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Silicon Nanowire Surface Preparation Using Chitosan

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Abstract. Chitosan (CS) is an interesting polysaccharide biopolymer that widely used in the fields of agriculture, horticulture, industry, biomedicine and chemical sensor due to its numerous advantage like non-toxic nature, excellent film forming ability, good mechanical strength, high permeability and cost effectiveness. The chitosan solution (0.05 %) was prepared by dissolving 0.05g chitosan (Sigma corp) in 10 ml of acetic acid (2mol/L). after the is the preparation of preparation of chitosan: A very small amount of chitosan were taken and dissolved in distilled water. The solution was then ultrasonicated for 90 minutes to obtain a homogenized solution. The spectra shows featureless absorption in the 400-800 nm and a sharp absorption peak at 250 nm regions which are similar to the spectra of chitosan in the previous research. The UV-vis spectra of chitosan in at different concentration. The spectra show featureless absorption in the 400-800 nm. A sharp absorption peak at approximately 300 nm. The observed absorption peak in chitosan solution depends on the solution concentration. When the chitosan concentration was less, the peak was not that clearly seen compared to the concentration of 0.05.

Introduction

The detection of biomolecule using semiconductor has become the major approach that will bridge the gap between physic and biology, with huge sophistication for fabrication technologies, silicon nanowire based biosensor have become potential candidates for recent nano-scale sensing device. It is particularly suitable for biomedical applications due to its desirable properties such as high sensitivity and selectivity, rapid response and potential for large-scale integration [1-5]. Thus, nanowires have been favorite research topics among researchers and a number of techniques have been explored employed to modify silicon surface amongare3-aminopropyl triethoxy silane(APTES,(3-aminopropyl)-dimethylethoxysilane APDMES), N-(2-aminoethyl)- 3-aminopropyl tri methoxy silane(AEAPS), 3-aldehydepropyltri metho xysilane (APMS), mercaptopropy ltrimethoxysilane (MPTMS), mercaptopropyltriethoxysilane (MPTES), biotin 4-nitrophenyl ester (BNPE) and 11-hydroxyundecyl-phosphonate (HUP). In most of these studies apply the silanization on the nanowire oxide layer[1, 6-11].

That utilizes APTES as most silane based agent, enabling the subsequent immobilization of carboxylic acid- or aldehyde terminated Biomolecules for chemically bind amine-terminated biomolecules. Unfortunately, these approaches has a serious disadvantage because silane compounds react with each other via cross-linking of the alkoxy units, resulting in rough, unordered multilayers that will subsequently introduce discontinuity between layer to layer. In order to improve the sensitivity of bio-molecule detection, the outer surface of the oxide layer of SiWNs is generally equipped with a functional bio-interface consisting of receptor molecules. This bio-interface plays key role in the detection of target bio-molecules[12-15]. The working principle is as follows. When a target molecule comes in close contact of the receptor, there appear non-negligible partial charges in the combination of receptor and target molecules. This modulates the surface charge profile of the functional layer. Modification in the surface charge, in turn, affects distribution of electrostatic potential throughout the nanowire. This change in electrostatic potential affects the

conductance of the nanowire which can be detected as fluctuations in current when a voltage is applied at the appropriate terminals of the silicon nanowire[16-19].

Methods and Materials

A number of researchers have addressed the effect of surface charge on the conductance of nanowire. As a result, a reasonable number of research articles on the topic appear in the literature. Among them, [1] considered a silicon nanowire, surrounded by a thin oxide layer and a functional bio-interface layer immerged in an electrolyte . They proposed a model for competitive screening of the surface charge by nanowire charge carriers as well as by the electrolyte. They derived analytical results and validated them through finite-element calculations. On the other hand [1] experimentally investigated effects of different functional bio-interfaces on the sensitivity of silicon nanowires. In their experiments, 3-aminopropyl trimethoxysilane (APTMS) and 3-mercaptopropyl trimethoxysilane (MPTMS) self-assembled monolayers (SAMs) were independently used to modify the surface the nanowire. The experimental results showed that the nanowire signal response to protein interactions were closely related to the uniformity of the surface modification. As a practical application, some researchers proposed a silicon nanowire field-effect transistor based system for detection of DNA of genetically modified maize. They equipped the functional layer of the biosensor with 21 mer DNA oligonucleotides as the receptors. The authors claimed that their biosensor could detect the target DNA with concentration down to approximately 200 pM. In spite of great efforts of the researchers, a commercially deployable solution is yet to be achieved. The major challenge comes from the Debye screening of the corresponding physiological liquid environments [1]. We made a fundamental investigation into the effect of the surface charge of the bio-interface layer on the conductance of the nanowire through integrating chitosan and SiNWs. The device under study consisted of a silicon nanowire on a silicon oxide substrate.

