson Community College (USA) . . . . . [10970-58]

9:40 am: **Shape memory alloys for earthquake building protection**, Massimiliano Ferraioli, Domenico Nuzzo, Univ. degli Studi della Campania Luigi Vanvitelli (Italy); Antonio Concilio, Ctr. Italiano Ricerche Aerospaziali (Italy) . . . . . [10970-60]

Coffee Break. . Thu 10:00 am to 10:30 am

CONFERENCE 10971

Nondestructive Characterization and Monitoring of Advanced Materials, Aerospace, Civil Infrastructure, and Transportation XIII

SESSION 10

LOCATION: ASPEN B  
THU 8:00 AM TO 10:00 AM

SHM-NDE Ultrasonics II

Session Chairs: **Wieslaw M. Ostachowicz**, The Szewalski Institute of Fluid-Flow Machinery (Poland); **Ehsan Dehghan-Niri**, New Mexico State Univ. (USA)

8:00 am: **Nondestructive evaluation with fully non-contact ACT-SLDV guided wave system**, Wenfeng Xiao, Lingyu Yu, Univ. of South Carolina (USA) . . . . . [10971-50]

8:20 am: **Stress recovery from application of an acoustoelasticity model to coda wave measurements**, Hanwan Jiang, Univ. of Wisconsin-Platteville (USA); Hanyu Zhan, Ruinian Jiang, New Mexico State Univ. (USA); Jinquan Zhang, Research Institute of Highway (China) . . . . . [10971-51]

8:40 am: **Analyzing nonlinear behavior of ultrasound wave in phase-space domain**, Ehsan Dehghan-Niri, Sina Zamen, New Mexico State Univ. (USA) . . . . . [10971-52]

9:00 am: **Non-contact excitation of guided waves using air-coupled ultrasonic transmitters for damage detection**, Wieslaw Ostachowicz, The Szewalski Institute of Fluid-Flow Machinery (Poland); Michal Jurek, The Szewalski Institute of Fluid-Flow Machinery (Poland) and Rzeszów Univ. of Technology (Poland); Pawel Kudela, Maciej Radziński, The Szewalski Institute of Fluid-Flow Machinery (Poland) . . . . . [10971-53]

9:20 am: **Measurement of stress wave attenuation in composite laminates**, Duy Tran, Mannur J. Sundaresan, North Carolina A&T State Univ. (USA) [10971-54]

9:40 am: **Identifying transition of fatigue cracks from tensile to shear mode based on acoustic emission signals**, Mannur J. Sundaresan, Kassahun Asamene, North Carolina A&T State Univ. (USA) . . . . . [10971-55]

Coffee Break. . Thu 10:00 am to 10:30 am

CONFERENCE 10972

Health Monitoring of Structural and Biological Systems XIII

Sessions 10A and 10B run concurrently.

SESSION 10A

LOCATION: CRIPPLE CREEK 2  
THU 8:20 AM TO 10:00 AM

Nonlinear Ultrasonic Techniques

Session Chairs: **Zhongqing Su**, The Hong Kong Polytechnic Univ. (Hong Kong, China); **Anthony J. Croxford**, Univ. of Bristol (United Kingdom)

8:20 am: **Scanning laser vibrometry imaging of fatigue cracks via nonlinear ultrasonic guided wave scattering and mode conversion**, Yanfeng Shen, Mingjing Cen, Wu Xu, Shanghai Jiao Tong Univ. (China) . . . . . [10972-50]

8:40 am: **Nonlinear phased array imaging using phase**, Anthony J. Croxford, Jack Potter, Univ. of Bristol (United Kingdom); Philippe Blanloeuil, The Univ. of New South Wales (Australia) . . . . . [10972-51]

9:00 am: **Analyzing the nonlinear mechanisms in active wave modulation spectroscopy and their influence on delamination detection in laminated strips and plates**, Christoforos Rekatsinas, Nikolaos Chrysochoidis, Dimitris Saravanos, Univ. of Patras (Greece) . . . . . [10972-52]

9:20 am: **Evidence of reduced order nonlinear state of Lamb wave due to stress-relaxation in composites**, Subir Patra, Ahmed Hossain, Mohammad Sadegh Sadatzi, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10972-53]

9:40 am: **Thermal sensitivity-based ultrasonic quantification of material acoustic nonlinearity**, Kai Wang, Zhongqing Su, The Hong Kong Polytechnic Univ. (Hong Kong, China); Shenfang Yuan, Nanjing Univ. of Aeronautics and Astronautics (China) . . . . . [10972-55]

Coffee Break. . Thu 10:00 am to 10:30 am

SESSION 10B

LOCATION: SILVERTON SALON 1  
THU 8:20 AM TO 10:00 AM

Civil Infrastructure Monitoring II

Session Chair: **Hadi Fekrmandi**, South Dakota School of Mines and Technology (USA)

8:20 am: **Comparison of two soft computing optimisation algorithms for fuzzy damage severity assessment of a wind turbine blade with degrading boundary**, Heather Turnbull, Piotr Omenzetter, Univ. of Aberdeen (United Kingdom) . . . . . [10972-56]

8:40 am: **Real-time monitoring system for multi-MW scale wind blades using FBG sensors**, Hongwei Liu, Zhichun Zhang, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China) . [10972-57]

9:00 am: **Sensitivity of localized bolted connection failures in steel structures to high frequency strain measurement**, Suryakanta Biswal, Univ. of Surrey (United Kingdom) . . . . . [10972-58]

9:20 am: **GroundEye: a mobile crowdsourcing structure seismic response monitoring system based on smartphone**, Xuefeng Zhao, Jinke Li, Dalian Univ. of Technology (China); Ruicong Han, North China Univ. of Water Resources and Electric Power (China); Botao Xie, Dalian Univ. of Technology (China); Jinping Ou, Harbin Institute of Technology (China) . . . . . [10972-59]

9:40 am: **Structural health monitoring strategy for wooden houses considering hysteretic response**, Natsuko Yamamoto, Akira Mita, Keio Univ. (Japan) . . . . . [10972-60]

Coffee Break. . Thu 10:00 am to 10:30 am

CONFERENCE 10966

Sessions 10A and 10B run concurrently.

