Modeling of FBAR Devices with Bragg Reflectors

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***Abstract*—**Film bulk acoustic resonators for radio frequency wireless applications are presented. Various simulations and modeling were carried out. The impedance of a five-layered FBAR showed almost the same trend of the wideband characteristics as that of an ideal FBAR, but the characteristics of the higher modes appear to be much more suppressed. In addition, the wideband impedance decreased with increasing device size. The resonance characteristics depend strongly on the physical dimensions..

***Index Terms*—**Resonator, Bragg reflector, Insertion loss S21, return loss S11.

I. INTRODUCTION

Recently, the film bulk acoustic resonator (FBAR) has become one of the most promising components mainly due to its small size, high device performance and its strong potential for MMICs applications [1]. FBAR is composed of two important parts: piezoelectric film sandwiched between conductors (for resonance) and multiple reflection layers (for acoustic isolation), affecting the overall resonance characteristic [2]. In spite of considerable efforts on piezoelectric ZnO films [3], few studies have been reported on the effects of reflector and thin film layers. In this paper, we present theoretical analysis and fabrication of FBAR devices.

II. SIMULATION & FABRICATION

Various simulations were carried out based on a derived input impedance equation on the FBAR with 0.13 μm Al for top and bottom electrodes as well as FBAR with 0.13um Al for top electrode and 0.13 μm Au for bottom electrode. For the simulation, the ZnO thickness was 1.4 μm, and both W and SiO2 films were λ/4. Two-port

FBAR devices were fabricated and measured for S-parameter extraction.

III. RESULTS AND DISCUSSION

The resonance characteristics were simulated to understand the acoustic mass loading effects, resonance area effects, and reflector layers number as well as thickness variation effects. Fig. 1 (a) & (b) show a schematic structure and SEM micrograph of the FBAR with the five-layered reflector, respectively.

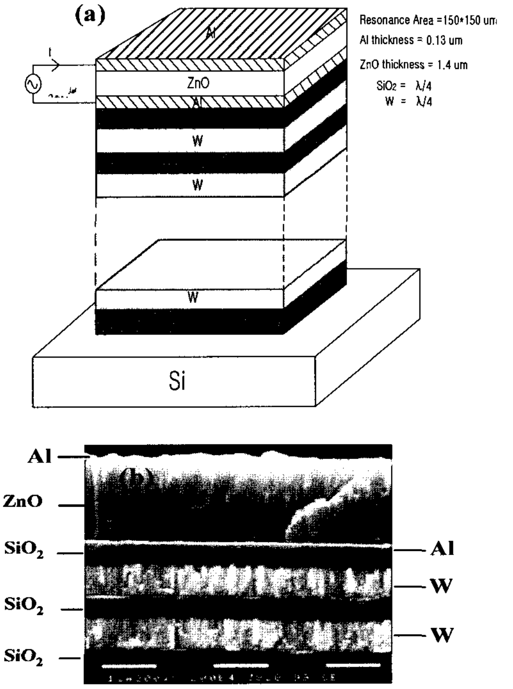

Fig. 1 (a) A schematic structure of the FBAR (b) The SEM micrograph of the fabricated FBAR with five-layered reflector

Fig. 2 (a) & (b) show reflection loss (S11) and insertion loss (S21) plots of the FBAR with the five-layered reflector, respectively where Q was 500 when calculated from S21.

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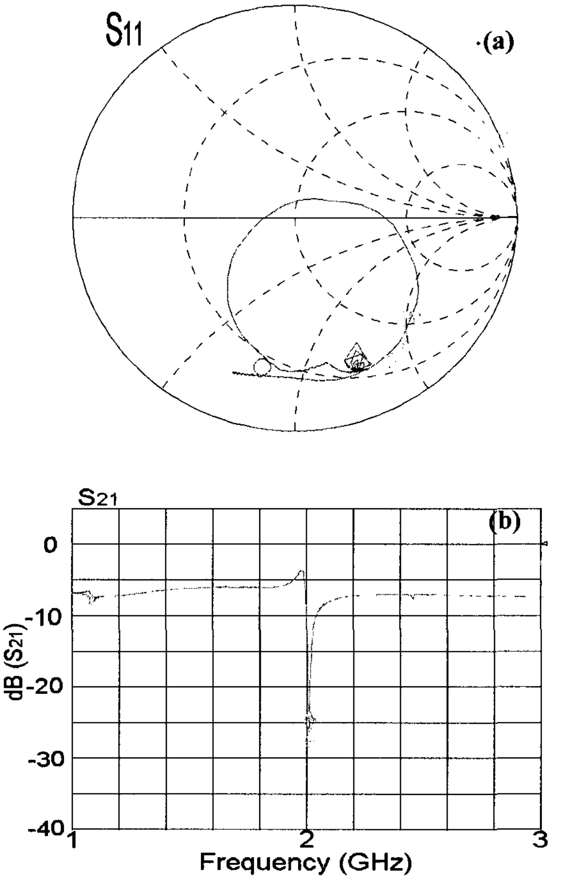

Fig. 2 (a) Reflection loss (S11) (b) Insertion loss (S21)

Fig. 3 shows a shift in the resonance frequency due to acoustic mass loading effect where Au and Al were used as bottom electrodes.

