Design Of MEMS Sensor For Generating The Vibration In A DNA Sequencing

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Abstract- *Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. Biomedical sensors are used to gain the information on body and pathology. Biomedical sensors are also used to monitor the safety of medicines, food, environmental conditions and other substances. - Electrochemical biosensors are simple devices based on the measurements of electric current, ionic or conductance changes carried out by bio electrodes.It is the type of biosensors based on the sensor devices and the type of biological material used. DNA sequencing is the process of determining the precise order of nucleotides within a DNA molecule. It include any method or technology that is used to determine the order of the four bases-adenine, guanine, cytosine, and thymine-in a strand of DNA. CMOS plate is used for making the resonator. A resonator used for changing the capacitance charge.When add blood drop as a sample of DNA that drop will be excite and vibrate. Due to that vibration of resonator a change in frequency takeplace due to variable frequency an EMF is induced and high frequency vibration generated by resonator sequence the DNA. The project describe design of mems sensor for generating the vibration in a dna sequencing. Simulation is done in Comsol multi-physics. The most commonly used enzymes are the dna selective enzymes.*

Keywords- Electrochemical Biosensor, Dna Sequencing, Mems Sensor, Electrode.

I. INTRODUCTION

MEMS are fabricated by microelectronics manufacturing techniques. They are coupled devices since they consist of small scale electrical and mechanical components for specific purpose. The mechanical behavior of MEMS is in general coupled with the electrical behavior. Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter into a signal which can be measured electrically. Sensor principles are based on physical or chemical effects. Biomedical sensors are used to gain the information on body and pathology, which is a branch of biomedical engineering. Biomedical sensors are also used to monitor the safety of medicines, food, environmental conditions and other substances. The most frequently used different types of sensors are classified based on the quantities such as Electric current or Potential or Magnetic or Radio sensors, Humidity sensor, Fluid velocity or Flow sensors, Pressure sensors, Thermal or Heat or Temperature sensors, Proximity sensors, Optical sensors, Position sensors, Chemical sensor, Environment sensor, Magnetic switch sensor , etc.

An electrochemical biosensor is a self-contained integrated device, which is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element (biochemical receptor) which is retained in direct spatial contact with an.electrochemical transduction element. Because of their ability to be repeatedly calibrated, we recommend that a biosensor should be clearly distinguished from a bioanalytical system, which requires additional processing steps, such as reagent addition. A device that is both disposable after one measurement, i.e. single use, and unable to monitor the analyte concentration continuously or after rapid and reproducible regeneration, should be designated a single use biosensor. Biosensors may be classified according to the biological specificity-conferring mechanism or, alternatively, to the mode of physico-chemical signal transduction. The biological recognition element may be based on a chemical reaction catalysed by, or on an equilibrium reaction with macromolecules that have been isolated, engineered or present in their original biological environment. In the latter cases, equilibrium is generally reached and there is no further, if any, net consumption of analyte(s) by the immobilized biocomplexing agent incorporated into the sensor. Biosensors may be further classified according to the analytes or reactions that they monitor: direct monitoring of analyte concentration or of reactions producing or consuming such analytes; alternatively, an indirect monitoring of inhibitor or activator of the biological recognition element (biochemical receptor) may be achieved. A rapid proliferation of biosensors and their diversity has led to a lack of rigour in defining their performance criteria. Although each biosensor can only truly be evaluated for a particular application, it is still useful to examine how standard protocols for performance criteria may be defined in accordance with standard IUPAC protocols or definitions. These criteria are recommended for authors, referees and

educators and include calibration characteristics (sensitivity, operational and linear concentration range, detection and quantitative determination limits), selectivity, steady-state and transient response times, sample throughput, reproducibility, stability and lifetime.

