© 2016 California Institute of Technology. Government sponsorship

The JPL's Electroactive Technologies Group and its NDEAA Lab

Yoseph Bar-Cohen, Ph.D.
Group Supervisor and Senior Research Scientist,
Jet Propulsion Laboratory, California Institute of Technology
yosi@jpl.nasa.gov http://ndeaa.jpl.nasa.gov/

Group members: Mircea Badescu, Xiaoqi Bao, Zensheu Chang, Hyeong Jae Lee, Shyh-Shiuh Lih and Stewart Sherrit

The focus is mostly on the use of elastic waves, mechanical vibrations and electroactive materials for actuators and sensors. The group efforts led to novel methods, processes, mechanisms and devices including piezo-electric actuated drills and motors, biomimetics and NDE.

http//ndeaa.jpl.nasa.gov

Focus technology areas

	Small amplitude	Large amplitude
Low frequency (KHz)	Subsurface probing	Actuation and drilling
High frequency (MHz)	NDE & diagnostics	Medical treatment

Jet Propulsion Laboratory
California Institute of Technology

+ View the NASA Portal

Search JPL

JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

NDEAA

Nondestructive Evaluation and Advanced Actuators Technologies

Privacy/Copyright

The JPL's Nondestructive Evaluation and Advanced Actuators (NDEAA) Technologies lab is involved with innovative research and development (R&D) for space applications and technology transfer to terrestrial applications. It was established by Dr. Yoseph Bar-Cohen in May 1991 and it is part of his JPL's Electroactive Technologies Group for which he is the Supervisor. Dr. Bar-Cohen and his Group members are internationally leading scientists in the fields of electroactive materials, biomimetics, and related mechanisms. The members of his Group are Dr. Mircea Badescu, Dr. Xiaoqi Bao, Dr. Zensheu Chang, Dr. Shyh-Shiuh Lih, Dr. Hyeong Jae Lee, and Dr. Stewart Sherrit. In addition, thru the JPL Educational Outreach Program professors, visiting scientists and students are participating in various studies at this lab. The current topics of Group's R&D efforts include novel actuators (using mostly using electroactive ceramics and polymers), drilling and sample handling systems, transducers, sensors, biomimetics, operation in extreme environments, robotic mechanisms and NDE methods. The Group conducts analytical modeling, simulation, design and fabrication of novel mechanisms and devices, performance testing and characterization. The analysis involves the multi-physics parameters: mechanical, electrical, magnetic and thermal, as well as their interactions. Between Jan. 1, 2000 and Jul. 2, 2001, this NDEAA webhub had 1,000,007 (crossed the one million) total hits with 87,082 unique hits and by Sept. 3, 2001 it crossed the one hundred thousand (100,006) unique hits. The highest hits per day was recorded on March 9, 2005, where 9063 total hits and 3626 unique hits were recorded. This lab has been the subject of many articles in the news media. The NDEAA lab is involved with a broad range of R&D topics as described in the following clickable icons. The photos of the NDEAA members are clickable to their biography

Dr. Y. Bar-Cohen, Supervisor, Electroactive Tech. Group & Senior Research Scientist | Dr. Mircea Badescu | Dr. Xiaoqi Bao | Dr. Zensheu Chang | Dr. Hyeong Jae Lee | Dr. Shyh-Shiuh Lih | Dr. Stewart Sherrit

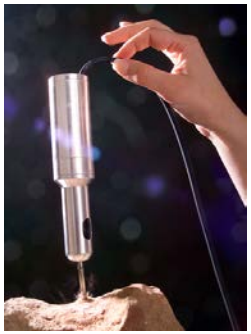
The mechanisms that were developed at the NDEAA Lab are driven by elastic waves, mechanical vibrations and/or electroactive materials. Examples of these mechanisms include the ultrasonic/sonic driller/corer (USDC) that uses low preload and is developed for planetary sampling, deep drilling, high-temperature drilling, probing, sensing and in situ analysis making it a Lab-on-a-Drill. Also, they developed ultrasonic and surface acoustic wave motors and piezoelectric pumps that are driven by traveling flexural waves, This lab made major contributions to the field of electroactive polymers for use as actuators (artificial muscles) and, thru various forums, is mentoring the activity worldwide. Other technologies that are being explored include Haptic interfaces, high power ultrasound for medical treatment, ferroelectric source that generates various radiations and charged particles, wireless high power transmission, biomimetic technologies and geophysical probing using elastic waves. In addition to planetary applications, the developed devices and mechanisms have potential terrestrial applications for medical, commercial, construction and others. These efforts involve technical cooperation with scientists and engineers at various universities, research institutes, medical centers and industry in the USA and internationally. Collection of photos that shows various activities of the Group can be seen oat the The Advanced Technologies Group and its NDEAA Lab - collection of photos website. Further, the Nov. 2001 issue of the NASA Tech Briefs covered Dr. Bar-Cohen and NDEAA in a "Who's Who in NASA" article.

Applications of electromechanical materials in space mechanisms is one of the links:
http://eis.jpl.nasa.gov/ndeaa/nasa-mp/nasaonly/flight-hardware/piezo-in-space.htm

