DESIGN AND SIMULATION OF ESTROGEN HORMONE DETECTION SENSOR

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***ABSTRACT*— In this paper, work focus on the design analysis of estrogen detection sensor based on the MEMS technology which uses surface acoustic wave model. The principle of mass loading on the sensing layer is used to detect presence of estrogen molecules in the milk sample. The work focuses on the nano composite of poly pyrrole-coated magnetite nanoparticles or DNA aptamer-coated gold nanoparticles with a thickness of 0.5micrometer on lithium niobate(LiNbo3)\lithium tantalite(LiTa03) piezoelectric substrate.Device design in this research is for surface sensing through mass loading effect detection. Design and simulation is carried out by using comsol multiphysics 4.3a which uses finite element modeling. simulation will help in understanding more on the behaviour and most efficient sensing layer material to be used as Bio/Estro sensor without having to perform actual fabrication process.**

***Keywords*— COMSOL, DNA ,Magnetite, ,Milk Sample, SAW**

1.0 INTRODUCTION

Estrogen, or estrogen, is the essential female sex hormone. It is in charge of the improvement and control of the female conceptive framework and optional sex attributes, for example, bosoms, pubic and armpit hair, and the direction of the menstrual cycle and regenerative framework. Estrogen is a hormone. Although it exhibit in the body in little sums, hormones have huge parts in keeping up your well being. Estrogen is regularly connected with the female body. Men additionally deliver estrogen, yet ladies create it in more elevated amounts[5]. Amid the menstrual cycle, estrogen delivers a domain appropriate for the treatment, implantation, and sustenance of an early fetus [1].

Smaller scale Electro-Mechanical Systems, or MEMS, is an innovation that in its most broad shape can be characterized as scaled down mechanical and electro-mechanical components (i.e., gadgets and structures) that are made utilizing the procedures of microfabrication. MEMS are comprised of segments in the vicinity of 1 and 100 micrometers in estimate (i.e., 0.001 to 0.1 mm), and MEMS gadgets by and large range in measure from 20 micrometers to a millimeter [3][4].

Surface acoustic wave are a piece of MEMS innovation. An acoustic wave utilizes mechanical (acoustic) to detect various wonders from the gadget environment, which are enrolled as changes in the wave's phase amplitude, frequency. Piezoelectric materials are utilized to produce SAWs speed of SAWs contrasts from material to material , Hormone detecting by SAW based sensors have been accounted for widely in writing overview. magnetite and gold particles indicate affectability towards hormone recognition [3].

In this paper, outline of SAW sensor that show affectability towards estrogen hormone in the utilized example milk sample. Aluminum go about as a resistive layer which gives numerous points of interest regarding dependability , life span and vigor , as it helps in restricting the SAWs at first glance only.It go about as a defensive shield to the cathodes and piezoelectric substrate. Likewise including a spacer layer empowers entire delicate layer to be in contact with test that aides in expanding mass [1][2].

The displacement and frequency shift in SAWs is investigated for the design. And additionally impact of thickness of the center layer(sensitive layer) is studied[3].

2.0 DEVICE DESIGN

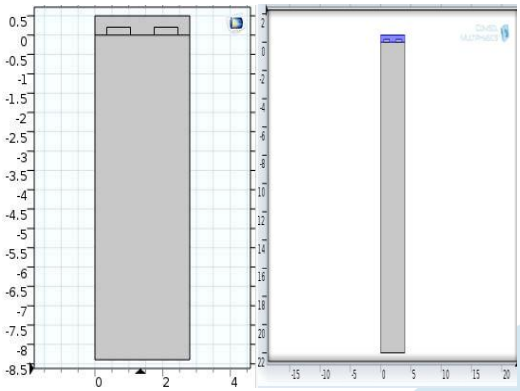
A. LiNbo3/LiTao3

The base layer made of LiTao3 of proposed single layered structure is 4μm and 22.5μm in length. Base layer material is piezoelectric in nature.

B. Magnetite/Al/LiTao3

As shown in figure 1(b) ,the design incorporates an additional center layer made of magnetite of thickness 1.0 μm and 0.2 μm in wide.It lies between electrodes layer above the base layer made of LiNbo3 or LiTao3,which is 4 wide and 22.5 in length ,electrodes layer made of aluminium which is 1 μm and 0.2 μm and thin sensing film of aptamer-coated gold nanoparticles/polypyrrole coated magnetite nanoparticles of thickness 4.0 and 0.5wide.

The electrodes of IDT are inside the center layer resting on piezoelectric substrate made of aluminium of width 1.0 and height 0.2.



