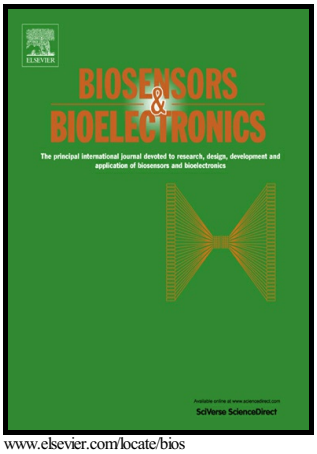

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Direct Label-free Protein Detection in High Ionic Strength Solution and Human Plasma Using Dual-Gate Nanoribbon-based Ion-Sensitive Field-Effect Transistor Biosensor

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Abstract

We report on direct label-free protein detection in high ionic strength solution and human plasma by a dual-gate nanoribbon-based ion-sensitive field-effect transistor (NR-ISFET) biosensor system with excellent sensitivity and specificity in both solution-gate (SG) and dual-gate (DG) modes. Compared with previously reported results, the NR-ISFET biosensor enables selective prostate specific antigen (PSA) detection based on antibody-antigen binding in broader detection range with lower LOD. For the first time, real-time specific detection of PSA of 10 pM to 1 μM in 100 mM phosphate buffer (PB) was demonstrated by conductance measurements using the polyethylene glycol (PEG)-modified NR-ISFET biosensors in DG mode with the back-gate bias (V_{BG}) of 20 V. Due to larger maximum transconductance value resulting from the modulation of NR-ISFET channel by the back gate in DG mode, the detection range can be broadened with larger linear detection region (100 pM to 100 nM) and lower limit of detection (LOD, 10 pM) as compared to those in SG mode. Moreover, the influence of different back-gate bias from V_{BG} = 5 V to V_{BG} = 25 V on the biosensor performance has been investigated. Furthermore, direct PSA detection of 100 pM to 1 μM in human plasma was demonstrated by using the PEG-modified NR-ISFET in DG mode, enabling direct detection of protein in human blood for clinical applications since the LOD of 100 pM PSA can meet the clinical requirements.