MICROWAVE ASSISTED ZnO NANOROD GROWTH FOR BIOSENSING

Paul Russell[1,2], Ken-ichi Ogata[2], Hideki Dobashi[2], Taichi Yoshida[2], and Shigehiko Sasa[2]

1. NanoJapan Program, Rice University and Department of Electrical and Computer Engineering, Clarkson University
2. Department of Electrical Engineering, Osaka Institute of Technology

The purpose of this research is to fabricate a biosensing device based on glucose oxidase immobilized on zinc oxide nanorods grown by microwave heating for sensing glucose in blood. A silicon based substrate with deposition of titanium and gold is used. Nanorods are grown on the surface of the gold through microwave radiation with the samples face down in zinc nitrate and hexamethylenetetramine (HMT). In a phosphate buffer solution with a *p*H value of 7.4, negatively charged glucose oxidase is immobilized on positively charged zinc oxide nanorods through electrostatic interaction. The sample is then used as a working electrode for an amperometric measurement in a stirred phosphate buffer solution. Glucose is added to the solution and the current level is observed. The addition of glucose is expected to increase the density of protons in solution resulting in spikes in the current. One successful sensing has occurred and attempts continue to obtain a consistently successful method of fabricating the biosensors.

Microwave Assisted ZnO Nanorod Growth for Biosensing

P.Russell,[1,2] K.Ogata,[3] S.Sasa,[3] T.Yoshida, [3] and H.Dobashi[3]

[1]NanoJapan Program, Rice University

[2]Department of Electrical and Computer Engineering, Clarkson University

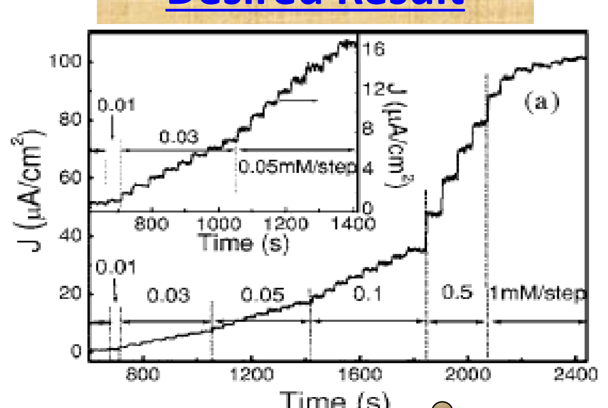
[3]Nanomaterials Microdevices Research Center, Osaka Institute of Technology

Objectives

The main objective is to fabricate a biosensing device based on glucose oxidase immobilized on zinc oxide nanorods grown by microwave heating for sensing glucose in blood. Microwave heating and ZnO are chosen because they provide an inexpensive and energy efficient means of nanorod growth.

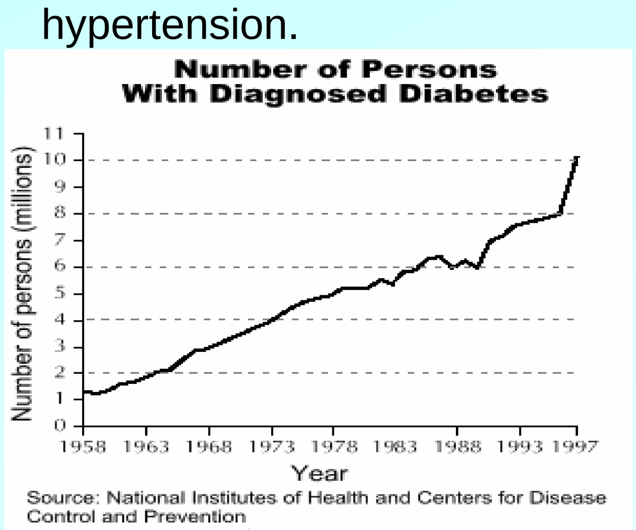
Finished Sensing Sample

Desired Result



Motivation

- Diabetes currently affects 246 million people worldwide and is expected to affect 380 million by 2025.
- Each year 3.8 million deaths are attributable to diabetes. Even more die from cardiovascular disease worsened by diabetes-related disorders and hypertension.

