Evaluation of Electrets for MEMS/NEMS

The term *electret* was conceived as a counterpart of *magnet* about one hundred years ago. A dielectric material that has been electricized (polarized) is called an electret.

The thermoelectret effect was discovered in 1925, when a Japanese scientist solidified a mixture of carnauba wax, resin, and beeswax in the presence of a high DC electric field. The energy absorbed during the charging process resulted in space-charge polarization by the trapping of positive and negative charges at the interstitial sites. Although electrets are formed by a variety of processes and in a variety of dielectrics, they are all basically a dielectric with charge trapped near the surface. Typical modern-day electrets are materials such as Teflon or silicon dioxide that have been charged. The beauty of the electret is that the charge stays in place over time and can be used in applications that require a charge source.

Typical commercial devices that use electrets are microphones, radiation detectors, and furnace filters.

Project Goals

Our interest in electrets is their eventual use for actuators and release mechanisms. Also we have an interest in scavenged energy generators. As a precursor to device fabrication, we have looked at making measurements of the various properties of electrets, such as charge density, surface voltage, and electrostatic force. Our goal has been to start with whatever commercial electrets we could obtain and make these measurements.

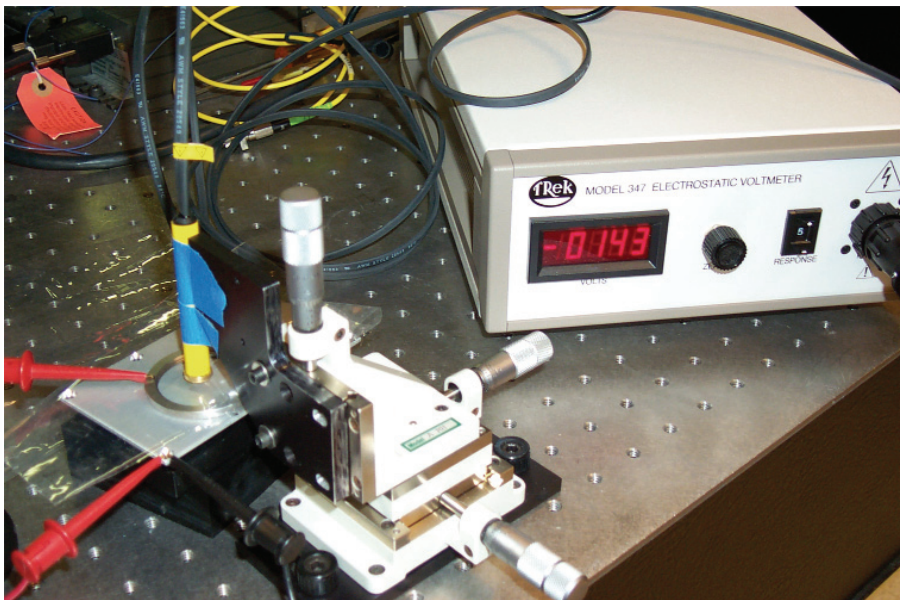

Figure 1. Electrostatic voltmeter and readout head (yellow) measuring surface voltage on a 3M electret (under metallic ground ring).

For more information contact
Michael D. Pocha
(925) 422-8664
pocha1@llnl.gov

Relevance to LLNL Mission

Incorporating electrets with MEMS technology may be useful for scavenged energy production by movement of conductors in an electric field. This energy could be used to power microsensors for various covert surveillance applications. In addition new types of microactuators and release mechanisms by countering induced charge are useful for microrobotics applications.

FY2005 Accomplishments and Results

Commercial electrets were procured from RadElec Inc., and 3M. RadElec uses electrets in radon detectors. These electrets are approximately 5-mil-thick sheets of Teflon that are on a conductive back plate. The 3M electrets are free-standing films of poly-carbonate, about 0.04 mm thick, with charge embedded on both sides.

