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Yoseph Bar-Cohen

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Contents

Part One

- xiii *Conference Committee*
xvii *Introduction*

SESSION 1 EAP AS EMERGING ACTUATORS I

- 9056 03 **Artificial muscles harvesting sensational power using self-sensing (Invited Paper)** [9056-2]
T. G. McKay, The Univ. of Auckland (New Zealand); T. A. Gisby, The Univ. of Auckland (New Zealand) and StretchSense Ltd. (New Zealand); I. A. Anderson, The Univ. of Auckland (New Zealand)

SESSION 2a SPECIAL SESSION: ELECTRODING MATERIALS AND SYSTEMS

- 9056 05 **Effects of electrode surface structure on the mechano-electrical transduction of IPMC sensors** [9056-4]
V. Palmre, Univ. of Nevada, Reno (United States) and Univ. of Nevada, Las Vegas (United States); D. Pugal, Univ. of Nevada, Reno (United States); K. Kim, Univ. of Nevada, Las Vegas (United States)
- 9056 06 **Geometry optimization of tubular dielectric elastomer actuators with anisotropic metallic electrodes** [9056-5]
B. Rechenbach, Univ. of Southern Denmark (Denmark); M. Willatzen, Technical Univ. of Denmark (Denmark) and Univ. of Southern Denmark (Denmark); R. Sarban, C. Liang, Danfoss PolyPower A/S (Denmark); B. Lassen, Univ. of Southern Denmark (Denmark)
- 9056 07 **Impact of electrode preparation on the bending of asymmetric planar electro-active polymer microstructures** [9056-6]
F. M. Weiss, Univ. Basel (Switzerland) and Empa (Switzerland); T. Töpper, B. Osmani, C. Winterhalter, B. Müller, Univ. Basel (Switzerland)
- 9056 08 **A soft creeping robot actuated by dielectric elastomer** [9056-7]
J. Zhao, J. Niu, L. Liu, J. Yu, Harbin Institute of Technology in Weihai (China)

SESSION 2b EAP AS EMERGING ACTUATORS II

- 9056 0B **Biodegradable and edible gelatine actuators for use as artificial muscles** [9056-10]
L. D. Chambers, Bristol Robotics Lab. (United Kingdom) and Univ. of Bristol (United Kingdom); J. Winfield, I. Ieropoulos, Bristol Robotics Lab. (United Kingdom) and Univ. of the West of England (United Kingdom); J. Rossiter, Bristol Robotics Lab. (United Kingdom) and Univ. of Bristol (United Kingdom)
- 9056 0C **Soft silicone based interpenetrating networks as materials for actuators** [9056-11]
L. Yu, L. B. Gonzalez, S. Hvilsted, A. L. Skov, Technical Univ. of Denmark (Denmark)

- 9056 0D **A novel method of fabricating laminated silicone stack actuators with pre-strained dielectric layers** [9056-12]
A. D. Hinitt, A. T. Conn, Univ. of Bristol (United Kingdom)

SESSION 4a EAP MATERIALS AND ACTUATORS

- 9056 0G **The viscoelastic effect in bending bucky-gel actuators** [9056-15]
K. Kruusamäe, K. Mukai, T. Sugino, K. Asaka, National Institute of Advanced Industrial Science and Technology (Japan)
- 9056 0I **Simple and strong: twisted silver painted nylon artificial muscle actuated by Joule heating** [9056-95]
S. M. Mirvakili, The Univ. of British Columbia (Canada) and Massachusetts Institute of Technology (United States); A. Rafie Ravandi, The Univ. of British Columbia (Canada); I. W. Hunter, Massachusetts Institute of Technology (United States); C. S. Haines, N. Li, The Univ. of Texas at Dallas (United States); J. Foroughi, S. Naficy, G. M. Spinks, Univ. of Wollongong (Australia); R. H. Baughman, The Univ. of Texas at Dallas (United States); J. D. W. Madden, The Univ. of British Columbia (Canada)

SESSION 4b ENERGY HARVESTING USING EAP I

- 9056 0J **A tapped-inductor buck-boost converter for a multi-DEAP generator energy harvesting system** [9056-17]
E. Dimopoulos, S. Munk-Nielsen, Aalborg Univ. (Denmark)
- 9056 0K **Actuation and buckling effects in IPMCs** [9056-18]
P. Nardinocchi, M. Pezzulla, Sapienza Univ. di Roma (Italy); B. J. Akle, Lebanese American Univ. (Lebanon); M. Guenther, T. Wallmersperger, Technische Univ. Dresden (Germany)

SESSION 4c DIELECTRIC ELASTOMERS EAP I

- 9056 0L **Characterization of dielectric electroactive polymer transducers** [9056-19]
D. Nielsen, Technical Univ. of Denmark (Denmark); M. B. Møller, Bang & Olufsen A/S (Denmark); R. Sarban, Danfoss PolyPower A/S (Denmark); B. Lassen, Univ. of Southern Denmark (Denmark); A. Knott, M. A. E. Andersen, Technical Univ. of Denmark (Denmark)
- 9056 0M **An instrument to obtain the correct biaxial hyperelastic parameters of silicones for accurate DEA modelling** [9056-20]
S. Rosset, L. Maffli, S. Houis, H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 9056 0N **Novel dielectric elastomer structures with electromechanical instability** [9056-21]
T. Li, C. Li, G. Mao, Z. Zou, Zhejiang Univ. (China); Y. Xie, Beijing Univ. of Posts and Telecommunications (China); S. Qu, Zhejiang Univ. (China)