(a) (b)

Fig1(a)substrate layer (b) layer with electrodes&detector

3.0 SIMULATION METHODOLOGY

2D structure mimicked in COMSOL Multiphysics is a unit cell of 3D SAW based Bio/Hormone/Estro sensor as IDT comprise of numerous comparative cathodes with their length 100 times of their width in a brush like mold disregarding edge effects. one terminal is furnished with voltage of RF recurrence figured from eq(1) while other is grounded. This produces electric field and because of piezoelectric effect, stress is created on the surface of gadget as surface acoustic waves.

$$F=v/R \text{ width} \quad -(1)$$

Where f is resonant frequency of device vR is Rayleigh wave speed and width will be width of unit cell. Intermittent conditions are connected on vertical limits of unit cell. At the point when gadgets go under contact of a drain test, the thickness of detecting layer expands .Density of a hormone in magnetite film(p) is ascertained with following conditions.

$$\text{Milk sample } \hat{}\text{magnetite}=KMC \quad -(2)$$
$$C= (c0.10\hat{}-6p)/RT \quad -(3)$$
$$K=10\hat{}8 \quad -(4)$$

Where, an is sample/magnetite segment coefficient of specific hormone,c0 is the concentration in parts per million , p is the load ,T is the temperature , R is hormone consistent , M is the molar mass of specific hormone.

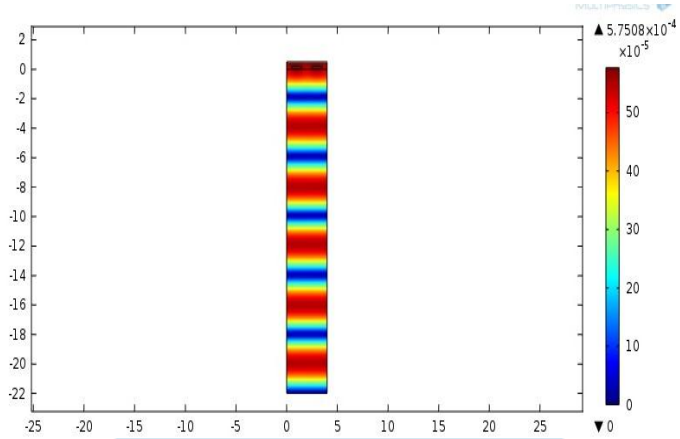
4.0 RESULTS & DISCUSSION

A . Electric Potential and Displacement

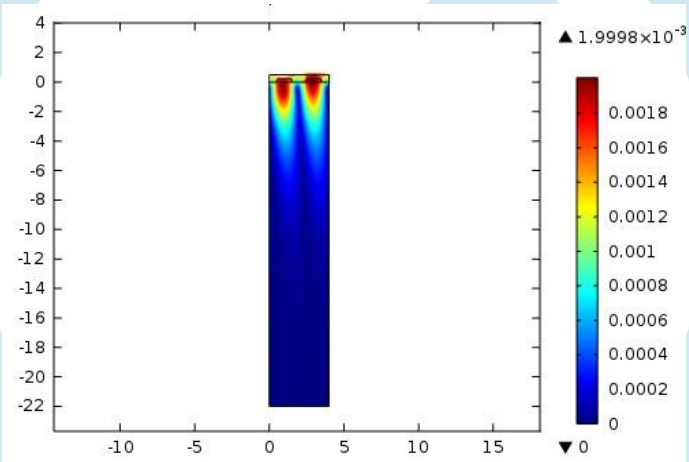
From Eq (1),calculated resonant frequency for magnetite/LiTao3 is 1.18GHz while for magnetite/Al/LiTao3 is 1.31GHz. Table 1 synopses the distinction in recurrence move and dislodging at the surface of device when presented to 1ppm drain test.

Table 1: Difference in qualities of the structure after presentation to Milk sample

Structure	Before Exposure to milk sample	After exposure to milk sample	Frequency shift	Displacement
Magnetite/ Al/liTao3	1.3182516861 7	1.3182507763	909.79	2.48



(a) Figure 2. Displacement plot of Multi-layered Sturcture after presentation to Milk Sample for eigen frequency 8.377



(b) Figure 2. Displacement plot of Multi-layered Sturcture after presentation to Milk Sample for eigen frequency 8.489

From Table (1), it can be obviously observed that multi-layered structure i.e. Magnetite/Al/liTao3 is more delicate towards milk test and shows greater relocation. From table (2) it shows material used for the design of sensor. Additionally from fig 2(a),displacement on the surface of structure magnetite/LiTa03 reflects in the upper piece of piezoelectric substrate and also in the detecting layer though from fig.2(b) it can be portrayed that relocation is more limited to the detecting layer for multilayered structure i.e .Magnetite/Al/LiTao3.

