# WorldWide ElectroActive Polymers


# EAP (Artificial Muscles) Newsletter

**December 2006** **WW-EAP Newsletter** **Vol. 8, No.2**

http://eap.jpl.nasa.gov


## FROM THE EDITOR

***Yoseph Bar-Cohen,*** *yosi@jpl.nasa.gov*

There is a growing recognition that nature offers enormous pool of inventions, concepts and ideas. Nature is the largest experimental lab that ever existed and even will exit. Thru trial-and-error experiments biological systems are improved to meet the changing challenges. Those systems that fail to meet the challenges become extinct while the successful ones are coded in the species genetic code and passed on to the off-springs. The field of learning, understanding and implementation of nature's methods, concepts and inventions is known as biomimetics. The potentially important role of Electroactive Polymers (EAP) to act as artificial muscles is well recognized by the biomimetic community. The characteristics of inducing large displacements and the functionality to emulate biological muscles made EAP materials attractive for consideration in many fields. Turning these materials into actuators-of-choice is requiring further solidification of the technical foundations and identifying niche applications where their unique capabilities would provide the needed edge.

Recent development at EMPA, Switzerland, of an active blimp that has EAP actuated surfaces is an excellent example of the possibilities that can be considered using these materials. Making such an active blimp that emulates the fish while operating in air would have been considered, not too far back, science fiction and now it is close to engineering reality. If progress and safety issues allow, such an active blimp will be demonstrated at the EAP-in-Action Session of the upcoming SPIE's EAPAD Conf. in San Diego that will be held on March 19, 2006.

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# ABOUT THE EXPERT

## Tony Talaie joined the industry in Japan

Tony Talaie is an EAP expert with focus on conductive polymers. Recently, he left Osaka University to work at the semiconductor and robotic industry in Japan. He is an Australian citizen and has been working in Japan over the last 5-years. In his new position, he intends to investigate the use of EAP for robotics, nanobots and nanobiobots especially for semiconductor equipments. Tony is a winner of several of prestigious fellowships, (co)author of many publications related to conductive polymers and he made plenary, keynote and invited presentations worldwide. His lectures include one at the University of California Santa Barbara (UCSB), which was invited by Nobel Laureate Alan Heeger (see photo in Figure 1).

For collaboration and technical information exchange his contact e-mails are:
*English:* ohhatony@yahoo.com
*Japanese:* ganbarutony@yahoo.co.jp

**FIGURE 1:** Tony Talaie (right) with Nobel Laureate Alan Heeger during a visit to lecture at UCSB.

# GENERAL NEWS

The WW-EAP Webhub is continually being updated with information regarding the EAP activity Worldwide. This webhub can be reached on http://eap.jpl.nasa.gov and it is a link of the JPL's NDEAA Technologies Webhub of the Advanced Technologies Group having the address: http://ndeaa.jpl.nasa.gov

## RIC Unveils World's First "Bionic Woman"

*First Use of Bionic Arm Technology in a Female Patient http://www.ric.org/bionic/bionicwoman.php*

The Rehabilitation Institute of Chicago (RIC) has been working on innovative rehabilitation approaches to assist disabled patients. Recently, they developed an interface system that allows amputees to operate robotic prosthetics directly from their brain without the need to directly couple the two. One of their recent patients is a woman whose name is Claudia Mitchell and she was successfully fitted with one of their Bionic Arms. This arm is neuro-controlled and it allows an amputee to move his or her prosthetic arm as if it is a real limb simply by "thinking" (i.e., activating the nerves that are responsible for operating the specific arm). The arm also empowers patients with more natural movement, greater range of motion and restores lost function. This technology was developed by Todd Kuiken, director of RIC's Neural Engineering Center for Bionic Medicine, and a team of leading rehabilitation experts with the support of grants from the National Institutes of Health (NIH). The arms are driven by conventional motors and it would be great to see the use of EAP as the replacement actuators once advances will lead to materials that are more capable to support such an application.

# RECENT CONFERENCES

## 10th Intern. Conf. on new Actuators (Actuator 2006)

*Roy Kornbluh and Peter Sommer-Larsen, roy.kornbluh@sri.com*

The biennial International Conference on New Actuators was held June 14 - 16 in Bremen,

Germany. This conference focuses on emerging actuator technologies. Polymer actuators were featured at this conference for the third time. Seventeen oral and poster presentations focused on polymer actuators. The conference is unique in that the session chairs review recent work in their respective topic areas. The reviews are presented to all attendees. At no time were more than two sessions conducted in parallel. Thus, the conference afforded a good opportunity to compare polymer actuators with other actuator technologies such as piezoelectrics, shape memory alloys and magnetostrictive materials, to name but a few. Polymer actuator presentations considered dielectric elastomers, IPMCs, electrostrictive materials, carbon nanotubes, liquid crystal elastomers as well as newer ferroelectrets and piezoelectric polymers. Application areas considered haptic displays, pumps and artificial muscles to name a few.

