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Fabrication of Silver Doped ZnO Nanosensor for Self Design Glucose Monitoring System

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***Abstract*—In the present work electronic nanosensor is developed to detect the presence of glucose in three stages with high accuracy. Silver doped ZnO nanoparticles are synthesized using biosynthesis and wet chemical method for Ag and Ag doped ZnO nanoparticles. The sensor was developed on a silicon substrate and synthesized nanomaterials was aligned over it using spin coating method. The enzyme was immobilized on to the electrode with nanomaterials using drop coating method by keeping the thin film 4^0c for 24 hrs to have a sensitive detection of glucose from the sample.**

The result UV spectral study helps to conformed the Ag Nanoparticles by showing the peak at 450nm wavelength. The crystal structure of fabricated silver doped ZnO nanoparticles was investigated by XRD at the average size of the particles to be 15nm.

In this study we developed the glucose monitoring device using PIC 16F877 microcontroller. The output signals of the nanosensor is fed input to the glucose monitoring system. The IC 741 is helps to amplifies the sensor output signals. Then amplified signal taken as input to the microcontroller. An LCD displays the various glucose concentration based on the condition LOW, NORMAL, HIGH.

Keywords*— *Silver doped ZnO nanoparticles; Glucose sensor; Glucose monitoring system; PIC 16F877

I. Introduction

As diabetes mellitus is rapidly increasing the development of a safe, convenient and continuous blood sugar level monitoring technology is a pressed need throughout the world. Glucose sensors are important biosensor that can be applied in biomedicine[1]. The enzyme glucose oxidase to improve the sensitivity and stability of the sensors. Among the various biosensors, development of glucose biosensor based on nanomaterials has been considered very important due to its application in clinical diagnostics.

In the past several years, nanosensors that directly measures the glucose and nanomaterials that improve glucose sensor fabrication[2] described by *kevin J cash et al*. Amperometric glucose biosensor has been fabricated on the basis of aligned ZnO nanorod grown on ITO published by *Qiong Wu et al*[3]. The extraction of silver nanoparticles from silver precursor using the bark extract and powder of novel cinnamon zeylanicum has been studied *by M. Sathish Kumar* et al.[4]. *Kathiresan et al*. have proposed the extracellular synthesis of silver Nanoparticles by a marine fungus penicillium fellutanum [5]. The sensor were placed in solutions of different glucose concentrations and their resistance was measured and it was found that in a solution of less concentration the resistance was greater.

The glucometer is an electric device converting a signal to a digital value which then shown on the display. *N. Anju Latha et al.*[6] have design and developed of a microcontroller based system for the measurement of blood glucose to display measured value of blood glucose. The MAX232 is a dual line driver/receiver, converts the signal from an RS-232 serial port to TTL compatible signals. Program is developed in C language using for MPLAB IDE for the Microchip Technology, due to the inherent language flexibility, the extent of support and its portability across a wide range of hardware. Working principles of the Amperometric glucose meter proposed by *Cuauhtemoc et al.*[7].

The organization of the paper is as follows: following the introduction in section (2) explains experimental study: A. synthesis of Silver doped ZnO nanomaterials, B. Sensor Fabrication. Result and discussions are explained in section (3). In section (4) explains system development. Finally, conclusion is made by summery of the present work.

II. Experimental

A. *Preparation of Silver doped ZnO nanoparticles*

Synthesis of silver Nanoparticles using biosynthesis method. Biosynthesis method has some advantages like no effect for environment and renewable reducing agent. In this method micro-organisms like fungi, bacteria, algae etc. and plant extracts are used as reducing agents. In our case tuber of plant "Diascoria pentaphylla" is used as reducing agent.

5g tuber powder of Diascoria pentaphylla is dissolved in 100 ml of distilled water. The solution is exposed to hot water bath for 45 minutes, till some of the plant extract completely dissolved in distilled water. Then filtrate is taken using wathman paper No.1. (1mM) of silver nitrate($AgNO_3$) is prepared then add 10 ml of filtrate to 100ml of $AgNO_3$ keep the solution for 20 hour in dark.

