# 12th International Symposium on MEMS & Nanotechnology

*Organized by:* Cosme Furlong, Worcester Polytechnic Institute; Gordon A. Shaw, National Institute of Standards and Technology; Barton Prorok, Auburn University; Ryszard J. Pryputniewicz, Worcester Polytechnic Institute

## *Sponsored by the SEM MEMS & Nanotechnology Technical Division*

Microelectromechanical systems (MEMS) and nanotechnology are revolutionary enabling technologies (ET). These technologies merge the functions of sensing, actuation, and controls with computation and communication to affect the way people and machines interact with the physical world. This is done by integrating advances in various multidisciplinary fields to produce very small devices that use very low power and operate in many different environments. Today, developments in MEMS and nanotechnology are being made at an unprecedented rate, driven by both technology and user requirements. These developments depend on micromechanical and nanomechanical analyses, and characterization of structures comprising nanophase materials.

To provide a forum for an up-to-date account of the advances in the field of MEMS and nanotechnology and to promote an alliance of governmental, industrial, and academic practitioners of ET, SEM initiated a *Symposium Series on MEMS and Nanotechnology*.

The 2011 Symposium is the twelfth in the series and addresses pertinent issues relating to design, analysis, fabrication, testing, optimization, and applications of MEMS and nanotechnology, especially as these issues relate to experimental mechanics of microscale and nanoscale structures.

It is with deep gratitude that we thank the Organizing Committee, Session Chairs, Authors and Keynote Speakers, Participants, and SEM Staff for making the 12th-*ISMAN* a valuable and unforgettable experience.

Thank you very much!

## Keynote Presentation:

**Hanchen Huang**
University of Connecticut

Monday, June 13 • 1:50 PM • Session 11

### *Deformation of Nanowires: How They Deform and How We Want Them to Deform*

Atomistic simulations, in synergy with experiments, provide a powerful tool to study mechanics of nanostructures such as nanowires. Like experiments, atomistic simulations are capable of determining the deformation behavior – such as stress-strain curves – of nanowires. In comparison, atomistic simulations also allow more detailed insights – in both time and spatial resolution. These insights guide science-based design of nanowires structures to make nanowires deform in the way we want them to. Upon experimental validation, the science-based design leads to validated discovery. This presentation includes two components: (1) gaining insights of mechanical deformation mechanisms of nanowires, and (2) using the insights to design nanowires structures according to how we want the nanowires to deform.

In terms of gaining insights, we investigate both elastic and plastic deformations of nanowires. For elastic deformation, our atomistic simulations show that nanowires can be elastically stiffer or softer than bulk materials, and that the stiffening/softening is a result of competition between bond saturation and bond loss on surfaces of nanowires. For plastic deformation, our atomistic simulations show that twin boundaries can strengthen nanowires, by forcing dislocation to glide on different and sometimes non-preferable planes. Using the insights, we have proposed a mechanism of controllably introducing twin boundaries into nanowires, and demonstrated its feasibility using atomistic simulations. Upon experimental validation, this mechanism will enable the design of nanowires with controllable twin boundaries and thereby controllable mechanical properties, for the first time.

**Hanchen Huang** holds a School of Engineering Named Professorship in Sustainable Energy at the University of Connecticut (UConn); is a recipient of the Royal Society of London KTP Visiting Professorship in 2010; and is an elected member of Connecticut Academy of Science and Engineering. His research focuses on atomistic simulations of nanofabrication and nanomechanics, and this focus is augmented by experiments of nanofabrication. He has delivered more than 80 keynote/invited talks and seminars, and is an associate editor of *Journal of Engineering Materials and Technology*.

## Keynote Presentation:

**Michael A. Sutton**
University of South Carolina

Monday, June 13 • 2:30 PM • Session 11

### *Quantifying Deformations on the Microscale: Development of an SEM- Based Measurement System for Crack-Tip Strain Measurements*

A series of SEM-based imaging studies at magnifications ranging from 2000X to 20000X demonstrated the presence of various image distortions. Defining the image distortions as either spatial or temporal (drift) in nature, a novel methodology was developed and converted into algorithmic form to quantify and remove both types of distortions from the image-based deformation measurements obtained via digital image correlation or similar image matching approach.

Results from numerical simulations, as well as translation and strain experiments are reported using the proposed methodology for distortion removal that clearly demonstrates the accuracy achievable using typical SEM imaging systems. Specifically, results from the rigid body motion and tensile loading experiments at 200X indicate that, after correction for distortions, (a) the displacements have nearly random variability with standard deviation of 0.04 pixels (0.16μm); (b) the measured strain fields are unbiased and in excellent agreement with previous full-field experimental data obtained with optical illumination and © the strain field standard deviation is on the order of 100 microstrain in all components, with a spatial resolution on the order of 25 pixels (100μm).

**Prof. Sutton** received his Ph.D. in 1981 in Theoretical and Applied Mechanics from the University of Illinois and joined the USC faculty in January, 1982. Prof. Sutton is Past-President of the Society for Experimental Mechanics, a Fellow of ASME and SEM and Honoris Causa Doctor from the Laboratory of Mechanics and Technology within Cachan Université in France. He has published 170+ journal articles, 8 book chapters and the first book on image correlation and solid mechanics in 2009. His current areas of research are experimental and analytical fracture mechanics, computer vision for high rate events and also biomechanics. Prof. Sutton is married to Elizabeth Ann Severns and they have two married daughters, Michelle Mary Katherine Sutton Spigner (32) and Dr. Elizabeth Marie Rosalie Sutton Gosnell (28).