SESSION 5a ENERGY HARVESTING USING EAP II

- 9056 0Q **Stack design for portable artificial muscle generators: is it dangerous to be short and fat?** [9056-24]
I. A. Anderson, The Univ. of Auckland (New Zealand); S. Rosset, Ecole Polytechnique Fédérale de Lausanne (Switzerland); T. McKay, The Univ. of Auckland (New Zealand); H. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 9056 0R **An experimental and numerical approach to understand the effect of the IPMC composition on its sensing and energy harvesting behavior** [9056-25]
B. Akle, R. Khairallah, E. Challita, Lebanese American Univ. (Lebanon)

SESSION 5b ELECTRO-RESPONSIVE MATERIALS

- 9056 0S **Filled liquid silicone rubbers: possibilities and challenges (Invited Paper)** [9056-27]
L. Yu, S. Vudayagiri, S. Zakaria, Technical Univ. of Denmark (Denmark); M. Y. Benslimane, Danfoss PolyPower A/S (Denmark); A. L. Skov, Technical Univ. of Denmark (Denmark)
- 9056 0U **Electromechanical response of NCC-PEO composites** [9056-29]
P. S. Bass, M. Baltzell, L. Zhang, D. Zhang, M. Tu, Z. Cheng, Auburn Univ. (United States)

SESSION 6a ENERGY HARVESTING USING EAP III

- 9056 0X **High stress actuation by dielectric elastomer with oil capsules** [9056-33]
T.-G. La, G.-K. Lau, L.-L. Shiau, A. W. Y. Tan, Nanyang Technological Univ. (Singapore)
- 9056 0Y **Harvesting energy from a water flow through ionic polymer metal composites' buckling** [9056-34]
F. Cellini, Y. Cha, M. Porfiri, NYU Polytechnic School of Engineering (United States)

SESSION 6b ROBOTIC APPLICATIONS I

- 9056 0Z **Design of an innovative dielectric elastomer actuator for space applications** [9056-35]
F. Branz, F. Sansone, A. Francesconi, Univ. degli Studi di Padova (Italy)
- 9056 10 **Towards shear tactile displays with DEAs** [9056-36]
L. E. Knoop, J. Rossiter, Univ. of Bristol (United Kingdom) and Bristol Robotics Lab. (United Kingdom)
- 9056 11 **Bucky gel actuators optimization towards haptic applications** [9056-37]
G. Bubak, A. Ansaldo, L. Ceseracciu, Istituto Italiano di Tecnologia (Italy); K. Hata, National Institute of Advanced Industrial Science and Technology (Japan); D. Ricci, Istituto Italiano di Tecnologia (Italy)
- 9056 12 **Highly sensitive resistive type single-axis tactile sensor with liquid pocket** [9056-38]
S. Kim, B. Kim, J. Jung, J. C. Koo, H. R. Choi, H. Moon, Sungkyunkwan Univ. (Korea, Republic of)

SESSION 7a DIELECTRIC ELASTOMERS EAP II

- 9056 13 **Optimized control of a flyback-converter for bidirectional feeding of DEAP transducers** [9056-41]
T. Hoffstadt, J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 9056 14 **Novel dielectric elastomer sensors for compression load detection (Invited Paper)** [9056-39]
H. Böse, E. Fuß, Fraunhofer-Institut für Silicatforschung (Germany)
- 9056 16 **Artificial muscles of dielectric elastomers attached to artificial tendons of functionalized carbon fibers** [9056-42]
Z. Ye, M. S. S. Faisal, R. Asmatulu, Z. Chen, Wichita State Univ. (United States)

SESSION 7b EAP SENSORS

- 9056 18 **Stretch sensors for human body motion (Invited Paper)** [9056-44]
B. O'Brien, T. Gisby, I. A. Anderson, StretchSense Ltd. (New Zealand) and The Univ. of Auckland (New Zealand)
- 9056 19 **Electromechanical sensing of ionic polymer metal composites** [9056-45]
Y. Cha, F. Cellini, M. Porfiri, NYU Polytechnic School of Engineering (United States)
- 9056 1A **Enabling large scale capacitive sensing for dielectric elastomers** [9056-46]
D. Xu, T. G. McKay, The Univ. of Auckland (New Zealand); S. Michel, Empa (Switzerland); I. A. Anderson, The Univ. of Auckland (New Zealand)
- 9056 1B **Identification of the mechanical state of DEAP transducers based on integrated DEAP sensors** [9056-47]
T. Hoffstadt, M. Griese, J. Maas, Hochschule Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 9056 1C **Highly sensitive proximity and tactile sensor based on composite with dielectric elastomer and carbon microcoils** [9056-48]
T. D. Nguyen, J. Park, C. Lee, C. T. Nguyen, D. Lee, U. Kim, H. Phung, J. Nam, J. C. Koo, H. Moon, H. R. Choi, Sungkyunkwan Univ. (Korea, Republic of)

SESSION 8a ENERGY HARVESTING USING EAP IV

- 9056 1D **The effect of converter efficiency on DEAP-based energy conversion: an overview and optimization method** [9056-49]
R. van Kessel, Technische Univ. Delft (Netherlands) and SBM Offshore (Monaco); A. Watzel, SBM Offshore (Monaco); P. Bauer, Technische Univ. Delft (Netherlands)
- 9056 1E **DEAP-based energy harvesting using vortex-induced vibrations** [9056-50]
T. Hoffstadt, Hochschule Ostwestfalen-Lippe (Germany); R. Heinze, T. Wahl, F. Kameier, Fachhochschule Düsseldorf (Germany); J. Maas, Hochschule Ostwestfalen-Lippe (Germany)

