International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue
National Conference "IAEISDISE 2014", 12-13 September 2014

Development of FBAR Filter for Wireless Applications

Shivani Chauhan, Paras Chawla
JMIT Radaur, kurukshtra university
PG Student, Asst. Professor
Email: chauhanshivani31@gmail.com, paraschawla@jmit.ac.in

Abstract- This paper presents the basic of Surface Acoustic Wave technology (SAW) and Bulk Acoustic Wave technology and Film Bulk Acoustic Resonator (FBAR) Filters based on BAW technology. We propose the designing of the Film Bulk Acoustic Resonator (FBAR) Filters for operation in Long Term Evolution (3.52-3.56GHz) communication system. Also, the effect of dimension of FBAR filters on the resonance frequency.

Index Terms- Bulk Acoustic Wave ; Coventorware ; Film Bulk Acoustic Resonator ; Long Term Evolution ; Surface Acoustic Wave**.**

1. INTRODUCTION

The use of microwave resonators includes a large number of devices such as filters, tuned amplifiers and oscillators. This means the development of the microwave devices depends on the development of resonators. An electromagnetic wave is used for the excitation to microwave resonators. Meanwhile, the size of the devices is usually directly related to the wavelength of the electromagnetic wave at a certain frequency, which at the same time is directly related to the propagation velocity of the electromagnetic wave. It is necessitate to have a filter which has the characteristic of switch to select the frequency band of interest for a given application [1]. And the filter are used at microwave frequencies have small size.

In wireless applications systems the goals of the designers of these systems are mainly focused on obtaining small size and high performance devices, and integration of the different devices in one chip (SoC). The resulting size of electromagnetic resonators at RF/Microwave frequencies is usually much greater than some other integrated components which is a limitation in portable communication systems. Acoustic resonators have become consolidated as a key technology in overcoming the limitations mentioned above [2].

Therefore in mobile communication, highly precise frequency generation and excellent radio-frequency (RF) filtering is realizable by the use of surface acoustic wave (SAW) devices, and electromechanical (EM) resonators are widely used in most sophisticated electronic equipment. For example, bulk acoustic wave (BAW) resonators using crystal quartz are indispensable for frequency or time generation owing to their outstanding performances[3].. FBAR Filters and duplexers have high power handling capability, high Q factors[4]where as in surface acoustic wave (SAW) devicrs acoustic wave propagates on the surface of material. But the use of these filters are limited in frequency below 3GHz range and cannot handle high power levels [5].

2. SAW FILTER

The first SAW device was experimentally realized in 1965 by White and Voltmer It was a uniform interdigital transducer (IDT) consisting of interleaved metal electrodes on a crystal quartz substrate, generating and receiving Rayleigh waves throught he direct and inverse piezoelectric effect[6].

In the SAW filter wave is generated and guided by an input and output interdigital transducer, two electrodes of aluminum deposited at either end of the substrate using photolithography as shown in Figure1.When a voltage is applied the gaps between the electrodes have electrical fields.[7] The piezo electric effect translates this into mechanical stress (flexing of the substrate) which acts as the source of the surface wave. As the generated wave propagate on the surface so these types of filter called as Surface Acoustic filter. If the frequency is chosen such that the SAW wavelength equals the transducer pitch, the waves generated by the subsequent gaps will be in phase and therefore will reinforce each other with an increased demand for higher frequencies the production of the SAW resonators have gradually increased. Although in a BAW resonator, the stress on the electrode is not as high as in SAW and therefore more power handling is allowed and there is less dependence on temperature. This can be easily understood considering that BAW resonators are based on a parallel plate capacitor instead of the long, narrow and thin interdigital fingers used in SAW.

