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First Selective Detection of Proteins

Using Top-Gate Carbon Nanotube Field Effect Transistor

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1. Introduction

The development of compact and inexpensive biosensors is indispensable for improving medical care facilities in remote localities. For medical applications, it is necessary for a biosensor to detect several biological species simultaneously. In this study, we have developed a protein biosensor based on a carbon nanotube field effect transistor (CNT-FET); the CNT functions as a channel. We first succeeded in detecting several proteins, selectively.

2. Experiment

A top-gate CNT-FET was modified for application as a protein biosensor. For the selective detection of pig serum albumin (PSA) and mouse immunoglobulin G (MIgG), we used CNT-FET immobilized either anti-PSA (a-PSA) or anti-MIgG (a-MIgG) antibodies that were physically adsorbed onto the top-gate of CNT-FETs (see figure 1) (in this abstract, CNT-FETs immobilized PSA and MIgG on the top-gate are referred to as the PSA biosensor and the MIgG biosensor, respectively). The antigens were dissolved in a buffer (pH 8.0) and reacted with the immobilized antibodies. A silicone rubber wall was placed around the top-gate to retain the antigen test solutions. Antigen test solutions were poured on the top-gate surrounded by silicon rubber wall and FET characteristics were measured. The selective detection of antigens was evaluated by comparing the drain current measured on the basis that the test solution contains a different concentration or type of antigen.

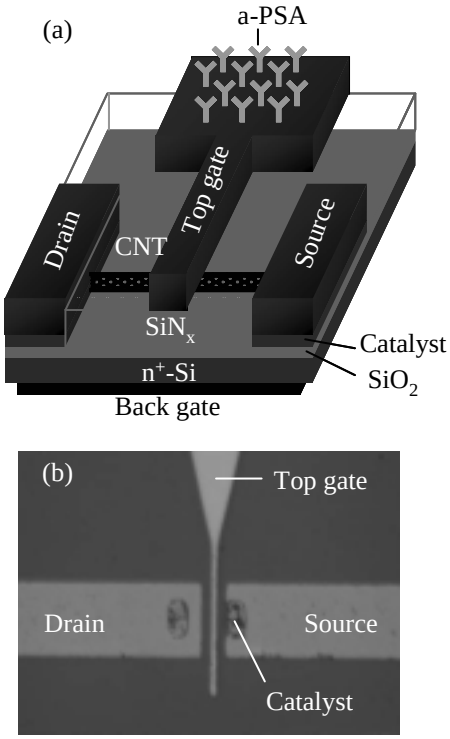

Figure 1. Structure of PSA biosensor
(a) Schematic image
(b) Optical micrograph

3. Results and discussions

Figure 2 shows the drain current time profiling of the PSA biosensor onto which the antigen solution was poured. The drain voltage and top-gate voltage were maintained at +0.1 V and +1 V, respectively. Drain current was sampled every 5 seconds. In case the PSA test solution was poured onto the PSA biosensor, the drain current decreased compared to that measured for a test solution without antigens (see figure 2(a)). As the concentration of PSA increased, there was a corresponding decrease in the drain current. The dependence of the drain current decrease on the PSA concentration was shown in figure 2(b). The drain current decrease was linearly proportional to the logarithmic scale of PSA concentration. This result well agreed with a traditional adsorption isotherm [1].

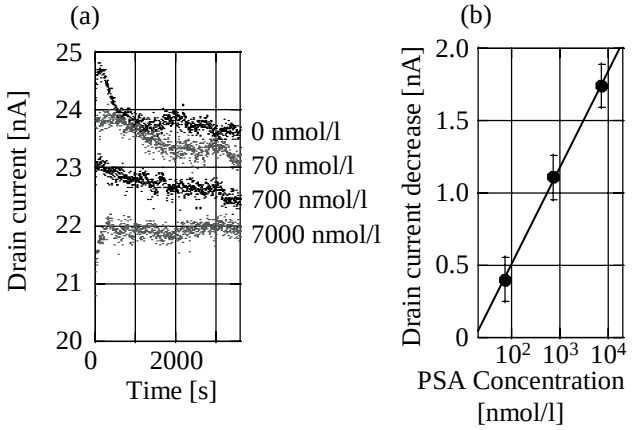

Figure 2. Drain current of PSA biosensor onto which PSA test solutions was poured
(a) Time profiling.
(b) Dependence of drain current decrease on PSA Concentration.