- 9056 1F **Loading system mechanism for dielectric elastomer generators with equi-biaxial state of deformation** [9056-51]
M. Fontana, G. Moretti, B. Lenzo, R. Vertechy, Scuola Superiore Sant'Anna (Italy)
- 9056 1G **In-tank tests of a dielectric elastomer generator for wave energy harvesting** [9056-52]
R. Vertechy, M. Fontana, G. P. Rosati Papini, Scuola Superiore Sant'Anna (Italy);
D. Forehand, The Univ. of Edinburgh (United Kingdom)
- 9056 1H **Energy scavenging strain absorber: application to kinetic dielectric elastomer generator** [9056-53]
C. Jean-Mistral, M. Beaune, LaMCoS, Univ. de Lyon (France); T. Vu-Cong, A. Sylvestre, G2Elab, Univ. of Grenoble (France)

SESSION 8b APPLICATIONS OF EAP TO OPTICS

- 9056 1J **Challenges of using dielectric elastomer actuators to tune liquid lens** [9056-55]
G.-K. Keong, T.-G. La, L.-L. Shiau, A. W. Y. Tan, Nanyang Technological Univ. (Singapore)
- 9056 1K **High transparent shape memory gel** [9056-56]
J. Gong, M. Arai, M. H. Kabir, M. Makino, H. Furukawa, Yamagata Univ. (Japan)
- 9056 1L **Optical functionality of natural photonic structures on the transparent insect wings for bio-mimetic applications** [9056-57]
P. Kumar, D. Shamoan, K. P. Singh, Indian Institute of Science Education and Research (India)

SESSION 9a DIELECTRIC ELASTOMERS EAP III

- 9056 1M **Dielectric elastomer cantilever beam sensor** [9056-58]
N. Ni, L. Zhang, J. Zhou, Y. Wang, F. Liu, Xi'an Jiaotong Univ. (China)
- 9056 1N **Parallel input parallel output high voltage bi-directional converters for driving dielectric electro active polymer actuators** [9056-59]
P. Thummala, Z. Zhang, M. A. E. Andersen, Technical Univ. of Denmark (Denmark);
R. Sarban, Danfoss PolyPower A/S (Denmark)
- 9056 1O **Aluminum nanoparticle/acrylate copolymer nanocomposites for dielectric elastomers with high dielectric constants** [9056-60]
W. Hu, S. N. Zhang, X. Niu, C. Liu, Q. Pei, Univ. of California, Los Angeles (United States)
- 9056 1P **How does static stretching decrease the dielectric constant of VHB 4910 elastomer?** [9056-61]
T. Vu-Cong, N. Nguyen-Thi, G2Elab, Univ. of Grenoble (France); C. Jean-Mistral, LaMCoS, Univ. of Lyon (France); A. Sylvestre, G2Elab, Univ. of Grenoble (France)
- 9056 1Q **Toward compression of small cell population: harnessing stress in passive regions of dielectric elastomer actuators** [9056-62]
A. Poulin, S. Rosset, H. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)

- 9056 1R **Open-access dielectric elastomer material database** [9056-64]
R. Vertechy, M. Fontana, Scuola Superiore Sant'Anna (Italy); G. Stiubianu, M. Cazacu, Petru Poni Institute of Macromolecular Chemistry (Romania)

Part Two

SESSION 9b	CONDUCTING POLYMERS AND IMPC
9056 1S	On the geometrical and mechanical multi-aspect optimization of PPy/MWCNT actuators [9056-65] N. Khalili, H. E. Naguib, R. H. Kwon, Univ. of Toronto (Canada)
9056 1T	Non-linear time variant model intended for polypyrrole-based actuators [9056-66] M. Farajollahi, J. D. W. Madden, F. Sassani, Univ. of British Columbia (Canada)
9056 1U	Robust control of a trilayer conducting polymer actuator [9056-67] M. Itik, Karadeniz Technical Univ. (Turkey); F. D. Ulker, Massachusetts Institute of Technology (United States); G. Alici, Univ. of Wollongong (Australia)
9056 1V	Carbide-derived carbon (CDC) linear actuator properties in combination with conducting polymers [9056-68] R. Kiefer, Univ. of Tartu (Estonia); N. Aydemir, The Univ. of Auckland (New Zealand); J. Torop, Univ. of Tartu (Estonia) and Linköping Univ. (Sweden); P. A. Kilmartin, The Univ. of Auckland (New Zealand); T. Tamm, F. Kaasik, A. Kesküla, Univ. of Tartu (Estonia); J. Travas-Sejdic, The Univ. of Auckland (New Zealand); A. Aabloo, Univ. of Tartu (Estonia)
9056 1W	Development, analysis, and comparison of electromechanical properties of Bucky paper IPMC actuator [9056-69] B. Sivasubramanian, D. Kim, Embry-Riddle Aeronautical Univ. (United States)
9056 1X	Buckling of an ionic polymer metal composite shell under uniaxial compression [9056-70] L. Shen, Y. Cha, A. Shams, M. Porfiri, NYU Polytechnic School of Engineering (United States)
9056 1Y	Force control of ionic polymer-metal composite actuators with carbon-based electrodes [9056-71] V. Vunder, Univ. of Tartu (Estonia); M. Itik, Karadeniz Technical Univ. (Turkey); A. Punning, A. Aabloo, Univ. of Tartu (Estonia)
SESSION 10a	GENERAL APPLICATIONS OF EAP MATERIALS
9056 20	Colour gamuts in polychromatic dielectric elastomer artificial chromatophores [9056-73] J. Rossiter, A. Conn, Bristol Robotics Lab. (United Kingdom); A. Cerruto, Stanford Univ. (United States); A. Winters, Rainbow Winters (United Kingdom); C. Roke, Bristol Robotics Lab. (United Kingdom)
9056 21	A new bistable electroactive polymer for prolonged cycle lifetime of refreshable Braille displays [9056-74] Z. Ren, X. Niu, D. Chen, W. Hu, Q. Pei, Univ. of California, Los Angeles (United States)