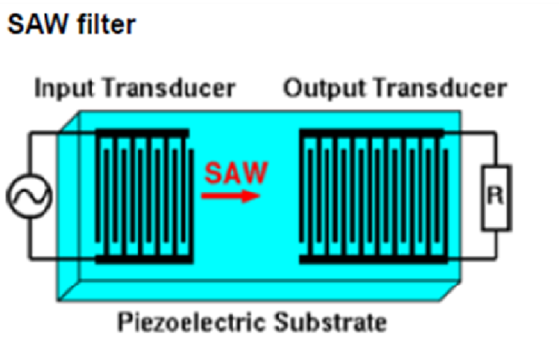


Fig.1. SAW Filter

3. FILTERS BASED ON BAW RESONATORS

The term bulk acoustic wave (BAW) refers to primary acoustic waves that propagation in the bulk of a material whose dimensions are infinite and wherein the wave occupies all of that volume[8].

a. Basic of FBAR

A bulk acoustic wave resonator consists a slab which is very thin and of piezoelectric crystal which is metalized on both sides for applying an exciting voltage Figure2 The plate exhibits a resonance whenever an integer multiple of half an acoustic wavelengths fits within the resonator thickness *t*, at frequencies given as in Eq.(1).

$$f_n = \frac{vn}{2t} \quad (1)$$

where *v* is the acoustic velocity of the wave mode (shear or longitudinal), *N* an integer multiplier, and *t* the thickness of the crystal. Only odd values of *N* lead to piezoelectric coupling as even *N* correspond to anti-symmetric modes. When an electric field is created between these electrodes, the structure is [9] mechanically deformed by the way of inverse piezoelectric effect and an acoustic wave is generated into the resonator which propagates parallel to the electric field and acoustic wave is reflected at the electrode air interfaces.

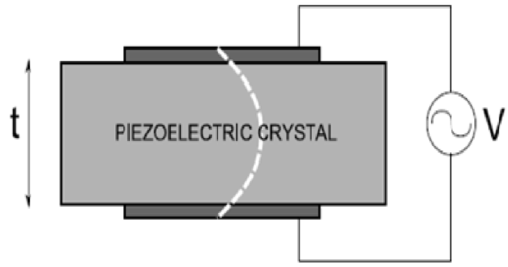


Fig. 2. The structure of a crystal resonator. Stress distribution of the fundamental half-wavelength thickness resonance is illustrated with the dashed line.

b. Impedance Characteristic Of FBAR

The electrical frequency response of the resonator have series resonance frequency (f_r) and have an anti-resonance (f_a) as shown in Figure3. Resonators which have high *Q*-value mean having small losses, can be fabricated from material like Zno, AlN etc. yielding for highly frequency selective resonators[10].

The common method of fabricating crystal oscillators include fabrication of bulk crystals, from which thin plates are diced, ground and polished down to a desired thickness.

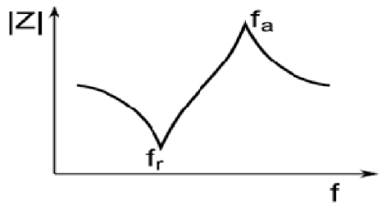


Fig.3. Magnitude of impedance of a piezoelectric crystal resonator showing resonance-antiresonance behavior.

4. SIMULATION OF FBAR

The designing of FBAR include selection of various parameters of top and bottom electrode and of piezoelectric layer.so if we design FBAR filter for that is for System LTE system (3.52-3.56GHz) then the thickness of top and bottom electrode is 80nm and material for both the electrodes is tungsten and for piezoelectric layer the material is AlN and thickness is 0.79312µm.The simulation of this FBAR filter is done through CoventorWare and the results are given in Figure4 is 3D design in preprocessor and when we simulate it the resulting impedance behavior in db and phase in degree is given in Figure5.

