

A Study on the Fabrication and Evaluation of the MEMS Based FBAR Filter for wireless systems

Eun Kyu Lee*, Chae Soo Kim*, Jae Joong Kim*, Hyung Rim Choi*,

* Dong-A University Research Park, 37 Nakdong-Daero 550beon-gil, Saha-gu, Busan, Korea 49315

jabanora@dau.ac.kr, cskim@dau.ac.kr, jjkgb@dau.ac.kr, hrchoi@dau.ac.kr

Abstract— The purpose of this research is study on the Fabrication and Evaluation of the MEMS Based FBAR Filter for wireless systems. In this research, composed ladder type filter using thin plate resonator by MBVD equivalent modeling. Use inductor, passive component, for low frequency band attenuation characteristic. Regarding better GND and adjust thermal conductivity, explained new via manufacturing method in this research. Quality value(Q) of the manufactured resonator is 687, and effective electro-mechanical coupling constant(K_{eff}) is 6.6%. Developed ladder type FBAR filter has less than -3.5dB insertion loss than -10dB return loss, and especially for attenuation characteristics less than -40dB at 1710~1785MHz.

Keywords— FBAR, MEMS, Resonator, Filter, MBVD

I. INTRODUCTION

Due to breakthrough advance in mobile and information technology area recent days, acceleration of higher frequency and smaller in size component development became an important issue to cope with the trend. Band Pass Filter, especially, is the one of passive component that is essential for mobile and wireless communication system. Many researches are on the way these days for RF MEMS filter, which can be replaced with conventional discrete dielectric filter. The RF MEMS filter can be made smaller, integrated, and has merit of co-integration possibility because it is compatible with IC process. FBAR band pass filter, especially, is implemented by combining volume elastic wave resonators which make use of the mechanical contraction and expansion of piezoelectric element when electric signal is applied. FBAR (Film Bulk Acoustic Resonator) filter is used as transmitting filter for US PCS, DCN, and GSM because of its superior power characteristic, low insertion loss, high isolation rate, and low ripple. FBAR filter, especially, has advantage of superior filter characteristic and power handling capability at high frequency band compare to SAW filter. But it still needs more functional improvement to guarantee functional fidelity. Accordingly, this dissertation introduce the research results of strengthening ground method to pass reliability test, and improving filter characteristic method using passive component.

Table 1.Spec.

Item	Specification
Center Frequency(F_c)	1880MHz
Insertion Loss@BW	0.8dB
Ripple@BW	0.2dB
Return loss@BW	19dB
In, Out Impedance	50 ohm

II. RESONATOR

FBAR resonator structure composed of top electrode-piezoelectric element-bottom electrode. Set thickness of electrodes and element as $0.35 \mu\text{m}$ - $1.22 \mu\text{m}$ - $0.35 \mu\text{m}$ to meet 1950MHz frequency, and manufactured as free standing type with $2 \mu\text{m}$ air gap. Resonator is pentagonoid form. Performance decision index to implement high performance FBAR resonator is evaluated according to κ_{eff}^2 . Use Modified Butterworth-Van Dyke Model(MBVD) as resonator modeling equivalent circuit, and extract physical property value based on actual measurement value for equivalent modeling work on unit resonator.

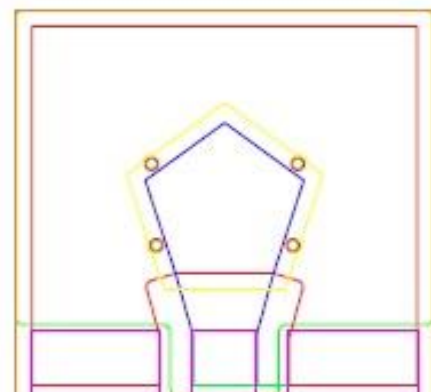


Figure 1. FBAR 2D Design



Figure 2. MBVD Equivalent Circuit

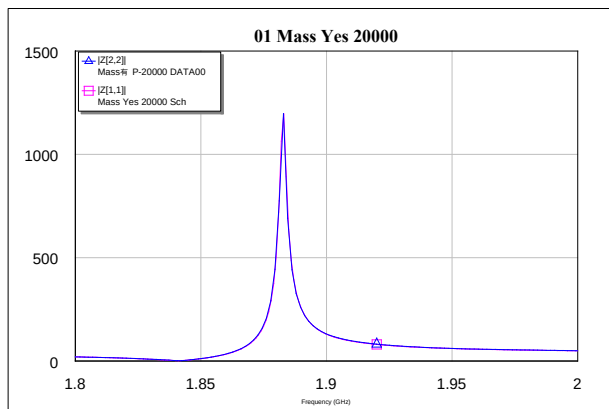
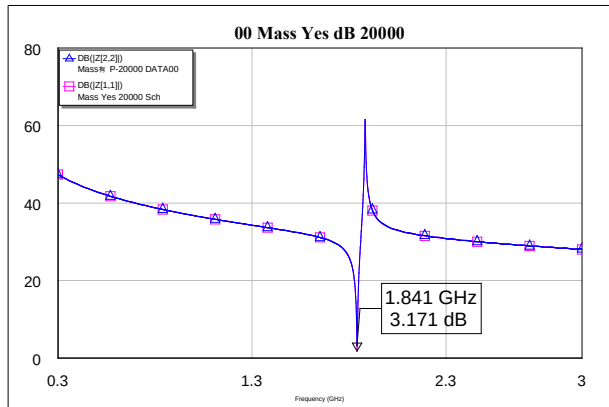