SESSION 10A

LOCATION: SILVERTON SALONS 2-3  
THU 10:30 AM TO 11:50 AM

Wearable and Tactile Applications

Session Chairs: **John D. W. Madden**, The Univ. of British Columbia (Canada); **Claire Jean-Mistral**, Institut National des Sciences Appliquées de Lyon (France)

10:30 am: **Necessary dielectric elastomer parameters for wearable tremor suppression**, Christopher R. Kelley, Jeffrey L. Kauffman, Univ. of Central Florida (USA) .....[10966-49]

10:50 am: **Woven and knitted artificial muscles for wearable devices**, Jose G. Martinez, Shayan Mehraeen, Freddy Escobar, Shazed Aziz, Linköping Univ. (Sweden); Milad Asadi Miankafshe, Nils-Krister Persson, Univ. of Borås (Sweden); Edwin W. H. Jager, Linköping Univ. (Sweden) .....[10966-50]

11:10 am: **Wearable soft sensor for monitoring of neck biomechanics**, Rami A. Abu Shammeh, Aaron D. Price, Western Univ. (Canada) ..... [10966-51]

11:30 am: **Large-area, flexible, integrable and transparent DEAs for haptics**, Ankit Ankit, Jun Yu Chan, Linh Lan Nguyen, Febby Krisnadi, Nripan Mathews, Nanyang Technological Univ. (Singapore) .....[10966-52]

Lunch Break ..... Thu 11:50 am to 1:20 pm

SESSION 10B

LOCATION: CRIPPLE CREEK 1  
THU 10:30 AM TO 11:50 AM

Applications of EAP II

Session Chairs: **Christoph Keplinger**, Univ. of Colorado Boulder (USA); **Holger Böse**, Fraunhofer-Institut für Silicatforschung ISC (Germany)

10:30 am: **Soft robotics for prosthetic devices: how dependent it is on smart materials?** (*Invited Paper*), Gursel Alici, Univ. of Wollongong (Australia) ..... [10966-53]

11:10 am: **Dynamically reconfigurable DEAs based on shape memory polymer fibers**, Bekir Aksoy, Herbert R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland) ..... [10966-54]

11:30 am: **High-voltage photonic switching in dielectric elastomers with amorphous silicon thin films**, Calum Gillespie, Asier Marzo, Fabrizio Scarpa, Jonathan Rossiter, Andrew Conn, Univ. of Bristol (United Kingdom) ..... [10966-55]

Lunch Break ..... Thu 11:50 am to 1:20 pm

CONFERENCE 10967

Sessions 11A and 11B run concurrently.

SESSION 11A

LOCATION: CRESTONE SALON A  
THU 10:30 AM TO 11:50 AM

Modeling and Analysis of Smart Structures

Session Chairs: **Ahmet Ozkan Ozer**, Western Kentucky Univ. (USA); **Francesco Danzi**, Politecnico di Torino (USA)

10:30 am: **An alternate numerical treatment for PDE models of piezoelectric laminates**, Ahmet Ozkan Ozer, Western Kentucky Univ. (USA) ..... [10967-61]

10:50 am: **Representation of a multi-electrodes piezoelectric transformer by experimental extraction of its electric parameters**, Thomas Martinez, École normale supérieure Paris-Saclay (France); Dejan Vasic, École normale supérieure Paris-Saclay (France) and Univ. de Cergy-Pontoise (France); Gaël Pillonnet, CEA-LETI (France) and Univ. Grenoble Alpes (France); François Costa, École normale supérieure Paris-Saclay (France) and Univ. Paris-Est Créteil (France) ..... [10967-62]

11:10 am: **Shape prediction of a composite wing panel under the action of an SMA wire and an MFC bimorph**, Aghna Mukherjee, Shaikh Faruque Ali, Arockiarajan Arunachalaksi, Indian Institute of Technology Madras (India) ..... [10967-63]

11:30 am: **An experimentally based cantilever model for vibration-to-electric energy harvesting of composite piezoelectric sheets**, Xiaomin Xue, Xi'an Jiaotong Univ. (China) ..... [10967-64]

Lunch Break ..... Thu 11:50 am to 1:40 pm

SESSION 11B

LOCATION: CRYSTAL SALON A  
THU 10:30 AM TO 11:50 AM

Magnetostrictive, Magnetolectric, and Magnetorheological Devices

Session Chairs: **Jae-Hung Han**, KAIST (Korea, Republic of); **Alper Erturk**, Georgia Institute of Technology (USA)

10:30 am: **A piezoelectric driven magnetostrictive device for communicating in the near field**, Joseph Schneider, Univ. of California, Los Angeles (USA); John Domann, Virginia Polytechnic Institute and State Univ. (USA); Paymon Shirazi, Univ. of California Los Angeles (USA); Mohanchandra Panduranga, Univ. of California, Los Angeles (USA); Casey Sennott, David Shahan, Skyler Selvin, Geoffrey McKnight, Walter Wall, HRL Labs., LLC (USA); Zhi Yao, Andres Chavez, Ethan Wang, Greg Carman, Univ. of California, Los Angeles (USA) ..... [10967-65]

10:50 am: **Finite element formulation for analysis of unsymmetric magnetolectric laminated plates**, Sudersan Sridhar, Arockiarajan Arunachalaksi, Indian Institute of Technology Madras (India) ..... [10967-66]

11:10 am: **Mass adaptation for moving parts using a magnetically induced placement of a certain amount of magnetorheological fluid**, Christian Hegger, Jürgen Maas, Technische Univ. Berlin (Germany) ..... [10967-67]

11:30 am: **Design and experimental investigation of a 3D joystick featuring two bidirectional MR actuators and a linear MR brake**, Quoc Hung Nguyen, Vietnamese-German Univ. (Viet Nam); Bao Tri Diep, Industrial Univ. of Ho Chi Minh City (Viet Nam) ..... [10967-68]

Lunch Break ..... Thu 11:50 am to 1:20 pm

CONFERENCE 10970

Sessions 11A and 11B run concurrently.

SESSION 11A

LOCATION: CRESTONE SALON B  
THU 10:30 AM TO 11:50 AM

**Modeling of Smart Materials and Sensor Performance**

Session Chairs: **Yong Xia**, The Hong Kong Polytechnic Univ. (Hong Kong, China); **Chunlin Zhang**, Northwestern Polytechnical Univ. (China)

10:30 am: **Theoretical model for laminated composite beam consisting of multiple superelastic shape memory alloy layers**, Nguyen V. Viet, Wael Zaki, Rehan Umer, Khalifa Univ. of Science, Technology and Research (United Arab Emirates) . . . . . [10970-61]

10:50 am: **Predictive circular-crested guided-wave propagation in layered plates using the NME approach**, Lingfang Li, The Hong Kong Polytechnic Univ. (Hong Kong, China); Victor Giurgiutiu, Univ. of South Carolina (USA); Yong Xia, The Hong Kong Polytechnic Univ. (Hong Kong, China) . . . . . [10970-63]

11:10 am: **Modeling and performance investigation of multi-stable, piezoelectric vibration energy harvesters with extendible potential equilibria**, Chunlin Zhang, Northwestern Polytechnical Univ. (China); Hongbin Fang, Fudan Univ. (China); Binqiang Chen, Xiamen Univ. (China) . . . . . [10970-65]

11:30 am: **A microscale percolation model for nanocomposite complex impedance**, Tyler N. Tallman, Purdue Univ. (USA) . . . . . [10970-67]

Lunch Break . . . .Thu 11:50 am to 1:20 pm

SESSION 11B

LOCATION: CRYSTAL SALON B  
THU 10:30 AM TO 11:50 AM

**Control and Actuation of Dynamic Systems**

Session Chairs: **Courtney Peckens**, Hope College (USA); **Raj Bridgelall**, North Dakota State Univ. (USA)

