FINAL PROGRAM

June 4 - 8, 2006
Hilton Head Island, South Carolina

Sponsored by

Educational Grants provided by
Defense Advanced Research Projects Agency - MTO/MEMS
The Transducer Research Foundation, Inc.
GENERAL INFORMATION

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The Information/Message Board will be located near the Registration Desk. Messages will be posted in this area throughout the Workshop.

Meeting Room Logistics
Please contact the Workshop Registration Desk if you find the temperature in the room uncomfortable or you are unable to hear or see because of equipment difficulties.

Evaluation
There is a Workshop evaluation form in your packet. Your feedback is very important to the improvement and development of this Workshop. Please return the completed form to the Workshop Registration Desk.

Technical Digest and CD-ROM
An extended abstract of each paper presented at the Workshop has been published in a Technical Digest and on a CD-ROM. One copy of the Digest and the CD-ROM is included with your material. Additional copies may be purchased at the Workshop Registration Desk. Purchase price of the Technical Digest will increase after the Workshop. Be sure to order your additional copies in advance.

You will also find a printed collection of the MEMS Educational Posters with your material and on the CD. The printing of this booklet was supported by the National Science Foundation and National Aeronautics and Space Administration Goddard Space Flight Center.

Additional Technical Digests
Additional Technical Digests may be purchased at the Workshop Registration Desk for $105.00 ($140.00 plus shipping and handling after the Workshop). To take advantage of the Workshop price and to avoid shipping and handling fees, please purchase additional copies during the Workshop.

Smoking
All meeting rooms and seated functions are smoke free. Please regard the smoking policy of the Crowne Plaza Resort and use designated smoking areas only.

Job Market Board
Please visit the Job Market Board located in the lobby near the Workshop Registration Desk to see current job opportunities or to place your resume on the board.

Cellular Phones, Beepers, Watch Alarms, Cameras and Tape Recorders
Out of courtesy to our speakers and other attendees, please turn off any cellular phones, pagers and watch alarms during sessions. Cameras and tape recorders are strictly prohibited in the plenary and poster sessions.

Shipping Service
If you need to ship or mail any packages, please visit the Business Center located across from the Workshop Registration Desk. Shipping is to be at attendees’ own expense. The Business Center is open 24 hours a day.
**High Speed Internet Connection**

All sleeping rooms at the Crowne Plaza are equipped with a wired Internet connection ($9.95 plus tax for 24 hours). The public space of the hotel is equipped with wireless Internet ($9.95 plus tax for 24 hours) and you will need to visit the Hotel front desk to receive a password. You may purchase a package (wired in room and wireless in the public space) for $14.95 plus tax. Please inform the front desk of this request.

You may connect your laptop at the Business Center for no charge for the first 15 minutes of connectivity, but there will be a charge of $8.00 plus tax for each additional 15 minutes.

**MEMS EDUCATION ROUNDTABLE DISCUSSION**

Please join us at the reserved tables during Monday's lunch to discuss a detailed acceptance criteria that might be used for selecting MEMS education abstracts at future Hilton Head meetings. The goal of this discussion would be to define a process for drafting a set of recommendation to the next Hilton Head Program Chair for how MEMS Education papers may be fully integrated into the meeting. Please sign up at the Workshop registration table if you would like to participate in this luncheon roundtable discussion.

**WORKSHOP SOCIAL EVENTS**

**Welcome Reception**

The Welcome Reception will be held in the pavilion, Sunday evening, June 4th, 6:00 p.m. – 9:00 p.m.

**Golf Tournament**

The Tuesday afternoon Golf Tournament will be on June 6th at Golden Bear at Indigo Run Golf Course. Tee times start at 1:00 p.m. If you are interested in joining the Golf Tournament, please see Katharine at the Workshop Registration Desk.

**Banquet**

The banquet will be held in the Pavilion on Tuesday, June 6th, 7:00 p.m. - 9:00 p.m.

**Guest Packages**

Guest meal packages are available for purchase for guests of attendees. The package includes the Sunday Welcome Reception, Hospitality Room Breakfasts (Signals Lounge 8:30 a.m. – 10:00 a.m.), Lunches and the Banquet.

Adult guest packages may be purchased for $100.00 at the Workshop Registration Desk. Child packages (7 – 12 years of age) are available for $50.00 and children under 6 are free.
ORGANIZING COMMITTEE

General Chairman          Thomas W. Kenny - Stanford University
Technical Program Chairman Leland "Chip" Spangler - Aspen Technologies
Treasurer                  Joseph M. Giachino - University of Michigan
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Kim Turner - University of California at Santa Barbara
Xin Zhang - Boston University
The Transducer Research Foundation (TRF) is a nonprofit organization whose mission is to stimulate research within the United States in science and engineering, with emphasis on technologies related to transducers, microsystems, and nanosystems, and to foster the exchange of ideas and information between academic, industrial, and government researchers.

The founders of TRF were also the founders of this biennial "Workshop on Solid-State Sensors, Actuators, and Microsystems," which began in 1984 under IEEE sponsorship. TRF took over the full sponsorship of the workshop in 1994. TRF also sponsors other topical workshops in the microsystems field and supports student development through travel grants that enable students to attend major microsystems conferences and workshops, worldwide.

If your organization would like to explore any of these options for TRF sponsorship or student grants, please contact someone at the Workshop registration desk, or a TRF officer/board member, or visit the web-site www.transducer-research-foundation.org for further information.

