WorldWide ElectroActive Polymers


EAP (Artificial Muscles) Newsletter

Vol. 20, No. 2 (40th issue) **WW-EAP Newsletter** **December 2018**
http://eap.jpl.nasa.gov

40th issue of the WW-EAP Newsletter

FROM THE EDITOR

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

This Newsletter issue reports the latest progress in the fields of Electroactive Polymers (EAP) and Biomimetics.

LIST OF CONTENTS

GENERAL NEWS

This issue is the 40th of the WW-EAP Newsletter. Over the last 20 years, this Newsletter has been published twice a year as an eDocument on the WW-EAP Webhub http://eap.jpl.nasa.gov This Webhub is a link of the JPL's NDEAA Lab Website http://ndeaa.jpl.nasa.gov of the Electroactive Technologies Group.

Standard for EAP

A paper about a standard for EAP materials is posted on the internet and can be read at http://dx.doi.org/10.1088/0964-1726/24/10/105025

POSTDOCTORAL FELLOWSHIP OPENINGS

Postdoc openings at UCLA

Dielectric elastomer materials and actuators,
Qibing Pei *qpei@seas.ucla.edu*

The Soft Materials Research Laboratory (SMRL) at the University of California, Los Angeles (UCLA) anticipates postdoctoral openings to develop dielectric elastomer materials and large-strain soft actuators. SMRL (https://www.peigroup.seas.ucla.edu/) is a multidisciplinary research group developing

synthetic polymers and nanocomposites for stretchable electronics, electromechanical, and photonic devices.

The positions will give the candidates opportunity to participate also in other innovative projects. The appointment is initially for 1 year, and may be extended for up to 3 years.

POSITION REQUIREMENTS

Required qualification and experience include:

1. PhD in polymer chemistry, materials science, mechanical engineering, chemical engineering, or related fields.
2. Strong hands-on experience in several of these fields: dielectric elastomers, polymer materials development, solution-based nanomaterial processing, polymer thin film coating, compliant electrode materials, 3D printing, multilayer stacking, soft polymer actuator design and fabrication.
3. Strong communication skills.

CONTACT

Interested candidates may contact Professor Qibing Pei at qpei@seas.ucla.edu for further information.

EQUAL EMPLOYMENT OPPORTUNITY

UCLA is an Affirmative Action/Equal Opportunity employer. Women and minorities are encouraged to apply. Hiring is contingent upon eligibility to work in the United States. It is the policy of UCLA not to discriminate against any individual based on race, color, religion, national origin, sex, sexual orientation, marital status, age, disability, citizenship, veteran status or other protected group status.

TECHNOLOGY DEVELOPMENT CHALLENGES

Seeking autonomous fully controllable "endoscope" concepts

Studor, George F. (LARC) [TEAMS3 NESC Affiliate] george.f.studor@nasa.gov

NASA Engineering and Safety Center, NDE Technical Discipline Team's lead for in-space inspection, George Studor, is looking for technologies that can enable the development of a fully controllable "endoscope" that is operational at zero-gravity onboard the ISS. This advanced endoscope is sought for inspection applications for reaching hardware areas that are difficult to access directly. The scope should be able to be inserted through existing (1/4") gaps in between racks of equipment or small (3/8") holes in the front of the racks normally used for fire suppression and controlled to inspection targets 3 to 4 feet behind the panel. It must sense contact and thermal hazards and be able to avoid creating a hazard during crew-based insertion or retraction. It must not rely on a pre-determined model of the physical interior, but build the model that it be guided through as it is inserted, with classification of fixed and moving objects as appropriate. Shape-following technology will be used to ensure the rest of the snake follows where the head went for insertion and that the entire snake follows the same path on extraction. As a minimum, an LED-illuminator will support the high res camera at the tip.

George is also looking for examples from Nature to apply to fully autonomous inspection methods Autonomous in that the inspection platform and sensors are able to complete a survey of a given surface for certain features and conduct characterization inspections of identified features of interest (such as MMOD damage) with no involvement of crew or other external controls. The platform will generate and process raw image/data on-board. The inspection base is initially thought of as a free-flying platform (UAV, SUV or inspection satellite), crawling robot, endoscope (such as above) or manipulator arm. Considerations of how Natural systems perform similar functions should be considered to ensure that efficiency and effectiveness are optimized for sensing, navigation, control, processing, communication, etc.

UPCOMING CONFERENCES

2019 SPIE EAPAD Conference

The SPIE's EAPAD conference is going to be held again in Denver, Colorado, from March 3 thru 7, 2019. This conference, which is part of the Smart Structures Symp., is going to be the 21st annual one and is chaired by Yoseph Bar-Cohen, JPL, and Co-

chaired by Iain A. Anderson, The Univ. of Auckland (New Zealand) and Nancy L. Johnson, General Motors Co., USA. The Conference Program Committee consists of representatives from 32 countries. The program of EAPAD is posted at http://www.spie.org/eap

The papers are focused on issues that help transitioning EAP to practical use thru better understanding the principles responsible for the electro-mechanical behavior, analytical modeling, improved materials and their processing methods, characterization of the properties and performance as well as various applications.

In the 2019 EAPAD Conf., a Special Session is dedicated to "EAP Materials and Devices Fabrication Methods (e.g., 3D Printing): Progress and Challenges" and its Session Chairs are Geoff M. Spinks, Univ. Wollongong, Australia, and Ray H. Baughman, The Univ. of Texas at Dallas.

