1P3-4

Application of lossy overlay to for spurious suppression of I.H.P. SAW resonators with double busbar configuration

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1. Introduction

Nowadays, I.H.P. SAW resonators have become one of the hottest research topics due to its low TCF and high *Q* factor[1)].

The multi-layered structure enhances energy confinement significantly to the thickness direction[1)]. As for the lateral direction, the authors' group proposed the double busbar configuration to suppress energy leakage through busbar and further improve *Q*[2)]. Moreover, it indicates that complete transverse mode suppression can be realized by flattening SAW slowness shape with assistance of piston mode design[3)].

Although double busbar structure provides better lateral energy confinement, it can generate a strong spurious resonance (gap mode) near the anti-resonance frequency (f_a)[4)]. This is due to difference in electrode periodicity at the gap and IDT finger regions, which causes SAW scattering in-plane and/or into the substrate through the Bragg scattering of incident SAW to bulk waves[5)].

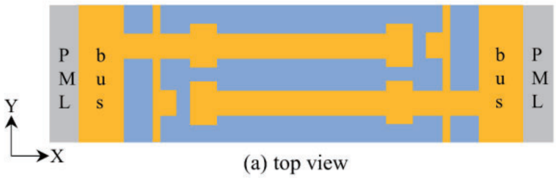
This paper discusses behaviors of gap mode in I.H.P. SAW resonators with double busbar configuration in detail and proposes application of a lossy overlay to the busbar region for mitigation of the gap mode response. Impact of structural parameters are studied and compared using periodic 3D FEM simulations.

2. Performance of I.H.P. SAW with double busbar configuration

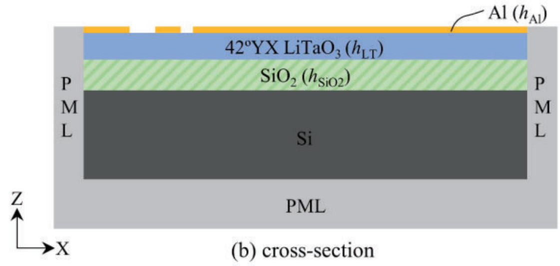
Figs. 1(a) and (b) show from top and side views, respectively, of the unit cell for the FEM analysis of double busbar configuration on the layered structure of Al/42°YX LiTaO$_3$/SiO$_2$/Si. The structural parameters are the same as those given in Ref. 6.

Fig. 2(a) shows calculated admittance (|*Y*|), conductance (*G*) and Bode *Q*[6)] of the designed double busbar structure. Although complete transverse mode suppression and high *Q* are achieved simultaneously, the gap mode can be seen near f_a, which generates a deep notch in the Bode *Q* curve (see the dashed line region).

Fig. 2(b) shows the field distribution near the finger edge region at this peak frequency.



(a) top view



(b) cross-section

Fig.1 Unit cell of I.H.P. SAW resonator with double busbar configuration: (a) top view; (b) cross-section.

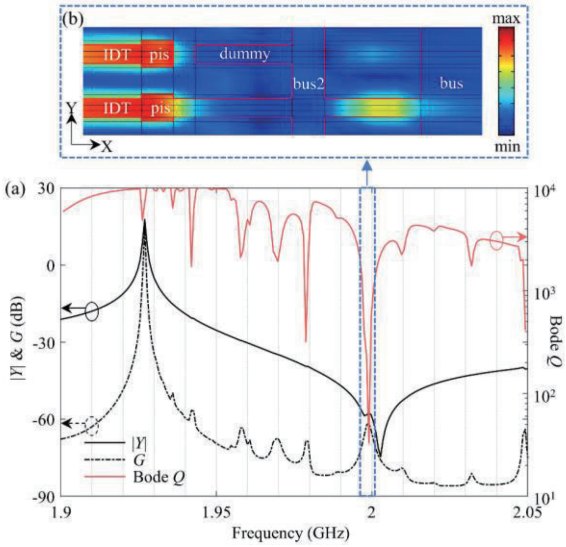


Fig.2 Calculated admittance (|*Y*|), conductance(*G*) and Bode *Q* of double busbar structure.