SESSION 10b EAP MECHANISMS AND PROCESSES

- 9056 25 **Artificial muscles on heat** [9056-78]
T. G. McKay, D. K. Shin, The Univ. of Auckland (New Zealand); S. Percy, C. Knight, S. McGarry, Commonwealth Scientific and Industrial Research Organisation (Australia); I. A. Anderson, The Univ. of Auckland (New Zealand)
- 9056 27 **Automated manufacturing process for DEAP stack-actuators** [9056-80]
D. Tepel, T. Hoffstadt, J. Maas, Ostwestfalen-Lippe Univ. of Applied Sciences (Germany)
- 9056 28 **Dielectrophoresis-assisted electroconductive polymer-based fabrication of high surface area electrodes** [9056-81]
V. H. Perez-Gonzalez, Tecnologico de Monterrey (Mexico) and Univ. of California, Irvine (United States); V. Ho, L. Kulinsky, Univ. of California, Irvine (United States); S. O. Martinez-Chapa, Tecnologico de Monterrey (Mexico)
- 9056 29 **3D printing for dielectric elastomers** [9056-82]
A. Creegan, I. Anderson, The Univ. of Auckland (New Zealand)

SESSION 11a CHARACTERIZATION OF EAP MATERIALS

- 9056 2A **Conducting IPN actuator/sensor for biomimetic vibrissa system (Invited Paper)** [9056-83]
N. Festin, C. Plesse, Institut des Matériaux, Univ. de Cergy-Pontoise (France); P. Pirim, Brain Vision Systems (France); C. Chevrot, F. Vidal, Institut des Matériaux, Univ. de Cergy-Pontoise (France)
- 9056 2B **In situ measurements with CPC micro-actuators using SEM** [9056-84]
F. Kaasik, I. Must, E. Lust, Univ. of Tartu (Estonia); M. Jürgens, Estiko Plastar AS (Estonia); V. Presser, Leibniz Institute for New Materials (Germany) and Saarland Univ. (Germany); A. Punning, R. Temmer, R. Kiefer, A. Aabloo, Univ. of Tartu (Estonia)
- 9056 2C **Evaluation of area strain response of dielectric elastomer actuator using image processing technique** [9056-85]
R. K. Sahu, National Institute of Technology Raipur (India); K. Sudarshan, K. Patra, S. Bhaumik, Indian Institute of Technology Patna (India)

SESSION 11b ROBOTIC APPLICATIONS II

- 9056 2F **Artificial heart for humanoid robot** [9056-88]
A. Potnuru, L. Wu, Y. Tadesse, The Univ. of Texas at Dallas (United States)
- 9056 2G **Towards a deployable satellite gripper based on multisegment dielectric elastomer minimum energy structures** [9056-89]
O. A. Araromi, I. Gavrilovich, J. Shintake, S. Rosset, H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 9056 2H **The mechanical design of a humanoid robot with flexible skin sensor for use in psychiatric therapy** [9056-90]
A. Burns, Y. Tadesse, The Univ. of Texas at Dallas (United States)

- 9056 2I **Modeling of a PVDF based gesture controller using energy methods** [9056-91]
K. R. Van Volkinburg, G. N. Washington, Univ. of California, Irvine (United States)
- 9056 2J **Multi degree of freedom IPMC sensor** [9056-92]
T. Stalbaum, S. E. Nelson, V. Palmre, K. J. Kim, Univ. of Nevada, Las Vegas (United States)
- 9056 2K **Optimal haptic feedback control of artificial muscles** [9056-93]
D. Chen, Auckland Bioengineering Institute (New Zealand); T. Besier, I. Anderson, Auckland Bioengineering Institute (New Zealand) and The Univ. of Auckland (New Zealand); T. McKay, Auckland Bioengineering Institute (New Zealand)
- 9056 2L **Soft segmented inchworm robot with dielectric elastomer muscles** [9056-94]
A. T. Conn, A. D. Hinitt, Univ. of Bristol (United Kingdom) and Univ. of the West of England (United Kingdom); P. Wang, Univ. of Bristol (United Kingdom)

