Solid State RF NEMS-CMOS Resonators

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Semiconductor micro-electromechanical (MEM) resonators, with quality factors (Q) often exceeding 10^4 can provide a high performance, low-power, compact CMOS-compatible alternative to electrical components in wireless communication and signal processing. The majority of electromechanical devices require a release step to freely suspend moving structures. This necessitates costly complex encapsulation methods and back end-of-line processing of large-scale devices. Development of *unreleased* Si-based MEMS resonators in CMOS allows seamless integration into Front End of Line processing with no post-processing or packaging.

In this talk, I will discuss the Resonant Body Transistor (RBT), which can be integrated into a standard CMOS process for low power clock generation and high-Q tank circuits. We recently demonstrated the first hybrid RF MEMS-CMOS resonators in Si at the transistor level of IBM's SOI CMOS process, without the need for any post-processing or packaging. The unreleased, Si bulk acoustic resonators are driven capacitively using the thin gate dielectric, and actively sensed using a body-contacted nFET incorporated into the resonant cavity. FET sensing with the high f_T, high performance transistors in CMOS amplifies the mechanical signal before the presence of parasitics. The resulting RF-MEMS resonators can provide low power, low cost, small footprint building blocks for on-chip signal generation and processing. For low loss and high power application, this concept can be extended to III-V semiconductors commonly used for mm-wave ICs (MMICs). I will discuss our latest results on active MEMS-HEMT resonators in GaN and their implications for channel-select radio design.

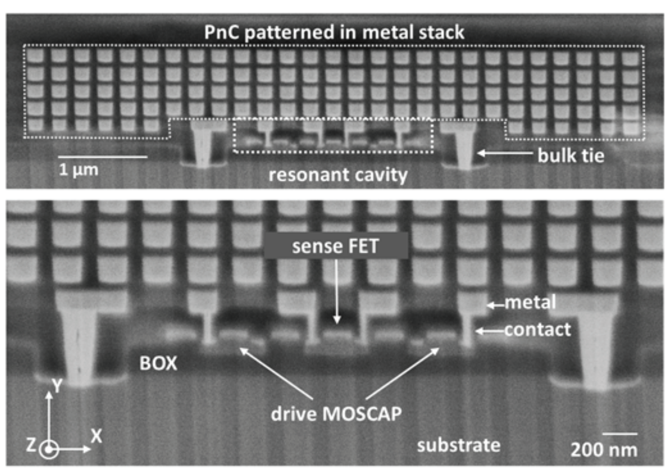

Fig. 1. Resonant Body Transistor operating at 2.8 GHz fabricated in IBM 32nm SOI process. While standard FETs are used to drive and sense acoustic resonance, the resonant mode is confined using a Phononic Crystal defined using the first 5 metal layers (Bahr, Marathe, Weinstein, IEEE Freq. Contr. Symp. 2014).