A biosensor can be defined as a "compact analytical device or unit incorporating a biological or biologically derived sensitive recognition element integrated or associated with a physio-chemical transducer". There are three main parts of a biosensor: (i) the biological recognition elements that differentiate the target molecules in the presence of various chemicals, (ii) a transducer that converts the biorecognition event into a measurable signal, and (iii) a signal processing system that converts the signal into a readable form. The molecular recognition elements include receptors, enzymes, antibodies, nucleic acids, microorganisms and lectins. The five principal transducer classes are electrochemical, optical, thermometric, piezoelectric, and magnetic .The majority of the current glucose biosensors are of the electrochemical type, because of their better sensitivity, reproducibility, and easy maintenance as well as their low cost. Electrochemical sensors may be subdivided into potentiometric, amperometric, or conductometric types Enzymatic amperometric glucose biosensors are the most common devices commercially available, and have been widely studied over the last few decades. Amperometric sensors monitor currents generated when electrons are exchanged either directly or indirectly between a biological system and an electrode.

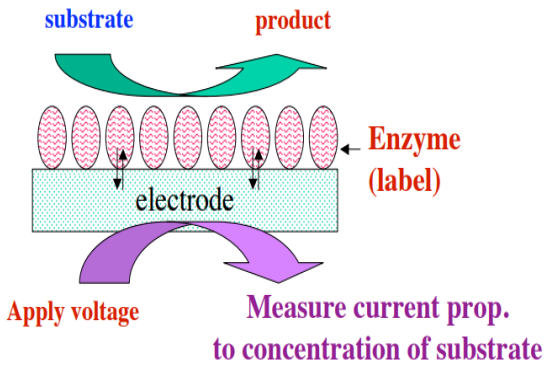

Fig-1: Sensor Design

II. ELECTROCHEMICAL BIOSENSOR

Electrochemical biosensors devices transform the effect of the electrochemical interaction analyte electrode into a useful signal. Such effects may be stimulated electrically or may result in a spontaneous inter-action at the zero-current condition.Electrochemical biosensors provide an attractive means to analyze the content of a biological sample due to the direct conversion of a biological event to an electronic signal. Electrochemical sensors and biosensors have as of late discovered broad applications in different commercial ventures. These days, numerous scientific instruments utilized as a part of natural, nourishment, pharmaceutical, or clinical labs furthermore the greater part of the business purpose of-consideration gadgets work utilizing synthetic sensors or biosensors, in general or a fundamental part. pH cathodes are the imperative and known cases of the electrochemical sensors.

An electrochemical biosensor is a self-contained integrated device, which is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element (biochemical receptor) which is retained in direct spatial contact with an.electrochemical transduction element. Because of their ability to be repeatedly calibrated, we recommend that a biosensor should be clearly distinguished from a bioanalytical system, which requires additional processing steps, such as reagent addition. A device that is both disposable after one measurement, i.e. single use, and unable to monitor the analyte concentration continuously or after rapid and reproducible regeneration, should be designated a single use biosensor. Biosensors may be classified according to the biological specificity-conferring mechanism or, alternatively, to the mode of physico-chemical signal transduction. The biological recognition element may be based on a chemical reaction catalysed by, or on an equilibrium reaction with macromolecules that have been isolated, engineered or present in their original biological environment. In the latter cases, equilibrium is generally reached and there is no further, if any, net consumption of analyte(s) by the immobilized biocomplexing agent incorporated into the sensor. Biosensors may be further classified according to the analytes or reactions that they monitor: direct monitoring of analyte concentration or of reactions producing or consuming such analytes; alternatively, an indirect monitoring of inhibitor or activator of the biological recognition element (biochemical receptor) may be achieved. A rapid proliferation of biosensors and their diversity has led to a lack of rigour in defining their performance criteria. Although each biosensor can only truly be evaluated for a particular application, it is still useful to examine how standard protocols for performance criteria may be defined in accordance with standard IUPAC protocols or definitions. These criteria are recommended for authors, referees and educators and include calibration characteristics (sensitivity, operational and linear concentration range, detection and quantitative determination limits), selectivity, steady-state and transient response times, sample throughput, reproducibility, stability and lifetime.