Figure 3. Resonator Characteristic Results (20,000 Å)

III. DESIGN METHODOLOGY FOR FILTERS

Design filter with arranging MBVD model equivalent serial/parallel resonators by their area, and assemble resonator in ladder type to construct passband filter. Ladder filter is composed with few units of FBAR in serial and parallel connection. To compose pass band filter, all serial connected unit FBARs should resonate at the same frequency, and parallel connected unit FBARs should resonate with small offset from serial FBAR. This means the design should be made so that the serial FBARs should provide maximum transmission peak at specified frequency while parallel FBARs should provide minimum transmission peak at the same frequency, to prevent the signal shorted to ground. One serial FBAR and parallel FBAR can be configured one set of ladder filter. Band rejection, or attenuation characteristic is improved as number of ladder set is increased, but it has

negative effect on insertion loss. It is desired to find optimized design using simulation tool to meet required specification. 3*2 type filter is used in this research, and adjust attenuation characteristic using passive component, inductor, to improve 1.7GHz attenuation characteristic. Passive component inductor value by measurement is 1.3nH, and Q is around 50..

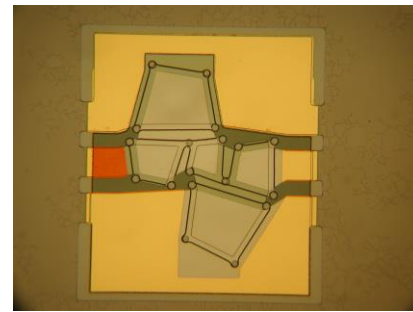


Figure 4. Ladder type FBAR Filters

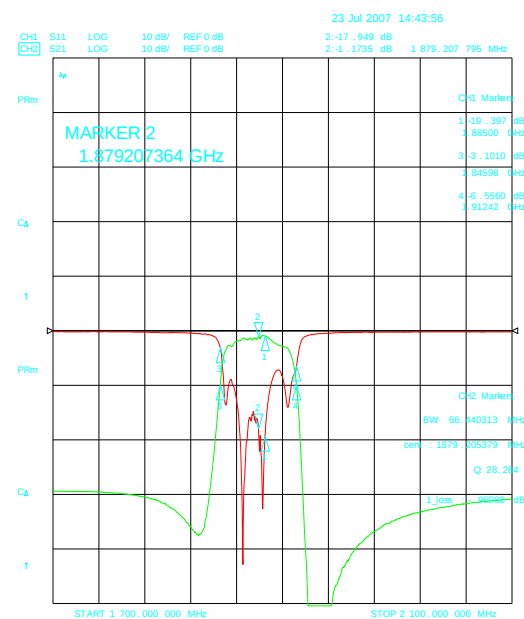


Figure 5. Result of ladder type FBAR Filters

A. PCB Packaging

Selected PCB board for FBAR filter in wafer state has low dielectric constant of 3.4.

Table 2. PCB

Point	Spec.	Data
1 Layer	Min 45 μm	52 μm
2 Dielectric layer	Nor 400 μm	399 μm
3 Layer	Min 45 μm	54 μm
Total thickness	0.49 mm	0.505 mm

It is Polypropylene resin PCB with loss coefficient of 0.002(@1MHz) for little change in board characteristic according to frequency. Adjust the height of PCB for high Q value of passive component inductor which is used in adjusting attenuation characteristic at 1.7GHz. To maximize GND effect between filter and PCB, and to minimize parasitic element, this research applied plating method to fill in all of via hole with conductive or non-conductive resin. It is expected to show better heat conductivity effect at later reliability test. It is found that the passive component inductor used for rejection tuning has 1.3nH and Q value of 50 when the size is 5mm length, and 0.1mm width.

