

Graphene based FET biosensor for the detection of SARS-CoV-2 variants of concern

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The development of highly sensitive and selective biosensors for the detection of SARS-CoV-2 variants of concern (VOCs) is crucial for effective diagnostics and pandemic management. Biosensors based on field-effect transistors (FET) have emerged as one of the most suitable methods as they offer several advantages, such as high sensitivity, fast detection speed, excellent limit of detection (LoD), miniaturization potential and low-cost manufacturing [1]. In addition, FET-based biosensors can be easily integrated into a microfluidic platform, which allows operation with small amounts of analyte and increases the sensitivity of the device [2]. Therefore, the FET-based biosensors are considered as promising technology for point-of-care diagnostics.

This study presents a comparative analysis of biosensors based on graphene field-effect transistors (G-FETs) using two different types of graphene — directly synthesized graphene by using microwave plasma-enhanced chemical vapor deposition (MW-PECVD) on SiO₂/Si substrates and commercial CVD-grown graphene transferred onto glass substrates. Both G-FETs were functionalized with 1-pyrenebutanoic acid succinimidyl ester (PBASE) to immobilize recombinant angiotensin-converting enzyme 2 (ACE2) for the detection of SARS-CoV-2 spike protein. Additionally, detection of VOCs (Wild Type, Alpha, Beta, Delta and Omicron) by G-FET biosensor based on transferred graphene was investigated.

A custom microfluidic system was used to test the performance of the biosensor by measuring the transfer characteristics after each step of surface modification and filling the microfluidic system with different concentration of spike protein. Sensitivity was evaluated by two methods: 1) measuring the Dirac voltage shifts and 2) relative current changes while keeping constant gate voltage upon binding of spike proteins. Electrical responses revealed distinct differences between the VOCs. Additionally, the selectivity of the system with the MERS spike protein was tested.

The results emphasize the potential of graphene FET-based biosensors for detection and monitoring of SARS-CoV-2 VOCs. MW-PECVD graphene sensor, demonstrated sufficient sensitivity comparable with transferred CVD-grown graphene sensor to detect changes in Dirac voltage and transconductance even at very low concentrations of spike protein. This study highlights the versatility of graphene-based biosensor platforms for pandemic response, contributing to the early diagnosis of virus infections and monitoring of emerging strains.

Keywords: graphene; direct PECVD synthesis; field-effect transistor-based biosensor; COVID-19; SARS-CoV-2 spike protein; ACE2 receptor; Dirac voltage shift.

References:

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