Our first goal was to measure the surface voltage, which can be mathematically transformed to calculate charge density. We were able to make accurate measurements of the surface potential with mm to cm spacing from the charged surface (Fig. 1).

The RadElec electret was measured to have a positive surface voltage around 800 V. This is consistent with the surface voltage quoted by RadElec for these electrets (~740 V). The 3M electret material was measured to have a negative surface potential of greater than -2000 V. This material did not have the conductive back plate, resulting in an increased effective surface voltage. A measurement without a back plate does not have an accurate reference to ground and therefore does not correlate directly to charge density. A second measurement with a conductive back plate yielded approximately -150 V.

Related References

1. Eguchi, M., *Philos. Mag.*, **49**, pp. 178–181, 1925.
2. Hsieh, W. H., T. Y. Hsu, and Y. C. Tai, "A Micromachined Thin Film Teflon Electret Microphone," *International Conference on Solid-State Sensors and Actuators*, pp. 425-428, June 16-19, 1997.
3. Huang, A., P.-J. Chen, J. Boland, D. Alberer, T.-S. Wong, H. Q. Yang, Y.-C. Tai, and C.-M. Ho, "Liquid-Rotor Electret Power Generator Energized by a MEMS-Based Pulsed Combustor," *Digest Tech. Paper, Power MEMS'04 Conference*, Kyoto, Japan, November 28-30, 2004.

FY2006 Proposed Work

With knowledge of the charge density we can calculate the force between electrets and other objects. We will perform this calculation, and attempt to verify the force by use of a force probe. A preliminary test has verified that both electrets exert sufficient force to support the weight of our miniature silicon platforms (~ 2.3 mg) (Fig. 2).

Future work will focus more on the actual fabrication and tailoring of electrets for specific MEMS devices such as power generators or release mechanisms.

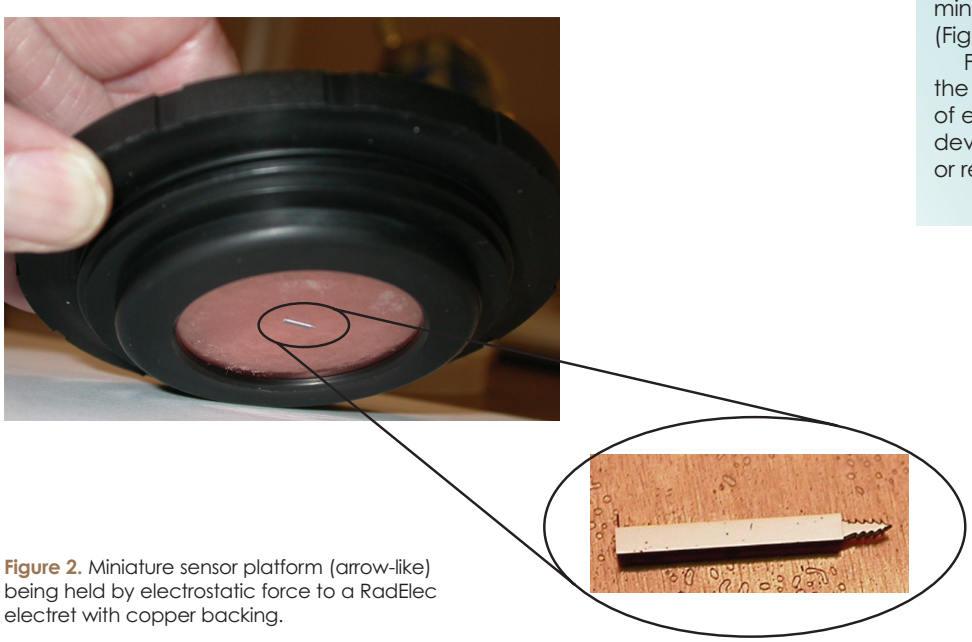

Figure 2. Miniature sensor platform (arrow-like) being held by electrostatic force to a RadElec electret with copper backing.