Session 4: Sensors, MEMS, and BioMEMS - Micro and Nano Electromechanical Systems
Monday, December 3, 1:30 PM
Continental Ballroom 1-3
Co- Chairs: F. Perez-Murano, IMB-CNM
J-B Yoon, KAIST

1:35 PM - 2:00 PM
4.1 Demonstration of 50-mV Digital Integrated Circuits with Microelectromechanical Relays, *Z. A. Ye, S. Almeida, M. Rusch, A. Perlas, W. Zhang, U. Sikder, J. Jeon, V. Stojanović, and T.-J. K. Liu University of California, Berkeley*

50-mV operation of digital integrated circuits at room temperature is demonstrated using body-biased microelectromechanical relays. An improved relay design and self-assembled molecular coating reduce contact adhesion and hysteretic switching behavior, allowing relays to operate reliably with sub-50-mV gate voltage, enabling ultra-low active power consumption and zero static power consumption.

2:00 PM - 2:25 PM
4.2 Highly sensitive spintronic strain-gauge sensor based on magnetic tunnel junction and its application to MEMS microphone (Invited), *Y. Fuji, Y. Higashi, S. Kaji, K. Masunishi, A. Yuzawa, T. Nagata, K. Okamoto, S. Baba, T. Ono, and M. Hara, Toshiba Corporation*

We describe spintronic strain-gauge sensors based on magnetic tunnel junctions that exhibit extremely high gauge factors exceeding 5000. This high gauge factor was realized by using a novel amorphous magnetostrictive sensing layer. We also introduce a Spin-MEMS microphone in which these highly sensitive strain-gauge sensors are integrated on a diaphragm.

2:25 PM - 2:50 PM
4.3 Intermixing of motional currents in suspended CNT-FET based resonators, *L. Kumar, L. Vera Jenni, M. Haluska, C. Roman and C. Hierold, ETH ZURICH*

Here, we report the intermixing of piezoresistive and conduction modulation current in a carbon nanotube field effect transistor (CNT-FET) based resonator. We show that due to static displacement of the nanotube as a result of electrostatic actuation, the motional current at the resonance frequency consist of both current components. For instance at a gate DC bias of 1.3 V, 3/4 of motional current is conduction modulation current while the rest arises from piezoresistive effects. The intermixing effect due to asymmetry influences the fundamental harmonic response as well as the physical nature of the electrical signal being sensed; both of which are important for understanding frequency harmonics in nanoresonators and developing efficient readout schemes for nanoscale sensors.

2:50 PM - 3:15 PM
4.4 Glowing Graphene Nanoelectromechanical Resonators at Ultrahigh Temperature up to 2650K, *F. Ye, J. Lee, and P. X.-L. Feng, Case Western Reserve University*

We report on the first experimental demonstration of electrothermally tuned few-layer graphene resonant nanoelectromechanical systems (NEMS) operating at high frequency (HF) simultaneously with strong visible light emission. In tri-layer graphene resonators with carefully controlled Joule heating, we have demonstrated ultra-wide frequency tuning up to $\Delta f/f0 \approx 1300\%$, which is the highest frequency tuning range known to date among reported 2D materials resonators. Simultaneously, device temperature variations imposed by Joule heating are monitored using Raman spectroscopy and emission spectrum; and we find that the device temperature increases from 300 K up to 2650 K, which is the highest operating temperature known to date for electromechanical resonators. When device temperature is above 1800K, the graphene vibrating NEMS starts glowing and emitting visible light with robust mechanical resonance. These results show that electromechanical resonance modes can be robustly sustained and read out at glowing temperatures with incandescent emissions in graphene NEMS, suggesting new perspectives for integrating and configuring timing functions in light emitting graphene devices for harsh and extreme environment applications.

3:15 PM Coffee Break

3:40 PM - 4:05 PM
4.5 Monolithic Integration of Micron-scale Piezoelectric Materials with CMOS for Biomedical Applications, *C. Shi, T. Costa, J. Elloian, and K. L. Shepard, Columbia University*

We present the monolithic integration of piezoelectric micromachined ultrasonic transducers (PMUT) in both polyvinylidene difluoride (PVDF) and lead zirconate titanate (PZT) with complementary metal–oxide–semiconductor (CMOS) technology. Characterization results of micro-fabricated devices reveal the preservation of the piezoelectric properties of PVDF/PZT and PMUT functionality with co-designed CMOS ICs.

4:05 PM - 4:30 PM
4.6 A Nano-Mechanical Resonator with 10nm Hafnium-Zirconium Oxide Ferroelectric Transducer, *M. Ghatge, G. Walters, T. Nishida and R. Tabrizian, University of Florida*

This paper reports, for the first time, on a 10nm hafnium-zirconium oxide (HZO) piezoelectric transducer for nano-electromechanical systems. The developed 10nm HZO transducer is used for excitation of a silicon-based multi-morph nano-mechanical resonator, with an overall thickness of ~350nm, at ~4MHz. Benefiting from large piezoelectric coefficient, fully conformal deposition, and CMOS-compatibility, ALD-deposited 10nm HZO transducer paves the way for realization of truly monolithic cm- and mm-wave RF front-ends for the emerging 5G wireless communication systems.

4:30 PM - 4:55 PM
4.7 Comprehensive optical losses investigation of VLSI Silicon optomechanical ring resonator sensors, *L. Schwab, P.E. Allain*, L. Banniard**, A. Fafin**, M. Gely**, O. Lemonnier**, P. ** M. Hermouet3** S. Hentz**, I. Favero*, B. Legrand and G. Jourdan **, Université de Toulouse, *Univ. Paris Diderot, **Univ. Grenoble Alpes, CEA LETI*

Cavity optomechanics devices are leading edge candidates for a new generation of sensors both in the quantum and classical realms. Several single devices have been demonstrated in numerous labs, however large-scale integration capability necessary for industrial deployment is still an issue. In this paper, we present very-large-scale integrated (VLSI) optomechanical sensors fabricated from standard 200 mm Silicon-On-Insulator (SOI) wafers. Optical properties over a statistically significant sample size have been systematically investigated and show an excellent modeling to experiment agreement, a coupling parameter dispersion of 7% and a manufacturing yield larger than 98%. Controlled versatile sensors, such as these, could easily be embedded in any chip where mass or force sensing is needed.