GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

Graphene online 2020 October 19-23

10 ANNIVERSARY

Graphene-based biosensors for COVID-19 diagnostics: review on latest applications

Enric Calucho, Ruslan Álvarez-Diduk, Arben Merkoçi
Institut Català de Nanociència i Nanotecnologia (ICN2), Bellaterra (Barcelona), Spain

Introduction

In December 2019, an outbreak of severe acute respiratory syndrome caused by a novel coronavirus (SARS-CoV-2) was originated in Wuhan, Hubei province, China, escalating into a global pandemic in just three months. The disease, officially named COVID-19, has saturated healthcare systems worldwide, thus demonstrating the urgent need to deploy rapid and reliable diagnostic tools. Along with contention measures such as social distancing and good hygienic practices, the rapid implementation of diagnostic strategies during the early stages of the pandemic can have a major impact on limiting the spread of the virus. Graphene and its derivatives have been applied in the development of biosensors for the detection of all kinds of analytes, e.g. bacteria, viruses, proteins, nucleic acids and heavy metals [1]. Moreover they are compatible with assays of clinical interest like liquid biopsies [2]. In the current context of emergency, graphene has an excellent opportunity to demonstrate its capabilities for biosensing applications. This poster shows the latest examples of graphene applied for the diagnosis of COVID-19, taking advantage of its high electronic conductivity.

Structure and biomarkers of SARS-CoV-2

COVID-19 can be diagnosed immunologically by detection of its antigens (see SARS-CoV-2 structure) or serologically by detection of IgG/M generated as an immune response. However, the gold standard method is the polymerase chain reaction (PCR), which consists on the conversion of viral RNA into DNA, its amplification and detection.