10:30 am: **Sensor system benefits and costs in positive train control**, Raj Bridgelall, Bryan King, Ying Huang, Denver D. Tolliver, Pan Lu, North Dakota State Univ. (USA) . . . . . [10970-62]

10:50 am: **Monitoring and control of structures considering diverse uncertainties**, M. Shamim Miah, Michael Kaliske, TU Dresden (Germany) [10970-64]

11:10 am: **Bio-inspired iterative learning techniques for more effective control of civil infrastructure**, Courtney Peckens, Camille Fogg, Hope College (USA) . . . . . [10970-66]

11:30 am: **A shock absorber with both tunable inertance and damping**, Wei-Min Zhong, Xian-Xu Bai, An-Ding Zhu, Hefei Univ. of Technology (China) . . . . . [10970-68]

Lunch Break . . . .Thu 11:50 am to 1:20 pm

CONFERENCE 10971

SESSION 11

LOCATION: ASPEN B  
THU 10:30 AM TO 11:50 AM

**SHM-NDE of Composite Materials II**

Session Chairs: **Victor Giurgiutiu**, Univ. of South Carolina (USA); **Ermias Koricho**, Georgia Southern Univ. (USA)

10:30 am: **Nondestructive evaluation of chopped fiber reinforced composite using optical transmission scanning (OTS) technique**, Ermias G. Koricho, Georgia Southern Univ. (USA); Anton Khomenko, General Photonics Corp. (USA); Oliver King, Georgia Southern Univ. (USA) . . . . . [10971-56]

10:50 am: **Eddy current non-destructive evaluation of manufacturing flaws and operational damage in CFRP composites**, Robin James, Mohammad Faisal Haider, Victor Giurgiutiu, Univ. of South Carolina (USA) . . . . . [10971-57]

11:10 am: **Impact localization in composite specimens with embedded transducers**, Mario Emanuele De Simone, Stefano Cuomo, Univ. of Bath (United Kingdom); Francesco Ciampa, Univ. of Surrey (United Kingdom); Michele Meo, Univ. of Bath (United Kingdom); Sandro Nitschke, Andreas Hornig, Niels Modler, TU Dresden (Germany) . . . . . [10971-58]

11:30 am: **A new method for Poisson's ratio measurement with time-of-flight technique: application to the preliminary design of smart composite structures**, Xianlong Chen, Yann Meyer, Univ. Bourgogne Franche-Comté (France); Rémy Lachat, Univ. Bourgogne Franche-Comté (France) and CNRS (France); Morvan Ouisse, Univ. Bourgogne Franche-Comté (France) and Institut Franche-Comte Electronique Mecanique Thermique et Optique (France) and CNRS (France) . . . . . [10971-59]

Lunch Break . . . .Thu 11:50 am to 1:20 pm

CONFERENCE 10972

Sessions 11A and 11B run concurrently.

SESSION 11A

LOCATION: CRIPPLE CREEK 2  
THU 10:30 AM TO 11:50 AM

**Sensors for Real-Time Monitoring III**

Session Chairs: **Alessandro Sabato**, Univ. of Massachusetts Lowell (USA); **Wei-Chih Wang**, Tsinghua Univ. (USA)

10:30 am: **Development of P(VDF-TrFE) yarn for strain sensing**, Chih-Cheng Kuo, Chih-Kung Lee, National Taiwan Univ. (Taiwan) . . . . . [10972-61]

10:50 am: **Fabrication, characterization, and integration of BaTiO<sub>3</sub>-cement-graphene based electro-active aggregates towards developing adaptive structural health monitoring devices**, Patrick Manghera, Faiaz Rahman, Maryam Nazari, The Nguyen, Sankha Banerjee, California State Univ., Fresno (USA) . . . . . [10972-62]

11:10 am: **Development of an IMU-radar sensor board for three-dimensional digital image correlation camera triangulation**, Alessandro Sabato, Christopher Niezrecki, Univ. of Massachusetts Lowell (USA) . . [10972-63]

11:30 am: **Thermal electrical analysis of serpentine shaped sensing element geometries to enhance the responsivity of thermoresistive sensor**, Wei-Chih Wang, Univ. of Washington (USA); Abhishek Gupta, Indian Institute of Technology Roorkee (India) . . . [10972-64]

Lunch Break . . . .Thu 11:50 am to 1:20 pm

SESSION 11B

LOCATION: SILVERTON SALON 1  
THU 10:30 AM TO 11:50 AM

**Elastic and Metamaterials IV**

Session Chairs: **Jinkyu Yang**, Univ. of Washington (USA); **Sourav Banerjee**, Univ. of South Carolina (USA)

10:30 am: **Degenerate polar lattices for cloaking in full 2D elasticity**, Hussein Nassar, Yangyang Chen, Guoliang Huang, Univ. of Missouri (USA) . . . . . [10972-65]

10:50 am: **Enhanced identifiability of nonlinear ultrasonic superharmonics for crack detection using an aluminum-lead composite bandgap meta-surface**, Yiran Tian, Yanfeng Shen, Shanghai Jiao Tong Univ. (China) . . . . . [10972-66]

11:10 am: **Dirac-like cone mo on for phononic crystals using deaf band**, Mustahseen Indaleeb, Hossain Ahmed, Mohammad Sadegh Saadatzi, Sourav Banerjee, Univ. of South Carolina (USA) . . . . . [10972-67]

11:30 am: **Computational design of phononic topological insulators**, Subbiah Nanthakumar, Xiaoying Zhuang, Leibniz Univ. Hannover (Germany); Harold S. Park, Boston Univ. (USA); Timon Rabczuk, Bauhaus-Univ. Weimar (Germany) . . . . . [10972-68]

Lunch Break . . . .Thu 11:50 am to 1:20 pm

CONFERENCE 10966

Sessions 11A and 11B run concurrently.

