Statistical Element Selection for RF N/MEMS Resonator Oscillators

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As frequency and scaling progress, relative variations increase, thus causing manufacturing yields to decrease. Statistical Element Selection (SES) offers to ameliorate the variations of scaled silicon by taking advantage of its density. By packing many devices into our circuits, we can "select" the ones with desirable properties, e.g., accurate resonance frequency. These device arrays can be sized to meet tolerances on a given set of specifications.

In this project, we take advantage of emerging high-Q 10+ GHz MEMS acoustic resonant devices called Resonant Body Transistors, or RBTs. These devices (Fig. 1), developed by our collaborators Dana Weinstein and Radhika Marathe at MIT, promise high Q in a compact, front-end-of-line design with no post-CMOS processing, compatible with commercial processes.

In order to demonstrate SES in a practical RF circuit, we have designed a 10 GHz oscillator, the first RF circuit to benefit from the high Q of the RBT. The small footprint of the RBT allows us to pack an array of RBT resonators, from which the devices with closest resonance frequencies are "selected" while the others are turned off. In simulation (Fig. 2), this allows a circuit otherwise hobbled by mismatch variations to become a functional oscillator.

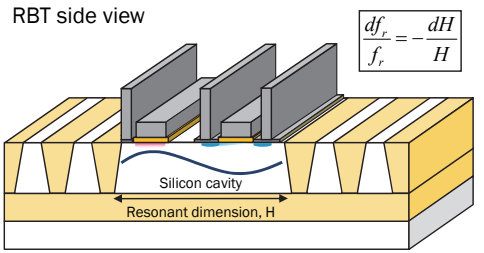

Fig. 1: Cross-sectional view of the RBT. The acoustic cavity has a resonance governed by the lateral dimension. Acoustic Bragg Reflectors flanking the cavity help sharpen the Q. The sense mechanism is a transistor, whose drain current is modulated by piezoresistance.

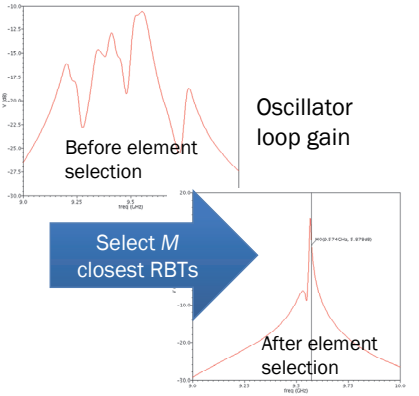

Fig. 2: Simulation of element selection. With mismatch variations dialed in, the oscillator loop gain is insufficient for oscillation. After the closest resonators are selected from the array, the loop gain becomes acceptable.