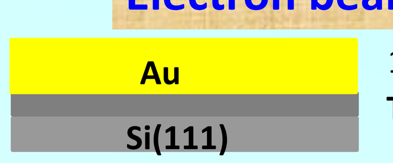


This research aims at combating this issue by developing a glucose sensing device with:

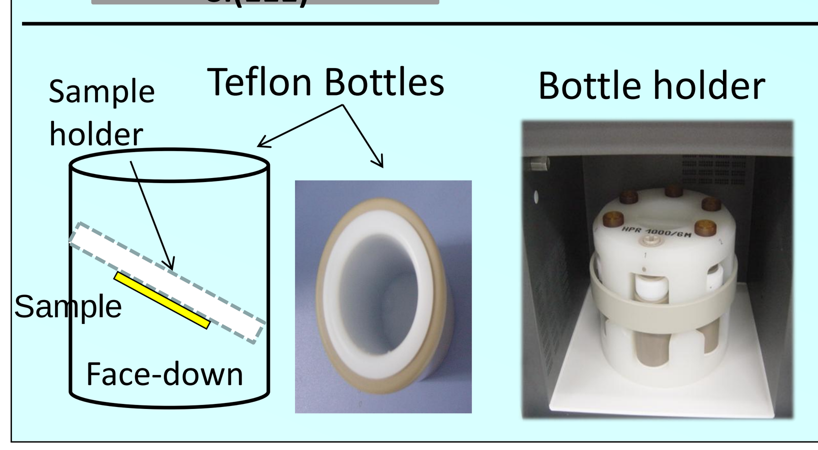
- Increased mobility
- Greater sensitivity
- Smaller environmental impact
- Greater energy efficiency and economic feasibility

Method

Electron beam deposition and microwave heating



- 20 nm of titanium and 100 nm of gold are deposited on silicon substrate



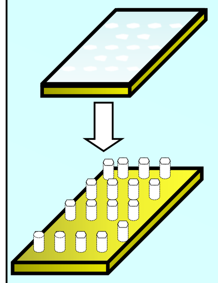
- After deposition the samples are placed in teflon bottles
- Each bottle contains 25 mL of Zinc Nitrate and Hexamethylenetetramine (HMT)
- The bottles are placed in microwave and are heated for 3 hours at 95˚ C

Method Contd.

During Heating

Zinc Nitrate HMT

$Zn(NO_3)_2 \cdot 6H_2O + C_6N_4H_{12} \rightarrow ZnO + H_2O + 2OH^-$

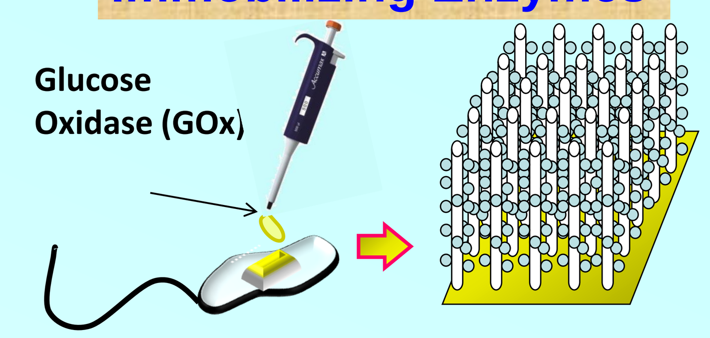


Zinc Oxide forms on the surface of Gold

Nanorods grow perpendicular to the surface

(C-Axis orientation)

