CPMD
Center of Excellence in
Piezoelectric Materials and Devices

Ben Franklin Technology PArtners
Center of Excellence in
Piezoelectric Materials and Devices

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Center Mission

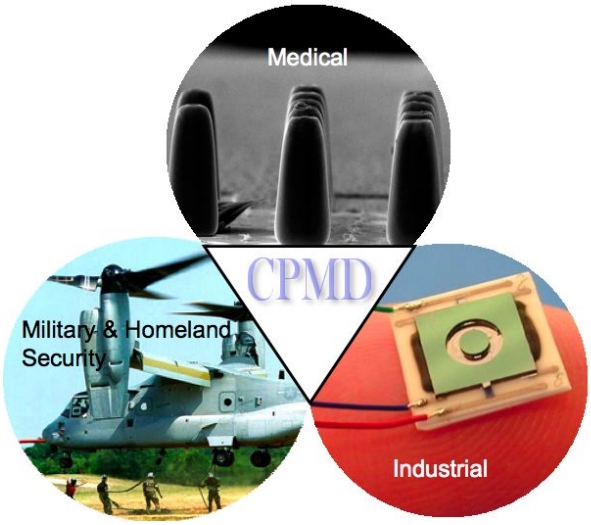
The Center of Excellence in Piezoelectric Materials and Devices (CPMD) fosters scientific and technical understanding of electromechanically active materials and the applications that utilize them. Among the products for which piezoelectrics play a pivotal role are: medical imaging and therapeutic ultrasound systems, non-destructive testing, actuators, flow meters, precision positioning devices, a wide variety of sensors (e.g. accelerometers, cardiac health monitors) timing standards, oscillators, and resonators. Center faculty focus on cutting-edge piezoelectrics research as well as seeding of new technology. The center trains scientists and engineers in the core areas of new piezoelectric materials development, new processing methods, device modeling, measurements, and prototyping. This provides a cadre of trained personnel to industry.

Benefits to center membership include:

- Access to world-class expertise and facilities
- Voting rights on center research directions & projects
- Focused and leveraged projects
- Timely reviews of developing technologies
- Tutorials and workshops
- Access to intellectual property

Research Program

The Penn State electroceramics faculty have led the field of piezoelectrics for >35 years, and in the last few years have pioneered the exploration of high strain piezoelectric single crystals, new high transition temperature morphotropic phase boundaries, high strain polymer piezoelectrics, Cu metallization for piezoelectric fuel injectors, and thin film piezoelectrics for microelectromechanical systems (MEMS). The faculty also has extensive experience in working with industry in this area, with recent projects from Agilent, APC Int., Bosch, Bridge Semiconductor, Intel, Northrop Grumman, TRS Ceramics, and Wilcoxon Research, among others. Consequently, they are poised to make significant contributions to the piezoelectrics industry.



Planned Research Directions

- **Piezoelectrics for Ultrasound Applications**
  - High frequency array transducers
  - High power & temperature stable single crystal transducers
  - Wireless ultrasound systems
  - Composites
- **New Piezoelectric Materials Development**
  - Piezoelectrics for harsh environments (high temperatures, exposure to radiation, etc.)
  - Lead-free piezoelectrics for RoHS compliance
  - Thin film piezoelectrics and MEMS
- **Piezoelectrics for Resonators and Sensors**
  - High coupling coefficient thin film resonators: deposition, structural, and electromechanical characterization
  - Wireless sensors
  - AlN films
  - Glass - ceramic piezoelectrics
  - Quartz measurements