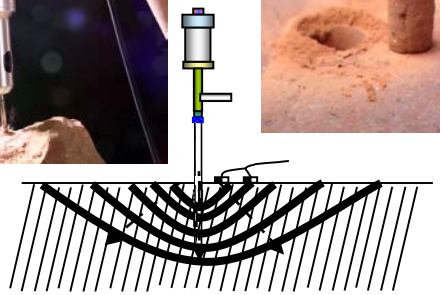
Y. Bar-Cohen, yosi@jpl.nasa.gov

In-situ sampling and electroactive mechanisms

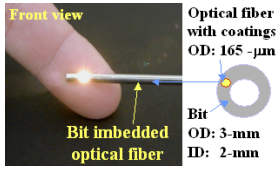
http://ndeaa.jpl.nasa.gov



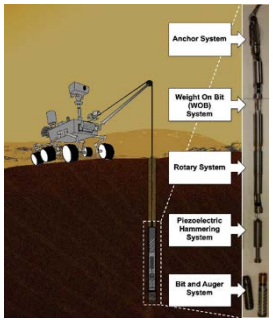
USDC



Probing, sampling and sensors platform



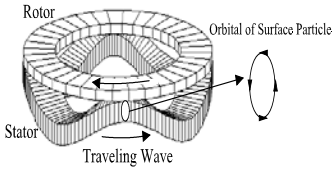
Gopher

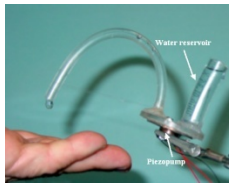


Mars and beyond

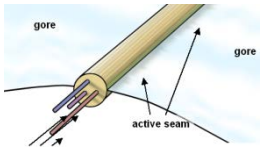
Concepts → Mission

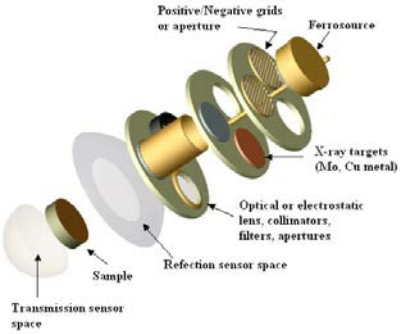
Actuators (USM, EAP, Piezopump)



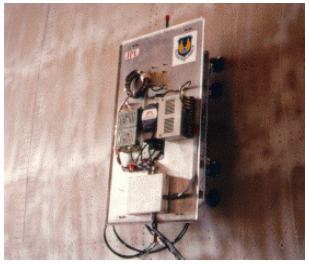


Other technologies (medical, etc.)





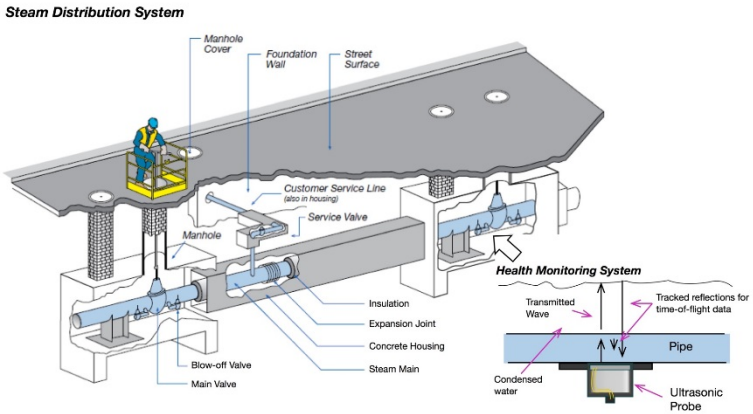
Robotics (MACS, MEMICA, Biomimetics)