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COMMERCIAL SUPPORT

Special acknowledgements to the Transducer Research Foundation, Inc. and the Defense Advanced Research Projects Agency (DARPA) MTO/MEMS Program for their educational grant support of this workshop.

The Transducer Research Foundation, Inc. would also like to thank the following companies for their support, encouragement, and involvement in the 2006 Solid State Sensors, Actuators and Microsystems Workshop.

**Coventor**
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**Tabletop Exhibits – the tabletops are located in the back of the plenary room.**
Monday, June 5

7:00 a.m.  Breakfast

7:45 a.m.  Welcome and Introduction
Thomas W. Kenny, Stanford University and Leland “Chip” Spangler, Aspen Technologies

Session 1 - Micromirrors and Displays
Session Chair – Hal Jerman, Coherent, Inc.

8:15 a.m.  Invited Speaker
TOWARD AN iMoD™ ECOSYSTEM
Mark W. Miles
Qualcomm MEMS Technologies, USA

9:00 a.m.  MAGNETIC TWO-AXIS MICROMIRROR FOR 3D OCT ENDOSCOPY
Draper Laboratory and Massachusetts General Hospital

9:25 a.m.  MEMS SPATIAL LIGHT MODULATOR FOR OPTICAL MASKLESS LITHOGRAPHY
Lucent Technologies

9:50 a.m.  AN OPTICAL MICROSYSTEM FOR DISPLAYS
Evans & Sutherland Corporation, Alces Technology, and Aspen Technologies

10:15 a.m.  Break

Session 2 - Motors
Session Chair – David Arnold, University of Florida

10:40 a.m.  DYNAMIC CHARACTERIZATION OF A LINEAR VARIABLE-CAPACITANCE MICROMOTOR
N. Ghalichechian, A. Modafe, A. Frey, J.H. Lang, and R. Ghodssi
University of Maryland and Massachusetts Institute of Technology

11:05 a.m.  MODELING AND CONTROL OF A 3-DEGREE OF FREEDOM WALKING MICROROBOT
University of Washington and Stanford University

11:30 a.m.  Poster/Oral Session Preview Presentations
Session Chair – Gary K. Fedder, Carnegie Mellon University

12:30 p.m.  Lunch and MEMS Education Roundtable Discussion
5:00 p.m.  Contributed Posters and Late News Posters  
Session Chair – Svetlana Tatic-Lucic, Lehigh University

See page 13 for listing of Contributed Posters and page 20 for Late News Posters.

Tuesday, June 6

7:30 a.m.  Breakfast

Session 3 - Mechanical Structures  
Session Chair – David Arch, Honeywell International

8:15 a.m.  Invited Speaker  
SiSonic™ – THE FIRST COMMERCIALIZED MEMS MICROPHONE  
Peter V. Loeppert and S.B. Lee  
Knowles Electronics, LLC

9:00 a.m.  A MICROMACHINED PIEZOELECTRIC MICROPHONE FOR AEROACOUSTICS APPLICATIONS  
S. Horowitz, T. Nishida, L. Cattafesta, and M. Sheplak  
University of Florida

9:25 a.m.  FLEXIBLE WIRELESS PASSIVE PRESSURE SENSORS FOR BIOMEDICAL APPLICATIONS  
M.A. Fonseca1, M.G. Allen1, J. Kroh2, and J. White2  
1Georgia Institute of Technology and 2CardioMEMS, Inc.

9:50 a.m.  A HIERARCHICAL GECKO-INSPIRED SWITCHABLE ADHESIVE  
M.T. Northen1, K.L. Turner1, C. Greiner2, and E. Arzt2  
1University of California at Santa Barbara and 2Max Planck Institute for Metals Research, GERMANY

10:15 a.m.  Break

Session 4 - Processes  
Session Chair – Aaron Knobloch, General Electric/Global Research

10:40 a.m.  SOI MEMS PROCESS INSENSITIVE TO SACRIFICIAL OXIDE ETCH INDUCED SUBSTRATE ANCHOR PERIMETER VARIATION  
G.J. O'Brien1, D.J. Monk2 and K. Najafi3  
1Arizona State University, 2Freescale Semiconductor and 3University of Michigan

11:05 a.m.  A PLANAR GLASS/SI MICROMACHINING PROCESS FOR THE HEAT EXCHANGER IN A J-T CRYOSURGICAL PROBE  
W. Zhu1, D.W. Hoch3, G.F. Nellis1, S.A. Klein1, and Y.B. Gianchandani1  
1University of Michigan and 2University of Wisconsin

11:30 a.m.  LIGHT-ACTUATED AC ELECTROOSMOSIS FOR OPTICAL MANIPULATION OF NANOSCALE PARTICLES  
P.-Y. Chiou, A.T. Ohta, A. Jamshidi, H.-Y. Hsu, J.B. Chou, and M.C. Wu  
University of California at Berkeley
Late News Oral Papers

11:55 a.m.  800 MHZ LOW MOTIONAL RESISTANCE CONTOUR-EXTENSIONAL ALUMINUM NITRIDE MICROMECHANICAL RESONATORS
P.J. Stephanou and A.P. Pisano
University of California at Berkeley

