IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 5, May 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.122

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 5, May 2021||

DOI:10.15662/IJAREEIE.2021.1005024

A Review on Design of MEMS Based Thin Film Bulk Acoustic Wave Resonator for PCS Application

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ABSTRACT: MEMS resonators are tiny electromechanical structures that vibrate at high frequencies. MEMS based thin film bulk acoustic wave resonators (FBAR) are operated at frequency of GHz range. FBAR is suitable for personal communication systems (PCS) asthe transmitter and receiver frequency bands used by PCS cell phone system are 4850-4910 MHz and 5030-5190 MHz respectively, In this thesis work we have designed MEMS based FBAR using COMSOL multi-physics simulation tool. In FBAR, a piezoelectric layer is sandwiched between two electrodes and deposited on silicon substrate. Piezoelectric material used for FBAR is aluminum nitride and zinc oxide. These materials are used for narrow band applications.

KEYWORDS: MEMS , FBAR , Piezoelectric, Narrow Band Applications

I. INTRODUCTION

This research is focused on design of MEMS based FBAR for PCS application. The design is simulated by using different piezoelectric materials. Those materials are zinc oxide and aluminum nitride. In this chapter an introduction of MEMS technology and its applications are discussed. After that types of resonator such as electrical and mechanical resonators are discussed in detail. Design challenges of FBAR are also discussed. MEMS resonators are tiny electromechanical structures that vibrate at high frequencies. They are utilized for timing references, signal separating, mass detecting, natural detecting, movement detecting, and other different applications. This thesis work concerns their application in frequency and timing references.

FBAR is operated at microwave frequencies between 1–10 GHz. At their higher frequencies, FBAR is fit for accomplishing high quality factor (Qs). Due to their higher frequency range and better quality factor compare to other resonators they are extensively used in communication industry. In this thesis work our focus is to design an FBAR which can be used in personal communication system (PCS) duplexer design. A resonator is a device or system that displays resonance or resonant operation at a few frequencies, called its resonant frequencies. Generally we can use Electrical Resonators or Mechanical Resonators. The design of MEMS based FBAR is affected by – Choice of piezoelectric material, Quality Factor , Admittance etc.

II. SYSTEM DESIGN AND WORKING PRINCIPLE

Acoustic waves may appear to be out of the helpful scope of RF/microwave outlines, yet such low-recurrence waves are very compelling in higher-recurrence frameworks. They frame the establishment for surface-acoustic-wave (SAW) and bulk acoustic-wave (BAW) resonators, channels, oscillators and postpone lines. Segments in light of these advances have discovered their courses into numerous applications, from automobile frameworks and cell phones to military radar frameworks. SAW and BAW devices gives extraordinary qualities that can't be found in absolutely electronic segments, with high performance levels [32].

Both SAW and BAW segments utilize bury computerized transducers to change over electrical signal to mechanical acoustic waves and afterward back to electrical energy, empowering signal handling in the acoustic domain. In SAW and BAW devices, piezoelectric materials are additionally utilized as a part of the creation of small scale electromechanical frameworks segments.

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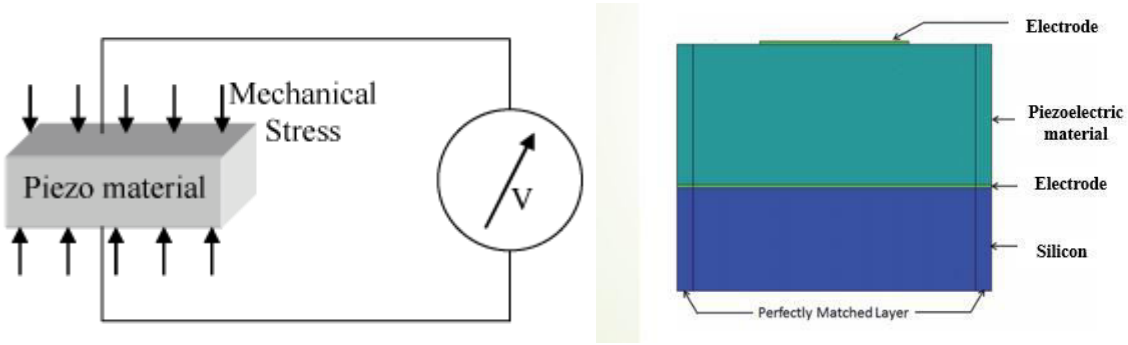