The Conference has two Keynote Speakers and they are:

1. Ray H. Baughman, NanoTech Institute at the Univ. of Texas in Dallas, who will present "Science and Technology Contributions and Accomplishments", in honor of his 75th birthday.
2. Douglas A. Litteken, NASA Johnson Space Ctr. (JSC) will present the paper "Inflatable Technology: Using Flexible Materials to Make Large Structures".

The invited papers in this Conference are

1. Design of reliable silicone elastomers for dielectric elastomers and stretchable electronics (Paper 10966-9) - Piotr Mazurek, Liyun Yu, Anne Ladegaard Skov, Technical Univ. of Denmark (Denmark)
2. Manufacturing dielectric elastomer stack actuators: challenges and applications for industrialization (Paper 10966-29) - Helmut F. Schlaak, Technische Univ. Darmstadt (Germany)
3. From soft microrobotics to macroscopic wearables (Paper 10966-32) - Edwin W. H. Jager, Linköping Univ. (Sweden)
4. Soft electronic and robotic systems from biocompatible and degradable materials (Paper 10966-39) - Martin Kaltenbrunner, Johannes Kepler Univ. Linz (Austria)
5. Soft robotics for prosthetic devices: how dependent it is on smart materials? (Paper 10966-53)- Gursel Alici, Univ. of Wollongong (Australia)
6. Dielectric elastomer spring-roll bending actuators: applications in soft robotics and design (Paper 10966-56) - Yanju Liu, Liwu Liu, Jinsong Leng, Harbin Institute of Technology (China)
7. Soft hybrid generators for harvesting human kinetic energy (Paper 10966-72) - Claire Jean-Mistral, Institut National des Sciences Appliquées de Lyon (France); Alain Sylvestre, Lab. de Génie Électrique de Grenoble (France)

The 21st Annual EAP-in-Action Session and Demonstrations will be held on Monday 4 March 2019, 4:30 PM - 5:45 PM. It is chaired by Yoseph Bar-Cohen, JPL, and it is part of the EAPAD Conference. This Session highlights some of the latest capabilities and applications of Electroactive Polymers (EAP) materials where the attendees are shown demonstrations of these materials in action. In addition, the attendees interact directly with technology developers and given "hands-on" experience with this emerging technology. The first Human/EAP-Robot Armwrestling Contest was held during this session of the 2005 EAPAD conference.

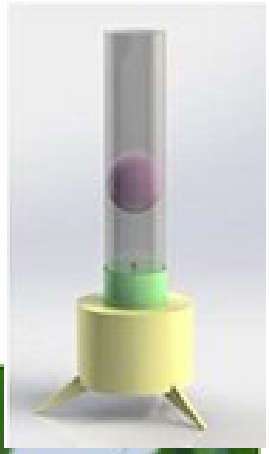
Novel dielectric elastomer membrane actuator concept for pneumatic valves - Steffen Hau, Saarland Univ. (Germany)

Despite being relatively easy to manufacture and providing large strokes, dielectric elastomer (DE) membrane actuators suffer from low force outputs (for single layer systems). This demo presents a novel design concept that permits to retune the stroke-force trade-off of DE actuators, by allowing increasing force output of the actuator at the expense of a

reduced stroke. This is of particular interest for valve applications, which typically need high closing forces and low strokes in the submillimeter regime. By means of the novel design concept, the valve closing force of single DE membranes can be increased by a factor of 3 to 4. The concepts still keeps the general advantages of DEAs, e.g., light weight, and energy efficiency. The use of strip-in-plane DE actuators additionally allows staying within the typical dimension of commercial valves.

DEA-based pneumatic pump - Philipp Linnebach, Saarland Univ. (Germany)

This demonstrator shows the use of circular out-of-plane dielectric elastomer actuators (COP-DEA) in a pneumatic pump application. The presented concept allows building very small and lightweight pumps. It is related to the paper with the title "Design of a dielectric elastomer actuator driven pneumatic pump".



A fast 200 mg DEA robot - X. Ji, B. Aksoy, H. Shea, EPFL (Switzerland)

We present the DEAnsect: an ultra-light (0.2 g) soft robot driven by stacked dielectric elastomer actuators (DEAs) operating at 450V. The DEAnsect has a flexible silicone body and three legs, each driven independently by a DEA stack. The DEAnsect moves at four body lengths per second and can be accurately steered thanks to the independent control of each DEA. It is robust, can climb slopes of 15°, and survives being flattened with a fly swatter.

Textile exoskeletons - Edwin W. H. Jager, Jose G. Martinez, Linkoping Univ. (Sweden), **Nils-Krister Persson**, Univ. of Boras (Sweden)