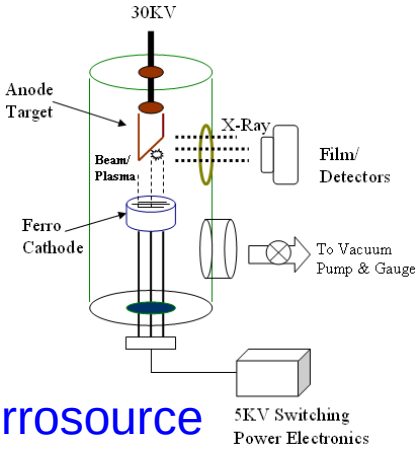
Components → Systems

Innovation at NDEAA

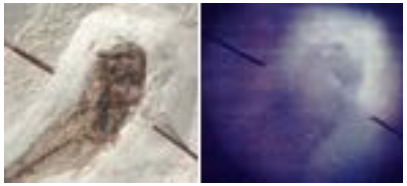
MACS

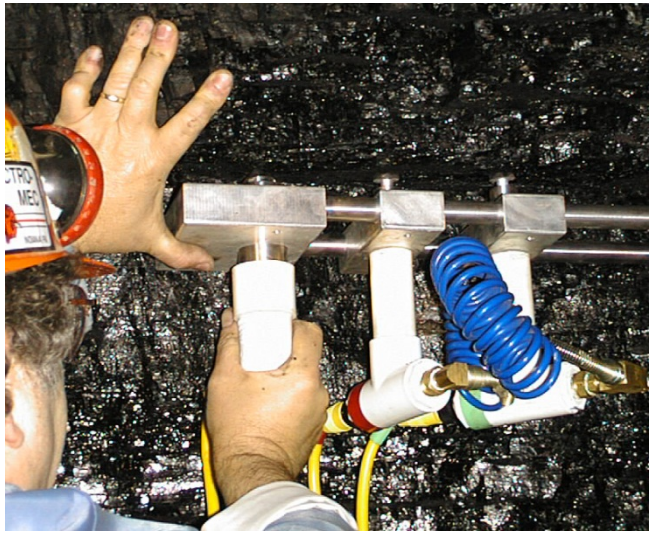


Ultrasonic monitoring of condensation

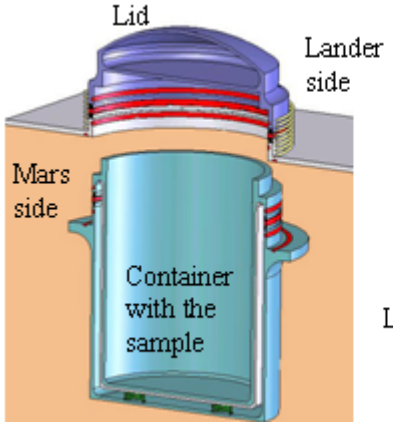


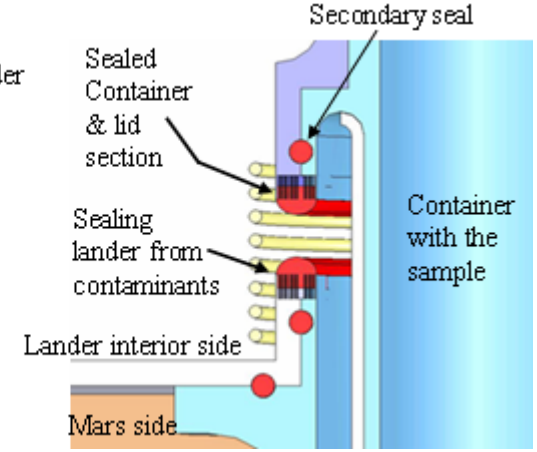
Ferrosource





Coal mine wall thickness gauging



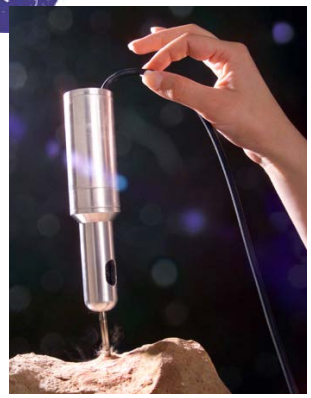


For potential Mars Sample Return (MSR) mission: Sample containerization using brazing and inductive heating

Pre-decisional: for information and discussion purposes only

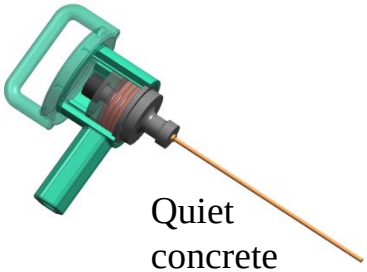
USDC

2000 R&D 100 award



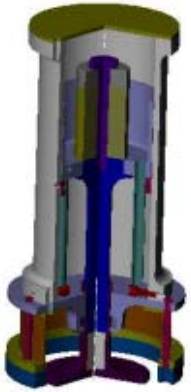
USDC

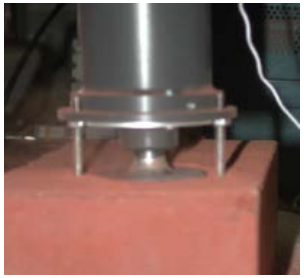
Packed soil penetrator



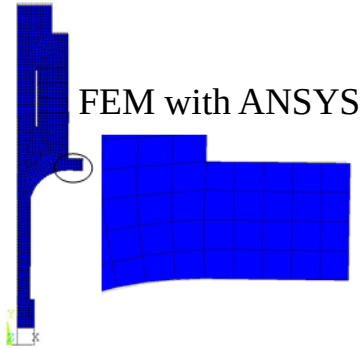
Quiet concrete drill

USDC anchor – operates forward and backward. Supported the steep terrain rover



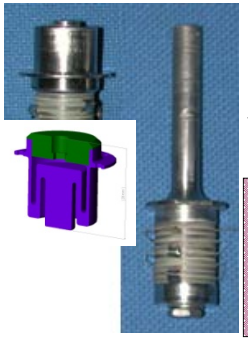


Ultrasonic Rock Abrasion Tool (URAT)

