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BIOSENSORS FOR PANDEMICS

Portable and real time DNA detection system using graphene transistor

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ABSTRACT

With the fast rising confirmed case due to the novel coronavirus disease (COVID-19) all over the world, a rapid, low-cost and non-laborious point of care (POC) diagnostic tool is urgently required. Graphene, an excellent two dimensional (2D) material with 1-atom thick carbon provides a new route towards ultrasensitive biomolecular detection for disease early diagnosis. In this study, we developed a portable and real time DNA detection system based on multi-array graphene field effect transistor (GFET) integrated with a miniaturized (credit card-size) Arduino output reading platform and an automatic micropump. Single layer graphene was applied as channels where biorecognition elements immobilized. To optimize probe DNA (pDNA) (amine-tagged, 35 mer) immobilization and to preserve graphene structure and functionality, 1-pyrene butyric acid succinimidyl ester (PBSE) linker was chosen since it could be attached to graphene through the π- π stacking [1]. To minimize the non-specific binding, ethanolamine (ETA) was applied prior to the addition of target DNA (tDNA). Signal acquisition was performed in a quick response time with a liquid gating setup [2] using 0.01x phosphate buffer solution (PBS). Preliminary results demonstrated successful surface modification and DNA hybridization signal of the pDNA and 1µM tDNA with Dirac point (V_{Dirac}) shift of ~90 mV. The integrated GFET system is also potential to detect specific viral RNA which carries the same charge as DNA, as well as for multiplex detection through multi-array configuration towards more rapid, portable and inexpensive detection highly needed in pandemic scene like in nowadays COVID-19 outbreak period.

EXPERIMENTAL SETUP & DNA DETECTION STRATEGY

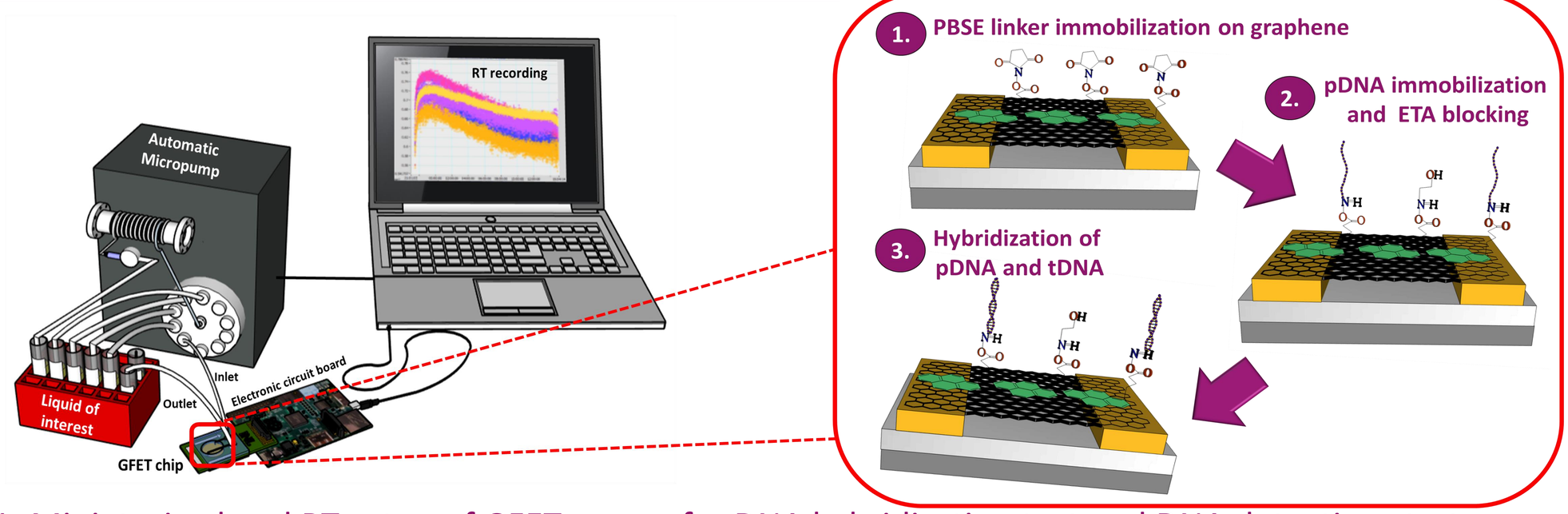


Figure 1: Miniaturized and RT setup of GFET sensor for DNA hybridization test and DNA detection strategy.