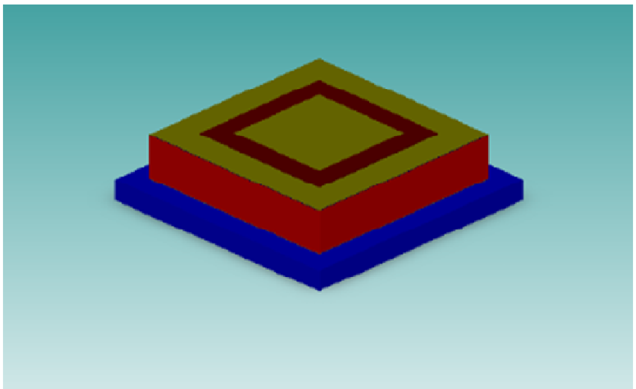
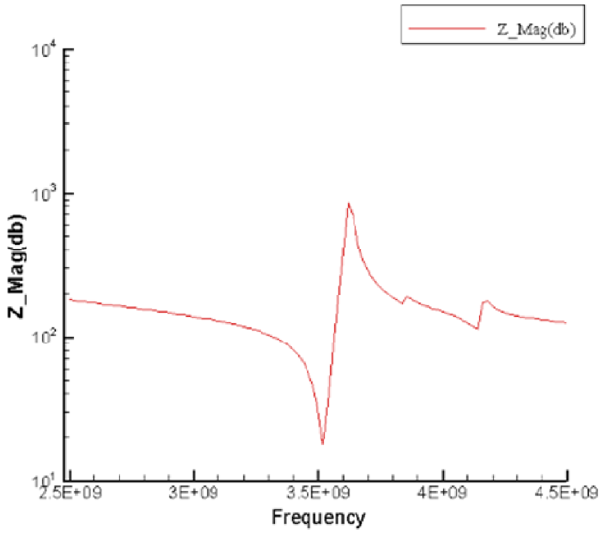
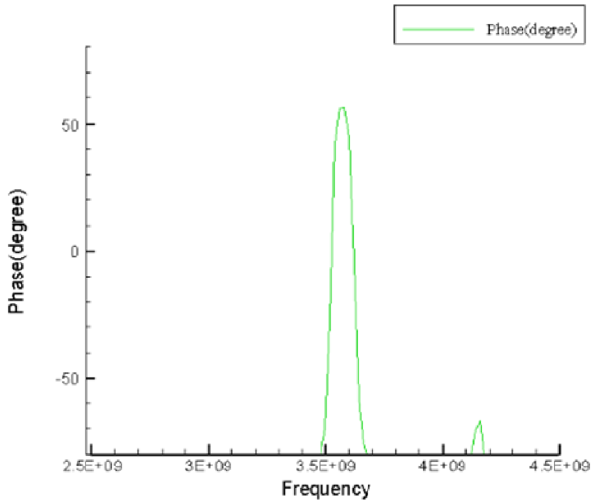


Fig. 4. 3-D model of FBAR in Coventor-Ware.

Resonance frequency of the FBAR is varying with the thickness of the electrode. So as the thickness of electrode is increases resonance frequency is decreases[11].