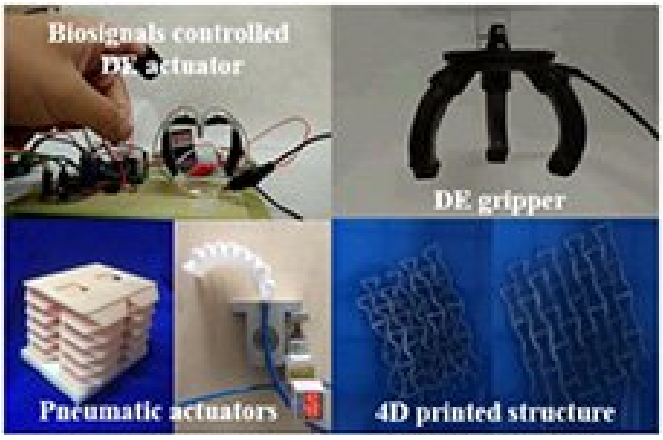
Various diseases or aging can cause a reduction in the muscle function of a person. Robotic exoskeletons have been developed to augment or replace the movement of various limbs and thus for instance assist walking or aid rehabilitation. Current exoskeletons are rigid, heavy, stiff and non-compliant. We are developing textile-based exoskeletons that can be worn like items of clothing being light-weight, soft, compliant and comfortable. In this EAP-in-Action, demonstrators of the prototype textile exoskeleton-arm-sleeves developed by Linköping University and University of Borås will be shown. The exoskeleton arm-sleeve prototypes use small electrical motors or McKibben actuators and enable lifting the arm, including a weight, of the wearer without using their own muscles.

Smart soft polymers and structures - Liwu Liu, Qinghua Guan, Jinrong Li, Yanju Liu, Jinsong Leng, Harbin Institute of Technology (China)

The demonstration will focus on the applications of smart soft polymers, including dielectric elastomer (DE), shape memory polymer (SMP) and other smart soft structures.

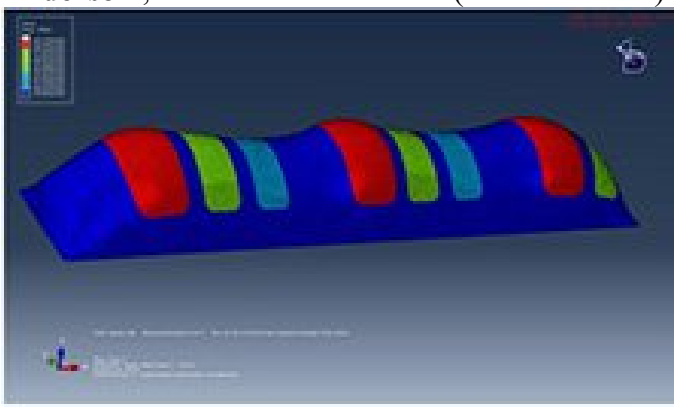
1. Biosignals controlled DE actuators. The biosignals will be acquired, processed and then amplified to drive DE actuators.
2. Smart morphing structures based on DE and SMP: Structures may include deployable gripping devices or lock-release structures, etc.
3. Flexible pneumatic actuators. Multi-degree-of-

freedom motions could be realized by combining multiple flexible pneumatic actuators together.



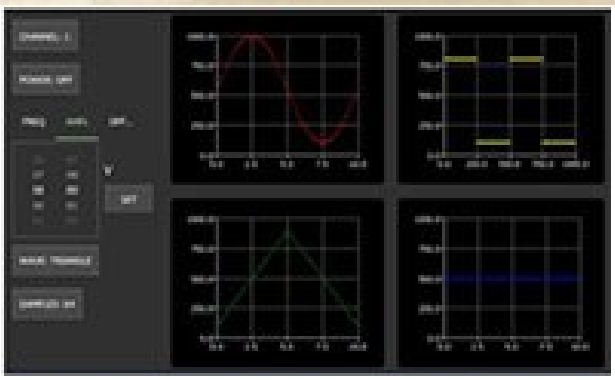
4. SMP based 4D printing technique. The 3D printable filaments with shape memory effect and some representative printed structures, which can change shape along with time, will be demonstrated.

Inflatable dielectric elastomer conveyor - Joseph Ashby, E. -F. Markus Henke, Sam Rosset, Iain Anderson , Biomimetics Lab. (New Zealand)



We present an inflatable robot, created from a sheet of silicone and airbrushed electrodes, which uses out of phase segmented actuation to produce linear conveyance of a light load along its length. Also presented: a finite element simulation of the model. This demonstrates one potential application for inflatable dielectric robotics.

High voltage EAP controller - E.-F. Markus Henke,, Biomimetics Lab. (New Zealand) and TU Dresden (Germany), **Patrin Illenberger, Katie Wilson, Sam Rosset, Iain Anderson**, Biomimetics Lab. (New Zealand)



This demo is a new EAP high voltage controller that is at the α stage. This new controller will help university labs and other research institutions to easily power their EAP actuators without the need of developing complicated driving electronics. It comes with four channels, a touch screen user interface and is battery powered. The controller provides DC, rectangle, sinusoidal and triangle signals, with an amplitude of up to 5kV @ 1mA per channel. The Channels can be programmed independently.

Geometric limit switches (gDES) for robotics and automation industry - E.-F. Markus Henke,, Biomimetics Lab. (New Zealand) and TU Dresden (Germany), **Patrin Illenberger, Katie Wilson, Sam Rosset, Iain Anderson**, Biomimetics Lab. (New Zealand)

Geometric dielectric elastomer switches (gDES) switch both high and low voltages. They only consist of soft materials such as silicones and carbon-doped conductive silicones. Arrays of these switches can be integrated in soft robotic grippers and extend the features of those grippers by touch and shear force detection. Furthermore, gDES can act as limit switches and can be introduced in automation technology. One of the key advantages is that the switches themselves are entirely shielded and not affected by environmental influences.