12:10 p.m.  COMPOSITE FLEXURAL MODE RESONATOR WITH REDUCED TEMPERATURE COEFFICIENT OF FREQUENCY
Stanford University

12:25 p.m. – 1:30 p.m.  Lunch

7:00 p.m. – 9:00 p.m.  Banquet

Wednesday, June 7

7:30 a.m.  Breakfast

Session 5 - Actuators
Session Chair – Michael Putty, Delphi Research Labs

8:15 a.m.  Invited Speaker
SUB-NANOMETER POSITION CONTROL USING A SECOND STAGE ACTUATOR IN HARD DISC DRIVES
Seagate Technology

9:00 a.m.  AUTOMATED OPTICAL FIBER ALIGNMENT IN 2-AXES USING 3D SHAPED ACTUATORS
B. Morgan and R. Ghodssi
University of Maryland

9:25 a.m.  HALF-MILLIMETER-RANGE VERTICALLY SCANNING MICROLENSES FOR MICROSCOPIC FOCUSING APPLICATIONS
A. Jain and H. Xie
University of Florida

9:50 a.m.  BILLION-CYCLE ULV ELECTROSTATIC RF MEMS SWITCH
T.-K.A. Chou, H. Bar, J. Heck, Q. Ma, J.B. Melki, Q. Tran, S. Tubul, B. Weinfeld, and N. Ziharev
Intel Corporation

10:15 a.m.  Break
Session 6 - Resonators
Session Chair – William P. Taylor, Alegro Microsystems, Inc.

10:40 a.m. COUPLED TORSIONAL CANTILEVERS FOR LABEL-FREE SINGLE MOLECULAR LEVEL BIO-DETECTION AND NANOMATERIALS CHARACTERIZATION
O. Sahin1, H.H.J. Persson2, C.F. Quate2, and O. Solgaard2
1Harvard University and 2Stanford University

11:05 a.m. DISSIPATION IN SINGLE-CRYSTAL 3C-SIC ULTRA-HIGH FREQUENCY NANOMECHANICAL RESONATORS
X.L. Feng1, C.A. Zorman2, M. Mehregany3, and M.L. Roukes1
1California Institute of Technology and 2Case Western Reserve University

11:30 a.m. AMPLITUDE NOISE INDUCED PHASE NOISE IN ELECTROSTATIC MEMS RESONATORS
M. Agarwal, K.K. Park, B. Kim, M.A. Hopcroft, S.A. Chandorkar, R.N. Candler, C.M. Jha, R. Melamud, T.W. Kenny, and B. Murmann
Stanford University

11:55 a.m. Lunch

Late News Oral Papers
Session Chair – Kimberly L. Turner, University of California at Santa Barbara

1:15 p.m. FAST, MEMS-BASED, PHASE-SHIFTING INTERFEROMETER
H. Choo1, R. Kant2, D. Garmire1, J. Demmel1, and R.S. Muller1
1University of California at Berkeley and 2Stanford University

1:30 p.m. ADVANCED MEMS SPATIAL LIGHT MODULATOR FOR COMMUNICATIONS, IMAGING, AND TARGETING
Lucent Technologies

1:45 p.m. PROXIMITY MODE INCLINED UV LITHOGRAPHY
Y.-K. Yoon and M.G. Allen
Georgia Institute of Technology

2:00 p.m. SILICON-ON-SILICON (SOS): A NEW CMOS COMPATIBLE LOW TEMPERATURE MEMS PROCESS USING PLASMA ACTIVATED FUSION BONDING
T. Galchev, W.C. Welch, III, and K. Najafi
University of Michigan

2:15 p.m. A MICROFABRICATED IMPEDANCE SENSOR FOR IONIC TRANSPORT IN NANOPOROUS
S. Prakash, J. Yeom, and M.A. Shannon
University of Illinois at Urbana-Champaign
2:30 p.m.  PASSIVE MICROFLOW REGULATION USING THERMALLY RESPONSEIVE POLYMERS
B. Stoeber¹, D. Liepmann², and S.J. Muller²
¹University of British Columbia, CANADA and ²University of California at Berkeley

2:45 p.m.  CONTROLLED DROPLET COALESCENCE IN AIR AND ITS APPLICATION TO MICROMIXING
C.-Y. Lee, H. Yu, and E.S. Kim
University of Southern California

6:00 p.m. – 8:00 p.m.  MEMS Educational Posters and Open Posters
Session Chair – James M. Bustillo, Lawrence Berkeley National Laboratory

See page 21 for listing of MEMS Educational Posters and page 22 for Open Posters.

8:00 p.m. – 10:00 p.m.  Rump Session
Session Chair – Jack Judy, University of California at Los Angeles

Thursday, June 8

7:30 a.m.  Breakfast

Session 7 - Micro Devices
Session Chair – Stephen Casalnuovo, Sandia National Laboratory

8:15 a.m.  Invited Speaker
CHIP-SCALE ATOMIC DEVICES
John Kitching¹, S. Knappe¹, P.D.D. Schwindt¹, Y.-J. Wang¹, H. Robinson¹, L. Hollberg¹, L.-A. Liew¹, J. Moreland¹, A. Brannon², J. Breitbarth³, B. Lindseth⁴, Z. Popovic⁵, V. Shah⁶, V. Gerginov⁷, and M. Eardley⁸
¹National Institute of Standards and Technology, ²University of Colorado, ³University of Notre Dame, and ⁴State University of New York

