# *Glucose Detection Using Disposable Nanosensor*

*Project Plan*

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# Contents

# 1 Introduction

## 1.1 PROJECT STATEMENT

Our group's project is “glucose detection using a disposable nanosensor”. As the project title implies, we are trying to develop a disposable nanosensor as well as develop a method of using one to continuously measure the glucose level in a certain substance. By researching various other existing methods of immobilizing glucose oxidase, we are attempting to find what will best fit our needs. We will be doing lots of testing ourselves in order to get a first hand idea of complications in this area of study.

## 1.2 PURPOSE

Currently, the method of detecting glucose can’t be considered efficient because of various limitations, mainly found in the diagnostic method. As such, this project strives to devise a method of using one of the recently developed nanosensor in an efficient way. We hope it will allow glucose to be monitored in an easier way than is currently available.. This project is beneficial to society due to the fact that glucose detection is an important aspect in detecting and treating diabetes. Diabetes is a rapidly growing problem across the world today and any developments made can help improve many lives.

## 1.3 GOALS

By completing this project, we would also like to expand our model to detect various other biomolecules. For example, levels of certain proteins can mean a higher risk for cancer. Although many of the device parameters would have to be changed, we would like this to be possible by the end of the design project. The future of the biomedical field will likely be largely assisted by nanotechnology, and we hope our project can be a part of that.

# 2 Deliverables

We need to make sure the nanosensor has a high selectivity and sensitivity to the targeted molecule. This is so that we can be sure that the nanosensor is not affected by various other substance that didn’t account for during the data collection process. A way for this project to be an even greater success, we could develop a nanosensor to monitor glucose continuously instead of instantaneously. By doing that, we can keep a close watch on the glucose level and even attain optimal control on it.

# 3 Design

## 3.1 Previous work/literature

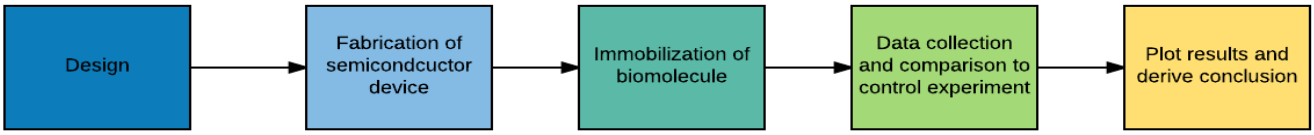
Our project is to create a nanoscale biosensor that can detect glucose levels in blood. We have read about three different approaches for creating these devices. The first research paper we read was Enzyme-Coated Carbon Nanotubes as Single-Molecule Biosensors by Besteman, Lee, et al (1). They were able to use a single walled carbon nanotube (SWNT) attached with the redox enzyme glucose oxidase (GOx) to measure glucose levels in bio-fluid. Conductance is the electrical property they measured to measure the change in glucose levels. When GOx is immobilized on the surface of the SWNT, conductance decreases. However, when glucose is added to the liquid surrounding the SWNT, conductance increases, nearly as step function. This methodology has several advantages. First, it demonstrates that an individual SWNT can be a biosensor and can be as small as 20nm in length. Second, the device is very sensitive, as it can detect changes of 0.1 pH. Finally, the device has good selectivity because the data shows that the GOx activity is the sole cause of the change in conductance, not simply the capacitance of the SWNT or the pH of the liquid. However, this design is not without issues. It is costly and difficult to produce SWNTs. Also, the fabrication is highly variable and it would be hard to create consistent SWNTs with all of the same parameters.

