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Yoseph Bar-Cohen
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Contents

Part One

- xiii *Conference Committee*
- xvii *Introduction*
- xix *EAP-in-Action Demonstrations*

ELECTRO-CHEMO-MECHANICAL ACTUATORS AND MECHANO-CHEMO-ELECTRICAL SENSORS

- 8687 05 **Reactive actuators and sensors integrated in one device: mimicking brain-muscles feedback communication (Invited Paper)** [8687-4]
T. F. Otero, J. G. Martinez, Univ. Politécnica de Cartagena (Spain)
- 8687 06 **Self-sensing ionic electromechanically active actuator with patterned carbon electrodes** [8687-5]
K. Kruusamäe, F. Kaasik, A. Punning, A. Aabloo, Univ. of Tartu (Estonia)
- 8687 07 **Fabrication and characterization of a two-dimensional IPMC sensor** [8687-6]
H. Lei, X. Tan, Michigan State Univ. (United States)
- 8687 08 **Conducting polymers are simultaneous sensing actuators** [8687-7]
F. G. Córdova, Univ. Politécnica de Cartagena (Spain); Y. A. Ismail, A'Sharqiyah Univ. (Oman); J. G. Martinez, Univ. Politécnica de Cartagena (Spain); A. S. Al Harrasi, Univ. of Nizwa (Oman); T. F. Otero, Univ. Politécnica de Cartagena (Spain)

ACTUATOR FOR SOFT ROBOTIC OR FOR BIOMEDICAL APPLICATIONS

- 8687 09 **Electroactive polymer and shape memory alloy actuators in biomimetics and humanoids (Invited Paper)** [8687-8]
Y. Tadesse, The Univ. of Texas at Dallas (United States)
- 8687 0B **Electroactive polymer (EAP) mobility device** [8687-10]
M. Stasik, M. Moore, C. Plaxico, J. Sayre, Battelle Memorial Institute (United States)
- 8687 0D **Power electronics concepts for driving EAP actuators** [8687-12]
L. Eitzen, T. Hoffstadt, J. Maas, Hochschule Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 0E **Understanding efficiency limits of dielectric elastomer driver circuitry** [8687-13]
H. Lo, The Univ. of Auckland (New Zealand); E. Calius, Industrial Research Ltd. (New Zealand); I. Anderson, The Univ. of Auckland (New Zealand)
- 8687 0F **Progress toward EAP actuators for biomimetic social robots** [8687-96]
D. Hanson, Hanson Robotics, Inc. (United States) and The Univ. of Texas at Arlington (United States)

ENERGY HARVESTING I

- 8687 OG **Finite element modeling of the sensing and energy harvesting performance in ionic polymer metal composites** [8687-15]
B. Akle, W. Habchi, Lebanese American Univ. (Lebanon)
- 8687 OH **Autonomous dielectric elastomer generator using electret** [8687-16]
T. Vu-Cong, Univ. of Grenoble (France); C. Jean-Mistral, Univ. of Lyon (France); A. Sylvestre, Univ. of Grenoble (France)
- 8687 OI **Oscillating-water-column wave-energy-converter based on dielectric elastomer generator** [8687-17]
R. Vertechy, M. Fontana, G. P. Rosati Papini, M. Bergamasco, Scuola Superiore Sant'Anna (Italy)
- 8687 OJ **3-dimensional fabrication of soft energy harvesters** [8687-18]
T. McKay, The Univ. of Auckland (New Zealand); P. Walters, Univ. of the West of England (United Kingdom); J. Rossiter, Univ. of Bristol (United Kingdom); B. O'Brien, I. Anderson, The Univ. of Auckland (New Zealand)
- 8687 OK **Electroactive polymers for gaining sea power** [8687-19]
B. Scherber, Bosch Rexroth AG (Germany); M. Grauer, Robert Bosch GmbH (Germany); A. Köllnberger, Wacker Chemie AG (Germany)