SESSION 11c DIELECTRIC ELASTOMERS EAP IV

- 9056 2M **A tunable millimeter-wave phase shifter driven by dielectric elastomer actuators** [9056-96]
O. A. Araromi, P. Romano, S. Rosset, J. Perruisseau-Carrier, H. R. Shea, Ecole Polytechnique Fédérale de Lausanne (Switzerland)
- 9056 2N **A novel duct silencer using dielectric elastomer absorbers** [9056-97]
Z. Lu, Y. Cui, J. Zhu, M. Debiassi, National Univ. of Singapore (Singapore)
- 9056 2O **Artificial vibrissae DEA-based module** [9056-98]
T. Assaf, A. Conn, J. Rossiter, P. Walters, M. Pearson, Bristol Robotics Lab. (United Kingdom)

POSTER SESSION

- 9056 2P **The effect of processing conditions on the crystal structure and electroactive properties of poly(vinylidene fluoride)/ multi-walled carbon nanotubes nanocomposites** [9056-99]
L. Yang, J. Qiu, K. Zhu, H. Ji, Nanjing Univ. of Aeronautics and Astronautics (China)
- 9056 2T **Novel encapsulation technique for incorporation of high permittivity fillers into silicone elastomers** [9056-104]
P. Mazurek, S. Hvilsted, A. L. Skov, Technical Univ. of Denmark (Denmark)
- 9056 2U **DEAP actuator and its high voltage driver for heating valve application** [9056-105]
L. Huang, Technical Univ. of Denmark (Denmark); L. F. Nørmølle, Lanoe Electronics (Denmark); R. Sarban, Danfoss PolyPower A/S (Denmark); E. N. Christiansen, Danfoss A/S (Denmark); Z. Zhang, M. A. E. Andersen, Technical Univ. of Denmark (Denmark)
- 9056 2V **The electrical breakdown of thin dielectric elastomers: thermal effects** [9056-108]
S. Zakaria, Technical Univ. of Denmark (Denmark); P. H. F. Morshuis, Technische Univ. Delft (Netherlands); M. Y. Benslimane, Danfoss Polypower A/S (Denmark); K. V. Gernaey, A. L. Skov, Technical Univ. of Denmark (Denmark)

- 9056 2Z **Inhomogeneous deformation of circular dielectric elastomer: simulation and experiment** [9056-112]
Y. Wang, J. Zhou, X. Wu, L. Zhang, N. Ni, F. Liu, Xi'an Jiaotong Univ. (China)
- 9056 30 **Autofocus fluid lens device construction and implementation of modified ionic polymer metal composite (IPMC) membrane actuators** [9056-113]
R. Kiefer, H. Kiveste, A. Punning, A. Kesküla, T. Lulla, A. Aabloo, Univ. of Tartu (Estonia)
- 9056 31 **Electrochemomechanical deformation (ECMD) of PPyDBS in free standing film formation and trilayer designs** [9056-114]
N. Aydemir, The Univ. of Auckland (New Zealand); T. Tamm, Univ. of Tartu (Estonia); J. Travas-Sejdic, P. A. Kilmartin, The Univ. of Auckland (New Zealand); A. Aabloo, Univ. of Tartu (Estonia); R. Kiefer, The Univ. of Auckland (New Zealand) and Univ. of Tartu (Estonia)
- 9056 32 **Leakage current of a charge-controlled dielectric elastomer** [9056-115]
J. Zhang, H. Chen, J. Sheng, L. Liu, B. Li, Xi'an Jiaotong Univ. (China)
- 9056 33 **Experimental investigations on energy harvesting performance of dielectric elastomers** [9056-116]
Y. Wang, X. Liu, H. Xue, H. Chen, S. Jia, Xi'an Jiaotong Univ. (China)
- 9056 34 **Effect of temperature on the electric breakdown strength of dielectric elastomer** [9056-117]
L. Liu, H. Chen, J. Sheng, J. Zhang, Y. Wang, S. Jia, Xi'an Jiaotong Univ. (China)
- 9056 35 **Comparison of plasma treatment and sandblast preprocessing for IPMC actuator** [9056-118]
C. Zhang, H. Chen, Y. Wang, Y. Wang, S. Jia, Xi'an Jiaotong Univ. (China)
- 9056 36 **Force control of ionic polymer-metal composite actuators with cellular actuator method** [9056-119]
Y. Inoue, N. Kamamichi, Tokyo Denki Univ. (Japan)
- 9056 37 **Optimized deformation behavior of a dielectric elastomer generator** [9056-120]
F. Foerster, H. F. Schlaak, Technische Univ. Darmstadt (Germany)
- 9056 38 **Dynamic performance of silicone dielectric elastomer actuators with bi-stable buckled beams** [9056-121]
D. Gatti, C. Tropea, H. F. Schlaak, Technische Univ. Darmstadt (Germany)
- 9056 39 **Dielectric elastomer bending actuator: experiment and theoretical analysis** [9056-122]
J. Li, L. Liu, Y. Liu, J. Leng, Harbin Institute of Technology (China)
- 9056 3C **Tactile feedback to the palm using arbitrarily shaped DEA** [9056-125]
H. Mößinger, H. Haus, M. Kauer, H. F. Schlaak, Technische Univ. Darmstadt (Germany)
- 9056 3G **Dielectric elastomer based active layer for macro-scaled industrial application in roto-flexographic printing** [9056-129]
F. Pinto, G. D'Orlando, M. Meo, Univ. of Bath (United Kingdom)
- 9056 3I **Compliant liquid metal electrodes for dielectric elastomer actuators** [9056-131]
L. R. Finkenauer, C. Majidi, Carnegie Mellon Univ. (United States)

