Wearable brain- machine interfaces with graphene EEG sensors

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Recent progress in Neuroscience and Artificial Intelligence has opened the path to the implementation of electroencephalography (EEG) as a non-invasive platform for brain-machine interface (BMI) [1]. Although the spatial-temporal resolution of EEG is inferior to the that of implanted interfaces, the wearable, surgery -free, nature of such BCI makes it a preferred route for large -scale uses and most applications that do not concern the mitigation of severe disabilities.
One of the main bottlenecks for further progress of the EEG -based BMIs is the availability of suitable dry sensors. Dry sensors tend to show a high contact impedance with the skin, which hampers an accurate read-out of the ~μV amplitude biopotentials at the scalp, because of their strong capacitive component at the contact [2]. In addition, their contact with the skin needs to be stable during movement and reliable over long-term usage outside lab settings, which is another key challenge due to corrosion, biocompatibility and slipping issues. 2D materials open new promising possibilities in this application area [3].
We demonstrate the use of epitaxial graphene on silicon carbide on silicon [4] as dry EEG sensors for a wearable brain-machine interface system which is reliable upon long-term usage [5]. The produced sensors are wafer- thin, biocompatible with the skin, and show a lower contact impedance as compared to bulkier commercial sensors. In particular, we observe that their contact impedance improves once in contact with the skin, thanks to a gradual wetting of the graphene's surface [5]. The produced sensors are wafer- thin, highly biocompatible, and show a lower contact impedance as compared to their bulkier commercial sensor counterparts and are remarkably resilient to corrosion in saline environments, showing minimal performance degradation upon storage in a highly saline environment for up to one year.
In this contribution, we will share the latest progress in the use of epitaxial graphene sensors mounted on a head helmet for the hands-free control of a remote robotic platform. The BMI evaluation used a steady -state visual evoked potential paradigm (SSVEP), presenting the individual with up to 6 command options to control hands-free the movement of a robotic quadruped. We have demonstrated up to 94% accuracy in the lab using 6 graphene sensors mounted on a rudimental helmet in the presence of 5mm length hair [6].

References

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