Design and Analysis of FBAR switches for RF Front-End Mobile Terminal

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ABSTRACT

In this paper, an introduction and overview of MEMS technology with a focus on RF applications of MEMS in the design of mobile terminal are presented. Such RF MEMS switches have displayed excellent RF characteristics, including lower insertion loss, higher isolation, zero power consumption, small size and weight and very low intermodulation distortion, and long battery life. It is desirable for a single device to access the additional several services like DCS, PCS, GSM, EGSM, CDMA, WCDMA, GPS, Wi-Fi, Wi-MAX, UMTS, Bluetooth, 802.11a, and 802.11b bands at anytime and anyplace has lead to the current efforts towards integration of different wireless access technologies. It is shown in this paper that the application of Film bulk acoustic resonator switches in reconfigurable and adaptive RF front end section promises an increase in efficiency and sensitivity, and a reduction in size as well as cost of future mobile phones. The reconfigurability is achieved through FBAR based switches which is integrated on various section of next generation mobile terminal. So, in this paper FBAR switches for RF front-end mobile terminal are designed and analysis.

***Keywords*:** FBAR, pull in voltage, BAW, RF-MEMS

1. INTRODUCTION

The design of a mobile device equipped with compact size and multiband internal RF front end for wireless terminal is a challenge which industry is facing now a days. Besides the design of antenna the integration of various services require different RF front end components[1] like BPFs, isolators, power amplifiers duplexers etc., there is a need to develop a reconfigurable switch which will avoid the use of various identical components required for different bands. This switch has to be integrated with reconfigurable antenna making the entire RF front end reconfigurable.

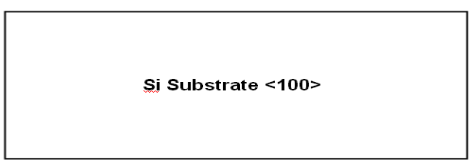
The technology used in present RF Front end mobile terminal[4] is that in order to reconfigurable the frequency there is the need of as many as components depending upon the requirement of frequency band. For example, consider a triple band mobile terminal (nokia 3310), in order to reconfigurable the circuit, three duplexers, three isolators, six low noise amplifiers, three power amplifiers, six Band pass filters are required. The use of FBAR switch avoids the multiplicity of components. The resonance frequency of a FBAR is determined by the thickness of the piezolayer and the neighboring layers. The required tolerance for the resonance frequency is around ±0.1% for typical mobile phone filters which translated into a thickness tolerance in the same range for the piezo layer and the electrode layers. Applying a DC voltage at the boundaries of FBAR electrodes involves a deformation of the piezoelectric material. This deformation changes the thickness of the piezoelectric material which affects the switch response. The total acoustic thickness of the FBAR includes the thickness of the support layer Si_3N_4, the thickness of the electrodes, piezoelectric material, and the thickness of the loading layer.

2. CONCEPT OF FBAR

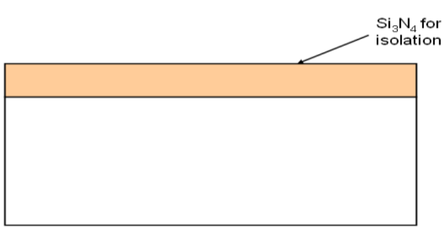
BAW device can manufacture on any substrate of choice but it work well on silicon. On the other hand manufactured on mono-crystalline substrates such as Lithium- Niobate or Lithium- Tantalate [2]. This inherent advantage enables to use processes, equipment and infrastructure known from mainstream IC manufacturing. Most of the processes needed for BAWs are perfectly feasible on standard IC equipment without any modifications. The ranges from 5 to 10 number of lithography steps are required for a BAW device. By solving the acoustic boundary problem and applying the transmission line theory the electrical impedance of an FBAR is calculated. As described before, the acoustic loading layer thickness has an important effect on the FBAR [7]. Changing the thickness of this layer according to the application implies a shift in the resonance frequencies. The acoustic propagation path is increased by simple adjustment of acoustic layer which can lead us to reconfigure resonators and filters. So, based on this advantage of the RF-MEMS switches, these kinds of switches could be preferred. When the movable hinge of the RF MEMS switch will stick on the top electrode of the FBAR, it will form an additional loading layer. This additional loading layer increases the total acoustic layer thickness[5]. When the switch passes to the ON state, which means it will stick on the top electrode, the FBAR thickness increases and the total thickness of the resonator will be the sum of the thickness of the piezoelectric layer in addition to the thickness of the bottom and top electrodes and the thickness of the RF MEMS switch. On the OFF state, the acoustic thickness of the resonator is equal to the thickness of the piezoelectric layer in addition to the thickness of the two electrodes.

