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Design of Lithium Niobate Mems Resonator

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Abstract: ***This paper reports on stress and displacement of the resonator's nodes. The search of the resonator's frequency is examined by using Lithium niobate (LiNbO3) as the resonator's major component material. By using the lithium niobate as a major component it makes a partial changes in stress and displacement of a resonator. The theoretical details of stress and displacement are given for respective eigen frequency. The line graph for the stress and displacement on the X and Y axis is examined by using the comsol software. The design of resonator by using the software makes easy to rectify the technical errors, before going to create a hardware product. For example the acoustic resonator's are used to reduce the noise in the automobile industries with the use of muffler. The resonator used for reducing the noise can be designed initially with the software such that the design clarity will be noticed. This report based on resonator design using lithium niobate(LiNbO3), other then lithium niobate materials like silicon can also be used but in this project lithium niobate is used as the major component because it is prepared by using lithium(Li), niobium(Nb), oxygen(O2) which is not directly present in nature.***

Keywords: MEMS, Lithium Niobate, stress, Eigen frequency, electric field, displacement.

I. INTRODUCTION

In the rapidly growing mechanism and the advancement of the mobile communication, use of mobile headsets and the IOT calls for RF had the high usability within the limited bandwidth had been increased. In mobile phones SAW (surface acoustic waves) filters are used to produce significant performance, and to maintain cost and size. The thin film bulk acoustic wave (FBAW) sensors are most commonly used in cell phones and other wireless applications, the resonance frequency change of FBAW devices happens when it is placed under the mechanical pressure. For the BAW devices the waves will pass into the material surface. The wave can only travel on the part of the surface in the SAW devices. MEMS (micro-electromechanical system) are a mechanical and electronic component miniature computer. A MEMS 'physical dimension can vary from several millimetres to less than one micro meter, several times less than a human hair's width.

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II. DESCRIPTION

In this paper we present the development of LiNbO3 resonator for lithium mems. It relies on a configuration of the six electrodes placed on the resonator plate to estimate the stress and displacement for the electrode nodes. As illustrated in fig (1), the top plate with six electrodes act as the IDT's. The piezoelectric field is applied on the IDT's to produce the stress on the electrodes by using this electric field at particular node the displacement is calculated. The IDT'S are connected to the thin film. By LiNbO3's strong piezoelectric is passed into the resonator body's four sides, the E-field induces both saw and baw waves in the resonator body. The resonant frequency is set by the metal electrode pitch. Several resonant frequencies on the same substrate can be noted.

III. METHODOLOGY

To achieve the goal of evaluating the stress, we approach with the eigen frequency on the resonator body by using the lithium niobate as the resonator major component. The author's process begins with the creation of simple thin film plate by using comsol tool the plate is dopped with the lithium niobate. The releasing windows are placed on either sides of the resonator body. The ground and power supply window are created on top and bottom end of the resonator plate. The significant spacing should be maintained for the releasing windows, the top and bottom windows which act as the power supply and ground. The electrodes are placed on the resonator this electrodes act as the IDT's this inter digited transducers are used for producing the electric field into the resonator body.

IV. THEORETICAL CONCEPT

The schematic of mems resonator using the LiNbO3 component, the lithium niobate consists of a suspended lithium niobate plates with (IDTs) inter digitated transducers which are connected to the power supply and ground.The mems resonator is divided into two parts: a) inactive region, b) electrode region In inactive region the area was not covered by the electrodes, it was uncovered by the electrodes. In electrode region it was covered with the electrodes (IDTs electrode). The theoretical values are identified by using the 3D structure, the 3D analysis is more comfortable to produce the significant results.

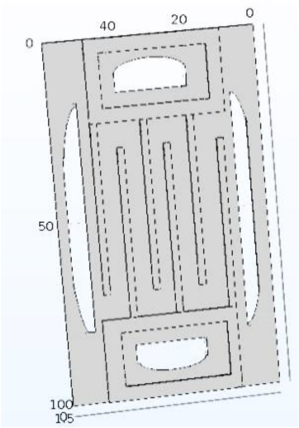

Figure 1: Lithium Niobate(LiNbO3) Resonator

a. Resonator

Resonator at particular frequencies oscillates with greater amplitude. These resonators can be used in applications for 200 MHz to 10 GHz. They are different types of resonator like saw, baw and yig resonators. This resonators have different applications and specific resonator are used for particular operation.

b. Mems

MEMS(micro electro mechanical systems) are the systems or devices used for the integrated elements, that combine both electrical and mechanical energies.

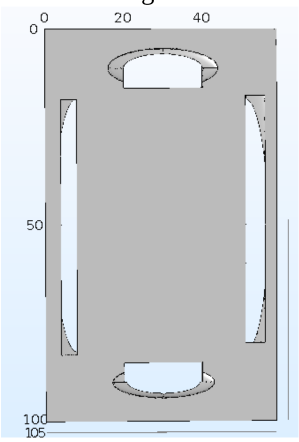

Figure 2: Schematic of LiNbO3(back view)

The wafer is dopped with LiNbO3 (lithium niobate. LiNbO3 it is a mixture of niobium, lithum, and oxygen. Their single crystals are an important material for optical waveguides, mobile phones, piezoelectric detectors, optical modulators and other linear and non-linear optical operators.

Parameters	Symbols	Value(µm)
Plate length	L	100
Plate width	W	59
Plate thickness	T	0.7
electrode	E	0.5

The above table represents that the basic parameters required for the construction of an mems resonator with different plate lengths, width, thickness and the electrode thickness. The dimensions of the LiNbO3 micro Resonator are (L=100, W=59, T= 0.7) all devices are fabricated with identical dimensions.

In operation the IDT'S are alternaly attached to signal and ground. Saw resonators operate on the basis of the propagation principle of acoustic waves. The waves are generated by injecting electrical energy into the piezoelectric material using IDT'S (interdigitated transducers) that transform it into mechanical wave.

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1. RESULT

Table 1: Stree & Displacement Values with respect to Eigen Frequency

Eigen frequency	Stress(N/m^2)	Displacement(µm)
10.364	0 5 5.5 8	0.2*10^6 2*10^6 2*10^6 2*10^6
34.054	0.2 0.6 1	1.5*10^6 1.1*10^6 1.1*10^6

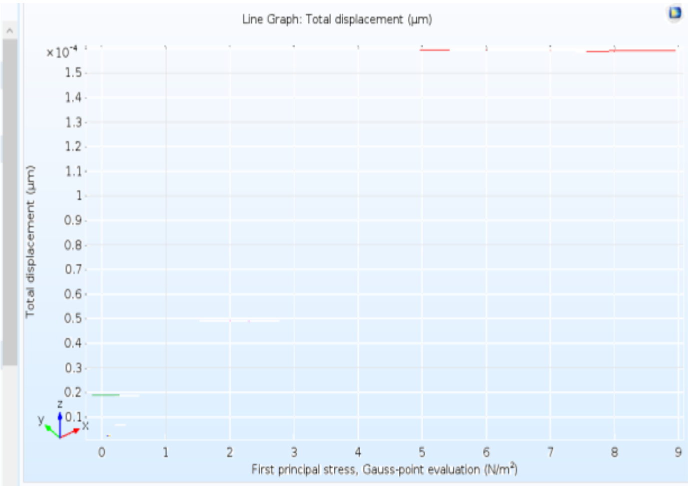

Figure 3: Line Graph Stress & Displacement

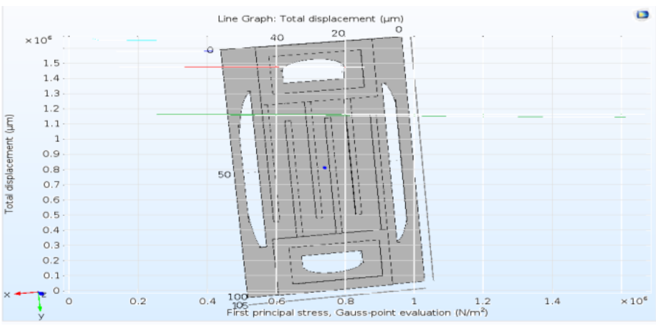

Figure 4: Line Graph Stress & Displacement

V. CONCLUSION

In this article we used the resonator plate which is dopped with Lithium Niobate (LiNbO3) to understand the stress and total displacement for the lithium niobate mems resonator is analyzed by using comsol tool, the line graphs at particular node point is verified and tabled for different Eigen frequency. The material used is not present directly in nature it is man made material.

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