Glucose Detection Using Disposable Nanosensor

Design Document

Team Number:	1721
Client:	Professor Long Que
Advisers:	Professor Long Que
Team Members/Roles:	Shir Linn Tan (Team Leader) Wai Han Kong (Team Communication Leader) Dalton Strauser (Team Key Concept Holder) XiongSheng Yi (Team Webmaster)
Team Email	May1721@iastate.edu
Team Website	N/A
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1 Introduction

1.1 Project statement

Our project of "glucose detection using a disposable nanosensor sensor" is as the name implies, developing a disposable nanosensor capable of detecting glucose and monitoring it continuously in a certain substance.

1.2 Purpose

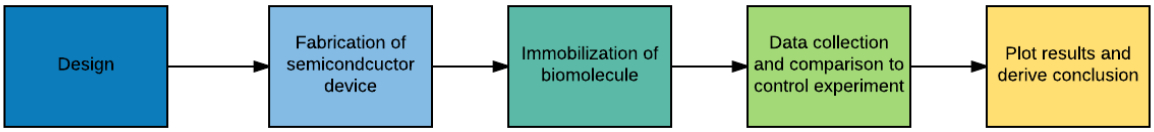
The reason we are working on this project is because currently, the methods of detecting glucose are not efficient enough to provide optimal results due to various complications. In order to alleviate this problem, we are trying to devise a way of utilizing the disposable nanosensor to provide us with a more efficient data collection and data processing method. This project is important because if we succeed, we will be able to provide a stepping stone in the direction of better health care and treatment for diabetics.

1.3 Goals

- Finding a method of detecting glucose with better efficiency by use of the disposable nanosensor
- Constructing a nanosensor that has the ability to monitor glucose level continuously instead of just instantaneously
- Extend model to detect biomolecules other than glucose, such as proteins that show risks for cancer

2 Deliverables

- Developing a nanosensor that has high selectivity and sensitivity to a specific biomolecule
- Developing a nanosensor that is capable of continuous monitoring of glucose concentration
- Well documented and easy to read results which prove our project's efficacy



3 Design

3.1 System specifications

To meet certain criteria with great selectivity and specificity, the Carbon Nanotube Thin Film(CNTF) must have a high sensitivity and be able to detect low levels of glucose across a wide range of concentrations. Aside from that, the nanosensor needs to be selective enough so that we would be able to isolate glucose out of all other biomolecules since the human body has many enzymes and proteins in the bloodstream.

3.1.1 Non-functional

(1) All students working on this project should have prior knowledge of EE432 because the fabrication process of the FET based biosensors have a very similar procedure.

3.1.2 Functional

(1) In MRC lab, fabricate the Carbon Nanotube Thin Film(CNTF) for FET based biosensors.

(2) Make sure the biosensor created has the functionality to detect glucose in a biofluid sample

(3) Develop the biosensor surface functionalization process

3.2 PROPOSED DESIGN/METHOD

For our design, we will be using the FET based biosensor. This consists of a channel in between source and drain electrodes made out of Carbon Nanotube Thin Film(CNTF). The fabrication process of creating the channel will include a combination of both optical microlithography and electrostatic Layer-by-Layer self-assembly deposition.

3.3 DESIGN ANALYSIS

Currently, we have only just started on doing some hand-on work. We still have not arrived at the part of the project where we will be able to do testing on the sensor itself. However, we have worked out that we will be using the enzyme glucose oxidase (GOx) to detect glucose. This enzyme causes the oxidation of glucose and will change the electrical properties of the substrate it is attached to. In our case, the GOx will be attached in the channel of our FET to the CNTF. By monitoring the electrical properties of our CNTF we will be able to accurately determine different levels of glucose. We do not have many technical constraints established at this point which makes explicit design work difficult.

4 Testing/Development

4.1 Hardware/software

Photolithography is often a part of the microlithography process. Photolithography is used to form patterns on the surface of the silicon wafer. The exposure process uses UV light to transfer a pattern from a photomask to the photoresist(light sensitive polymer). The exposed area is weakened and can be dissolved away with a solvent. After this patterning process is complete the underlying material can be modified by diffusion or further etching.

The Layer-by-layer(LbL) self assembly process is a deposition process used to form a thin film on the silicon wafer. The Carbon Nanotube Thin Film(CNTF) is formed by repeatedly depositing layers in the same region. The assembly process includes various type of acid solution with wash steps in between each step. By using a vacuum filtration setup and membrane filter the Carbon Nanotube Thin Film(CNTF) is filtered out from the acid mixture. In the final step, a furnace annealing process is used to remove any water molecules that might be trapped in the thin-films. This annealing process will also makes quantum mechanical tunneling easier.

4.2 Process

As of now, we still have not done any individual testing on each part of the design yet as we have not arrive at the point where we can individually isolate out that specific part and just get a result out of it. Though we expect that in due time, it would be possible for us to do partial testing on our sensor and this part of the design document would have further update in version 2 after we completed our training in the following week.

5 Results

Since we have not started any tests about the project yet, we will show the experimental results in the future design documents version 2.

6 Conclusions

To conclude, our goal for this project is to create a disposable biosensor that could efficiently detect different concentration of glucose in a biofluid. If the process could be easily fabricated and are cost effective, this would contribute to the management of diabetes for research purposes in the future.

7 References

(1) K. Besteman et al, "Enzyme-coated carbon nanotubes as single-molecule biosensors," *Nano Letters*, vol. 3, no. 6, 727-730, Mar. 2003.

(2) T. Zhang et al, "Nanostructured optical microchips for cancer biomarker detection," *Biosensors and Bioelectronics,* vol. 38, no. 1, 382-388, Oct. 2012.

(3) P. Pathank and L. Que, "Characterization of field effect transistor biosensors fabricated using layer-by-layer nanoassembly process," *Journal of Nanoscience and Nanotechnology*, vol. 15, no. 12, 9689-9692, 2015.

(4) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2996880/

(5) http://www.sciencedirect.com/science/article/pii/S0956566312003880

(6) http://pubs.acs.org/doi/pdf/10.1021/nl034139u