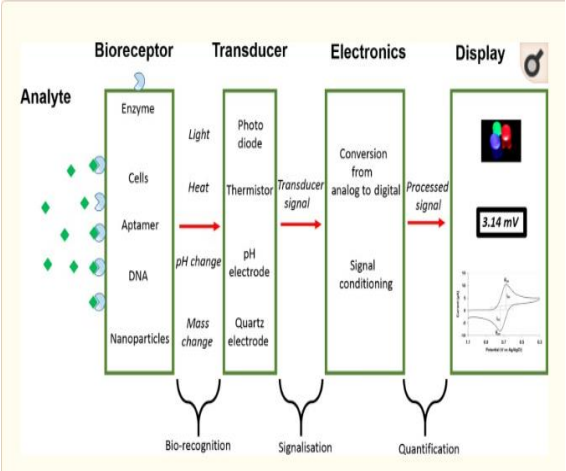

Figure 2: Schematic of electrochemical biosensor

III. DNA SEQUENCING

DNA sequencing is the process of determining the precise order of nucleotides within a DNA molecule. It includes any method or technology that is used to determine the order of the four bases—adenine, guanine, cytosine, and thymine—in a strand of DNA. The advent of rapid DNA sequencing methods has greatly accelerated biological and medical research and discovery.

Knowledge of DNA sequences has become indispensable for basic biological research, and in numerous applied fields such as medical diagnosis, biotechnology, forensic biology, virology and biological systematics. The rapid speed of sequencing attained with modern DNA sequencing technology has been instrumental in the sequencing of complete DNA sequences, or genomes of numerous types and species of life, including the human genome and other complete DNA sequences of many animal, plant, and microbial species.

The first DNA sequences were obtained in the early 1970s by academic researchers using laborious methods based on two-dimensional chromatography.

All living things contain a map for the development and function of the organism encoded within their DNA, also known as their genome. In the 1970s, Frederick Sanger, developed Sanger Sequencing. Although the introduction of Sanger sequencing was revolutionary for science at the time, and won Sanger his second Nobel Prize, the length of genetic material that could be decoded limited the technique. Sequencing entire genomes was incredibly time-consuming and prohibitively expensive. By reading sequences of multiple DNA fragments and even multiple samples at the same time, Next Generation Sequencing can deduce the sequence of a genome at a much faster rate and lower cost.

hundreds of genes at a time or sequencing samples with a low amount of starting material However, both Sanger sequencing and Next Generation Sequencing have their place in molecular biology! When you only need to know the sequence of a short fragment or to simply identify particular marks within the genome (such as microsatellites, which are sensitive enough to be used for paternity analysis), Sanger sequencing is more applicable. Next generation sequencing is best for examining.

IV. LITERATURE REVIEW

Pradyumna S.Singh[1] Showed , “From Sensor to system: CMOS-Integrated Electrochemical Biosensor”. Electronic detection techniques are being increasingly sought as components of highly scalable technologies for high-throughput biosensing application.Advancement in nano scale electrochemistry makes this an opportune moment to consider the prospects of its integration with CMOS process.It focuses on the new properties & challenges that emerge from the downscaling of electrode dimension on redox-cycling based approaches to nanoscale electrochemical devices.

S. Sarkar, K. Mathwig, S. Kang, A. F. Nieuwenhuis, and S. G. Lemay [2] showed a Redox cycling without reference electrodes**.** The reference electrode is a key component in electrochemical measurements, yet it remains a challenge to implement a reliable reference electrode in miniaturized electrochemical sensors. Here we explore experimentally and theoretically an alternative approach based on redox cycling which eliminates thereference electrode altogether. We show that shifts in the solution potential caused by the lack ofreference can be understood quantitatively, and determine the requirements for accurate measurements in miniaturized systems in the absence of a reference electrode.

C. Ma, N. M. Contento, and P. W. Bohn [7] it presents Redox cycling on recessed ring-disk nanoelectrode arrays in the absence of supporting electrolyte. In canonical electrochemical experiments, a high-concentration background electrolyte is used, carrying the vast majority of current between macroscopic electrodes, thus minimizing the contribution of electromigration transport of the redox-active species being studied. In contrast, here large current enhancements are achieved in the absence of supporting electrolyte during cyclic voltammetry at a recessed ring-disk nanoelectrode array (RRDE) by taking advantage of the redox cycling effect in combination with ion enrichment and an unshielded ion migration contribution to mass transport.