From StretchSense Ltd.: the latest in EAP gloves - Marco Tabor, Iain Anderson, StretchSense Ltd. (New Zealand)

StretchSense is putting EAP sensors into garments using fabric-backed sensors and combining information from different sensor types. To illustrate the technology we present an EAP glove that can capture and send in real-time hand-posture (rotation) and finger bending to a device with an application to visualize the data e.g. game.

Synthetic Muscle in prosthetics
Lenore Rasmussen, Damaris Smith, Ras Labs, Inc. (United States)

Ras Labs Synthetic Muscle™ is an EAP based actuator that contracts, and with reversed electric input polarity, expand. Ras Labs has begun testing their EAP system on amputees to maintain continual perfect prosthetic socket fit and is going to present their prototype. These EAPs serve dual use as sensors, which can be tied in to automatic adjustment and touch biofeedback, and can determine the number of impacts (or steps) and severity of impact/pressure for protective gear and comfortable shoe wear and insoles.

Versatile dielectric loudspeakers - Florian Klug, Technische Univ. Darmstadt (Germany)

Electronic EAPs, such as the dielectric elastomer transducer, offer higher frequencies up to several kilohertz. Therefore, different kinds of EAP loudspeakers have been presented. Due to their nonlinear behavior and high driving voltages, they suffer from poor audio quality and high costs. Within this demonstration, we are presenting different configurations for low cost, flexible or low

distortion loudspeakers. Sound pressure levels higher than 100 dB with <10 kHz bandwidth and distortion < 2 % can be achieved. Depending on the configuration, they can be adaptable to various shapes and produced with large surfaces.

On the record of the EAPAD conferences archive, the following is the list of the Co-chairs since the start in 1999 at Newport Beach, CA.

Year	Co-chair	Country
1999	Mohsen Shahinpoor, U. of New Mexico	USA
2000	Steve Wax, DARPA	USA
2001	Danilo De Rossi, Univ. degli Studi di Pisa	Italy
2002	Yoshihito Osada, Hokkaido University	Japan
2003	Geoff Spinks, University of Wollongong	Australia
2004	Peter Sommer-Larsen, Risoe National Lab.	Denmark
2005	John D. Madden, U. of British Columbia	Canada
2006	Jae-Do Nam, Sung Kyun Kwan University	S. Korea
2007	Gabor Kovacs, EMPA	Switzerland
2008	Emillio P. Calius, Industrial Res. Limited	New Zealand
2009	Thomas Wallmersperger, Univ. Stuttgart	Germany
2010	Jinsong Leng, Harbin Institute of Tech.	China
2011	Federico Carpi, Univ. of Pisa	Italy
2012	Keiichi Kaneto, Kyushu Inst. of Tech.	Japan
2013	Siegfried Bauer, Johannes Kepler U.	Austria
2014	Barbar J. Akle, Lebanese American Univ.	Lebanon
2015	Gal deBotton, Ben-Gurion U. of the Negev	Israel
2016	Frédéric Vidal, U. de Cergy-Pontoise	France
2017	Jonathan Rossiter, University of Bristol	England
2018	Iain A. Anderson, The Univ. of Auckland	New Zealand
2019	Iain A. Anderson, The Univ. of Auckland	New Zealand
	Nancy L. Johnson, General Motors Co.	USA

EuroEAP 2019 – 9th international Conf. on EAPs

Andreas Richter, Technische Universität Dresden, Germany, andreas.richter7@tu-dresden.de
Edwin Jager, Linköping University, Sweden, edwin.jager@liu.se

The annual international EuroEAP conference is going to be held in Dresden, Germany from 4 to 6 June 2019 and will be chaired by Prof. Andreas Richter, Technische Universität Dresden. Detailed information is at www.euroeap.eu/conference. The EuroEAP conferences are attended by experts from a diversity of countries worldwide and is designed to maximize interactions among participants, with invited lectures mixed with participant presentations that comprise a short orals and an extended poster session. The invited oral presentations are given by world-leading scientists, young emerging researchers, as well as representatives of industry. The oral sessions, which allow all contributors to present their works, are intertwined by long poster sessions that facilitate discussions in a friendly atmosphere. In addition, there is ample time for spontaneous meetings during breakfasts, coffee and lunch breaks, as well as the evening social events, as all the participants stay in the same hotel during the conference. The cost for all the organized lunches and dinners are entirely included within the registration fees, which are also maintained competitively low by the non-for-profit approach taken in organizing this unique event. Confirmed plenary and main speakers include:

- Oliver Schmidt, Leibniz Institute for Solid State and Materials Research Dresden, Germany
- Metin Sitti, Max Planck Institute for Intelligent Systems, Germany
- Herbert Shea, École Polytechnique Fédérale de Lausanne, Switzerland
- Frank Fitzek, Centre for Tactile Internet with Human-in-the-Loop, Germany
- Christoph Keplinger, University of Colorado Boulder, USA
- Dorina Opris, Swiss Federal Laboratories for Materials Science and Technology, Switzerland
- Aaron Price, Western University, Canada
- Alvo Aablo, University of Tartu, Estonia