9:00 a.m.  A MEMS SINGLET OXYGEN GENERATOR
T.F. Hill¹, L.F. Velásquez-García¹, B.A. Wilhite², K.F. Jensen¹, A.H. Epstein¹, and C. Livermore¹
¹Massachusetts Institute of Technology and ²University of Connecticut

9:25 a.m.  A MICRO DIRECT METHANOL FUEL CELL WITH SELF-PUMPING OF LIQUID FUEL
D.D. Meng and C.-J. Kim
University of California at Los Angeles

9:50 a.m.  AN IMPROVED SILICON DIRECT FORMIC ACID FUEL CELL FOR PORTABLE POWER GENERATION
K.-L. Chu, R.I. Masel, and M.A. Shannon
University of Illinois at Urbana-Champaign

10:15 a.m.  Break
Session 8 - Chemical Devices
Session Chair – Storrs Hoen, Agilent Labs

10:40 a.m. CHANNEL-TO-DROPLET EXTRACTIONS FOR ON-CHIP SAMPLE PREPARATION
U.-C. Yi, W. Liu, P.-P. de Guzman, and C.-J. Kim
Core Microsolutions, Inc.

11:05 a.m. ENGINEERING SURFACE MICRO-STRUCTURE TO CONTROL FOULING AND HYSTERESIS IN DROPLET BASED MICROFLUIDIC BIOANALYTICAL SYSTEMS
A. Shastry, S. Goyal, A. Epilepsia, M.J. Case, S. Abbasi, B. Ratner, and K.F. Böhringer
University of Washington

11:30 a.m. A NOVEL BENZOCYCLOBUTENE-BASED DEVICE FOR STUDYING THE PHYSICS OF THE EBULLITION PROCESS
S. Moghaddam, K.T. Kiger, A. Modafe, and R. Ghodssi
University of Maryland

11:55 a.m. STREAMLINE BASED DESIGN OF A MEMS DEVICE FOR CONTINUOUS BLOOD CELL SEPARATION
S. Zheng and Y.-C. Tai
California Institute of Technology

12:20 p.m. Closing Remarks
Thomas W. Kenny and Leland “Chip” Spangler

12:25 p.m. – 2:00 p.m. Lunch

Contributed Posters

CHEMICAL

P1 A LOW-POWER PRESSURE- AND TEMPERATURE-PROGRAMMABLE µGC COLUMN
J.A. Potkay, G.R. Lambertus, R.D. Sacks, and K.D. Wise
University of Michigan

P2 A NANO INTERDIGITATED ELECTRODES ARRAY ON POLYMER FOR DISPOSABLE IMPEDIMETRIC BIOSENSORS
Z. Zou, J. Kai, M.J. Rust, and C.H. Ahn
University of Cincinnati

P3 A MICROMACHINED INKING CHIP FOR SCANNING PROBE NANOLOITHOGRAPHY USING LOCAL THERMAL VAPOR INKING METHOD
S. Li, K.A. Shaikh, S. Szegedi, E. Goluch, and C. Liu
University of Illinois at Urbana-Champaign
P4 A PNEUMATICALLY-ACTUATED MICROVALVE FOR SPATIALLY-SELECTIVE CHEMICAL DELIVERY
K. Baek, Y. Li, M. Gulari, and K.D. Wise
University of Michigan

P5 CHARACTERIZATION AND DESIGN OF DIGITIZING PROCESSES FOR UNIFORM AND CONTROLLABLE DROPLET VOLUME IN EWOD DIGITAL MICROFLUIDICS
J. Gong and C.J. Kim
University of California at Los Angeles

P6 DEVELOPMENT OF A WATER MONITORING SYSTEM BASED ON INTEGRATED POLYMER MICROFLUIDICS
L. Zhu1, D. Meier1, Z. Boger2,3, C. Montgomery2, S. Semancik2, and D.L. DeVoe1
1University of Maryland, 2National Institute of Standards and Technology, and 3OPTIMAL – Industrial Neural Systems Ltd., ISRAEL

P7 EXPERIMENTAL CHARACTERIZATION OF FREQUENCY DEPENDENT ELECTROSTATIC ACTUATOR FOR AQUEOUS MEDIA
V. Mukundan and B.L. Pruitt
Stanford University

P8 LAB-ON-A-CARD ASSAY FOR ENTERIC PATHOGENS
B.H. Weigl1, J. Gerdes2, P. Tarr3, P. Yager1, L. Dillman1, J. Gerlach1, M. Steele1, R. Peck1, S. Ramachandran1, M. Lemba1, D. Hoekstra2, M. Kokoris2, M. Nabavi1, F. Battrell2, D.M. Denno3, and E.J. Klein1
1Program for Appropriate Technology in Health, 2Micronics, Inc., 3University of Washington at Seattle, and 4Washington University at St. Louis

P9 IMPEDANCE BASED BIOSENSOR WITH DIELECTROPHORESIS CONCENTRATION FOR CARDIAC MYOCYTE HYPERTROPHY SENSING
M. Yang1, C.C. Lim1, R. Liao2, and X. Zhang1
1Boston University and 2Harvard Medical School

P10 IN-DROPLET PARTICLE SEPARATION BY TRAVELLING WAVE DIELECTROPHORESIS (twDEP) AND EWOD
Y. Zhao1, U.-C. Yi2, and S.K. Cho1
1University of Pittsburgh and 2Coremicrosolutions Inc.

