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Broadband Piston Mode Applied in A_1 Lamb Mode Solidly Mounted Resonator

SMR 構造 A_1 モードラム波共振器の広帯域ピストンモード動作

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1. Introduction

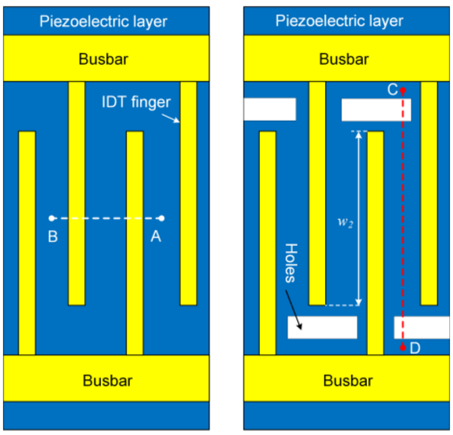
Recently, A_1 Lamb mode resonators using $LiNbO_3$ (LN) thin plates are paid much attention as a possible solution to develop extremely wideband filters in the SHF range[1].

Suppression of transverse mode resonances is one of the most urgent research targets in this kind of devices. Wong, et al., pointed out[2] that when the rotated Y-cut LN is employed, transverse mode resonances and lateral energy leakage can be suppressed well by placing release windows (via holes) placed near electrode tips. This is due to the fact that free edges (X plane of LN) serve as mechanically free boundaries for SH waves, and are ideal for the piston mode operation[3].

This paper discusses applicability of this technology named broadband pistion mode (BPM) operation to the A_1 mode resonators with the solidly mounted resonator (SMR) topology[4]. The SMR structure is more preferable than the free-standing one from its mechanical strength and heat transfer.

2. Device configuration used for the analysis

Fig. 1(a) shows the top view of the A_1 Lamb mode resonator used for the 3D FEM analysis. This



(a) standard (b) BPM

Fig. 1 Top view of A_1 Lamb mode resonator.

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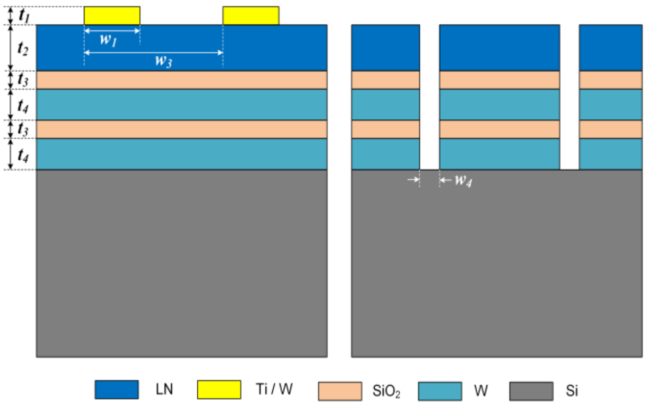
structure is assumed to be aligned periodically. 128° YX-LN is chosen as the piezoelectric layer where the LN X-axis is aligned to the electrode length direction. On the other hand, Ti/Al is used as electrodes.

Fig. 2(a) shows its cross-sectional view, where SiO_2 and W are chosen as low and impedance layers, respectively.



(a) standard (A-B) (b) BPM (C-D)

Fig. 2 Cross sectional view of A_1 Lamb mode resonators shown in Fig. 1.

Fig. 1(b) and **Fig. 2(b)** shows top and cross-sectional views of the resonator for the BPM operation. Trenches are placed near the electrode tips, and serve as mechanically free boundaries for obliquely propagating SH modes although the trenches are disconnected under the electrodes.

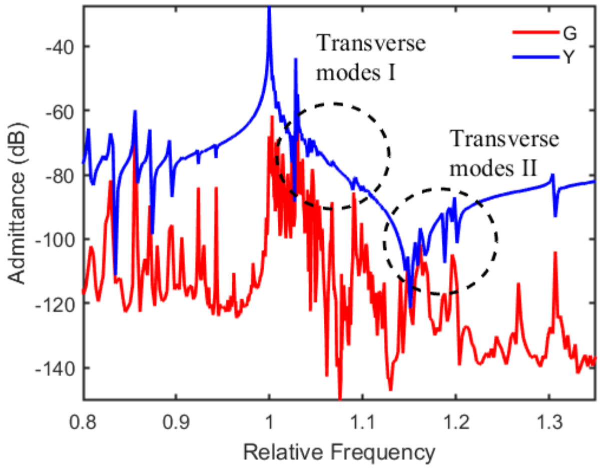
Table 1 shows structural parameters used for the following simulation, where " *t* " and " *w* " mean thickness and width, respectively.