- 9056 3J **An investigation of electrochemomechanical actuation of conductive Polyacrylonitrile (PAN) nanofiber composites** [9056-132]
M. A. Gonzalez, W. W. Walter, Rochester Institute of Technology (United States)
- 9056 3K **Design and fabrication of an IPMC-embedded tube for minimally invasive surgery applications** [9056-133]
J. Liu, Y. Wang, D. Zhao, C. Zhang, H. Chen, D. Li, Xi'an Jiaotong Univ. (China)
- 9056 3L **Sequential growth and monitoring of a polypyrrole actuator system** [9056-135]
J. C. Sarrazin, S. A. Mascaró, The Univ. of Utah (United States)
- 9056 3M **Electrode of ionic polymer-metal composite sensors: modeling and experimental investigation** [9056-136]
Q. Shen, BeiHang Univ. (China) and Univ. of Nevada, Las Vegas (United States); K. J. Kim, Univ. of Nevada, Las Vegas (United States); T. Wang, BeiHang Univ. (China)
- 9056 3N **Characterization of close-loop performance of double drive modes unimorph deformable mirror** [9056-137]
Y. Liu, Univ. of Science and Technology of China (China); J. Ma, Ningbo Univ. (China); J. Chen, B. Li, J. Chu, Univ. of Science and Technology of China (China)

Author Index

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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 I
Yoseph Bar-Cohen, Jet Propulsion Laboratory (United States)
Barbar J. Akle, Lebanese American University (Lebanon)
- 2a Special Session: Electroding Materials and Systems
Qibing Pei, University of California, Los Angeles (United States)
Iain A. Anderson, The University of Auckland (New Zealand)
- 2b EAP As Emerging Actuators II
Kwang Jin Kim, University of Nevada, Las Vegas (United States)
Barbar J. Akle, Lebanese American University (Lebanon)
- 4a EAP Materials and Actuators
Karl Kruusamäe, National Institute of Advanced Industrial Science and Technology (Japan)
Robert Shepherd, Cornell University (United States)
- 4b Energy Harvesting Using EAP I
Anne Ladegaard Skov, Technical University of Denmark (Denmark)
Ingrid M. Graz, Johannes Kepler Universität Linz (Austria)
- 4c Dielectric Elastomers EAP I
Xuanhe Zhao, Duke University (United States)
Adrian Koh, National University of Singapore (Singapore)

- 5a Energy Harvesting Using EAP II
Iain A. Anderson, The University of Auckland (New Zealand)
Ilkwon Oh, KAIST (Korea, Republic of)
- 5b Electro-Responsive Materials
Art Muir, ViviTouch | A Bayer Brand (United States)
Anne Ladegaard Skov, Technical University of Denmark (Denmark)
- 6a Energy Harvesting Using EAP III
John D. W. Madden, The University of British Columbia (Canada)
Ilkwon Oh, KAIST (Korea, Republic of)
- 6b Robotic Applications I
Qibing Pei, University of California, Los Angeles (United States)
Samuel Shian, Harvard University (United States)
- 7a Dielectric Elastomers EAP II
Todd Gisby, StretchSense (New Zealand)
Rick C.L. van Kessel, SBM Offshore (Netherlands)
- 7b EAP Sensors
Hyouk Ryeol Choi, Sungkyunkwan University (Korea, Republic of)
Thomas G. McKay, The University of Auckland (New Zealand)
- 8a Energy Harvesting Using EAP IV
Holger Böse, Fraunhofer-Institut für Silicatforschung (Germany)
Oscar Lopez-Pamies, University of Illinois at Urbana-Champaign
(United States)
- 8b Applications of EAP to Optics
Christoph Keplinger, Harvard University (United States)
Benjamin M. O'Brien, StretchSense (New Zealand)
Todd Gisby, StretchSense (New Zealand)
- 9a Dielectric Elastomers EAP III
Xuanhe Zhao, Duke University (United States)
Helmut F. Schlaak, Technische Universität Darmstadt (Germany)
- 9b Conducting Polymers and IMPC
Frédéric Vidal, Université de Cergy-Pontoise (France)
Holger Böse, Fraunhofer-Institut für Silicatforschung (Germany)
- 10a General Applications of EAP Materials
Philipp Rothemund, Harvard University (United States)
Christoph Keplinger, Harvard University (United States)

- 10b EAP Mechanisms and Processes
Ingrid M. Graz, Johannes Kepler Universität Linz (Austria)
Jonathan M. Rossiter, University of Bristol (United Kingdom)

- 11a Characterization of EAP Materials
Jonathan M. Rossiter, University of Bristol (United Kingdom)
Geoffrey M. Spinks, University of Wollongong (Australia)

- 11b Robotic Applications II
Carter S. Haines, The University of Texas at Dallas (United States)
Rudolf Kiefer, University of Tartu (Estonia)

- 11c Dielectric Elastomers EAP IV
John D. W. Madden, The University of British Columbia (Canada)
Thomas G. McKay, The University of Auckland (New Zealand)

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 Barbar J. Akle, Lebanese American University, Lebanon, and included 141 presentations, which has been a record number.

The Conference was well attended by internationally leading experts in the field including members of academia, industry, and government agencies from the USA and overseas. This year the Keynote speaker was Robert Shepherd, Cornell, and the titled of his talk is titled "Soft robotics: a review and progress towards faster and higher torque actuators". In his presentation he highlighted that the field of soft robotics is taking advantage of compliant actuators and passive dynamics to achieve several goals: reduced design, manufacturing and control complexity, improved energy efficiency, more sophisticated motions, and safe human-machine interactions to name a few. In his presentation he described the potential for combinations of different classes of soft actuators (e.g., electrically and pneumatically actuated systems) to improve the utility of soft robots and their potential impact.

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 Electroding Materials and Systems. 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

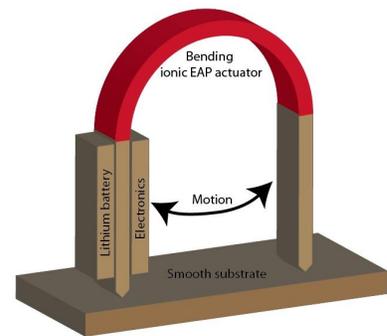
The efforts described in the presented papers are showing significant improvements in understanding of the electromechanical principles and better methods of dealing with the challenges to the materials applications. Researchers are continuing to develop analytical tools and theoretical models to

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.

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 nine demonstrations with presenters from Estonia, Germany, Japan, New Zealand, Switzerland, United Kingdom, and USA. The presentation of 9 demonstrations has been a record for the EAPAD Conference.

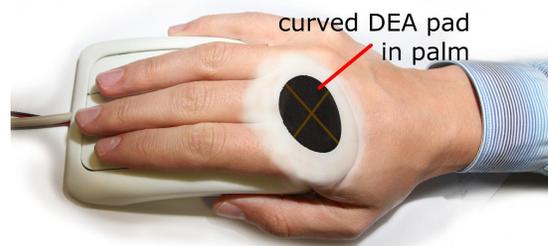
Bio-inspired autonomous robot actuated by ionic EAPs - Indrek Must, Friedrich Kaasik, Inga Põldsalu, Lauri Mikhels, Urmas Johanson, Andres Punning, Alvo Aabloo; Intelligent Materials and Systems Lab (<http://www.ims.ut.ee>), University of Tartu (Estonia)

An autonomous crawling microrobot with locomotion inspired by an inchworm and propelled by ionic liquid-based bending EAPs was presented. This microprocessor-controlled robot was powered by an on-board lithium battery and is able to move in ambient air on a smooth surface. The construction takes advantage of the unique properties of soft EAP technology.



DEA enhanced PC-mouse for improving human machine interaction -

Henry Haus, Holger Mößinger, and Helmut F. Schlaak, Technische Universität Darmstadt (Germany)

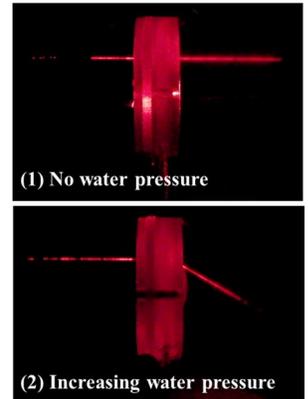
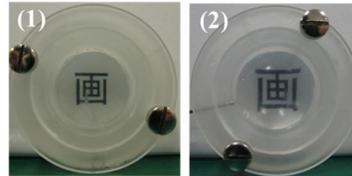


The flexibility of rubber-like dielectric elastomer actuators allows adjusting the shape of tactile interfaces to fit onto arbitrary surfaces. This flexibility offers the opportunity to provide tactile stimulus not only the fingertips but also to other parts of the human body, using greater parts of the human skin to transmit information. A fully functional PC-mouse, enhanced with DEA technology, providing tactile feedback into the palm of the user hand was demonstrated. The audience was offered to try out the tactile feedback while interacting with specially designed demo software on a PC, giving everyone the opportunity to experience the advantages of flexible DE-actuators for human machine interaction.

Smart Gel Robotics with Flexible & Transparent Shape Memory Gel (FT-SMG)

Jin Gong, and Hidemitsu Furukawa, Yamagata University (Japan)

A smart varifocal lens is designed with flexible & transparent shape memory gel (FT-SMG), which freely adjusts the focal length based on simple mechanism of changing water pressure inside. Except for a soft eye of a robot, we have also developed other FT-SMG gel for robots including soft touch paper and soft skin finger.



Wearable and portable energy harvesters and soft sensor technologies

Presenters: Iain Anderson^{1,2}, Thomas McKay¹, Daniel Xu¹, Andrew Lo¹, Tony Tse¹, Todd Gisby²

¹ Biomimetics Laboratory and ²StretchSense Ltd, Auckland, Contact: Iain A. Anderson, Biomimetics Lab (New Zealand)

²Stretchsense Ltd (New Zealand)

The Biomimetics Lab and the new spinoff StretchSense Ltd. have demonstrated advances leading to an exciting future of wearable and portable energy harvesters and soft sensor technologies that include a wireless glove.

(1) Getting low voltage power from a dielectric elastomer generator (DEG) is now possible. The developed electronics is specifically designed for small portable DEGs that are capable of efficiently transforming high voltage to low voltage.



(2) To get the most out of a DEG, its mechanical strain should be sensed. The best way to do this is to monitor the elastomer directly: to self-sense. The DEGs can now self-sense, simultaneously harvesting energy and sensing mechanical state without the need for bulky sensors.

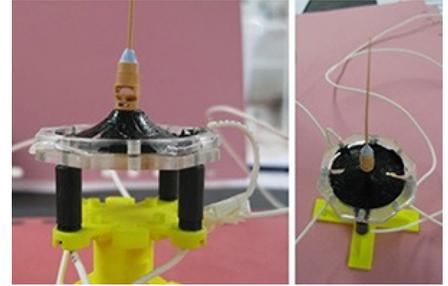
(3) Measuring human body motion can provide valuable feedback for sports, medical, video and game applications. The next generation of soft sensor technologies, including a wireless glove, will be presented.