P11 METAL-CORED CARBON MICROPOSTS FOR THREE-DIMENSIONAL Li+ MICROBATTERY
F. Chamran, U.-C. Yi, and C.-J. Kim
University of California at Los Angeles

P12 MICRO-MRI VELOCIMETRY IN MICROCHANNEL NETWORKS
L.G. Raguin, D.C. Karapminos, S. Honecker, and J.G. Georgiadis
University of Illinois at Urbana-Champaign
P13  MICROFLUIDIC MIXERS FOR THE INVESTIGATION OF PROTEIN FOLDING USING SYNCHROTRON RADIATION CIRCULAR DICHROISM SPECTROSCOPY
A.S. Kane¹,², D. Hertzog¹, P. Baumgartel³, J. Lengefeld³, D. Horsley², B. Schuler⁴, and O. Bakajin³
¹Lawrence Livermore National Laboratory, ²University of California at Davis, ³University of Potsdam, GERMANY, and ⁴University of Zurich, SWITZERLAND

P14  MULTILAYERED POLYMER MICROFLUIDIC CHIP WITH NANOFLOWDIC INTERCONNECTS FOR MOLECULAR MANIPULATION
University of Illinois at Urbana-Champaign

P15  NANO SELF-ASSEMBLED ION-SENSITIVE FIELD-EFFECT TRANSISTORS FOR ACETYLCHOLINE BIOSENSING
Y. Liu, A.G. Erdman, and T. Cui
University of Minnesota

P16  SURFACE-MICROMACHINED IN-CHANNEL PARYLENE DUAL VALVES FOR UNPOWERED MICROFLOW REGULATION
P.-J. Chen¹, D.C. Rodger², E. Meng³, M.S. Humayun², and Y.-C. Tai¹
¹California Institute of Technology and ²University of Southern California

P17  SURGICALLY IMPLANTED MICRO-PLATFORMS IN MANDUCA-SEXTA MOTHS
A. Paul, A. Bozkurt, J. Ewer, B. Blossey, and A. Lal
Cornell University

P18  WIRELESS CHEMICAL SENSORS FOR HIGH TEMPERATURE ENVIRONMENTS
E. Birdsell and M.G. Allen
Georgia Institute of Technology

PHYSICAL
P19  ARRAYS OF COUPLED NANOMECHANICAL RESONATORS
M.K. Zalalutdinov¹, J.W. Baldwin², M.H. Marcus², B.H. Houston², R.B. Reichenbach³, and J.M. Parpia³
¹SFA, Inc., ²Naval Research Laboratory, and ³Cornell University

P20  A 2-AXIS QUASI-PASSIVE PLATFORM FOR NANOSCALE PHOTONIC ASSEMBLY
B. Li, M. Pietrusky, and A. Sharon
Fraunhofer USA

P21  A MONOLITHIC CMOS-MEMS 3-AXIS ACCELEROMETER WITH A LOW-NOISE, LOW-POWER DUAL-CHOPPER AMPLIFIER
H. Qu, D. Fang, and H. Xie
University of Florida

P22  A COMBUSTIBLE/ELECTRONEGATIVE GAS DETECTOR UTILIZING URANIUM DOPED CAST CERAMIC MICROCHANNELS
J.D. Olivier and C.G. Wilson
Louisiana Technical University
A DIGITAL MEMS OPTICAL SWITCH
R.C. Gutierrez¹, T.K. Tang¹, R. Calvet¹, D. Harrington¹, S. Vargo¹, and I. Chakraborty²
¹Siimpel Corporation and ²Bain & Company, Inc.

A MAGNETICALLY ENHANCED WIRELESS MICRO-GEIGER COUNTER
C.K. Eun¹, R. Gharpurey², and Y.B. Gianchandani¹
¹University of Michigan and ²University of Texas at Austin

A MICROASSEMBLED LARGE-DEFLECTION TIP/TILT MICROMIRROR FROM A SINGLE-MASK DRIE PROCESS
M.E. Last, V. Subramaniam, and K.S.J. Pister
University of California at Berkeley

A NANOMECHANICAL PROTEIN CONCENTRATION DETECTOR USING A NANO-GAP SQUEEZING ACTUATOR WITH COMPENSATED DISPLACEMENT MONITORING ELECTRODES
W.C. Lee¹², Y.-H. Cho¹, and A.P. Pisano²
¹Korea Advanced Institute of Science and Technology, KOREA and ²University of California at Berkeley

A PIEZOELECTRICALLY ACTUATED CERAMIC-SI-GLASS MICROVALVE FOR DISTRIBUTED COOLING SYSTEMS
J.M. Park¹, R.P. Taylor¹, A.T. Evans¹, T.R. Brosten², G.F. Nellis², S.A. Klein³, J.R. Feller³, L. Salerno³, and Y.B. Gianchandani¹
¹University of Michigan, ²University of Wisconsin, and ³NASA Ames Research Center

A RESONANT SISO SENSOR BASED ON A COUPLED ARRAY OF MICROELECTROMECHANICAL OSCILLATORS
B.E. DeMartini¹, J.F. Rhoads², S.W. Shaw², and K.L. Turner¹
¹University of California at Santa Barbara and ²Michigan State University

A VARIABLE FOCUS MICROLENS USING EWOD ON A TAPERED SU-8 STRUCTURE
Y.-J. Chang, V.M. Bright, E. Schonbrun, and K. Mohseni
University of Colorado at Boulder