SESSION 11A

LOCATION: SILVERTON SALONS 2-3  
THU 1:20 PM TO 3:00 PM

EAP Actuators

Session Chairs: **Qibing Pei**, Univ. of California, Los Angeles (USA); **Ji Su**, NASA Langley Research Ctr. (USA)

1:20 pm: **Dielectric elastomer spring-roll bending actuators: applications in soft robotics and design** (*Invited Paper*), Yanju Liu, Liwu Liu, Jinsong Leng, Harbin Institute of Technology (China) . . . . . [10966-56]

2:00 pm: **Active surfaces powered by HASEL artificial muscles**, Eric Acome, Shane K. Mitchell, Christoph Keplinger, Univ. of Colorado Boulder (USA) . . . . . [10966-57]

2:20 pm: **Simulation-driven design for liquid dielectric electrostatic actuators**, Shardul S. Panwar, Umesh Gandhi, Michael Rowe, Toyota Research Institute North America (USA) . . [10966-58]

2:40 pm: **High performance actuators for untethered applications**, Seyed Mirvakili, Ian Hunter, Massachusetts Institute of Technology (USA) . . . . . [10966-59]

Coffee Break. . . . . Thu 3:00 pm to 3:30 pm

SESSION 11B

LOCATION: CRIPPLE CREEK 1  
THU 1:20 PM TO 3:00 PM

Applications of EAP III

Session Chairs: **E.-F. Markus Henke**, The Univ. of Auckland (Germany); **Seyed Mirvakili**, Massachusetts Institute of Technology (USA)

1:20 pm: **Transition from horizontal to vertical wrinkles in a viscoelastic dielectric elastomer**, Jian Zhu, Ujjaval Gupta, National Univ. of Singapore (Singapore); Matthias Kollosche, Univ. Potsdam (Germany); Guggi Kofod, Inmold (Denmark) . . . . . [10966-60]

1:40 pm: **Silicone elastomer map: design the ideal elastomer**, Justina Vaicekauskaite, Piotr Mazurek, Anne Ladegaard Skov, Technical Univ. of Denmark (Denmark) . . . . . [10966-61]

2:00 pm: **Synthetic Muscle Electroactive Polymer (EAP) based actuation and pressure sensing for prosthetic and robotic applications**, Lenore Rasmussen, Ras Labs., Inc. (USA) and Worcester Polytechnic Institute (USA); Simone Rodriguez, Matthew Bowers, Damaris Smith, Ras Labs, Inc. (USA); Greig Martino, United Prosthetics, Inc. (USA); Jesse d'Almeida, Worcester Polytechnic Institute (USA); Cole Scheiber, Tufts Univ. (USA); Curran Dillis, Ras Labs, Inc. (USA) . . . . . [10966-62]

2:20 pm: **Steady and chaotic oscillation of dielectric elastomer balloon incorporating stiffening and damping effect**, Xiongfei Lv, Liwu Liu, Jinsong Leng, Yanju Liu, Harbin Institute of Technology (China) . . . . . [10966-63]

2:40 pm: **Biosignals controlled dielectric elastomer actuators**, Jinrong Li, Harbin Institute of Technology (China); Yang Wang, Univ. of California, San Diego (USA); Liwu Liu, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China); Shengqiang Cai, Univ. of California, San Diego (USA) . [10966-64]

Coffee Break. . . . . Thu 3:00 pm to 3:30 pm

CONFERENCE 10967

Sessions 12A and 12B run concurrently.

SESSION 12A

LOCATION: CRESTONE SALON A  
THU 1:40 PM TO 3:00 PM

Shape Memory Alloys

Session Chairs: **Nam Seo Goo**, Konkuk Univ. (Korea, Republic of); **Shima Shahab**, Virginia Polytechnic Institute and State Univ. (USA)

1:40 pm: **Shape memory polymer composite hinge with heating element at low temperature**, Nam Seo Goo, Van Luong Le, Konkuk Univ. (Korea, Republic of) . . . . . [10967-69]

2:00 pm: **Dynamics of focused ultrasound actuated shape memory polymers**, Aarushi Bhargava, Shima Shahab, Virginia Polytechnic Institute and State Univ. (USA) . . . . . [10967-70]

2:20 pm: **Thermomechanical characterization and modeling of shape memory alloy springs**, Corin Bowen, John Shaw, Univ. of Michigan (USA) . . . . . [10967-71]

2:40 pm: **Position estimation of shape memory alloy actuators using high-frequency electrical reflectometry**, Nima Zamani, Igor Ruvinov, Smarter Alloys (Canada) . . . . . [10967-73]

Coffee Break. . . . . Thu 3:00 pm to 3:30 pm

SESSION 12B

LOCATION: CRYSTAL SALON A  
THU 1:20 PM TO 3:00 PM

Energy Harvesting V: General

Session Chairs: **Yabin Liao**, Penn State Behrend (USA); **Francesco Danzi**, Politecnico di Torino (USA)

1:20 pm: **A variable stiffness coupled resonator for energy harnessing from ambient vibrations**, Francesco Danzi, Politecnico di Torino (Italy); James M. Gibert, Purdue Univ. (USA) . . . . . [10967-74]

1:40 pm: **Generalized modeling and analysis of piezoelectric vibration energy harvesters**, Yabin Liao, Penn State Behrend (USA); Junrui Liang, ShanghaiTech Univ. (China) . . . . . [10967-75]

2:00 pm: **An arc-shaped electromagnetic energy harvester for ultra-low frequency vibrations and swing motions**, Kangqi Fan, Xidian Univ. (China) . . . . . [10967-76]

2:20 pm: **Improvement of the equivalent impedance model for electromagnetic energy harvesting system**, Hong Tang, Junrui Liang, ShanghaiTech Univ. (China) . . . . . [10967-77]

2:40 pm: **An extended rotary energy harvester with multiple piezoelectric cantilevers for broadband operation**, Shitong Fang, Xinlei Fu, Wei-Hsin Liao, The Chinese Univ. of Hong Kong (Hong Kong, China) . . . . . [10967-78]

Coffee Break. . . . . Thu 3:00 pm to 3:30 pm



CONFERENCE 10970

Sessions 12A and 12B run concurrently.

SESSION 12A

LOCATION: CRESTONE SALON B  
THU 1:20 PM TO 3:00 PM

Optical Fiber Sensors

Session Chairs: **R. Brian Jenkins**, U.S. Naval Academy (USA); **Roger M. Groves**, Technische Univ. Delft (Netherlands)

1:20 pm: **Structural health monitoring of solar trackers using distributed fiber optic sensors**, Jon Mariñelarena, Juan José Mompó, Jesús Zurita, Univ. Pública de Navarra (Spain); Javier Urricelqui, Uptech Sensing S.L. (Spain); Aitor Judez, Manuel López-Amo, Univ. Pública de Navarra (Spain); Sergio Jiménez, Alvaro Achaerandio, STI Norland (Spain); Alayn Loayssa, Univ. Pública de Navarra (Spain) . . . . . [10970-69]

1:40 pm: **Discerning localized thermal impulses using an embedded distributed optical fiber sensor network**, R. Brian Jenkins, Peter Joyce, Adam Kong, Charles Nelson, U.S. Naval Academy (USA). . . . . [10970-71]

2:00 pm: **Analysis of FBG reflection spectra under uniform and non-uniform transverse loads**, Luigi Fazzi, Aydin Rajabzadeh, Technische Univ. Delft (Netherlands); Alberto Milazzo, Univ. degli Studi di Palermo (Italy); Roger M. Groves, Technische Univ. Delft (Netherlands). . . . . [10970-73]

2:20 pm: **Test results of lateral load insensitive FBGs embedded in composites to suppress spectral distortion**, Lun-Kai Cheng, Ronald Hagen, Amir Vosteen, Bilim Atli-Veltin, Peter Toet, Freek Molkenboer, Floris van Kempen, Oana van der Togt, Aleksandra Jedynska, Rob Jansen, TNO (Netherlands). . . . . [10970-75]

