# *Electroactive Polymer Actuators and Devices (EAPAD) 2012*

**Yoseph Bar-Cohen**
*Editor*

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Energy Harvesting
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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 Keiichi Kaneto, Kyushu Institute of Technology, Japan, and included 107 presentations.

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 there were two Keynote speakers, Jeff Corsiglia, Spin Master Ltd., Canada, and John A. Rogers, Univ. of Illinois at Urbana-Champaign, United States. The title of Corsiglia's presentation was "Bringing toys to life: toys today and unique opportunities for EAP sensors and actuator," and the title of Rogers's presentation Bio-integrated electronics. In Corsiglia presentation, he gave a review of how toys imitate life, the type of "smart" toys that his company is making and the areas that could benefit from advances in EAP. In Rogers presentation, he reviewed the development in flexible electronics and unique capabilities for mapping cardiac electrophysiology, in both endocardial and epicardial modes, and for performing electrocorticography.

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 include:

- 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 EAP-in-Action Session was held on Monday, March 12, 2012 and it included nine demonstrations covering products like the high definition feel in mobile and gaming applications, by Artificial Muscle, Inc., Bayer MaterialScience Co. (United States); prototypes by Biomimetics Lab., Auckland Bioengineering Institute (New Zealand); EPFL-LMTS (Switzerland); Univ. of California, Los Angeles (United States); Univ. of Michigan (United States), and Univ. of Maryland, College Park (United States); Strategic Polymer Sciences, Inc. (USA); and EPFL/ZHAW, Optotune Inc. (Switzerland).  A prototype in components form that received a significant attention is the large energy harvesting system that was presented by SBM Offshore (France).  The demo presenters included Geoffrey M. Spunks, Univ. of Wollongong (Australia); Iain Anderson, Emilio Calius, Todd Gisby, Andrew Lo, Thomas McKay, Ben O'Brien, Biomimetics Lab., Auckland Bioengineering Institute (New Zealand); S. Rosset, L. Maffli, S. Akbari, B. O'Brien, Herbert R. Shea, EPFL-LMTS (Switzerland); James Biggs, Artificial Muscle, Inc., Bayer MaterialScience Co. (United States); Xiaofan Niu, Paul Brochu, Sungryul Yun, Zhibin Yu, Qibing Pei, Univ. of California, Los Angeles (United States); Eugene Dariush Daneshvar, Univ. of Michigan (United States); Elisabeth Smela, Univ. of Maryland, College Park (United States); Daryl Kipke, Univ. of Michigan (United States); Shihai Zhang, Qiming Zhang, and Ralph Russo, Strategic Polymer Sciences, Inc. (USA); Pit Gebbers, EPFL/ZHAW, Optotune Inc. (Switzerland); and Philippe Jean, Guillaume Ardoise, Ambroise Wattez, SBM Offshore (France).

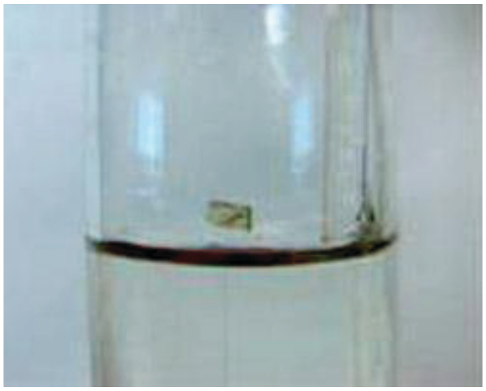
In closing, we would like to extend a special thanks to all the conference attendees, session chairs, the EAP-in-Action demo presenters, and the members of the EAPAD program organization committee.  In addition, special thanks are extended to the SPIE staff that helped in making this conference a great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

**Yoseph Bar-Cohen**

# EAP-in-Action Demonstrations

### PolyCarbon nanotube torsional muscles

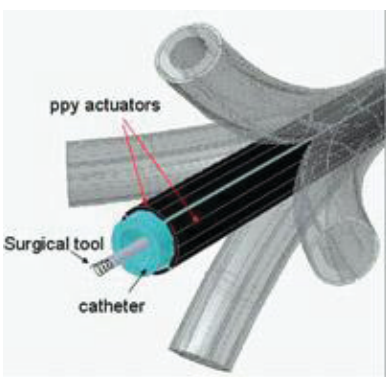
**John D. W. Madden, Univ. of British Columbia (Canada), Geoffrey M. Spunks, Univ. of Wollongong (Australia)**

