High Frequency Silicon Nanowire Resonators for mass sensing

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Abstract

For the last two decades, nanoelectromechanical systems (NEMS) such as silicon nanowires have exhibited incredible potential for both fundamental science and applications, providing new tools for studying quantum physics including electromechanics and optomechanics[1]. Technological applications of NEMS are also emerging: these include integrated frequency clocks[2], logic switches[3], mixer filters[4], ultra-sensitive force detectors[5] and mass sensors[6]. A variety of NEMS detection techniques, such as capacitive[7], magnetomotive[8], piezoresistive[9] and field-emission[10] transduction, have been proposed. However, interfacing NEMS and more specifically nanowires with the macro world remains a challenge. During the talk, an overview of the transduction schemes used for detecting tiny displacements of suspended nanowires will be presented. The presentation will briefly introduced VLSI-NEMS manufacturing with or without its co-integrated CMOS readout electronics. As an example, highly efficient in-plane motion detection based on suspended p^{++}-doped piezoresistive nanowires (the minimum section achieved is on the order of 40nmx30nm) will be presented. The smallest devices have been co-integrated with their readout electronics (on 40nm-Fully depleted technology[11]) to arise the useful signal from the background with a fairly good Allan deviation lower than 1ppm. Results on high frequency vibrating silicon nanowires (the minimum section achieved is on the order of 40nmx30nm and 1µm-long) will also be presented. This last device can be transduced through piezoresistive technique and junction-less field-effect as well. Allan deviation of the same Si-NW has been measured with both schemes, and we obtained 20ppm for the FET detection and 3ppm for the PZR detection at room temperature and low pressure.

Finally, the talk will conclude on several emblematic applications related to mass sensing. Recent results on multi-gas detections and mass spectrometry with NEMS including silicon nanowires will be reported.

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