For the synthesis of ZnO Nanoparticles 0.2M Zinc Acetate is prepared and 20ml of di-methylene sulphoxide is added. The solution is stirred for 30 mints using magnetic stirrer. 1.2M KOH solution is mixed with 10 ml of ethanol and is added to stirred solution drop wise. Stirring is continued for 5 mints then 0.12ml of thioglycerol and 10ml of silver Nanoparticles solution is added. The solution is then stirred for 1 hour till the solution turns milky. Finally the precipitation is washed with methanol for 2 times. Disperse the particles in methanol.

B. Fabrication of enzymatic Glucose Sensor

The base of the sensor is a silicon substrate in the dimension of 2x1cm. Mainly the substrate is washed with distilled water to remove the surface impurities like dust, colloidal particles etc. Then the 1/4 position of the silicon wafer is masked. The pure and silver doped ZnO dispersed in methanol. The solution was coated on a substrate using Spin coating method and dried using hot air oven at 60^0 for 30 minutes. After drying, uniformity of the coating is ensured.

The enzyme was immobilized on to the electrode with nanomaterials using drop coating method by keeping the thin film 4^0c for 24 hrs to have a sensitive detection of glucose from the sample. Introducing the metal contact using the silver paint it acting as a electrode. Then the sensor were dried naturally.

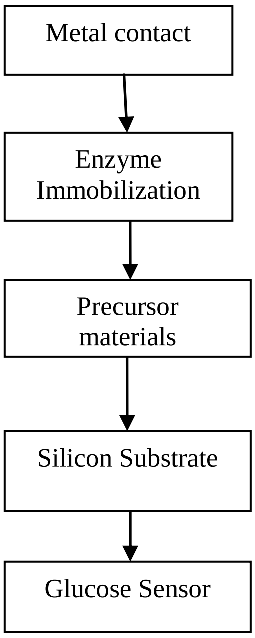

Fig. 1. Flow diagram for the manufacture process of glucose sensor.

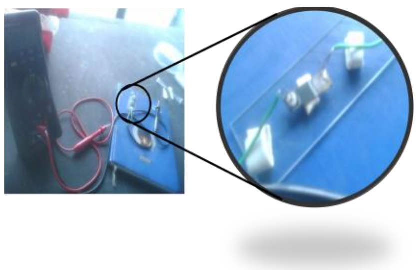

Fig. 2. Experimental setup of enzymatic Glucose Sensor

III. RESULTS AND DISCUSSION

A. Characterization of silver doped ZnO nanoparticles

The visible spectroscopy (UV-1700 Pharma Spec, SHIMADZU) was carried out to study the optical property of the nanoparticles. Figure.1 shows the absorbance spectra of the Ag nanoparticles. The curve peaks at 450nm which is the characteristic feature of Ag nanoparticles

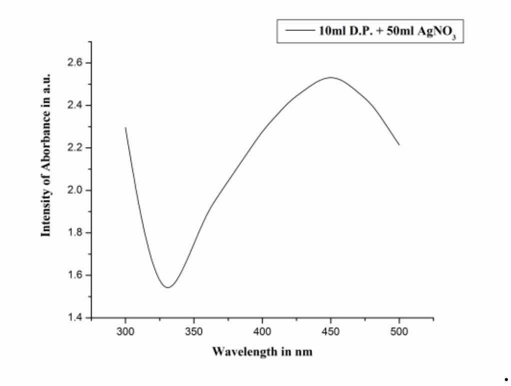

Fig. 3. Absorption Spectrum of the Ag Particles

The formation of Ag nanoparticles were confirmed using XRD. X-ray diffraction pattern was recorded using an X-ray diffractometer (-Hitachi) using Cu Kα radiation of wavelength, λ = 0.15418 nm in the scan range 50 to 600. Using the Scherer's relation, d=Kλ/βcosθ, the primary particle size of the nanoparticles was estimated corresponding to the (101) peak and it is found to be 15.043nm.

