The modeling of the transverse mode in TC-SAW using $SiO_2/LiNbO_3$ structure

$SiO_2/LiNbO_3$ 基板を用いた TCSAW における横モード解析

Rei Goto[1, 2†], Hiroyuki Nakamura[1], Ken-ya Hashimoto[2]
([1]Skyworks Solutions, Inc., [2]Chiba University)
後藤令 [1, 2†]，中村弘幸 [1]，橋本研也 [1] ([1]スカイワークスソリューションズ,[2]千葉大学)

1. Introduction

TC-SAW (Temperature Compensated Surface Acoustic Wave) by $LiNbO_3$ covered with SiO_2 film structure is proposed for one of the temperature compensation methods [1-6]. Supurious supression method is studied on the transverse mode for the TC-SAW filter application [7-8]. In this study, the transverse mode is modeled and compared with the one-port resonator measurement result. This model applied to the design of DMS with reduced transverse mode.

2. Transverse mode modeling

Figure 1 show cross sectional view of TC-SAW composed of $SiO_2/LiNbO_3$ substrate. One of the spurious responses comes from transverse mode. Transverse mode suppression method is widely reported by using the piston mode operation. By using these technique, transverse mode are almost suppressed, however perfect suppression is still difficult. Prediction of the transverse mode is important for the filter design. Figure 2 show the illustration of the transverse mode simulation model. Propagation angle and excitation efficiency can be derived from the scalar potential method. Obliquely propagating characteristics is calculated by FEMSDA [9-11]. To apply the scalar potential method result to COM (Coupling of Mode) model, overall IDT characteristics can be calculated. Figure 3 show simulated admittance of 1-port resonator. Transverse modes are observed between the resonant frequency and anti-resonant frequency. Modeled geometry is λ=4.9um, h=0.04λ, H=0.275λ, Number of IDT is 120 and aperture length is 25λ. Blue plot also shows the measurement result. Simulated result can predict the each transverse modes frequency and magnitude correctly.

3. Spurious reduction design on DMS

Parallel connected DMS structure was proposed to improve the insertion loss by reducing the IDT resistivity. In this section, the transverse

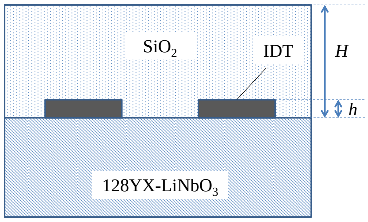

Figure 1 Cross sectional view of TC-SAW structure.

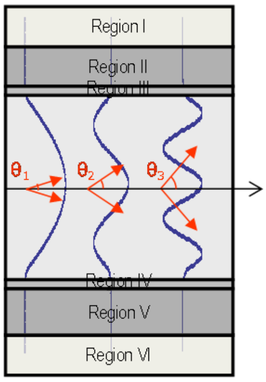

Figure 2 Illustration of the transverse mode modelling.

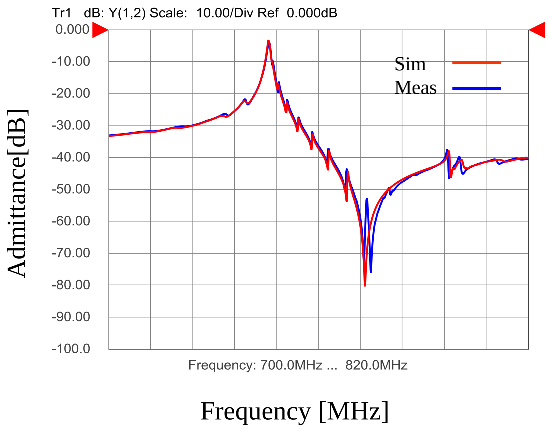

Figure 3 Measured and simulated admittance of 1-Port resonator

.

Rei.Goto@skyworksinc.com

mode model applied to design the parallel connected DMS for transverse mode spurious reduction. Figure 4 shows the two types of Parallel connected DMS structure. Figure 4 (a) is designed with same aperture length *W* on the right and left DMS. Figure 4 (b) is designed with optimized aperture W_1 and W_2 respectively. Precise simulation model is necessary to optimize the DMS design. Because DMS is composed by the modulated IDT pitch. Figure 5 show the simulated DMS transmission characteristics of structure (a) and (b) on Figure 4. Blue plot show the transmission characteristics of parallelized DMS structure of same aperture length. Transverse mode excited on each DMS overwrapped and strong spikes observed in the filter pass band. Red plot shows optimized DMS aperture length by using the transverse mode model. Transverse mode spurious is effectively reduced by optimization of the aperture length.

