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Review Paper On Design Of Electrode To Make It Self-powered

Ms. Sonali V. Turale[1], Dr. Pankaj Agrawal[2]

[1]MTech,Dept. Of Electronics & Communication Engineering, GHRAET, Maharashtra, India
[2]Hod, Dept. Of Electronics & Communication Engineering, GHRAET, Maharashtra, India

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Abstract - *Blood glucose monitoring has been established as a valuable tool in the management of diabetes. Since maintaining normal blood glucose levels is recommended, a series of suitable glucose biosensors have been developed. glucose biosensor technology including point-of-care devices, continuous glucose monitoring systems and noninvasive glucose monitoring systems has been significantly improved. However, there continues to be several challenges related to the achievement of accurate and reliable glucose monitoring. Further technical improvements in glucose biosensors, standardization of the analytical goals for their performance, and continuously assessing and training lay users are required. Our objective is to design electrode for a sensor to genrate high value of voltage. Electrode should be design of such material that it should generate an EMF. The output voltage generate with the help charge pump. A charge pump is a kind of DC to DC converter that uses capacitors as energy storage element to create either a higher or lower voltage power source.*

KeyWords: **GLUCOSE BIOSENSOR, CANTILEVER ELECTRODE, POINT-OF-CARE TESTING, SELF-MONITORING OF BLOOD GLUCOSE, AIR GAP**

1. 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. Here we describe the characterization of a self-powered glucose biosensor that is capable of generating electrical power from the biochemical energy stored in glucose to serve as the primary source of power for microelectronic devices. . The most commonly used enzymes are the glucose selective enzymes, glucose oxidase and glucose dehydrogenase and oxygen reducing enzymes, laccase and bilirubin oxidase as the bioanode and biocathode enzymes. Significant research efforts have been made to develop enzymatic-based biofuel cells, which generate bioelectricity via oxidation-reduction (redox) reactions.

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.

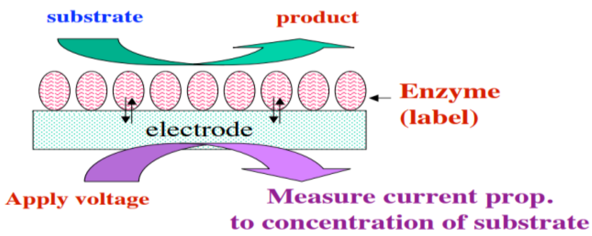

Fig-1: Sensor Design

2. Glucose Monitoring

2.1. Glucose Monitoring Methods in Blood

As a preventative treatment or cure for diabetes is yet to be developed, managing the life impeding conditions of this disease is currently the most successful means for its control. Monitoring glucose levels in blood, as a disease marker, has proven to prolong life expectancy by enabling diabetics to manage episodes of hypo- or hyperglycaemia, hence providing better control over their condition and preventing some of the debilitating side effects. In addition, glucose monitoring can be used to optimise patient treatment strategies, and provide an insight into the effect of medications, exercise and diet on the patient. Although blood-glucose monitoring is the gold standard medium for glucose sampling, measurements carried out in this fluid are invasive. Blood-glucose concentrations are typically in the range of 4.9–6.9 mM for healthy patients, increasing to up to 40 mM in diabetics after glucose intake. Electrochemical sensors were chosen for blood-glucose measurements due to their high sensitivity, on the order of µM to mM, good reproducibility and ease of fabrication at relatively low cost. GOx was employed as the enzymatic basis for the sensor, owed to its high selectivity for glucose. Less common enzymes, such as hexokinase and glucose-1dehydrogenase were also used for glucose measurements, but GOx can tolerate extreme changes in pH, temperature and ionic strength in comparison with other enzymes. Withstanding these conditions can be important during any manufacturing processes, making it a prime candidate for glucose monitoring devices. GOx catalyses the oxidation of glucose to gluconolactone in the presence of oxygen, while producing hydrogen peroxide (H2O2) and water as by-products. Gluconolactone further undergoes a reaction with water to produce the carboxylic acid product, gluconic acid. GOx requires a redox cofactor to carry out this oxidation process, where flavin adenine dinucleotide (FAD+) is employed. FAD+ is an electron acceptor which becomes reduced to FADH2 during the redox reaction. Subsequent reaction with oxygen to produce H2O2 regenerates the FAD+ cofactor. This reaction occurs at the anode, where the number of transferred electrons can be correlated to the amount of H2O2 produced and hence the concentration of glucose[9].