Figures: Working Principle Of Piezoelectric Materrial and Model (2-D) Of FBAR

III. DESIGN OF FBAR FOR PCS APPLICATION

This research is focused on design of FBAR for PCS application. Simulation and analysis is completed with software package COMSOL Multiphysics version 5.3a using the MEMS module. Working of FBAR is based on the principle of piezoelectric effect. On the application of applied stress charge is produced at the surface of piezoelectric material.
COMSOL multiphysics is a cross-platform finite element analysis, solver and multiphysics simulation software. It permits physics based user interface and coupled systems of partial differential equations .The purpose of the simulations is to study how various parameters may affect the quality factor and frequency of the bulk acoustic wave resonator by varying parameters such as piezoelectric material thickness, electrode thickness and size of the silicon material. In this model, COMSOL Multiphysics solves for both structural and electrical equations in the piezoelectric layer.

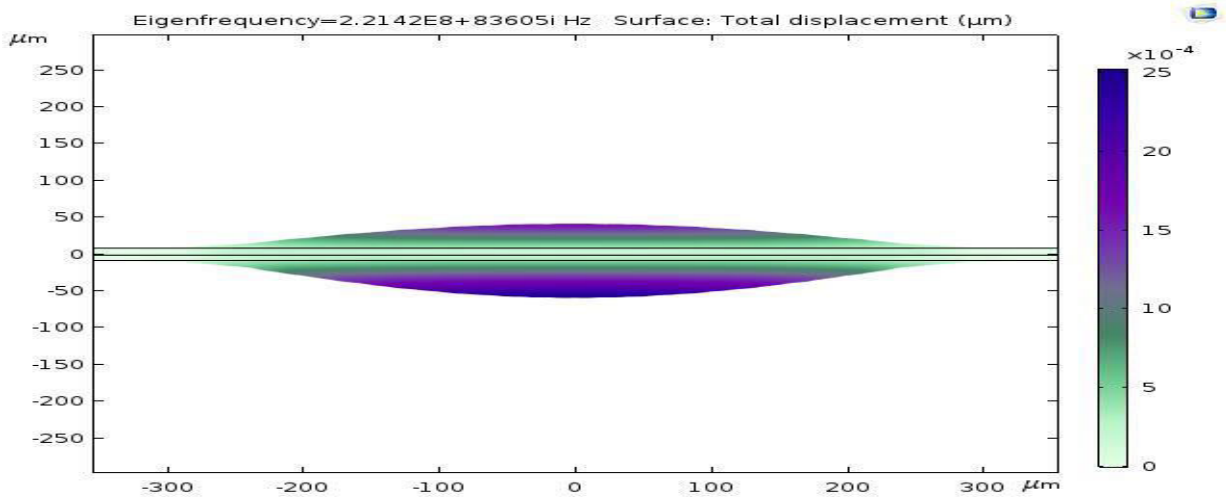
IV. RESULT AND DISCUSSION

A methodical analysis has been done to illustrate the features of proposed FBAR. This chapter deals with the extensive simulation performed in designing the FBAR. Quality factor and admittance for different thickness of piezoelectric layer have been presented in this section. The comparisons between characteristics of different piezoelectric materials have been also shown.

ZnO based FBAR

1. Displacement of ZnO based FBAR

This plot was generated from the results of the Eigen frequency analysis. This is the fundamental longitudinal thickness mode. The plot shows scaled deformation only to be used for visualization of the mode shape.



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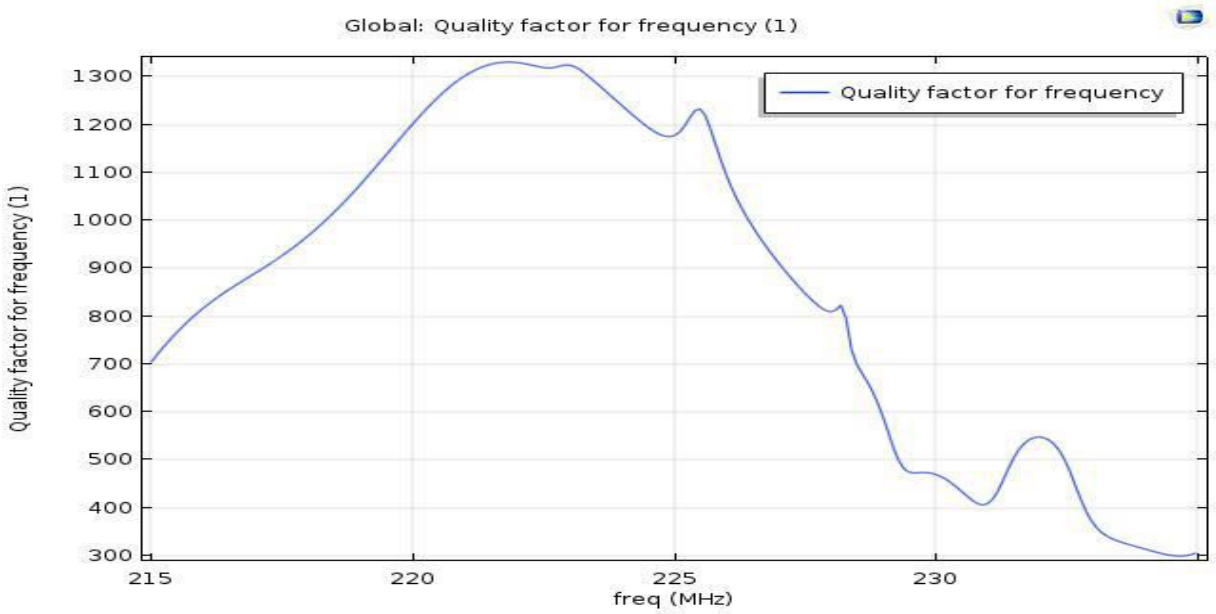
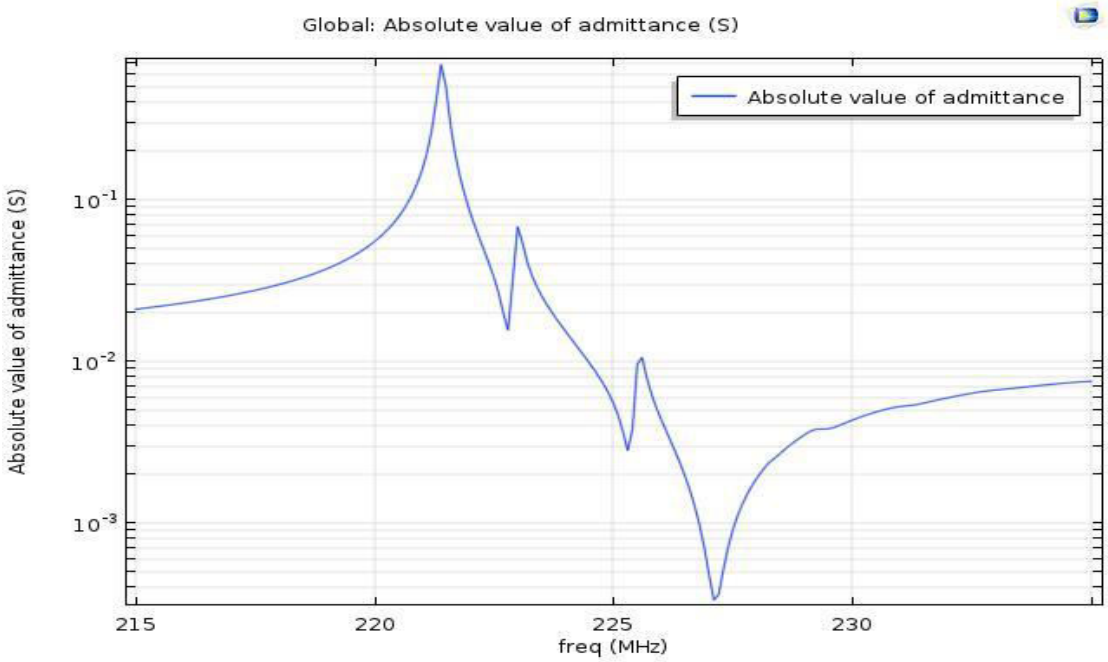
2. Quality Factorvs Frequency Curve



3.Admittance vs Frequency Curve



V. CONCLUSION

In this thesis work we have designed an FBAR by COMSOL Multiphysics tool using aluminum nitride as piezoelectric material for PCS application. Piezoelectric layer thickness used ranges from 215 nm to 930 nm. Quality factor achieved at lowest bulk acoustic wave mode is 308**.** The highest peak in admittance occurs at the lowest BAW mode of 3.2 GHz.

