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POSSIBILITY OF APPLICATION OF POROUS SILICON AS GLUCOSE BIOSENSOR

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1. Introduction

In the last decade a new interconnection between electronics and biochemistry arise which brought to the formation of new field of science – bioelectronics. The first step in this area was the development of biosensors, the devices which will allow analyzing and processing information. Biosensors are the devices which "recognize" biological agents and give out the information about its presence and quantity in the form of electrical signal.

It is well known that any biosensors consists of two basic functional elements: bioselective membranes, using various biological structures such as ferments, antibodies, receptors, living cell, etc., and physical converter of a signal – so-called transducer, which converts chemical signal into electrical one [1]. On the other hand, for the integration of such devices into semiconductor technology it is necessary to utilize widely used semiconductor materials. As is known, silicon is a widely using material in semiconductors industry. So, it will be preferable to utilize the silicon based devices. From this point of view, porous silicon layers may attract the interest aiming the properties of high sensitivity of porous silicon surface to different type external excitations such as gas, light, and especially bioagents.

In this work the possibility of application of porous silicon material as transducing layer for glucose biosensor was investigated.

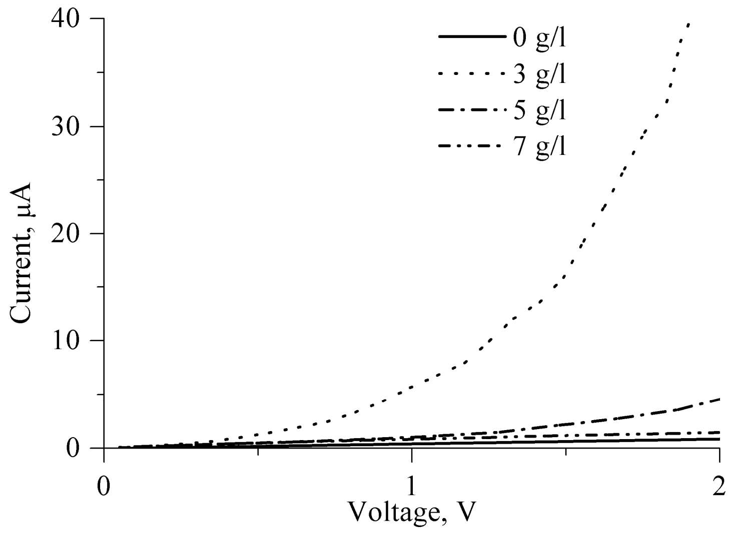
2. Experimental

The Ag/porous silicon structure was prepared on the <111> boron doped p-type silicon wafers for using it as a glucose biosensor. In order to remove contaminations from the silicon surface before the anodization, samples were first boiled in isopropyl alcohol for 5 minutes, after that washed in distilled water. Then wafers were cut into 15×15 mm size samples. Porous silicon layers with 10 mm in diameter were prepared on silicon surfaces by anodic etching. Etching solution was prepared on the basis of hydrofluoric acid and ethanol in ratio HF [48%wt] : EtOH [96%], mixed 1:1 by volume. The current density during the anodization was 50 mA/cm^2, the anodizing time 3 min. The anodization was carried out in galvanostatic regime. After that silver metallic contacts were deposited onto the surface of porous silicon by the ion-beam sputtering method through metallic mask. Thereafter the surface of porous silicon was exposed to the glucose of various concentrations (ranging from 3 to 7 g/l). Current-voltage characteristics were measured for studying changes in current passing through the structure depending on the glucose concentration.

3. Results and discussion

For the investigation of response of obtained structures to the glucose, they were dipped into glucose solution with various concentrations. We used glucose commonly employed in medicine which was diluted in distilled water at different concentrations ranging from 3 to 7 g/l. The structures were incubated in 2 ml glucose solutions for 20 min. The removal of non-adsorbed glucose molecules was accomplished by immersing the samples in 2 ml of distilled water for 5 min. This process was repeated twice. So, only immobilized glucose molecules remained on porous silicon surface [2]. As it known, the large specific surface area of porous silicon is responsible for bio-activity providing numerous available bonding sites and, as a result, of the electrochemical formation process in hydrofluoric acid based solutions [3]. On the other hand, silicon is biocompatible with organism [2].

Current-voltage measurements were performed with use of pressure contacts by the instrumentality of automatized measurement scheme connected to the computer. Figure shows the current-voltage characteristics of the structure after exposure of various glucose concentrations on porous silicon. Such concentrations are typical for the case of hyperglycemia.



Current-voltage characteristics at different glucose concentrations

As seen in figure, the current-voltage characteristics of such structure are asymmetric and have rectifying behavior which observed in all tested glucose concentrations. It should be noted that with the decrease in the concentration of immobilized glucose the current flowing through the structures increases, i.e., the glucose concentration reduction leads to increase of the current at a given value of the voltage. Hence, porous silicon-based biosensor structure proposed by us is sensitive at small glucose concentrations. It is very important for medical and clinical applications, when it is necessary to measure small quantities of glucose. In addition, the reduction of porous silicon conductance with the increase in the concentration of glucose is a result of appearing of immobilized glucose molecules on the surface rather than dissolution of glucose in distilled water, since water, on the contrary, increases the conductivity of porous silicon.

The main advantage of such a structure for application in biosensor is the absence of any additional transducers because of high sensitivity of porous silicon surface.

The obtained results are encouraging. Our further works are focused on the improvement of obtained structure characteristics and investigate the effect of aging of porous silicon on the structure characteristic with preserving of porous silicon from aging effect.

4. Conclusion

Porous silicon-based devices were fabricated and their current-voltage characteristics under influence of glucose with different concentrations were measured. Glucose molecules were immobilized on porous silicon surface from solutions of glucose in distilled water. It was shown that decreasing glucose concentration leads to increase of current values at given voltages.

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