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ACCEPTED MANUSCRIPT

Optimal Design of Nanowire Field-Effect Troponin Sensors

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Abstract

We propose a design strategy for affinity-based biosensors using nanowires for sensing and measuring biomarker concentration in biological samples. Such sensors have been shown to have superior properties compared to conventional biosensors in terms of LOD (limit of detection), response time, cost, and size. However, there are several parameters affecting the performance of such devices that must be determined. In order to solve the design problem, we have developed a comprehensive model based on stochastic transport equations that makes it possible to optimize the sensing behavior.

Keywords: Silicon nanowire, field-effect transistor, biosensor, sensor response, limit of detection.

1. Introduction

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality for both men and women in developed and developing countries [1]. In the US in 2010, the overall rate of death attributable to CVD was 235.5 per 100 000 [2]. Additionally, each year cardiovascular diseases cause over 4.3 million deaths (48%) in Europe and over 2.0 million deaths (42%) in the European Union [3]. Acute myocardial infarction (AMI), also known as heart attack, occurs when the flow of blood to the heart is blocked, most often by a build-up of fat, cholesterol, and other substances, which form a plaque in the arteries that feed the heart (coronary arteries). The interrupted blood flow can damage or destroy part of the heart muscle.

Rapid and accurate diagnosis of CVDs is extremely important since it increases patient survival and saves enormous costs for the health-care system. An electrocardiogram (ECG) is a traditional test that checks for problems with the heart electrical activity. However, ECG is a poor diagnostic test for AMI, since more than half of the CVD patients who go to the Emergency Department show normal or no diagnostic electrocardiograms, which makes the early diagnosis of CVD more difficult [4, 5]. A range of biochemical markers are available for diagnosis of AMI of which the cardiac troponins, namely cardiac troponin T (cTnT), and cardiac troponin I (cTnI), are the newest and clinically the most interesting. The unique features of the cardiac troponins (cTn) are that they are highly sensitive

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