WorldWide ElectroActive Polymers


EAP (Artificial Muscles) Newsletter

June 2006 **WW-EAP Newsletter** **Vol. 8, No.1**

http://eap.jpl.nasa.gov

FROM THE EDITOR

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

The field of Electroactive Polymers (EAP) is continuing to grow. 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.

The first wrestling match contest of EAP actuated robotic arms and human, which took place on March 7, 2005, was an important part of the history of this field. In the second contest that we held on Feb. 27, 2006, at the SPIE's EAP-in-Action Session of the EAPAD Conference, lessons learned from this first competition were implemented. As of this Conference, we shifted the focus from wrestling with human to performance measurement. In a future conference, once advances in developing such arms reach sufficiently high level, a professional wrestler will be invited for the next human/EAP-actuated robot wrestling match. Further information about this challenge and information about the related competitions is available on http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/ EAP-armwrestling.htm

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ABOUT THE EXPERTS

NASA Honor Award Medal – EAP Achievements

On June 7, 2006, the Editor of this Newsletter received a NASA Honor Award Medal for Exceptional Technology Achievement. He received this Medal for his accomplishments and contributions to the field of electroactive polymers as artificial muscles. This prestigious NASA Award is Bar-Cohen's 2nd Honor Award Medal. He received the previous one in 2001 for Exceptional Engineering Achievement related to his accomplishments in piezoelectric mechanisms. The photo above shows from right to left: Colleen Hartman, Deputy Associate Administrator, NASA Science Mission Directorate; Y. Bar-Cohen, JPL; and Charles. Elachi, Director, JPL.

Obituary to Alberto Mazzoldi

University of Pisa - Interdepartmental Research Centre "E. Piaggio"

We are very sad to inform that Dr. Ing. Alberto Mazzoldi is no longer with us. He passed away on May 11, 2006. He served as a Researcher in Biomedical Engineering at the Research Centre "E. Piaggio" of the University of Pisa. He contributed to advances in the field of ElectroActive Polymers with significant scientific publications. We are deeply sorry for his untimely demise and all of us who worked with him will always feel his absence. We deeply sympathize with his wife Alessandra and his parents.

His colleagues of the
Interdepartmental Research
Centre "E. Piaggio"

In memory of Alberto Mazzoldi, a special Session will be dedicated during the next SPIE's EAPAD Conference. This session will be held on Tuesday, March 20, 2007 and will be chaired by Danilo DeRossi and Ray Baughman.

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

Shape controlled Tire Award - winner design

James Owen Design recently conceived a novel Michelin E.A.P. tire for the Mazda RX-9 and won the Michelin Challenge Design Award at the 2006

North American International Auto Show. The designed tire takes advantage of current and forthcoming advances in hybrid drive train technology. Further, EAP materials were crossbred with hybrid engine technology and electrostatic collectors to suggest a concept for adaptive tires. This award winning concept suggests making EAP actuated tires with shape control. Further information about this design is available at: http://www.leftlanenews.com/2006/04/26/electroactive-polymer-tire-can-change-size-shape/

Popular Science Article about EAP

The armwrestling that we held in March 2005 was covered in an excellent article by Dan Ferber that appeared in the September 2005 issue of Popular Science. The article is entitled "Will Artificial Muscle Make You Stronger?" and it was part of a special issue that was fully dedicated to the topic of the future of the human body. This article is now scheduled for publication in The Best of Technology Writing 2006, which is an anthology from digitalculturebooks (www.digitalculture.org), a division of the University of Michigan Press.

Article about using inkjet printing of EAP

On June 21, the online International Science and Technology, OhmyNews, published an article entitled "Printable Robots - Advances in inkjet technology forecast robotic origami" that suggests the use of EAP. This article was inspired by the Editor's vision of future fabrication of parts and devices using ink-jet printing of EAP materials. The article can be viewed on http://english.ohmynews.com/articleview/article_view.asp?article_class=4&no=299900&rel_no=1

Reference: Y. Bar-Cohen (Ed), "Electroactive Polymer (EAP) Actuators as Artificial Muscles - Reality, Potential and Challenges," **2nd Edition**, ISBN 0-8194-5297-1, SPIE Press, Vol. PM136, (March 2004), pages 736, 745 and 750.

