Inkjet-printed Two-Dimentional Material Biosensors on Flexible Substrates

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Point-of-care (PoC) diagnostic technology is poised to be a key tool for addressing some of the complex healthcare challenges faced by a growing and ageing global population. Without the utilization of diagnostic tests, patient diagnoses are little more than educated guesses based on anecdotal descriptions, regularly resulting in misdiagnosis and mistreatment.[1] By moving sensing devices away from the lab, PoC devices offer rapid, cheaper, patient centred care.[2] In the myriad of proposed sensor technologies, two-dimensional materials (2DMs) have risen as promising candidates owing to their unique combination of characteristics.[3] Graphene for example, is a stable biocompatible, semi-metal with high mobility which is well suited for sensing of biologically relevant analytes.[4] Moreover, 2DMs can be dispersed as inks – combining conducting, insulating and semiconducting inks together offers a route for economical, flexible printed electronics devices on a wearable platform. However, there persist challenges in producing stable, high-concentration inks for scalable production of such printed electronic devices made using 2DMs.[5]

In this work, we demonstrate inkjet-printed field-effect transistors on rigid and flexible form factors for wearable applications. In our work, transistor structures were printed by utilizing graphene inks as the active channel area, h-BN inks as the dielectric material and MXene and silver inks as the electrodes. A systematic analysis of alcohol-polyvinylpyrrolidone (PVP) based 2DM inks was carried out to improve stability and achieve concentrations ranging from 0.1 mg mL^{-1} to > 10 mg mL^{-1}. Raman spectroscopy indicated that the inks comprised of electronically decoupled layers of graphene. The lateral flake size was characterized by AFM, SEM and TEM, with a likely modal average of 0.4 – 0.5 µm within a range of flakes extending between 0.2 µm and 5 µm and flake thicknesses of up to 30 nm. The synthesized inks were then inkjet-printed and characterised as solution-gated and back-gated structures and their field-effect mobilities measured. Finally, we also demonstrate how the transistor performance can be modulated as a function of the analyte of interest, establishing their viability for printed large-scale biosensors.

References

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Figures

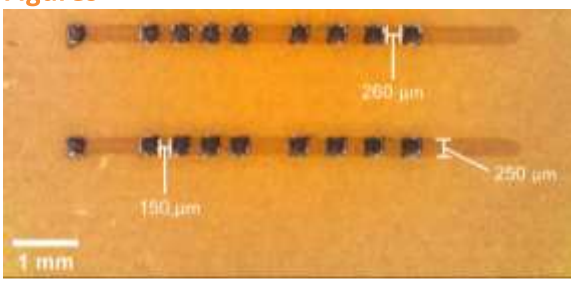

Figure 1: Inkjet-printed graphene field effect transistors with silver electrodes.