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 [1] gas sensor as a third way between optical and metal oxides sensors. We have been developing a chemo-sensitive graphene sensor. Our sensor has proven to be ppb sensitive to NO_2 (fig. 1). Nevertheless, we are experiencing low selectivity, high response time and instabilities due to the substrate.
In order to enhance our sensor selectivity and sensitivity to NH_3, we are willing to fluorinate the graphene with an electron beam in order to mute graphene into fluorographene with a high spatial resolution [2]. Indeed, there is a strong binding energy between fluorine and ammonia, which leads to the enhanced sensitivity of the gas sensor. Before performing electrical and gas sensing characterizations with such sensor, we are working to determine the performance over time and temperature of the fluorographene through an X-ray photoelectron spectroscopy (fig. 2.). This technique will support us to investigate the electron affinity between the gases and the graphene or the fluorographene by studying adsorption and desorption mechanisms.
The second step of this work involves the use of a Boron Nitride substrate as it will enhance electron mobility and sensor response time meanwhile reducing substrate effect [3]. We are exploring two leads. Firstly, the processing of an "all-CVD" (Chemical Vapour Deposition) device build with consecutives liquids transfers of commercial CVD BN and CVD graphene (Graphene Supermarket and Graphenea). Secondly, the use of a BN substrate synthesized by CVD in our laboratory, at the ONERA [4]. This BN shows continuous, single crystalline and sp2-hybridized multilayer film on the nickel (111) substrate. (fig. 3). A new approach would be to build the sensor directly on the BN growing substrate of nickel, avoiding the damage induced by the liquid transfer of the BN film.
Lastly, our aim is to combine the use of fluorinated graphene with a BN substrate as an innovative solution for the development of an ultrasensitive NO_2 and NH_3 gas sensor.

References

[1] F. Schedin et al., Nat. Mater., vol. 6, no. 9 (2008) pp. 652–655
[2] H. Li et al., Appl. Phys. Rev., vol. 7, no. 1 (2020)
[3] E. Mania et al., Sensors Actuators B Chem., vol. 266 (2018) pp. 438–446
[4] H. Prevost et al., 2D Mater., vol. 7, no. 4 (2020)

Figures

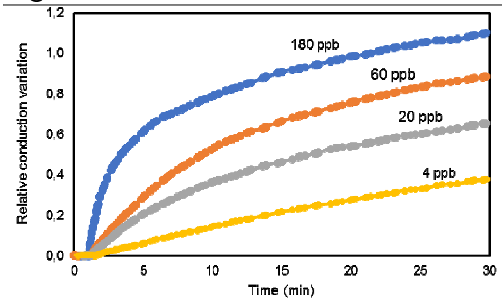

Figure 1: ONERA graphene based gas sensor response to several NO_2 concentration exposure

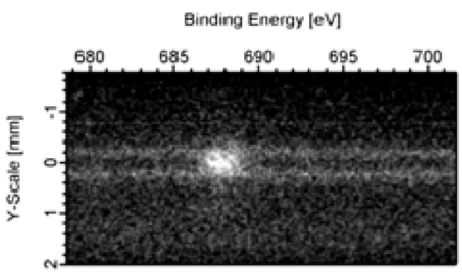

Figure 2: XPS cartography of the fluorinated graphene area after annealing at 450°C

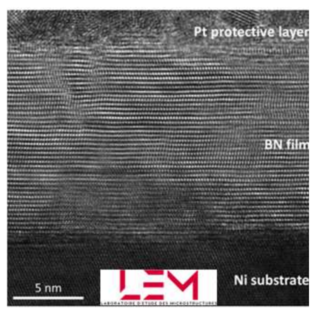

Figure 3: HRTEM analysis of the BN/Ni(111) interface: