Optimization of BAW Resonator for Wireless Applications Using Taguchi's Orthogonal Array Method

R. Dudhe[1], A. Sumathy[1], T. Desai[1]

[1]Manipal University, Dubai, UAE

Abstract

INTRODUCTION:
BAW has several advantages as they are remarkably small in size, have better power handling abilities and better temperature coefficients leading to more stable operation and hence preferred over SAW. From a practical point of view SAW filters have considerable drawbacks beyond 2 GHz whereas BAW devices up to 16 GHz have been demonstrated [1]. Due to good selectivity and steep transition band offered for cellular applications, modeling and development of high Q thin-film BAW devices is a topic of research gaining attention [2]. Transmit and receive bands of the US-PCS standard are close in frequency in the commercially available for US-PCS (1.85GHz-1.91 GHz) applications. These applications need nearly lossless high Q resonators for RF filters [3-6]. The resonator is of thin film [7], [8], [9] type in which the substrate is etched away on the back side. The natural frequency of the material and the thickness are used as design parameters to obtain the desired operating frequency. BAW devices have natural temperature compensation, often dependent on the material used for the uppermost reflector layer [10]. There are many fabrication challenges and issues to be taken care by optimization of the process. To address these issues our work is focused towards the optimization of BAW resonator for wireless applications using Taguchi's orthogonal array method.

USE OF COMSOL Multiphysics: COMSOL Multiphysics' MEMS module was used for this simulation based optimization study where the BAW resonator model was used as base to optimize the performance.

RESULTS: Different piezoelectric materials (GaAs and Lead, ZnO etc.) were used in the simulation with variation in thickness of various layers and the effect on deflection, displacement, electric potential, Admittance and Quality factor are studied exhaustively. Taguchi's orthogonal array method was used to optimize the results. The huge variation was observed in the displacement for µm and nm range of layer thickness as shown in the Figure 1 and Figure 2 respectively. The Admittance and Quality factor variation for the frequency response of the resonator within the desired bandwidth of 215 MHz to 235 MHz for µm range of layer thickness are shown in Figure 3 and Figure 4 respectively. Here very few results are added as a sample, while the complete paper will have lot more of results, analysis and discussion for optimization. Here we could not include due to space constraints. .

CONCLUSION: The optimization simulation study done using Taguchi's orthogonal array method for BAW resonator is very useful for designers to design the complex structure before fabrication. It will lead to reduce the fabrication efforts and will also be very useful to minimize the design errors. The highest and lowest deformation will allow the designer to choose the resonator for specific application. The admittance plot in each reading will be useful to determine the resonant frequency.

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Figures used in the abstract

Figure 1: freq(201)=2.3500E8 Surface: Total displacement (µm) (for µm range).

Figure 2: freq(201)=2.3500E8 Surface: Total displacement (µm) (for nm range).

Figure 3: Absolute value of the admittance vs. frequency.

Figure 4: Quality factor vs. frequency.