When the 700 nmol/l MIgG test solution was poured onto the PSA biosensor, the drain current remained unchanged compared to that measured for a test solution without antigens (figure 3 (a), (b)). When a mixture of 700 nmol/l PSA and 700 nmol/l MIgG test solution was poured onto the PSA biosensor, the drain current was generally comparable to that measured using the 700 nmol/l PSA solution alone. That shows the PSA biosensor detected only PSA as shown schematically in figure 4(a). We took further measurements using the MIgG biosensor onto which antigen test solutions were poured. When the MIgG solution was poured onto the MIgG biosensor, the drain current decreased. When the PSA solution was poured onto this biosensor, the drain current remained unchanged. These results are the reverse of those obtained using the PSA biosensor. These results show that PSA bound only to a-PSA and MIgG bound only to a-MIgG on the top-gate of the CNT-FET (see figure 4 (a), (b)).

In conclusion, by using a top-gate CNT-FET, we have first succeeded in selectively detecting of PSA and MIgG antigens.

Reference

[1] M. I. Temkin and V. Pyzhev, Acta Physiochim. URSS **12** (1940) 327.

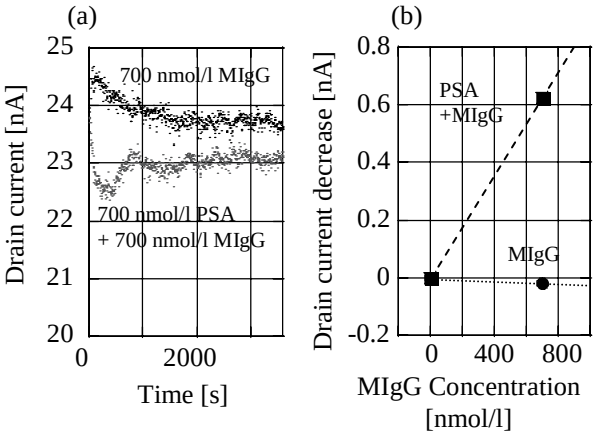

Figure 3. Drain current of PSA biosensor onto which MIgG test solutions was poured
(a) Time profiling.
(b) Dependence of drain current decrease on PSA Concentration

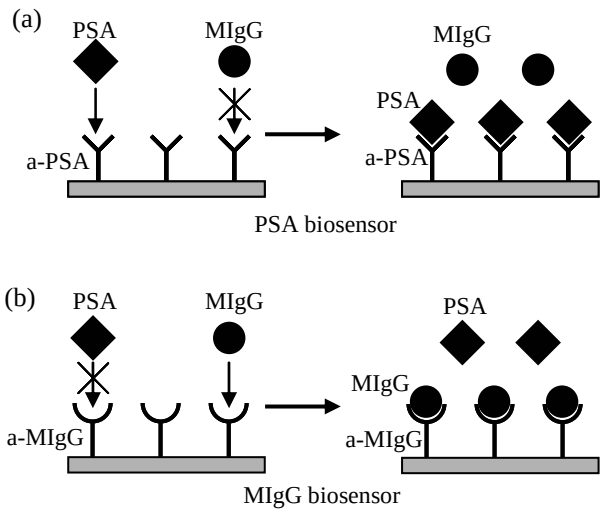

Figure 4. Schematic image of selective detecting of proteins.
(a) PSA biosensor
(b) MIgG biosensor