Finite Element Analysis of BAW Sensor

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Introduction: Cell-phone population rate in Japan has been increased rapidly as shown in Fig.1[1]. We need to handle various data communication such as voice, video, control etc. This demands to achieve passive device working over two GHz bands for next generation mobile phone. BAW(Bulk Acoustic Wave) resonator can be a promising device because it has been studied in the industrial field[2]. When it is used as a filter device, BAW has spurious modes which cause a ripple in Passband shown in FIg.2

This paper concerns with BAW resonator spurious suppression by using FEM commercial software, COMSOL Multiphysics 4.3b. It was found that the optimized shape of the border-framed electrode of BAW could remove the spurious modes and it was due to lateral wave attenuation along the electrode surface.

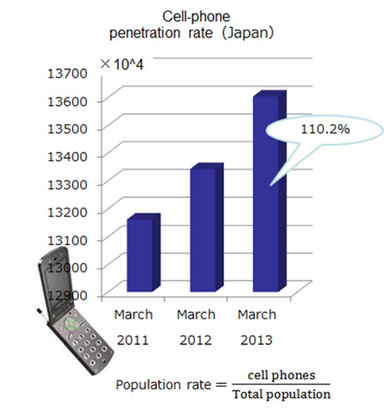
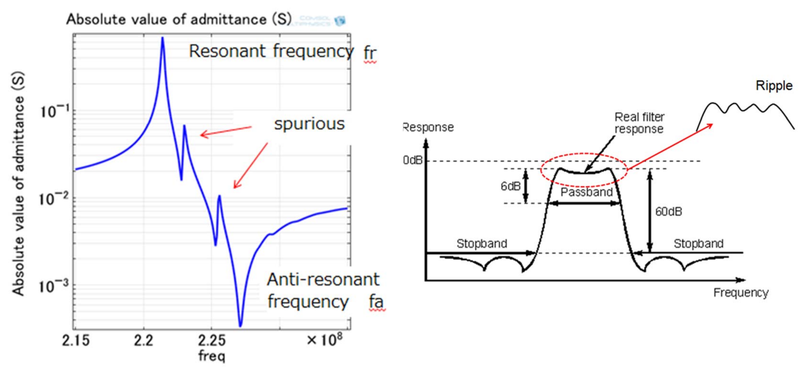


Figure 1. Cell-phone population in Japan.



(a) Spurious modes (b) Ripple

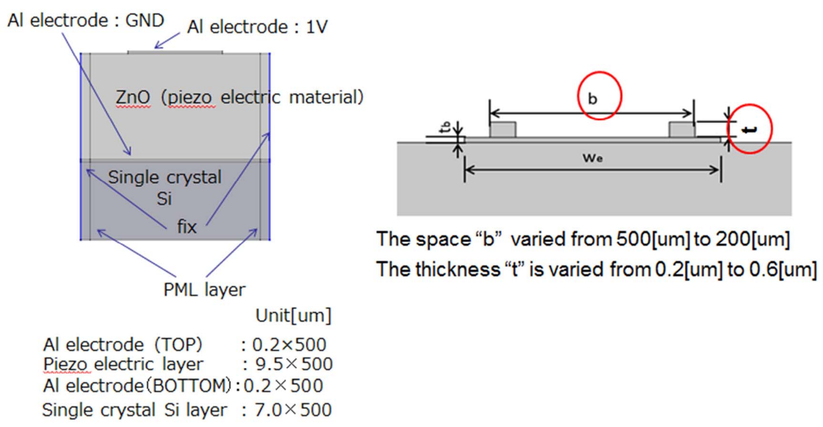
Figure 2. Spurious modes and ripple.

Computational Procedures: Two-dimensional model of BAW is concerned here. As a piezoelectric material for BAW, ZnO is selected. Constitutive relations for BAW solid mechanics simulation are as follows:

$$\mathbf{T} = c_E\mathbf{S} - e^T\mathbf{E}$$

$$\mathbf{D} = e\mathbf{S} + \varepsilon_S\mathbf{E}$$

Piezoelectric Device interface of the Structural Mechanics Engineering module with tensor material data of ZnO was utilized for getting numerical solutions. We assumed loss factors for elasticity matrix and electrical permittivity as η_{cE}=0.001 and η_{eS}=0.01,respectively.



(a) Flat electrode (b) Border-framed electrode

Figure 3. Computational model for BAW resonator.

Results and discussion: Finite-element model for BAW resonator is built as shown in Fig.3. First, configuration with flat electrode (Fig.3(a)) was studied to obtain admittance curve and the result was compared with ref. [3]. The agreement regarding to resonance frequencies was good as shown in Fig.4.

