Improvement of spurious modes suppression for YBAR resonators using piston mode design

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With the development of wireless communications, the new communication standards are evolving towards higher frequencies and larger bandwidths while keeping small footprints for the filters. Thin-film lithium niobate (LN) resonators like YBAR resonators have been recently presented as a very promising solution for 5G-sub 6GHz filters due to very high coupling (k^2)[1].

YBAR resonators are FBAR-type resonators using a suspended LN membrane sandwiched between IDTs on the top surface and a bottom floating electrode. A vertical electric field excites a shear-horizontal mode SH_1 with a resonance frequency dictated by the piezoelectric thickness. The main resonance mode is accompanied by lateral higher order spurious modes that appear in the bandwidth and that deteriorate the response of the resonator. The current solution used to suppress them is to partially etch the LN membrane between the IDTs to confine the main mode and hinder the propagation of the transverse modes. While this solution is quite efficient, the suppression is not complete and might also affect the main mode.

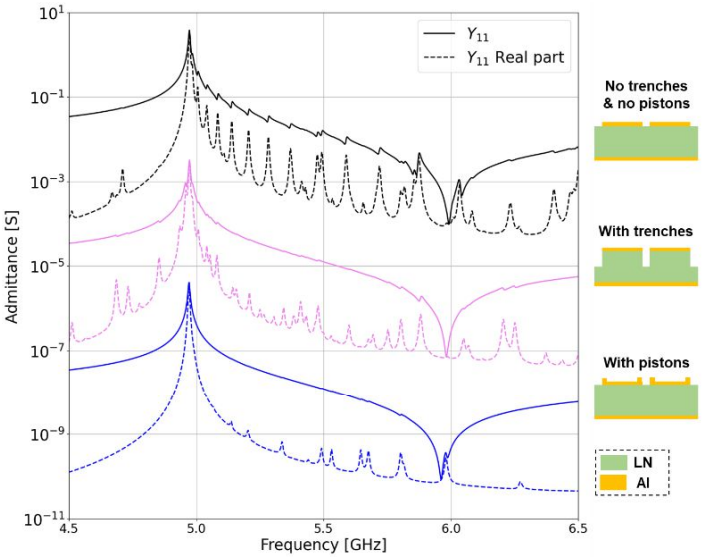

Fig. 1: Simulated admittance curves for YBAR resonators without trenches nor pistons, with trenches only and with pistons only. Pink and blue curves shifted down vertically for clarity.

In this work, we are applying a spurious mode suppression technique presented for FBARs[2] and exploited for other resonator types like SH_0. Without additional features, the IDT boundary conditions allow more than one mode to couple with the vertical electric field, leading to the appearance of spurious modes. In order to suppress them, an intermediate region is modified between the active area and the outside area by creating a border region. The border width is tuned using dispersion curves of the 3 regions so that only the main mode is coupled to the electric field. FEM simulations were performed and results visible on Fig.1 show improvement of spurious mode removal using 50nm thick and 100nm wide Al pistons on top of 75nm Al IDTs.

Resonance frequency region is now spurious free and remaining modes could be suppressed entirely by even finer tuning or by complementary features that need to be studied. YBARs using pistons are now being fabricated to verify the theory and simulations results.

[1] Yandrapalli, S., et al. , Journal of Microelectromechanical Systems (2023).

2 Kaitila, J., et al. , IEEE Symposium on Ultrasonics, 2003. Vol. 1. IEEE, 2003.