Ben Franklin Technology PArtners
Central and Northern Pennsylvania

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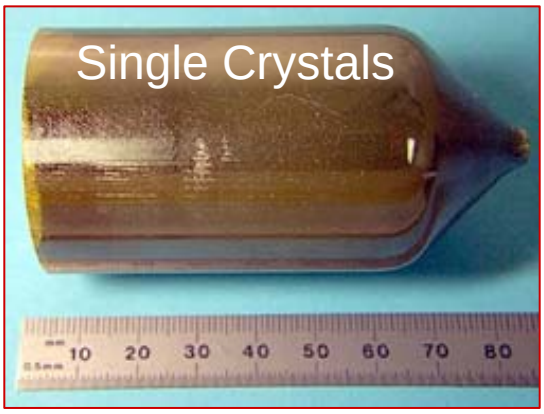
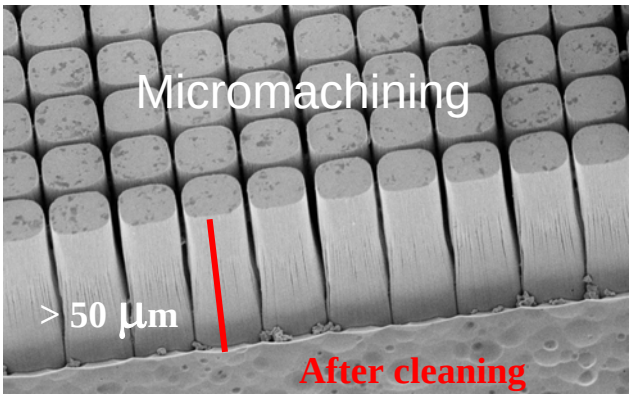




Facilities

The Center of Excellence in Piezoelectric Materials and is housed in the Pennsylvania State University's 70,000 square foot Materials Research Laboratory building, which is designed for the needs of interdisciplinary materials research. The laboratory maintains central facilities for scanning and transmission electron microscopies, two and four circle X-ray diffraction, thermal analysis, particle size analysis, wet chemical analysis, and sample preparation.

Processing and Prototyping

Extensive facilities are available for powder synthesis, ceramic processing, and ceramic machining. In addition, the W.M. Keck Smart Materials Integration Laboratory includes a cleanroom for processing piezoelectric materials, a low temperature ceramic co-fire processing line, as well as facilities for rapid prototyping and electroding.

Piezoelectric single crystal growth capabilities include flux growth, Bridgman, Czochralski, and laser heated pedestal growth. Alignment and machining facilities are also available.

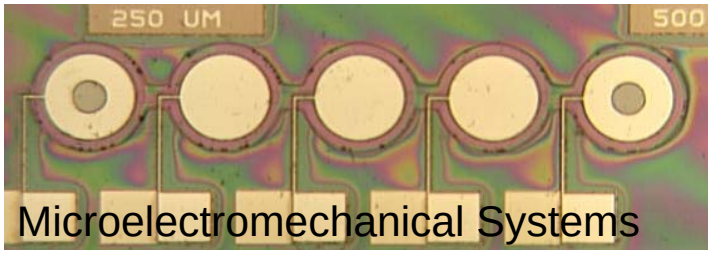
MEMS facilities include a full suite of piezoelectric/metal film growth tools (rf and dc magnetron sputtering, chemical solution deposition, pulsed laser deposition, and mist deposition) as well as patterning, etching, and release facilities for 4" substrates. Multiple mask level processes are run routinely.

Measurements

Pennsylvania State University has one of the most comprehensive electrical and electromechanical measurement facilities in the world. Low and high field piezoelectric measurements can be made from liquid nitrogen to 200 °C on bulk samples and thin films. Induced displacements can be tracked down to 10^{-4} Å. Electromechanical measurements can be made at temperatures up to 1200 °C over a wide frequency range. Complementing this facilities are ultrasound methods to self-consistently determine the full dielectric, elastic, and piezoelectric tensors of samples.

Transducer Design and Modeling

Penn State faculty have extensive experience in KLM and finite element modeling of piezoelectric materials devices, and systems. Composite piezoelectrics, flextensional motion amplification, phase field modeling, and phenomenology are particular strengths. In addition, there is staff and facilities available for the development of associated electronics. Close-coupling between the modeling and the fabrication efforts enables modeling to be verified by prototyping devices.



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