Tuning the Bandwidth and Center Frequency of Micromechanical Acoustic Resonators

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As the radio frequency (RF) spectrum has become more crowded, the need for adaptable RF components, especially filters, has grown. Recently, aluminum nitride (AlN) microresonator filters have been reported. These filters/resonators are small (<1mm^3), have the high quality factors (>1000) desired for steep filter roll-off, can achieve many filters covering a very wide frequency span (kHz to GHz) on a single chip and can be monolithically integrated with CMOS transistors for reconfiguring the filter array. Using AlN microresonator on CMOS technology, miniature, adaptable RF filters based on banks of switched filters have recently been reported.

To complement and expand upon the adaptability provided by the switched filter arrays, there is a desire to tune both the center frequency and bandwidth of miniature acoustic filters. This paper will present techniques for tuning the resonant frequency of miniature acoustic resonators including reactive loading and Joule heating. The fundamental limitations of both approaches will be discussed. It will be shown that the center frequency tuning achievable by reactive loading is limited by the resonator coupling coefficient, k_t^2, a fundamental property of electrically excited (piezoelectric, capacitive, electrostrictive) acoustic resonators. A tunable bandwidth filter constructed from tunable center frequency microresonators will be presented. Finally, the prospect for higher coupling coefficient microresonators with increased tuning range by constructing microresonators in advanced materials will be presented.

In addition to center frequency tuning, the bandwidth of microresonator filters can be adjusted by tuning the networks that couple the resonators together and the matching networks at the input and output of the filters. An ultra-high frequency (UHF) filter that achieves nearly an order of magnitude bandwidth tuning (from 0.1 to 1% of the filter center frequency) will be presented.