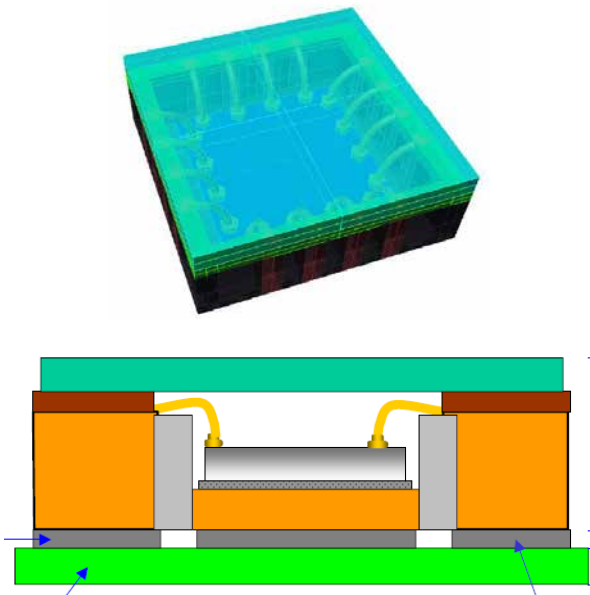


Figure 6. Lead Frame type FBAR Package

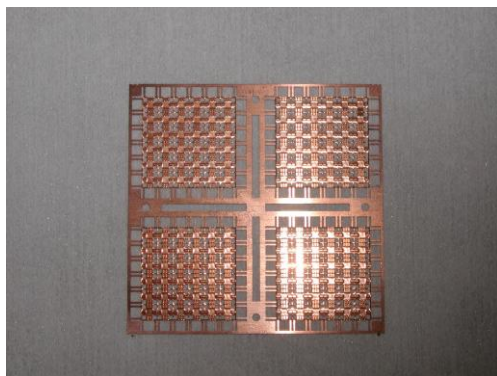


Figure 7. Lead Frame type FBAR Package

B. Measurement Method

Measurement jig used in this research is FR4 board designed with dielectric constant of 4.6, 50Ω characteristic impedance, and $\lambda/4$ length. Following are the before and after measurement results.

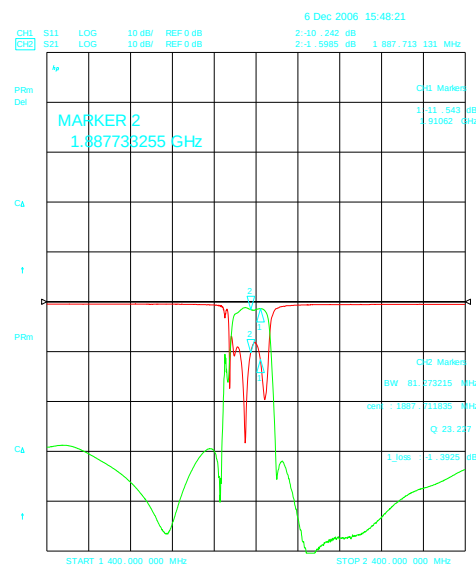
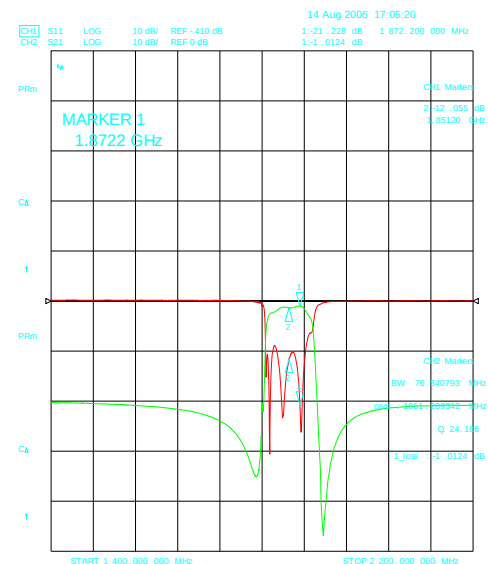


Figure 7. Measured characteristics of FBAR Filter

IV. CONCLUSIONS

This research is to improve characteristic of FBAR filter used in 1880MHz wireless system. Even with perfect FBAR filter characteristic from wafer state, it should have correct PCB pattern design, and consider ground strengthening for proper signal flow to get correct measurement result and prevent various parasitic elements. It is important to get GND effect from PCB for FBAR characteristic. The filter characteristic is acquired in this research using the method of filling via hole with conductive resin to achieve maximum GND effect between FBAR filter and PCB.

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Eun Kyu Lee is an Assistant Researcher of Dong-A University. He received the B.S degree in information communication department from Young Dong University, Korea in 1999, and M.S degree in electronic information communication from Kunkok University, Seoul, Korea, in 2001. He is currently Ph.D. candidate in electronic information communication from Kukkuk University. His main research topics are active RFID and container security Device.



Chae Soo Kim is a professor of Dong-A University. He received his Ph.D. degree in Industrial Engineering from KAIST, Daejeon, Korea, in 1999. His main research topics are a RFID/USN application and design & development of Port Logistics Systems.



Jae Joong Kim is a professor of Dong-A University. He received his Ph.D. degree in Civil Engineering from Seoul University, Seoul, Korea, in 1989. His main research topics are a RFID/USN application and Port and Logistics Systems.



Hyung Rim Choi is a professor of Dong-A University. He received his Ph.D. degree in Management Science from KAIST, in 1993. His main research topics are a RFID/USN application and Port and Logistics Systems.