This year, the conference was held in parallel with the RoboCup 2006 Competition, affording attendees a good opportunity to see the state of the art in robotics. Hundreds of teams from around the world gather to compete in soccer games or simulated rescue operations with teams of intelligent sensor-equipped robots. While most soccer-playing robots are motor-driven wheeled platforms, there are divisions for the more biomimetic Sony Aibo dogs as well as divisions for humanoid robots. In fact, a goal of the RoboCup competition is to make a team of humanoid robots that can defeat the human World Cup champion team by the year 2050. So far, the humanoid robots can barely walk let alone kick a moving ball. The fact that the FIFA World Cup was also being hosted by Germany at the same time allowed observers to clearly see the huge gap between human and robot abilities. While the goals for RoboCup are more ambitious than the Polymer Actuator vs. Human Arm Wrestling Challenge posed by Y. Bar-Cohen in 1999, an artificial muscle technology that can win an arm wrestling match might help realize the goals of RoboCup long before the 2050 deadline.

For more information on Actuator 2006 and future Actuator conferences please visit http://www.actuator.de/

### MRS Fall 2006

As part of the Fall 2006 MRS Symposium an EAP related conference was held and its titled is “Smart Dielectric Polymers Properties, Characterization and Their Devices,” Symposium C. The Chairs were V. Bharti, Y. Bar-Cohen, Q. M. Zhang, Z.-Y. Cheng, and G. M. Sessler. For information contact Vivek Bharti, vbharti@mmm.com.

## UPCOMING CONFERENCES

### ROBIO 2006

The International Conference on Robotics and Biomimetics (ROBIO) is an annual IEEE conference. The ROBIO 2006 Conference will be held in Kunming, China from December 18 to 20, 2006. This conference brings together leading scholars and researchers worldwide to disseminate their most recent and advanced findings to bridge the frontier of knowledge between robotics and biomimetics – from meter scale down to nanometer scale. Major topics that are covered by ROBIO include

- Robotics - humanoids, bio-mimicking robots/ systems, flying robots, medical robots, rescue robots, manipulators, path planning, tele-operation, vision, sensing, tracking, control, fuzzy/neural net/genetic algorithms, etc
- Advanced Actuation Materials - artificial muscles, electroactive polymer actuators, electrostrictive polymer actuators, conjugated polymer actuators, ionic conducting polymer actuators, smart materials, etc
- Micro/Nano Technology - AFM/SPM based manipulation, micro/nano fluidics, nanotube/nanowire/DNA based sensors, MEMS/ Nano fabrication, sensors, and actuators, micro/nano robotics, assembly, and manipulation, etc.
- Cellular Biomimetics - molecular motors, DNA/protein manipulation and detection, molecular and cellular imaging, micro/nano scale energy conversion and storage, DNA/molecular circuits, molecular self-assembly, bio-informatics, etc.

For further information about this Conference: http://www.cs.ualberta.ca/~zhang/robio2006/

## ICMENS 2006

The next International conference on MEMS, Nano and Smart Systems (ICMENS) is going to be held in Cairo, Egypt from Dec. 27 to 29, 2006. The objective of this Conference is to provide a forum for discussing new developments, recent progress, and innovations in the design and implementation of MEMS, NANO, and Smart Systems-on-Chip. It addresses various aspects of design methods of these systems. The emphasis is on current and future research and development challenges in both academia and industry.

