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Study of Spurious Response near the fast-shear-wave in the SiO_2/Al/$LiNbO_3$ Structure

SiO_2/Al/$LiNbO_3$ 基板における速い横波近傍に発生する不要応答に関する検討

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1. Introduction

SH mode on SiO_2/Al/$LiNbO_3$ structure is studied because of their sufficient electromechanical coupling factor (K^2) and good temperature coefficient of frequency (TCF)[1-3]. Authors proposed the suppression method of the spurious response of the Rayleigh mode and the transverse mode for the narrow duplex gap application[4-5]. For the narrow duplex gap application, SiO_2 thickness must be increased to achieve the good TCF characteristics. However, another spurious response is appeared near the fist-shear-wave as increasing the SiO_2 thickness. This paper discusses the suppression mechanism of the spurious response near the fast-shear-wave.

2. Analysis of the SiO_2/Al/$LiNbO_3$ structure

First, the spurious response of the SAW resonator on a SiO_2/Al/$LiNbO_3$ structure was analyzed by using FEMSDA[6]. Fig.1 shows the cross-sectional view of the SiO_2/Al/$LiNbO_3$ structure. Fig.2 shows calculated TCF and K^2 characteristics dependance of the SiO_2 thickness H_2 as shown in Fig.1. Here, the cut angle of Y-cut $LiNbO_3$ is 2.5°, and H_1=0.08λ and H_3=0.04λ, metalization ratio is 0.5. TCF is improved by increasing the H_2. Almost zero TCF is achieved near the H_2=0.3λ. Fig.3 shows the calculated admittance characteristics dependance of the SiO_2 thickness H_2. Spurious response is appeared near the frequency corresponding to the fast-shear bulk wave velocity as increasing the SiO_2 thickness. This spurious response affects attenuation characteristics for the filter performance. Fig.4. shows the calculated fielded distribution at the frequency of (a)main mode and (b)spurious mode, respectively. Main mode is SH mode. The spurious mode is higher-order SH mode guided into the SiO_2 layer.

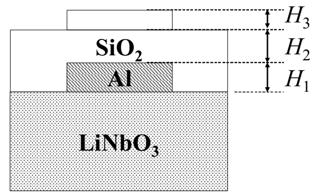

Fig.1. Cross-sectional view of the SiO_2/Al/$LiNbO_3$ structure.

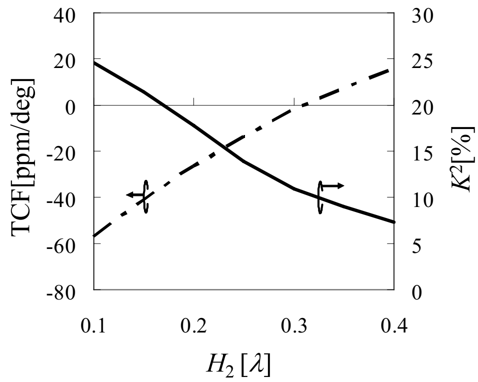

Fig.2. Calculated TCF and K^2 varying the SiO_2 thickness.

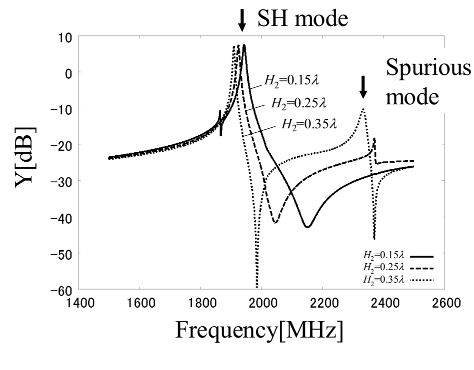

Fig.3. Calculated admittance characteristics dependence of the SiO_2 thickness H_2.

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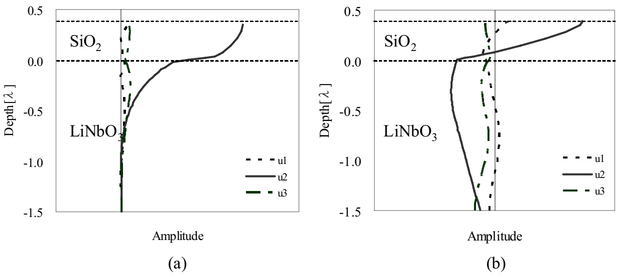

Fig.4. Calculated field distribution of (a)SH mode and (b) Spurious mode.

3. Suppression of the spurious response

In this section, suppression method of the spurious response is discussed. For the suppression, the cut angle of the substate is changed. Here, both parameters rotating cut angle ϕ and propagating angle φ defined on euler angles (ϕ, θ, φ) are changed to consider the PFA (power flow angle) condition. Fig.5 shows the calculated admittance characteristics at (ϕ, θ, φ)= (0, -87.5, 0) and (ϕ, θ, φ)=(6, -87.5, 6). Calculated the fast-shear bulk wave frequencies corresponding to their velocities are also shown in Fig.5. The freqency decreases by changing the cut angle and propagating angle. Spurious response can be suppressed because velocity of the spurious response is faster than that of the fast-shear bulk wave. In these condition, K^2 values of SH mode are almost same. This structure achieved excellent TCF characteristics TCF=-5[ppm/deg] and preferable electromechanical coupling coefficient K^2=9.5[%]. Fig.6 shows the calculated ladder-type filters characteristics. Spurious response affect the filter performance almost suppressed at (ϕ, θ, φ)=(6, -87.5, 6) condition. The spurious response in higher frequency could be suppressed by changing cut angles of the substrate.

4. Conclusions

This paper discussed the suppression of the spurious response near the fast-shear wave. The spurious response is higher-order SH-mode propagating in the SiO_2 layer. Suppression of the fast shear-wave spurious could be achieved without degradation of the SH SAW responses by selecting the crystal cut angle. This technique could be improved the SAW devices performances for the narrow duplex gap application.

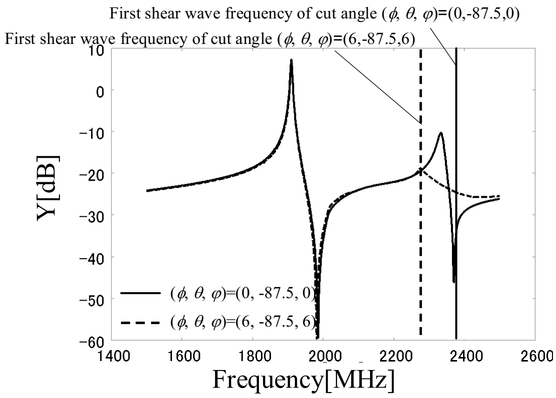

Fig.5. Calculated admittance characteristics.

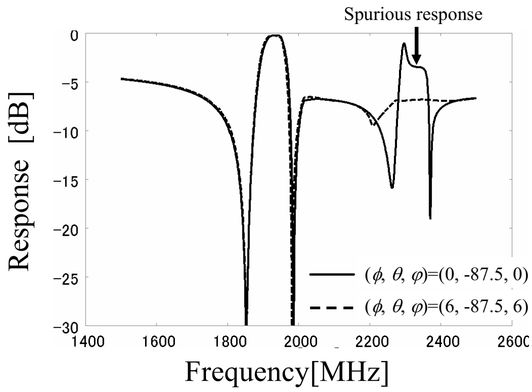

Fig.6. Calculated filter characteristics.

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