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Center for Energy Harvesting Materials and Systems

The CEHMS Chronicle

Special points of interest:

- Upcoming—**Advances in Energy Harvesting Colloquium/IAB meeting** will take place in Roanoke, VA from August 26—28.
- The 11th International Workshop on Piezoelectric Materials and Applications in Actuators & The 9th Energy Harvesting Workshop (IWPMA & EHW 2014) will be held in Suzhou, China on Sept. 22nd-25th, 2014.

Inside this issue:

The State of CEHMS Report

CEHMS had a very successful Energy Summit in January at UT Dallas. A recap of the event follows this note. Many companies attended and several new companies were introduced to CEHMS.

The IAB meeting was very successful. Virginia Tech presented 9 ongoing projects and 2 new proposals. UT Dallas presented an additional project. All ongoing projects will continue to receive funding and one new project was given the approval to start.

During the IAB meeting, Dr. Foster Agblevor from Utah state and Dr. Jim Cotton from McMaster University presented on behalf of their universities with the intent of joining CEHMS. The IAB approved of both universities joining, so we hope to have two new sites in the coming year.

Over the past year, CEHMS has produced more than 50 journal articles, 20 conference presentations and 2 patents. Over the next few months, we expect to graduate 4 PhD students who have contributed greatly to the success of many CEHMS projects. We will also have several new Postdoctoral researchers joining the Center in the upcoming months.

With these accomplishments and more, we look forward to the next meeting where we can share ideas related to Energy Harvesting, Integration and Powering the Internet of Things.

The First Colloquium on Advances in Energy Harvesting will be held in conjunction with the 5th Anniversary Celebration of CEHMS to bring together leading researchers in the fields of energy harvesting and storage. This large gathering of academic and industrial researchers will provide in-depth information on smart materials and their applications in energy harvesting. Because of its emphasis on energy related issues, eminent scientists and program managers from various funding agencies will lead panel discussions. Presentations will concentrate on following topics:

- Materials in Energy Harvesting
- System Integration and Production
- Application Test Beds
- Energy Storage
- Mechanical Energy Harvesting
- Thermal Energy Harvesting
- Powering the Internet of Things

The First Colloquium on Advances in Energy Harvesting will be held on August 26th and 27th at the Roanoke Hotel and Conference Center located at 110 Shenandoah Avenue in Roanoke Virginia. The IAB meeting will follow on August 28.

The website for the conference can be found at http://www.cpe.vt.edu/ehw/index.html

2014 Energy Summit: Powering the Internet of Things

The Center for Energy Harvesting Materials and Systems (CEHMS) held its second annual "Energy Summit" this past January with a theme of *Powering the Internet of Things*. The two day conference was well attended with over 60 representatives from both industry and academia and featured plenary talks, technical sessions, poster presentations, and networking events. Energy Summit 2014 focused on the fundamental science and technologies which will enable the Internet of Things (IoT) by finding answers to critical energy generation and management challenges in the field.

The IoT is a description of the exploding number of interconnected devices in the marketplace. Projected to exceed 50 billion devices by 2020, the IoT has pushed the bounds of both electronics and computer science. A critical challenge to the IoT is the development of sensors which will enable device-device communication. Powering these sensors, including power management, storage, and supply, is currently of great interest to the IoT community. CEHMS is uniquely positioned to find solutions to these critical challenges as energy harvesting provides an excellent route to circumvent current limitations by providing power from ambient sources and eliminating the need for wired devices or batteries.

Energy Summit 2015, to be held again at UT Dallas, will continue this focus on the IoT and will also expand to include other energy initiatives at UT Dallas and Virginia Tech. Bringing together researchers from CEHMS, WindSTAR, the Renewable Energy and Vehicular Technology (REVT) Laboratory, the Center for Advanced Energy systems (CAE), and the Center for Fundamental Energy Studies (CFES), Energy Summit 2015 will focus on energy challenges related to energy harvesting, renewable energy, power management, smart grids, and much more.

