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Mems resonator for Transreceiver

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ABSTRACT

A micromechanical 221 MHz silicon resonator is designed and demonstrated. The vibration mode can be characterized as a 2–D plate expansion that preserves the original square shape. The prototype resonator is fabricated of single-crystal silicon by reactive ion etching a silicon-on-insulator (SOI) wafer. The measured high quality factor and current output make the resonator suitable for reference oscillator applications. An electrical equivalent circuit based on physical device parameters is derived and experimentally verified.

Introduction

Resonators can be used as narrow band filters in radio-frequency applications. The chief advantage compared with traditional ceramic electromagnetic resonators is that BAW resonators, thanks to the acoustic wavelength for being much smaller than the electromagnetic wavelength, which can be made much smaller (Makkonen et al. 2001).In addition to the desired bulk acoustic mode, the resonator structure may have many spurious modes with very narrow spacing (Mattila et al. 2002). The design goal is usually to maximize the quality of the main component and to reduce the effect of spurious modes. This example shows how you can model thin film BAW resonators in 2D using eigenfrequency and frequency response analysis.

Resonator structure and fabrication

The lowest layer of the resonator is silicon (Kaajakari et al. 2003). On top of that, there is an aluminum layer, which operates as the ground electrode. The next layer is the active piezoelectric layer, made of zinc oxide (ZnO) (Milsom et al. 1983). On top of the resonator there is another aluminum electrode. A block of silicon has been removed from the center of the resonator.

Thus the thickness of the stacked resonator structure at the active center area is very small, making this resonator a thin film composite BAW resonator as shown in Fig 1.The thickness of the silicon layer at the central area is 7 µm. Both aluminium layers are 200 nm thick, and the piezoelectric layer is 9.5 µm thick. The width of the rectangular top electrode is 500 µm (Takahashi et al. 1994). The thin silicon area is roughly 1.7 mm wide. The model geometry is a symmetric 1-mm section in the center of the geometry. In the frequency response version we apply PML domains outside the truncation boundaries, to effectively increase the length of the resonator.

Resonator model

This design is modeled in 2D, using the plane strain assumption as shown in Fig 2. First compute and investigates the eigenmodes of a 950 µm wide structure, with its ends fixed. In the second step analyze the frequency response of the resonator.

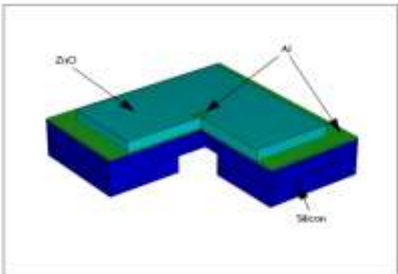

Fig.1 Geometry of a thin film BAW resonator

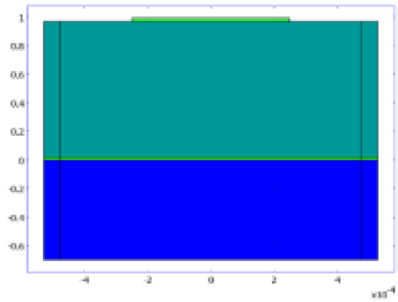

Fig.2 Resonator model

For this analysis, you extend the geometry by 25 µm wide, perfectly match the layer (PML) domains at both ends. You should estimate the losses in the piezoelectric material using complex material parameters, which you supply as structural and dielectric loss factors. In the frequency response analysis, evaluate the admittance of the resonator as

$$Y(\omega) = \frac{J_{ns}}{V_0}$$

where Jns is the current through the top electrode and V0 the applied potential at the electrode, and the quality of the resonator .With the exception of loss factors, all material parameters used in this model are taken directly from the MEMS

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Module material library which gives material quality Qm and dielectric loss tangent tan δ for many materials. The magnitude of Qm is roughly 100–1000, and the magnitude of tan δ is roughly 0.001–0.01. Based on that data, the following values are used

