# Good research proposal about field-effect transistor-based biosensors

Technology, Development

# Proposal for enhancing the sensor performance or make nanowire sensor more selective and sensitive for cancer cells or for DNA.

Abstract

An experiment to show how different amount of estrogen receptors requires detailed and sensitive procedures to reveal the difference between subtle in DNA binding affection. Si-NW biosensors better exposure in finding out nuclear withdrawals in cancerous cells. Extreme hypersensitive disclosure of protein-DNA synergy. A proposal in making Nanowire sensors being more selective and sensitive. Electrical implementation of Silicon-nanowire field-effect sensitive for usage in discovering cancer. Array relationship between receptors and nanowire sensors.

## Introduction

[2] Cancer detection or finding cure for DNA disease have become two of the famous areas in medicine, which scientists are likely to investigate in. Cancer detection and its treatment have become easier and faster with a technology evolution. Nanosystems with its nanowire sensors bring a new method, which helps researchers measure and analyze cancer biological markers.

[3] The relationship between different biological and nanosystems bring science and technology into one harmony, which main goal is to bring a revolution into medical and science world. Combination of such ranges supply healthcare medicine with a new and powerful tool, which is going to discover and analyze any disease. This electronics are based on nanowire sensor technologies and can be described, as vigorous platform that

provides disclosure of species in direct and hypersensitive way. Nanotechnology is a wide-range science with a distinct scientific knowledge, with the main goal: to study fusion characteristics and materials that have the scale range of 100nm or less [6]. Nanotechnology suggest science and medicine converge. One of the greatest aspects in nanotechnology is the size of the structures. It implements a new technology, which allows to establish a new inquiry and gadgets that detects and finds a cure for the disease in new and more powerful way, that medical care used to face before. Term of nanomedicine appear, when medicine and nanotechnology submerge.

[6] Diagnosis of diseases using biomarkers – is an early warning system disease, which localizes disease at a stage when it is easiest for treatment, as it increases the rate of success. Biomarkers – are special chemicals, whose appearance in the body indicates the pathogenic process, reactions to therapeutic interventions, or restoration of a normal activity. Nowadays a new diagnostic method for detecting the disease at an early stage is being at the stage of development. The technology is based on a chip, works on the principle of microfluidics, with tiny channels in which blood samples taken from the patient circulates. The chip keeps track of protein markers - indicators of cancer. The measured concentration of the tumor marker will help doctors diagnose the disease at an early stage. These techniques already exist, but they are not sufficiently accurate and can detect molecules in the blood only in high concentrations. Moreover, such a diagnosis should be carried out in the laboratory. [2] This diagnostics take time and can be really expensive. Biofunctional nanoparticles are a key element of the new

sensor. Compared with the already existing techniques, scientists were able to increase the limit of detection in a hundred times. If earlier detection of tumor markers had to be a hundred molecules in a certain amount of blood sample, now it needs only one. This means that the disease can be diagnosed much earlier than it was possible with currently existing methods. Nanoparticles which are disposed on the electrode sensor are attached to the antibodies do " catch" the corresponding proteins. Next the blood run multiple times along the surface of the electrode. The fastest stream is observed in the canals that are closer to the middle. If antibody " catches" the corresponding protein, the tumor marker, the distribution of electric charge changes, and this change is detected by an electrode. [2]

Magnetic nanosensor has a wide sensitivity scale - simply from small amounts previously described, at concentrations of up to six orders of magnitude, or one million times smaller. Most analytical methods available today in the clinic, able to determine a concentration of proteins not more than two orders of magnitude. Most sensitive platforms currently in use are limited in finding a single protein during analysis, but as the magnetic nanosensors - a part of the microchip 64 embedded sensors, each of which may determine a specific protein, researchers can look up to 64 different proteins simultaneously in one analysis. The analysis usually takes about one to two hours - much smaller than most existing methods. Scientists have also demonstrated that the sensor is equally effective in any biological fluid in which doctors need to determine presence of cancer biomarkers. These fluids include urine, saliva, plasma, and serum and cell lysates.