A proceeding of the conference will be published. Specific subjects that were solicited for the program include:

- Nanoelectronics, Spintronic Devices and Systems
- Smart Sensor Technology and Measurement Systems
- Electroactive Polymer Actuators and Devices
- Damping and Isolation
- Micro-fluidic Systems
- Nano-imaging, Scanning Probes, and Molecular Manipulation and Devices
- Active Materials: Behavior and Mechanics
- Industrial and Commercial Applications of Smart Structure Technologies
- Smart Electronics, Smart Structures, Integrated Systems, MEMS, and BioMEMS
- Nano-optics and Nano-photonic Devices
- Novel Fabrication Processes, Laser Micromachining and Nanomachining
- Nano-composites
- Bio-electronics, Bionanotechnology, and Molecular Nanotechnology

For further information contact Wael Badawy at badawy@ucalgary.ca

## 2007 SPIE EAPAD Conference

The EAPAD Conferences, which started in 1999, is continuing to be the leading international forum for the field of EAP. The next conference will be held again in San Diego, California, from March 18-22, 2007, and with a course on Sunday, March 18. The 2007 EAPAD will be chaired by Y. Bar-Cohen, JPL, and Co-chaired by Gabor Kovacs, EMPA Dübendorf. As in past years, this conference will include presentations from leading world experts in the field including members of academia, industry, and government agencies from the USA and overseas. The papers will focus on issues that can help transitioning EAP to practical use thru better understanding of the principles responsible for the electro-mechanical behavior, improved materials, analytical modeling, methods of processing and characterization of the properties and performance as well as various applications. As in past years, a Course will be given on Sunday, March 18, and an EAP-in-Action Session will be held on Monday, March 19, 2007.

The Keynote Speaker in this conference is going to be George V. Lauder, who is an Alexander Agassiz Professor of Zoology and Professor of Organismic and Evolutionary Biology at Harvard University (Figure 2). His paper is entitled “How fishes swim: flexible fin thrusters as an EAP platform.” In his paper, he is going to discuss the results of recent experimental kinematic, biomechanical, and hydrodynamic studies of fish fin function, with a special focus on possible applications of Electroactive Polymer (EAP) technology in aquatic robots. Recent high-resolution video analyses of fish fin movements during locomotion show that fins undergo much greater deformations than previously suspected. Experimental work on fin mechanics shows that fishes also possess a novel mechanism for actively adjusting fin surface curvature to modulate locomotor force. Experimental study of fish propulsion in combination with computational fluid dynamic analysis is providing the basis for the design of robotic fin-thrusters for use in low-speed maneuvering underwater vehicles. EAP technology could play an important role in the development of such biomimetic thrusters.

**FIGURE 2:** George V. Lauder, Harvard University, is going to be the Keynote Speaker in the EAPAD 2007

We are going to have this year nine invited papers. While most will be given over 40 minutes two papers will be given over 20 minutes only. The invited papers and the speakers are listed below:

- Jean-Sebastien Plante, MIT (with Steve Dubowsky), "A Road to Practical Dielectric Elastomer Actuators Based Robotics and Mechatronics: Discrete Actuation"
- Federico Carpi, U. of Pisa, Italy, " Contractile folded dielectric elastomer actuators"
- Tony Jun Huang, Penn State U., "Towards Artificial Molecular Motor-Based Electroactive/ Photoactive Biomimetic Muscles"
- Toribio Fernandez Otero, Univ. Politécnica de Cartagena, "Attempting a classification for electrical polymeric actuators."
- John D. Madden, Canada, "Electro-active polymer actuator database and online reference"
- Barbar J. Akle, Virginia Polytechnic Institute and State Univ., "Development and Modeling of Novel Extensional Ionic Polymer Transducers"
- Rick Minato (& Gürsel Alici) Univ. of Wollongong, Australia (Only 20 minutes), "Tri-layer Conducting Polymer Actuators with Variable Dimensions"
- Seon-Jeong Kim,, Hanyang Univ. (Only 20 minutes), "New Modified EAP Nanofibers for Biomedical Applications"
- James L Tangorra, MIT, "The Application of Conducting Polymers to Biorobotic Fins and Other Devices"

Also, we plan to hold the EAP-in-Action session as part of the EAP-in-Action Session of the SPIE's Electroactive Polymer Actuators and Devices (EAPAD) Conference on Monday, March 19, 2007. This Session is intended to turn the spotlight on Electroactive Polymers (EAP) materials and their applications as well as increase the recognition of their potential. It offers a forum of interaction between the technology developers and potential users as well as "hands-on" experience with this emerging technology. The attendees are given a great opportunity to see the capability of state-of-the-art of EAP as potential actuators-of-choice. The Session consists of EAP Armwrestling Contest and demonstrations of EAP actuators and devices. We are going to have five research and industry presenters demonstrating their latest EAP actuators and devices. The affiliation of the presenters includes Artificial Muscle, Inc.; EMPA - Materials Science & Technology, Switzerland; Ras Labs, L.L.C., Intelligent Materials for Prosthetics & Automation; SRI International; and University of Pisa, Research Centre "E. Piaggio", Italy. The group from EMPA is considering demonstration of a large EAP-actuated blimp that will perform indoor flying using controlled surfaces. Issues related to safe and the maturity of blimp will determine if this demonstration will take place. At the section of Available Positions in this issue, EMPA is seeking hire PhD student to support the development of this blimp.