ABSORPTION FILTERS FOR WAVELENGTH TUNING AND FINESSE SWITCHING OF LONG WAVE INFRARED THERMAL DETECTORS
Y. Wang, B.J. Potter, M. Sutton, and J.J. Talghader
University of Minnesota

ADHESION AND FRICTION MEASUREMENT METHOD FOR A MEMS PROBE ARRAY
W.S. Smith, P.G. Hartwell, and R.G. Walmsley
Hewlett-Packard Laboratories

DESENSITIZING METHOD FOR MEASUREMENT OF THIRD-ORDER INTERMODULATION DISTORTION IN CMOS-MEMS MICROMECHANICAL RESONATORS
C.-C. Lo and G.K. Fedder
Carnegie Mellon University
P33  DESIGN & CHARACTERIZATION OF A MEMS THERMAL SWITCH
1Washington State University and 2Portland State University

P34  DESIGN, FABRICATION, AND CHARACTERIZATION OF A
MICROTURBOPUMP FOR A RANKINE CYCLE MICRO POWER
GENERATOR
C. Lee, M. Lianini, and L.G. Fréchette
1Columbia University and 2Université de Sherbrooke, CANADA

P35  DEVELOPMENT AND CHARACTERIZATION OF HIGH-SENSITIVITY
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1General Electric Global Research Center and
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1University of California at Berkeley and 2California Institute of Technology

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University of California at Los Angeles
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J. Liu1, D.L. DeVoe1, and L. Fan2
1University of Maryland and 2Naval Surface Warfare Center

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J.M. Engel, N. Chen, K. Ryu, S. Pandya, C. Tucker, Y. Yang, and C. Liu
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PRESSURE ENHANCED AIR DAMPING IN ENCLOSED LATERALLY OSCILLATING MICROSTRUCTURES
K.Y. Yasumura1 and H. Jerman2
1FormFactor Inc. and 2Coherent Inc.

SELF-POWERED HUMIDITY SENSOR POWERED BY NICKEL-63 RADIOISOTOPE
R. Duggirala1, A. Lal1, C. Pollock1, and M. Kranz2
1Cornell University and 2Morgan Research Corporation

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University of Minnesota

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H. Yu, H. Zhang, W. Pang, and E.S. Kim
University of Southern California

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J. Lee, T. Beecham, K. Park, Z. Zhang, S. Graham, and W.P. King
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WIDE DYNAMIC RANGE MICROELECTROMECHANICAL VISCOSITY SENSOR
R.L. Borwick, III, P.A. Stupar, and J.F. DeNatale
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WIREBONDER ASSEMBLY OF HINGELESS 90° OUT-OF-PLANE MICROSTRUCTURES
S.H. Tsang, D. Sameoto, I. Foulds, A.M. Leung, and M. Parameswaran
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P55 EVALUATION OF O² PLASMA AND XeF² VAPOR ETCH RELEASE PROCESSES FOR RF-MEMS SWITCHES FABRICATED USING CMOS INTERCONNECT TECHNOLOGY
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N. Duarte, Q. Xiong, S. Tadigadapa, and P.C. Eklund
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P57 HIGH SPEED ANISOTROPIC ETCHING OF GLASS AND PIEZOCERAMICS FOR MICROSYSTEM APPLICATIONS
A. Goyal, S.S. Subasinghe, V. Hood, and S. Tadigadapa
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P58 LATERAL LAMINATION APPROACH FOR MULTILAYER PIEZOELECTRIC MICROACTUATOR
X. Wu, G. Yuan, S.-O. Choi, Y. Zhao, S.-H. Kim, Y.-K. Yoon, and M.G. Allen
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P59 LONG-TERM RELIABILITY, BURN-IN AND ANALYSIS OF OUTGASSING IN Au-Si EUTECTIC WAFER-LEVEL VACUUM PACKAGES
J. Mitchell, G.R. Lahiji, and K. Najafi
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P60 MEMS CANTILEVER BEAM ELECTROSTATIC PULL-IN MODEL
G.J. O’Brien1, D.J. Monk2, and L. Lin3
1Arizona State University, 2Freescale Semiconductor, and 3University of California at Berkeley

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X. Jiang1, J.R. Yuan2, A. Cheng3, G. Lavelle3, P. Rehrig1, K. Snook1, S. Kwon1, W. Hackenberger1, J. Catchmark3, J. McIntosh3, and X. Geng4
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P62 MICROMANIPULATOR CONTROLLED FABRICATION OF MICRO- AND NANOSCALE POLYMER FIBERS AND APPLICATION AS SACRIFICIAL STRUCTURES IN THE PRODUCTION OF MICROCHANNELS
S.M. Berry, T.J. Roussel, S.D. Cambron, S.A. Harfenist, R.W. Cohn, and R.S. Keynton
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P63 OPTIMAL PARAMETERS FOR ArF LASER MICROMACHINING OF SiC AND PZT
J.-P. Desbiens and P. Masson
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P66 WIRELESS SENSING OF DISCHARGE CHARACTERISTICS FOR QUALITY CONTROL IN BATCH MODE MICRO-ELECTRO-DISCHARGE MACHINING
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1University of Michigan and 2University of Texas at Austin

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D.J. Laser, C.T. Hardham, and J. Kim
Wave 80 Biosciences, Inc.