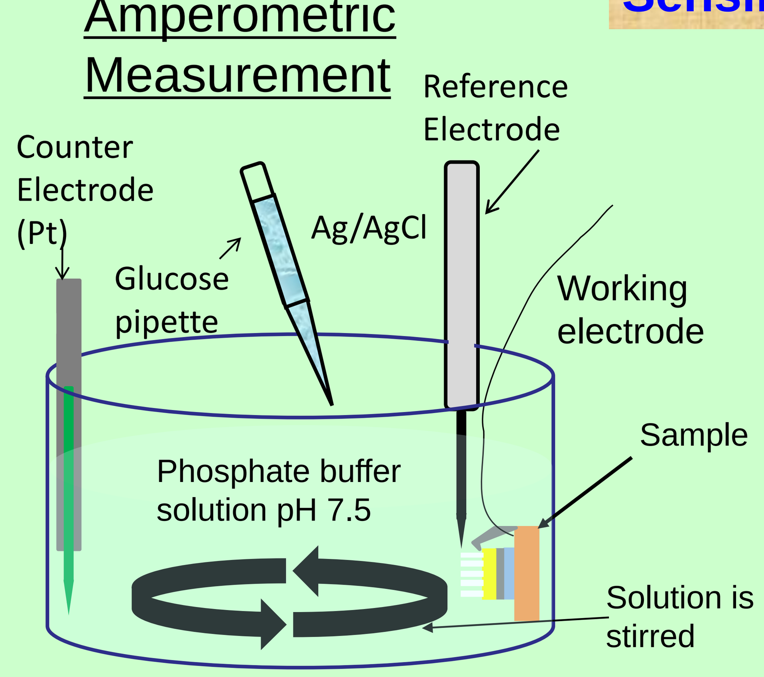
Immobilizing Enzymes



- Nanorods increase surface area allowing up to a 1000 times more enzymes (glucose oxidase) to be immobilized than a film
- Enzymes are immobilized by pipetting 5 μL of 10mg/mL Glucose Oxidase solution

Sensing Test

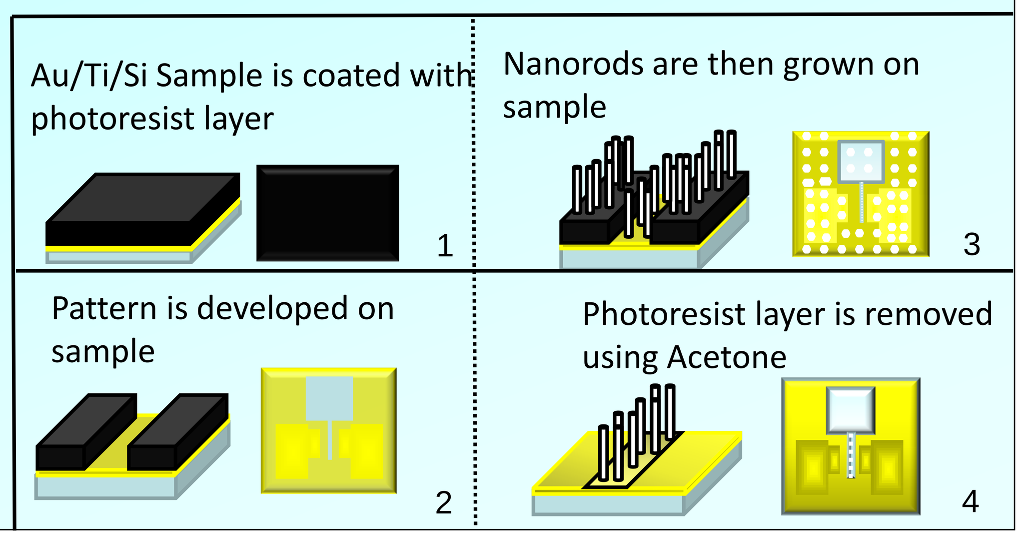
Amperometric Measurement



- In a stirred Phosphate buffer solution the sample is used as the working electrode
- Current flows from the counter electrode through nanords, this current level is monitored
- Glucose is added periodically and the current response is observed
- The reaction between glucose and glucose oxidase produce extra protons which allow for greater current flow

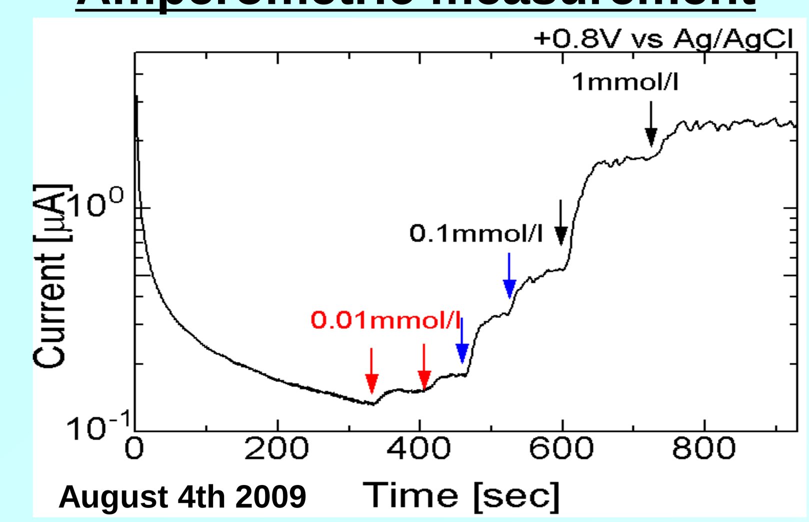
Selective Area Growth

- Selective area growth focuses on integrating nanorods with field effect transistors
- This is achieved by growing nanorods only along the gate area of transistor
- Allows for current to be amplified and lowers the detection limit for biosensing