In addition to the demonstration, this session will include the 3rd Artificial Muscles Armwrestling Contest was held in San Diego CA. Again as in 2006, rather than wrestling with a human opponent, the contest will consisted of measuring the arms performance and comparing the results. The measuring fixture (see Figure 3) will be used to gauge the speed and pulling force of the EAP actuated arms. The fixture will be strapped to the contest table and the competing EAP actuated arms (currently there one arm planned to be made by students from the University of Toronto) will pull the fixture cable having a force gauge on its other end. To simulate a wrestling action a 0.5-kg weight is mounted on the pulling cable and it has to be lifted to the top of the fixture (see Figure 4). The

time to reach the top will be measured to determine the wrestling speed.

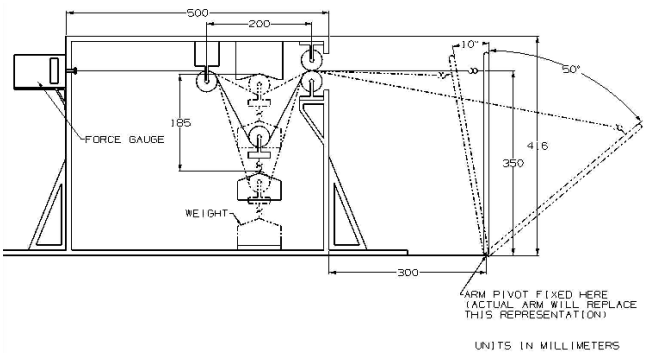



**FIGURE 3**: The competing arms testing fixture (see larger drawing on http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-armwrestling.htm).

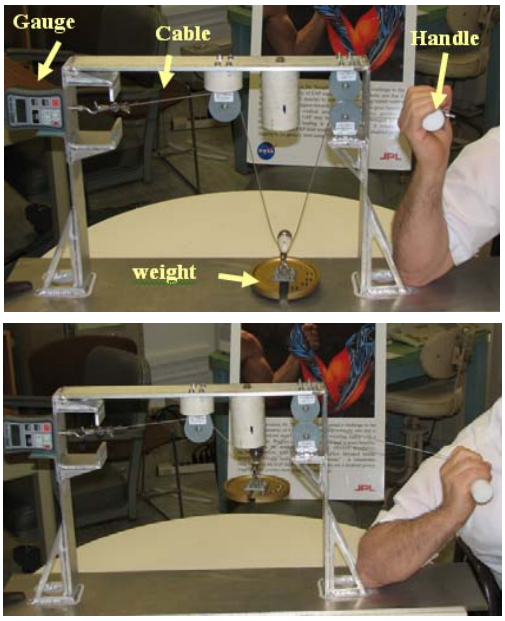



**FIGURE 4**: The fixture for testing the force and speed of the EAP actuated robotic arms.

Information about the EAPAD Conf. is at:
http://spie.org/Conferences/Programs/07/ss/conferences/index.cfm?fuseaction=6524
EAP-in-Action session is available on:
http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAPIA/EAP-in-Action-Demos-2007.htm
EAPAD course will be available soon at
http://spie.org/Conferences/Programs/07/ss/shortcourses/index.cfm?fuseaction=shortcoursedetail&course=SC634

## Comparing Design in Nature with Sci. & Eng. Conf.

The planning of the 4th International Conference on Comparing Design in Nature with Science and Engineering has begun and information about it will be announced soon. This Conference will cover various aspects of biomimetics and will also solicit related EAP papers. This Conference is going to be held in Algarve, Portugal from June 24 to 26, 2008. For further information contact Carlos Brebbia, Wessex Institute of Technology, UK.
E-mail: carlos@wessex.ac.uk

# ADVANCES IN EAP

## Jet Propulsion Laboratory (JPL)

**Medical device applications of Cold Hibernated Elastic Memory (CHEM) self-deployable structures** - *Witold Sokolowski*
*Witold.M.Sokolowski@jpl.nasa.gov*

The concept called "Cold Hibernated Elastic Memory" (CHEM) utilizes polyurethane-based shape memory polymers (SMP) in open cellular (foam) structures or sandwich structures made of SMP foam cores and polymeric composite skins. The CHEM foam technology takes advantage of the polymer's heat activated shape memory in addition to the foam's elastic recovery to deploy a compacted structure. In practice, the CHEM foams are compacted to small volume above their softening (glass transition) temperature Tg. They may then be stored below their Tg without constraint. Heating to a temperature above their Tg restores their original shape. The CHEM processing cycle is illustrated in Figure 5 below.

