Liquid gate field effect transistor for SARS-CoV-2 spike protein detection

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COVID-19, also known as the coronavirus disease 2019, is a recently emerged infectious disease that affects humans and causes severe respiratory distress. Due to its rapid spread among individuals, the World Health Organization (WHO) declared the COVID-19 outbreak as a pandemic on 12 March 2020. As of January 2024, there have been more than 774 million confirmed cases of COVID-19 worldwide, resulting in over 7 million deaths, according to the World Health Organization's official website [1]. Although the specific mechanism by which SARS-CoV-2 causes the disease is not fully understood, recent research has indicated that SARS-CoV-2 utilizes angiotensin-converting enzyme II (ACE2) as a receptor to enter host cells.

The growing prevalence of diseases and their associated risks necessitates the exploration of novel sensor types for detection purposes. The recent encounter with the COVID-19 pandemic highlighted the crucial significance of virus detection methods, particularly due to the virus's rapid mutation and emergence of different variants. Among the many diagnostic methods currently available, field-effect transistor (FET)-based biosensor devices offer several advantages due to their small size and sensitivity.

Two-dimensional (2D) nanomaterials offer many unique possibilities for FET-based biosensors due to their atomically thin nature and extra-large surface-to-volume ratio [2]. Graphene has drawn tremendous attention in the scientific community due to its extraordinary electronic and mechanical properties. Remarkably, the large surface-to-volume ratio of the graphene provides a lot of the exposed atoms available for functional group attachment, resulting in significantly enhanced surface reactivity. Combined with easily tunable electrical properties, it opens up new possibilities for biosensing applications [3].

This contribution presents the study of liquid gate graphene field effect transistor (G-FET) based biosensors for SARS-CoV-2 spike protein detection [4]. Two technologies of graphene preparation were investigated: wet transfer (T) and direct growth by the microwave plasma-enhanced chemical vapor deposition (MW-PECVD) on the SiO_2 substrate. The prepared samples were incorporated into a microfluidic system, allowing to use low volumes of analyte. Both types of sensors were functionalized by 2.5-dioxopyrrolidin-1-yl 4-(pyrene-1-y) butanoate (PBASE) and receptor ACE2 and treated with spike protein solution. Transfer characteristic curves and real-time resistance changes of the G-FET devices were measured and analyzed.

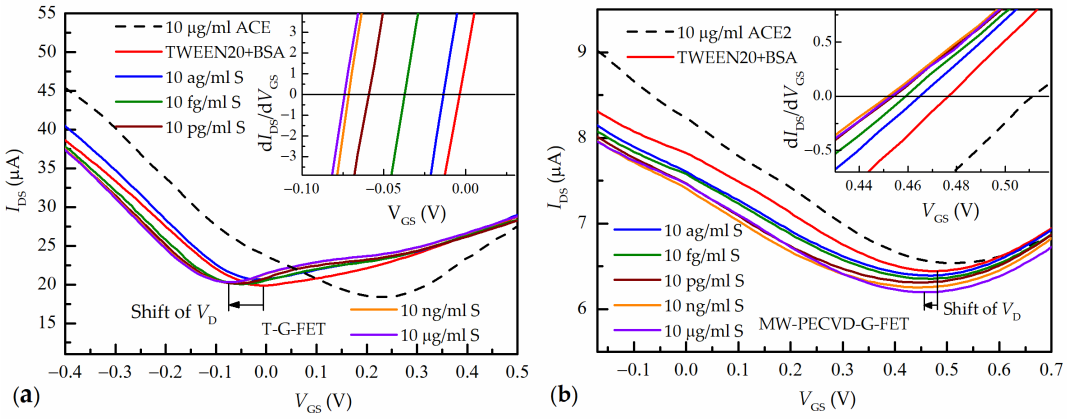

Fig. 1. Transfer characteristics at different spike S protein concentrations for transferred G-FET sensors (a) and MW-PECVD G-FET (b). Insets: the derivatives of transfer characteristics close to the Dirac point at which the derivative is equal to zero.

References

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