DARPA funded prosthetic arms

Under funding from DARPA, revolutionary prosthetics are being developed that are controlled directly by the human brain. This effort led already to impressive success as recently been reported by Newsweek at the MSNBC website http://www.msnbc.msn.com/id/13325828/site/newsweek/?GT1=8211 Such arms were connected to a patient at the Rehabilitation Institute of Chicago (RIC). This patient is Jesse Sullivan, 59, from Dayton, TN, who lost both arms in a power-line accident. Doctors have "rewired" him using the severed arm nerves in his chest muscles. Now his brain actually "senses" his missing hands and he moves his mechanical arm by contracting those muscles. DARPA is funding these efforts at the level of about 50 million dollars pulling together 30 science and industry leaders to do what the private sector could never do alone.

The 2006 EAP Armwrestling Contest

On Monday, Feb. 27, 2006, the 2nd Artificial Muscles Armwrestling Contest was held in San Diego CA, as part of the EAP-in-Action Session of the SPIE's Electroactive Polymer Actuators and Devices (EAPAD) Conference. In this year's contest, there were three participants including ERI Limited, Albuquerque, NM; and two groups of students from Virginia Tech. Rather than wrestling with a human opponent, the contest this year consisted of measuring the arms performance and comparing the results. A measuring fixture (see Figure 1) was used to measure the speed and pulling force of the EAP actuated arms. The fixture was strapped to the contest table and the competing EAP actuated arms pulled the fixture cable having a force gauge on its other end. To simulate a wrestling action a 0.5-kg weight was mounted on the pulling cable and had to be lifted to the top of the fixture (see Figure 2). The time to reach the top was measured to determine the wrestling speed.

To establish a baseline for performance comparison, Panna Felsen's (the student that served as the human wrestler in 2005) capability was measured first (see Figure 3) and then the three participating robotic arms were tested. Before the

start of the contest, a representative of each of the participants gave a short description of the competing arm.

The participants and the winners of the contest this year were as follows:

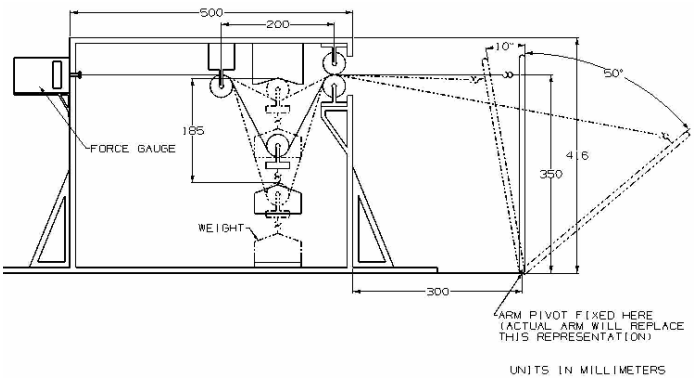

FIGURE 1: The competing arms testing fixture (see larger drawing on http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-armwrestling.htm).

1. The strongest arm (Figure 4) – This arm was made by senior students from the Department of Engineering Science and Mechanics, Virginia Tech, and it was an enhancement of the VT arm that participated in 2005. For this group the Primary Advisor: John Cotton; the Student Team Leader: Josh Oechslin; and the participating students:: Joseph Ash, Matthew Degner, Sara Jasin, Jordan Milford, Kevin Nash, Catherine Ross, and Brandon Shue.
2. The fastest arm (Figure 5) – Under the lead of Mohsen Shahinpoor, Environmental Robots Incorporated (ERI), Albuquerque, New Mexico, the previous year arm was used with enhanced artificial muscle material. Unfortunately, two of the four EAP actuator strips failed (possibly due to damage during shipping) but still this arm managed to exhibit the fastest speed.
3. Senior students from the Mechanical Engineering Department, Virginia Tech, made the third arm. These students used an arm that was driven by Dielectric Elastomer EAP (Figure 6) but unfortunately many of the EAP actuators were damaged during shipping while others failed during the activation when turned on during the measurement. The Primary Advisor: Barbar Akle; Co-Advisors: Nakhiah Goulbourne and Don Leo; Student Team Leader: Jaime Schmieg; and the participating students: Dave Griffiths, Heath Folmsbee, Anthony Ribaudo, Josh Leong, Erin Lucas, and Charley Sessoms.