The CHEM foam structures are under development by the Jet Propulsion Laboratory (JPL) and industry. Currently, the CHEM foam concept is well formulated, with clear space applications. Although space community is the major beneficiary, a lot of potential commercial applications are foreseen for the "earth environment" especially in bio-medical area.

Polyurethane-based CHEM foam structures have very unique and appealing properties for the design and manufacturing of self-deployable

medical devices. Similar like solid SMP, they have an excellent biocompatibility and the $T_g$ can be tailored for shape restoration/self-deployment when inserted in the human body.

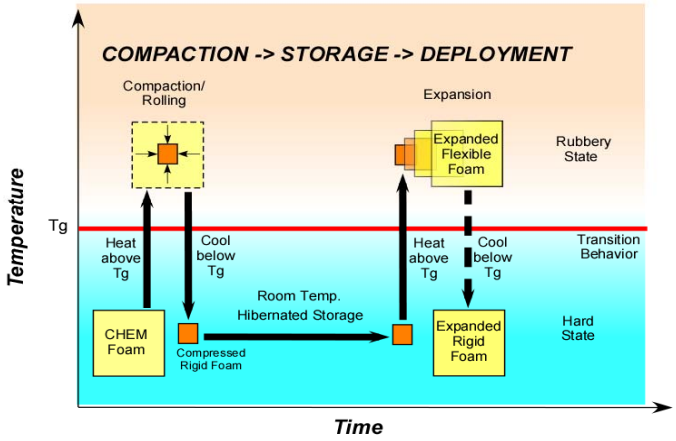



**FIGURE 5:** CHEM processing cycle

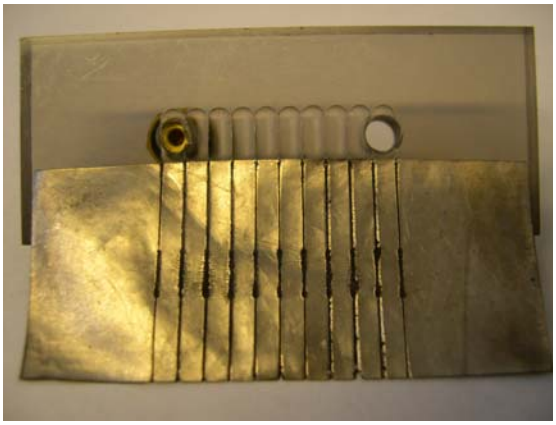
The CHEM foams can be miniaturized, deformed and inserted in the body through small catheters. Then, under the body heat, they can precisely self-deploy/recover a much larger predetermined required shape in satisfactory position. Currently, several important CHEM applications are being considered for self-deployable vascular and coronary devices. One of these applications, endovascular treatment of aneurysms, was experimentally investigated at CHUM Research Center, Notre-Dame Hospital, Montreal, in collaboration with École Polytechnique, Montreal with encouraging results. The major conclusion of this investigation was that new embolic devices for endovascular interventions could be designed and built using CHEM's unique physical properties.

The developers believe that SMP materials and CHEM foam structures will significantly and positively impact the medical device industry. They have unique characteristics that enable the manufacture of devices not possible with current materials, including SMA (shape memory alloys). It will open a door to design and build novel, exciting and often, life-saving, medical products and devices.

## Medipacs LLC

**Working prototypes of EAP medical pump and a new EAP polymer gel actuator** - *Mark Banister, Sonia Vohnout, Kwang Kim, Dominic McGrath,* *mbanister@medipacs.com*

Medipacs LLC reported the successful completion of its US Army Medical Research Command Phase I SBIR project by developing two working prototype EAP medical pump configurations and also developing new EAP polymer gel actuator material. One pump design was developed in collaboration with Kwang Kim at the University of Nevada, Reno, using IPMC materials fabricated and laser cut by his group (Figure 6)