2:40 pm: **Simultaneous position and displacement sensing using two fiber Bragg grating sensors**, Nakash Nazeer, Roger M. Groves, Rinze Benedictus, Technische Univ. Delft (Netherlands). . . . . [10970-77]

Coffee Break. . . . Thu 3:00 pm to 3:30 pm

SESSION 12B

LOCATION: CRYSTAL SALON B  
THU 1:20 PM TO 3:00 PM

SHM Applications to Concrete Structures

Session Chairs: **Branko Glisic**, Princeton Univ. (USA); **Ying Huang**, North Dakota State Univ. (USA)

1:20 pm: **Integrative workflow for documentation, analysis, and structural health monitoring of marine infrastructure**, Anna Blyth, Rebecca Napolitano, Branko Glisic, Princeton Univ. (USA) . . . . . [10970-70]

1:40 pm: **Development of open-source structural health monitoring software for seismic safety monitoring of dams**, Erol Kalkan, U.S. Geological Survey (USA). . . . . [10970-72]

2:00 pm: **Investigating polymer coated piezo-ceramic sensor for the very early strength monitoring of cementitious materials**, Yen-Fang Su, Guangshuai Han, Adlan Amran, Sean T. Graham, Na (Luna) Lu, Purdue Univ. (USA). [10970-74]

2:20 pm: **Experimental crack detection in concrete pavement using point strain sensors**, Mohanad Alshandah, Ying Huang, Jerry Gao, Pan Lu, Denver D. Tolliver, North Dakota State Univ. (USA) . . . . . [10970-76]

2:40 pm: **Numerical assessment of fatigue life of concrete frame using PZT sensors**, Moinul Haq, Tabassum Naqvi, Aligarh Muslim Univ. (India) . . . [10970-78]

Coffee Break. . . . Thu 3:00 pm to 3:30 pm

CONFERENCE 10971

SESSION 12

LOCATION: ASPEN B  
THU 1:20 PM TO 3:20 PM

SHM-NDE Science and Theory III

Session Chairs: **Zhu Mao**, Univ. of Massachusetts Lowell (USA); **Ajay M. Koshti**, NASA Johnson Space Ctr. (USA)

1:20 pm: **A video classification approach for data driven damage detection**, Aral Sarrafi, Zhu Mao, Univ. of Massachusetts Lowell (USA) . . [10971-60]

1:40 pm: **Direct waveform extraction via a deep recurrent denoising autoencoder**, Meng Ma, Yang Qin, Univ. of Massachusetts Lowell (USA); Mulugeta Haile, U.S. Army Research Lab. (USA); Zhu Mao, Univ. of Massachusetts Lowell (USA) . . . . . [10971-61]

2:00 pm: **NDE flaw detectability size estimation using smaller number of hit-miss data-points**, Ajay M. Koshti, NASA Johnson Space Ctr. (USA) . . . [10971-62]

2:20 pm: **Experimental measurements of artificial sub-surface crack vibrations and their potential usability for the electro-mechanical impedance SHM-method**, Christoph Kralovec, Martin Schagerl, Johannes Kepler Univ. Linz (Austria). . . . . [10971-63]

2:40 pm: **Monitoring of interfacial properties in integrated circuit packages using carbon nanotube smart membrane**, Javaid Ikram, Intel Corp. (USA); Siddhant Datta, Aditi Chattopadhyay, Arizona State Univ. (USA) . . . . . [10971-72]

3:00 pm: **Application of flexible PAUT probe for weld inspection of piping elbows**, Ik Keun Park, Seoul National Univ. of Science and Technology (Korea, Republic of); Tae Sung Park, Seoul National Univ. of Technology (Korea, Republic of); Seung Mi Lee, Seoul National Univ. of Science and Technology (Korea, Republic of); Seong Jin Lim, Korea Inspection & Engineering Co. (Korea, Republic of); Yukio Ogura, Japan Probe Co., Ltd. (Japan) . . . . . [10971-73]

Conference End.

CONFERENCE 10972

Sessions 12A and 12B run concurrently.

SESSION 12A

LOCATION: CRIPPLE CREEK 2  
THU 1:20 PM TO 3:00 PM

Guided Waves for SHM II

Session Chairs: **Lingyu Yu**, Univ. of South Carolina (USA); **Yanfeng Shen**, Shanghai Jiao Tong Univ. (China)

1:20 pm: **Lamb wave defect detection and evaluation using a fully non-contact laser system**, Zhaoyun Ma, Lingyu Yu, Univ. of South Carolina (USA) . . . . . [10972-69]

1:40 pm: **Lamb wave virtual time reversal damage detection algorithm with transducer transfer function compensation**, Junzhen Wang, Yanfeng Shen, Shanghai Jiao Tong Univ. (China). . . . . [10972-70]

2:00 pm: **Experimental investigation of Lamb wave-based edge detection methods**, Christoph Schaal, California State Univ., Northridge (USA) and Univ. of California, Los Angeles (USA); Matthew Brown, Katja Schulz, California State Univ., Northridge (USA) . . . . . [10972-71]

2:20 pm: **Acoustic source localization in anisotropic plates without knowing their material properties: an experimental investigation**, Novonil Sen, The Univ. of Arizona (USA); Mateusz Gawronski, Pawel Packo, Tadeusz Uhl, AGH Univ. of Science and Technology (Poland); Tribikram Kundu, The Univ. of Arizona (USA) . . . . . [10972-72]

2:40 pm: **Finite element modeling and validation of guided wave scattering**, Paul Fromme, Univ. College London (United Kingdom) . . . . . [10972-73]

SESSION 12B

LOCATION: SILVERTON SALON 1  
THU 1:20 PM TO 3:00 PM

Medical / Biomedical Applications

Session Chair: **Xiaoning Jiang**, North Carolina State Univ. (USA)

1:20 pm: **Evaluation of electromechanical impedance based structural health monitoring for detection of loosening in total knee arthroplasty**, Robert Ponder, Tennessee Technological Univ. (USA); Robert M. Meneghini M.D., Indiana Univ. School of Medicine (USA); Steven R. Anton, Tennessee Technological Univ. (USA) . . . . . [10972-74]

1:40 pm: **Blood volume flow measurement using a flexible ultrasound transducer**, Daniel Morrow, Ho-Wuk Kim, Taeyang Kim, Xiaoning Jiang, North Carolina State Univ. (USA) . . [10972-75]

2:00 pm: **Investigation of mechanical boundary conditions on impedance based structural health monitoring in a biomedical environment**, Nathan W. Ghattas, Robert Ponder, Steven R. Anton, Tennessee Technological Univ. (USA). . . . . [10972-76]

2:20 pm: **Design of a flexible endotracheal tube holder device and study of its effect on cutaneous blood flow in the skin using laser Doppler velocimetry**, Aman Garg, Bishakh Bhattacharya, Indian Institute of Technology Kanpur (India) . . . . [10972-77]

2:40 pm: **Non-contact trapping and stretching of biological cells using dual-beam optical stretcher on microfluidic platform**, Aotuo Dong, Norfolk State Univ. (USA); Balaadithya Uppalapati, Univ. of Dayton (USA); Md. Shariful Islam, Norfolk State Univ. (USA); Brandon Gibbs, Old Dominion Univ. (USA); Sacharia Albin, Makarand Deo, Norfolk State Univ. (USA) . . . . [10972-78]

Coffee Break. . . . Thu 3:00 pm to 3:30 pm

CONFERENCE 10966

Sessions 12A and 12B run concurrently.