ADVANCES IN EAP

Aerospace Engineering-Propulsion/MEMS

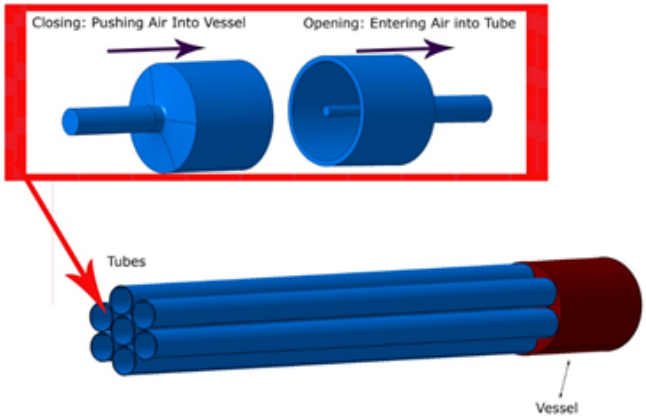
Proper Specifications That Dielectric Elastomers Need to Be Used to Make DEA Compressor

Babak Aryana, Independent Researcher/ Inventor Babak.Aryana@gmail.com

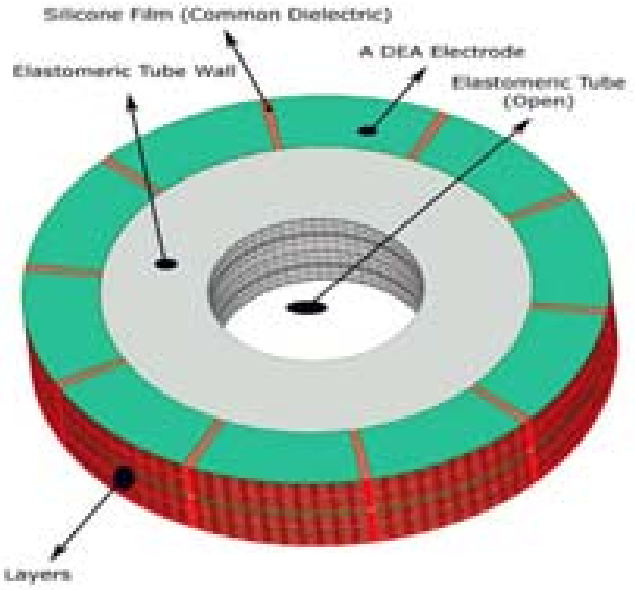
During the past decade, I have developed a conceptual compressor (DEA compressor) designed based on DEAs [Aryana, 2010; Aryana 2016], and

two different conceptual aeroengines based on the compressor itself. The goal of developing such a compressor has been reaching a context-aware aeroengine.

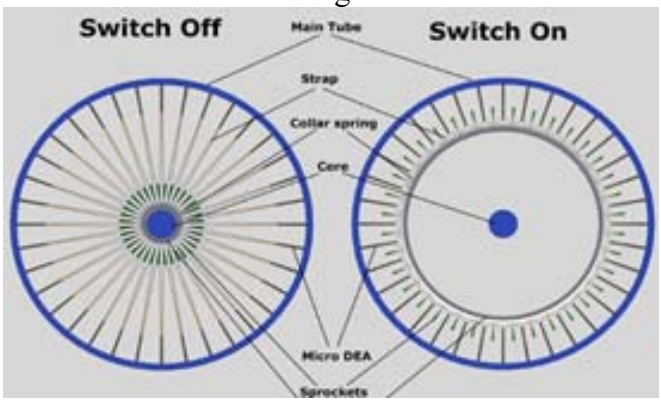
DEA compressor construction and specification as well as engines performance have been the most important points that my study has been focused on since introducing DEA compressor. Consequently, although configuration of the compressor has not been changed, but its cell has redesigned toward the optimum compressor performance (**Figure 1)**. The compressor has showed considerable compatibility with context-awareness specification (**Figure 2**), however, two major characteristics that a compressor need to have in order to work as a section of an aeroengine. These are endurance and response time. Response time is a function of working frequencies and has been subject to study by many researchers in this field. Endurance of dielectric elastomer, nevertheless, has not been under study, particularly in the standards of aeroengines. In fact, dielectric elastomers should be able to work for several thousand cycles under though condition (change of temperature, work frequencies etc.). As a result, this is crucial to focus on endurance of dielectric elastomers to choose a proper material to configure DEA compressor.



a. Schematic of DEA compressor construction

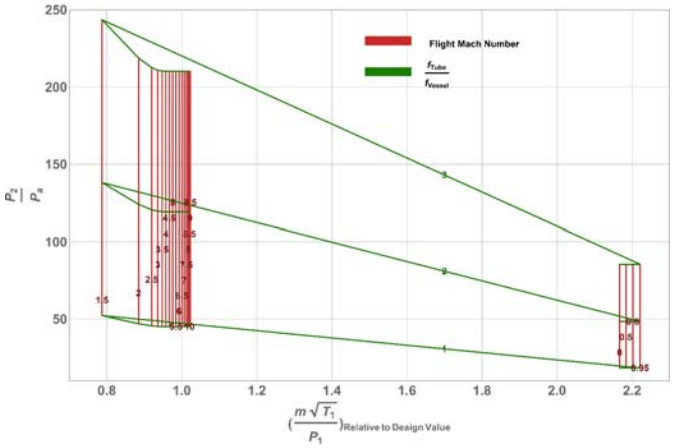


b. First design of a cell



c. Current design of a cell

Figure 1: Although construction of DEA compressor has not been changed as a whole, but its cell configuration has completely redesigned.



