“Ultimate MEMS Sensors”

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Electro-thermal excitation of micromechanical structures is an alternative to electrostatic and piezoelectric actuation that has received very limited attention. This is mainly due to the power consumption and slow response of electro-thermal actuators in the macro and microscale. Physics of scaling however reveals that shrinking the actuator dimensions into the nanoscale can significantly improve both response time and power consumption of such actuators. This, combined with degradation of other electromechanical actuation mechanisms upon further miniaturization, makes thermally actuated resonant devices a winning contender for sub-femtogram mass sensing. Electro-thermal resonant devices have tremendous potential for various sensing applications that will be presented in this session. Such applications range from nano-particle mass measurements, gas sensing, and biomolecular detection, to nano-precision displacement and force sensing. Furthermore, integration of electro-thermal actuation with piezoresistive sensing within the same element results in active electromechanical devices that can absorb energy from a DC source and turn it into mechanical vibration. This allows implementation of single device fully micromechanical electronic oscillators. The same internal energy pump can be used to amplify the effective quality factor of resonant structures by orders of magnitude. Extreme quality factors turn minuscule mechanical forces (e.g. otherwise undetectable Lorentz or Coriolis forces) into measurable vibration amplitudes. This can lead to extreme sensitivities currently only achievable by quantum devices.

Siavash Pourkamali received the B.S. degree in electrical engineering from Sharif University of Technology, Tehran, Iran, in 2001, and the M.S. and Ph.D. degrees in electrical engineering from Georgia Institute of Technology, Atlanta, Georgia in 2004 and 2006, respectively. Currently he is an Associate Professor at the Department of Electrical Engineering, University of Texas at Dallas. His main research interests are in the areas of electro-thermal nanomechanical actuation, M/NEMS resonators and filters, nanomechanical resonant sensors, integrated silicon-based MEMS and microsystems, and micromachining and nanofabrication technologies. Dr. Pourkamali is a recipient of the 2011 NSF CAREER Award, and the 2006 Georgia Tech Electrical and Computer Engineering Research Excellence Award.