SESSION 12A

LOCATION: SILVERTON SALONS 2-3  
THU 3:30 PM TO 5:50 PM

EAP Sensors and Actuators

Session Chairs: **Caleb Christianson**, Univ. of California, San Diego (USA); **Liwu Liu**, Harbin Institute of Technology (China)

- 3:30 pm: **Dual sensing and actuation of ultrathin conducting polymer transducers**, Ngoc Tan Nguyen, Univ. de Valenciennes et du Hainaut-Cambrésis (France); Cédric Plesse, Frédéric Vidal, Univ. de Cergy-Pontoise (France); Sebastien Grondel, Univ. de Valenciennes et du Hainaut-Cambrésis (France); Eric Cattan, Institut d'Electronique de Microélectronique et de Nanotechnologie (France); John D. W. Madden, The Univ. of British Columbia (Canada) .....[10966-65]
- 3:50 pm: **A roadmap towards strong and tunable Peano-HASEL actuators**, Nicholas Kellaris, Vidyacharan Gopaluni Venkata, Philipp Rothemund, Christoph Keplinger, Univ. of Colorado Boulder (USA) .....[10966-66]
- 4:10 pm: **Bistable electroactive polymers: recent progress in materials development and application exploration**, Qibing Pei, Univ. of California, Los Angeles (USA) .....[10966-67]
- 4:30 pm: **Electrostatic actuator for tactile display based on soft structures hydraulically coupled with dielectric fluids**, Giacomo Moretti, Scuola Superiore Sant'Anna (Italy); Rocco Vertechy, Univ. degli Studi di Bologna (Italy); Marco Fontana, Univ. degli Studi di Trento (Italy) .....[10966-68]
- 4:50 pm: **Electroactive actuation by liquid conductors in shape memory polymers**, Gurmeet Singh, Nakhiah C. Goulbourne, Univ. of Michigan (USA) .....[10966-69]
- 5:10 pm: **A novel approach to improve the design and fabrication of dielectric elastomer tactile sensor**, Yuting Zhu, Samuel Rosset, Andreas Tairych, Iain A. Anderson, The Univ. of Auckland (New Zealand) .....[10966-70]
- 5:30 pm: **An uncooled pyroelectric infrared detector with high performance based on P(VDF-TrFE)**, Liwu Liu, Guanghua Hou, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China) .....[10966-71]

SESSION 12B

LOCATION: CRIPPLE CREEK 1  
THU 3:30 PM TO 5:50 PM

Applications of EAP IV

Session Chairs: **Rocco Vertechy**, Univ. degli Studi di Bologna (Italy); **Edwin W. H. Jager**, Linköping Univ. (Sweden)

- 3:30 pm: **Soft hybrid generators for harvesting human kinetic energy (Invited Paper)**, Claire Jean-Mistral, Institut National des Sciences Appliquées de Lyon (France); Alain Sylvestre, Lab. de Génie Électrique de Grenoble (France) .....[10966-72]
  - 4:10 pm: **Design, fabrication, and customized driving of dielectric loudspeaker arrays**, Florian Klug, Susana Solano-Arana, Helmut F. Schlaak, Christian Endl, Technische Univ. Darmstadt (Germany) .....[10966-73]
  - 4:30 pm: **Active catheter driven by hybrid actuator consisting of ionic polymer-metal composites and hydraulics**, Justin Neubauer, Zachary Frank, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) .....[10966-74]
  - 4:50 pm: **Ionic redox transistor-gated ion transport in aqueous and organic electrolytes**, Vishnu Baba Sundaresan, Travis Hery, The Ohio State Univ. (USA) .....[10966-75]
  - 5:10 pm: **Sulfonated silica-based IPMC as actuators in soft robotics application**, Krishna C. Solasa, Kwang Jin Kim, Univ. of Nevada, Las Vegas (USA) .....[10966-76]
  - 5:30 pm: **ZnO-epoxy-BaTiO3 based viscoelastic and electro-active composites toward enhancing acoustic absorption**, Diego Ruggiero, The M. Nguyen, Maryam Nazari, Sankha Banerjee, California State Univ., Fresno (USA) .....[10966-77]
- Conference End.

CONFERENCE 10967

Sessions 13A and 13B run concurrently.

SESSION 13A

LOCATION: CRESTONE SALON A  
THU 3:30 PM TO 5:50 PM

Sensing, Actuation, and Diagnostics

Session Chairs: **Jung-Ryul Lee**, KAIST (Korea, Republic of); **Ahmet Ozkan Ozer**, Western Kentucky Univ. (USA)

- 3:30 pm: **Structural compatibility of thin film sensors embedded in a composite laminate**, Vivek T. Rathod, Yiming Deng, Michigan State Univ. (USA) .....[10967-79]
  - 3:50 pm: **Development of pulse-echo ultrasonic imager capable of automatic scan area detection of any customizable shape**, Hasan Ahmed, Jung-Ryul Lee, KAIST (Korea, Republic of) . . . .[10967-80]
  - 4:10 pm: **Piezoelectric wafer active sensors for sensing acoustic emission due to crack rubbing/clapping**, Roshan Joseph, Yeasin Bhuiyan, Victor Giurgiutiu, Univ. of South Carolina (USA) . [10967-81]
  - 4:30 pm: **A smart sensor for the measurements of strain and vibrations: a work in progress**, Jorge de-J. Lozoya-Santos, Tecnológico de Monterrey (Mexico); Juan Carlos Tudon-Martinez, Alan Martinez de la Riva, Univ. de Monterrey (Mexico); Natalia A. Navarrete-Alzate, Metalsa S.A. de C.V. (Mexico); Ruben Morales-Menendez, Ricardo Ramirez-Mendoza, Tecnológico de Monterrey (Mexico) . . . . .[10967-82]
  - 4:50 pm: **Thermal shock damage monitoring of PBX based on self-adjusted wavelength demodulation technology**, Tao Fu, Zhiwei Qiu, Xin Tian, Xiaohui Liang, Maoping Wen, China Academy of Engineering Physics (China) . . . . .[10967-83]
  - 5:10 pm: **Nonlinear characterization of piezoelectric patches and piezoelectric stacks from vibrations of piezo-actuated structures**, Shivashankar P., S. Gopalakrishnan, Sanjay Sharma, S. B. Kandagal, Indian Institute of Science (India) . . . . .[10967-84]
  - 5:30 pm: **Design and modeling of surface bondable piezoelectric stack actuators for actuation of large structures**, Shivashankar P., S. Gopalakrishnan, Sanjay Sharma, Indian Institute of Science (India) . . . . .[10967-85]
- Conference End.