[4] Nanowire systems Field-effect transistor-based biosensors is a system that consists out of three electrodes Fig a. These electrodes are: gate electrodes, source (S) and drain (D). Field-effect transistor – a semiconductor connects to a metal source and allows electrodes to pass through, and then get injected and stored. Si-NW device use BOX (Buried oxide layer) to separate the chip (main body) from Si

(silicon) substrate. Si-NW G conductance are usually controlled with two gates: Front (FG) and Back (BG). [5]

[5] The whole system is dwelled of measurement device, which have three voltage sources such as Vds, Vfg and Vbg. " C" – are a small capacitors, which serve as capacity reactance among substrate silicon and Si-NW, isolated by Buried-oxide layer (BOX). Front capacitors and back capacitors can be referred to Front Gate (FG) and Back Gate (BG) capacitance. The main usage of FG and BG is device conductance control, which is relative to resistance RNW. With the incline of BG which is typically larger then FG, analogous field-effect can be established, as BOX layer have frequently wideness and have similar symmetry as FG. Si-NW have a possibility to measure the drain and source voltage Vds which is applied to them, it may be AC or DC. AC voltage has a small advantage in usage, as it can measure minuscule electronic bandwidth using amplifiers that use carrier wave for signal extraction. Signal frequency should be kept low in order to establish small influence on filter that is located at the input. [5]

FET devices have three modes, each mode have an operation to follow. Operation modes are: cumulation (storage), extenuation (reduction) or inversion. These operations are implemented in semiconductor due to the Si substrate potential control ψs. In the Cumulation mode constrained ionized contamination charge Qc routinely dominates, while extenuation or inversion mode free charges only dominate at the surface. When we consider to work with Si-NW devices, where gates are controlled with voltage, we need to contemplate the voltage charge behavior of MOS (metal-oxide-semiconductor) system.

[5] Figure c describes the electrolyte-oxide-semiconductor (EOS). MOS surface is shown with silicon charge Qs, while Front gate voltage varies from negative to positive. Poisson's equation is illustrated for three distant consolidations. Voltage function is described among the FOX layer with its thin characteristics tf, where potential control ψs diverge with Front gate voltage at the cumulation mode. Device sensitivity increases, since small potential control ψs changes which are caused, due to Front gate voltage control.

Si-NW devices do have a new changes in the device structure, and if compared to its predecessors, we can tell that they are a lot different. These changes were implanted in chemical and biochemical gadgets. One of the main differences is SVR increase, because of multi-layer gate structure. Second major difference is nanoscale potentiometric qualities. The difference is described as generation of small molecule numbers, which have equal potential change as macroscale sensors [5].

[5] Mechanism on figure d describes the relationship between normal conductance's ΔG over G and the circular nanowire radius. It describes FOX change in potential surfaces Δψo = 3 mV, tf = 5 nm, L = 10 μm. Mobility dependence and many different concentrations are being doped.

## Proposal

[5] Detection of different disease biomarkers is implemented using SI-NW FET biosensors. This method depends on time, as the conductance have to be resolved, as a result of low streptavidin addition. The amount of 250 nM leads to increase of conductance up to 50 nS, which is approximately 3% in change. The idea of using modified ligands has been probed to use in different directions. Si-NW show shifting antibody binding and dependent concentration that may occur at the moment. PSA covalent bindings with cancerous antibodies exceed to conductivity adjustment. Conductivity adjustment was led due to different response to electrical field variations.

[6] SI-NW FET allows to sensitively detect biomolecular object, since it play a huge role in patient treatment and rehabilitation. The sensor is about 1000 times more sensitive than any other technology currently used in the clinic, thus it is not dependent on the environment in which the organism is a biological marker, and can detect concentrations of proteins in the range three times broader than any existing method. Nanosensor chip showed to be effective in the early detection of tumors in mice. It can be searched at a time up to 64 different proteins. Nanosensor also allows doctors to quickly determine how the patient responds to a particular course of chemotherapy. The sensor works on the basis of magnetic detection nanotechnology that can detect a given protein biomarker of cancer at a concentration of one to one hundred billion (or 30 molecules in a cubic millimeter of blood). The most impressive new nanosensor advantage lies in the fact that the magnetic nanosensor can successfully detect tumors in mice, when the concentration of the biomarkers is much lower. [6]