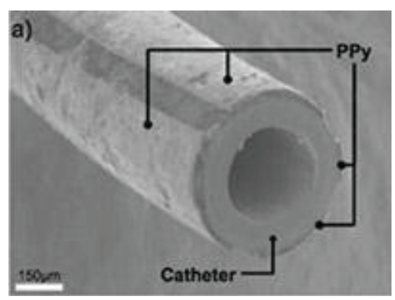


The demo will consist of a rapid rotation of a plastic paddle in air driven by carbon nanotube yarn. The torsional muscle operates with part of the yarn immersed in a liquid electrolyte that is electrochemically charged by application of a small voltage. The charging of the yarn causes the yarn to partially untwist and produce rotation of the attached paddle. Discharging the yarn causes it to re-twist. The demonstration will illustrate the very rapid and large rotations achievable in these simple actuator systems.

### Steerable Catheter

**U. N. Rana, K. Lee, T. Shoa, S. Nafici, G. M. Spinks, V. X. D. Yang, J. D. W. Madden, Univ. of British Columbia (Canada)**




A catheter is coated with polypyrrole, and patterned to enable tip deflection. This is intended to enable navigation and imaging within the neuro-vascular system.

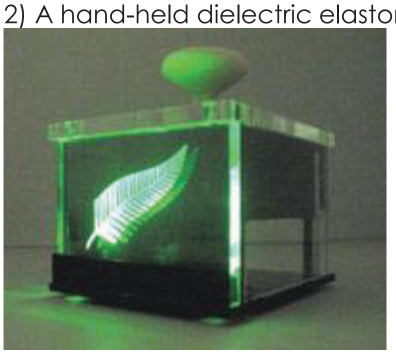
**Dielectric elastomer (DE) technology for self-sensing, portable energy harvesting, and product development**

**Iain Anderson, Emilio Calius, Todd Gisby, Andrew Lo, Thomas McKay, Ben O'Brien, Biomimetics Lab., Auckland Bioengineering Institute (New Zealand)**

This showcase will include the following demonstrations:
1) Cyber-proprioception and cyber-pain

Like natural muscles, DE-based artificial muscles can now provide in real time both positional feedback (cyber-proprioception) and condition-monitoring information (cyber-pain). These capabilities, essential for the control and performance of soft machines, will be demonstrated using the lab's Self-Sensing Unit coupled to a DE actuator.

2) A hand-held dielectric elastomer generator



DE can be used to extract useful low voltage power from human movement. This will be demonstrated using a device that can be held in one hand

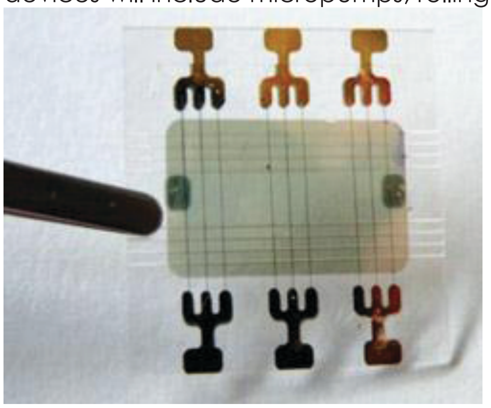
3) The four-channel Artificial Muscle Control Unit


This stand-alone portable laboratory instrument simplifies the generation and control of high voltages for artificial muscle research. Features include 4 independent output channels, computer control, battery operation, and safety features that make it suitable for bench-top use.

**Miniaturized EAPs based on ion-implanted compliant electrodes: mm-size pumps, motors, and robots**

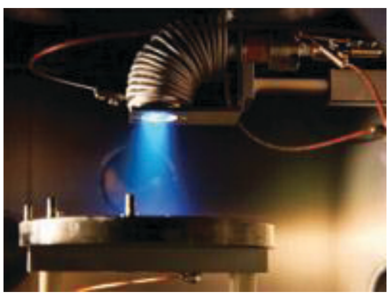
**S. Rosset, L. Maffli, S. Akbari, B. O'Brien, Herbert R. Shea, EPFL-LMTS (Switzerland)**

Several miniaturized dielectric elastomer devices will be demonstrated. By using metal ion-implantation compliant electrodes can be made with features as small as 50 µm. The developed devices will include micropumps, rolling robots, rotary motors, and cell-stretchers.