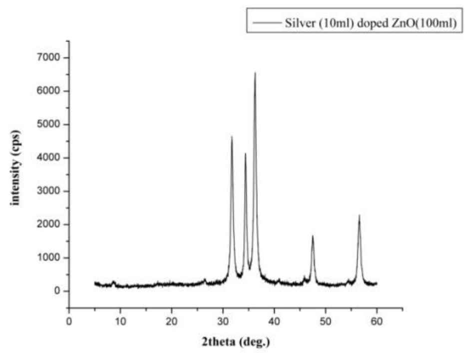

Fig. 4. XRD Pattern of Ag Doped ZnO Nanoparticles

The surface structure of the synthesized nanoparticles was studied using Atomic Force Microscope. The image was obtained using Nanosurf easy Scan 2 Basic AFM/STM package. The figure depicts the uniformity of the nanoparticles with a few tens of nm in diameter. The images taken by considering cross-sectional area 500 nm×500 nm is shown below.

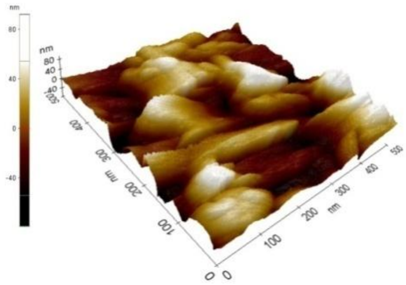

Fig. 5. AFM Image of ZnO nanoparticles coated on Wafer

B. Characterization of Sensor

After each step we should ensure that the sensor fabrication of particular layer was done properly. Here this was done by checking the variation of the resistance using resistance meter. The graph of the resistance versus change in concentration of glucose showed a linearity which ensures the quality of the sensor.

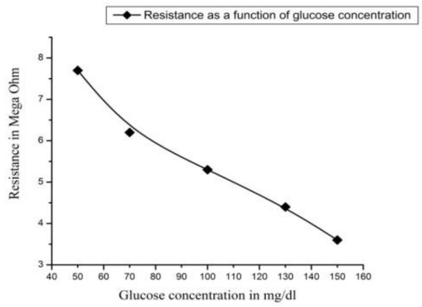

Fig. 6. Graph of resistance versus glucose concentration.

IV. System Designing

A. Hardware Designs

The block diagram of the microcontroller based system for the measurement of glucose is shown in fig.7.

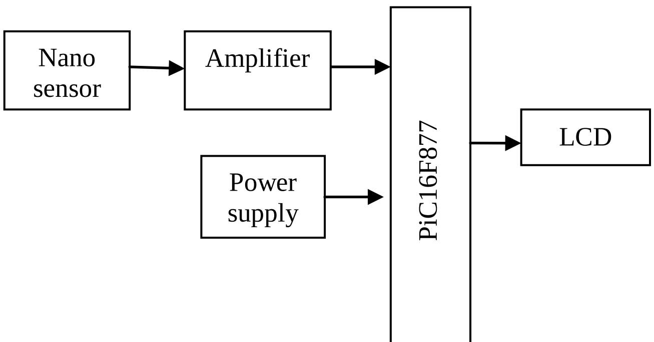

Fig. 7. Block diagram of Microcontroller based system for the measurement of glucose

The basic operation of glucose biosensor is based on the fact that the enzyme glucose oxidase (GOD) catalyses the oxidation of glucose to gluconic acid. The Enzyme acts as a biorecognition element, which recognizes the glucose molecules, acting as transducer. As soon as the enzyme recognizes the glucose molecules, it acts as catalyst to produces gluconic acid and hydrogen peroxide from glucose and oxygen. The electrode recognizes the number of electron transfer due to hydrogen peroxide/oxygen coupling. This electron flow is proportional to the number of glucose molecule present in the blood or glucose concentration. The signals from the glucose sensor are transmitted to the operational amplifier 741 IC.

B. Amplifier Design

The Operational amplifier 741IC is used to amplifying the output response of the sensor. Sensor output will be change in resistance in the terms of Mega ohms. These response range can be amplified using amplifier with feedback resistor (R_F) 1M pot. It is connected to the inverting (-) input as the pin no.2. Nanosensor acts as resistor denoted as R1. One end of the sensor is connected to inverting i/p, on the other hand, another end is connected to the ground.