4. Conclusion

This paper proposed the transverse mode modelling in TC-SAW composed of $SiO_2/LiNbO_3$ structure. Simulated result of the One-port resonator agrees very well with the measurement result. Design method to reduce the spurious mode by using proposed model is also demonstrated.

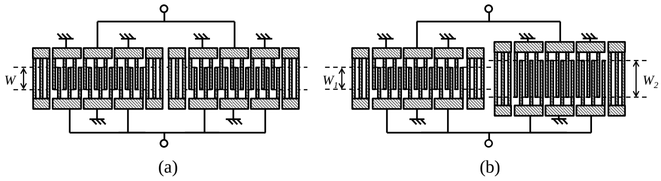

Figure 4 Schematics of the parallelized DMS structure, (a) Without aperture optimization (b) With aperture optimization.

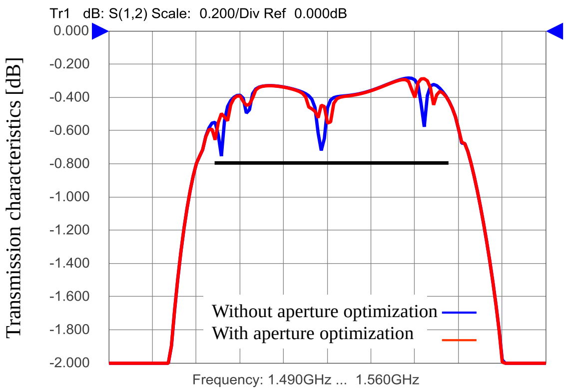

Figure 5 Simulated DMS performance of with and without aperture length optimization.

References

1. I. K. Yamanouchi, Y. Satoh, H. Isono, and D. Kawasaki: Jpn. J. Appl. Phys. **44** (2005) 4520.
2. M. Kadota, T. Nakao, K. Noshiyama, S. Kido, M. Kato, R. Omote, H.Yonekura, N. Takada, and R. Kita: Jpn. J. Appl. Phys. **46** (2007) 4714.
3. H. Nakamura, H. Nakanishi, T. Tsurunari, K. Matsunami, Y. Iwasaki, K.Hashimoto, and M. Yamaguchi: Jpn. J. Appl. Phys. **47** (2008) 4052.
4. H. Nakamura, H. Nakanishi, R. Goto, K. Hashimoto, and M. Yamaguchi: Jpn. J. Appl. Phys. **49** (2010) 07HD20.
5. H. Nakanishi, H. Nakamura, T. Tsurunari, J. Fujiwara, Y. Hamaoka, and K.Hashimoto: Jpn. J. Appl. Phys. **51** (2012) 07GC15.
6. Rei Goto, Joji Fujiwara, Hiroyuki Nakamura , Tetsuya Tsurunari, Hidekazu Nakanishi, and Yosuke Hamaoka: Jpn. J. Appl. Phys. **52** (2013) 07HD12.
7. M. Solal, J. Gratier, R. Aigner, K. Gamble, B. Abbott, T. Kook, A. Chen, and K. Steiner, Proc. IEEE Ultrasonics Symp., 2011, p. 324.
8. M. Solal, J. Gratier, R. Aigner, K. Gamble, B. Abbott, T. Kook, A. Chen, and K. Steiner, Proc. IEEE Ultrasonics Symp., 2010, p. 624.
9. K. Hashimoto, G. Q. Zheng, and M. Yamaguchi: Proc. IEEE Ultrasonics Symp., 1997, p.279.
10. K. Hashimoto, T. Omori, and M. Yamaguchi: Proc. IEEE Frequency Control Symp., 2000, p. 307.
11. K. Hashimoto, T. Omori, and M. Yamaguchi: Proc. IEEE Ultrasonics Symp., 2007, p. 711.