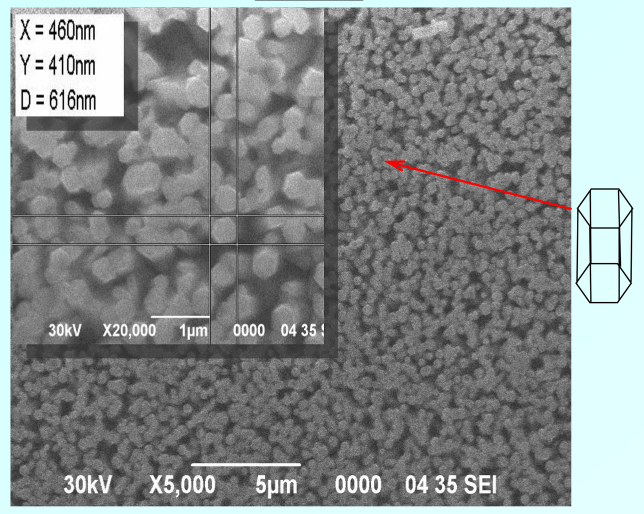
Results

Amperometric measurement



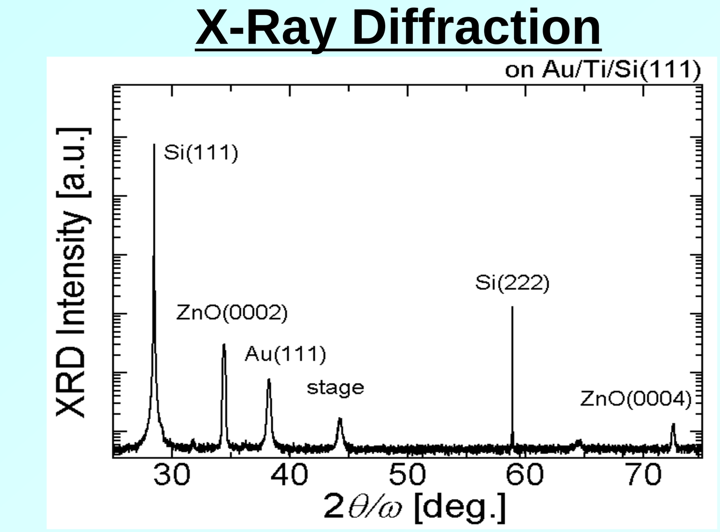
This graph shows a successful sensing test. The current reading steps up after addition of glucose, the greater the concentration the higher the step.

SEM



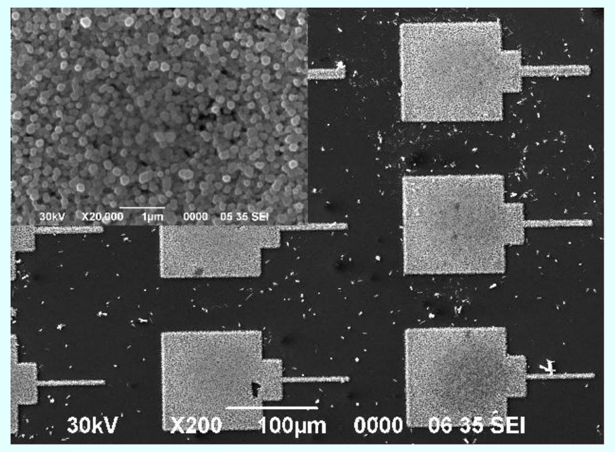
This image shows successful growth of nanorods. Hexaganol crystal structure can be seen.

X-Ray Diffraction



The image above shows the composition of the sample and the orientation of it's components.

Selective Area Growth



The SEM image above shows successful selective area growth

Conclusion

- Microwave assisted nanorod growth with perpendicular orientation was achieved and enzymes successfully immobilized on nanorod surfaced and glucose concentrations as low as 0.01 mM/L were detected
- Selective area growth was proven possible and in the future will be applied to decreasing detection limit of glucose sensing
- The results show promise for the capability of ZnO nanorod based biosensors and great economic promise for microwave assisted growth

References

1)A.Wei et al. Appl. Phys. Lett. **89**, 123902 (2007)

2) B.S. Kang et al. Appl. Phys. Lett. **91**, 252107 (2007)

3) K.Ogata et al. Mater. Res. Symp. Proc. **1035**-L08-16 (2008)

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RICE 大阪工業大学 Osaka Institute of Technology

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