SESSION 13B

LOCATION: CRYSTAL SALON A  
THU 3:30 PM TO 4:30 PM

Energy Harvesting VI: General

Session Chairs: **Mariantonieta Gutierrez Soto**, Univ. of Kentucky (USA); **Yabin Liao**, Penn State Behrend (USA)

- 3:30 pm: **Power and efficiency of piezoelectric vibration energy harvesters**, Yabin Liao, Penn State Behrend (USA) .....[10967-86]
- 3:50 pm: **Study of piezo embedded negative mass metamaterial using generalized Bloch theorem for energy harvesting system**, Ankur Dwivedi, Indian Institute of Technology Kanpur (India) . . . . .[10967-87]
- 4:10 pm: **The fatigue behavior study of micro piezoelectric energy harvester under different working temperature**, Yu Chun Kuo, Wen-Jong Wu, Jui-Ta Chien, Chao-Ting Chen, Shun-Chiu Lin, National Taiwan Univ. (Taiwan) . . . . .[10967-88]

CONFERENCE 10970

Sessions 13A and 13B run concurrently.

SESSION 13A

LOCATION: CRESTONE SALON B  
THU 3:30 PM TO 5:50 PM

Sensor Development and Applications

Session Chairs: **Haifeng Zhang**, Univ. of North Texas (USA); **Wei-Hsin Liao**, The Chinese Univ. of Hong Kong (Hong Kong, China)

3:30 pm: **Micro-machined hot-wire anemometer arrays to measure local airflow**, Gregory Bewley, Pablo Naoki Manzano Miura, Cornell Univ. (USA) . . . . . [10970-79]

3:50 pm: **Design and fabrication of a self-powered piezoelectric MEMS accelerometer**, Xuewen Gong, Wei-Hsin Liao, The Chinese Univ. of Hong Kong (Hong Kong, China); Chao-Ting Chen, Wen-Jong Wu, National Taiwan Univ. (Taiwan). . . . . [10970-89]

4:10 pm: **CMUT sensors based on circular membranes array for SHM applications**, Pauline Butaud, Gilles Bourbon, Patrice Le Moal, Univ. Bourgogne Franche-Comté (France) and Institut Franche-Comte Electronique Mecanique Thermique et Optique (France); Eric Joseph, Univ. de Franche-Comté (France) and Institut Franche-Comte Electronique Mecanique Thermique et Optique (France); Benoit Verdin, Univ. Bourgogne Franche-Comté (France) and Institut Franche-Comte Electronique Mecanique Thermique et Optique (France); Emmanuel Ramasso, Vincent Placet, Univ. Bourgogne Franche-Comté (France) and Institut Franche-Comte Electronique Mecanique Thermique et Optique (France) . . . . . [10970-83]

4:30 pm: **Analysis of performances of MEMS infrared sensor based on piezoelectric bending resonators in air**, Xiaoqi Bao, Stewart Sherrit, Clifford Frez, Valerie Scott, Mina Rais-Zadeh, Jet Propulsion Lab. (USA) . . . . . [10970-85]

4:50 pm: **Application of piezoelectric MFC sensors and fiber Bragg grating sensors in structural health monitoring of composite materials**, Mohammad Azarbajegani, New Mexico Institute of Mining and Technology (USA) . . . . . [10970-87]

5:10 pm: **CO2 sensing characteristics of SAW sensor operated at high temperature**, Abhishek Ghosh, Chen Zhang, Haifeng Zhang, Univ. of North Texas (USA). . . . . [10970-81]

5:30 pm: **Langasite-based BAW resonator coated with ZnO for high temperature CO2 gas sensing with temperature compensation**, Chen Zhang, Abhishek Ghosh, Haifeng Zhang, Univ. of North Texas (USA) . . . . . [10970-91]

SESSION 13B

LOCATION: CRYSTAL SALON B  
THU 3:30 PM TO 5:30 PM

Skin-based Distributed Sensing for SHM Applications

Session Chairs: **Kenneth J. Loh**, Univ. of California, San Diego (USA); **Simon Laflamme**, Iowa State Univ. of Science and Technology (USA)

3:30 pm: **Model-assisted validation of a strain-based dense sensor network**, Jin Yan, Xiaosong Du, Simon Laflamme, Leifur Leifsson, Chao Hu, An Chen, Iowa State Univ. of Science and Technology (USA) . . . . . [10970-80]

3:50 pm: **Soft-matter capacitive pressure sensor for turbulence detection**, James P. Wissman, Kaushik Sampath, Charles A. Rohde, U.S. Naval Research Lab. (USA) . . . . . [10970-82]

4:10 pm: **Large-area distributed strain monitoring using patterned nanocomposite sensing skins**, Sumit Gupta, Gianmarco Vella, Kenneth J. Loh, Univ. of California, San Diego (USA) . . . . . [10970-86]

4:30 pm: **Feasibility of force detection in 3D printed flexible material using embedded sensors**, Robert Ponder, Heather R. Roberts, Mohsen Safaei, Steven R. Anton, Tennessee Technological Univ. (USA) . . . . . [10970-88]

4:50 pm: **Sensing sheets based on large area electronics for structural health monitoring of bridges**, Vivek Kumar, Branko Glisic, Princeton Univ. (USA) . . . . . [10970-90]

5:10 pm: **Piezoresistive type graphene nano platelet sensor for SHM application in structural components**, Debadatta Sethy, Indian Institute of Technology Madras (India) . . . . . [10970-92]

Conference End.

CONFERENCE 10972

SESSION 13

LOCATION: CRIPPLE CREEK 2  
THU 3:30 PM TO 5:10 PM

Civil Infrastructure Monitoring III

Session Chairs: **Zhongqing Su**, The Hong Kong Polytechnic Univ. (Hong Kong, China); **Henrique L. Reis**, Univ. of Illinois (USA)

3:30 pm: **Hoisting safety detection technology based on faster R-CNN**, Xuefeng Zhao, Yang Zhang, Zhen Yang, Mingyuan Zhang, Dalian Univ. of Technology (China); Dongfang Li, Guangyi Zhou, Northeast Branch China Construction Eighth Engineering Division Corp., Ltd. (China) . . [10972-79]

3:50 pm: **Communication performance evaluation of a real-time bridge structural monitoring and warning system**, Ittipong Khemapech, Univ. of the Thai Chamber of Commerce (Thailand) . . [10972-80]

4:10 pm: **Method for detecting road pavement damage based on deep learning**, Jiaqi Li, Xuefeng Zhao, Dalian Univ. of Technology (China) . [10972-81]

4:30 pm: **Deep learning-based bridge damage detection using YOLOv3 and field inspection images**, Chaobo Zhang, Chih-Chen Chang, Hong Kong Univ. of Science and Technology (Hong Kong, China) . . . . . [10972-82]

4:50 pm: **Research on 2D digital image correlation measurement based on smartphones**, Botao Xie, Xuefeng Zhao, Jinke Li, Dalian Univ. of Technology (China) . . . . . [10972-83]

Conference End.