E. Kätelhön, K. J. Krause, K. Mathwig, S. G. Lemay, and B. Wolfrum [3] showed Noise phenomena caused by reversible adsorption in nanoscale electrochemical devices. We theoretically investigate reversible adsorptionin electrochemical devices on a molecular level. To this end, a computational framework is introduced, which is based on 3D random walks including probabilities for adsorption and desorption events at surfaces. We demonstrate that this approach can be used to investigate adsorption phenomena in electrochemical sensors by analyzing experimental noise spectra of a nanofluidic redox cycling device. The evaluation of simulate and experimental results reveals an upper limit for the average adsorption time of ferrocene dimethanol of ∼200 μs. We apply our model to predict current noise spectra of further electrochemical experiments based on interdigitated arrays and scanning electrochemical microscopy.

Y. Huang, Y. Liu, B. L. Hassler, R. M. Worden, and A. J. Mason [9] showed A protein-based electrochemical biosensor array platform for integrated Microsystems. This paper elucidates challenges in integrating different classes of proteins into a microsystem and presents an electrochemical array strategy for heterogeneous protein-based biosensor.The overlapping requirements and limitations imposed by bio interface formation, electrochemical characterization, and microsystem fabrication are identified. A planar electrode array is presented that synergistically resolves these requirements using thin film Au and Ag/AgCl electrodes on a dielectric substrate. Using molecular self-assembly, electrodes were modified by nano-structures of two diverse proteins, alkali ion-channel protein and alcohol dehydrogenase enzyme. Electrochemical impedance spectroscopy and cyclic voltammetry measurements were performed to characterize sensor response to alkali ion and alcohol, respectively.

Design of electrode

MEMS are fabricated by microelectronics manufacturing techniques. They are coupled devices since they consist of small scale electrical and mechanical components for specific purpose. The mechanical behavior of MEMS is in general coupled with the electrical behavior. A cantilever is a rigid structural element, such as a beam or a plate, co-ordinate at one end to a support. Membranes, bridges and cantilevers are the basic's mechanical structures of MEMS. Their typical dimension varies from a few micrometers to a few millimeters. A structure having a cantilever configuration is a basic element of most MEMS actuators and sensors such as switches, capacitive pressure sensors, accelerometers, filters, resonators and many others [4]. The major advantages are their versatility and fabrication steps simplicity. The interest in cantilevers has driven investigations from various aspect including static and dynamic performances under certain influences such as potential fields. The electrostatic actuation is commonly used in MEMS devices, where pull-in voltage represents a topic of high interest in the study of micro-beams such as suspended cantilevers.

In MEMS, the shock due to electrical actuation can cause failures inducing large deflection of cantilevers, which may lead to device failure. Therefore, the concern of designers is to investigate how to prevent such problems. For this purpose, several analytical and numerical methods of modeling were used as a design tool for understanding the mechanical behavior of microstructures.

In this paper, we present the mechanical behavior simulation of MEMS based cantilever beam made of poly-silicon; which is the most common structural materials used for a large variety of MEMS applications. In this simulation we have used COMSOL MULTIPHYSICS through the couplings of three modes: -

The plane strain and electrostatics (ES) modes from MEMS module.

- Moving mesh (ALE) from COMSOL module.

The main objective of this study is to acquire MEMS devices design ability in terms of design rules and multidisciplinary approach in order to build reliable microsystem[7].

From the literature we have to note that different shape of cantilevers is used as shown in figure 1; mostly they have a characteristic length around 0.5 mm, thickness ranging from 3 to 8 μm and electrode gaps nearby 10 μm.

