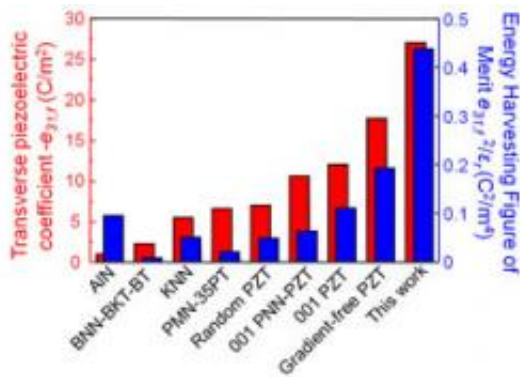


# Giant piezoelectric effect to improve MEMS devices

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Comparison of the figure of merit for PMN-PT film with other reported piezoelectric values for micromachined actuators and energy harvesting devices. Credit: Trolier-McKinstry, Penn State

Researchers in the Department of Materials Science and Engineering and the Materials Research Institute at Penn State are part of a multidisciplinary team of researchers from universities and national laboratories across the U.S. who have fabricated piezoelectric thin films with record-setting properties. These engineered films have great potential for energy harvesting applications, as well as in micro-electro-mechanical-systems (MEMS), micro actuators, and sensors for a variety of miniaturized systems, such as ultrasound imaging, microfluidics, and mechanical sensing.

Piezoelectric materials can transform electrical energy into mechanical

energy and vice versa. Most MEMS utilize silicon, the standard material for semiconductor electronics, as the substrate. Integrating piezoelectric thin films onto silicon-based MEMS devices with dimensions from micrometers to a few millimeters in size will add an active component that can take advantage of motion, such as a footstep or a vibrating motor, to generate electric current, or use a small applied voltage to create micron level motion, such as in focusing a digital camera.

Previously, the best piezoelectric [MEMS devices](#) were made with layers of silicon and lead zirconium [titanate](#) (PZT) films. Recently, a team led by Chang-Beom Eom of University of Wisconsin-Madison synthesized a lead magnesium niobate-lead titanate (PMN-PT) thin film integrated on a [silicon substrate](#).

The Penn State team, led by Susan Trolier-McKinstry, professor of ceramic science and engineering, and including research associate Srowthi Bharadwaja, PhD, measured the electrical and piezoelectric performance of the thin films and compared the PMN-PT films against the reported values of other micromachined actuator materials to show the potential of PMN-PT for actuator and energy harvesting applications.

In a recent article in Science, the team reported the highest values of piezoelectric properties for any piezoelectric thin film to-date, and a two-fold higher figure of merit than the best reported PZT films for energy harvesting applications. This increase in the effective piezoelectric activity in a thin film will result in a dramatic improvement in performance. For example, energy harvesting using such [thin films](#) will provide local power sources for wireless sensor nodes for bridges, aircraft, and potentially for human-body sensors.

Along with the researchers from Penn State and UW-Madison, the participating institutions included the National Institute of Standards and

Technology (NIST), University of Michigan, University of California, Berkeley, Cornell University, and Argonne National Laboratory. The paper, titled “Giant Piezoelectricity on Si for Hyperactive MEMS,” appeared in the Nov. 18 issue of *Science*. Work at Penn State was supported by a National Security Science and Engineering Faculty Fellowship. Other support was provided by the National Science Foundation, the Department of Energy, the Air Force Office for Scientific Research, and a David Lucile Packard Fellowship.

Provided by Pennsylvania State University

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