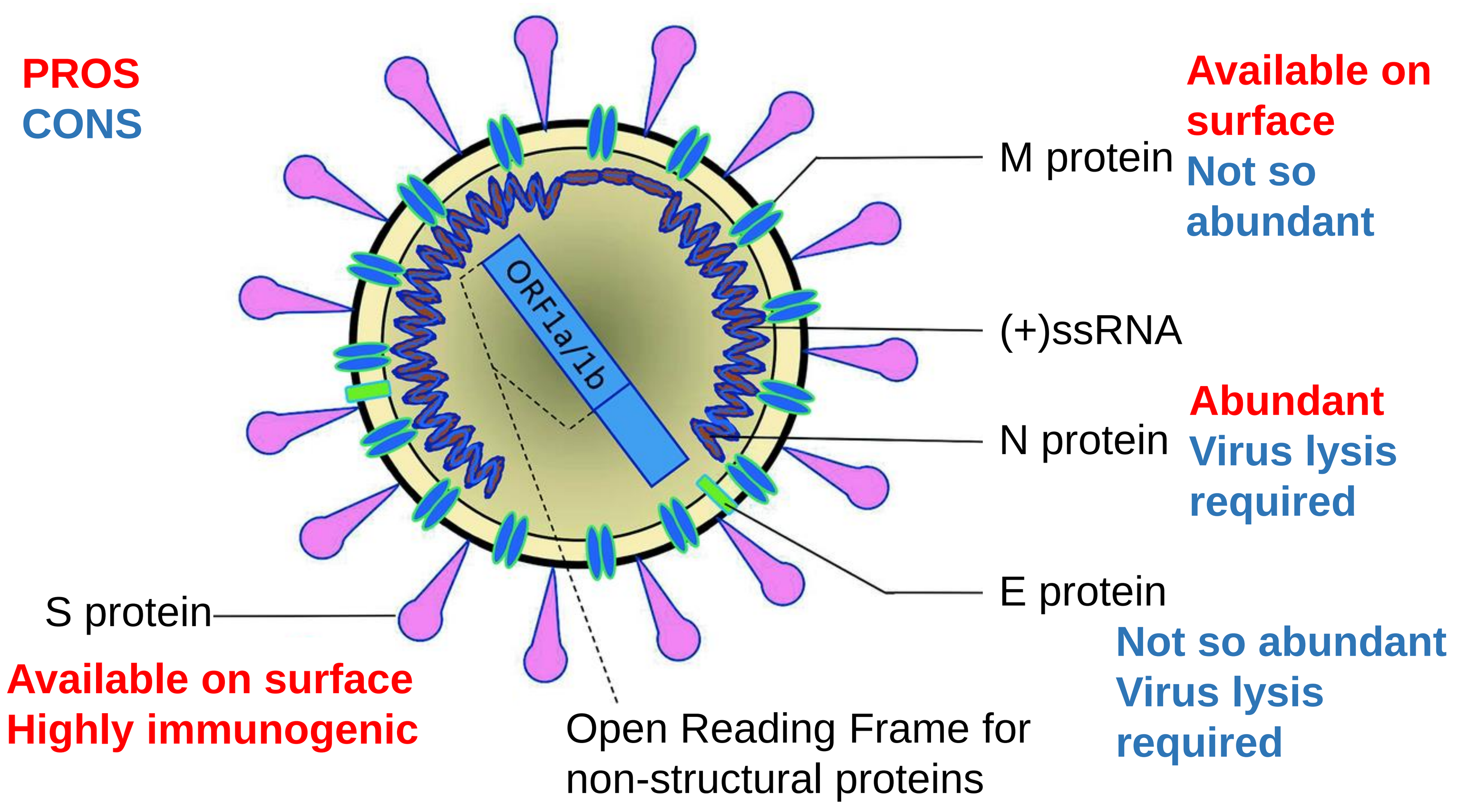

Figure 1. Structure of SARS-COV-2: S, spike protein; E, envelope protein; M, membrane protein; N, nucleoprotein. Structural proteins are typical biomarkers. Adapted from reference [3]. Permission not required. Copyright © 2020, Springer Nature.

