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Enhanced characteristics of SAW filter with SiO_2 thin film
Si02 膜を用いた SAW ﾌｨﾙﾀの高性能化

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1. Introduction

We have studied a method to improve and enhance the characteristic of SAW filter by using SiO2. There are some operation bands for FDD/CDMA system on the universal mobile telecommunication system (UMTS). So, the SAW filter which has become widely used as one of a key device used in cellular phone is required to satisfy the specification of every band. However it is difficult because the band width of SAW filter is almost determined by electro-mechanical coupling coefficient (K^2) and temperature coefficient of frequency (TCF) of substrate material. Then the technique to change the material characteristics of substrate is necessary to actualize SAW filters for several operation bands on UMTS. SiO_2 thin film coating is one of the methods. Although this method might improve the TCF, SiO_2 degrades the performance of SAW devices. Several researchers have reported the method to get the SAW filter with good performance in case of using SiO_2 coating[1-3]. In this paper, we will show that the profile of SiO_2 thin film is important factor in SiO_2/IDT/LT system and show that it is possible to improve the characteristics of SAW with SiO_2/IDT/ $LiTaO_3$ (LT) structure by changing the profile of SiO_2.

2. The characteristics of SAW resonators having several profile of SiO_2 in SiO_2/IDT/$LiTaO_3$ system

For investigating influence of profile of SiO_2 on the characteristics of SAW device in SiO2/IDT/LT system, we employed the synchronous 1-port SAW resonator as a test device. The sectional structure of the test SAW resonator is illustrated in **Fig. 1**.

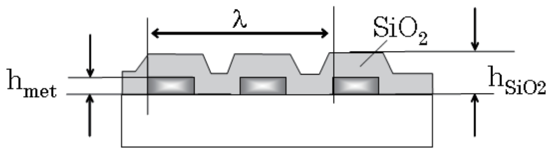

Fig.1 Sectional structure of test device

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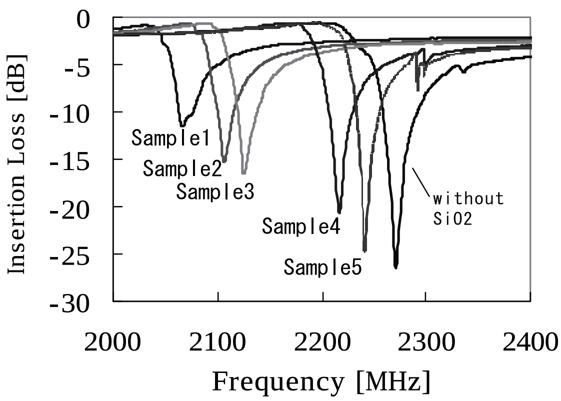

Fig.2 Transmission characteristics of SAW resonator with SiO_2/IDT/LT structure

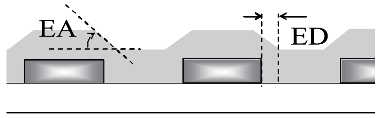

Fig.3 Two SiO2 layer-profile parameter EA and ED

Table I SiO_2 layer-profile parameters of evaluation samples used in Fig.2

Sample	EA	ED
No.1	0.98rad	0.078 λ
No.2	0.75rad	0.048 λ
No.3	0.65rad	0.016 λ
No.4	0.09rad	0 λ
No.5	(0.07rad)	(0 λ)

In the Fig1, h_{met} means a height of IDT and h_{SiO2} means a height of SiO_2. **Fig. 2** shows the transmission characteristics of several SAW resonators having SiO_2/IDT/LT structure with different profiles of SiO_2. In this figure, every SAW resonator has $0.07\lambda$of h_{met} and 0.2λ of h_{SiO2}. Here, we defined 2 parameter, EA and ED shown in **Fig.3**, which characterize SiO_2 layer profile. EA show the angle of convex edge of SiO2. Another actual reflection surface, which is different from the edge of IDTs/reflectors, forms and becomes clear as EA comes close to 0.5π (=1.57) and ED becomes large.