The FBAR presents mainly two resonance pulsations: the parallel resonance (ω_p), when the electrical impedance approaches to infinity and the series resonance (ω_s), when the electrical impedance approaches to zero. For rest of the frequencies far from the resonances, the FBAR presents static capacitance behavior. The electromechanical coupling coefficient of the piezoelectric layer is used to calculate the difference between the two resonances. Following steps are involved for designing the FBAR as a switch -

Step1



Step 2



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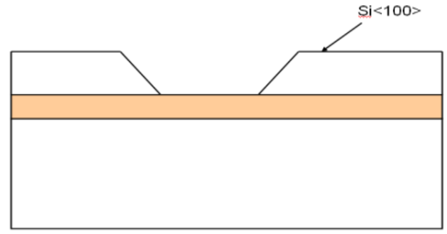

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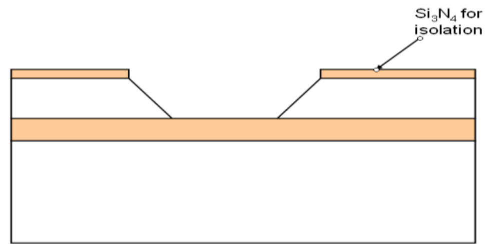

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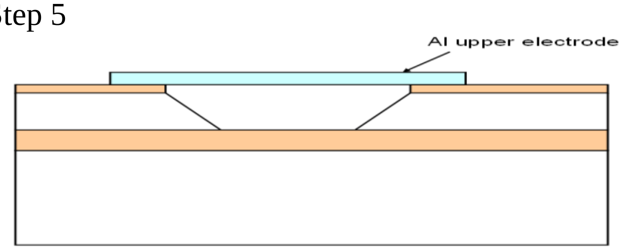
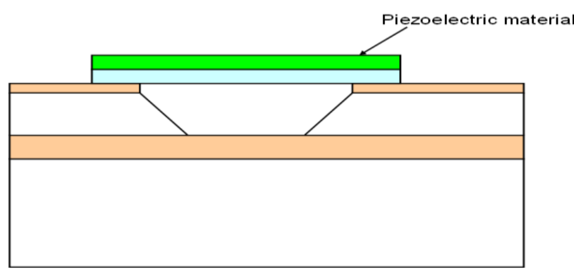
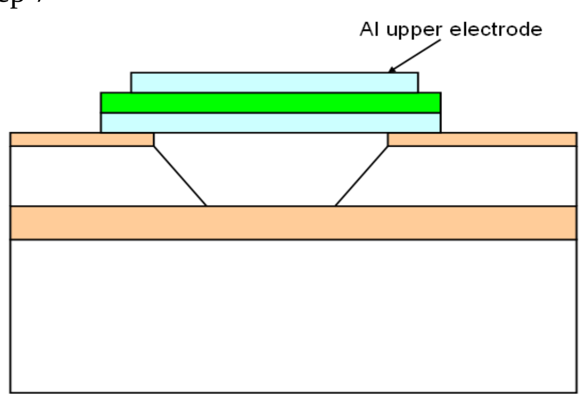