ENERGY HARVESTING II

- 8687 OL **Platform based design of EAP transducers in Danfoss PolyPower A/S** [8687-20]
R. Sarban, Danfoss PolyPower A/S (Denmark); T. V. Guðlaugsson, Technical Univ. of Denmark (Denmark)
- 8687 OM **The electro-mechanical phase transition of Gent model dielectric elastomer tube with two material constants** [8687-21]
L. Liu, X. Luo, F. Fei, Y. Wang, J. Leng, Y. Liu, Harbin Institute of Technology (China)
- 8687 ON **Optimized energy harvesting materials and generator design** [8687-22]
C. Graf, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany); J. Hitzbleck, T. Feller, K. Clauberg, J. Wagner, J. Krause, Bayer MaterialScience AG (Germany); J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 OO **Comparison of the dielectric electroactive polymer generator energy harvesting cycles** [8687-23]
E. Dimopoulos, I. Trintis, S. Munk-Nielsen, Aalborg Univ. (Denmark)
- 8687 OP **Modular DC-DC converter system for energy harvesting with EAPs** [8687-24]
L. Eitzen, C. Graf, J. Maas, Hochschule Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 OQ **Dielectric elastomer generator with equi-biaxial mechanical loading for energy harvesting** [8687-25]
J. Huang, S. Shian, Z. Suo, D. R. Clarke, Harvard Univ. (United States)

- 8687 OR **Electrode effect on the cellulose piezo-paper energy harvester** [8687-26]
L. Zhai, B.-W. Kang, J.-H. Kim, J. Kim, Inha Univ. (Korea, Republic of); Z. Abas, H. S. Kim, Dongguk Univ. (Korea, Republic of)

POSTER SESSION

- 8687 OS **Hot-embossing of microstructures on addition-curing polydimethylsiloxane films** [8687-89]
S. Vudayagiri, L. Yu, S. S. Hassouneh, A. L. Skov, Technical Univ. of Denmark (Denmark)
- 8687 OT **Evolutionary algorithms for the multi-objective optimization of stacked dielectric elastomer actuators** [8687-90]
A. D. Price, ABB Corporate Research (Germany)
- 8687 OU **Anticipating electrical breakdown in dielectric elastomer actuators** [8687-91]
D. P. Muffoletto, K. M. Burke, J. L. Zirnheld, The Univ. at Buffalo, SUNY (United States)
- 8687 OV **Kinetics evaluation of using biomimetic IPMC actuators for stable bipedal locomotion** [8687-93]
M. Hosseini-pour, M. Elahinia, The Univ. of Toledo (United States)
- 8687 OW **The effects of electrode surface morphology on the actuation performance of IPMC** [8687-94]
V. Palmre, D. Pugal, K. K. Leang, The Univ. of Nevada, Reno (United States); K. J. Kim, The Univ. of Nevada, Las Vegas (United States)
- 8687 OX **Scalable low nDOF hp-FEM model of IPMC actuation** [8687-95]
D. Pugal, The Univ. of Nevada, Reno (United States); A. Aabloo, Univ. of Tartu (Estonia); K. J. Kim, The Univ. of Nevada, Las Vegas (United States)
- 8687 OY **Development of an active isolation mat based on dielectric elastomer stack actuators for mechanical vibration cancellation** [8687-98]
R. Karsten, K. Flittner, H. Haus, H. F. Schlaak, Technische Univ. Darmstadt (Germany)
- 8687 OZ **Strain-enhanced nanoparticle electrostrictive polymer blends for actuator applications** [8687-99]
B. Pawlik, Technische Univ. Dresden (Germany) and Fraunhofer-Institut für Photonische Mikrosysteme (Germany); C. Schirrmann, K. Bornhorst, F. A. Costache, Fraunhofer-Institut für Photonische Mikrosysteme (Germany)
- 8687 10 **EAP high-level product architecture** [8687-101]
T. V. Gudlaugsson, N. H. Mortensen, Technical Univ. of Denmark (Denmark); R. Sarban, Danfoss PolyPower A/S (Denmark)
- 8687 12 **Validated numerical simulation model of a dielectric elastomer generator** [8687-103]
F. Foerster, H. Moessinger, H. F. Schlaak, Technische Univ. Darmstadt (Germany)

- 8687 14 **A comparison study of ionic polymer-metal composites (IPMCs) fabricated with Nafion and other ion exchange membranes** [8687-106]
J. Park, V. Palmre, The Univ. of Nevada, Reno (United States); K. Kim, The Univ. of Nevada, Las Vegas (United States); D. Shin, Rice Univ. (United States); D. H. Kim, The Univ. of Texas, Houston (United States); W. Yim, The Univ. of Nevada, Las Vegas (United States); C. Bae, Rensselaer Polytechnic Institute (United States)
- 8687 19 **Improvement of foamed ionic polymer metal composites actuator** [8687-124]
C. J. Kim, B. C. Kweon, S. W. Cha, Y. P. Park, Yonsei Univ. (Korea, Republic of)