SARS-CoV-2 RapidFlex

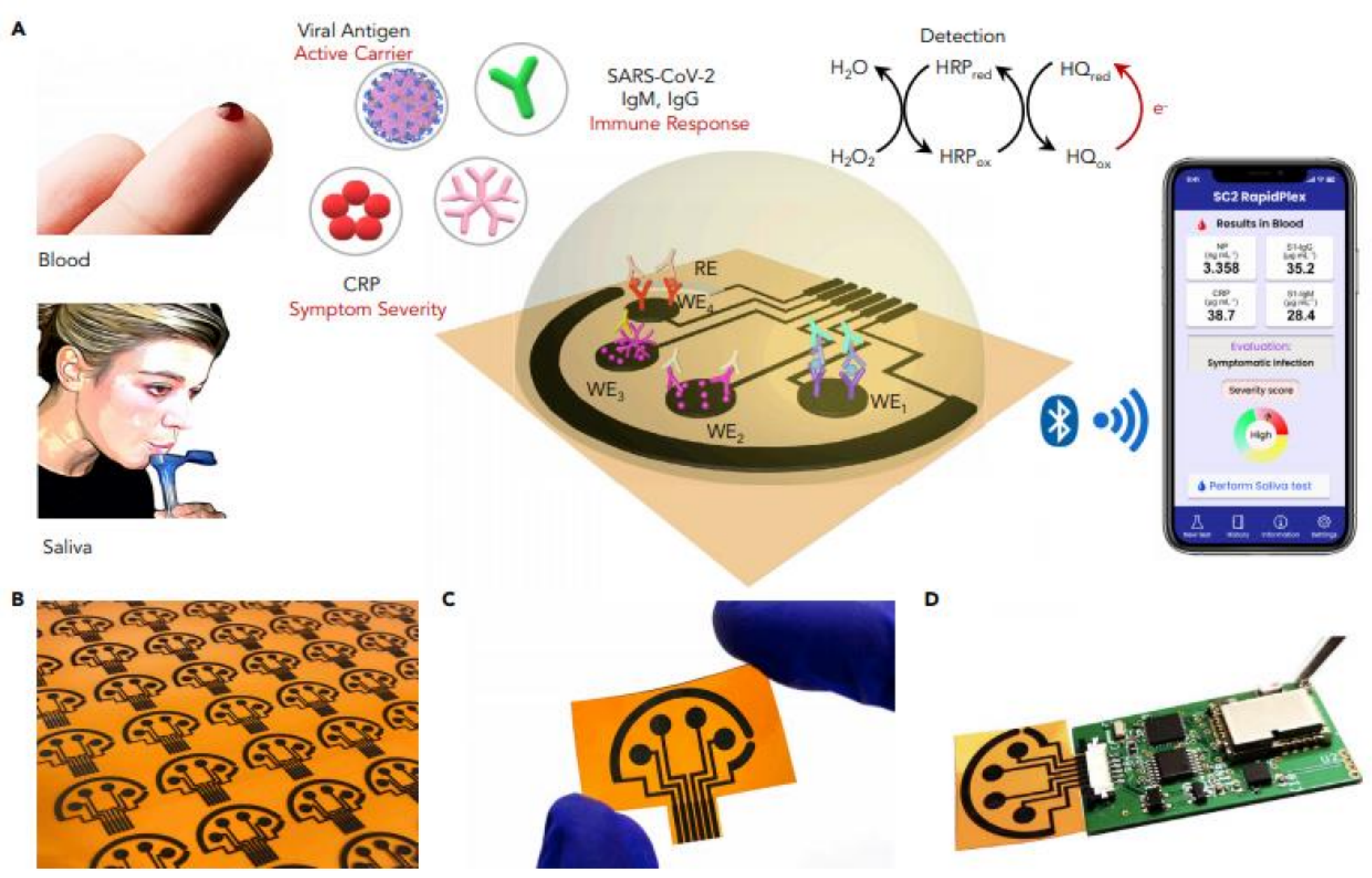

Figure 2. SARS-COV-2 RapidFlex is an electrochemical device capable of simultaneously detecting viral antigen, IgG/M antibodies and inflammatory biomarker C-reactive protein from blood and saliva samples. Moreover, the device sends the results to the user's smartphone to allow for remote assessment from medical professionals. Adapted from reference [5] with permission.

Field-Effect Transistor-based biosensor

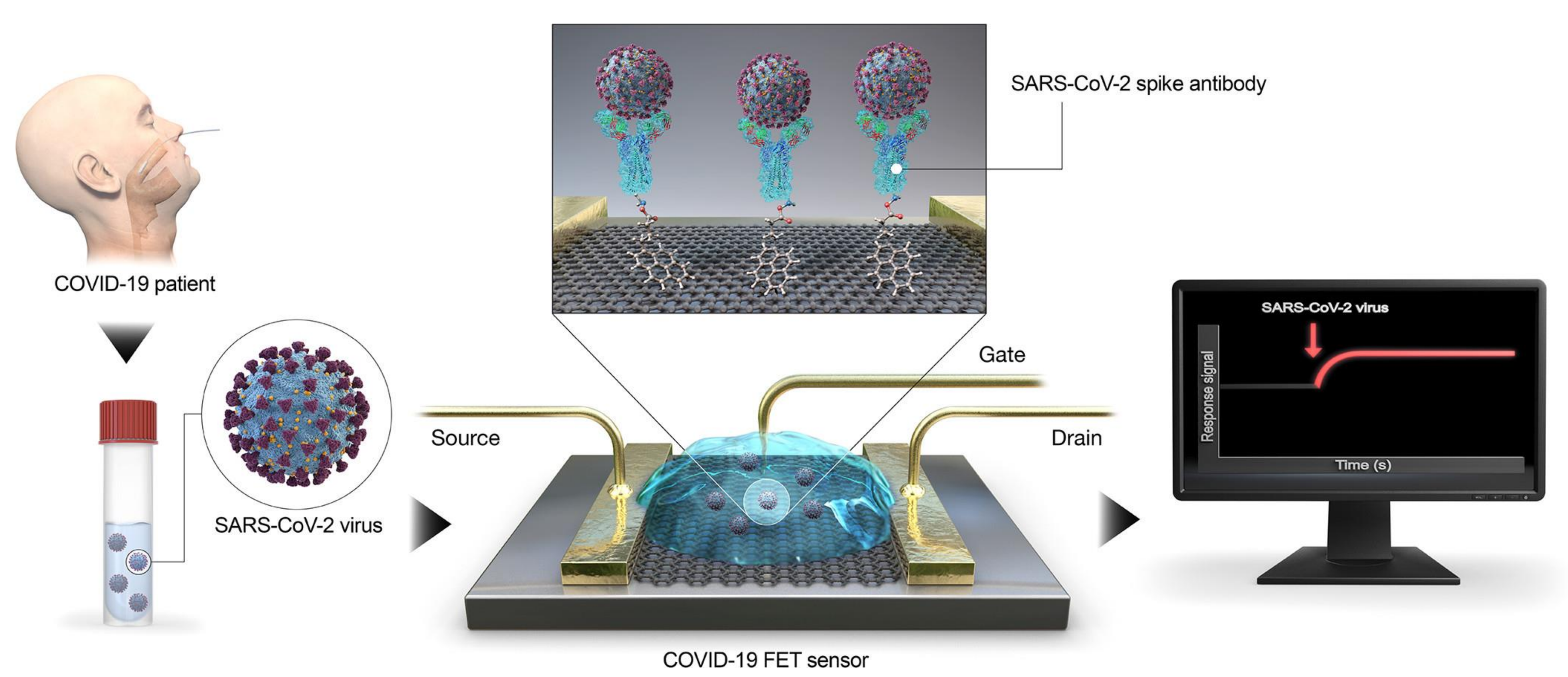

Figure 3. Seo *et al* developed a highly sensitive FET biosensor which has been tested on samples from nasopharyngeal swabs, with a limit of detection of 100 fg/mL (1 fg/mL in PBS). Anti-spike protein antibodies were functionalized onto the graphene with an interface coupling agent as probe linker [4] (https://pubs.acs.org/doi/10.1021/acsnano.0c02823) (further permissions related to the material should be directed to the ACS). Similar approaches have been reported [6], even though it was only tested in PBS (limit of detection: 0.1 pM).