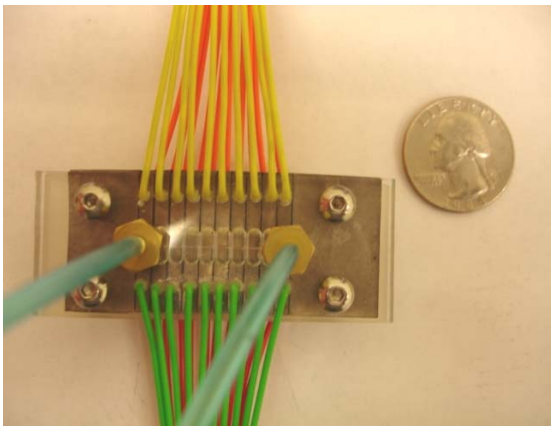
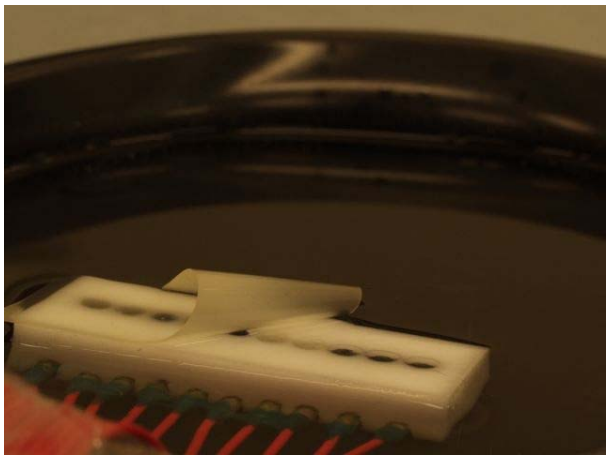


**FIGURE 6:** Laser fabricated IPMC actuator unit. This IPMC system has 210 electrodes that can be independently controlled. This IPMC system is designed to be used as the driving motor for the miniature pump. The pump chamber (top half) is shown.

The second pump was developed in collaboration with Dominic McGrath at the University of Arizona using new EAP gel actuators co-developed with the Medipacs lab (Figure 7). Testing of the two pump designs, control system and new EAP gel are ongoing now and the results will be presented in March at the SPIE Smart Materials Conference in San Diego CA. To date the EAP gel actuators have individually attained pressures of over 5-psi and, when actuated in the pump system, it has been able to hold back pressures over 28-psi.



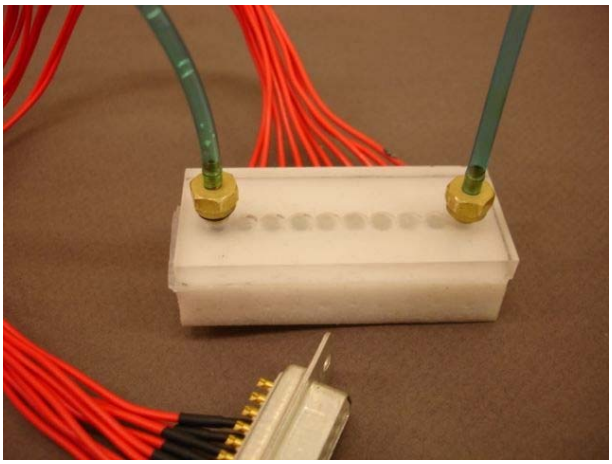


**FIGURE 7:** EAP gel actuated pump using 10 in-line actuators and electrodes that are independently controlled.
Left: the pump without its chamber
Right: The assembled pump with the chamber.

# AVAILABLE POSITIONS

Generally, available positions are listed on http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/Positions.htm

## Postdoc position at JPL

**Caltech Postdoctoral Scholars Position at JPL: Piezoelectric Mechanisms and Devices**

The California Institute of Technology (Caltech) Postdoctoral Scholars Program at the Jet Propulsion Laboratory (JPL) is inviting applicants to apply for a position at JPL's Advanced Technologies Group in the area of piezoelectric mechanisms and devices. The research activity will include electromechanical studies towards the development of a mechanism of actuation for planetary applications. The activity involves theoretical studies, analytical modeling, and experimental corroboration as described on the JPL's NDEAA Technologies Website.

Candidates should have a recent Ph.D. in physics, mechanical engineering, and/or materials science with a strong background in experimental research. The appointment is contingent upon evidence of completion of a Ph.D. The annual starting salary for a recent Ph.D. is US$52,000 and can vary somewhat according to the applicant's qualifications. Postdoctoral scholar positions are awarded for a one-year period. Appointments may be renewed in one-year increments for a maximum addition of two years. Dr. Yoseph Bar-Cohen, Senior Research Scientist and Supervisor of the JPL's Advanced Technologies Group, will serve as JPL postdoctoral advisor to the selected candidate. The appointee will be guided by the JPL advisor to ensure that the research work will result in publications in the open literature.