RESULTS

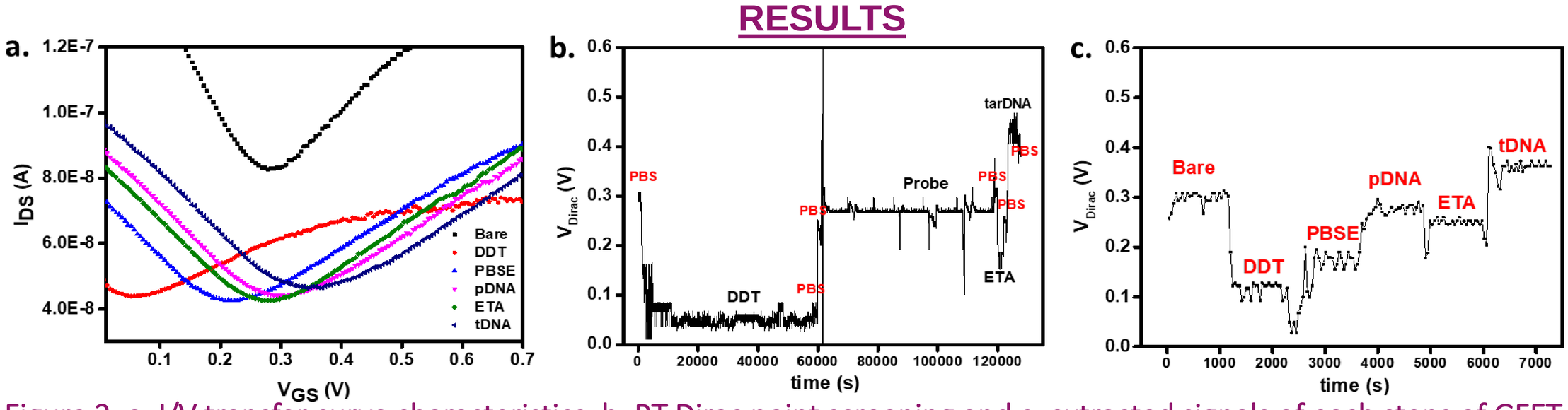
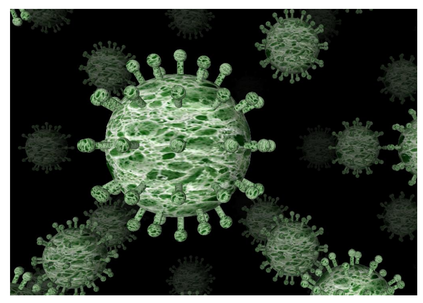


Figure 2: a. I/V transfer curve characteristics, b. RT Dirac point screening and c. extracted signals of each steps of GFET surface modification and DNA hybridization detection using 1 µM target DNA.

POSSIBLE STRATEGIES FOR COVID-19 DETECTION

- On-site, rapid and real time screening for early detection with considerably low-cost instrumentation
- Direct Corona Virus RNA hybridization detection through a known unique sequence and/or via Reverse Transcription methods
- Plausible screening design for the virus envelope protein-receptor binding for frontline detection of COVID-19



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[1] R. Campos et al., ACS Sensors, vol. 4, no. 2, 2019, pp. 286–293.
[2] M. T. Hwang et al., Nat. Commun., 11, 2020, pp. 1543.

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