Fig3 and fig4 demonstrates the electric potential dispersion in the Magnetite/Al/LiTao3 device when presented to milk sample. It can be seen that potential is symmetric as for the cathodes.

Table2:It shows various types of material used to design estrogen detection sensor

SI.NO	Substrate Material	Transducer Material	Sensing Material
1)	Quartz	Aluminium	Polypyrrole coated magnetite nanoparticles
2)	Lithium Tantalate (LiTao3)	Tungsten	DNA apatmer coated gold nanoparticles
3)	Lithium Niobate (LiNbo3)		
4)	Langasite		

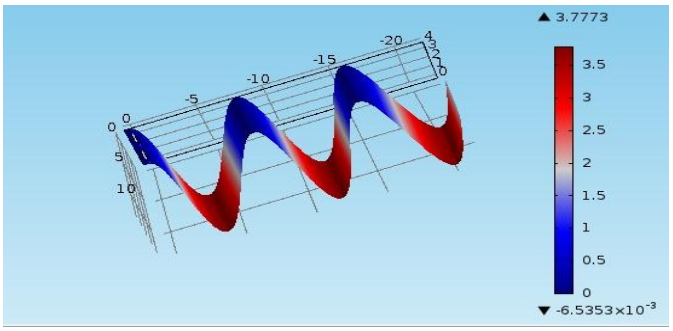


Figure3:Electric Potential distribution in Magnetite/Al/LiTao3 device for Eigen frequency 8.377181e8

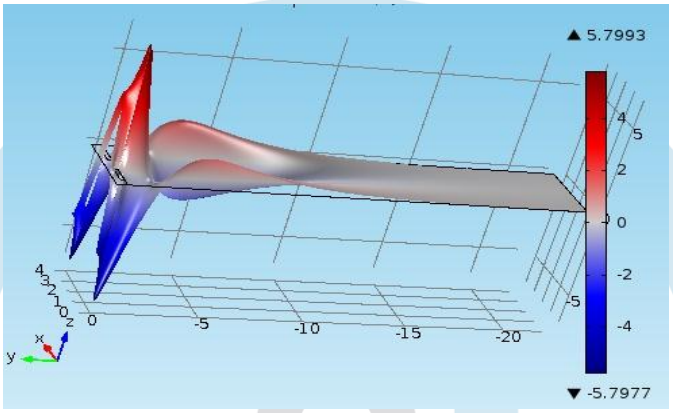


Figure4:Electric Potential distribution in Magnetite/Al/LiTao3 device forEigen Frequency 8.489842e8

B. Sensitive capability of sensor towards concentrations of milk sample

As the centralization of milk test builds more Estrogen particles can be identified at the surface of detecting layer. It causes more unsettling influences in spread way of surface acoustic waves and this outcome in increment in recurrence move with increment in grouping of Estrogen atoms, progressively the move in recurrence is more is the affectability of sensor.

Affectability of sensor with spacer and without spacer increments with increment in grouping of milk test. Likewise as announced multi-layered outline with spacer is more sensitive capability.

C. Frequency Shift Vs Spacer Thickness

It shows effect of thickness of spacer layer ie Al on the behavior of sensor Magnetite/Al/LiTao3. From the plot it can be clearly seen that sensitivity of device increases with increase in thickness of spacer layer.

D. Effect of Environmental Conditions

Effect of temperature and pressure on Magnetite/Al/LiTao3 is studied. and It shows the how surface acoustic waves travelling on the surface of sensor are effected when temperature is varied. It can be clearly observed that frequency shift decreases with increase in temperature.

As temperature increases in the environment the milk sample get spoiled or spread out losing the contact with sensor. Hence less number of Estrogen molecules is absorbed on the surface of sensor which causes less modification in the surface acoustic waves.

5.0 CONCLUSION

Multi-layered structure Magnetite/Al/LiTao3 shows more sensitivity towards Estrogen Hormone than single layered Magnetite/LiTao3.As the thickness of spacer layer is increased , frequency shift increases. Also space layer make it possible to keep the displacement and surface acoustic waves more confined to surface sensor and also protecting electrodes and substrate and thus increasing its durability and such sensor keeps potential to be used at the hospital to detect Estrogen molecule levels and preventing it from side effects.

6.0 FUTURE SCOPE OF WORK

Various other good sensing material or good receptors can be investigated for spacer layer or detector layer and analysis can be performed to know the best suited material. Different IDT materials can also be analyzed.

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