DIELECTRIC ELASTOMERS EAP I

- 8687 1C **Modeling of mechanical properties of stack actuators based on electroactive polymers** [8687-28]
D. Tepel, C. Graf, J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 1D **Electrical modeling of dielectric elastomer stack transducers** [8687-29]
H. Haus, M. Matysek, H. Moessinger, K. Flittner, H. F. Schlaak, Technische Univ. Darmstadt (Germany)
- 8687 1E **Modelling of dielectric elastomer loudspeakers including dissipative effects** [8687-30]
B. Lassen, The Univ. of Southern Denmark (Denmark)
- 8687 1F **Modeling of roll-actuators based on electroactive polymers** [8687-31]
T. Hoffstadt, C. Graf, J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 1G **A comparison of the electromechanical characteristics of dielectric elastomer minimum energy structures (DEMES) and planar dielectric elastomer actuators (p-DEAs)** [8687-32]
G. Buchberger, J. Schoeffner, S. Bauer, B. Jakoby, W. Hilber, Johannes Kepler Univ. Linz (Austria)
- 8687 1H **Novel silicone compatible cross-linkers for controlled functionalization of PDMS networks** [8687-33]
F. B. Madsen, A. Egede Dagaard, S. Hvilsted, A. L. Skov, Technical Univ. of Denmark (Denmark)

Part Two

DIELECTRIC ELASTOMERS EAP II

- 8687 1I **Novel silicone elastomer formulations for DEAPs** [8687-34]
A. L. Skov, S. Vudayagiri, Technical Univ. of Denmark (Denmark); M. Benslimane, Danfoss PolyPower A/S (Denmark)
- 8687 1K **Effects of filler modification and structuring on dielectric enhancement of silicone rubber composites** [8687-37]
S. Javadi, M. Razzaghi-Kashani, Tarbiat Modares Univ. (Iran, Islamic Republic of)

- 8687 1M **Multilayer stack actuator made from new prestrain-free dielectric elastomers** [8687-109]
X. Niu, R. Leo, D. Chen, W. Hu, Q. Pei, Univ. of California, Los Angeles (United States)

FIELD-ACTIVATED EAP

- 8687 1N **Field-distribution in EAP-transducers with diagonal-edge contacts** [8687-39]
T. Hoffstadt, C. Graf, J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 8687 1O **Uncertainty quantification and stochastic-based viscoelastic modeling of finite deformation elastomers** [8687-40]
W. S. Oates, M. Hays, Florida A&M Univ.-Florida State Univ. (United States); P. Miles, Grove City College (United States); R. Smith, North Carolina State Univ. (United States)
- 8687 1P **More than 10-fold increase in the actuation strain of silicone dielectric elastomer actuators by applying prestrain** [8687-41]
S. Akbari, S. Rosset, H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 8687 1R **Very high breakdown field strength for dielectric elastomer actuators quenched in dielectric liquid bath** [8687-43]
T.-G. La, G.-K. Lau, Nanyang Technological Univ. (Singapore)
- 8687 1S **New operating limits for applications with electroactive elastomer: effect of the drift of the dielectric permittivity and the electrical breakdown** [8687-45]
T. Vu-Cong, G2Elab., CNRS, Univ. of Grenoble (France); C. Jean-Mistral, Univ. of Lyon (France); A. Sylvestre, G2Elab., CNRS, Univ. of Grenoble (France)

NANOTUBES AND AND THE USE OF NANOPARTICLES

- 8687 1U **Electrochemistry of electromechanical actuators based on carbon nanotubes and ionic liquids (Invited Paper)** [8687-46]
K. Asaka, K. Mukai, T. Sugino, National Institute of Advanced Industrial Science and Technology (Japan); H. Randriamahazaka, ITODYS, CNRS, Univ. Paris Diderot - Paris 7 (France); T. F. Otero, Univ. Politécnica de Cartagena (Spain)
- 8687 1V **Carbon nanotube network evolution during deformation of PVDF-MWNT nanocomposites** [8687-47]
R. Rizvi, H. E. Naguib, The Univ. of Toronto (Canada)
- 8687 1W **Improving dry carbon nanotube actuators by chemical modifications, material hybridization, and proper engineering (Invited Paper)** [8687-48]
M. Biso, A. Ansaldo, D. Ricci, Istituto Italiano di Tecnologia (Italy)
- 8687 1X **Measuring the bending of asymmetric planar EAP structures** [8687-49]
F. M. Weiss, X. Zhao, P. Thalmann, H. Deyhle, P. Urwyler, Univ. of Basel (Switzerland); G. Kovacs, Swiss Labs. for Materials Science and Technology (Switzerland); B. Müller, Univ. of Basel (Switzerland)
- 8687 1Y **Fabrication of shape memory nanofibers by electrospinning method** [8687-50]
F. Zhang, Z. Zhang, Y. Liu, J. Leng, Harbin Institute of Technology (China)