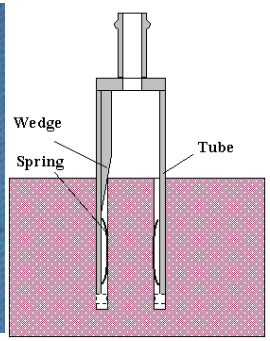


FEM with ANSYS

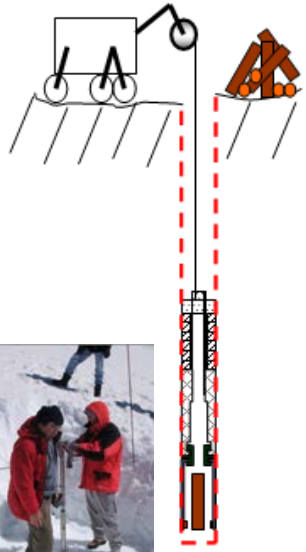
High Low temperatures



Folded horn



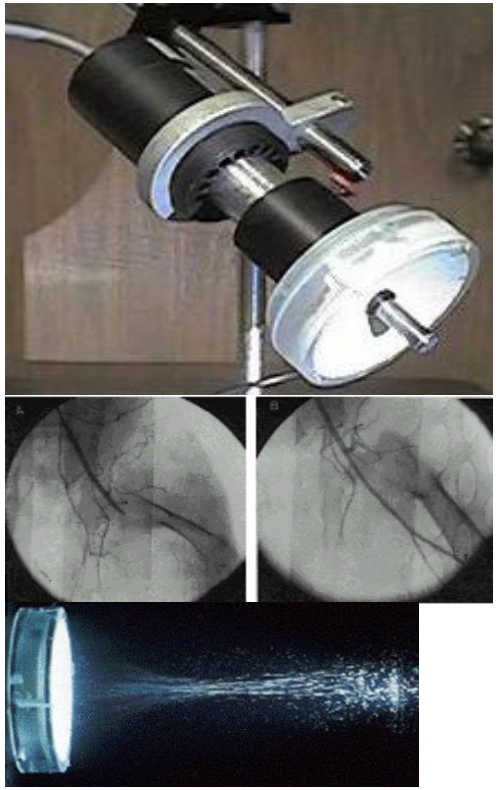
All-in-one bit

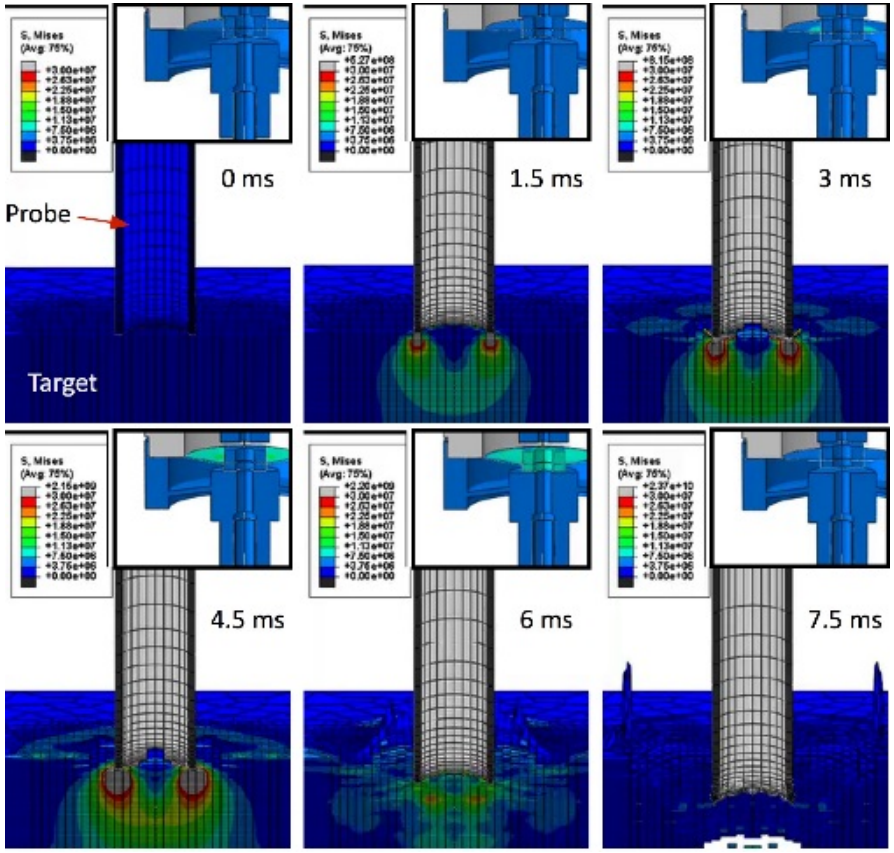


Gopher was field tested in Mt. Hood and Antarctica

Medical applications

- Blood clots transcutaneous decomposition
- Piezoelectric actuated lithotripter
- Wireless communication and remote charging
- “Roto-rooter” – Calcified occlusions penetrator

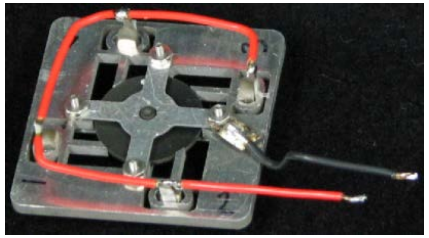


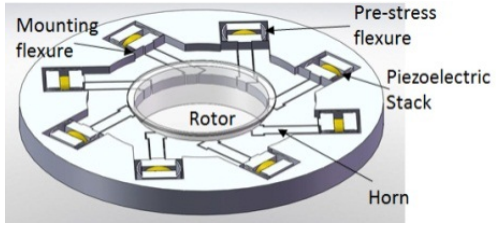


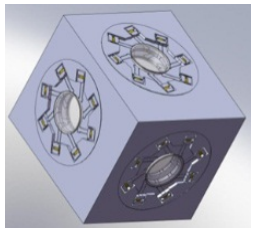
Actuation for dexterous manipulation and mobility

Piezo-Barth and piezo-ratcheting motors were developed.

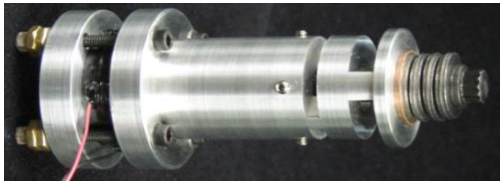
- The Piezo-Barth provides superior advantage of making multi-dimension motors that are integrated into the robotic structure allowing multi-functionality, low mass while operating as efficient low power actuators.
- The piezo-ratcheting motor has the unique advantage of allowing operation through walls.