In the present work the constant dc voltage can be applied to the non-inverting input i.e., pin no.3. Output signal of the amplifier is taken with pin 6 and is directly interfaced with the microcontroller. With the various voltages from the sensor, produced as a result of different concentration of glucose applied on the sensor the glucose monitoring system detects the level of glucose. Considering the various voltage ranges of less than 2V, in between 2V to 3V and greater than 3V, the system displays LOW, NORMAL and HIGH which corresponds to below 70mg/dl, in between 70-130mg/dl, and above 130mg/dl respectively. Table.1. shows the various voltages corresponding to resistance with respect to the different Glucose concentration.

PIC 16F877 microcontroller is CMOS 8-bit flash controller. It consists of five I/O pins, 8-bit analog to digital converter. Amplifier output is taken as input to the Microcontroller 'PORTA' pin number 2. The relative measured Glucose concentration signal are displayed on the 16X2 LCD display.

TABLE I.

Sl. No	Glucose concentration in mg/dl	Resistance in MΩ	Voltages in V
1	50	7.8	3.7
2	70	6.4	3.3
3	100	5.4	2.7
4	130	4.6	2.0
5	150	3.8	1.7

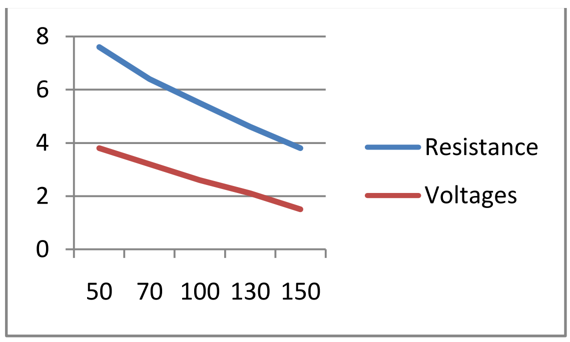

Fig. 8. Relation between the response of glucose concentration, resistance and voltages

C. Software Desing

In our present work includes 'Embedded C' program language. It is help to the Development of Microcontroller based Glucose Monitoring System. A software method of digitally sampling the concentration of glucose level is described. When we contact the sensor with microcontroller automatically detects the presence of sensor, when we drop of glucose sample, it measures the glucose concentration and display the output glucose concentration.

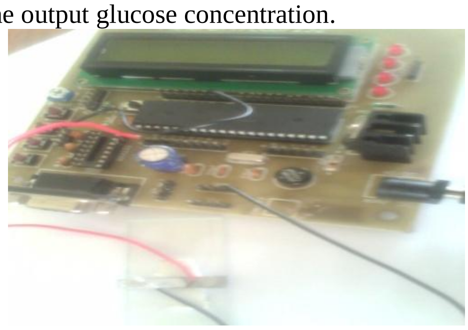

Fig. 9. Developed System

The microcontroller based Glucose monitoring system is designed and developed. The result of the present study, a microcontroller based system, which converts the glucose concentration into voltages compatible with microcontroller input requirements. The microcontroller software determines the glucose concentration related voltage. Once the various glucose concentration applied on the sensor, corresponding values related LOW, NORMAL, HIGH are displayed on the LCD

CONCLUSION

Silver doped ZnO nanoparticles based enzymatic glucose sensor is successfully fabricated whose resistance varies in accordance with the glucose concentration. Silver doped ZnO nanosensors are more sensitive and compatible compare with the previous ZnO nanosensors. A novel real time performance of microcontroller based system for the glucose monitoring system is studied. Silver doped ZnO nanoparticles are synthesized using biosynthesis and wet chemical method for Ag and Ag doped ZnO nanoparticles. The electrical characteristic of the sensor shows variation in resistance for different concentration of glucose solution. The output of the sensor is amplified by using an amplifier designed microcontroller. Microcontroller processes and analyses the amplified voltage and the result will be displayed on 16X2 LCD. A LCD displays the various glucose concentration based on the condition as LOW, NORMAL, and HIGH.

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