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ダイヤモンド表面固定アプタマーによるトランジスタ型バイオセンサ

Diamond-Transistor-based Biosensor for Protein Detection by DNA/RNA Aptamers

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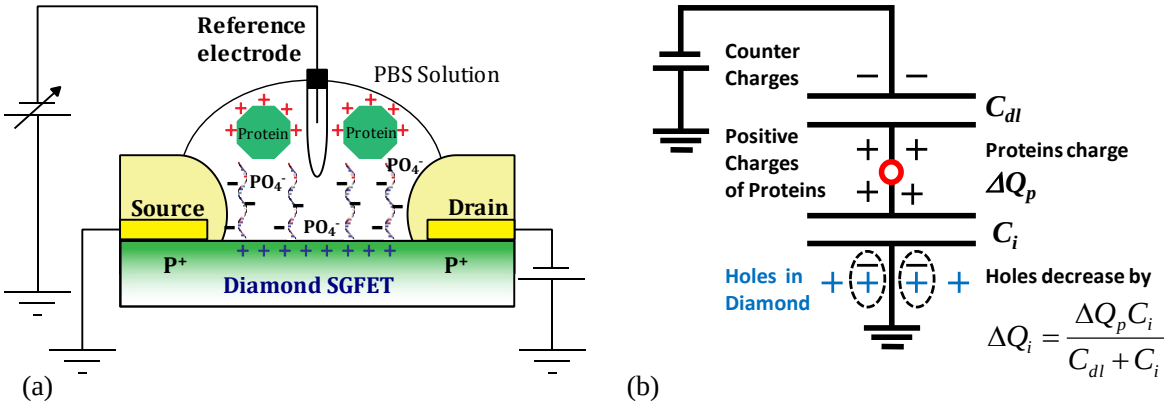
For protein detection, we have developed aptamer (DNA/RNA) immobilized transistor-type biosensors on functionalized diamond surfaces [1-7]. As a kind of insulating gate FETs operating in electrolyte solution we named “solution gate FET (SGFET)” [1,6]. Using amine termination and carboxyl termination, aptamers are immobilized directly on diamond surface within 5nm from the surface. Due to high areal capacitance, such as a liquid electric double-layer capacitor and a solid channel capacitor, the change in surface charge caused by charged protein binding to DNA/RNA aptamers can be efficiently detected. The detection of biomolecules such as one-base-mismatch DNA [3], protein such as platelet-derived growth factor (PDGF) [4] and HIV Tat protein [5,7] can be realized. In the miniaturization of field effect transistors (FETs), diamond surface provides better sensing property compared with conventional Si ion sensitive FET (ISFET). The advantage of diamond SGFET sensor compared with Si ISFET is its thin sensing layer [1,2]. The layer is formed by the hole accumulation formed by H-terminated surface of undoped diamond or thin B-doped diamond layer (Fig.1 (a)). For Si ISFET, gate oxide (SiO_2) and protective insulator layers are inevitable Because of large insulator thickness, the solid-side capacitance C_i decreases resulting in low transconductance (low sensitivity). While on diamond, probes such as DNA are immobilized directly to the sensing surface [2,3] as shown in Fig.1(a), where proteins are captured within Debye length by DNA/RNA aptamers [4-7] like antibody-antigen reaction. Since the C_i on diamond is as high as 1~5μF/cm^2 comparable to the electric double layer capacitor C_{dl} (1~5μF/cm^2) (Fig.1(b)), the charge increased by positively charged protein such as PDGF or HIV Tat peptide. The increase of positive charge ΔQ_p is effectively reflected as hole decrease ΔQ_i (Fig.1(b)) in channel [5,6]. This hole increase or decrease is measured as drain current change or gate voltage shift clearly.



(a)　(b)

Fig.1 (a) aptamer immobilized diamond SGFET for protein detection. (b) equivalent circuit for charge change ΔQ_p between an electric double layer capacitor C_{dl} and a capacitor on solid side C_i. [4-7].

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