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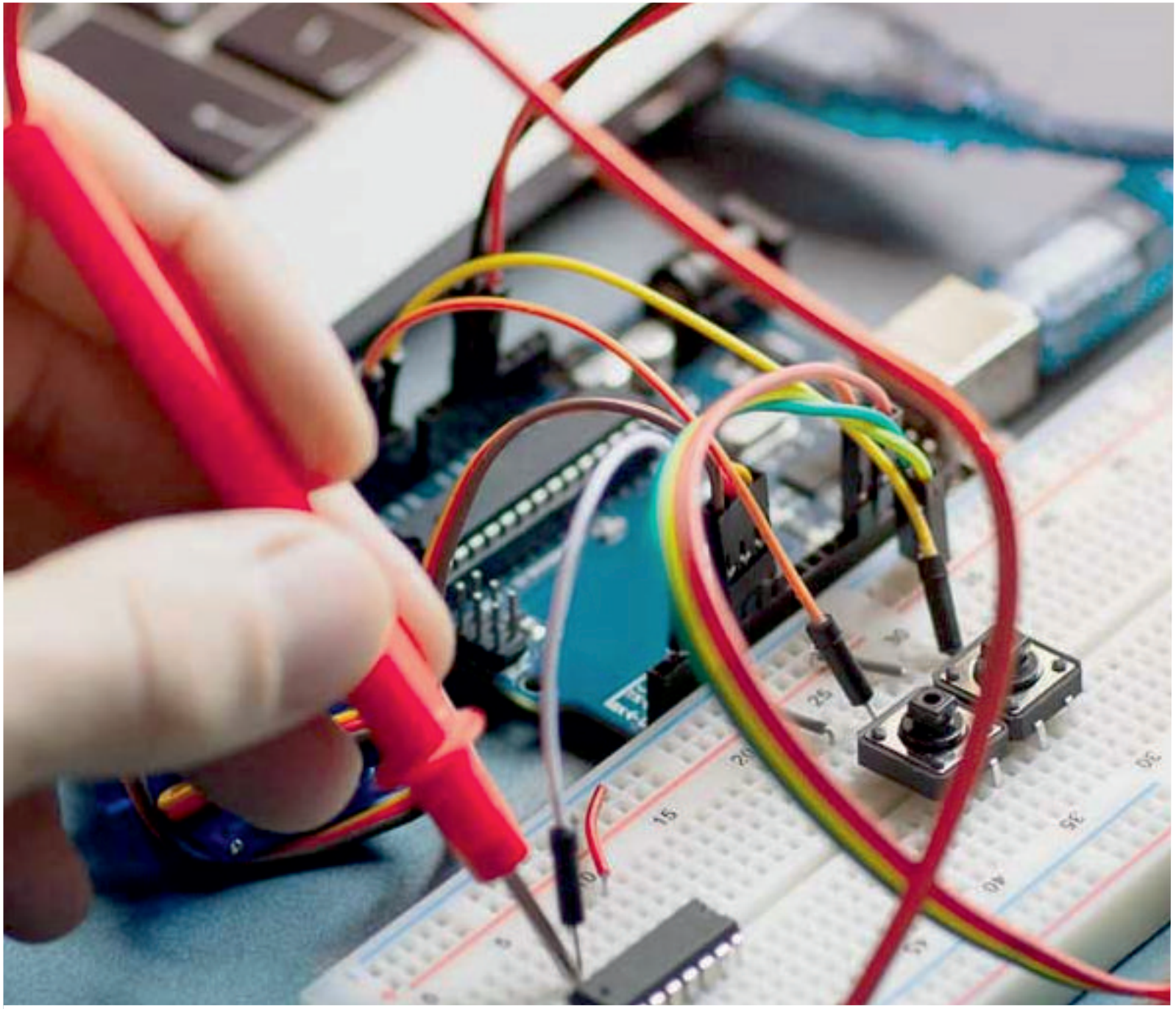

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in Electrical, Electronics and Instrumentation Engineering

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