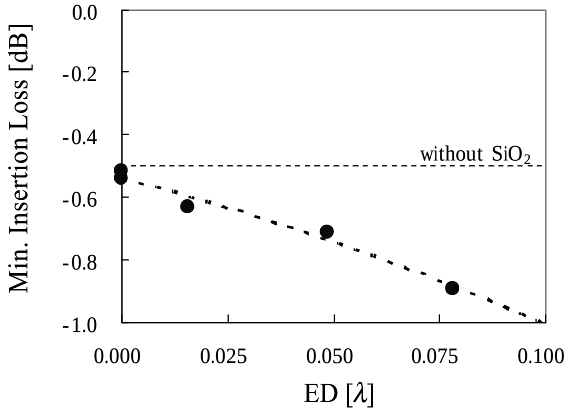

Fig.4 The influence of SiO_2 layer-profile on minimum insertion Loss of SAW resonators

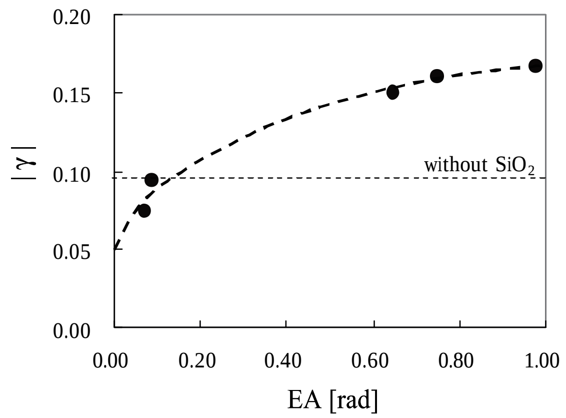

Fig.5 The influence of SiO_2 layer-profile on reflection coefficient of SAW resonators

Table I shows these 2 parameters of SAW resonators used in Fig.2. These varied profiles of SiO_2 were formed by changing deposition condition of SiO_2. From fig.2 and Table I, the characteristic of anti-resonant point becomes worse as another actual reflection surface form and become clear. An influence of SiO_2 layer-profile on an insertion loss and a reflection coefficient (|γ|) of SAW resonator are shown in **Fig.4** and **Fig.5** respectively. A |γ| was roughly evaluated from the resonant frequency and the frequency of spurious which came from stop band of reflector. Fig.4 shows the insertion loss of SAW resonator with SiO_2/IDT/LT structure recovers as the ED comes close to 0. On the other hand, Fig.5 shows a |γ| becomes small as EA comes close to 0. Both an insertion loss and a |γ| are important factors for SAW resonator. Fig.4 and Fig.5 show that it is necessary to control the dimension and profile of convexo-concave of SiO_2 to get good performance of SAW resonator with SiO_2/IDT/LT structure.

3. The temperature coefficient of frequency of SAW resonators with SiO_2/IDT/$LiTaO_3$ structure

The dependence of TCF at anti-resonance frequency of SAW filter with SiO_2/IDT/LT structure is shown in **Fig.6**. The all SAW resonators in this figure are coated with SiO_2 under the same deposition condition as SAW resonator of sample No.5 in Table I. From Fig.6, TCF is improved as h_{SiO2}/λ. becomes large. Especially, zero-TCF can be achieved at h_{SiO2} of approximately 0.3λ in SAW resonator with 0.7λ of h_{met}.

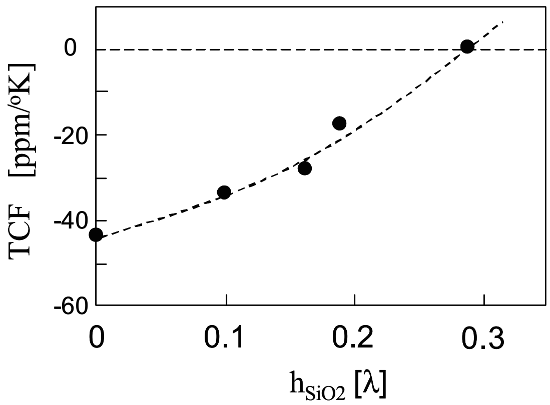

Fig.6 The dependence of TCF on h_{SiO2}

4. Conclusion

We could successfully get SAW resonators with good performance and with low TCF in SiO_2/IDT/LT system by changing the SiO_2 layer-profile. Especially, it is necessary to control dimension and profile of convexo-concave of SiO_2 to achieve SAW resonators having both low insertion loss and proper |γ| in this system. It has reported controlling SiO_2 layer-profile is also effective in the spurious suppression[4-5]. We believe this technology is essential to master a SiO_2/IDT/substrate system.

References

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