P68 DIRECTIONAL REASSEMBLY OF MYOFIBRILS IN CULTURED CARDIAC MYOCYTES USING A THREE-DIMENSIONAL POLYMERIC SUBSTRATE
Y. Zhao and X. Zhang
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P69 AN ELASTIC MEMS DEVICE FOR CELLULAR FORCE MEASUREMENT
Y. Sun, X. Liu, W. Wang, and B.M. Lansdorp
University of Toronto, CANADA

P70 ENVIRONMENT-ADAPTIVE VARIABLE-FOCUS LIQUID MICROLENSES
L. Dong, A.K. Agarwal, D.J. Beebe, and H. Jiang
University of Wisconsin

P71 TEMPERATURE REGULATED NONLINEAR MICROVALVES FOR SELF-ADAPTIVE MEMS COOLING
M. McCarthy1, N. Tiliakos1,2, V. Modi1, and L.G. Fréchette1,2
1Columbia University, 2Université de Sherbrooke, CANADA, and 3ATK – GASL
MEMS Educational Posters

**EP1** A MEMS/MICROSYSTEM CURRICULUM WITH INTERNATIONAL DISSEMINATION
L.C. McAfee¹, K. Najafi¹, Y.B. Gianchandani¹, K.D. Wise¹, M.M. Maharbiz¹,
D.M. Aslam², P.L. Bergstrom³, and C.R. Friedrich⁴
¹University of Michigan, ²Michigan State University, and
³Michigan Technological University

**EP2** ADAPTING INTERDISCIPLINARY MEMS TEACHING AND TRAINING IN A “SMALL” FACULTY ENVIRONMENT
S. Bhansali
University of South Florida

**EP3** AN INTERDISCIPLINARY LABORATORY COURSE IN MICROSYSTEM DEVELOPMENT
K.D. Wise, K.T. Beach, T.F. Briggs, R.J. Gordenker, and M.N. Gulari
University of Michigan

**EP4** BENCHTOP POLYMER MEMS AS A LOW-COST EDUCATIONAL TOOL
M. Urdaneta, R. Delille, and E. Smela
University of Maryland

**EP5** EVOLUTION OF THE HILTON HEAD WORKSHOP RESEARCH COMMUNITY
A.D. Troy, G.-Q. Zhang, and M. Mehregany
Case Western Reserve University

**EP6** HANDS-ON MEMS: BUILDING COMPETENCE THROUGH PRACTICAL LEARNING EXPERIENCES
L.G. Fréchette¹,², C.W. Wong³, K. Chin³, K.F. Farmer⁴, G. Georgiou³, F. Miller³,
and V. Modi⁵
¹Université de Sherbrooke, CANADA, ²Columbia University,
³New Jersey Institute of Technology, ⁴TSI Incorporated, and ⁵Lehigh University

**EP7** INTRODUCTORY MICROMACHINING AND MEMS COURSE FOR GRADUATE AND UNDERGRADUATE STUDENTS
J.W. Judy¹ and P.S. Motta²
¹University of California at Los Angeles and ²Innovative Micro Technology

**EP8** MEMS CURRICULUM AT AUBURN UNIVERSITY’S MICROELECTRONICS CENTER
R. Ramadoss
Auburn University

**EP9** COMPREHENSIVE MEMS CURRICULUM AT UCLA
J.W. Judy, G.P. Carmen, F.M.-C. Chang, Y. Chen, H.H. Fetterman, N.N. Ghoniem,
W.S. Grudfest, V. Gupta, C.-M. Ho, Y.S. Ju, W.J. Kaiser, P. Kavehbour, C.-J. Kim,
R.T. M’Closky, C.D. Montemagno, L. Pilon, J.J. Schmidt, E. Yablonovitch,
and X. Zhong
University of California at Los Angeles
### EP10 Micro and Nanoscale Education at Stanford University

A.A. Barlian, R.T. Howe, G.T.A. Kovacs, and B.L. Pruitt

Stanford University

### EP11 NSF/NASA-GSFC MEMS Education Workshop Outcomes

B.L. Pruitt¹, M.T.A. Saif², R. Ghodssi³, K.L. Turner⁴, J.W. Judy⁵, and M.A. Schmidt⁶

¹Stanford University, ²University of Illinois at Urbana-Champaign, ³University of Maryland, ⁴University of California at Santa Barbara, ⁵University of California at Los Angeles, and ⁶Massachusetts Institute of Technology

### EP12 Self-Assembly of a BiomeMS Syllabus: Teaching BiomeMS Through the Developing Organism

M.M. Maharbiz

University of Michigan

### EP13 The 18mm² Classroom

T. Dallas, R. Gale, and J. Berg

Texas Tech University

### EP14 What Should a First College Course on MEMS Be?

K. Najafi and M. Maharbiz

University of Michigan

### Open Posters

#### CHEMICAL

**OP1** Chitosan for Biofunctionalization of MEMS


University of Maryland

**OP2** Design and Characterization of a Polymer-Based Microfluidic System for Electrophysiological Studies

E.D. Moss, N. Reddy, and A.B. Frazier

Georgia Institute of Technology

**OP3** Force-Sensing Pillars for the Study of Locomotion in the Nematode C. elegans

S.M. Coulthard¹, S.-J. Park¹, S. Lockery², M.B. Goodman¹, and B.L. Pruitt¹

¹Stanford University and ²University of Oregon

**OP4** InP Optical MEMS for Integrated Sensing and Photonics Applications

N. Siwak, J. McGee, and R. Ghodssi

University of Maryland

**OP5** Integrated System to Analyze the Genic Effects of the Space Environment on Living Cells in Culture: Genesat

A.J. Riccu¹, E. Agasid², V. Barker², T. Fahlen², M. Henschke², J.W. Hines², L. Levine², R. Mancinelli², D. Oswell¹, R. Ricks², K. Ronzano², D. Squires², C. Storment¹, G. Swaiss², L. Timucin¹, J. Tucker², U. Udoh³, and B. Yost²