Results and Discussion

There are two types of affinity based biosensors. These are called immunosensors and DNA sensors. The immunosensors exploit the property of complex formation between an antigen and its antibody. And the other utilizes attraction between the complimentary sequences of the DNA strands. Mainly CNTs were utilized in developing electrochemical, optical and electronic sensors.

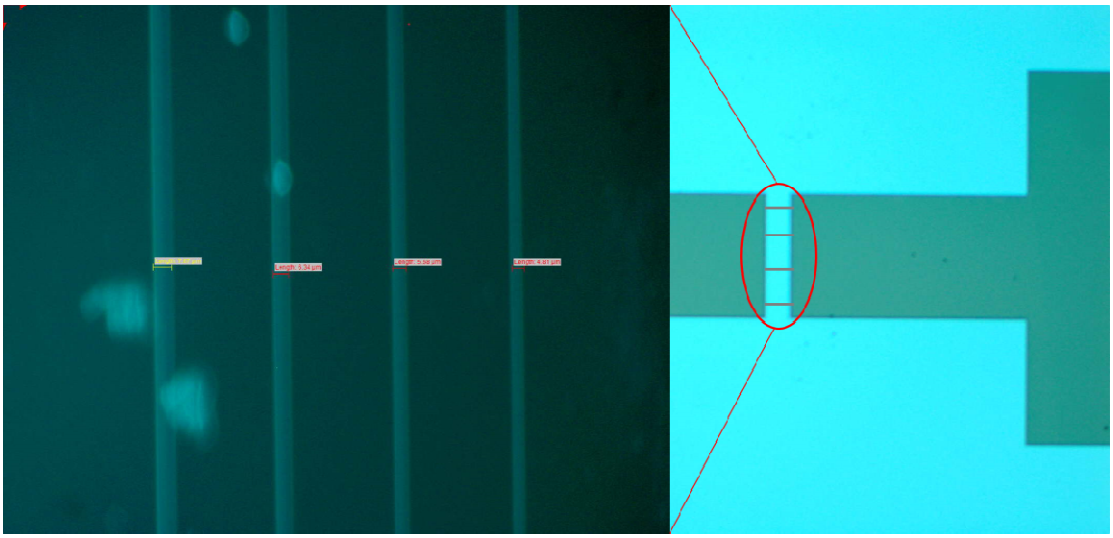
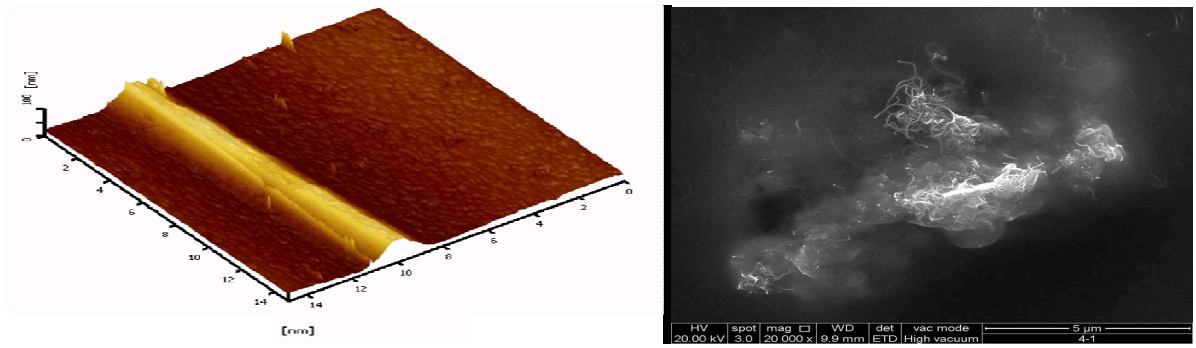