- 8687 1Z **Silicone resembling poly (propylene glycol) interpenetrating networks based on no pre-stretch as basis for electrical actuators** [8687-51]
K. Goswami, F. B. Madsen, A. E. Daugaard, A. L. Skov, Technical Univ. of Denmark (Denmark)

IPMC

- 8687 20 **Characterization and modeling of humidity-dependence of IPMC sensing dynamics** [8687-52]
C. Lim, H. Lei, X. Tan, Michigan State Univ. (United States)
- 8687 21 **Charge dynamics of ionic polymer metal composites in response to electrical bias** [8687-53]
Y. Cha, M. Porfiri, Polytechnic Institute of New York Univ. (United States)
- 8687 22 **Design optimization of rod shaped IPMC actuator** [8687-54]
S. A. Ruiz, B. Mead, The Univ. of Nevada, Las Vegas (United States); H. Yun, Korea Univ. (Korea, Republic of); W. Yim, K. J. Kim, The Univ. of Nevada, Las Vegas (United States)
- 8687 23 **Viscoelastic model of IPMC actuators** [8687-55]
V. Vunder, A. Punning, A. Aabloo, Institute of Technology (Estonia)
- 8687 24 **Deformation behavior of ionic polymer metal composite actuator in several pH solutions** [8687-56]
M. Omiya, W. Aoyagi, Keio Univ. (Japan)

NOVEL

- 8687 27 **On the development of planar actuators for variable stiffness devices** [8687-60]
M. Henke, G. Gerlach, Technische Univ. Dresden (Germany)
- 8687 28 **Electromechanical and electro-optical functions of plasticized PVC with colossal dielectric constant** [8687-61]
H. Sato, T. Hirai, Shinshu Univ. (Japan)
- 8687 29 **High-dielectric permittivity elastomers from well-dispersed expanded graphite in low concentrations** [8687-62]
A. Egede Daugaard, S. S. Hassouneh, M. Kostrzewska, A. G. Bejenariu, A. L. Skov, Technical Univ. of Denmark (Denmark)
- 8687 2B **Silver nanowires embedded gel electrodes** [8687-104]
Y. Abe, J. Gong, H. Furukawa, Yamagata Univ. (Japan)

APPLICATION OF EAP

- 8687 2C **Stable electroosmotically driven actuators (Invited Paper)** [8687-64]
D. Sriharan, M. Motsebo, J. Tumbic, E. Smela, Univ. of Maryland, College Park (United States)

- 8687 2D **High-speed, compact, adaptive lenses using in-line transparent dielectric elastomer actuator membranes** [8687-65]
S. Shian, R. M. Diebold, D. R. Clarke, Harvard Univ. (United States)
- 8687 2E **Design optimization of a linear actuator** [8687-67]
B. Rechenbach, The Univ. of Southern Denmark (Denmark); M. Willatzen, Technical Univ. of Denmark (Denmark) and The Univ. of Southern Denmark (Denmark); K. L. Preisler, Danfoss PolyPower A/S (Denmark); B. Lassen, The Univ. of Southern Denmark (Denmark)
- 8687 2F **Tunable grating with active feedback** [8687-68]
S. Rosset, Ecole Polytechnique Fédérale de Lausanne (Switzerland); B. M. O'Brien, T. Gisby, D. Xu, The Univ. of Auckland (New Zealand); H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland); I. A. Anderson, The Univ. of Auckland (New Zealand)
- 8687 2G **Dielectric elastomer actuators for active microfluidic control** [8687-69]
D. McCoul, C. Murray, D. Di Carlo, Q. Pei, Univ. of California, Los Angeles (United States)
- 8687 2H **All inkjet-printed electroactive polymer actuators for microfluidic lab-on-chip systems** [8687-70]
O. Pabst, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany) and Friedrich-Schiller-Univ. Jena (Germany); E. Beckert, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); J. Perelaer, U. S. Schubert, Friedrich-Schiller-Univ. Jena (Germany); R. Eberhardt, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany); A. Tünnermann, Fraunhofer Institute for Applied Optics and Precision Engineering (Germany) and Friedrich-Schiller-Univ. Jena (Germany)
- 8687 2I **Actuators based on intrinsic conductive polymers/carbon nanoparticles nanocomposites** [8687-92]
S. Bocchini, Istituto Italiano di Tecnologia (Italy); D. Accardo, Istituto Italiano di Tecnologia (Italy) and Politecnico di Torino (Italy); P. Ariano, Istituto Italiano di Tecnologia (Italy); M. Lombardi, Istituto Italiano di Tecnologia (Italy) and Politecnico di Torino (Italy); M. Biso, A. Ansaldo, D. Ricci, Istituto Italiano di Tecnologia (Italy)