Please send curriculum vitae, bibliography, statement of research interest and a list of three references to Dr. Yoseph Bar-Cohen at the address listed below. Dr. Yoseph Bar-Cohen, Jet Propulsion Laboratory (82-105), 4800 Oak Grove Dr., Pasadena, CA 91109-8099,

e-mail: yosi@jpl.nasa.gov
Website: http://ndeaa.jpl.nasa.gov/

The California Institute of Technology (Caltech) Postdoctoral Scholars Program and the Jet Propulsion Laboratory (JPL) are Equal Opportunity/Affirmative Action employers. Women, minorities, veterans and disabled persons are encouraged to apply.

## PhD position at EMPA

**PhD position at EMPA: Development of a Blimp with Bionic Propulsion based on Electro Active Polymers**

Empa is an inter- and transdisciplinary research institution for material science and technology within the ETH domain. The Electro Active Polymers Group at Duebendorf /Zürich is looking – in collaboration with the Institute of Mechanical Systems of ETH Zürich (Prof. Ermanni) – for a highly innovative project in the filed of lightweight smart structures and the subject is "Lighter-than-Air Vehicles using Electro Active Polymers (EAP)."

A PhD student is sought for the development of this Lighter-than-Air Vehicle (See schematic view in Figure 8). In the first phase a novel bionic propulsion system based on Electro Active Polymers (EAP) for a Blimp will be designed, optimized and verified based on experimental work in the lab. In the second phase together with project partners, a blimp for indoor flying will be developed and fabricated. The PhD work will focus on technical-scientific questions arising during the project. The fluid dynamics, structural mechanics, flight performance will we explored with systematic experimental studies. The work will end in feasibility studies for applying the novel propulsion system for larger Blimps, used for transportation, observation and reconnaissance, as well as stratospheric platforms.

A candidate is being sought having master degree in mechanical engineering, experimental physics or equivalent, with special knowledge in aeronautics, structural mechanics (of membranes), fluid dynamics, and aircraft design. He/she will work experimentally in a highly innovative project team.

For further information please contact Giovanni Terrasi, Tel. +41 44 823 41 17, or Silvain Michel, Tel. +41 44 823 45 88 at EMPA, Materials and Engineering, Ueberlandstrasse 129, CH-8600 Duebendorf, Switzerland.
e-mail: silvain.michel@empa.ch
web: http://www.empa.ch/abt117

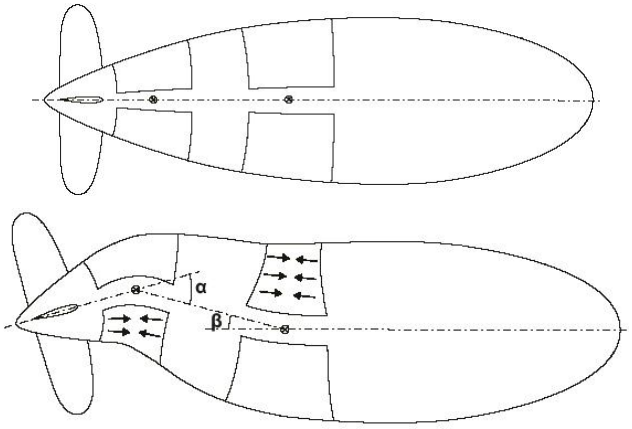



**FIGURE 8:** A graphic view of the envisioned EAP activated blimp.

# NEW BOOKS

## Biomimetics - Biologically Inspired Technologies

*Y. Bar-Cohen (Editor)*
*http://ndeaa.jpl.nasa.gov/nasa-nde/yosi/yosi-books.htm*

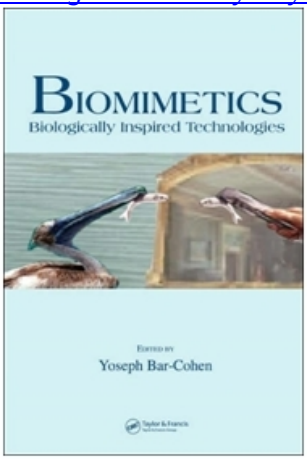



**FIGURE 9:** The cover page of the new book on biomimetics

The book entitled "Biomimetics - Biologically Inspired Technologies" (see Figure 9) that was edited and coauthored by Y. Bar-Cohen, which was published by CRC Press in 2005, was the subject of book review in the November 23 issue of the