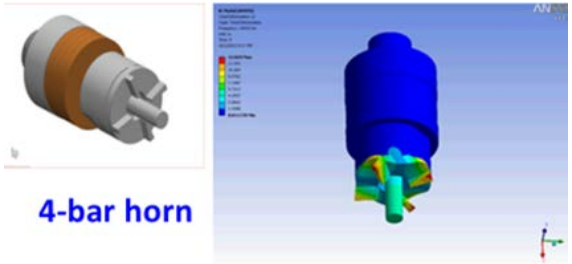


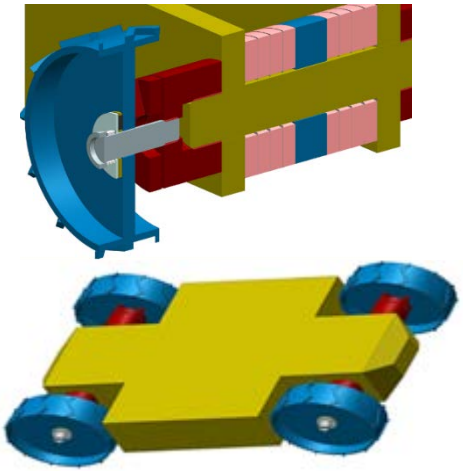


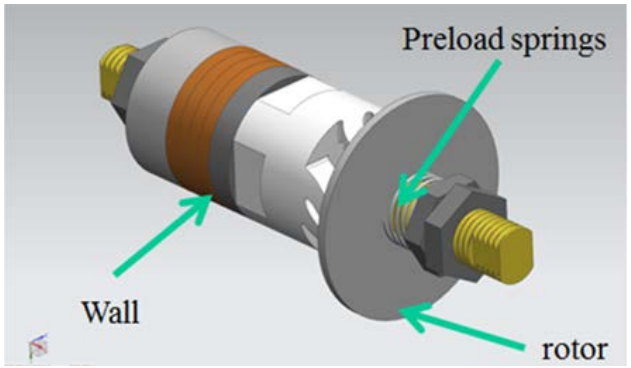


Piezo-Barth-Motor



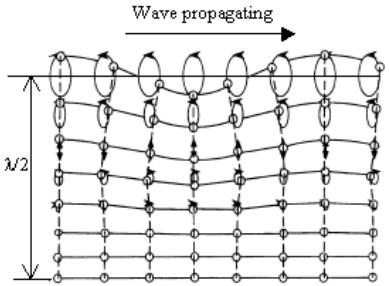


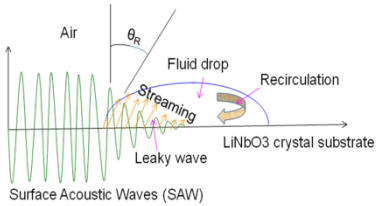


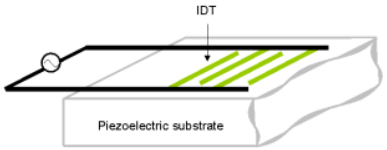


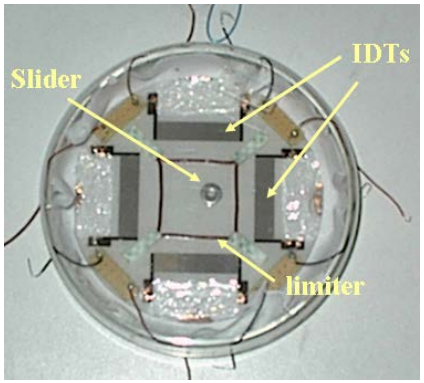
Piezo-ratcheting motor

Surface Acoustic Wave motors

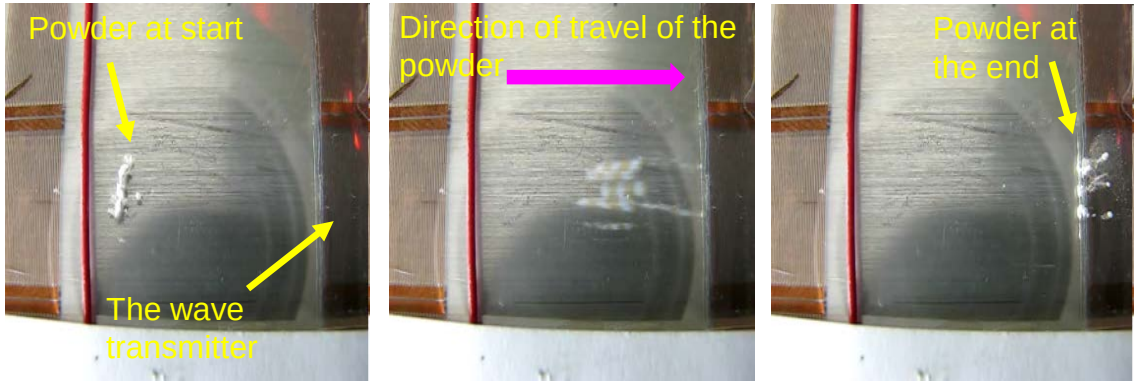




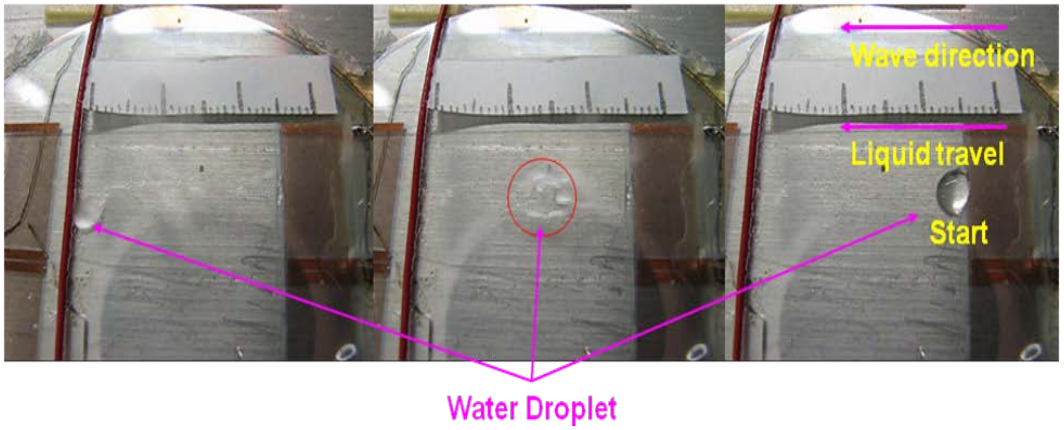




SAW motor



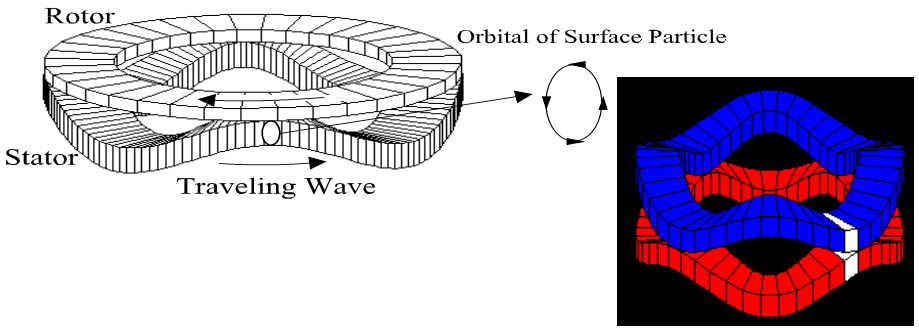
Snapshots from the travel of WCA 12 powder with 50% 7–8.5 μm particles.