DEA-Based Whisker for Robotics - Tareq Assaf, Jonathan Rossiter, Andrew Conn, Martin Pearson, and Peter Walters, Bristol Robotics Lab. (United Kingdom)

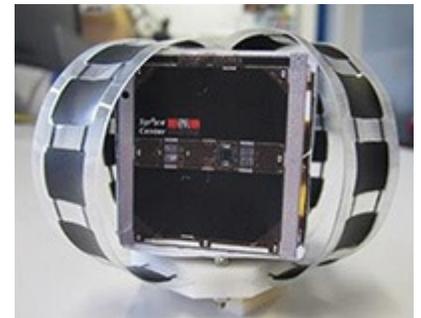
DEA-based whisker module was presented showing the results of the efforts to scale and overcome critical issues for the exploitation of this artificial muscle technology in robotics, in particular as actuator to drive active tactile sensing. The modularity, dimensions, low weight and soft features make of this technology ideal for such application with relatively easy access to 2 Degrees of freedom and achieving both actuator and sensor capabilities. During the demonstration the prototypes were shown and actuated together with the new upcoming release that contains improvements both on the design and performance point of view.

Acknowledgement: The DEA-based whisker module has been developed under the BELLA Project funded by EPSRC under grant EP/I032533/1



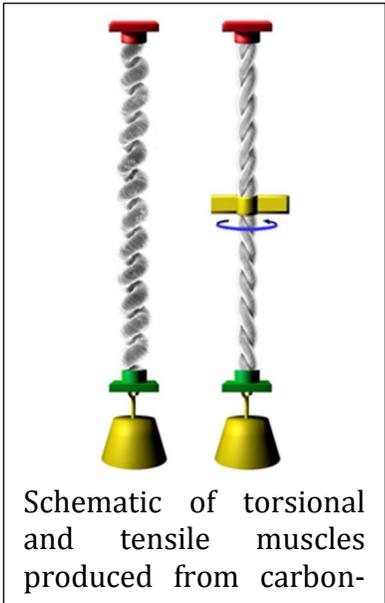
High speed silicone DEAs - S. Rosset, S. Araromi, A. Poulin, L. Maffli, J. Shintake, and H. Shea, École Polytechnique Fédérale de Lausanne (Switzerland)

μm - to cm-scale dielectric elastomer actuators will be presented. Processes to manufacture DEAs were developed with a high quality and reliability. Large area silicone membrane casting and precise patterning of electrodes allows producing small-scale and robust DEAs with a high yield. Different functioning devices will be demonstrated, such as a 4 fingers multi-segment gripper, seen in the photo grabbing a mockup of EPFL's SwissCube. This DEA-based gripper is a soft-actuator candidate to be mounted on CleanSpace One, the EPFL's next satellite whose task is to demonstrate the possibility of orbital debris removal by capturing and deorbiting the now-decommissioned SwissCube [<http://space.epfl.ch/page-61745-en.html>].



Carbon-Based Tensile and Torsional Artificial Muscles - Carter S. Haines, Marcio D. Lima, Ray H. Baughman, University of Texas at Dallas

Carbon-based artificial muscles have been designed to provide fast torsional and tensile actuation. In tension, these muscles can provide in excess of 20% stroke without hysteresis when powered electrically or by using hot liquids such as water. More than a million cycles of reversible tensile actuation have been performed without a significant loss of performance. Torsional muscles that can move heavy loads and operate from ambient temperature gradients have also been shown. Such muscles can be woven into braids and fabrics to produce smart textiles and actuating fabric. Demonstrations include torsional and tensile muscles exhibiting large stroke and giant force performance.



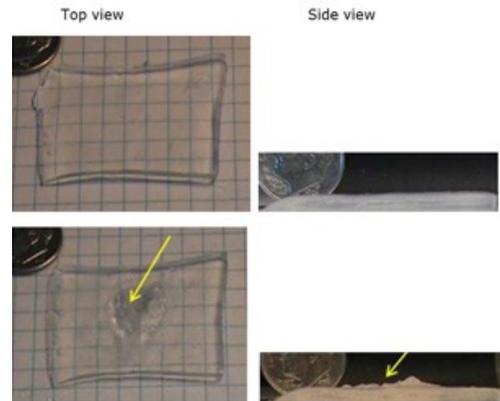
ViviTouch® HD Feel enables advanced and multi-dimensional communication through touch - Dirk Schapeler, ViviTouch, A Bayer Brand

An EAP stacked actuator was demonstrated that is smaller than a thumb tack that is easily integrated as wearable devices and unique spaces. It can be used as a bracelet or line clothing, in trigger buttons or thumb sticks, in a game controller for direct contact with skin as well as individually controlled haptic feedback zones. The device provides high definition feel with a broad spectrum of haptic effects having silent operation and without any audible buzzer.



Synthetic Muscle™: EAP-based materials and actuators - Lenore Rasmussen and Eric Sandberg, (United States)

The most recently enhanced EAP material called Synthetic Muscle™ was demonstrated contracting and expanding. The material can be activated in a controlled zone (the photos show expansion in the middle of the film) offering the potential of haptic interfacing with programmable reasons.



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