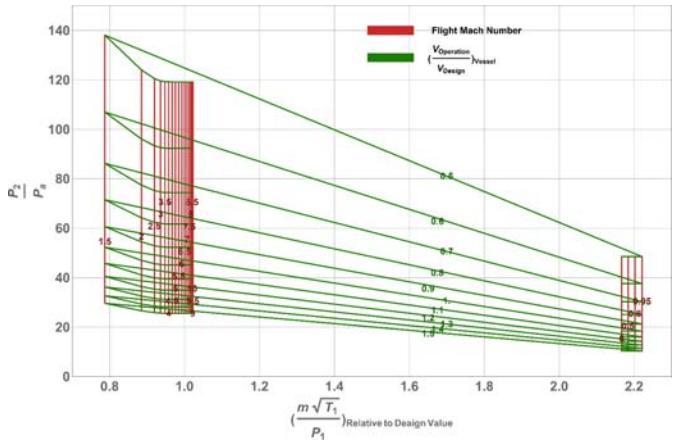


Figure 2: DEA compressor is basically designed to fit into a context-aware system. Operation of compressor can regulate by changing few key factors toward the optimum performance regarding environmental elements. However, a compressor servicing as a section of a aeroengine needs to have some traits like proper endurance and capability to tolerate tough working conditions.

References

Aryana B., "Implementing DEA to create a novel type of compressor," Materials Science and Engineering C, p. 30 42–49, 2010.

Aryana B., "New version of DEA compressor for a novel hybrid gas turbine cycle: TurboDEA," Energy, pp. 111 676-60, 2016.

JOURNALS RELATED TO EAP & BIOMIMETICS

Bioinspiration & Biomimetics - Peer-reviewed journal publishing research that discovers and uses principles from natural systems to create physical models, engineering systems and technological designs.
http://iopscience.iop.org/journal/1748-3190

Biomimetics - Peer-reviewed open access journal regarding biomimicry and bionics published quarterly online.
https://www.mdpi.com/journal/biomimetics

International Journal of Smart and Nano Materials – Peer-reviewed open access journal publishing cutting-edge research into smart and nano materials and their applications, including energy harvesting, sensing, self-healing, and self-assembly.
https://www.tandfonline.com/toc/tsnm20/current

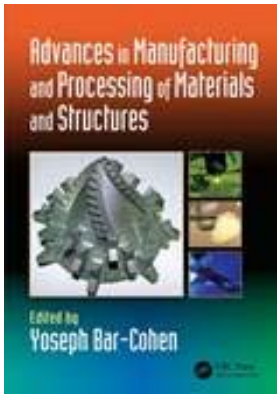
Smart Materials and Structures – multi-disciplinary journal dedicated to technical advances in (and applications of) smart materials, systems and structures; including intelligent systems, sensing and actuation, adaptive structures, and active control.
http://iopscience.iop.org/journal/0964-1726

Soft Robotics - Peer-reviewed journal covering research on the emerging technologies and developments of soft and deformable robots, including coverage of flexible electronics, materials science, computer science, and biomechanics.
http://home.liebertpub.com/publications/soft-robotics/616

NEW BOOKS

Advances in manufacturing and processing of materials and structures

The 10th book of this Newsletter Editor has been published by CRC Press. This edited and coauthored book is entitled "*Advances in manufacturing and processing of materials and structures*" and it contains 544 pages [https://www.amazon.com/Advances-Manufacturing-Processing-Materials-Structures/dp/1138035955]. The book covers the latest advances in manufacturing and processing including additive and subtractive processes and it is intended to provide a compiled resource that reviews details of the advances. 3D printing is a key development that has been incorporated into this book covering its use to produce complex parts including composites with odd shape fibers as well as tissue and body organs.



