Piezoelectric MEMS for Defense Applications

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Piezoelectric materials have been available to the microsystems community for years, yet there remain substantial challenges with regards to successfully integrating piezoelectric materials and high-performance silicon electronics. Multiple unmet requirements for DoD applications necessitate the incorporation of piezoelectric material capabilities with CMOS integrated circuits. Significant opportunities exist for realizing large-force, large-displacement MEMS actuators; low-impedance resonators; low-power, low-noise sensors; low-loss ultra-capacitors; and most recently energy harvesters. The fundamental unsolved technical problem of attaining good IC-compatible piezoelectric materials despite the thermal processing constraints presents significant challenges.

This talk outlines to the broad scientific community the need for additional research on new types of MEMS devices based on piezoelectric materials and their integration with MEMS microstructures and integrated electronics. Particularly important are new technical approaches that will specifically focus on the use, optimization of properties, and integration of piezoelectric materials for MEMS applications. New insights include materials processing and optimal properties, low-temperature CMOS-compatible thin film deposition and annealing, self-assembled structures, advanced ceramic micro molding methods, stacking by successive thin film depositions, electrical poling, and synthesis of new materials such as Pb-free Langasite materials. Future advances in these piezoelectric materials processing areas will lead to new MEMS opportunities in DoD-relevant applications requiring low-impedance, low-loss nanoresonators, high-force microactuators, energy harvesters / nanogenerator arrays, low-loss ultracapacitors, and biocompatible MEMS.