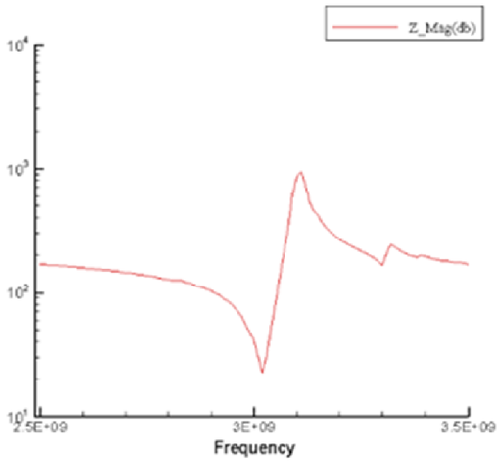
(a) **Magnitude response**



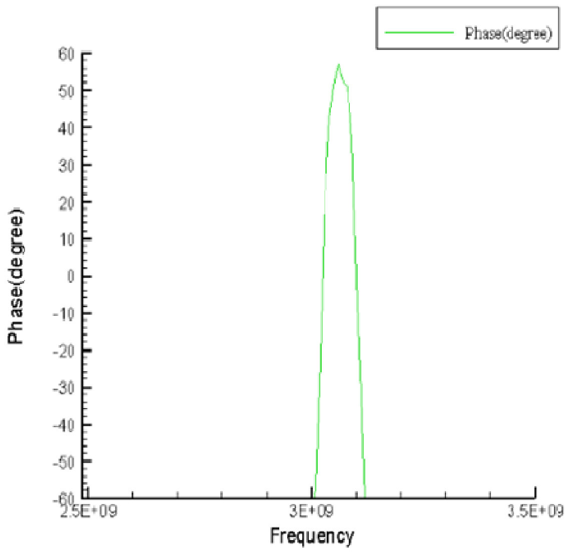
(b) Phase response.

Fig. 5. Input impedance vs. frequency plot of FBAR (a)magnitude response(b) Phase response.

so if the top layer thickness is increased from 80nm to 0.162µm then resonance frequency decrease from 3.52-3.56GHz to 3.2-3.21GHz.so this result of changing of resonance frequency of FBAR filter can be used for different wireless
lications.



(a)**Magnitude response**



(b) Phase response.

Fig. 6. Input impedance vs. frequency plot of FBAR after increasing thickness of top electrode.(a) magnitude response (b) Phase response.

5. CONCLUSION

This paper presents the importance of FBAR filter in the wireless communication that is for LTE system and FBAR Filters have the characteristics of high power handling capability, high Q factors, a low volume, good thermal stability, a low cost and compatible with IC chip integration. and also presents the effect of changing dimension of filter.

REFERENCES

[1]Xinen Zhu, Victor Lee, Jamie Phillips :An Intrinsically Switchable FBAR Filter Based on Barium Titanate Thin Films. IEEE Microwave And Wireless Components Letters,Vol.19, NO. 6, JUNE 2009.

[2]Jordi Verdú Tirado :Bulk Acoustic Wave Resonators and their Application to Microwave Device. Departament de Telecomunicacionsi d'Enginyeria de Sistemes.

[3]Ken-ya Hashimoto :RF Bulk Acoustic Wave Filters for Communications .Artech House Microwave LibraryISBN-13: 978-1-59693-321-7.

[4] Park Yun-Kwon, Nam Kuang-Woo, Yun Seok-Chool,Ha Byeoung-Ju,Hong Seog-Woo, Kim Chul-Soo, Shin Jea-Shik and Song In-Sang :Fabrication of Monolithic 1-Chip FBAR Duplexer for W-CDMA Handsets. MEMS 2007, Kobe, Japan, 21-25 January 2007 1-4244-0951-9/07/©2007 .

[5]P.; Bradley :A Film Acoustic Bulk Resonator (FBAR) Duplexer for USPCS Handset Applications.IEEE MTT-S, pp. 367-370 A, 2001.

[6]Lilia Arapan :Thin film acoustic wave resonator for frequency control and sensing application. uppsala university department of engineering and science,solid state electronics box959.78pp.Uppsala ISBN 978-91-554-8437-8.

[7] Vijay K.; Varadan, K.J. ;Vinoy K.A.; Jose :RF MEMS. John Wiley & Sons Ltd and Their Applications

[8]K.M.; Lakin and J.S.; Wang :AcousticBulk Wave Composite Resonators. Applied Physics Letters, pp. 125–127, 1981

[9]Sose, R.J.E.; Hueting and A.B.M.; Jansman : Modelling of Bulk Acoustic Wave Resonators for Microwave Filters. MESA Institute for Nanotechnology, Semiconductor Components, University of Twente, Enschede (NL) 2 NXP Research, Eindhoven (NL).

[10]J. F.; Rosenbaum :Bulk Acoustic Wave Theory and Devices (ArtechHouse, Boston, 1988).

[11]M.; El Hassan, E.; Kerherve, :A Study On Fbar Filter Reconfiguration. IXL Microelectronics Laboratory – UMR 5818 CNRS – University of Bordeaux.