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2014 Energy Summit: Powering the Internet of Things

Keynote speaker Orlando Auciello from UT Dallas/MRS—Science and Technology of Integrated Oxide Piezoelectric/ Ultrananocrystalline Diamond Films: Films Synthesis and Integration into Piezoelectric Actuated Energy Harvesting

Mario Romero (UT Arlington) – Implantable Peripheral Nerve Sensors for the Control and

Srinath Hosur from Texas Instruments (TI) - Perpetual Sensor Nodes: A Case Study and Future Directions

Walter Voit from UT Dallas—How Engineered Materials and Low Power Electronics are Enabling the Ubiquitous Sensor Revolution

David Peterson from Nissan North America—Driving in a Connected World

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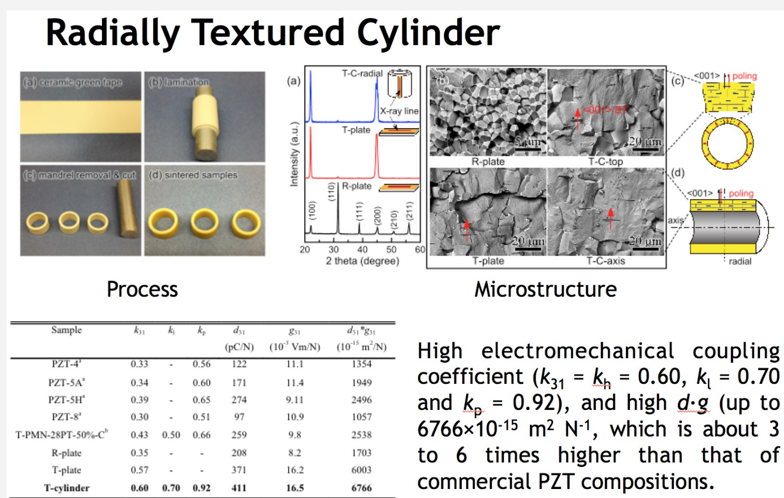
2014 Energy Summit: Powering the Internet of Things

High Energy Density in Piezoelectric Textured Ceramics
First place in the poster competition by Dr. Yongke Yan (Virginia Tech)

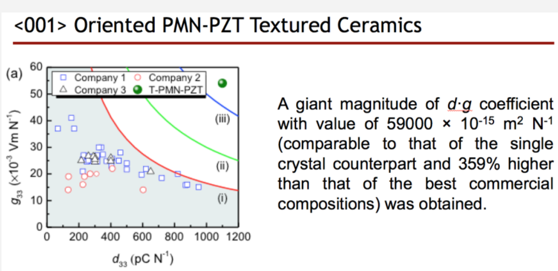
This work investigates the creation of high performance piezoelectric materials for vibration-based energy harvesting devices. The primary factor for the selection of piezoelectric materials is the transduction rate whose magnitude is governed by the product of piezoelectric strain constant, *d*, and the effective piezoelectric voltage constant, *g,* since electric energy density available under an alternating stress excitation is given by:

$$u_e = \frac{1}{2}(d \cdot g) \cdot (\frac{F}{A})^2$$

where F is the applied force, A is the area of active piezoelectric material. This equation shows that under given experimental conditions, a material with high $(d \cdot g)$ product will generate high power. However, there is fundamental challenge in achieving high $d \cdot g$ coefficient in conventional piezoelectric materials because any increase in the piezoelectric constant (d) is always accompanied by the large increase in dielectric susceptibility (ε), thus, high d usually shows low g.
In this work, Yan et. al found that template grain growth (TGG) technique yields textured relaxor-PT/PZT piezoelectric materials with large $(d \cdot g)$ magnitude.
Photo shot form poster:
This research will demonstrate that piezoelectric energy harvesting for capturing ambient mechanical vibration energy can be significantly improved by tailoring the magnitude of electro-mechanical parameters through grain texturing. Largest energy density (d · g) magnitude can be achieved in textured relaxor-PT/PZT piezoelectric materials.