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**Bold = SPIE Member**

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**Monday 4 March · 7:00 AM - 5:00 PM**

**Tuesday 5 March · 7:30 AM - 5:00 PM**

**Wednesday 6 March · 7:45 AM - 5:00 PM**

**Thursday 7 March · 7:45 AM - 5:00 PM**

### CONFERENCE REGISTRATION

Includes admission to all conference sessions, plenaries, panels, and poster sessions, Welcome Reception, coffee breaks, and a choice of online proceedings, or online collection.

### Course and Workshop Registration

Courses and workshops are priced separately. Course-only registration includes your selected course(s), course notes and coffee breaks. Course prices include applicable taxes. Onsite, please go to SPIE Registration after you pick up your badge.

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- SPIE Members receive conference and course registration discounts. Discounts are applied at the time of registration.
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Registration Area · Open during registration hours

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If you are paying by cash or check as part of your onsite registration, wish to add a course, workshop, or special event requiring payment, or have questions regarding your registration, visit the SPIE Cashier.

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### Speaker Check-In and Presentation Upload

3rd Floor Leadville Room

Monday through Thursday · 7:30 AM - 5:00 PM

- All presenters must stop by Speaker Check-In to upload their file(s) at least two hours before their scheduled talk. Authors are not able to present using their own devices. View Oral Presentation Guidelines
- All conference rooms have a laptop, projector, screen, lapel microphone, and laser pointer.

### Poster Setup Instructions

3rd Floor Crestone and Crystal Foyer

Tuesday 5 March

Poster presenters may set up between 10:00 AM and 4:00 PM on Tuesday 5 March. Presenters who have not set up by 4:00 PM will be considered a “no show” and their manuscript will not be published. Presenters must remove their posters by 7:30pm that same night. Posters not removed will be considered unwanted and will be discarded. SPIE assumes no responsibility for posters left up after the poster sessions.

## **SPEAKERS ARE NOT ABLE TO PRESENT USING THEIR OWN LAPTOP OR OTHER DEVICE**

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You are required to upload your presentation file at least two hours before your session or the day before if presenting in the first morning session.

### 2. Preview your presentation onsite

All presenters are strongly encouraged to visit Speaker Check-In at least 2 hours prior to their presentation to preview their files through the SPIE presentation system, or the day before if presenting in first morning session).

SPIE will record the audio plus screen content of all presentations; Recordings will be published on the SPIE Digital Library with author permission only.

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#### SPIE Conference and Exhibition App

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#### Business Center

4th Floor Lobby near Hotel Check-In Desk

Hours 24 Hours

Services include self-service fax, copy/printing services, a computer, and wireless high-speed internet.

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SPIE Cashier, Registration Hours

Found items will be kept at SPIE Cashier until end of the meeting and then turned over to the Embassy Suites Hotel

#### Press

For credentialed press and media representatives only. Please email contact information, title, and organization to [media@spie.org](mailto:media@spie.org).

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#### Dining

Home to award-winning chefs and restaurateurs, Denver has emerged as one of the top dining locations in the country. Denver's local culinary scene is thriving, offering everything from farm-to-table bistros to classic steakhouses to historic Denver restaurants.

[www.denver.org/restaurants/denver-dining](http://www.denver.org/restaurants/denver-dining)

#### What to do in Denver

Get local tips on attractions, activities, scenic sightseeing and tours.

[www.denver.org/things-to-do/](http://www.denver.org/things-to-do/)

#### Child Care Services

urbansitter

Website: [urbansitter.com](http://urbansitter.com)

Note: SPIE does not imply an endorsement nor recommendation of these services. They are provided on an "information only" basis for your further analysis and decision. Other services may be available.

#### Conference Hotel

Embassy Suites by Hilton Denver

1420 Stout St., Denver, CO 80202 USA

(303) 592-1000

### Food and Beverage Services

#### Coffee Breaks

2nd Floor Foyer

Complimentary coffee will be served daily, from the opening of registration until 4:00 PM.

#### Hotel Food and Refreshments

4th Floor Foyer

**Free Breakfast:** 4th Floor - for Hotel Guests

A daily, made-to-order breakfast from 6:00 to 9:30 AM

**Free Evening Hotel Reception:\*** 4th Floor - for Hotel Guests

Available nightly 5:50 to 7:30 PM with complimentary appetizers and beverages, both business and leisure travelers looking for a relaxed, upscale experience will feel right at home.

\*Service of alcohol subject to state and local laws. Must be of legal drinking age.

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Monday-Sunday 11:00 AM - 11:00 PM

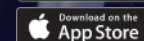
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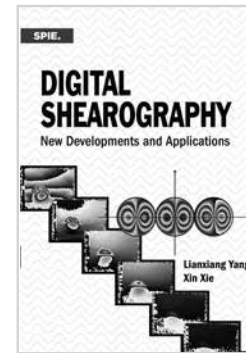
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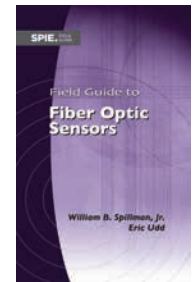
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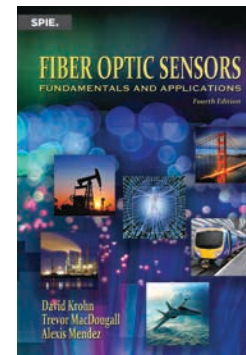
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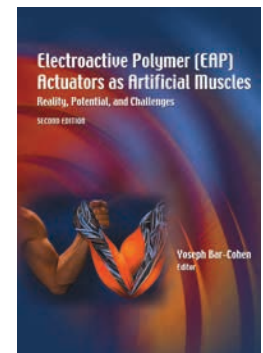
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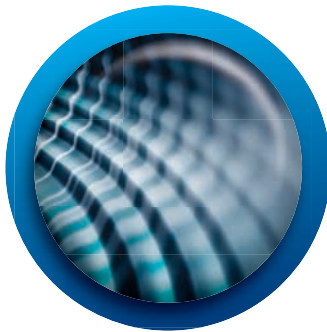


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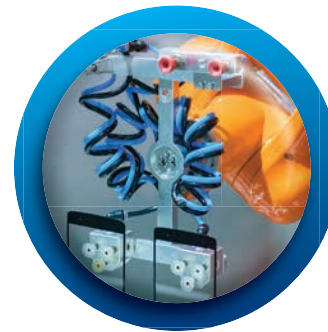
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