C-Band Lithium Niobate MEMS Filter with 10% Fractional Bandwidth for 5G Front-Ends

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Background, Motivation, and Objective

As 5G promises to open new horizons for paradigm-shifting applications, miniature wideband filters in C-band (4-8 GHz) are one of the outstanding challenges in front-end. Currently, the commercial solutions for 4G front-ends are surface acoustic wave (SAW) resonators and thin-film bulk acoustic wave (FBAW) resonators. However, they are limited in the fractional bandwidth (FBW<4%) due to their moderate electromechanical coupling (k_t^2<8%), are thus insufficient to meet several allocated 5G C-bands with more than 4% FBW in an acoustic-only approach. $LiNbO_3$ first-order antisymmetric (A1) Lamb wave mode resonators have recently been studied as a compelling solution for C-band wideband filters due to their high k_t^2 (>20%). This work focuses on the first-time demonstration of $LiNbO_3$ MEMS filters based on A1 mode with 10% FBW.

Statement of Contribution/Methods

This work exploits the A1 mode in single-crystal Z-cut $LiNbO_3$ thin films (t=500 nm) with well-rationalized spurious suppression techniques and multi-frequency monolithic implementation. As shown in the inset of Fig. 1(A), the A1 mode is efficiently excited in a Z-cut $LiNbO_3$ thin film with top-only interdigital transducers (IDTs), and the spurious modes are mitigated based on the optimization of the E-field. With the optimized resonators, a simple ladder topology consisting of series and shunt resonators is adopted for the filter demonstrations. To achieve intended large bandwidth, the required frequency offset between series and shunt resonators is attained by varying the electrode separation (G) as suggested by the dispersion of the A1 mode. To attain an adequate C_0 for matching to 50 Ω, the numbers and lengths of electrodes are adjusted respectively for series and shunt resonators.

Results/Discussion

To validate our design, the devices were fabricated on a 500 nm thick Z-cut $LiNbO_3$ thin film. The fabricated standalone A1 resonator shows a k_t^2 of 28% and a Q of 430 [Fig. 1(A)]. The fabricated ladder filter [Fig. 1(B)], based on one series resonator and four shunt resonators, exhibits a compact footprint of 0.36 mm^2, a center frequency of 4.5 GHz, a large FBW of 10%, a small insertion loss (IL) of 1.7 dB, and a spurious-free in-band response [Fig. 1(C)]. This work marks the largest demonstrated FBW for acoustic-only filters at 5G frequencies.

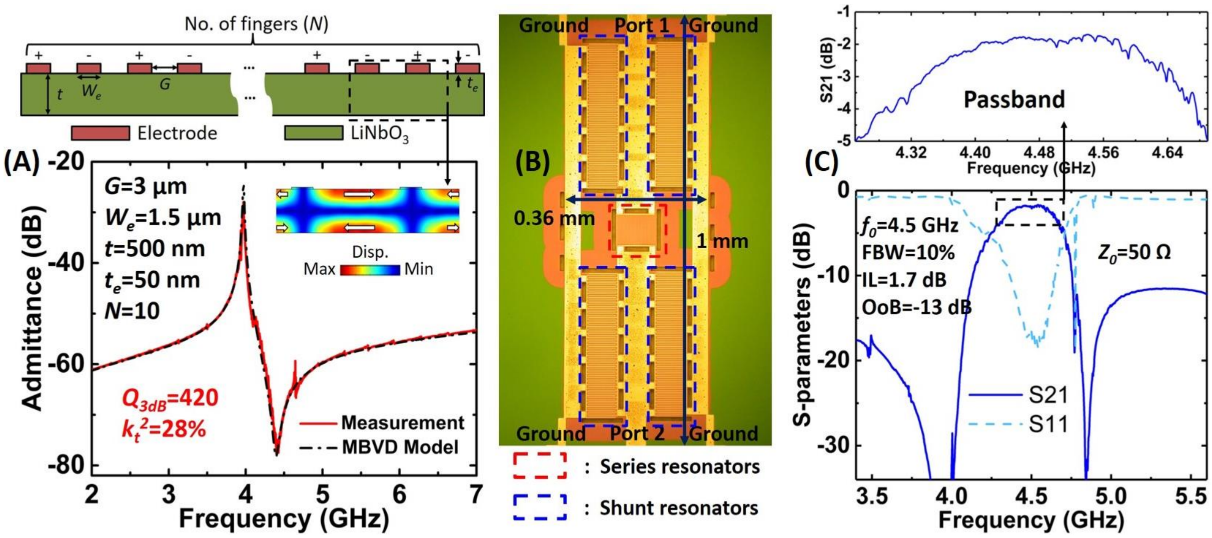

Fig. 1. (A) Measured performance of the fabricated A1 resonator with the configuration and displacement mode shape. (B) Optical microscope image of the fabricated filter. (C) Measured performance of the fabricated filter with zoomed-in response of the intended passband.