Sample	k_{31}	k_l	k_p	d_{31} (pC/N)	g_{31} (10^{-3} Vm/N)	$d_{31}*g_{31}$ (10^{-15} m^2/N)
PZT-4[a]	0.33	-	0.56	122	11.1	1354
PZT-5A[a]	0.34	-	0.60	171	11.4	1949
PZT-5H[a]	0.39	-	0.65	274	9.11	2496
PZT-8[a]	0.30	-	0.51	97	10.9	1057
T-PMN-28PT-50%-C[b]	0.43	0.50	0.66	259	9.8	2538
R-plate	0.35	-	-	208	8.2	1703
T-plate	0.57	-	-	371	16.2	6003
T-cylinder	**0.60**	**0.70**	**0.92**	**411**	**16.5**	**6766**

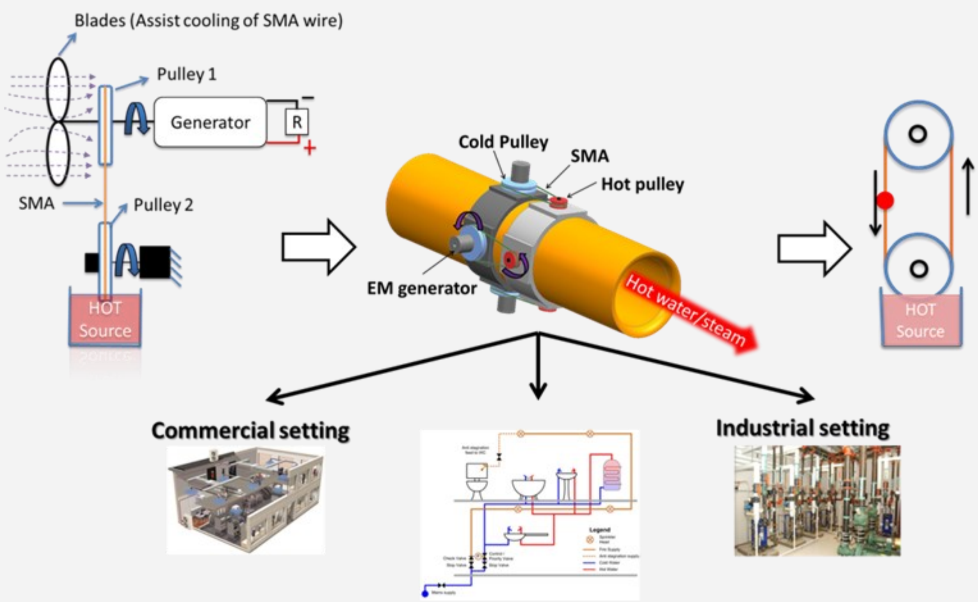


Dielectric and piezoelectric properties of random plate (R-Plate), textured plate (T-plate), and textured thin-walled cylinder (T-cylinder) samples.

2014 Energy Summit: Powering the Internet of Things

Miniature Shape Memory alloy Heat Engine for Powering Wireless Sensor Nodes
Second place in poster session by Dragan Avirovik (Virginia Tech)

Shape Memory Alloys (SMAs) are intelligent materials that go through reversible phase transformation (martensite to austenite phase) when heated and as a result generate strain. This deformation can be exploited in the development of a heat engine. The work is based on the fact that 60% of all energy generated is wasted heat of which, 90% is below 100°C. As a result, the heat which can be found in abundance can be converted to mechanical energy through the SMA deformation and then into electrical energy using a micro electro-magnetic generator. Accordingly, this system was tailored as a miniature energy harvesting device which can find applications in wireless sensor nodes applications. The results in the lab showed that a miniature SMA heat engine can produce 1.7mW of electrical power. Finally, a successful demonstration illustrated that the available electrical power was sufficient to power a wireless sensor node.



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