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高密度 Cu 溝電極からなる広帯域共振子とその応用

Ultra Wide Band Resonator composed of Grooved Cu-Electrodes and its Application

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A leaky surface acoustic wave on 0-15°YX-$LiNbO_3$ has a large electro-mecahnical coupling factor, but it has a leaky component. In order to change to Love wave without its leaky component, Au or Cu electrode with a low velocity has been used. It was reported that a resonator composed of a Cu-electrode/15°YX-$LiNbO_3$ had wide bandwidth of 12%. This time, authors attempted to fabricate an one-port resonator composed of a grooved Cu-electrode/4°YX-$LiNbO_3$. As the result, it had a wider bandwidth of 17% of 1.3 times and higher resonant and anti-resonant frequencies of 1.3 times than that on Cu electrode on 4°YX-$LiNbO_3$. This resonator was applied to a tunable filter, and the tunable filters having tunable range of 7% in center frequency was realized.

1. Introduction

0-15ºYX-$LiNbO_3$ substrates for surface acoustic wave (SAW) have a large electromechanical coupling factor[1)]. A leaky SAW on them has a leaky component, so Au and Cu electrodes with low velocity have been used to eliminate the leaky component[2)-4)]. A resonator composed of Cu-electrode/15ºYX-$LiNbO_3$ having a wide bandwidth of 12% was reported[2)]. This time, authors attempted to realize a wider band resonator using a grooved Cu-electrode/substrate. The resonators composed of same grooved-Al-electrodes thickness as the depth of the grooves and about 1/4 Al-electrodes thickness of that depth were reported as the SAW devices using the grooved electrode[5-7)]. But they didn't have the wider bandwidth than reference [1] and report Love wave on $LiNbO_3$. This time, the authors fabricated a conventional Cu-electrode/4°YX-$LiNbO_3$ and a grooved Cu-electrode/one. The resonator having wider bandwidth of 17% of 1.3 times and higher frequencies of resonance and anti-resonance of 1.3 times than ones of the former was realized.

2. Calculated Stopband and Coupling Factor

Figures 1 and 2 show stopband frequencies on the Cu-electrodes/4°YX-$LiNbO_3$ and the grooved Cu-electrodes/one as a function of Cu-electrode thickness. The metalization ratio of interdigital transducer (IDT) is 0.5. They were calculated by FEM. In the former, an upper stopband frequency of open grating electrodes is equal to that of short grating. Lower stopband frequencies of open and short grating correspond to resonant and anti-resonant frequencies, respectively. On the other hand, in the latter, a lower stopband frequency of the open grating is equal to a upper one of the short grating. An upper one of open grating and a lower one of short grating correspond to resonant and anti-resonant frequencies, respectively. Compared with the latter, the former velocity and frequency greatly decrease to the Cu-electrode thickness and the former resonant and anti-resonant frequencies are very low at same Cu thickness. A spurious response due to the stopband corresponding to anti-resonant frequency

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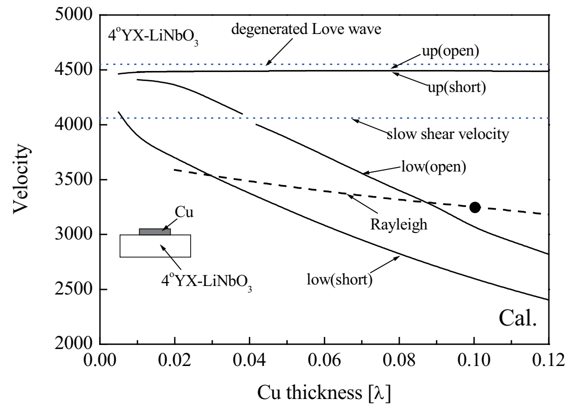

Fig.1 Stop band on Cu-IDT/4°YX-$LiNbO_3$

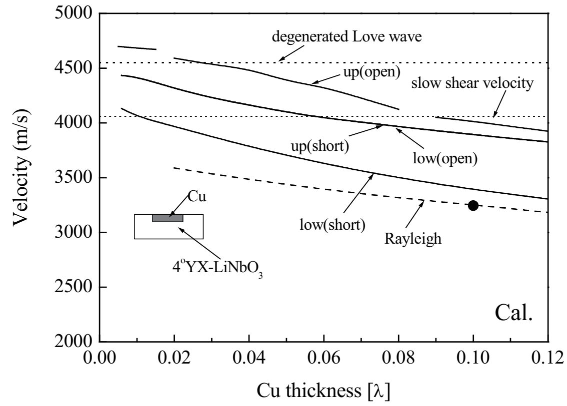

Fig. 2　Stop band on grooved Cu-IDT/4°YX-$LiNbO_3$

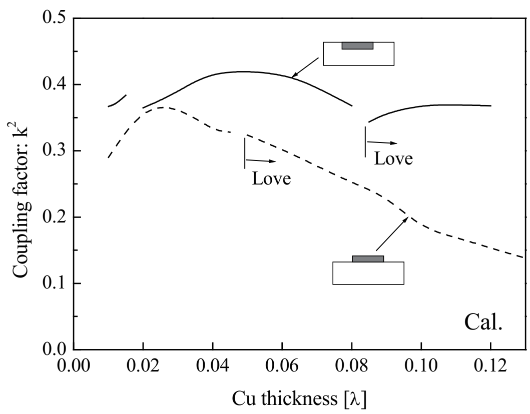

Fig.3 Electro-mechanical coupling factor on Cu-IDT and Grooved Cu-IDT/4°YX-$LiNbO_3$