APPLICATION OF EAP: FOCUS ON SENSORS

- 8687 2J **Six-axis capacitive force/torque sensor based on dielectric elastomer** [8687-71]
D. Kim, C. H. Lee, B. C. Kim, D. H. Lee, H. S. Lee, C. T. Nguyen, U. K. Kim, T. D. Nguyen, H. Moon, J. C. Koo, J. Nam, H. R. Choi, Sungkyunkwan Univ. (Korea, Republic of)
- 8687 2L **Scalable sensing electronics towards a motion capture suit** [8687-73]
D. Xu, T. A. Gisby, S. Xie, I. A. Anderson, The Univ. of Auckland (New Zealand)
- 8687 2M **Mm-size bistable zipping dielectric elastomer actuators for integrated microfluidics** [8687-74]
L. Maffli, S. Rosset, H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 8687 2N **Development of a dual-axis hybrid-type tactile sensor using PET film** [8687-75]
K. Seonggi, J. C. Koo, H. R. Choi, H. Moon, Sungkyunkwan Univ. (Korea, Republic of)

ELECTRODES AND CONTROL

- 8687 2O **Dielectric elastomers with novel highly-conducting electrodes** [8687-76]
H. Böse, D. Uhl, Fraunhofer-Institut für Silicattforschung (Germany)
- 8687 2P **The effect of folds in thin metal film electrodes used in dielectric elastomer actuators** [8687-77]
S.-H. Low, G.-K. Lau, Nanyang Technological Univ. (Singapore)
- 8687 2Q **Closed-loop control of a tube-type cylindrical IPMC** [8687-78]
B. Mead, S. Ruiz, W. Yim, The Univ. of Nevada, Las Vegas (United States)

FIELD-ACTUATED EAP

- 8687 2S **New DEA materials by organic modification of silicone and polyurethane networks** [8687-80]
B. Kussmaul, Fraunhofer-Institut für Angewandte Polymerforschung (Germany); S. Risse, Univ. Potsdam (Germany); M. Wegener, M. Bluemke, Fraunhofer-Institut für Angewandte Polymerforschung (Germany); J. Krause, J. Wagner, T. Feller, K. Clauberg, J. Hitzbleck, Bayer MaterialScience AG (Germany); R. Gerhard, The Univ. of Potsdam (Germany); H. Krueger, Fraunhofer-Institut für Angewandte Polymerforschung (Germany)
- 8687 2T **Effect of viscoelastic relaxation on the electromechanical coupling of dielectric elastomer** [8687-81]
B. Li, National Univ. of Singapore (Singapore); H. Chen, J. Qiang, J. Sheng, J. Zhou, Xi'an Jiaotong Univ. (China)
- 8687 2U **Synthesis and electromechanical characterization of a new acrylic dielectric elastomer with high actuation strain and dielectric strength** [8687-82]
W. Hu, X. Niu, X. Yang, Univ. of California, Los Angeles (United States); N. Zhang, Univ. of California Los Angeles (United States); Q. Pei, Univ. of California, Los Angeles (United States)
- 8687 2V **Effect of mechanical parameters on dielectric elastomer minimum energy structures** [8687-83]
J. Shintake, S. Rosset, D. Floreano, H. R. Shea, École Polytechnique Fédérale de Lausanne (Switzerland)

CONDUCTIVE AND IONIC

- 8687 2W **GEM printer: 3D gel printer for free shaping of functional gel engineering materials** [8687-84]
H. Furukawa, H. Muroi, K. Yamamoto, R. Serizawa, J. Gong, Yamagata Univ. (Japan)
- 8687 2X **Polyelectrolyte gels as bending actuators: modeling and numerical simulation** [8687-85]
T. Wallmersperger, Technische Univ. Dresden (Germany); K. Keller, Univ. Stuttgart (Germany); A. Attaran, Technische Univ. Dresden (Germany)