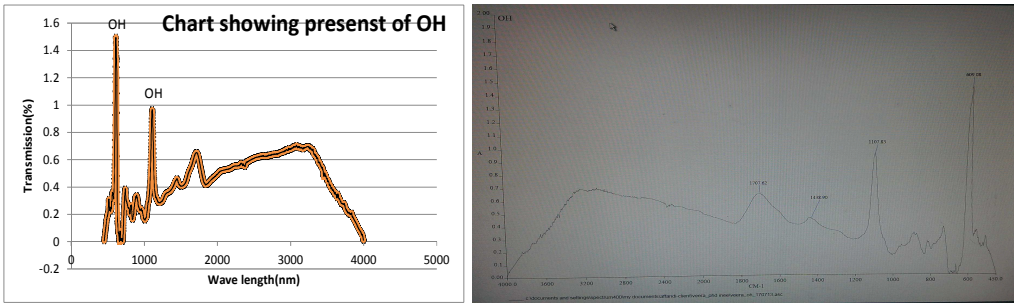
Fig. 1, HPM image fabricated silicon nanowire



(a) (b)

Fig. 2, (a) AFM image fabricated silicon nanowire (b) Surface modified silicon nanowire with Chitosan

Fig.1 & 2, show the chitosan modfied silicon nanowire because chitosan have several interesting properties suitable for developing affinity based biosensors. They have good electrical properties, electrochemical properties and amenable for immobilisation of biomolecules by various methods. They are stable and biocompatible. They are already exploited for detection of several pathogens and biomarkers for various diseases. Their properties can be enhanced by incorporation of nano gold and platinum. Since they are having one dimensional structure and semiconducting properties they are being studied as potential materials for FET based biosensor. Since they are nano materials, it is possible to make array of sensors on a single platform so that it is possible to develop multianalyte systems. The results of affinity based sensors using chitosan indicate high



(a) (b)

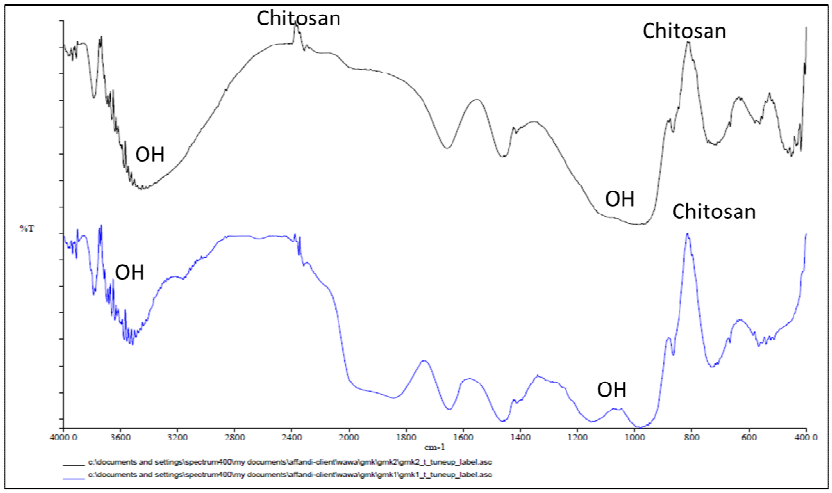


Fig.3, (a)FTIR spectra of OH (b) UV-vis spectra of OH (c) UV-vis spectra of the chitosan at different concentration.

The silicon nanowire was pretreated with ethanol to create OH and the is shown in fig.3 (a and b), this is done in order to create an adhesive layer between the silicon nanowire and chitosan-chitosan layer. Fig.3c, show two UV-vis spectra of chitosan, the spectra show featureless

transmission in the 1500-2200 nm which are similar to the spectra of covalently functionalized chitosan with other polymer. A sharp absorption peak at variuos wave length were observed 500 nm and 2400can be attributed to the characteristic transmiited of chitosan. The observed peak in CS solution depends on the solution concentration. When the concentration of chitosan less than chitosan, the graph features more toward chitosan as there are many in the solution.

Summary

The study demostrate a surface preparation with chitosan- -silicon for probe attachment to silicon nanowire, this study was done in order to undestand the binding chemistry between inoganic silicon nanowire and probe. We found out that the , Chitosan improve the affinity of silicon surface to the detection of the biomolecule. Chitosan is a linear polysaccharide with fine biocompatibility and adhesive capability to chemically modified surfaces. Pretreated with –COOH groups on silicon nanowire dispersed among chitosan containing –NH2 groups due to the peptide bonds formed between –COOH and –NH2, a strong binding was established.

References

[1] Low Foo Wah, U. Hashim, Wei-Wen Liu, Tijjani Adam, , Passivation Layers Deposition: The Effect of Chemical Solutions (Isopropyl Alcohol, Dichloromethane, Acetone and Triton X-100) on the Dispersion of Single-Walled Carbon Nanotubes, Journal of Applied Sciences Research, 9(6) (2013) 3411-3416.