Journal 'Nature'. The review article was written by Robert W. Cahn, and it is entitled "**Learning from nature"** *Nature* Vol. **444**, pp. 425-426. Subscribers of Nature can view the article at http://www.nature.com/nature/journal/v444/n7118/full/444425b.html

This book about Biomimetics review technologies that were inspired by nature and outlook for potential development in biomimetics in the future. This book is intended as a reference comprehensive document, tutorial resource, and set challenges and vision for the future direction of this field. Leading experts (co)authored the 20 chapters of this book and the outline can be seen on http://ndeaa.jpl.nasa.gov/ndeaa-pub/Biomimetics/Biologically-Inspired-Technology.pdf

# UPCOMING EVENTS

| Date | Conference/Symposium |
|---|---|
| Dec. 18 -20, 2006 | ROBIO 2006 Conference will be held in Kunming, China, Dec. 18 to 20, 2006. For information contact Hong Zhang zhang@cs.ualberta.ca Web: http://www.cs.ualberta.ca/~zhang/robio2006 |
| Dec. 27 - 29, 2006 | International conference on MEMS, Nano and Smart Systems (ICMENS), Cairo, Egypt. |
| March 18-22, 2007 | 2007 EAPAD, SPIE's Smart Structures & Materials and NDE Symposia, San Diego, CA., For information contact: Mike Stiles , SPIE, mikes@SPIE.org Website: http://spie.org/Conferences/Programs/07/ss/conferences/index.cfm?fuseaction=6524 |
| End of 2007 | During the Fall 2006 MRS meeting an EAP related Symposium is planned to be held in Boston, MA. For information contact Vivek Bharti vbharti@mmm.com |
| June 24 - 26, 2008 | 4th Intern. Conf. on Comparing Design in Nature with Sci. & Eng., to be held at Algarve, Portugal. For information contact Carlos Brebbia, Wessex Institute of Technology, UK, carlos@wessex.ac.uk |

# EAP ARCHIVES

Information archives and links to various websites worldwide are available on the following (the web addresses below need to be used with no blanks):

**Webhub**: http://eap.jpl.nasa.gov
**Newsletter**: http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/WW-EAP-Newsletter.html

**Recipe:** http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-recipe.htm

**EAP Companies**: http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-material-n-products.htm

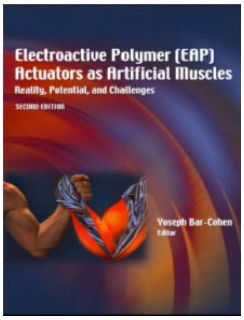
**Biomimetics**: http://ndeaa.jpl.nasa.gov/nasa-nde/biomimetics/bm-hub.htm
**Armwrestling Challenge**: http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-armwrestling.htm

## Books and Proceedings:

http://ndeaa.jpl.nasa.gov/nasa-nde/yosi/yosi-books.htm

## 2nd Edition of the book on EAP

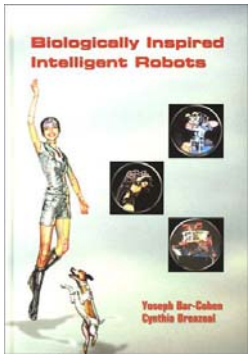
*Y. Bar-Cohen (Editor)*




In March 2004, the 2nd edition of the "Electroactive Polymer (EAP) Actuators as Artificial Muscles - Reality, Potential and Challenges" was published. This book includes description of the available materials, analytical models, processing techniques, and characterization methods. This book is intent to provide a reference about the subject, tutorial resource, list the challenges and define a vision for the future direction of this field. Observing the progress that was reported in this field is quite heart warming, where major milestones are continually being reported.

## Biologically Inspired Intelligent Robots

*Y. Bar-Cohen and C. Breazeal (Editors)*




The book that is entitled "Biologically-Inspired Intelligent Robots," covering the topic of biomimetic robots, was published by SPIE Press in May 2003. There is already extensive heritage of making robots and toys that look and operate similar to human, animals and insects. The emergence of artificial muscles is expected to make such a possibility a closer engineering reality. The topics that are involved with the development of such biomimetic robots are multidisciplinary and they are covered in this book. These topics include: materials, actuators, sensors, structures, control, functionality, intelligence and autonomy.


# Happy New Year


***WorldWide Electroactive Polymers (EAP) Newsletter***

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