1P3-8

Study of Excess Loss Mechanism in TC-SAW Devices Based on FEM Simulation Using Hierarchical Cascading Technique

階層的縦続法を用いた有限要素法解析に基づく TC-SAW デバイスの過剰損失機構に関する検討

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1. Introduction

Surface acostic wave (SAW) devices SiO_2 overcoated 128°YX $LiNbO_3$(128LN) are also widely used in this decade, and are called the tempereture compensated SAW (TC-SAW).[1] Recently SAW devices employing a thin plate bonded to a high velocity substrate such as I.H.P. SAW[2] are paid much attention due to their high perfomance owed to suppressed bulk wave leakage. Although TC-SAW devices using SiO_2 employ non-leaky SAW, reported Q-values are not high as those of I.H.P. SAW.

This paper discusses the excess loss in SiO_2-based TC-SAW theoretically. The simulation is performed by combination of the finite element method (FEM) and hierarchical cascading technique (HCT) [3-5], where additional loss components, i.e. material viscous loss, dielectric loss and electrode ohmic loss, are excluded. Net leakage and/or scattering losses are evaluated toward longitudinal and transverse directions using the 2.5D and 3D periodic FEM, respectively.

2. Losses in longitudinal direction

At first, an infinitely long and infinitely wide inter digital transducer (IDT) structure shown in figure 1 is simulated by the 2.5D FEM. Design parameters are given in table I.

The result is shown in figure 2. Estimated Q is very high and almost flat. In this case, no loss exists theoretically at frequencies below the bulk wave cutoff. Finite Q is due to SAW penetration to the perfect matching layer (PML) region.

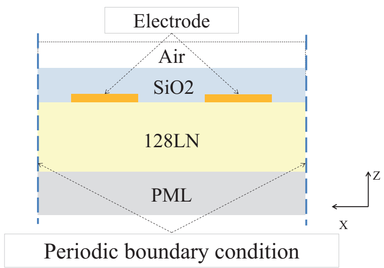

Fig.1. 2.5D Model of periodic TC-SAW structure.

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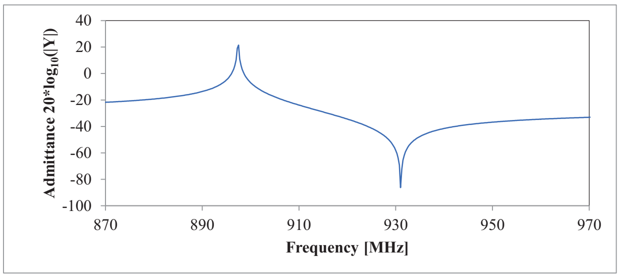
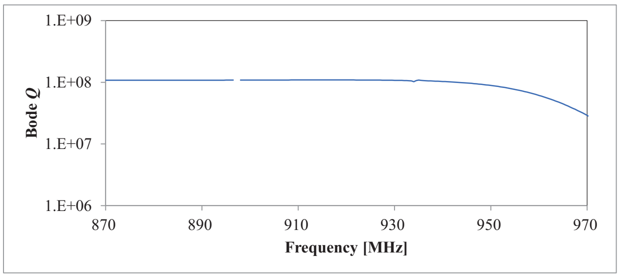
Table I. Design parameters of simulated model

IDT pitch	4 μm
Cu Electrode thickness	260 nm
Metalization ratio	0.5
SiO_2 thickness	1.4 μm



(a) Admittance characteristics.



(b) Bode Q characteristics.

Fig.2. Simulation results for 2.5D TC SAW structure.

Next, an infinitely wide IDT structure with the finite length is simulated by the 2.5D FEM with HCT to study influence of the structural discontinuity in longitudinal direction. The model structure is shown in figure 3, and design parameters are the same as those used for the previous model. The numbers of IDT and reflectors are chosen as 257 and 32, respectively.

Simulation results are shown in figure 4. Although the Q factor is much lower than that shown in figure 2(b), it is still very high. The figure also shows the result when the number of reflectors are increased to 1,024. The Q factor improvement is significant only near the resonance. These results indicate discontinuities in the longitudinal direction does not contribute to the excess loss.