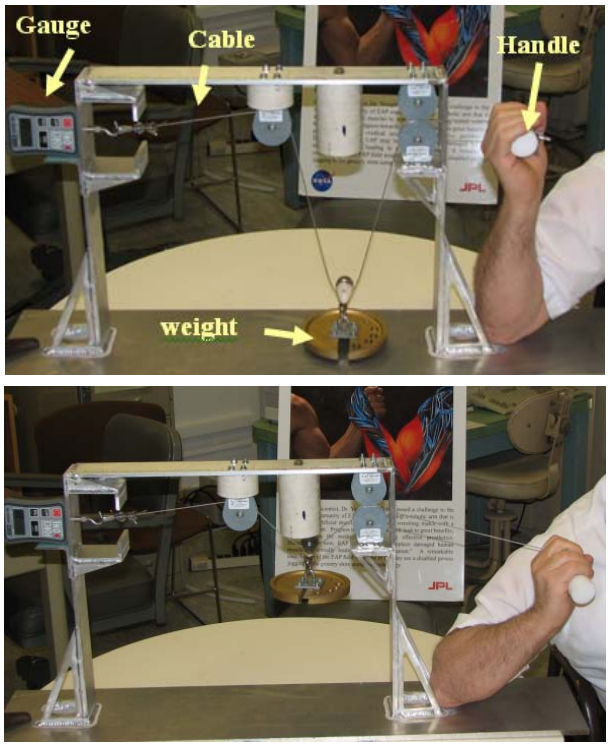

FIGURE 2: The fixture for testing the force and speed of the EAP actuated robotic arms.

FIGURE 3: Panna Felsen, the former high school student from San Diego, who was the human opponent in the first Armwrestling Competition. Panna is now a student at Caltech.

FIGURE 4: The Department of Engineering Science and Mechanics, VT, arm was the strongest in the 2006 Contest.
Top: The students preparing the arm.
Bottom: The arm in wrestling action with the test fixture.

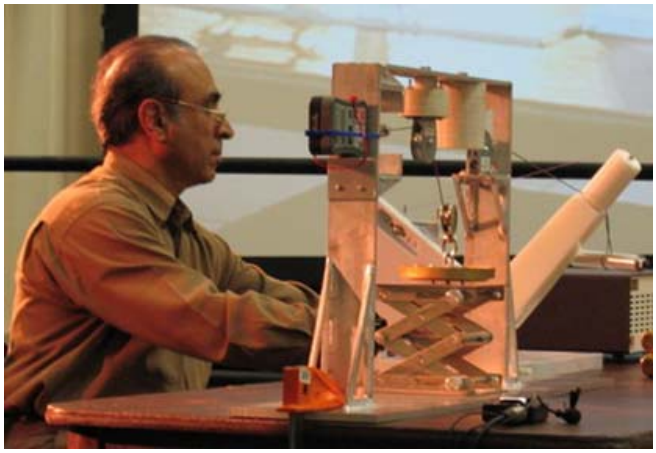

FIGURE 5: The ERI arm was the fastest in the 2006 Contest

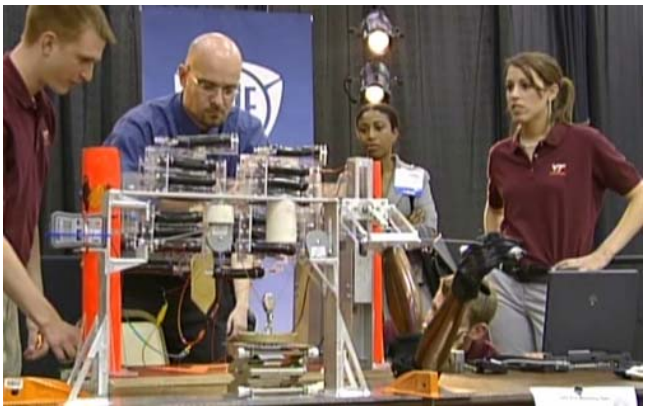

FIGURE 6: The Mechanical Engineering Dept., VT arm that was driven by Dielectric EAP Elastomer EAP.

In a future conference, once advances in developing such arms reach sufficiently high level, a professional wrestler will be invited for the next human/machine wrestling match. For 2007, indications were given that more university professors will encourage their students to participate in the contents and also various research organizations are considering participating.

Acknowledgement
The wrestling fixture for the 2006 contest was drawn (see Figure 1) by Ayoola K Olorunsola, JPL, was constructed by Qibing Pie and his students from UCLA (Figure 2) and finalized by Chris Jones, JPL. The measurements during the contest were recorded by Zheng Chen, who is a PhD candidate, Electrical Engineering Department, Michigan State University.