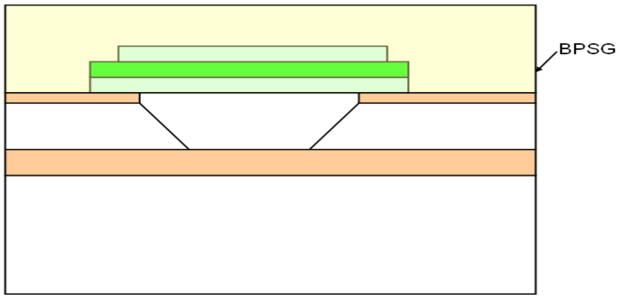
Step 6



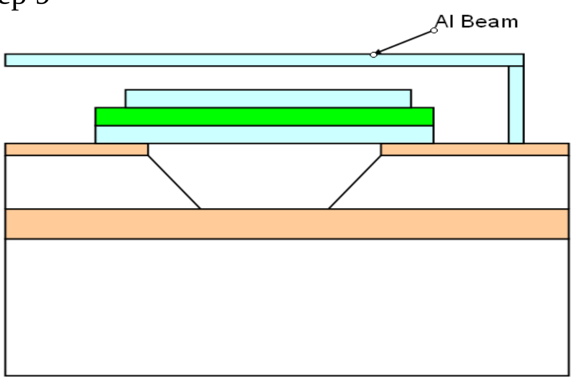
Step 7



Step 8



Step 9



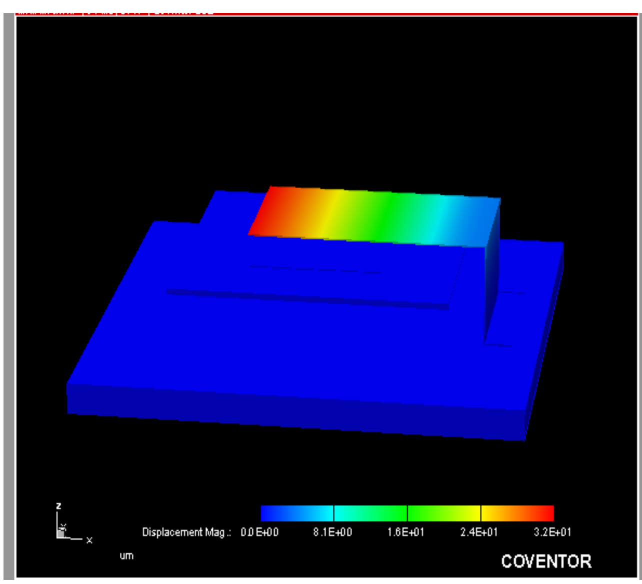


Fig 1:- FBAR switch showing magnitude of displacement

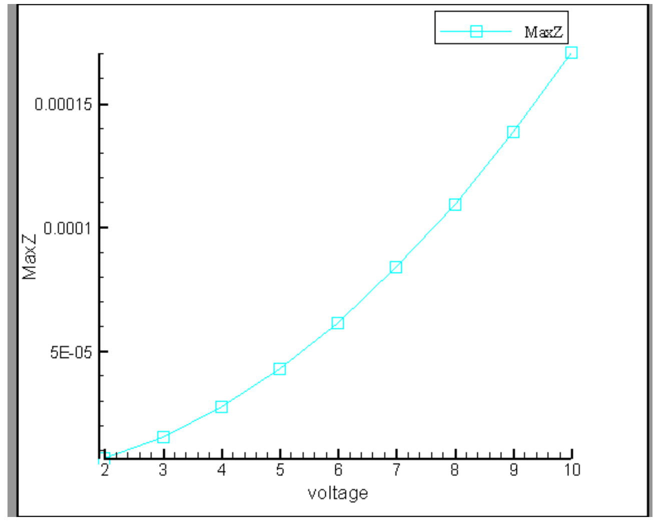


Fig 2:- Displacement vs. Voltage

Number	Step Name	Layer Name	Material Name	Thickness
0	Substrate	Substrate	SILICON_100	10
1	Stack Material	Nitride	SIN	0.25
2	Straight Cut			
3	Stack Material	Silicon	SILICON_100	20
4	Straight Cut			
5	Stack Material	Membrane	SIN	0.25
6	Straight Cut			
7	Stack Material	ElectrodeBottom	ALUMINUM(FILM)	0.4
8	Straight Cut			
9	Stack Material	PZE	ZnO	1.24
10	Straight Cut			
11	Stack Material	ElectrodeTop	ALUMINUM(FILM)	0.32
12	Straight Cut			
13	Planar Fill	Sacrificial	BPSG	10
14	Straight Cut			
15	Planar Fill	Anchor	ALUMINUM(FILM)	0.5
16	Straight Cut			
17	Delete		BPSG	

Fig 3:- Designing dimension of FBAR as a switch showing thickness and material used.

3. CONCLUSION

In this paper we have presented the possibility of an FBAR based RF MEMS switch for RF front end section of a mobile terminal which is used at different sections like as filter, duplexer and in order to provide the reconfigurabilty to the microstrip antenna. All the simulation is done on coventoreware software. For top and bottom electrode, Aluminum film is used having thickness of 0.32um and 0.4um respectively. The pull in voltage is found to be 47.2V. The sacrificial layer is of

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BPSG material having thickness of 10um.The combination of modern design techniques and an advanced integration technology like ASIC MEMScap foundry which combines CMOS-MEMS allowing designer high performance and optimized circuits. It enables very compact and optimized solutions in terms of module or monolithic integration.

4. REFERENCES

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