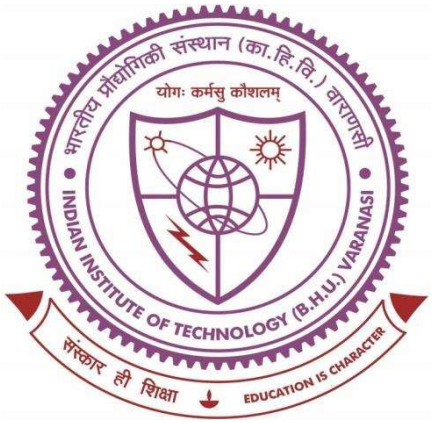
Fabrication and Characterization of CuO Nanostructure based Non-Enzymatic Glucose Sensors



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5.1 Introduction

The main objective of this thesis is to make available CuO nanostructure-based working electrodes for glucose sensing applications. CuO nanowire, CuO nanoparticle, and ZnO nanorod have been used as active materials. This thesis includes three structures of non - enzymatic based glucose sensing. Au nanoparticle/CuO NWs, CuO NWs on Cu foil used an extended gate of FET, CuO NPs/ ZnO NRs used as an extended gate of the FET. In the first structure, CuO nanowire on Cu electrode used as a catalyst, whereas gold nanoparticle on CuO NWs has been used as co-catalyst. In this type of structure, active materials are submerged in 0.1M, 0.5M, and 1M concentrations of (NaOH) along with electrode, Pt counter electrode, and Ag/AgCl (reference electrode).In the second structure, CuO NWs have been used as active materials and connected to the gate of MOSFET, which is submerged in the 100mM PBS solutions (pH=7.4) with Ag/AgCl reference electrode. The third structure is ZnO NRs with CuO NPs also connected to the MOSFET gate and submerged in 100mM PBS solutions with reference electrodes (Ag/AgCl). In the first structure, different concentrations of NaOH are used to get the broader variation of linearity with good sensitivity. The solvent concentration of pH =7.4 has been used in two other structures, which is a nearly neutral medium and suitable for detecting glucose in human blood. This chapter is used to conclude and summarize the works of different chapters of this thesis and discussed in

the following.

5.2 Summary and Conclusion

Chapter-1: discuss the importance of monitoring for which blood glucose sensing is required, different type of glucose sensing has been discussed. A brief history of glucose-sensing has been introduced. Additional glucose-sensing characterization, which is used in this thesis, has been discussed in this chapter. Detail literature survey on enzymatic and non-enzymatic type glucose sensing has been discussed. Metal oxide-based nanostructured (non-enzymatic) glucose sensing has been mainly discussed in this literature survey. This literature survey shows that a lot of opportunities have been present in the area of fabrication and characterizations of CuO nanostructure-based non-enzymatic glucose sensing by using low-cost chemical etching, heating, and hydrothermal techniques. Based on the literature surveys of the 1 chapter, the scope of the thesis has been discussed at the end of this chapter.

Chapter-2: discusses the effect of the active layer of the working electrode on glucose-sensing CuO NWs with gold nanoparticles on copper foil works as an active layer. This active layer has been dipped in different solvent concentrations (0.1M, 0.5M and, 1M of NaOH). The critical observations of this chapter are summarized below.

1. The gold nanoparticles (GNP) have been deposited on CuO NWs electrode using an in-situ chemical reaction. These Au NPs on the surface of CuO NWs increase the electrode's effective surface-to-volume ratio, increasing the catalytic property of the Au NPs modified CuO nanowire.

2. CuO NWs with gold nanoparticles had higher sensitivity as compared to that of

the bare CuO NWs. It is due to better redox property properties of Au Modified CuO NWs.

3. The enhanced properties as mentioned above of the Au NPs modified CuO NWs electrode have been explored for improving the detection capability of the CuO NWs based glucose sensors.

4. The Au NPs modified CuO NWs based glucose sensor understudy in 0.1 M NaOH solution gives a sensitivity of 4398.8 μAmM-1cm-2 with maximum linearity up to 5.9 mM, which is the promising results for any metal oxide-based glucose sensors.

5. The sensitivity of 1591.44 **μ**AM-1cm-2 with a wide linear range up to 44.36mM is observed for the proposed sensor with 1M NaOH. At 0.5M NaOH, the linearity of the sensor was up to 31.05 mM with sensitivity sensors of 1425.69**μ**AM-1cm-2.

6. The proposed glucose sensor can also measure the amount of glucose in human blood in a realistic situation.

Chapter-3: CuO nanowire electrode on copper foil has been fabricated, and fabrication steps have been discussed in chapter2.In this chapter, this working electrode has been connected at the Gate of FET. Working electrode immersed in 100mM PBS solution of pH (7.4) with reference electrode (Ag/AgCl). The major observation of this chapter is discussed below.This paper demonstrates the glucose-sensing capability of a CuO NWs, based on EGFET biosensor.

1. This paper demonstrates the glucose-sensing capability of CuO NWs, based on EGFET biosensor.

2. The enzyme-free glucose detection using the proposed EGFET shows good glucose sensitivity (~3.03mV/mM) and excellent linearity of 99.67%.

3. The sensor can effectively measure the glucose concentration over a wide concentration range (1 mM-12mM), covering the sugar levels of normal healthy persons and moderate diabetic patients.

4. This is the first time enzyme-free/receptor-free glucose detection has been found with the help of EGFET.

5. This sensor is capable of detecting blood glucose levels in human blood in realistic situations.

6. Results are awe-inspiring as compared to that of other commercially available glucose sensors.

Chapter-4: In this chapter, a CuO nanoparticle (NPs) decorated zinc oxide nanorods (ZnO NRs) on fluorine-doped tin oxide (FTO) substrate has been evaluated as a working electrode. This working electrode has been used as an extended gate for field-effect transistors. The main essential observations of this chapter have been discussed below.

1. In this chapter, glucose sensing performance has been done with the help of EGFET. ZnO NRs decorated with CuO NPs on FTO substrate have been used as a sensing electrode. In previously published articles, ZnO NRs modified with

CuO NPs based electrodes have not been used as a glucose-sensing device with EGFET in previously published articles.

2. The sensitivity of this proposed glucose sensing devices is 6.643mV/mM with linearity range (1mM-8mM). Linearity range (1mM-8mM) of this sensor covers the sugar level (3.6mM-6.6mM) of healthy human.
3. Sensing of the glucose has been done without the use of Enzyme and receptor.
4. This vertically grown ZnO nano rod decorated CuO NPs based electrode gives, good repeatability, stability, and reliable selectivity.

5.3 Future Scope of Work

- CuO NWs can be also grown on Polyimide (flexible substrate) and it can be used in photo detectors and gas sensing application.
- ZnO nanorod with CuO NPs can also be used for gas sensing and optoelectronics applications
- Different doping concentrations of gold with CuO NWs can be used for achieving different linearity range of glucose sensing.
- CuO NWs with gold nano particle can be used in photo detectors and gas sensing applications