Humanlike Interfaces for Expressive Face

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A PhD dissertation "Humanlike Interfaces--Experiments in Humanizing Robots", is about to be completed. This study is dedicated to developing the required interfaces for advancing the capability of humanlike robots and its head in particular. The face is the dynamic icon of the human identity. A considerable portion of our brain activities are associated with social cognition and the face

serving as primary input-output device. A humanlike robotic face may be a promising paradigm for computer interfaces, if the nuances of the human face could be mastered in robotic media. Does a realistic humanlike robot need to be as intelligent as a person to be effective? Perhaps the efficacy of such robots depends on the quality of the aesthetic and interaction design, regardless of the level of realism. This question, as well as the aesthetic, cognitive and philosophical issues related to humanlike robots, are address in this dissertation.

FIGURE 7: Android portrait of the science-fiction writer Philip K Dick (e.g. Blade Runner and Minority Report and Total Recall).

FIGURE 8: A human-like head of Albert Einstein making facial expressions

The reported study involved replicating the dynamic action of the face in robots, explicating the technology, concepts, and artistry. Specific robots that were included in this study are an android portrait of the sci-fi writer Philip K Dick, (see Figure 7) and a walking Einstein portrait Albert-Hubo (see Figure 8). The study includes experiments with human reaction to these near-realistic robots. Results indicate that, if the robots and interactions are properly designed, people enjoy the interaction. Further information about these robots is available at
www.HansonRobotics.com

J. ISSUES DEDICATED TO EAP

J. Smart Materials & Structures

The Journal of Smart Materials and Structures (http://www.iop.org/EJ/journal/0964-1726/) will dedicate one of its upcoming issues to the topic of EAP. The Guest Editors of this issue are: Yoseph Bar-Cohen, Kwang J. Kim, Hyouk Ryeol Choi, and John D. Madden. Selected authors who submitted manuscript to the 2006 EAPAD conference were invited to submit a paper for publication consideration. The total number of papers that were considered has been 77 and 20 authors were invited to submit a revised/updated version. In choosing the papers for publication consideration the following criteria were used: 1) new development (science and/or engineering) and high quality work in the following four fields: Dielectric elastomers, IPMCs, conducting polymers/CNT, and ionic gels/others; and 2) one paper per research group and per field of research

MRS Bulletin

The Materials Research Society (MRS) has agreed to dedicate a future issue of is MRS Bulletin to the subject of electro-responsive polymers. Current plans are to have this issue published in January 2008. The Guest Editors of this issue are Qiming Zhang and Y. Bar-Cohen. The acceptance of this issue is attributed to MRS recognition of their unique inherent properties of light weight, mechanical flexibility, high dielectric strength, and easy processing, as well as the fact that they are

finding a broad range of applications including electro-mechanical energy conversions, artificial muscles, and charge/energy-storage devices. Recent advances in these materials reveal the great potential to significantly improve their electro-responsive properties and that their response can mimic biologic systems. The overall scope of this special issue is to provide fundamental understanding of these polymers and related nano-composites, recent advances, application examples, and challenges. Six topics and authors were selected for submittal of papers.

J. Bioinspiration and Biomimetics

The Journal of Bioinspiration and Biomimetics has agreed to dedicate one of its upcoming issues to the topic of EAP and biomimetics. The Guest Editor is Y. Bar-Cohen and he will soon start selecting candidate authors for paper submittal. In its first issue that came out in March this year, this journal published a review paper on EAP as can be seen at http://ej.iop.org/links/q09/cGZkj2k6nj3eoUJKBSMvfA/bb6_1_p01.pdf

J. NeuroEngineering & Rehabilitation

New Online Journal publishes work on artificial muscles and biomedical applications of EAPs

The Journal of NeuroEngineering and Rehabilitation (JNER), publishing since late 2004 is an Open Access, peer-reviewed online journal that aims to foster the publication of research work that results from cross-fertilization of the fields of neuroscience, biomedical engineering, and physical medicine & rehabilitation. As such, the journal is well suited to the publication of articles on EAPs for artificial muscles, haptic and proprioceptive feedback and other bioengineered devices. Several EAP researchers have already published papers in this journal and a special issue on artificial muscles will be released this year.

For information on the journal and how to submit articles, please visit
http://www.jneuroengrehab.com/home/
or contact Roy Kornbluh at roy.kornbluh@sri.com

RECENT CONFERENCES

MRS Fall 2005

From Nov. 28 to Dec. 2, 2005, as part of the MRS Fall Symposium, an EAP related conference entitled "Electro Responsive Polymers (ERP) and Their Applications," was held in Boston.