Strong vibration can be seen near the secondary gap and is origin of the gap mode. The author's group has proposed a mitigation technique for this gap mode to deposit relative thick (2~3 μm) Al on the top of busbar as the second metal layer (M2). It can decrease *Q* factor of the gap mode while gives no impact to the main mode. However, the M2

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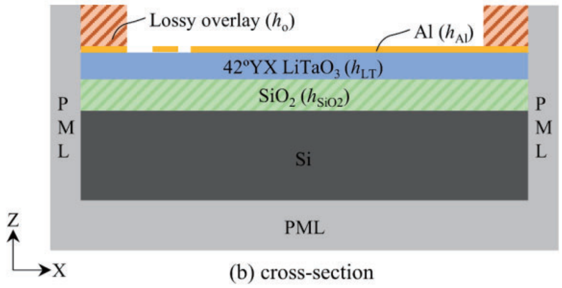
layer is required to cover the M1 layer from the secondary gap edges in this design. Thus, this technique
requires alignment accuracy between the M1 and M2 layers, which may be troublesome for mass fabrication.

3. Application of lossy overlay for spurious mitigation

Here we propose use of a lossy overlay instead of M2 layer. Photo-sensitive polymers seem appropriate for the use. Here we choose PMMA (polymethyl methacrylate) as the material for the following FEM simulation.

Fig. 3 shows the unit cell of double busbar structure with lossy overlay. It is known that the viscosity is the dominant loss factor in the material. Thus, its impact will be investigated by adjusting its viscosity.

(a) top view



(b) cross-section

Fig. 3 Unit cell of double busbar structure with lossy layer: (a) top view; (b) cross-section.

Fig. 4 shows the variation of resonator performance ($|Y|$ and G) with viscosity of lossy overlay when the overlay thickness h_o is 2 μm. It is seen that larger viscosity makes the gap mode response weaker in the admittance curve. However, larger viscosity also causes performance around f_a worse, namely, large viscosity causes severe Q reduction. This is because large viscosity causes large reflection instead of absorption. Therefore, viscosity in the range of 10 cp~1000 cp seems appropriate for the purpose.

Note that variation of h_o from 0.5 μm to 3 μm gives negligible impact on this spurious mitigation. This means that the gap mode can not penetrate in deep in the lossy overlay and is absorbed mainly near its bottom surface. In addition, high accuracy is not necessary for alignment between busbars and lossy overlay. These features are quite advantageous for application of this technique to mass production.

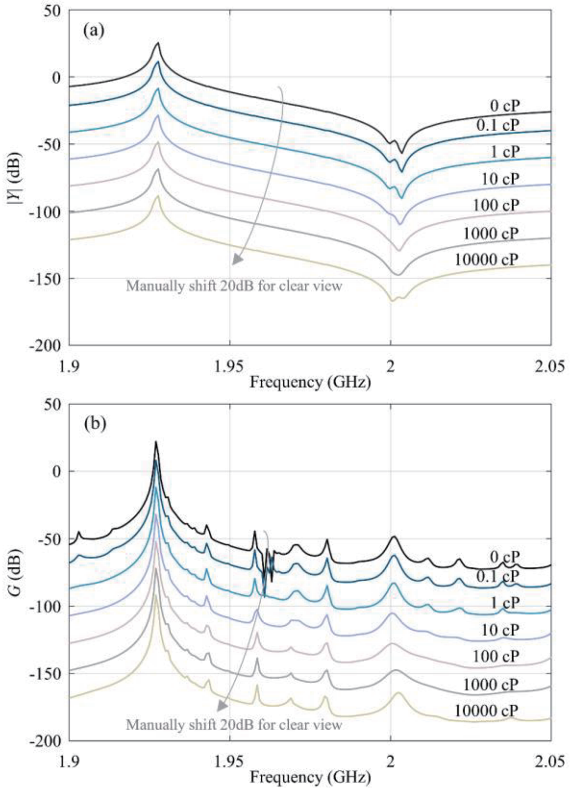


Fig. 4 Variations of $|Y|$ and G with viscosity of lossy overlay.

4. Conclusion

This paper discussed behaviors of gap mode in I.H.P. SAW resonators with double busbar configuration in detail and proposed application of a lossy overlay to the busbar region for mitigation of the gap mode response.

It was shown that lossy overlay can effectively mitigate gap mode in the adequate range of viscosity and the layer thickness.

Acknowledgment

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