Detection of ammonia via charge transfer-induced shift of graphene charge neutrality point

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Due to its unique transport properties, high surface-to-volume ratio and low electrical noise, graphene is highly sought after for high sensitivity detection of gases. A notable example is ammonia which has garnered increased research interest due to its usefulness in the early detection of kidney ailments via non-invasive techniques [1]. However, graphene sensors for ammonia with ppb sensitivity have generally relied on the chemical modification of graphene thereby changing its carrier properties to induce faster and low concentration detection [2]. While this has resulted in improved gas sensitivity towards ammonia, it is expected to also alter some of the unique properties of graphene such as its mobility, and the recovery time for the sensor. Recently, we showed using density functional theory calculations that the charge transfer characteristics, van der Waals interactions and the gas adsorption characteristics in various graphene-gas systems including (ammonia) can be modulated by applied gate voltage [3].

In this work, we achieve fast detection of ammonia via gate voltage modulation of the carrier density of graphene and polarization of the ammonia molecule (Fig.1b). The back gate voltage accelerates molecular adsorption onto the graphene channel. In order to study the change in charge neutrality point (CNP) and charge-transfer characteristics of the ammonia-graphene system, we measured the CNP shift for different gate voltage ranges (Fig.1c). Furthermore, the results indicate that the fast detection time and shift in the CNP may be attributed directly to the charge transfer between graphene and ammonia facilitated by gate voltage modulation. The data shows possibility for ppb-level detection of ammonia without chemical modification of graphene. Detailed measurement results will be discussed in the presentation.

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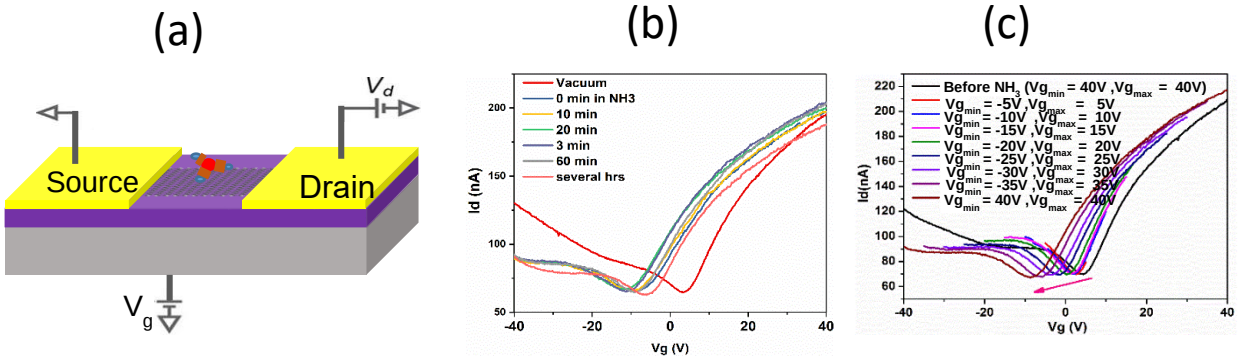

Fig. 1 (a) Schematics of the fabricated device (b) Shift in CNP induced by ammonia adsorption (at 100ppm) (c) gate voltage dependent variation of electron-hole transport characteristics of graphene-ammonia system.

References:

1. S. Bevc *et al.*, *Clin. Nephrol.* **2017**, 88: Suppl. 1/ (S14-S17)
2. S.M.M. Zanjani, *et al.*, *Appl. Phys. Lett.* **2016**, 108, 033106
3. M. Muruganathan *et al.*, *Nano Lett.* 2015, 15, 8176−8180