The focus of this symposium included: Class-1: Sensor and actuators; and Class-2: Dielectrics and Charge Storage. This Conference was organized by Vivek Bharti, 3M Center; Qiming Zhang, The Penn State University; John Madden, The University of British Columbia, Canada; Yoseph Bar-Cohen, Jet Propulsion Lab; and ZhongYang Cheng, Auburn University.

Invited speakers included: Mitch Thompson (MSI, USA), John Main (DARPA, USA), Jan Obrzut (NIST, USA), Geoffrey Spinks (Univ. of Wollongong, Australia), Ray Baughman (UT Dallas, USA), Mark Dadmun (University of Tennessee, USA), S. Bauer (Johannes-Kepler University, Austria), Qiming Zhang (Penn State).S. B. Lang (Ben-Gurion University of the Negev, Israel), Timothy Swager (MIT, USA), and Mark Zahn (MIT, USA).

2006 SPIE'S EAPAD Conference

The EAPAD conference this year included about ninety presentations and was well attended by leading world experts in the field including members of academia, industry, and government agencies from the USA and overseas. Significant progress was reported in each of the topics of the EAP infrastructure. The papers focused on 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. Papers in this conference covered the following topics:

- Electroactive polymers (EAP) and non-electro active-polymer (NEAP) materials
- Theoretical models, analysis and simulation of EAP and computational chemistry.

- Support technologies, including electroding, synthesis, processing, shaping and fabrication
- Methods of testing and characterization of EAP
- EAP as multifunctional materials
- EAP scalability to miniature (MEMS, micro and nano) and large dimensions
- 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 have shown 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 tool 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 electrostrictive, IPMC, dielectric, carbon nanotubes, conductive polymers, and other types.

The Keynote Speaker was Rainer Stahlberg, from the University of Washington (see Figure 9) and the title of his presentation was “What can we learn from nastic plant structures? The phytomimetic potentiality of nastic structures,” In this presentation, he covered the topic of plants as active structures the efforts to emulated them using EAP technology.

As in the past years, the EAP-in-Action Session was held as part of this SPIE’s EAPAD conference and it was intended to continue turning the spotlight on EAP materials and their applications as well as increase the recognition of their potential. This session provides the attendees an opportunity to see a demonstration of the latest EAP materials in action. This Session offers a forum of interaction between the technology developers and potential users as well as a "hands-on" experience with this emerging technology. This year, the participants included Federico Carpi, University of Pisa, who shown two types of dielectric elastomer actuators. SRI International jointly with UCLA showed also a dielectric elastomer EAP demo. Charlie Duncheon, Artificial Muscle, Inc. showed a series of demos including a pump, valve and flapping wing (see Figure 10). NanoSonic showed their latest Metal RubberTM Flexible Conducting Interconnects and Sensors. Keiichi Kaneto, Kyushu Institute of Technology (KIT), showed recent soft actuators from KIT and Demo videos from Eamex.

FIGURE 9: The 2006 EAPAD Keynote Speaker, Rainer Stahlberg, from the University of Washington.

FIGURE 10: Charlie Duncheon, Artificial Muscle, Inc. is showing several EAP actuated demos including pump, and flapping wing.

To provide the attendees with opportunity to learn about EAP, an introductory course was given on Sunday, February 26, 2006 as part of the

EAPAD Conference. The course was entitled "Electroactive Polymer Actuators and Devices," and the lead instructor was the Conf. Chair, Y. Bar-Cohen, who presented an overview, and covered applications that are currently developed and ones that are being considered. The subject of Ionic EAP was covered by J. Madden from the University of British Columbia, Vancouver, Canada. Further, the topic of Electronic EAP was covered by Q. Pei from the University of California at Los Angeles (UCLA). This course was intended for Engineers, scientists and managers who need to understand the basic concepts of EAP, or are interested in learning, applying or engineering mechanisms or devices using EAP materials. Also, it was intended for those who are considering research and development in EAP materials and their present and/or future applications.

SAMPE 2006

In its 2006 Symposium, SAMPE included for the first time a session on EAP. This Symposium was held from April 30 to May 4, in Long Beach, California. The session was Chaired by Yoseph Bar-Cohen, JPL, and Qibing Pei, UCLA and it gave materials and process scientists and engineers an opportunity to interaction with EAP experts. The session was opened with a Plenary Presentation by Bar-Cohen and was followed by a demo of Dielectric EAP actuators that were made by Qibing Pei and his students from UCLA. Six other presentations were given by Qibing Pie, UCLA; Kwang J. Kim, University of Nevada, Reno, NV; Han Xu, Han-Kuan A. Tsai, Anuj Taneja, Lawrence Kulinsky, Marc Madou, UC Irvine; Chris Henry, Elena Sherman, and William Barvosa-Carter, HRL Laboratories; Liangti Qu and Liming Dai, the University of Dayton, OH; as well as Cameron Massey, William Barvosa-Carter, David Chang, Ping Liu, HRL Laboratories LLC

Symp. on Biomimetics Designs&Eng.