Alternative roles for graphene

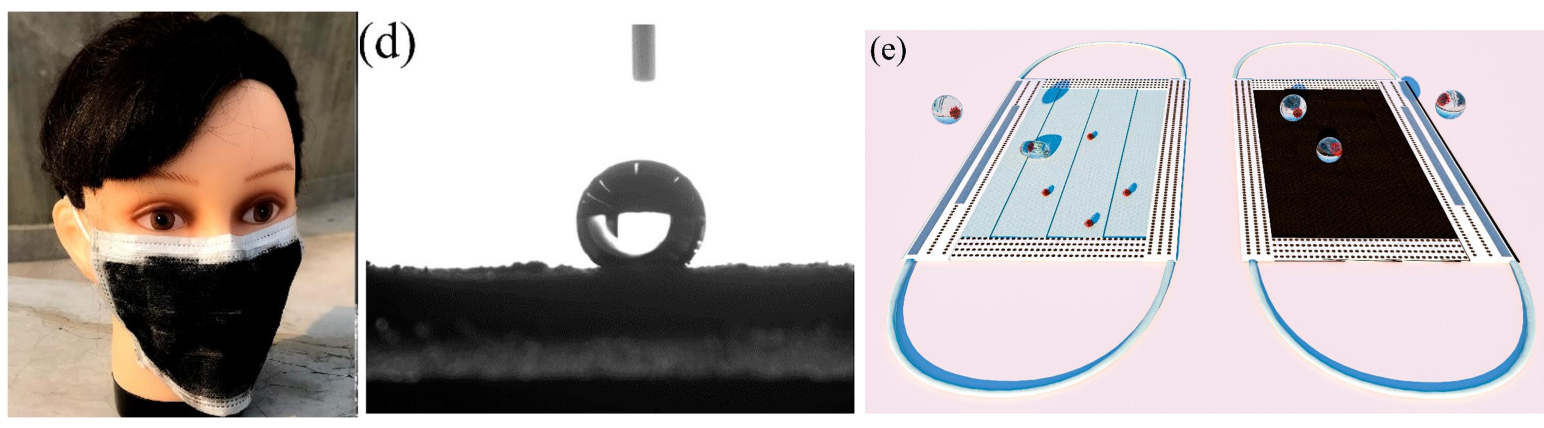

Figure 4. Graphene can potentially contribute in halting the pandemic by more direct means. Graphene-coated surgical masks are superhydrophobic and have self-cleaning properties, thus providing the user with better protections against virus-containg droplets [7]. De Maio *et al* have recently shown that viral particles incubated with graphene oxide have their infectivity reduced [8]. Figure adapted from reference [7] with permission.

Future perspectives

The ongoing COVID-19 pandemic has shown how we are in real need of point-of-care devices, not only for fast diagnostics, but for telemedical assistance as a way to avoid expansion of the virus. Graphene is compatible with both concepts. Taking into account the effects of COVID-19 in our lifestyles, it is of utmost importance to keep developing diagnostic fast, interconnected devices for the current situation in order to confront further outbreaks.

CONTACT PERSON

Prof. Arben Merkoçi
Arben.merkoci@icn2.cat

REFERENCES

[1] Adv. Mater. 2017, 29, 1604905.
[2] Nanomaterials 2020, 10, 1014.
[3] Military Med. Res., 2020, 7-11.
[4] ACS Nano 2020, 14 (4), 5135-5142.
[5] Matter 2020, 3, 1-18.
[6] arXiv:2003.12529v1 [physics.app-ph] (2020)
[7] ACS Nano 2020, 14 (5), 6213-6221.
[8] medRxiv, 2020. doi: https://doi.org/10.1101/2020.09.16.20194316

We acknowledge support from MINECO, Spain for MAT2017-87202-P, the Severo Ochoa program (Grant No. SEV-2017-0706) and Graphene Flagship Core Project 2 (Ref.: 785219). This work is also funded by the CERCA Programme/Generalitat de Catalunya. Enric Calucho acknowledges Autonomous University of Barcelona (UAB) for the possibility of performing this work inside the framework of Biotechnology Ph.D. Programme.

Graphene online 2020