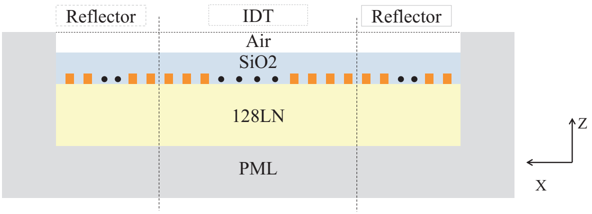
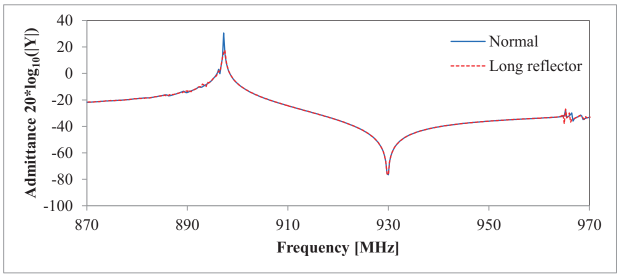
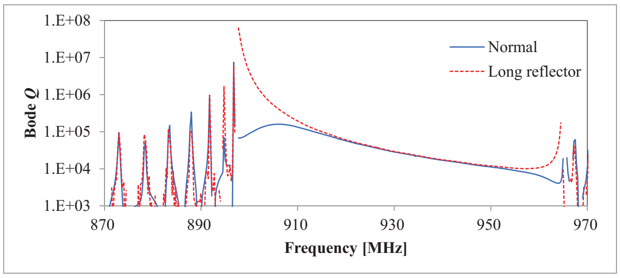


Fig.3. 2.5D Model of SiO_2/128LN TC-SAW synchronous resonator.



(a) Admittance characteristics.

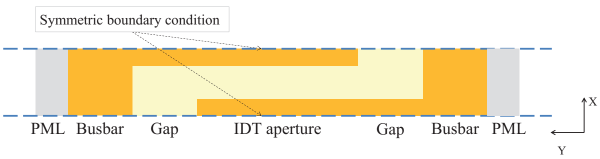


(b) Bode Q characteristics.

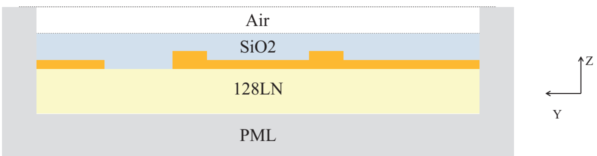
Fig.4. 2.5D simulation results of SiO_2/128LN TC-SAW synchronous resonator.

3. Consideration transverse direction

Next, influence of structural discontinuities to the transverse direction is studied by the 3D periodic FEM with HCT. The model structure is shown in figure 5. Design parameters are the same as those used for the 2.5D FEM model, and the aperture is set at 104.9 μm. Here the piston mode structure shown in figure 5[1] is simulated in addition to the normal one without the slow region at finger edges.



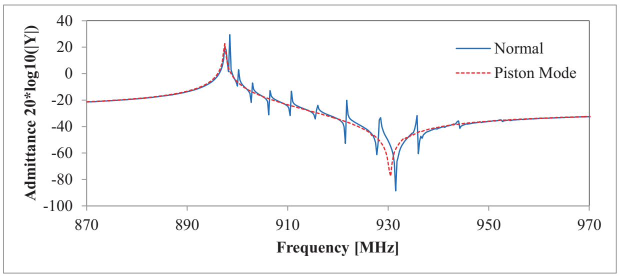
(a) Top view.



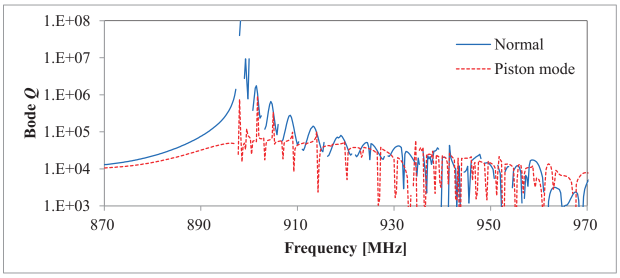
(b) Side view.

Fig.5. 3D Model of periodic SiO_2/128LN TC-SAW resonator

Simulation result is shown in figure 6. It is seen achievable Q in this case is much lower than the 2.5D case. Although the piston mode design reduces the Q factor near the resonance frequency significantly, the Q value is still much higher than the reported one.[1]



(a) Admittance characteristics.



(b) Bode Q characteristics.

Fig.6. 3D simulation results of periodic SiO_2/128LN TC-SAW synchronous resonator.

4. Conclusions

Excess loss mechanism in SiO_2/128LN TC-SAW devices was studied by using 2.5D and 3D periodic FEM with HCT. The results indicated that acoustic losses are extremely small for structural discontinuities concerned in this paper.

The authors will examine impact of discontinuities in bus-bars at boundaries between IDT and reflectors [6].

Acknowledgment

Xinyi Li acknowledges the support of the Japanese Government (MEXT) for the scholarship through the Super Global University Project.

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