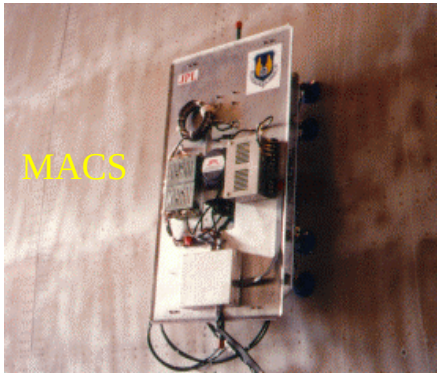


Snapshots from the travel of water droplet (the travel direction here is from right to left).

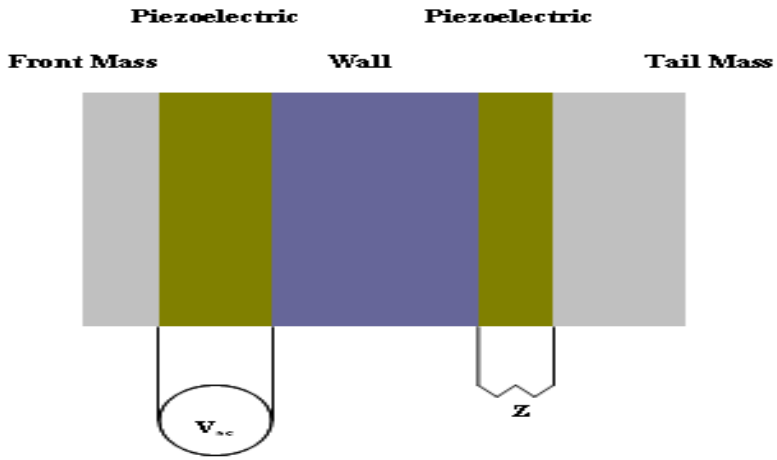
ULTRASONIC MOTORS (USM)

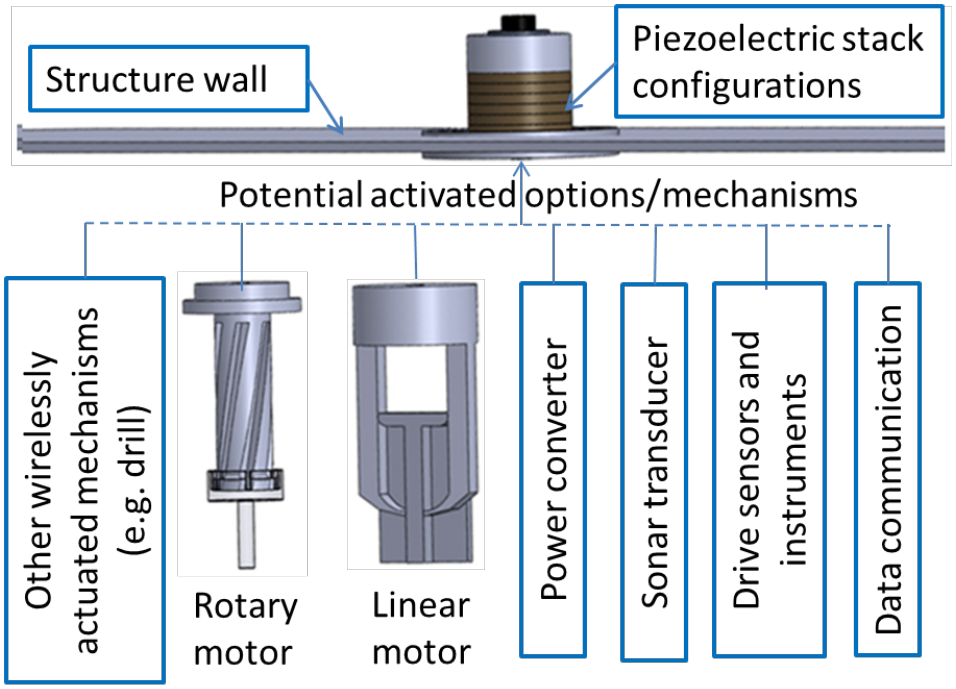
- Low speed and direct drive
- Order of magnitude higher torque density than electromagnetic motors
- Unique configurations: Pancake as well as annular shape for electronic packaging
- Lower cost, easy to miniaturize and to mass produce
- Inherently backdrivable (self braking)
- Not affected by magnetic field or radiation

