Session 22: Sensors, MEMS, and BioMEMS– MEMS and Resonator
Tuesday, December 16, 2:15 p.m.
Imperial Ballroom B
Co-Chairs: Nuria Barniol, Universitat Autonoma de Barcelona
Dana Weinstein, Massachusetts Institute of Technology

2:20 p.m.
22.1 Nanosystems Monolithically Integrated with CMOS: Emerging Applications and Technologies, J. Arcamone, J. Philippe, G. Arndt, C. Dupré, M. Savoye, S. Hentz, T. Ernst, E. Colinet, L. Duraffourg and E. Ollier, Univ. Grenoble Alpes, CEA, LETI, MINATEC

This paper reviews the last major realizations in the field of monolithic integration of NEMS with CMOS. This integration scheme not only drastically improves the efficiency of the electrical detection of the NEMS motion. Our analysis is that it also represents a compulsory milestone to practically implement breakthrough applications of NEMS, such as mass spectrometry, that require large capture cross section (VLSI-arrayed NEMS) and individual addressing (co-integration of NEMS arrays with CMOS electronic loop).

2:45 p.m.
22.2 A Self-sustained Nanomechanical Thermal-piezoresistive Oscillator with Ultra-Low Power Consumption, K.-H. Li, C.-C. Chen, M.-H. Li and S.-S. Li, National Tsing Hua University

This work demonstrates wing-type thermal-piezoresistive oscillators operating at about 840 kHz under vacuum with ultra-low power consumption of only 70 μW for the first time. The thermally-actuated piezoresistively-sensed (i.e., thermal-piezoresistive) resonator can achieve self-sustained oscillation using a sufficient dc bias current through its thermal beams(see Fig. 1) without additional electronic circuits [1]. The combination of N-type heavily doped silicon with negative piezoresistive coefficients and sub-micron cross-sectional dimensions of the actuated beams is key to ensuring self-sustained oscillation under sub-100μW level. In addition, shrinking thermal beam cross-sections is a simple and effective approach to achieve better figure of merit (e.g., FOM, defined by the ratio of transconductance gm to dc power consumption PDC) of the self-sustained oscillators. By using proper control of silicon etching (ICP) recipe, the sub-micron cross-sectional dimension of the thermal beams can be easily and reproducibly fabricated in one process step. The phase noise of the proposed wing-type oscillators was also reported in this work with -93.41 dBc/Hz at 1-kHz offset and -97.95 dBc/Hz at 100-kHz offset in air, and -95.9 dBc/Hz at 1-kHz offset and -95.7 dBc/Hz at 100-kHz offset in vacuum, respectively

3:10 p.m.
22.3 Optimizing the Close-to-Carrier Phase Noise of Monolithic CMOS-MEMS Oscillators Using Bias-dependent Nonlinearity, M.-H. Li, C.-Y. Chen, C.-H. Chin, C.-S. Li and S.-S. Li, National Tsing Hua University

A fully monolithic 1.12-MHz CMOS-MEMS nonlinear oscillator comprising a double-ended tuning fork (DETF) resonator and a transimpedance sustaining amplifier has been proposed to enable significant close-to-carrier phase noise reduction while maximizing the output power for far-from-carrier phase noise improvement. By operating the resonator in its anharmonic regime using bias-dependent nonlinearity, we have experimentally demonstrated the phase noise (PN) improvement more than 27 dB in the close-to-carrier offset as compared to our previous work. The best-case PN of -77 dBc/Hz at 10-Hz offset, -97 dBc/Hz at 100-Hz offset, and -113 dBc/Hz at 1-kHz offset is realized in a monolithic CMOS-MEMS flexural-mode resonator oscillator for the first time, which is on par with bulk-mode MEMS oscillators using resonator Q > 100,000.

3:35 p.m.
22.4 High Performance Polysilicon Nanowire NEMS for CMOS Embedded Nanosensors, I. Ouerghi, J. Philippe, L. Duraffourg, L. Laurent, A. Testini, K. Benedetto, A.M. Charvet, V. Delaye, L. Masarotto, P. Scheiblin, C. Reita, K. Yckache, C. Ladner, W. Ludurczak and T. Ernst, CEA LETI

We present for the first time sub-100nm poly-Silicon nanowire (poly-Si NW) based NEMS resonators for low cost co-integrated mass sensors on CMOS featuring excellent performance when compared to crystalline silicon. In particular, comparable quality factors (130 in the air, 3900 in vacuum) and requency stabilities are demonstrated when compared to crystalline Si. The minimum measured Allan deviation of $7x10^{-7}$ leads to a mass resolution detection down to 100 zg (100×10^{-2} g). Several poly-Si textures are compared and the impact on performances is studied (quality factor, gauge

factor, Allan variances, noise, temperature dependence (TCR)). Moreover a novel method for in-line NW gauges factor (GF) extraction is proposed and used.

4:00 p.m.
22.5 Integration of RF MEMS Resonators and Phononic Crystals for High Frequency Applications with Frequency-selective Heat Management and Efficient Power Handling, H. Campanella, N. Wang, M. Narducci, J. B. W. Soon, C. P. Ho*, C. Lee* and A. Gu, A*STAR, *National University of Singapore

A radio frequency micro electromechanical system (RFMEMS) Lamb-wave resonator made of aluminum nitride (AlN) that is integrated with AlN phononic crystal arrays to provide frequency-selective heat management, improved power handling capability, and more efficient electromechanical coupling at ultra high frequency (UHF) bands. RFMEMS+PnC integration is scalable to microwave bands.

4:25 p.m.
22.6 A Monolithic 9 Degree of Freedom (DOF) Capacitive Inertial MEMS Platform, I. E. Ocak, D. D. Cheam, S. N. Fernando, A. T. H. Lin, P. Singh, J. Sharma, G. L. Chua, B. Chen, A. Y. D. Gu, N. Singh and D. L. Kwong, IME A*STAR Singapore

A 9 degree of freedom inertial MEMS platform, integrating 3 axis gyroscopes, accelerometers, and magnetometers on the same substrate is presented. This method reduces the assembly cost and removes the need for magnetic material deposition and axis misalignment calibration. Platform is demonstrated by comparing fabricated sensor performances with simulation results.