Table. 1 Structural parameters used in the simulation

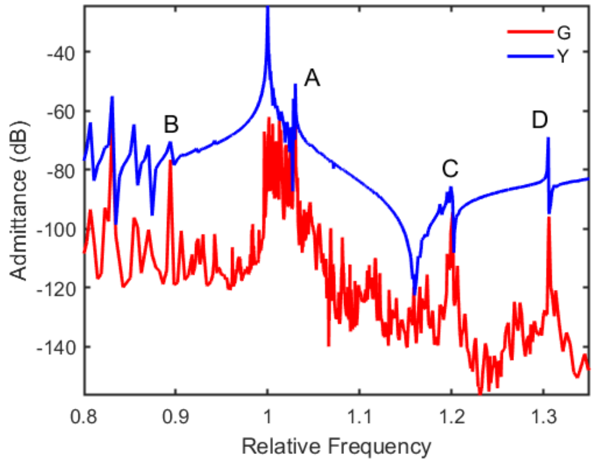
t_1 (Ti/W)	10nm/10nm	w_1 (Ti/W)	1.5μm
t_2 (LN)	480 nm	w_2 (aperture)	36 μm
t_3 (SiO_2)	245 nm	w_3 (pitch)	6 μm
t_4 (W)	465 nm	w_4 (holes)	3 μm

3. BPM effects in SMR

Fig. 3(a) shows calculated input admittance Y and conductance G of the IDT per period of the standard structure shown in **Figs. 1(a)** and **2(a)**. Strong ripples are seen near the main resonance, which are due to the transverse mode resonances. Increase in G is seen near the anti-resonance. This is mainly due to the lateral leakage to the busbar regions.



(a) standard



(b) BPM

Fig. 3 calculated input admittance Y and conductance G per IDT period.

Fig. 3(b) show calculated Y and G for the BPM structure shown in **Figs. 1(b)** and **2(b)**. Comparison of this figure with **Fig. 3(a)** reveals impact of the BPM clearly. Namely, transverse mode resonances lateral wave leakage are well suppressed. However, relatively strong resonances remain near the main resonance even after BPM is applied.

Fig. 4 shows calculated Bode Q[5]. It is seen that the Q value near the anti-resonance is improved significantly by the BPM. However, the Q value just above the main resonance is not enhanced by the spurious resonances described above.

From the field distribution, peaks A and C are caused by longitudinal waves propagating along the IDT direction while the peak B and D are due to the leaky and higher order of A_1 modes, respectively.

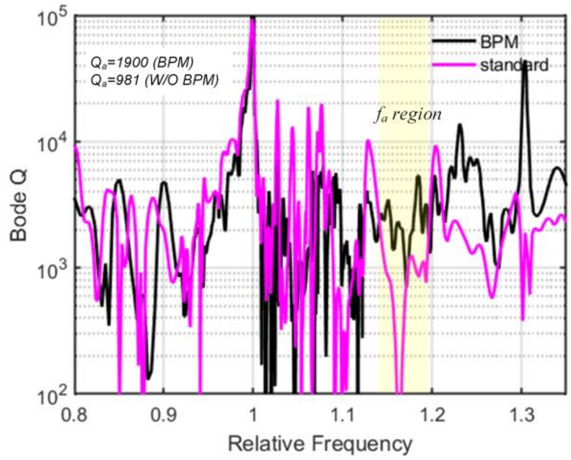


Fig. 4 Calculated Bode Q.

For comparison, **Fig. 5** shows calculated Y of the free-standing A_1 Lamb mode resonator. In this case, most of all spurious resonances can be suppressed well by the use of BPM operation. Thus we expect further suppression is possible by setting structural parameters properly.

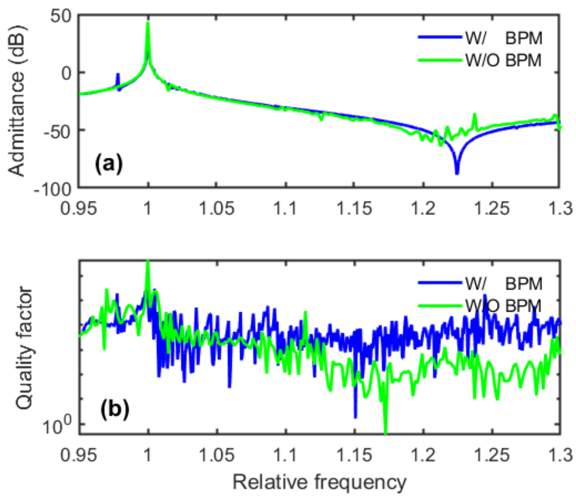


Fig. 5 BPM applied in free-standing structure while the aperture width is 3λ. Pure Aluminum is used as electrodes with optimization.

Acknowledgment
This work was financially supported by the grant from the National Natural Science Foundation of China and the China Academy of Engineering Physics Grant (Project No.U1430102)

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