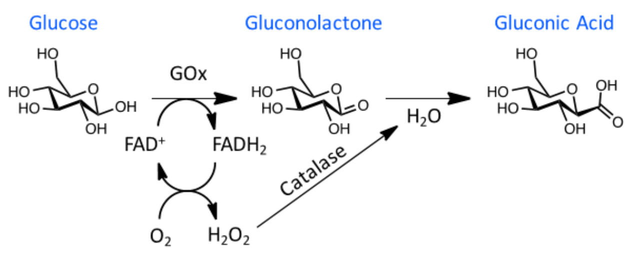

Fig-2: Conversion Of Glucose To Gluconic Acid Using Glucose Oxidase.

In the sensor design it present indirect quantification of glucose concentrations was achieved by placing a thin layer of the GOx enzyme on a platinum electrode via a semipermeable dialysis membrane. This sensor measured the decrease in oxygen concentration and the liberation of hydrogen peroxide, which was proportional to the glucose concentration. The main obstacle to overcome with this approach was the interference of other electroactive species present in blood, such as ascorbic acid and urea.

3.Design of electrode

3.1 Cantiliver 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.

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.

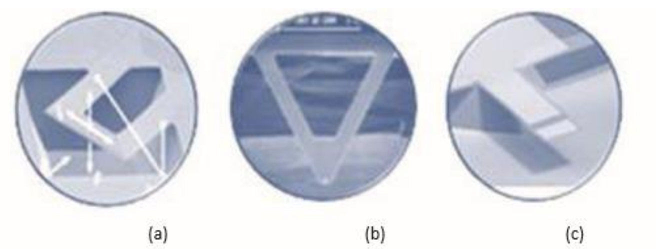

Fig-3: Different Types Of Micro-cantilevers Used In MEMS Devices

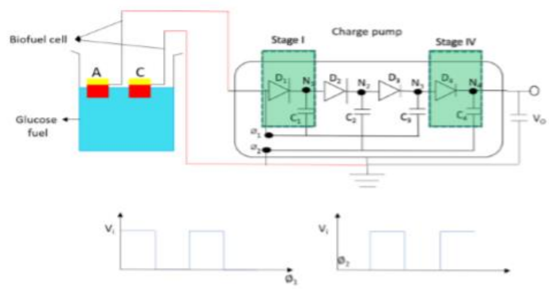

Fig-4: The Construction Of The Self-powered Glucose Biosensor Via A Charge Pump.