- 8687 2Z **PEDOT/TBACF₃SO₃ bending actuators based on a PEDOT-PEDOT sandwich complex**
[8687-87]
J. Trava-Sejdic, The Univ. of Auckland (New Zealand); T. Tamm, Univ. of Tartu (Estonia);
P. A. Kilmartin, The Univ. of Auckland (New Zealand); R. Temmer, A. Aabloo, Univ. of Tartu
(Estonia); R. Kiefer, The Univ. of Auckland (New Zealand) and Univ. of Tartu (Estonia)

Author Index

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Jonathan M. Rossiter, University of Bristol (United Kingdom)
Anuvat Sirivat, Chulalongkorn University (Thailand)
Anne Ladegaard Skov, Technical University of Denmark (Denmark)
Elisabeth Smela, University of Maryland, College Park (United States)
Peter Sommer-Larsen, Risø National Laboratory (Denmark)
Ji Su, NASA Langley Research Center (United States)
Minoru Taya, University of Washington (United States)
Jadranka Travas-Sejdic, The University of Auckland (New Zealand)
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Frédéric Vidal, Université de Cergy-Pontoise (France)
Thomas Wallmersperger, Technische Universität Dresden (Germany)
Qiming M. Zhang, The Pennsylvania State University (United States)
Pawel Zylka, Wroclaw University of Technology (Poland)

Session Chairs

- 1 EAP as Emerging Actuators
Yoseph Bar-Cohen, Jet Propulsion Laboratory (United States)
Siegfried G. Bauer, Johannes Kepler Universität Linz (Austria)
- 2 Electro-chemo-mechanical Actuators and Mechano-chemo-electrical Sensors
Toribio Fernández Otero, Universidad Politécnica de Cartagena (Spain)
Qibing Pei, University of California, Los Angeles (United States)
- 3 EAP-in-Action
Yoseph Bar-Cohen, Jet Propulsion Laboratory (United States)
- 4 Actuator for Soft Robotic or for Biomedical Applications
Barbar J. Akle, Lebanese American University (Lebanon)
Larry L. Howell, Brigham Young University (United States)

- 5 Energy Harvesting I
Yonas T. Tadesse, The University of Texas at Dallas (United States)
William S. Oates, The Florida State University (United States)
- 6 Energy Harvesting II
John D. Madden, The University of British Columbia (Canada)
Thomas G. McKay, The University of Auckland (New Zealand)
Iain A. Anderson, The University of Auckland (New Zealand)
- 7 Dielectric Elastomers EAP I
Iain A. Anderson, The University of Auckland (New Zealand)
- 8 Dielectric Elastomers EAP II
Herbert R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
Kinji Asaka, National Institute of Advanced Industrial Science and Technology (Japan)
- 9 Field-activated EAP
Deepa Sritharan, University of Maryland, College Park (United States)
Jonathan M. Rossiter, University of Bristol (United Kingdom)
- 10 Nanotubes and the Use of Nanoparticles
Samuel Shian, Harvard University (United States)
Jinsong Leng, Harbin Institute of Technology (China)
- 11 IPMC
William S. Oates, The Florida State University (United States)
Kwang Jin Kim, University of Nevada, Las Vegas (United States)
- 12 Novel
Ray Henry Baughman, The University of Texas at Dallas (United States)
Tissaphern Mirfakhrai, Stanford University (United States)
- 13 Application of EAP
Hyook Ryeol Choi, Sungkyunkwan University (Korea, Republic of)
Seyed Mohammad Mirvakili, The University of British Columbia (Canada)
- 14 Application of EAP: Focus on Sensors
Siegfried G. Bauer, Johannes Kepler Universität Linz (Austria)
- 15 Electrodes and Control
Thomas Wallmersperger, Technische Universität Dresden (Germany)
Ji Su, NASA Langley Research Center (United States)

- 16 Field-actuated EAP
Vinh Ho, University of California, Irvine (United States)
Jürgen Maas, Hochschule Ostwestfalen-Lippe (Germany)
- 17 Conductive and Ionic
Marc J. Madou, University of California, Irvine (United States)
Reza Montazami, Iowa State University (United States)

Introduction

This SPIE's Electroactive Polymers Actuators and Devices (EAPAD) Conference is the leading international forum for presenting the latest progress and holding discussions among the attendees regarding the capabilities, challenges and potential future directions. The conference this year was co-chaired with Siegfried G. Bauer, Johannes Kepler Univ. Linz, Austria, and included 109 presentations.