The 20 chapters are

1. "State-of-the-art of the manufacturing and processing methods in the digital era", Y. Bar-Cohen, JPL
2. "Computer-aided design (CAD)", Nikolaos Bilalis, Technical University of Crete, Greece; and Emmanuel Maravelakis, School of Applied Sciences, Technological Educational Institute of Crete
3. "Biologically inspired designs", Jacqueline Power University of Tasmania, Launceston TAS; and Rina Bernabei, University of New South Wales, Sydney, Australia
4. "Current capabilities and research trends in rapid and virtual prototyping", Sriram Praneeth Isanaka and Frank Liou, Missouri University of Science & Technology
5. "Biofabrication and Bio-Inspired Manufacturing Techniques for the Built Environment", Brook S. Kennedy, School of Architecture + Design, Virginia Tech, Blacksburg, VA; Christopher Maurer, Redhouse Studio, Cleveland, OH; and William Sullivan, FLEXcon Company, Inc., Spencer, MA
6. "Cyber Manufacturing" Mostafa Bedewy, Mai Abdelhakim, and Alex K. Jones, University of Pittsburgh, PA
7. "Manufacturing via 3D printing techniques and 4D with functionality", R. Peter Dillon, Bryan McEnerney, John Paul Borgonia, JPL
8. "Medical Applications for 3D Printing", David K. Mills, Karthik Tappa, Uday Jammalamadaka, Patrick A.S. Mills, Jonathan S. Alexander and Jeffery A. Weisman, Louisiana USA
9. "Additive, subtractive and hybrid manufacturing processes", Javaid Butt and Hassan Shirvani, Anglia Ruskin University, UK
10. "Integrated Manufacturing", Robert Richardson, Jordan Boyle, and Nicholas Fry, School of Mechanical Engineering, University of Leeds,
11. "Adhesion bonding techniques", M. Costaa, R. Carbasa, E. Marques, G. Viana, L. F. M. da Silva, Portugal
12. "Metal joining techniques using brazing", Y. Bar-Cohen, JPL; Dusan P. Sekulic and Rui Pan University of Kentucky, Lexington, KY; Sudarsanam Suresh Babu and Anming Hu, University of Tennessee, Knoxvile, TN; Xiaoqi Bao, Mircea Badescu, Hyeong Jae Lee, and Stewart Sherrit, JPL
13. "Diffusion Bonding", Rui Pan, Dusan P. Sekulic, College of Engineering, University of Kentucky, Lexington, KY
14. "Manufacturing technologies for electroactive composite actuators and sensors", Hyeong Jae Lee, JPL; and Shujun Zhang, ISEM, Australian Institute for Innovative Materials, University of Wollongong, NSW, 2500, Australia
15. "Guidelines for making Ionic Polymer-Metal Composite (IPMC) materials as artificial muscles by advanced manufacturing methods: State-of-the-Art," Kwang J. Kim, Tyler Stalbaum, Sarah Trabia, Taeseon Hwang, Zakai Olsen, Shelby Nelson, Qi Shen, Dong-Chan Lee, University of Nevada, Las Vegas; James Carrico, Kam K. Leang, University of Utah; Viljar Palmre, Jungsoo Nam, The University of Texas Health Science Center at Houston; Ilseok Park, UES Inc.; Rashi Tiwari, Dow Chemical: Doyeon Kim, Apple; Sungjun Kim, Samsung Electronics
16. "Multifunctional Materials and Structures", Paul E. Kladitis, University of Dayton Research Institute, Dayton, OH;
17. "In-Situ Resources Utilization (ISRU)", Gerald E Voecks, JPL
18. "Sustainable Manufacturing", Sara Behdad, University at Buffalo; Jacquelyn Nagel, JMU; and Mostafa Sabbaghi, University of Buffalo
19. "Nondestructive Evaluation (NDE) of materials and structures from production to retirement", Weibin Li and Tribikram Kundu (Bikram), University of Arizona College of Engineering, Tucson, AZ
20. "Past and the outlook at the manufacturing and processing technologies", Y. Bar-Cohen, JPL

FUTURE CONFERENCES

Date	Conference/Symposium
March 3 - 7, 2019	The 2019 SPIE's EAPAD Conf. is going to be held again in Denver, Colorado. This Conf. will be the 21th annual one and is going to be chaired by Y. Bar-Cohen, JPL, and Co-chaired by I. A. Anderson, The Univ. of Auckland (New Zealand) and Nancy L. Johnson, GM Motors Co., USA. The call for papers is posted at: http://www.spie.org/eap
June 4–6, 2019	EuroEAP 2019 – the 9th international Conference on EAPs, Dresden, Germany 4 to 6 June 2019. Information about the call is available at www.euroeap.eu/conference
June ?, 2019	Nature, Art & Habitat Residency (NAHR): An ECO-Laboratory of Multidisciplinary Practice Taleggio valley, Bergamo - Northern Italy. Information is available at https://nahr.it/NAH_Residency-Grasses-Erbe
October 27 - 31, 2019	The Tenth International Conference on Sensor Device Technologies and Applications, SENSORDEVICES 2019 will be held in Nice, France. Information is available at http://www.iaria.org/conferences2019/SENSORDEVICES19.html

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

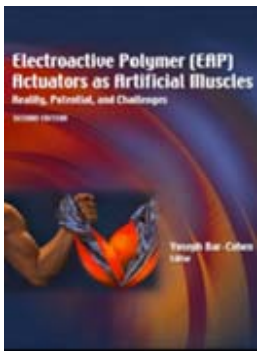
Newsletter: http://ndeaa.jpl.nasa.gov/nasa-nde/lommas/eap/WW-EAP-Newsletter.html

Recipes: 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
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.

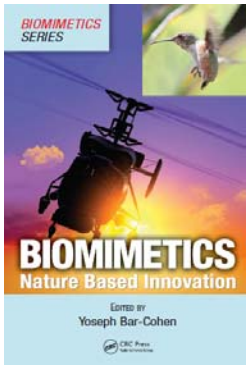


This book includes description of the available materials, analytical models, processing techniques, and characterization methods. This book is intent to provide a reference about the subject, tutorial resource, list the challenges and define a vision for the future direction of this field. Observing the progress that was reported in this field is quite heartwarming, where major milestones are continually being reported.

Biomimetics books series

Biomimetics – Nature Inspired Innovation

Yoseph Bar-Cohen (Editor)



This book contains 20 chapters covering various aspects of the field of biomimetics including Nature as a source for inspiration of innovation; Artificial Senses & Organs; Bio-mimicry at the Cell-Materials Interface; Multiscale modeling of plant cell wall architecture and tissue mechanics for biomimetic applications; Biomimetic composites; EAP actuators as artificial muscles; Refreshable Braille Displays Actuated by EAP; Biological Optics; Biomimicry of the Ultimate Optical Device: Biologically Inspired Design: a tool for interdisciplinary education Enhancing Innovation Through Biologically-Inspired Design; Self-reproducing machines and manufacturing processes; Biomimetic products; Biomimetics for medical implants; Application of biomimetics in the design of medical devices; Affective Robotics: Human Motion and Behavioral Inspiration for Safe Cooperation between Humans and Humanoid Assistive Robots; Humanlike robots - capabilities, potentials and challenges; Biomimetic swimmer inspired by the manta ray; Biomimetics and flying technology; The Biomimetic Process in Artistic Creation; and Biomimetics - Reality, Challenges, and Outlook. Further information is available at: http://www.crcpress.com/product/isbn/9781439834763