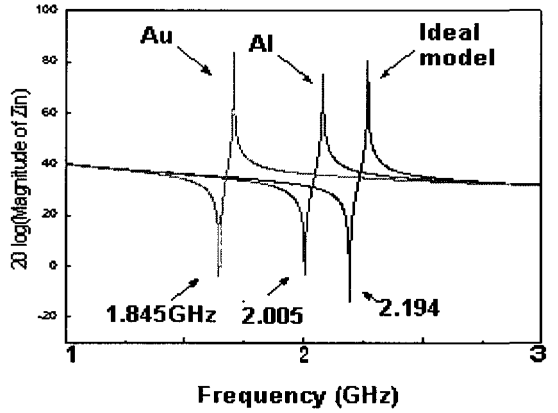

Fig. 3 Simulated resonance frequency shifts of FBAR devices due to acoustic mass loading effect of bottom electrodes

Fig. 4 shows the wideband response of the FBAR with various resonance areas where the impedance has the same wideband capacitive characteristics as that of ideal FBAR. In addition, the wideband impedance level decreases with increasing device size, and the optimum size was 150 x 150μm2 with 50Ω impedance.

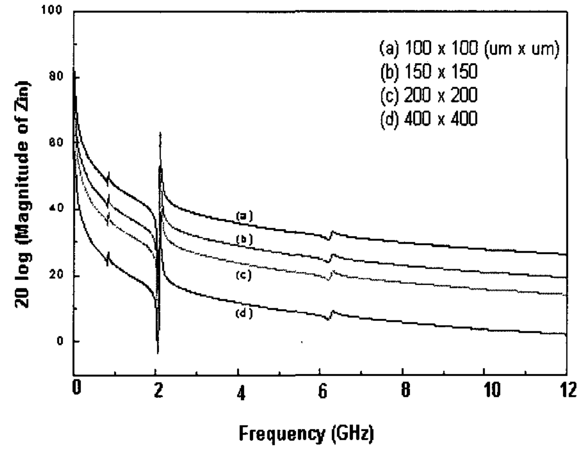

Fig. 4 Simulated wideband responses of FBAR devices with various resonance areas

Fig. 5 (a) shows the simulated narrowband response of FBAR with SiO2 thickness variation where the thinning of SiO2 film from λ/4 results in higher resonance frequency. Also, W thickness variation showed the same trend, but much less shift than SiO2 film as shown in Fig. 5 (b).

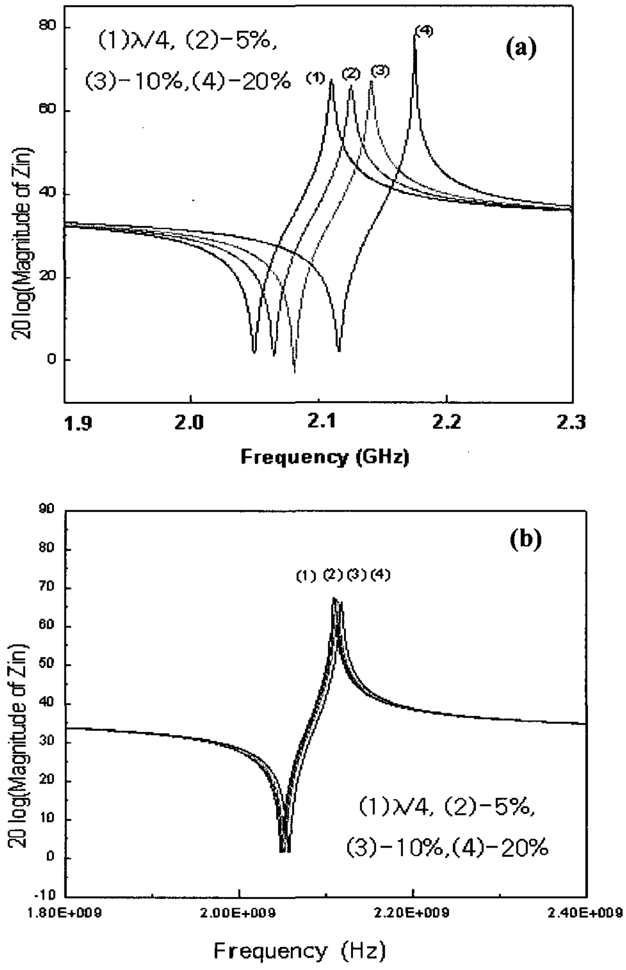

Fig. 5 Simulated narrowband response of FBAR with thickness variation (a) in SiO2 and (b) in W.

IV. CONCLUSION

The resonance dependence of the FBAR device on mass loading, resonance area, reflector layer number and variation are presented. High-Q of 500 was obtained at 2 GHz possibly due to optimized design and process. This FBAR technology will be very promising for RF filter applications.

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