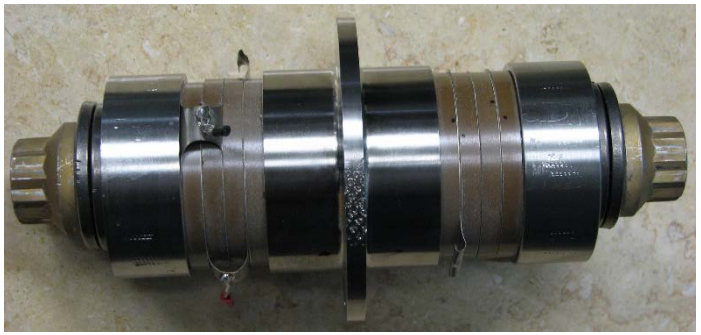


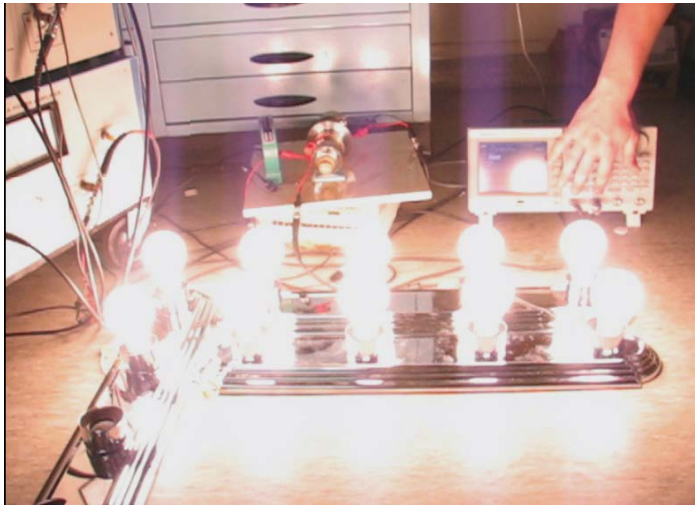


Acoustic Mechanical Feedthroughs









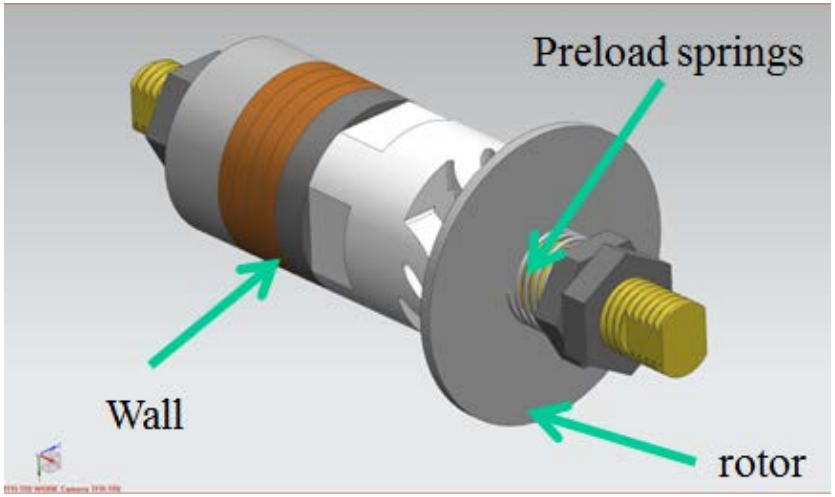
Wireless transmission of 1KW

Video of the three configurations

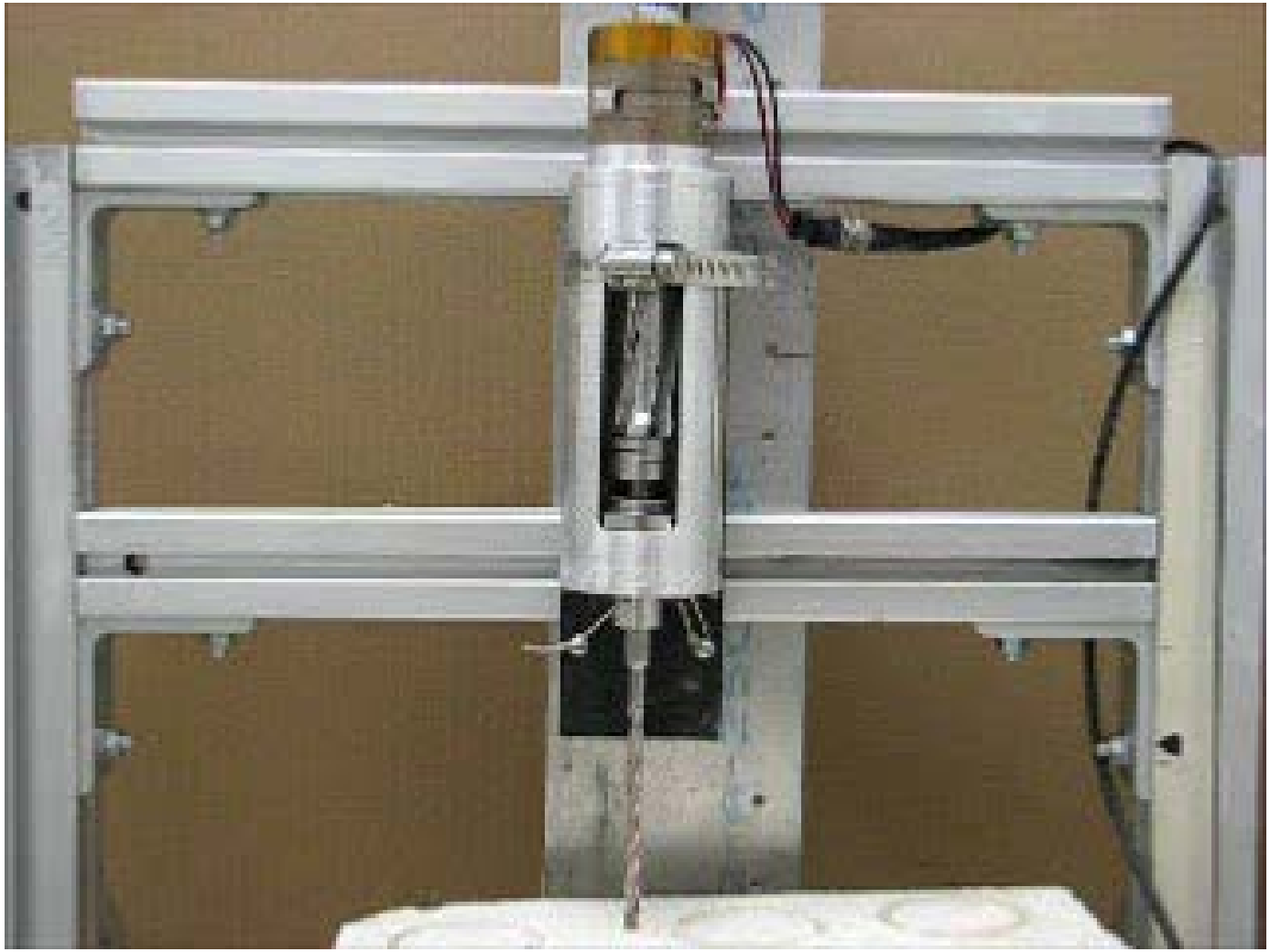
4 Bar-horn configuration

2 Bar-horn configuration

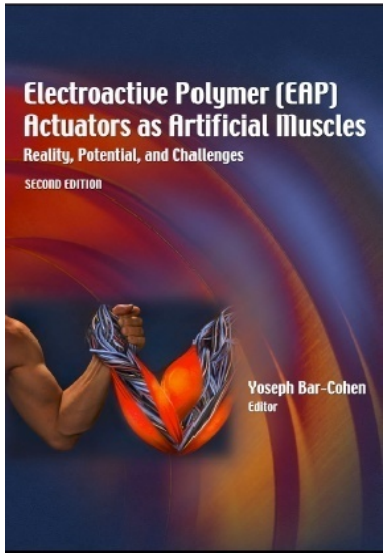
Flexure fingers horn



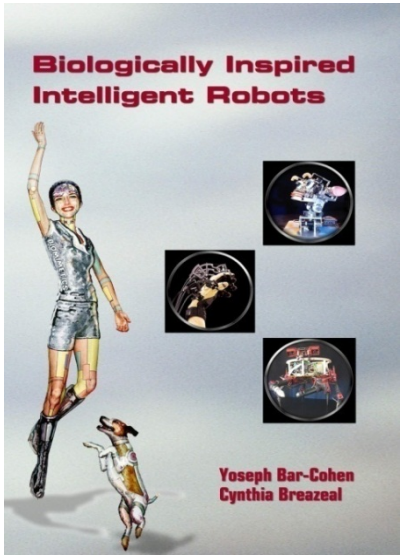