The first International Symposium on Biologically-Inspired Design and Engineering was held at Georgia Tech from May 11 to 12. The Symposium was chaired by Jeannette Yen and Marc Weissburg, Georgia Tech. This Symposium included presentations that covered various topics related to biomimetics ranging from better understanding of biological processes to the application of biomimetic concepts and designs.

UPCOMING CONFERENCES

MRS Fall 2006

As part of the Fall 2006 MRS Symposium an EAP related conference entitled "Smart Dielectric Polymers Properties, Characterization and Their Devices," Symposium C. The Chairs will be V. Bharti, Y. Bar-Cohen, Q. M. Zhang, Z.-Y. Cheng, and G. M. Sessler. For information contact Vivek Bharti, vbharti@mmm.com. Further information about this Symposium is available on http://www.mrs.org/fall2006

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 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.

All papers must be submitted electronically in PDF format by **July 1, 2006**. The maximum number of pages is limited to six in two-column IEEE format. An additional two pages will be allowed subject to extra page charges. Information can be obtained from Hong Zhang zhang@cs.ualberta.ca Web: http://www.cs.ualberta.ca/~zhang/robio2006/

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. Information about this conf. is on: http://spie.org/Conferences/Calls/07/ss/conferences/index.cfm?fuseaction=SSN02

ADVANCES IN EAP

Penn State University

Braille display pin actuators

Qiming Zhang <qxz1@psu.edu>

Refreshable full page Braille display that shows text and graphics is the dream of many blind and visually-impaired. Even after many years of efforts, the progress in developing such Braille displays has been very limited. Present refreshable Braille displays have been developed based on the piezoelectric actuation using the conventional piezoceramic materials. The small strain level (<0.05%) in the piezoceramics requires the Braille actuator to be in bimorph form occupying large space and hence these refreshable Braille displays are limited to single line (see Figure 11).

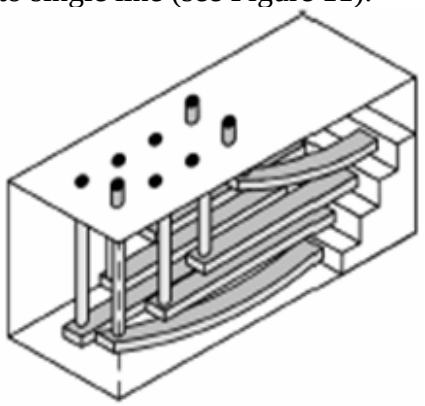

FIGURE 11: Braille display cell using piezo-ceramic bimorph.

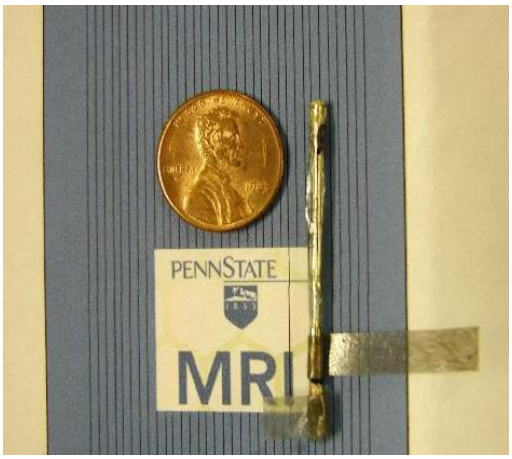

FIGURE 12: Electrostrictive polymer actuator

The large induced strain (>5%) and stress level (>20 MPa) with fast response speed offered by the electrostrictive PVDF based polymers provide great potential to fabricate compact Braille actuators. Such actuators can generate large motion using small size pins, as required for full page Braille display. Under funding of NIH, our research group

has successfully demonstrated compact actuators using electrostrictive PVDF polymers (see Figure 12). The actuator, which uses a commercial spring core, has a diameter of less than 2 mm and can generate 1 mm tip motion with several gm force, which is more than adequate for a refreshable Braille. Further improvement in the spring core is expected to allow reducing the actuator diameter below 1 mm. Such a compact and robust actuator can be used to replace the piezoceramic bimorph actuator and make it possible to produce full page Braille display allowing for making a computer monitor for the blind and visually impaired. The Penn State team is led by Qiming Zhang and it includes Kailiang Ren, Sheng Liu, Minren Lin, and Don Natila. A video showing the actuation of the polymer Braille actuator can be made available upon request

Update from Artificial Muscle, Inc.

