PROCEEDINGS OF SPIE

Electroactive Polymer Actuators and Devices (EAPAD) 2013

Yoseph Bar-Cohen
Editor

11–14 March 2013
San Diego, California, United States

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SPIE

Part One of Two Parts

Volume 8687

Proceedings of SPIE 0277-786X, V. 8687

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Electroactive Polymer Actuators and Devices (EAPAD) 2013, edited by Yoseph Bar-Cohen,
Proc. of SPIE Vol. 8687, 868701 · © 2013 SPIE · CCC code: 0277-786X/13/$18 · doi: 10.1117/12.2021506

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Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Electroactive Polymer Actuators and Devices (EAPAD) 2013*, edited by Yoseph Bar-Cohen, Proceedings of SPIE Vol. 8687 (SPIE, Bellingham, WA, 2013) Article CID Number.

ISSN: 0277-786X
ISBN: 9780819494702

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

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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 titled 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

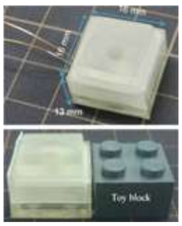
The efforts described in the presented papers are showing significant improvements in understanding of the electromechanical principles and better methods of dealing with the challenges to the materials applications. Researchers are continuing to develop analytical tools and theoretical models to describe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

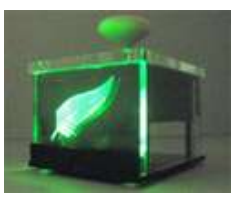
This year, the conference included a half-day course about electroactive polymers, and the instructors were Yoseph Bar-Cohen, Jet Propulsion Lab/Caltech., Pasadena, CA; John Madden, U. of British Columbia, Vancouver, Canada; and Qibing Pei, University of California, Los Angeles. Also, an EAP-in-Action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

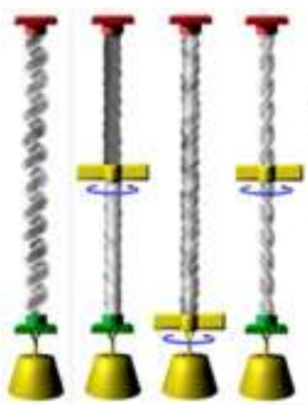
(3) A four channel Artificial Muscle Control Unit was demonstrated as a stand-alone portable laboratory instrument simplifying the generation and control of high voltages for artificial muscle research. It features include 4 independent output channels, computer control, battery operation, and safety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

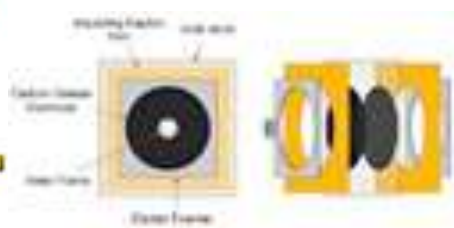
(4) The Self-Sensing Unit was demonstrated that provides real-time sensory feedback from artificial muscles

(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.

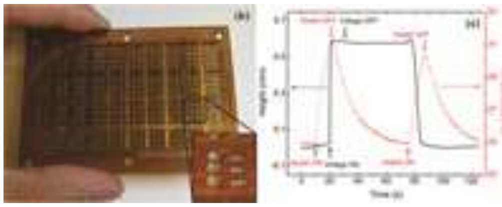




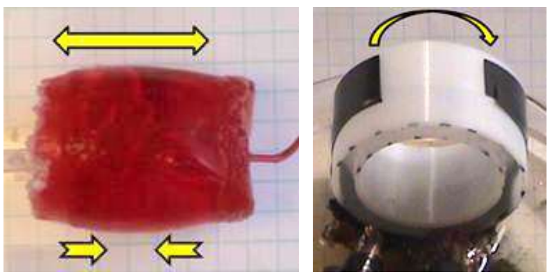
Marcio Lima, Na Li, Monica Jung de Andrade, Carter S. Haines, Ray H. Baughman, NanoTech Institute, University of Texas at Dallas, USA, presented "Torsional and Tensile Carbon Nanotube Hybrid Yarn Muscles". Their presentation has been focused on electrolyte-free carbon nanotube based artificial muscles 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.

<u>Reference</u>: 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.