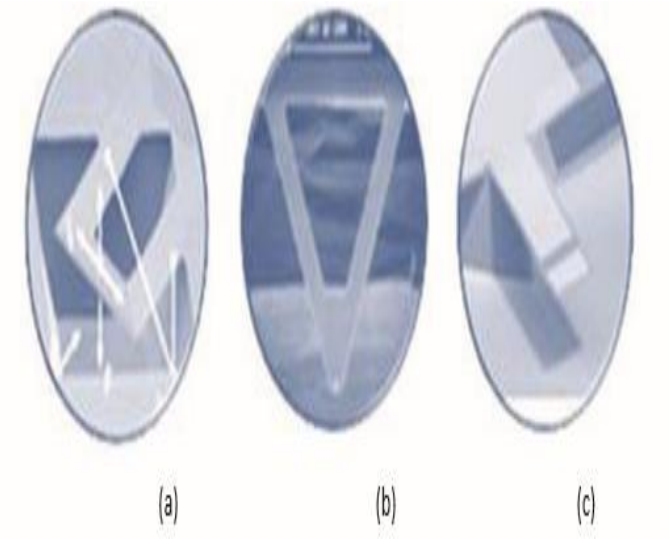

Fig-3: Different Types Of Micro-cantilevers Used In MEMS Devices

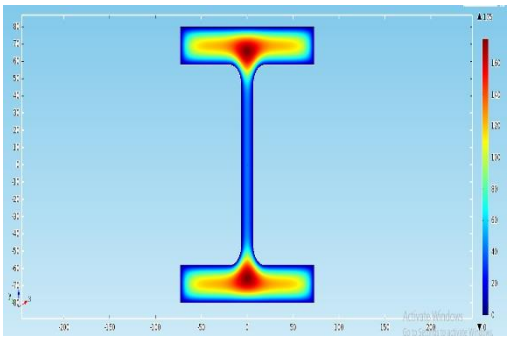

Fig-4 Design Of Eletrode
(Beam Shape Electrode)

