AlN Piezoelectric NanoElectroMechanical Resonators and Switches for RF Signal Processing, Sensing and Computing

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Date: March 25th, 2011
Time: 1:30 pm-2:30pm Location:
CUTR 102

NanoElectroMechanical Systems (NEMS) resonators and switches have been identified as some of the most interesting technologies that will enable the More Moore and More than Moore evolution of the semiconductor industry. These NEMS devices will yield transformational improvements over state-of-the-art semiconductor-based products by decreasing power consumption, increasing frequency of operation and increasing sensing resolution – which will revolutionize computing, chemical/biological sensing, and radio frequency (RF) and microwave communication.

A major challenge for developing NEMS based technology is the ability to efficiently transduce the mechanical device at the chip scale. This talk presents remarkable opportunities associated with the scaling of piezoelectric AlN films to the nano realm and their application to the making of efficient NEMS resonators and switches that can be directly interfaced with conventional electronics.

Experimental data showing NEMS AlN resonators (250 nm thick with lateral features as small as 300 nm) vibrating at record-high frequencies approaching 10 GHz with *Qs* in excess of 500 will be presented. The extremely compact form factor of these devices permits to envision large scale integration (LSI) of NEMS to develop low power and highly reconfigurable microwave radio transceivers. Similarly, experimental results will show how these NEMS resonators can yield unprecedented sensitivities and be employed to form miniaturized gas sensor arrays and tag gas analyte concentrations that reach the part per trillion levels.

Finally, nano-piezoelectric films (50-100 nm thick) for switching applications and experimental data confirming that bimorph AlN nano-piezo-actuators achieve the same piezoelectric properties of microscale counterparts will be presented. These NEMS devices set a realistic pathway towards the development of low energy nanomechanical computing.

Gianluca Piazza is the Wilf Family Term Assistant Professor in the department of Electrical and Systems Engineering (ESE) at the University of Pennsylvania. His research interests focus on piezoelectric micro and nano electromechanicalsystems (MEMS/NEMS) for RF wireless communication, chemical/biological detection, and all mechanical computing. He also has a general interest in the areas of micro/nano fabrication techniques and integration of micro/nano devices with state-of-the-art electronics. He received his Ph.D. degree from the University of California, Berkeley in 2005. He has more than 10 years of experience working with piezoelectric materials. He holds several patents in the field of micromechanical resonators some of which have been succesfully acquired by industry (IDT and Qualcomm). He received the IBM Young Faculty Award in 2006 and has won, with his students, the Best Paper Award in Group 1 and 2 at the IEEE Frequency Control Symposium in 2008 and 2009, respectively.

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