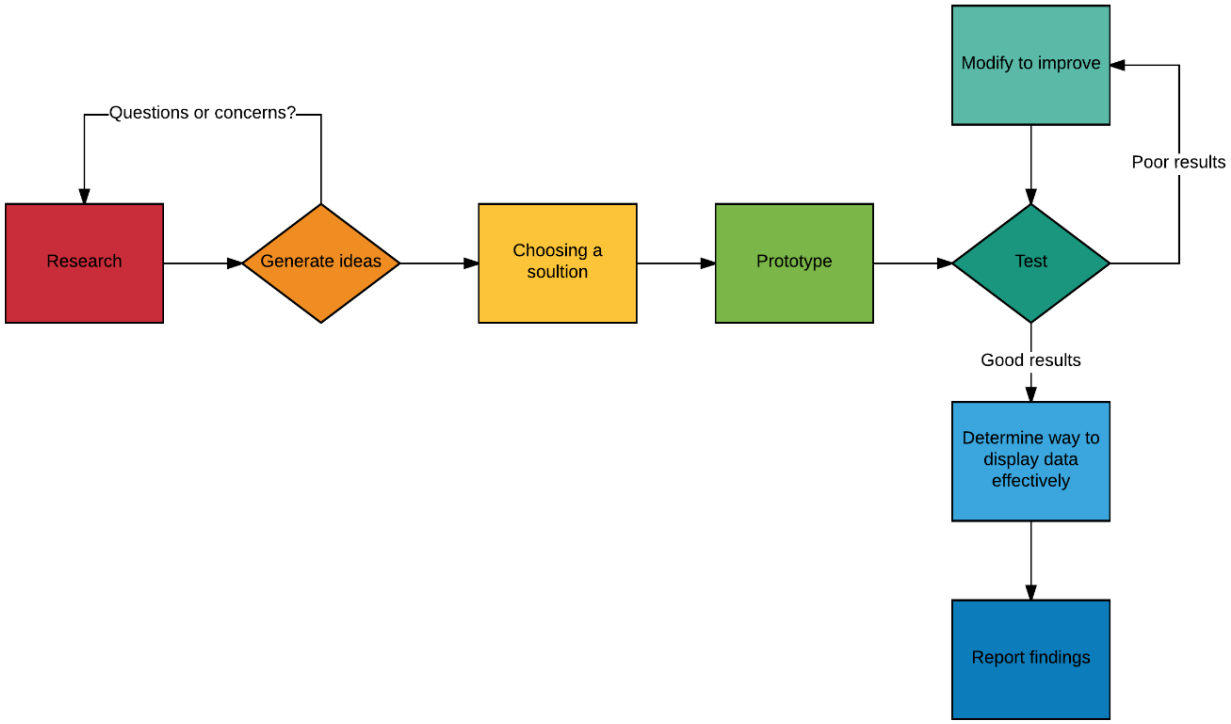
The next research paper we read was Nanostructured optical microchips for cancer biomarker detection by Zhang, He, Wei and Que (2). The researchers here were attempting to measure levels of the free prostate-specific antigen (f-PSA) in the bio-fluid. Low levels of f-PSA correspond to higher risk of prostate cancer, so devices of this nature could potentially aid in early detection of cancer. The researchers used the wavelength of reflected light to measure levels of f-PSA. The device consisted of nanopores to increase surface area of the channel, allowing for more binding sites. When binding between the biomolecules occurs, the effective refractive index changes. This change can be measured as a shift between fringes in wavelength of reflected light. There are many benefits to this methodology. This device has a very high selectivity and specificity. It does not require any fluorescent dyes to detect biomarkers. This model can also be extended to detect different viruses or cancers. There are issues with this model too. The optical testing setup is very complex. The nano and micro processes used are expensive and some of the steps used in the fabrication of Fabry-Perot interferometer (FPI) devices are not compatible with standard lithography processes. This device works very well, but is simply not cost effective to make.