Architecture Follows Nature - Biomimetic Principles for Innovative Design

Authored by Ilaria Mazzoleni ***www.imstudio.us*** *info@imstudio.us in collaboration with Shauna Price* http://www.crcpress.com/product/isbn/9781466506077

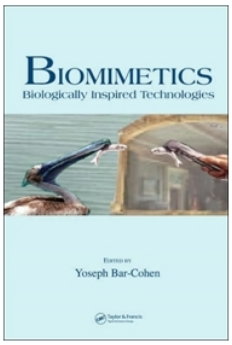
The book entitled "Architecture Follows Nature - Biomimetic Principles for Innovative Design" has been published by CRC Press as part of the book series on Biomimetics for which Y. Bar-Cohen is the editor. The homepage of this book series is: http://www.crcpress.com/browse/series/?series_id=2719

Biomimetics - Biologically Inspired Technologies

Y. Bar-Cohen (Editor)

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

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



Ocean Innovation: Biomimetics Beneath the Waves

Authored by Iain A. Anderson i.anderson@auckland.ac.nz, Julian Vincent, and John Montgomery
https://www.crcpress.com/Ocean-Innovation-Biomimetics-Beneath-the-Waves/Anderson-Vincent-Montgomery/p/book/9781439837627

Generally, biomimetics is the idea of creating new technologies abstracted from what we find in biology. The book "Ocean Innovation: Biomimetics Beneath the Waves" seeks that technological inspiration from the rich biodiversity of marine organisms. Bringing both a biological and engineering perspective to the biomimetic potential of oceanic organisms, this richly illustrated book investigates questions such as:

- How can we mimic the sensory systems of sea creatures like sharks, sea turtles, and lobsters to improve our ability to navigate underwater?
- What can we do to afford humans the opportunity to go unnoticed by marine life?
- How can we diffuse oxygen from water to enable deep diving without the risk of decompression sickness?

Each chapter explores an area where we, as divers and technologists, can benefit from understanding how animals survive in the sea, presenting case studies that demonstrate how natural solutions can be applied to mankind's engineering challenges.

Books about robotics

The Coming Robot Revolution - Expectations and Fears about Emerging Intelligent, Humanlike Machines

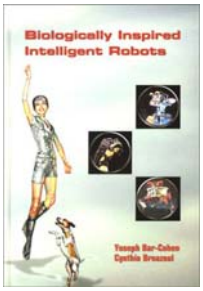
Yoseph, Bar-Cohen and David Hanson (with futuristic illustrations by Adi Marom), Springer, ISBN: 978-0-387-85348-2, (February 2009)

This book covers the emerging humanlike robots. Generally, in the last few years, there have been enormous advances in robot technology to which EAP can help greatly in making operate more lifelike. Increasingly, humanlike robots are developed for a wide variety of applications. These "smart" lifelike robots are designed to help with household chores, as office workers, to perform tasks in dangerous environments, and to assist in schools and hospitals. In other words, humanlike robots are coming and they may fundamentally change the way we live, even the way we view ourselves.

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

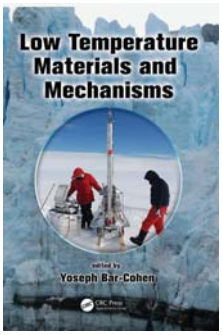


possibility a closer engineering reality. The topics that are involved with the development of such biomimetic robots are multidisciplinary and they are covered in this book. These topics include materials, actuators, sensors, structures, control, functionality, intelligence and autonomy.

Other books

Low Temperature Materials and Mechanisms

Yoseph Bar-Cohen (Editor)
https://www.crcpress.com/Low-Temperature-Materials-and-Mechanisms/Bar-Cohen/p/book/9781498700382



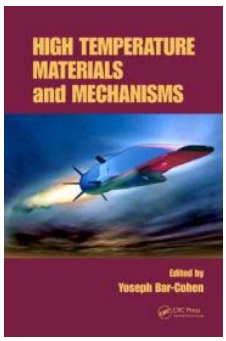
Published on July 1, 2016, this book addresses the growing interest in low temperature technologies. Since the subject of low temperature materials and mechanisms is multidisciplinary, the chapters reflect the broadest possible perspective of the field. Leading experts in the specific subject area address the various related science and engineering chemistry, material science, electrical engineering, mechanical engineering, metallurgy, and physics.

High Temperature Materials and Mechanisms

Yoseph Bar-Cohen (Editor)
http://www.crcpress.com/product/isbn/9781466566453

This book is addressing the growing interest in high-temperature technologies. This book covers technology related to energy, space, aerospace, electronics, metallurgy, and other areas. While some applications involve the use of materials at high temperatures, others require materials processed at high temperatures for use at room temperature.

Reflecting the multidisciplinary nature of the subject of high-temperature materials and mechanisms, the chapters bring as broad a perspective to the field as possible and are authored by leading experts in the specific subject. The book addresses the various related science and engineering disciplines, including chemistry, material science, electrical and mechanical engineering, metallurgy, and physics.



Happy New Year

WorldWide Electroactive Polymers (EAP) Newsletter

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