Development of a graphene and fluorographene based gas sensor

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Nowadays the reinforcement of health and environmental standards implies a compact and ppb sensitive air quality monitoring. This can be achieve through graphene ultrasensitive gas sensor as a third way between optical and metal oxides sensors. In this context, ONERA is pushing for the development of an ammonia and NOx sensor. This gas sensor relies on the chemosensitivity [1] of the graphene when exposed to a gas. It is produced by several steps of photolithography and graphene transfer. Our sensor has proven to be ppb sensitive (fig. 1)
A major purpose of this work is to enhance the electronic properties of graphene concurrently with a depletion of the instabilities observed inside the SiO_2 substrate.
An initial approach involves the use of a Boron Nitride substrate as it will enhance electron mobility and reduce substrate effect [2]. The few BN suppliers available on the market as well as the difficulties encountered during the processing limit this perspective. Nevertheless, we are exploring two leads: firstly, the peeling of BN crystal before graphene transfer (fig. 2) and secondly, the use of a BN substrate synthesized by Chemical Vapour Deposition at the ONERA.
A second step of the research implies to implant fluorine atoms into the pristine graphene section [3], or to fluorinate the graphene with an electron beam in order to mute graphene into fluorographene with a high spatial resolution [4], with the aim of detect both ammonia and nitrogen dioxide molecules.

References

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[2] J. Dauber *et al.*, "Ultra-sensitive Hall sensors based on graphene encapsulated in hexagonal boron nitride," *Appl. Phys. Lett.*, vol. 106, no. 19, 2015, doi: 10.1063/1.4919897.
[3] H. Li *et al.*, "Site-selective local fluorination of graphene induced by focused ion beam irradiation", *Sci. Rep.*, vol. 6, pp. 1–7, 2016.
[4] H. Li *et al*., "Direct writing of lateral fluorographenenanopatterns with tunable bandgaps and its application in new generation of moiré superlattice", Appl. Phys. Rev. 7, 011403 (2020).

Figures

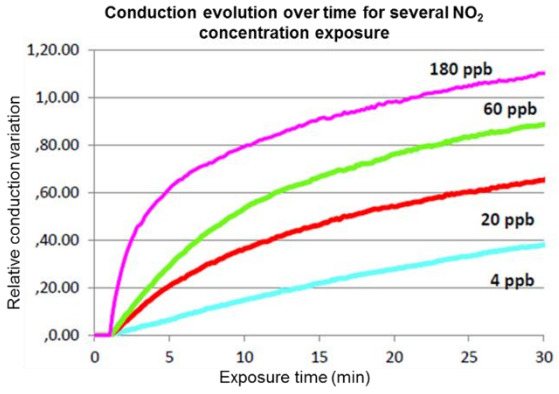

Figure 1: ONERA graphene based gas sensor response to several NO_2 concentration exposure

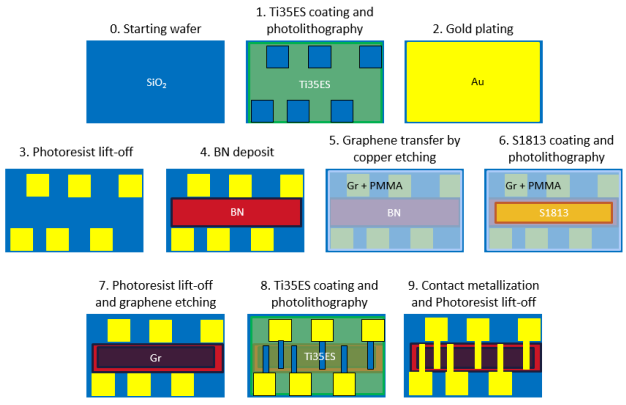

Figure 2: Sensor manufacturing process with BN deposit before graphene transfer