2Pa3-2

Influence of Phase Shifter Location to Piston Mode Operation of TC-SAW Using SiO_2/LN Structure

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1. Introduction

SiO_2 is widely used for temperature compensation (TC) of surface acoustic wave devices (SAWs) using highly piezoelectric substrate such as $LiNbO_3$ (LN) [1][2]. In this configuration, a design challange is to suppress lateral spurious modes without sacrificing main resonance performances.

Piston mode structures have been studied extensively for the purpose[3][4]. When SiO_2 is deposited on the interdigital transducer (IDT), the SiO_2 top surface can be used for placing phase shifters[5] necessary for the piston mode operation. In general, the phase shifters are given to the ends of IDT aperture similar to the traditional piston mode design. Although they can be designed more freely, detailed discussions have not been reported yet.

This paper discusses influence of location of the phase shifters to the device performances.

2. Phase shifter operation

Fig. 1 shows the device configuration used for the Periodic 3D FEM simulation. Periodic boundary conditions were applied for the side surfaces while the perfect matching layer (PML) was given to the bottom surface to avoid unnecessary reflections. All material parameters were taken from the COMSOL® material library. No material loss was added for the simulation. The LN rotation angle θ was set at 131° so as to suppress the SH SAW response.

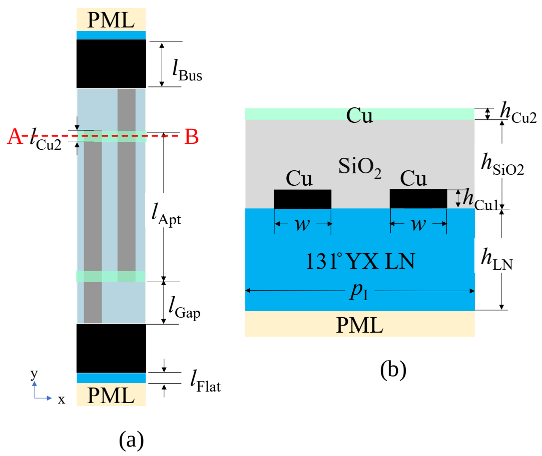

Fig.1 Periodic 3D model for TC-SAW device. (a) top view, and (b) cross-sectional view along A to B in Fig. 1 (a).

Employed structural parameters are given in Table 1.

Table. 1 Employed structural parameters

h_{SiO2}	570 nm	p_I	1.9 μm
h_{Cu1}	95 nm	w	475 nm
h_{LN}	10 μm	l_{Flat}	2 μm
l_{Apt}	32 μm	l_{Bus}	6 μm
l_{Gap}	1.9 μm	h_{Cu2}	76 nm

Fig. 2 shows calculated admittance $|Y|$ and admittance G when the phase shifters (Cu overlay) are given just inside of the IDT aperture ends on the SiO_2 top surface (see Fig. 3(a)). In this calculation, l_{Cu2} is set at $0.1p_I$ for the best suppression of transverse modes. Fig. 4 shows Y and G when the phase shifters are not given. Comparison of the figures clearly indicates that the designed phase shifters are effective to suppress transverse mode resonances.

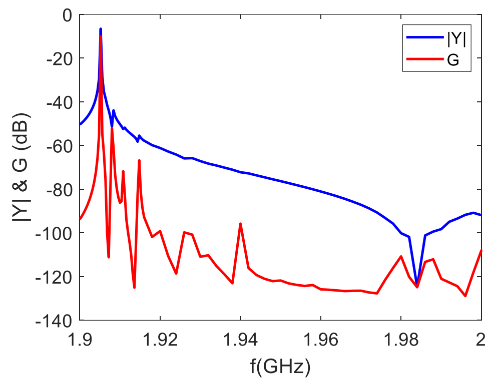

Fig.2 Calculated Admittance $|Y|$ and conductance G when phase shifters are given just inside of the aperture region.

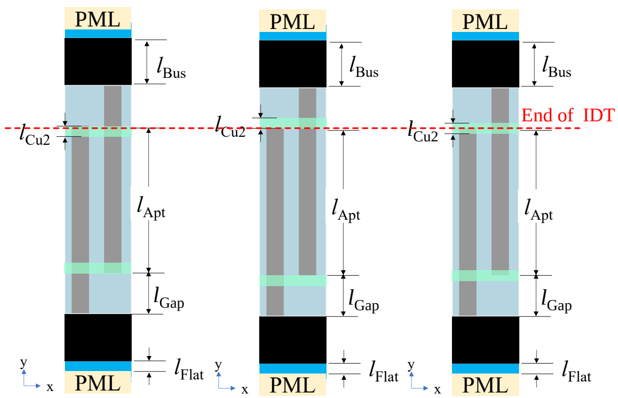

Fig. 3 Three phase shifter locations. The red dotted line represents the IDT aperture end.