The third research paper we read was Characterization of Field Effect Transistor Biosensors Fabricated Using Layer-by-Layer Nanoassembly Process by P. Pathak and L. Que (3). The researchers here used a FET based semiconductor with a carbon nanotube thin film (CNTF) as a channel. The drain current will then be modified by the activity of biomolecules binding onto the CNTF in the channel. The researchers immobilized Protein A on the CNTF and detected the rabbit immunoglobulin (IgG) at levels as low as 1pg/mL. The benefits of this device is that is forgoes some of the costs and complications of other nanoscale devices that have been made previously. The fabrication process for creating a FET with a CNTF channel is far simpler than creating a single carbon nanotube (CNT). The process only requires a combination of photolithography and layer-by-layer self-assembly.

## 3.2 Proposed System Block diagram

Process flow:




Design flow:

## 3.3 Assessment of Proposed methods

For our design, we will be using the FET strategy. It is easier and cheaper to fabricate, has great selectivity, and measuring current and voltage is simple. It is easily fabricated and easy to test and measure. We are very familiar with FET devices and it is easier to understand and explain than an FPI device. We are also familiar with the fabrication steps because we have practiced them in EE432. Our system must meet certain criteria. It needs to be accurate, reproducible and must prove to be highly effective. We need to create a nanoscale device that can consistently detect glucose levels in biofluid. We will first need to do research and determine what an acceptable detection range will be for our device. If it can't detect small amounts, or a large range it may prove to be less useful. An obvious extension of our project would be its application in the medical field. This device could be used by diabetics as a way to monitor glucose perhaps without having to draw blood. We may be able to use saliva as the biofluid for example. If we want this device to

be useful we need to take into consideration how and why it will be used. We are currently in the generating ideas and research step of the design process.

## 3.4 VALIDATION

Our solution will work if we meet certain criteria. These criteria are determined by the scope of our project. If we want it to be used by human diabetics, it needs to be useful for their needs. That is, it needs to be sensitive enough to detect low levels of glucose and have a wide range. If our results cut off at a moderate glucose concentration, that will be unhelpful and possibly even dangerous. If we don't know if glucose levels are dangerously high, our device may not be as effective. The detection method needs to create linear results so that we can extrapolate the data and have a high level of confidence. The device needs to be selective, that is to say, not have similar results when other sugars or carbohydrates are in the fluid we are testing. Human biofluids are very complex, they aren't just water with some glucose molecules. Our device needs to have a real world application and not just exist within the constraints of a laboratory experiment.

# 4 Project Requirements/Specifications

## 4.1 FUNCTIONAL

(1) Fabricate the nanosensors in MRC lab

(2) Develop the sensor's surface functionalization process

(3) Detect glucose samples

(4) Explain the results obtained from experiment

## 4.2 NON-FUNCTIONAL

(1) Students should have prior knowledge of EE432 and understand the functionality of biosensors

(2) The nanosensors created should allow us to detect glucose samples.

# 5 Challenges

One of the major challenges that we know that will surface sooner or later is the fact that when we did this project, we do not have the knowledge of implementing nanosensor into people's body. From what we know, there are many more matters that we need to take into account aside from the capability of the nanosensor, one example of it is the biocompatibility of the nanosensor and the human body.

# 6 Timeline

## 6.1 First Semester

- Understand the key components, concepts and background about the project (Glucose Detection Using a Disposable Nanosensor)
- Set up regular meeting with assigned professor and his PhD students for discussing and updating the information about the project
- Design graphic prototype and collect components needed in the project
- Assemble and build the prototype of the Glucose Detection Nanosensor

## 6.2 Second Semester

- Continue to build the complete nanosensor
- Run tests and investigate problems
- Revise the design and upgrade the prototype
- Product achieves all design goals
- Organize data and deliver a presentation

# 7 Conclusions

Our goal is to effectively detect levels of glucose in a biofluid by use of a nanosensor. If we can develop a way to do so continuously or without drawing blood we can help improve the lives of many people. We can make early detection of diabetes easier as well as help people have more confidence in results of their glucose levels. Previously, methods have been developed but are prohibitively expensive or use uncommon equipment. We would like to make a cheaper and better way to make these nanosensors so even smaller labs can make them.

# 8 References

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