is not generated in the range of Cu thickness that this stopband frequency is lower than a slow bulk velocity, that is, thicker than 0.04 λ in the former and 0.09 λ in the latter. Fig.3 shows their coupling factor on the Cu thickness. The latter has larger coupling factor than the former.

3. Characteristics of two kinds of Structures

Figures 4(a) and (b) show side views of the Cu-electrodes and the grooved Cu-electrodes/4°YX-$LiNbO_3$. The Cu electrodes were deposited into the grooves by a vacuum evaporator, after the grooves on a substrate were fabricated by a dry etcher. They have a same Cu-IDT apodized by a diamond shape electrode and same Cu-reflectors. They consist of metalization ratio=0.5, wavelength =2.044μm, Cu thickness=0.1λ, apeature=15.8λ, finger pair=120, and each reflector finger=20. Fig. 5 shows their frequency characteristics. The latter's resonant and anti-resonant frequencies are 1.63 GHz and 1.9GHz, which are 1.3 times higher than former's ones of 1.28GHz and 1.45GHz, respectively. Though the former spurious due to Rayleigh wave is higher than the anti-resonant frequency, the latter one lower than resonant frequency as shown in Fig.5. When the Cu-electrode is thinned, the former spurious is largely generated in the band between the resonance and anti-resonance, but the latter one ia always generated lower than the resonance. The latter bandwidth is very wide as 17 % compared with the former bandwidth of 13 %.

These results show the same result as the calculated results in Figs.1, 2 and 3. Thus, the grooved Cu-electrode structure is suitable to construct SAW devices required wideband and high frequency.

Fig.4 Side views of (a)Cu-IDT/$LiNbO_3$ and (b) grooved Cu-IDT/$LiNbO_3$.

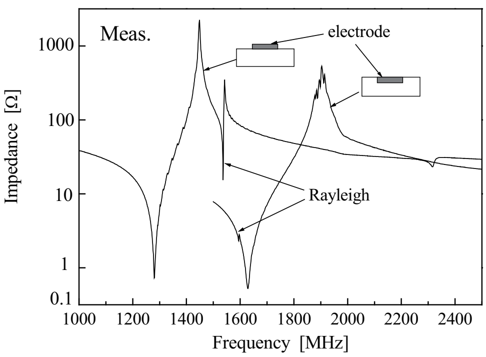

Fig.5 Frequency characteristics of resonators composed of (a) and (b) structures in Fig.4.

4. Application to Tunable Filter

Q of inductance component SAW resonator is larger than one of a conventional coil. The authors attempted to construct a tunable filter at the circuit shown in Fig.6 by using the SAW resonator. Center frequency is tuned in the range of 7 % from 1.73GHz to 1.86GHz as shown in Fig.7 by adjusting the capacitance of C2 and CP in Fig.6. It is considered that a wider tunable range could be obtained by optimizing a circuit or its electrical parts.

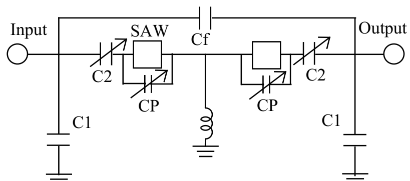

Fig.6 Circuit for tunable filter.

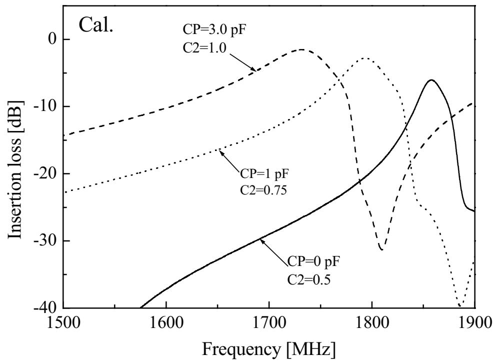

Fig.7 Frequency characteristics of tunable filters.

5. Conclusion

The SAW resonator composed of the grooved Cu-electrode/4°YX-$LiNbO_3$ was fabricated. This resonator had resonant frequency (1.63GHz) and anti-resonant one (1.9GHz) of 1.3 times higher and bandwidth of 17 % of 1.3 times wider compared with the Cu-electrode/substrate. Moreover, the tunable filter with tunable width of 7 % was obtained by applying this resonator to our proposed circuit.

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