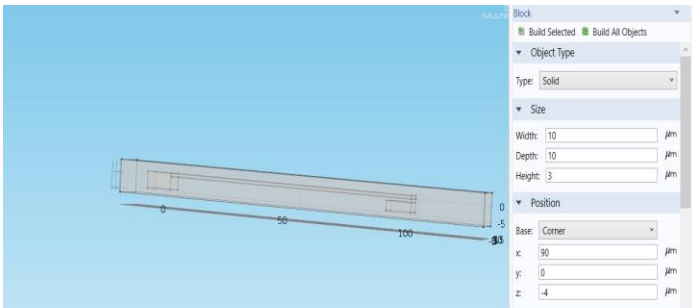

Fig-5: Solid Mechanism Of Electrode

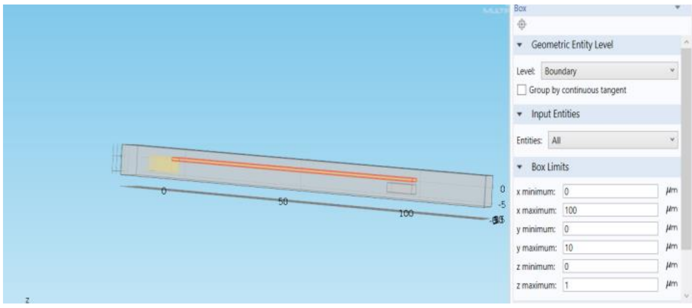

Fig-6: Cantilever Beam

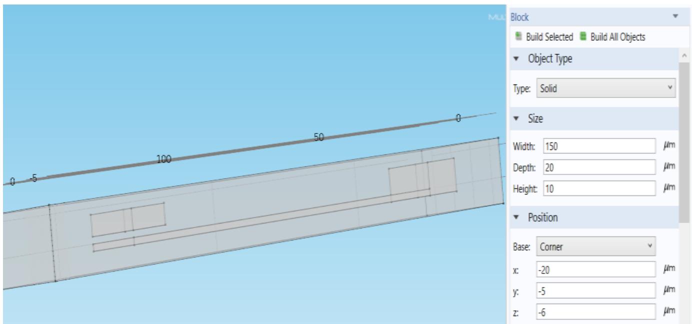

Fig-7: Air Gap Between The Cantilever Beam And Electrode

In fig 4 it shows the The construction of the self-powered glucose biosensor via a charge pump integrated circuit and a capacitor functioning as a transducer. The input voltage, Vi, generated by the biofuel cell was applied to the first stage of the charge pump, where 'ø 1' and 'ø2' are the clock cycles with same amplitude as the input voltage and are complimentary to each other. When ø 1 is ON, odd number stages operate and the capacitor 'C1' gradually charges. At this time instant, clock ø 2 is in OFF state and the charge accumulates at node 'N1'. When ø 2 switches ON, even number stages are active thus, carrying the built up voltage at stage 1 to stage 2. At this time instant, clock signal from ø 1 is OFF and the charge accumulates at node 'N2'. The alternate clock cycle carries the charge towards the output capacitor which results in the amplified output voltage governed by Equation 1.

VOUT = N(VIP)………………………………………….. (1)

where N is the number of stages and VIP represents the input voltage

In fig 5 it shows the solid mechanism of electrode with Width and depth 10µm and height 3µm. and in another fig 6 it shows the cantilever beam such as a beam or a plate, co-ordinate at one end to a support for generating the high voltage. And in fig 6 it shows the air gap this 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.

4. LITERATURE REVIEW

Tanmay Kulkarni and Gymama Slaughter[1] showed the characterization of a self- powered glucose biosensor that is capable of generating electrical power from the biochemical energy stored in glucose to serve as the primary source of power for microelectronic devices. One self-powered glucose biosensor is based on MWCNTs modified with PQQ-GDH and laccase at the bioanode and biocathod .Other employed bilirubin oxidase at the biocathode. The use of bilirubin oxidase biocathode resulted in a 3-fold increase in performance for a single biofuel cell capable of driving a charge pump circuit and enabling the system to function effectively under physiological conditions.

G. Slaughter, T. Kulkarni[2] showed a self-powered glucose biosensor(SPGS) system is fabricated and in vitro characterization of the power generation and charging frequency characteristics in glucose analyte. The bioelectrodes consist of compressed network of three-dimensional multi-walled carbon nanotubes with redox enzymes,pyroquinoline quinone glucose dehydrogenase(PQQ-GDH) and laccase functioning as the anodic and cathodic catalyst. This demonstrate a stable self-powering glucose bio-sensing system constructed by combining a charge pump IC and a capacitor functioning as a transducer with a glucose biofuel cell.

A. Achelia and R. Serhane [7] it presents the studies of mechanical behavior of MEMS cantilever beam made of poly-silicon material, using the coupling of three application modes (plane strain, electrostatics and the moving mesh) of COMSOL Multi-physics software. The cantilevers playing a key role in Micro Electro-Mechanical Systems (MEMS) devices (switches, resonators, etc) working under potential shock.

G. Slaughter, T. Kulkarni[3] it has different types of glucose biofuel cells with emphasis on enzymatic glucose biofuel cells. Unlike conventional fuel cells, which use fuel such as ethanol, methanol, formic acid, etc. to generate electricity, enzymatic glucose biofuel cells convert chemical energy stored in glucose into electricity.

Danielle Bruen, Colm Delaney, Larisa Florea [9] and Dermot Diamond[9] showed highlights recent advances towards non-invasive and continuous glucose monitoring devices, with a particular focus placed on monitoring glucose concentrations in alternative physiological fluids to blood.

5. EXPECTED OUTCOME

The expected outcomes of the proposed work is the ratio of voltage to area of electrode will get reduced higher value of voltage. we achieve with smaller area of electrode by using the chemical properties the material used for designing of electrode. 20 percentage improvement is excepted.

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