Micro and Nanoscale Acoustic Devices for Communication, Sensing, and Energy

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Abstract

Continued scaling of micromechanical systems has enabled devices with improved performance and new functionalities that address needs in electronic, telecommunication, and medical industries. In this talk, I will focus on micro- and nano-scale Silicon Carbide (SiC) acoustic devices, which are lithographically defined and fabricated using standard CMOS-compatible processes. I will first present design, modeling, fabrication, and characterization of high-overtone lateral bulk acoustic resonators (LOBARs) with quality factors exceeding 100,000 at 3GHz, resulting in the highest $f/Q$ product demonstrated to date in any acoustic device, at any length scale.

I will then present a new class of nanoscale acoustic resonators based on Phononic Crystals (PnC) or acoustic bandgap meta-materials. Phononic crystals, due to their ability to precisely control and manipulate propagation of acoustic waves, have a wide range of applications in communication systems, acoustic imaging, sensing, acoustic isolation, and thermal energy management. Micro and nanoscale acoustic Fabry-Perot cavities with phononic crystal acoustic mirrors allow for decoupling of piezoelectric transducers from the low loss resonating structure. I will present SiC phononic-based cavities with low insertion losses and high quality factors at microwave frequencies, while achieving a small form factor. These resonators are ideal for on-chip multi-frequency, multi-bandwidth filter banks, spectrum analyzers, low phase noise oscillators, and ultra-sensitive chemical and biological sensors. Phononic crystals can also be used to shape the thermal phonon distribution that leads to reduced thermal conductivities. Phononic crystal-based thermoelectric devices can be used for highly efficient thermoelectric energy scavenging, on-chip accelerated cooling, and thermal noise reduction. I will conclude the talk by discussion of hybrid electronic/phononic and phononic/photonic systems, where fundamental investigation of coupling between acoustic, electrical, and optical waves at the nanoscale, will enable smaller, lighter, lower power, and fully integrated systems in communication, computation, energy, and sensing applications.

Biography

Maryam Ziaei-Moayyed is currently a postdoctoral scholar in the Advanced MEMS department at Sandia National Laboratories. She obtained her B.S. degree (Summa Cum Laude) in electrical engineering from Arizona State University in 2003, and her MS degree in electrical engineering and computer sciences from University of California, Berkeley in 2005. She received her Ph.D. degree in Electrical Engineering from Stanford University in December 2009, working with Professor Roger Howe. Her research interests are in the area N/MEMS and nanoscale phononic crystals for communication, sensing, and energy management. She is a National Science Foundation fellow and a member of IEEE, Etta Kappa Nu, and Tau Beta Pi.