[2] Chee, P.S., Arsat, R., Adam, T., Hashim, U., Rahim, R.A., Leow, P.L. Modular architecture of a non-contact pinch actuation micropump Sensors (Switzerland), 12 (9) (2012) 12572-12587.

[3] Tijjani Adam, U. Hashim, Th. S. Dhahi, Pei Ling Leow and Pei Song Chee. “Novel In-House Fabrication of Nano Lab-on-chip Devices. Current Nanoscience, 9(1) (2013) 543-551.

[4] Tijjani Adam, Hashim, U., Leow, P.L., D, Q.H. Fabrication of nanowire using ash trimming technique Advanced Materials Research, 626 (2013)1042-1047.

[5] Tijjani Adam, Hashim, U., Foo, K.L.Microfluidics design and fabrication for life sciences application Advanced Science Letters, 19 (1) (2013) 48-53.

[6] Adam, T., Hashim, U., Leow, P.L., Foo, K.L., Chee, P.S. Selection of optimal parameters in fabrication of poly(dimethylsiloxane) microfluidics using taguchi method Advanced Science Letters, 19 (1) (2013) 32-36.

[7] Tijjani Adam, Hashim, U., Ali, M.E., Leow, P.L. The electroosmosis mechanism for fluid delivery in PDMS multi-layer microchannel Advanced Science Letters, 19 (1) (2013) 12-15.

[8]Tijjani Adam, Hashim, U., Foo, K.L., Dhahi, T.S., Nazwa, T. Technology development for nano structure formation: Fabrication and characterization Advanced Science Letters, 19 (1) (2013) 132-137.

[9] Tijjani Adam, Hashim, U. Taguchi's method of statistical design to form an ultra thin silicon dioxide Journal of Applied Sciences Research, 8 (8) (2012) 4249-4253.

[10] Farid Amalou, Etienne L. Bornand, and Martin A. M. Gijs, “Batch-Type Millimeter-Size Transformers for Miniaturized Power Applications,” IEEE Transactions on Magnetics, Vol. 37, Issue 4 (2001) 2999-3003.

[11] Tijjani Adam., Hashim, U., Leow, P.L., Ali, M.E. Micro/nanoscale biosensing in microfluidics: Selection of polymers and microstructures Journal of Applied Sciences Research, 8 (1) (2012) 420-430.

[12] Tijjani Adam, Hashim, U. Three-dimensional channel design and fabrication in polydimethylsiloxane (PDMS) elastomers using capillary action mechanism in fluidics for life sciences) Journal of Applied Sciences Research, 8 (4) (2012) 2203-2208

[13] Hashim, U., Diyana, P.N.A., Adam T.Numerical simulation of microfluidic devices) Journal of Applied Sciences Research, 8 (4) (2012) 2162-2174.

[14] Adam, T., Hashim, U., Leow, P.L. Design and fabrication of passive fluid driven microchamber for fast reaction assays in Nano lab-on-chip domain Journal of Applied Sciences Research, 8 (8), (2012) 4262-4267.

[15] Hashim, U., Tijjani Adam, Resist uniformity evaluation through swing curve phenomena Journal of Applied Sciences Research, 8 (8) (2012) 4268-4272.

[16] Hashim, U., Ariffin, S.A.B., Tijjani Adam, Fabrication of polysilicon nanowires using trimming technique Journal of Applied Sciences Research, 8 (4) (2012) 2175-2186.

[17] Low Foo Wah, U. Hashim, Wei-Wen Liu, Tijjani Adam, , Passivation Layers Deposition: The Effect of Chemical Solutions (Isopropyl Alcohol, Dichloromethane, Acetone and Triton X-100) on the Dispersion of Single-Walled Carbon Nanotubes, Journal of Applied Sciences Research, 9(6): (2013) 3411-3416.

[18] Tijjani Adam, U. Hashim, Design and Fabrication of Microchannel for Microfluidic in Biosynthesis, Journal of Applied Sciences Research, 9(6) (2013) 3417-3427.

[19] Low Foo Wah, U. Hashim, Wei-Wen Liu and Tijjani Adam, Development and Fabrication of Carbon Nanotube (CNT) based Morphological and Electrical Characterization. Journal of Applied Sciences Research, 9(6) (2013) 3436-3443.