The Conference was well attended by internationally leading experts in the field including members of academia, industry, and government agencies from the United States and overseas. This year the Keynote speaker was Larry L. Howell, Brigham Young University, and the title of his talk is titled "Compliant mechanisms: ideal opportunity for integrated sensors and actuators". In his presentation he highlighted the significance of compliant mechanisms in providing alternate solutions for transferring or transforming motion, force, or energy; Specifically, he stated that they show promise for such applications as medical implants that closely mimic the biological systems, mechanical devices in the micro and nano size scales, and hyper-compact devices for spacecraft. These mechanisms rely on the deflection of flexible members for their mobility rather than using traditional components like bearings and hinges. The functionality of future compliant mechanisms may be enhanced by embedding sensors and actuators, resulting in monolithic devices capable of complex tasks. Employing EAP actuators will greatly benefit developed compliant mechanisms.

Significant progress was reported in each of the topics of the EAP infrastructure with focus on such areas as energy harvesting, biomimetics, haptics, braille displays, and miniaturization. The papers addressed issues that can forge the transition to practical use, including improved materials, better understanding of the principles responsible for the electromechanical behavior, analytical modeling, processing and characterization methods as well as considerations and demonstrations of various applications. The Special Session this year was dedicated to the topic of EAP Actuated Medical and Tactile Devices. Other topics that were covered in this conference included:

- Electroactive polymers (EAP) and non-electro active-polymer (NEAP) materials
- Theoretical models, analysis and simulation of EAP.
- Methods of testing and characterization of EAP
- EAP as artificial muscles, actuators and sensors
- Design, control, intelligence, and kinematic issues related to robotic and biomimetic operation of EAP
- Under consideration and in progress applications of EAP

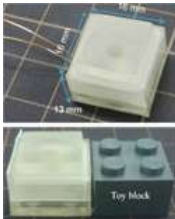
The efforts described in the presented papers are showing significant improvements in understanding of the electromechanical principles and better methods of dealing with the challenges to the materials applications. Researchers are continuing to develop analytical tools and theoretical models to describe the electro-chemical and -mechanical processes, non-linear behavior as well as methodologies of design and control of the activated materials. EAP with improved response were described including dielectric elastomer, IPMC, conductive polymers, gel EAP, carbon nanotubes, and other types. Specifically, there seems to be a significant trend towards using dielectric elastomers as practical EAP actuators.

In closing, I would like to extend a special thanks to all the conference attendees, session chairs, the EAP-in-Action demo presenters, the members of the EAPAD program organization committee. In addition, special thanks are extended to the SPIE staff that helped making this conference a great success.

Yoseph Bar-Cohen

EAP-in-Action Demonstrations

This year, the conference included a half-day course about electroactive polymers, and the instructors were Yoseph Bar-Cohen, Jet Propulsion Lab/Caltech., Pasadena, CA; John Madden, U. of British Columbia, Vancouver, Canada; and Qibing Pei, University of California, Los Angeles. Also, an EAP-in-Action Session was held and it consisted of the following seven demonstrations

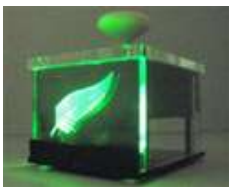


Hidemitsu Furukawa, Jin Gong, Soft and Wet Matter Engineering Laboratory (SWEL), Yamagata University, Japan, presented "Smart Push Button with Shape Memory Gel." This demo consisted of a smart push button that is designed by using shape memory gel as a contact disc. The push button has the similar small size as a toy block, and it's on/off switch function can be smartly controlled by temperature.

Iain Anderson, Andrew Lo, Thomas McKay, and Daniel Xu, Biomimetics Laboratory, Auckland, New Zealand www.abi.auckland.ac.nz/biomimetics, presented "Dielectric elastomer (DE) technology for self-sensing, portable energy harvesting and product development." Their presentation included:



(1) 8 channel capacitive sensing unit for multi-degree-of-freedom robots was demonstrated using the latest in-house developed sensing electronics to provide multi-degree-of-freedom sensing. This sensing unit can simultaneously capture the capacitance of 8 independent sensors.



(2) A hand-held dielectric elastomer generator was demonstrated as a tool for artificial muscle portable energy harvesting.



(3) A four channel Artificial Muscle Control Unit was demonstrated as a stand-alone portable laboratory instrument simplifying the generation and control of high voltages for artificial muscle research. It features include 4 independent output channels, computer control, battery operation, and safety features that make it suitable for bench-top use.