Video



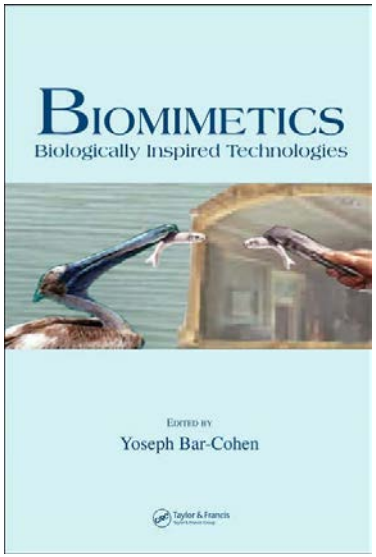
2000



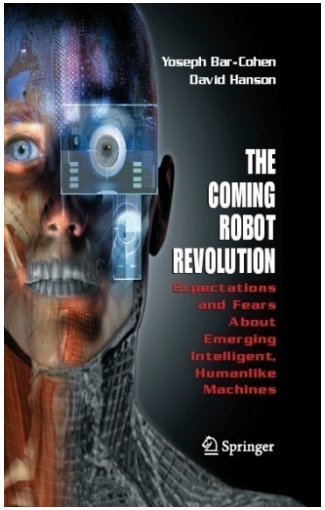
1st Ed. (2001)
2nd Ed. (2004)



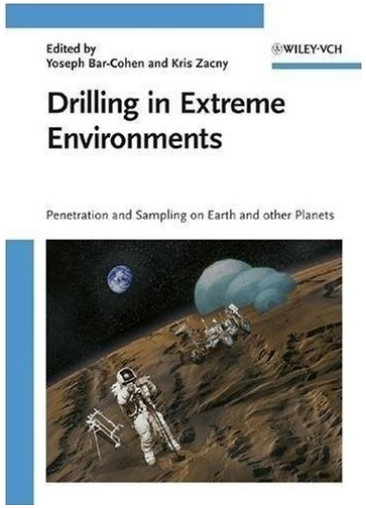
2003



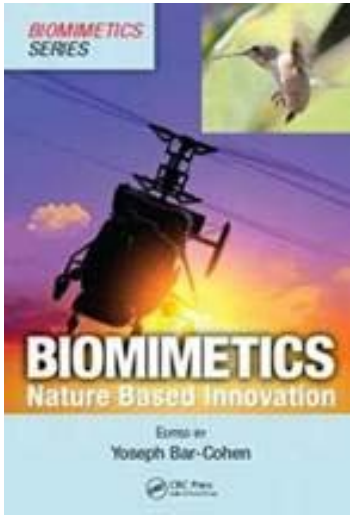
2005



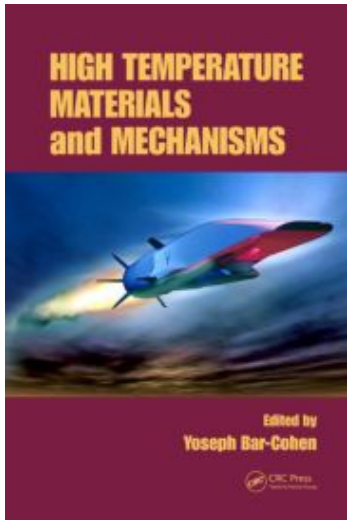
2009



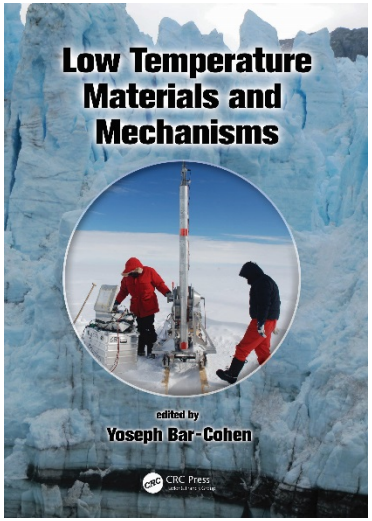
2009



2011



2014



2016

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