Charlie Duncheon, Acting CEO
charlie.duncheon@artificialmuscle.com

Much has happened at Artificial Muscle, Inc. (AMI) since the last issue of this WW-EAP Newsletter.

- In January, AMI announced the first standard EAP platform product, the Universal Muscle Actuator (UMA) platform. This UMA platform is now available in Development Kit configurations and is integrated with AMI products such as the new DV35 Proportional Valve (see Figure 13). It is AMI's belief that EAP commercialization can be expedited by focusing first on a single EAP configuration like the double diaphragm UMA. In looking at applications in the EAP community, it appears that the diaphragm UMA application has the broadest range of applications including pumps, valves, power generation, sensing and vibration generation.
- In the last two years, AMI has been working on the EAP challenge of high operating voltage and recently developed a family of small, low cost, high-voltage, low-power DC-DC converters. These new power supplies are now being integrated with the AMI actuator products (Figure 14). In addition, a new division was formed, AMI Electronics, which is independently selling the family of power supplies to the broader market. This is another step taken to facilitate the creation of high-voltage DC power supplies in a very small form factor at low costs.
- In May, AMI received the Frost and Sullivan's Actuator Technology Innovation of the Year award.
- Also in May, Nippon Koki, Inc. announced a spin out company, Hyperdrive, Ltd., which will be developing an energy harvesting product based onto the AMI's EPAM technology in the UMA configuration. Hyperdrive's future products include power generators for buoys and seawalls.

AMI continues to make advancements in materials and encourages members of the EAP community to contact us about development partnerships. This will help move rapidly toward the commercialization of this exciting technology.

FIGURE 13: UMA Based DV35 Proportional Valve with Integrated Thunder Power Supply

FIGURE 14: UMA Based Linear Actuator with Integrated Thunder Power Supply

EAP INITIATIVES

EAP database is being formed

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The world is starting to take notes of the capability of electroactive polymers. This has led to the formation of several companies specializing in producing EAP materials and devices, a growing number of researchers are studying these materials and funding is increasingly becoming available for

the development of mechanisms that are driven by EAP. One of the shortcomings of the field of electroactive polymers is the lack of a database containing related properties, configurations, and applications. Recently, the University of Evansville has funded a student project dedicated to gathering required information for such a database. Contribution of information about the available materials will be highly beneficial to the field. A website was formed for the archival of the information and to aid potential contributors of information for the database. The address is: http://csserver.evansville.edu/~eap.

AVAILABLE POSITIONS

Generally, available positions are listed on http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/Positions.htm Other new opportunities include the following:

Full time position

Polymer chemist position available at Pavad Medical Incorporated

A position of polymer chemist is available at Pavad Medical. The polymer chemist will be responsible for the material development, characterization, testing, reports and task co-ordination. The required chemist will be a key member of the material development group and will be working very closely with other team members, vendors and OEM manufacturers.

The person will work closely with other engineers and technicians in our company. Some of the duties include fabrication and characterization of electro active polymer using SAXS, SEMs, FTIR, NMRs etc, as well as conducting failure mode analysis and process improvement. Job duties also include writing of standard operating procedures, test methods and manufacturing process instructions, test sample preparation, testing and report generation as well as lab setup and up keeping. He/she will be responsible for managing polymer development project, concept prototyping and maintaining project timeline. He/she may have the responsibility of supervising technicians and other operators in the team. Having a working knowledge in the health care industry is a plus.

Candidates require MS or PhD in polymer chemistry or in a similar discipline with a strong background in organic chemistry. The candidate should have at least two years experience in polymer synthesis and characterization. Working experience in healthcare industry is a plus. Also, working experience with IPMC and other electroactive polymers is a plus.