Structural loss factor:

$$\eta_{cE} = 1/Q_m = 0.001$$

Dielectric loss factor:

$$\eta_{\varepsilon S} = \tan\delta = 0.01$$

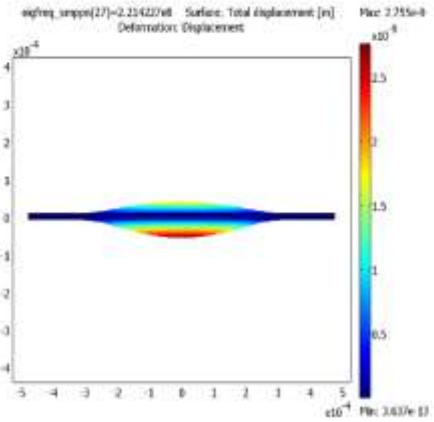

Fig.3 Maximum displacement of resonator

Fig 3 shows the lowest BAW mode of the structure, at 221MHZ. This is the fundamental longitudinal thickness mode. Due to the finite extent of the structure, and the constraints on the sides, this mode also has a small Lamb wave component.

Measured resonator characteristics

The Fig 4 and Fig 5 shows the frequency response analysis graph shows the admittance as a function of the frequency. Throughout the investigated range, from 215 MHz to 235 MHz, the admittance is very similar to that computed. Note that the peak frequency coincides with the eigenfrequency of the lowest BAW mode, 221 MHz.

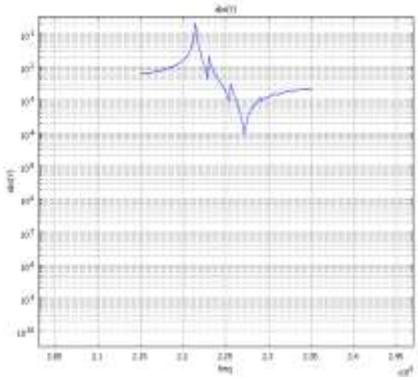

Fig.4 Frequency response analysis (V0=1v)

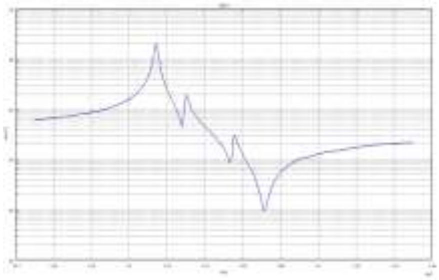

Fig.5 Frequency response analysis (V0=10v)

The Fig 6 shows quality factor as a function of the frequency. The value at 221 MHz is around 1320, which is not far from the global maximum.

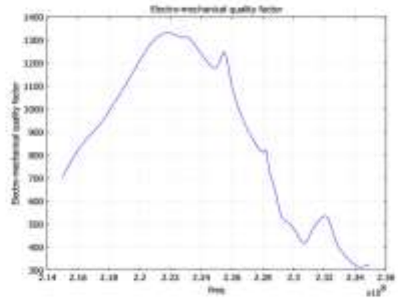

Fig.6 Quality factor of the resonator

Table 1: The resonator dimensions and characteristic parameters measured

Resonator height	**16.9µm**
Resonator length	950 µm
Frequency response	221MHz
Quality factor(Qm)	1320
Structural loss(ηcE)	0.001
Dielectric loss(ηεs)	0.01

Table 1 shows the resonator dimensions and the characteristic parameters measured.

Conclusion

This paper has demonstrated a bulk acoustic wave plate resonator operating at 221 MHz and has a quality factor of 1320. Throughout the investigated range, from 215 MHz to 235 MHz, the admittance is very similar to that computed. Note that the peak frequency coincides with the eigenfrequency of the lowest BAW mode, 221 MHz.

References

1. Kaajakari, V., Mattila, T., Kiihamaki, J., Kattelus, H., Oja, A., Seppa, H. (2003), “Nonlinearities in Single-Crystal Silicon Micromechanical Resonators”, TRANSDUCERS, Solid-State Sensors, Actuators and Microsystems, 12th International Conference, vol.2, pp 1574 - 1577.

2. Mattila T., Kiihamaki J., Lamminmaki T., Jaakkola O., Rantakari P., Oja A., Seppa H., Kattelus H.,Tittonen I.(2002) “12 MHz Micromechanical Bulk Acoustic Mode Oscillator”, Sensors and Actuators: Physical, Volume 101, Number 1, 30 September , pp. 1-9(9).