[7] Nanotechnology often involve the study of gadgets and materials and its quality, the size of the components is less than 100 nm. DNA nanotechnology, in particular, are a pattern of the increase of self-assembly molecules, molecular components that immediately group into balanced structure; the specific structure formation is determined both of physical and chemical characteristics of the segments of the selected designers.
Nanotechnology which target DNA material consist of filaments are nucleic acids such as DNA, are well suited for the construction of nanoscale objects, because the double helix of nucleic acids has a diameter of 2 nm and a length of one portion of a turn of 360 ° - 3, 5 nm.

The key feature that makes nucleic acids easier to build structures that distinguish them from other materials is that the connection between the two nucleic acids depends on the simple and well-studied rules of paired bases, while it forms a clearly defined structure, all of which allows easy to assemble structures of nucleic acids through the design of nucleic acids. This feature is not present in other nanotech materials, including - proteins, which are very difficult to design, as well as - nanoparticles that do not have the capacity for controlled self-assembly

The formation of the nucleic acid molecule comprises an arrangement of nucleotides that differ contained therein nitrogenous bases. In DNA are four bases: thymine, adenine cytosine and guanine. Nucleic acids do have the same qualities that the molecules in the formation of the double helix, communicate with one another only if the two arrays of nitrogenous bases are complimentary. That is, it means: they implement a suitable base pair sequence, in which Adenine is attached only to Thymine, and Cytosine is attached only to the Guanine. Since the arrangement of properly selected energetically benign base pairs, it is expected that nucleic acid in the majority of cases are associated with one another in a conformation which increases the number of paired bases. Thus, the sequence of the ground in the strands allow the sample to determine the ligaments and the comprehensive arrangement of the object is easily controlled manner.

[5] Changeable DNA nanotechnogy allow to rebuild the assembly of the nucleic acids use a mechanism called Toehold-mediated strand displacement. In this kind of reaction, a part single stranded strand binds with the double-stranded region of the support assembly and replace the original associated assembly process using a " branch replacement". As a result, one branch is replaced by another. Furthermore, assembly and tunable gadgets that can be created using nucleic acids just as ribozymes and deoxyribozymes, which have an opportunity for chemical reaction and producing aptamers that can be bonded with different kind of proteins or other molecules.

Real-time detection Figure. (A) Nanowire sensors are modified with PNA and DNA receptors before and after duplex formation. (B) Nanowire silicon DNA sensing, arrow changes to the addition of 60 fM DNA sample, inset describes following 100 fM mutant DNA conductance. (C) Conductance vs DNA based on two devices (different dot colors). (D) Telomerase binding and assay activity. (E) Conductance vs time plot, data which was recorded for 100 HeLa cells and dNTPs, dCTPs introduction. (F) Device following introduction solutions

Nanowire sensors allows to do a real-time detection on cancer or DNA. To make nanowire sensor more selective and sensitive for DNA recognition sequence of peptide nucleic acids (PNA) is used. PNA is used as a receptor, as PNA do have better qualities such as affinity and stability. P-type nanowire silicon with a modification of PNA receptors are designed to reveal wild-type against the mutation sites. Receptor gene shows increase of conductance of over 60 wild-type DNA solutions. P-type silicon nanowire device is stable with the increase of negative surface charge density bonded with the negatively charged DNA structures. Careful controls experiments showed that binding responses had a specific reaction to different wild-type sequences. This sequences didn't show any stable conductance changes.

Charles Lieber do marker detection to fundamental cell nano-electrophysiology through development of novel hybrid tissue. As for us, we are going to do detection using peptide nucleic acids. As it allows to do the experiment more stable and accurate.

In future we are planning to develop a new methods for dna or cancer type reactions using blood. Nanowire sensors will implement new techniques that will allow to realize blood structures, see what ferments are missing and describe what is wrong with its structures. If we do find this, it will allow cancer prevention on its development.

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