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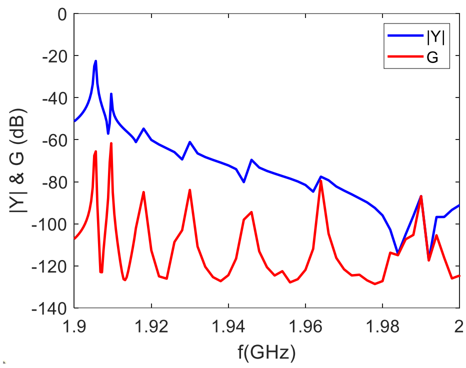

Fig.4 Calculated Admittance $|Y|$ and conductance G when phase shifters are not given.

Fig. 5 compares the Bode Q[6] of these two designs. It is seen that adding the phase shifters degrades Q only near the resonance. However, the degradation is not important because influence of the electrode ohmic resistance is more severe near the resonance.

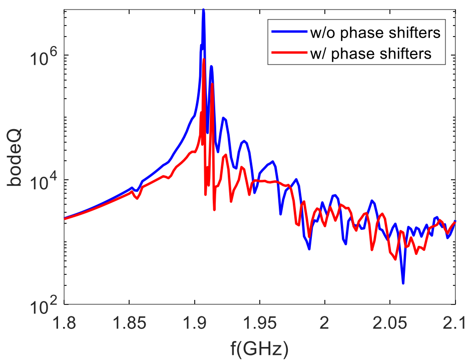

Fig.5 Variation of Bode Q with and without phase shifters.

3. Influence of Position of Phase shifters

Here other two designs shown in Fig. 5(b) and (c) are examined, where the phase shifters are placed (b) just outside of the aperture, and (c) to overlap half of the phase shifters to the electrodes.

Fig. 6 shows calculated $|Y|$ and G when the phase shifters are placed just outside of the aperture region. In this case, l_{Cu2}=0.12p_I for the best suppression of transverse modes. This design also offers good transverse mode suppression comparable to the design (a). Although transverse mode resonances near the main resonance seem a little stronger than those in the design (a), more detailed comparison is necessary.

Fig. 7 shows calculated $|Y|$ and G when half of the phase shifters overlaps to the electrodes. In this case, l_{Cu2}=0.12p_I for the best suppression of transverse modes. This design gives the best transverse mode suppression among three. However, loss increase may be its reason. This is expected from the fact that the resonance Q of this design seems to be worse than the others.

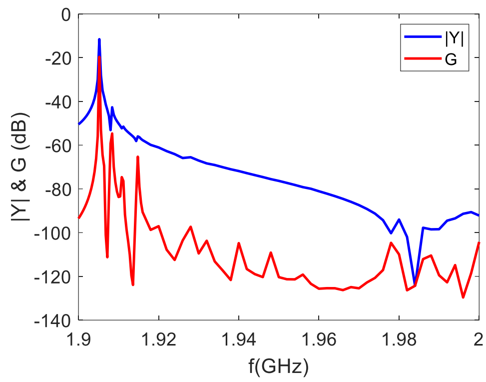

Fig.6 Calculated Admittance $|Y|$ and conductance G when phase shifters are given just outside of the aperture region.

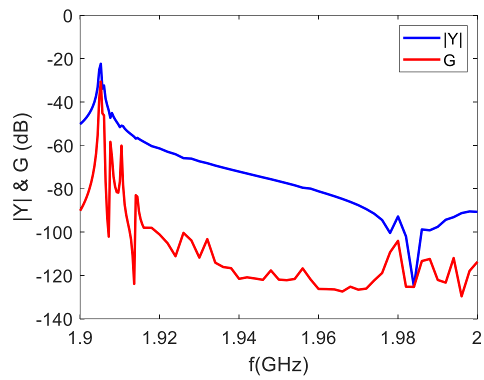

Fig.7 Calculated Admittance $|Y|$ and conductance G when half of the phase shifters overlaps to the electrodes.

4. Conclusion

This paper influence of location of the phase shifters was discussed. It was shown that under proper design, location does not give apparent differences in achievable performances. This means that patterning of the phase shifters may offer interesting features without degrading the other performances.

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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