Experimental overtone modulation by adding external frequency in the oscillating loop of laterally coupled HBAR

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For RF applications a high quality factor (Q) resonator is essential to obtain a low phase noise of oscillator. HBAR resonators exhibit one of the highest quality factor (Q) among the existing piezoelectric resonators. Nevertheless, the effective selection of one of its multi overtones is challenging to develop HBAR oscillators. W. Pang *et al.* use FBAR filter to select one overtone[1]. It is also possible to filter HBAR overtone with SAW filter, but the commercial SAW band-pass filter are not dedicated to this use and present bandwidths too wide to select just one overtone. So, the oscillator starts to one of the overtones in an uncontrolled manner due to initial conditions. In this work, we present an innovative principle for selecting the desired oscillator operating frequency among the consecutive overtones (n-1), (n), (n+1) by adding in the oscillating loop a reference frequency (f_i).

We fabricated a laterally coupled HBAR resonator on composite structure as Fig 1(a). This resonator exhibits a Qxf product of 8.13×10^{12} (*e.g.* Q=6,876 at $f_{n-1}\approx1.1828$GHz), CTF≈-5ppm/K and 0.5mm^3 of size. Its overtone separation is Δf≈3.3MHz. In the Fig 1(b), the series connection between HBAR and SAW filters with 40MHz bandwidth (GSRF TA0582F). On Fig 1(c), the oscillator start operating with unwanted overtone (n) at ν_n=1.186GHz. By adding in the loop a frequency (f_i) as Fig 1(d), we can switch the oscillator operating frequency ν with f_i near f_{n-1} or f_{n+1} ,which correspond to overtone (n-1) or (n+1) respectively. This oscillator frequency stays fixe and stable when added frequency (f_i) is removed from the loop. Additionally, measurement of this HBAR oscillator operating at ν_{n-1}=1.1828GHz exhibits a phase noise of -140dBc/Hz at 10kHz from carrier.

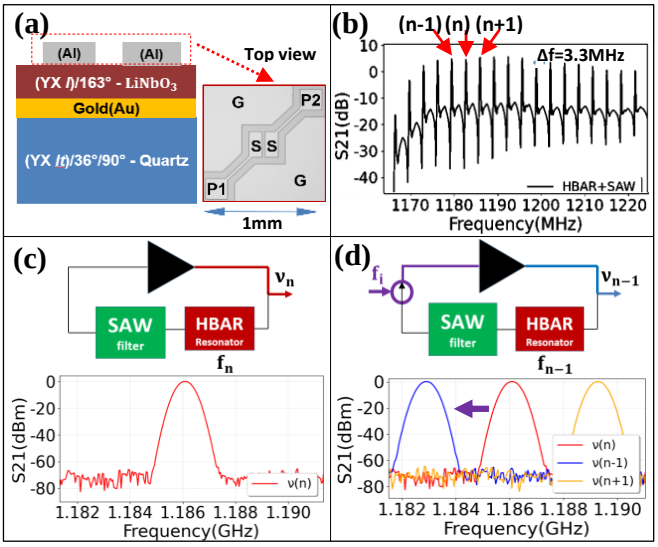

Fig 1: (a) Material stacks and top electrode parameters (P1: port one, P2: Port two, S: signal "effective electrode surface" and G: ground). (b) Electrical response of series HBAR+SAW. (c) Initial operating frequency of HBAR oscillator (ν_n). (d) Modulation loop to switch (ν_n) at (ν_{n+1}) or (ν_{n-1}) by (f_i).

In conclusion, this work shows a principle which allows us to choose the pulsation (ν_{n+1}), (ν_n) or (ν_{n-1}) of the oscillator produced with an HBAR. Ongoing work to increase the harmonic number excursion and phase noise improvement will also be presented.

[1] W. Pang et *al*, "High Q Single-Mode High-Tone Bulk Acoustic Resonator Integrated With Surface-Micromachined FBAR Filter", IEEE 2005. doi:10.1109/MTT67880.2005.9387931