Channel-Select RF MEMS Filters

CNF Project # 1380-05
Principal Investigator: Sunil Bhave

Abstract:

The vast majority of radio frequency (RF) systems currently in production implement the heterodyne architecture developed by Edwin Armstrong 75 years ago. Today, this architecture relies on discrete components such as quartz crystals and ceramic filters to provide stable references and frequency selection. However, quartz and ceramics are not easily integrated with on-chip circuits, preventing the fabrication of a fully monolithic radio. In recent years, high quality factor (Q) micromechanical resonators have emerged as a possible alternative to quartz and ceramic components. The key benefit of these lateral-mode MEMS resonators is the ability to fabricate multiple frequencies in a single lithography step.

Summary:

The OxideMEMS Lab at Cornell University is developing sub-10 µWatt power consumption receivers for sensor network radios operating in the ISM bands. ISM band receivers require narrow channels and are susceptible to nearby strong interferers. To filter out unwanted frequencies, channel-select filter arrays with small bandwidth, good stop-band rejection, and excellent shape factor must be implemented. We have designed and fabricated RF MEMS resonators with high Q (> 7000) and low motional impedance (RX < 60 Ohms) using high-κ dielectric transducers [1]. Channel-select filters are formed by electrically and mechanically coupling these resonators. Electrical coupling is achieved by routing the electrical signal from successive resonators in a ladder configuration. In a typical ladder filter configuration, the parallel frequency fparallel of the shunt resonator is matched to the series frequency fseries of series resonators, defining the filter center frequency (fc). The filter bandwidth is determined by notches on either side of the passband and is twice the pole-zero separation of the series and shunt resonators. The filter array’s frequency characteristics can achieve the best insertion loss reported to date for contour-mode MEMS filters [2,3].

Presently the OxideMEMS Lab is fabricating new resonators with frequencies up to 3.5 GHz and developing a voltage tuning scheme to dynamically tune the filter center frequency and bandwidth for channel agility.

References:

Channel-Select RF MEMS Filters

CNF Project # 1380-05
Principal Investigator: Sunil Bhave
Users: Hengky Chandrahalim, Dana Weinstein, Chen Chen, Lih Feng Cheow

Affiliation: Electrical and Computer Engineering, Cornell University
Primary Funding: Cornell Center for Nanoscale Systems
Contact: sunil@ece.cornell.edu, hc287@cornell.edu, dw222@cornell.edu, cc458@cornell.edu, lc259@cornell.edu
Web Site: http://mems.ece.cornell.edu

Figure 1, top left: SEM of a hafnium dioxide-on-silicon fully released bar resonator.

Figure 2, bottom left: SEM of an array of ladder configuration electrically-coupled thickness shear filters.

Figure 3, above: SEM of 804 MHz thickness shear-mode arc array filter.

Figure 1, top left: SEM of a hafnium dioxide-on-silicon fully released bar resonator.

Figure 2, bottom left: SEM of an array of ladder configuration electrically-coupled thickness shear filters.

Figure 3, above: SEM of 804 MHz thickness shear-mode arc array filter.