¹Stanford University, ²NASA Ames Research Center, and ³ALine, Inc.
OP6  OPTICAL CARBON MONOXIDE SENSING WITH NANO-COMPOSITE THIN FILMS OF NiO/Au IN SiO$_2$
M.L. Post$^1$, A. Martucci$^2$, D. Buso$^3$, and M. Guglielmi$^2$
$^1$National Research Council of Canada and $^2$University of Padova, ITALY

OP7  ORIENTED AND VECTORIAL PATTERNING OF CARDIOMYOCYTES USING A MICROFLUIDIC DIELECTROPHORESIS CHIP - TOWARDS ENGINEERED CARDiac TISSUE WITH CONTROLLED MACROSCOPIC ANISOTROPY
M. Yang and X. Zhang
Boston University

OP8  A MICROFLUIDIC BASED HIGH THROUGHPUT RESISTIVE-PULSE SENSOR FOR BIOPARTICLE DETECTION AND COUNTING
J. Zhe, A. Jagtiani, and J. Hu
University of Akron

EDUCATION

OP9  A NANOGRAM MICROROBOT DEMONSTRATION COMPETITION FOR ROBOCUPSOCCER
C. McGray$^1$, F. Arai$^2$, A. Jacoff$^1$, S. Tadokoro$^2$, and M. Gaitan$^1$
$^1$National Institute of Standards and Technology and $^2$Tohoku University, JAPAN

PHYSICAL

OP10  A SILICON-ON-INSULATOR INERTIAL MEMS MULTISENSOR
M. Kranz$^1$, J. McKee$^1$, M. Whitley$^1$, T. Hudson$^2$, and S. Holt$^3$
$^1$Morgan, A Stanley Company and $^2$U.S. Army AMRDEC

OP11  MODELING OF CMOS COMPATIBLE MEMS ACTUATORS FOR WIRELESS COMMUNICATIONS
R.Kotha and A.A. Ayon
University of Texas

OP12  TEMPERATURE-STABILIZED MICROMECHANICAL RESONATORS
M.A. Hopcroft$^1$, B. Kim$^1$, S.A. Chandorkar$^1$, M. Agarwal$^1$, R. Melamud$^1$, C.M. Jha$^1$, R.N. Candler$^2$, G. Yama$^2$, and T.W. Kenny$^1$
$^1$Stanford University and $^2$Robert Bosch Corporation

OP13  THE PHAZIR™: A PORTABLE MEMS-BASED NEAR-INFRARED SPECTROMETER
S.D. Senturia, M. Butler, E. Deutsch, D. Day, M. Smith, A. McAllister, K. Zafiriou, K. Bober, J. Booth, E. Jahn, and F. Haibach
Polychromix, Inc.

TECHNICAL

OP14  APPLICATION OF A MODIFIED QUALITY FUNCTION DEPLOYMENT METHOD FOR MEMS
T. Lamers, R. Flynn, P. Chiang, Y.R. Rau, B. Pruitt, and K. Ishii
Stanford University

OP15  FULLY DRY MICROASSEMBLY AND PARALLEL PART TRANSFER USING ADHESION FORCE AT THE SOLID/SOLID INTERFACE
K. Wang$^1$, R. Baskaran$^2$, and K.F. Böhringer$^1$
$^1$University of Washington and $^2$Intel
IN-PLANE STRAIN DETERMINATION IN NANOSCALE CANTILEVERS USING SCANNING MOIRÉ INTERFEROMETRY
Y. Zhao and X. Zhang
Boston University

LENGTH-SCALE EFFECT ON NANOINDENTATION CREEP IN PLASMA-ENHANCED CHEMICAL VAPOR DEPOSITED SILICON OXIDE FILMS
Z. Cao and X. Zhang
Boston University

LEVERAGING STANDARD IC PACKAGING FOR MEMS OSCILLATORS
SiTime Corporation

PARAMETERIZED METHOD FOR MEMS GEAR DESIGN
E.S. Kolesar and C.A. Edwards
Texas Christian University

SIMULTANEOUS MEASUREMENT OF TEMPERATURE AND STRESS IN MEMS DEVICES USING RAMAN SPECTROSCOPY
T. Beechem and S. Graham
Georgia Institute of Technology

SMART CERAMIC PACKAGING
C. Sippola and C. Ahn
University of Cincinnati

THEORY AND EXPERIMENTS FOR GRADIENT RESIDUAL STRESS IN MEMS-BASED INFRARED DETECTOR STRUCTURES
S. Huang and X. Zhang
Boston University

THERMALLY DRIVEN MICRO/NANO GAS FLOWS: NUMERICAL TECHNIQUES AND PHYSICAL PHENOMENA
N. Masters and W. Ye
Georgia Institute of Technology