Qualified candidates should send in their resumes to Nikhil Bhat: nikhil@pavad.com or Pavad Medical Incorporated, 40539 Encyclopedia Circle, Fremont, CA 94538

Postdoc positions

Postdoctoral Fellowship Opportunities in Cognitive Information Processing (CIP) at the Nevada System of Higher Education

Several two-year post-doctoral fellowships in CIP tools and techniques and their applications in bio-informatics, bio-robotics, modeling and inversion, and security and surveillance are available. Each of the fellowships provides a direct salary of $40,000 per year for two (2) years plus additional funds to cover institutional fringe benefits. The selected applicants will have access to a variety of new equipment and CIP facilities in University of Nevada-Reno, University of Nevada-Las Vegas, and Dessert Research Institute. Fellowships are expected to begin in September 2006. A Ph.D. (or equivalent) in a discipline relevant to computational cognitive modeling or the application areas in bio-informatics, bio-robotics, modeling and inversion, and security and surveillance is required. Candidates should possess a demonstrated potential and strong commitment to quality research. For information particularly for bio-robotics and/or electroactive polymers, contact Dr. Kwang Kim (kwangkim@unr.edu) at University of Nevada, Reno

NEW BOOKS

Biomimetics - Biologically Inspired Technologies

Y. Bar-Cohen (Editor)

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

A new edited book about Biomimetics was published at the end of October 2005 covering the subjects of biomimetics and. Figure 15 shows the

book cover-page and the graphics (prepared by David Hanson) illustrates the editor's idea of biomimetics where human learns from nature to produce mechanisms and devices.

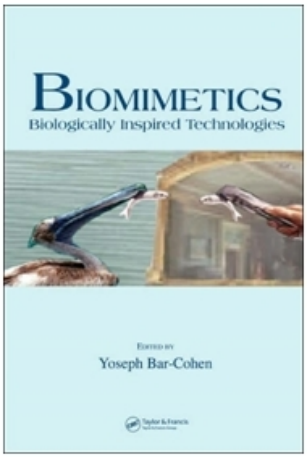


FIGURE 15: The cover page of the new book on biomimetics

Evolution has resolved many of nature's challenges leading to lasting solutions with maximal performance using minimal resources. Nature's inventions have always inspired human achievements and have led to effective algorithms, methods, materials, processes, structures, tools, mechanisms, and systems. This field, which is known as Biomimetics, offers enormous potential for inspiring new capabilities for exciting future technologies. There are numerous examples of biomimetic successes including making simple copies, as the use of fins for swimming. Others examples involved greater mimicking complexity including the mastery of flying that became possible only after the principles of aerodynamics were better understood.

Some commercial implementations of biomimetics, including robotic toys and movie subjects, are increasingly appearing and behaving like living creatures. More substantial benefits of biomimetics include the development of prosthetics that closely mimic real limbs and sensory-enhancing microchips that are interfaced with the brain to assist in hearing, seeing, and controlling instruments.

This book 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
Nov. 27 to Dec. 1, 2006.	Fall 2006 MRS Symposium C entitled "Smart Dielectric Polymers Properties, Characterization and Their Devices," will be held in Boston, MA. For information contact Vivek Bharti, vbharti@mmm.com Website: http://www.mrs.org/fall2006
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/
March 18-22, 2007	2007 EAPAD, SPIE's joint Smart Structures and Materials and NDE Symposia, San Diego, CA., For information contact: Mike Stiles , SPIE, mikes@SPIE.org Website: http://spie.org/Conferences/Calls/07/ss/conferences/index.cfm?fuseaction=SSN02

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

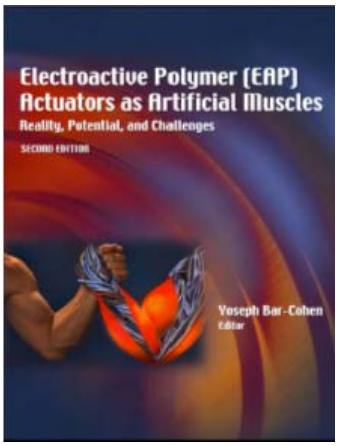
EAP Companies: http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/EAP-material-n-products.htm

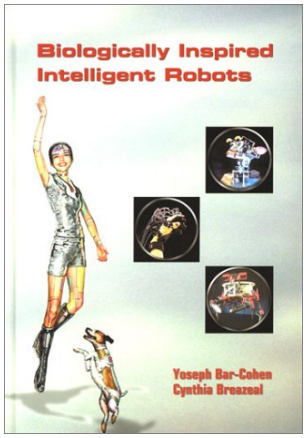
Biomimetics: http://ndeaa.jpl.nasa.gov/nasa-nde/biomimetics/bm-hub.htm

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.

WorldWide Electroactive Polymers (EAP) Newsletter

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