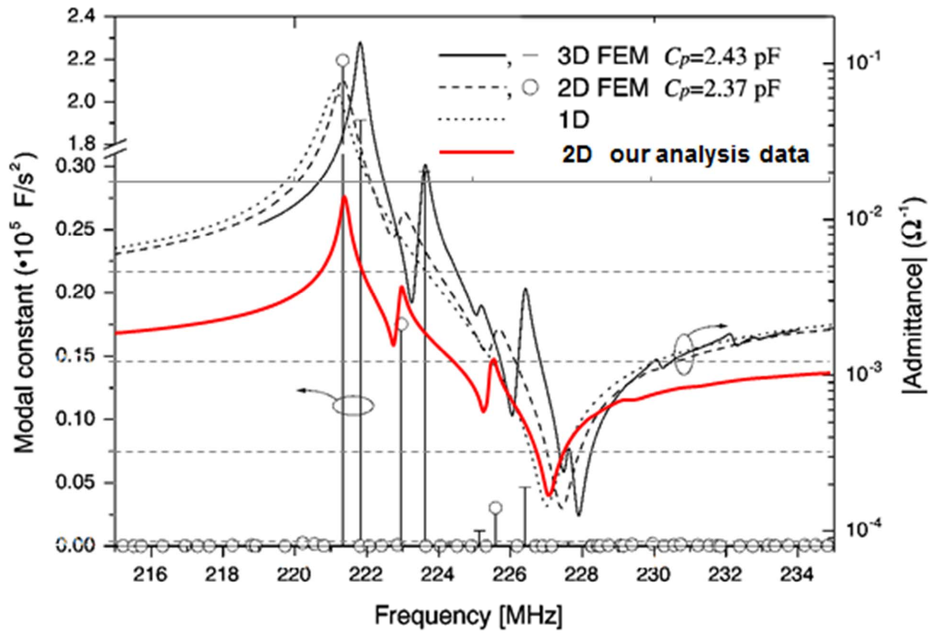


Figure 4. Validation result for admittance curve.

Then systematic study was executed for parametric border-framed electrodes (Fig.4(b)) . As a result, the optimized shape was obtained as shown in Fig.5, where no spurious modes were appeared. It is also found the mechanism of reducing spurious modes was due to the attenuation of lateral wave as shown in Fig.6.

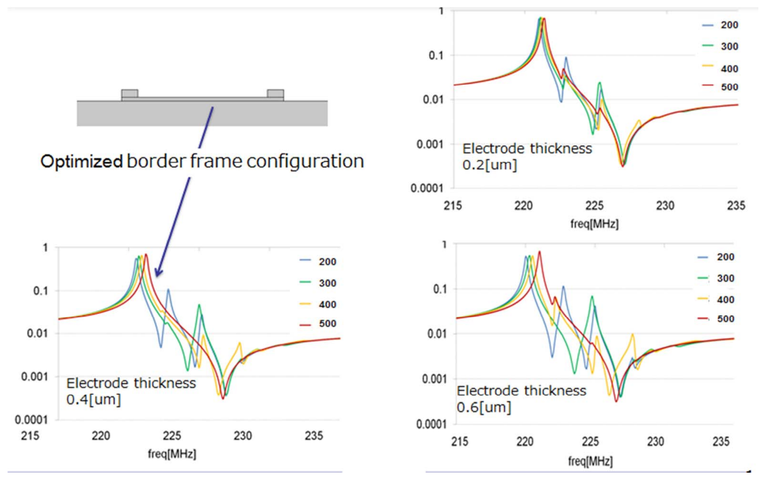
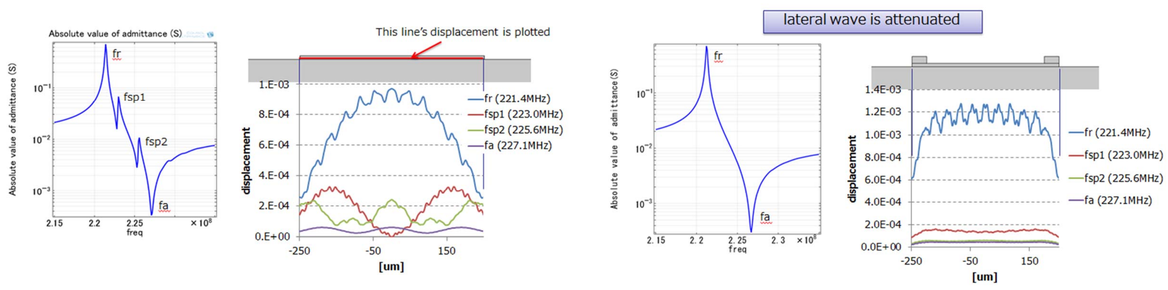


Figure 5. Systematic study for parameterized electrode.



(a) Flat electrode (b) Optimized electrode

Figure 6. Admittance curve and spurious removal mechanism.

References:

1. http://www.soumu.go.jp/menu_news/s-news/
2. T. Nishihara et al., IEEE Ultrasonics symposium,pp.969-972, 2002.
3. T. Makkonen et al., IEEE Trans. on Ultrasonics, Ferroelectrics, and Frequency Control, Vol. 48, no.5,2001.