(4) The Self-Sensing Unit was demonstrated that provides real-time sensory feedback from artificial muscles



(5) High voltage surprise – this unit was presented as a high voltage generator that creates sparks at level of 40 KVolts.

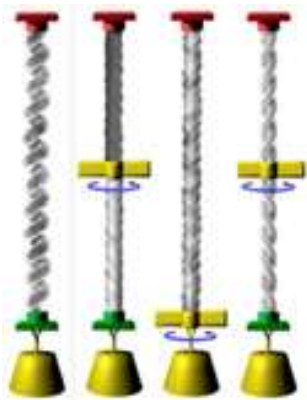


S. Rosset, L. Maffli, S. Akbari, J. Shintake, S. Araromi, A. Poulin, and H. Shea, EPFL, Switzerland, presented "High-speed silicone DEAs". Their presentation covered μm - to cm-scale dielectric elastomer

actuators that uses of silicone membranes and silicone-carbon electrodes, and operate at speeds up to several kHz, limited by the device resonance frequency. Applications range from soft robotics to tissue engineering.



Roger Hitchcock (Director of Power Supply Engineering), and Michael Lipton (Mechanical Engineer), ViviTouch, a Bayer MaterialScience Brand in Sunnyvale, California, United States, presented their company's new product "ViviTouch Audio: Take the Power of Live Music Anywhere". This demo showcased how ViviTouch actuators are applying EAP to portable headphones.



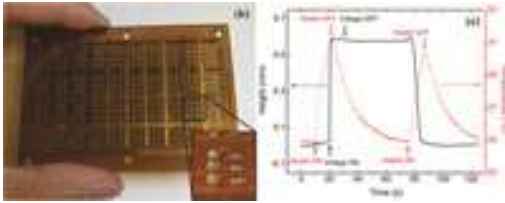
Marcio Lima, Na Li, Monica Jung de Andrade, Carter S. Haines, Ray H. Baughman, NanoTech Institute, University of Texas at Dallas, USA, presented

"Torsional and Tensile Carbon Nanotube Hybrid Yarn Muscles". Their presentation has been focused on electrolyte-free carbon nanotube based artificial muscles that have been designed to provide fast torsional and

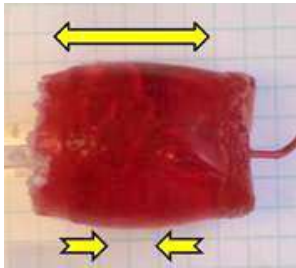
tensile actuation. As recently published in the journal Science [Lima et al, 2012], these muscles can spin a rotor at an average 11,500 revolutions/minute (20 times higher than previously demonstrated for an artificial muscle) and provide up to 27.9 kW/kg of mechanical power density during muscle contraction (85 times higher than for natural skeletal muscle). More than a million cycles of tensile and torsional actuation have been performed without a significant loss of performance. These actuators can operate from cryogenic temperatures to 2500°C. Demonstrations include torsional rotors and contractile muscles exemplifying large stroke and high rate performance.

Reference: M. D. Lima, N. Li, M. Jung de Andrade, S. Fang, J. Oh, G. M. Spinks,

M. E. Kozlov, C. S. Haines, D. Suh, J. Foroughi, S. J. Kim, Y. Chen, T. Ware, M. K. Shin, L. D. Machado, A. F. Fonseca, J. D. W. Madden, W. E. Voit, D. S. Galvão, R. H. Baughman, "Electrically, Chemically, and Photonically Powered Torsional and Tensile Actuation of Hybrid Carbon Nanotube Yarn Muscles", Science (2012)



Xiaofan Niu, Xinguo Yang, Paul Brochu, Hristiyan Stoyanov, Sungryul Yun, Zhibin Yu, and Qibing Pei, Department of Materials Science and Engineering, University of California, Los Angeles, United States, presented "Bistable electroactive polymers (BSEP) and refreshable Braille display devices". The presentation showed the application of their bistable electroactive polymer that has been developed via a prestrain-free synthesis. The actuation stability has been significantly improved. High-performance bistable electroactive polymer actuators and a refreshable Braille display device were demonstrated.



Lenore Rasmussen, Ras Labs, LLC, Picatinny Arsenal, NJ, United States, presented "Electrically Driven Mechanochemical Actuators". Using Carbon infused contractile EAP, a demonstration has been made showing an electrically driven mechano-chemical actuators performing rotational and push-pull

motions.