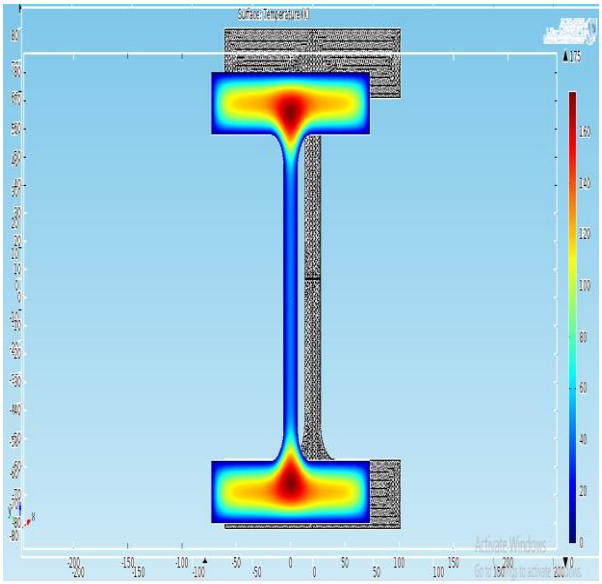

Fig -5 Electrode in mesh form

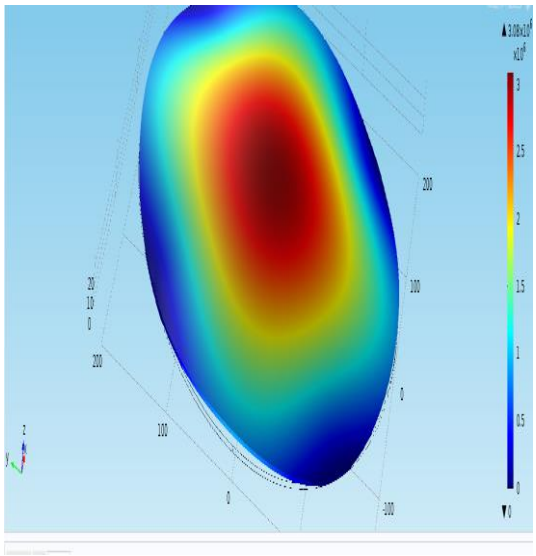

Fig 6 disk shape of electrode

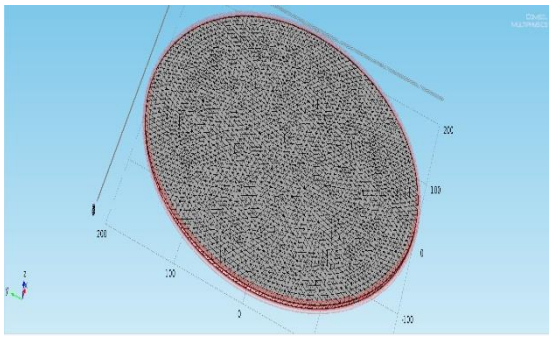

FIG 7 disk electrode in mesh form

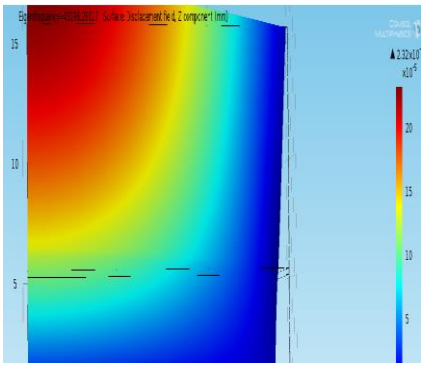

FIG 8: square shape of electrode

Fig9: square shape electrode in mesh form

As we see in the fig 4 it is a design of electrode in that it divided into 3 parts the upper one is anode lower one is cathode and middle one is output.and it also contain the air gap in anode and cathode because air gap helps to generate the high voltage . in this firstly we have to set the range limit after that when blood passes through that air gap if the glucose level is in that limit which we have set then it get laps and it generate the frequency. For make it self powered we have to defined in various frequency level. After that in fig 6 that electrode convert into mesh form with the help of geometry in comsol multiphysics and in fig 7 it shows the height of electrode as we reduced the height of electrode to generate the high voltage.

Result

Fig 7 conductivity of electrode(1)

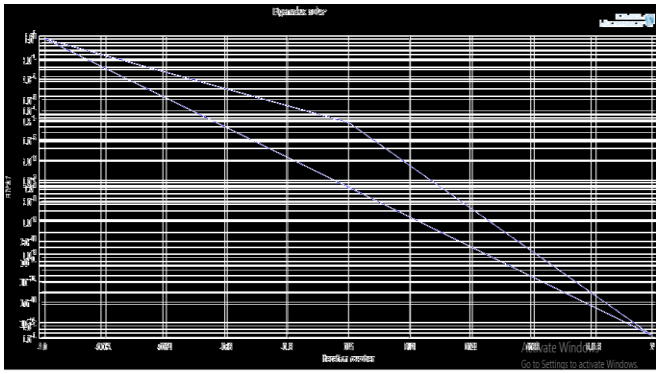

Fig 8 conductivity of electrode(2)

In the above figure it show the result of conductivity of electrode between the anode and cathode. Conductivity specified the material conducts electricity, calculated as the ratio of the current density in the material to the electric field which causes the flow of current.

Application

1) In the discipline of medical science, the applications of biosensors are growing rapidly. Glucose biosensors are widely used in clinical applications for diagnosis of diabetes mellitus, which requires precise control over blood-glucose levels.

2) Glucose biosensors have evolved to be more reliable, rapid, and accurate and are also more compact and easy to use.

3) The monitoring of glucose levels in fermentation, bioreactors, and to control glucose in vegetal raw material and food products.

4)Enzymatic glucose biosensor use an electrode instead of O_2 to take up the electrons needed to oxidize glucose and produce an electronic current in proportion to glucose concentration.

5) It also helps remove oxygen from food packaging, or D-glucose from egg white to prevent browning.

V. CONCLUSION AND FUTURE SCOPE

In the propose work the DNA structure gate channelized in a single structure vary efficiently as high frequency vibrations are generated by the resonator. Because of high frequency of resonator large value of EMF is induced corresponding to the value of DNA structure.

Future scope is the enormous activity in the field of DNA biosensors is a reflection of the major clinical importance. . Major fundamental and technological advances have been made for enhancing the capabilities and improving the reliability of glucose measuring devices. Such intensive activity has been attributed to the tremendous economic prospects and fascinating research opportunities associated with glucose monitoring. The success of glucose blood meters has stimulated considerable interest in in-vitro and in-vivo devices for monitoring other physiologically important compounds.

As this field enters its fifth decade of intense research, we expect significant efforts that couple the fundamental sciences with technological advances. This stretching of the ingenuity of researchers will result in advances including the use of nanomaterials for improved electrical contact between the redox center of GOx and electrode supports, enhanced "genetically engineered" GOx, new "painless" invitro testing, artificial (biomimetic) receptors for glucose, advanced biocompatible membrane materials, the coupling of minimally invasive monitoring with compact insulin delivery system, new innovative approaches for noninvasive monitoring, and miniaturized long-term implants.

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