Array of 72 devices on a 2×2 $cm^2$ chips

Zipping peristaltic pump



Inside the ion implanter

3 mm

2-axis tilting mirror

**"Feel the game" with ViviTouch™ technology**

**Marcus Rosenthal, Andy Cheng, Artificial Muscle, Inc., Bayer MaterialScience Co. (United States)**

This demo will include the latest ViviTouch haptic actuators integrated into consumer products for "high definition feel" in mobile and gaming applications.

**Improved bistable electroactive polymers (BSEP) and refreshable Braille display devices**

**Xiaofan Niu, Paul Brochu, Sungryul Yun, Zhibin Yu, Qibing Pei, Univ. of California, Los Angeles (United States)**

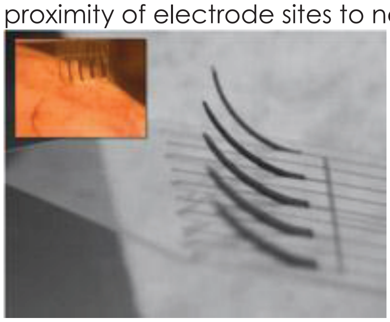
This demo is a bistable EAP actuators with significantly improved actuation performance, and refreshable Braille display device consisting of 1 to 4×10 cells.

Braille screen fabricated on a plastic sheet.

**Articulating neural interfaces**

**Eugene Dariush Daneshvar, Univ. of Michigan (United States); Elisabeth Smela, Univ. of Maryland, College Park (United States); Daryl Kipke, Univ. of Michigan (United States)**

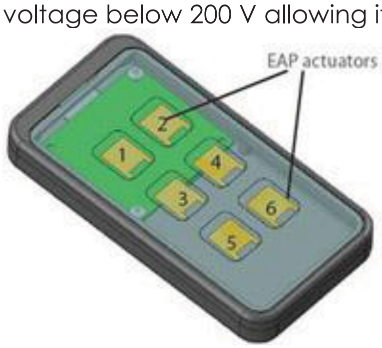
Articulating neural interfaces will be demonstrated that can guide the trajectory as well as the proximity of electrode sites to neural tissues.



**Haptics based on EAP actuators**

**Shihai Zhang, Qiming Zhang, and Ralph Russo,** Strategic Polymer Sciences, Inc. (USA)

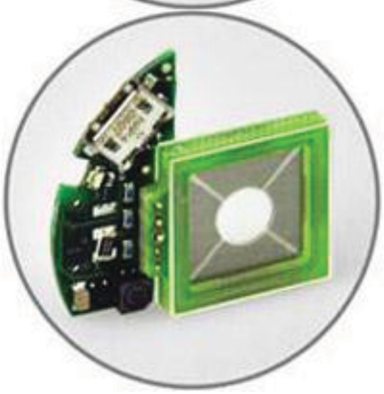
A high definition localized smartphone haptics device will be demonstrated using EAP actuators. The actuator provides sharp and concentrated multi-touch HD haptic feedback. It is driven by voltage below 200 V allowing its activation by low cost miniature power supply.



**A laser speckle reducer**

**Pit Gebbers, EPFL/ZHAW, Optotune Inc. (Switzerland)**

A laser speckle reducer that is actuated by DEAs will be demonstrated. The actuators cause a diffuser to perform in-plane, resonant movements. When a laser beam is directed through the moving diffuser, its speckle noise is significantly reduced by averaging the local interferences. The demonstrated device is significantly smaller and less expensive to produce than the commercial ones.

**Standing wave tube electro active polymer wave energy converted**

**Philippe Jean, Guillaume Ardoise, Ambroise Wattez, SBM Offshore (France)**

SBM Offshore will present the development of a fully flexible EAP based Wave Energy Converter. The demo will include videos of the wave tank model tests where large EAP ring generators are used on a flexible tube underwater to directly convert wave energy into high voltage DC electrical power. Large EAP ring generators of 800mm diameter with multiple layers will be displayed.