

Graphene-based Schottky device for low ppm detection of NH₃ in environmental conditions

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Abstract

Graphene represents more and more the focal point for basic and applied research in physics and material science, thanks to its unique and supreme properties. Being a two-dimensional fabric, it provides the maximum sensitive area per unit volume and consequently it exhibits very strong changes of the physical properties during the interaction with several substances; for such reasons it has attracted the attention of the researchers for environmental monitoring of different toxic gases, such as NH₃ or NO₂ [1]. Apart from the high sensitivity, the focus on this kind of applications is also due to the mechanical flexibility of the graphene and not least to its technological compatibility with metals and semiconductors, widely used in portable electronic devices [2-3].

Herein, we report on a graphene-based Schottky junction for NH₃ detection at level of few tens of parts-per-million (ppm). The hetero-junction consists of chemically exfoliated graphene sheets lying on n-type Si ($N_D \approx 5 \cdot 10^{15} \text{ cm}^{-3}$).

The basic device structure was prepared by depositing 250nm of SiO₂ on the Si wafer. During the deposition, an area of 4x4mm² was masked to leave uncovered the underlying silicon. The top contact was an e-beam evaporated film of Cr/Au (30 nm/120 nm) annulus shaped, whereas a Ti/Pd/Ag alloy was used as back contact [2].

Graphene was synthesized by Liquid Phase Exfoliation as reported in Ref 4 using a mixture of 2-propanol and water instead of N-methyl-pyrrolidone solvent. To realize the graphene/Si interface, few microlitres of the feed solution were simply drop-casted on the structure previously fabricated, so that graphene covers simultaneously the entire structure, top contact, oxide and silicon. This exfoliated graphene results lightly p-doped and plays the role of a metal in the Schottky barrier. The I-V characteristic, reported in Fig. 1, clearly shows the typical Schottky junction behavior, as confirmed by the heterojunction parameters obtained from electrical characterization.

The device was biased at -3V and tested in a Gas Sensor Characterization System (Kenosistec) towards about 25 ppm of NH₃ for 10 min in wet air, by exposing the whole graphene sheet, with a flow of 500sccm, at 22°C and relative humidity of 50%. The current signal shows a remarkable response ($\Delta I/I_0$) of $\approx 10\%$ upon the exposure to the analyte (Fig. 2).

At the aim of understanding the interactions which take place on the graphene/Si hetero-junction here presented, further investigations are ongoing to compare its performances with those of a similar diode based on different graphene solutions or graphene grown by different techniques.

References

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Figures

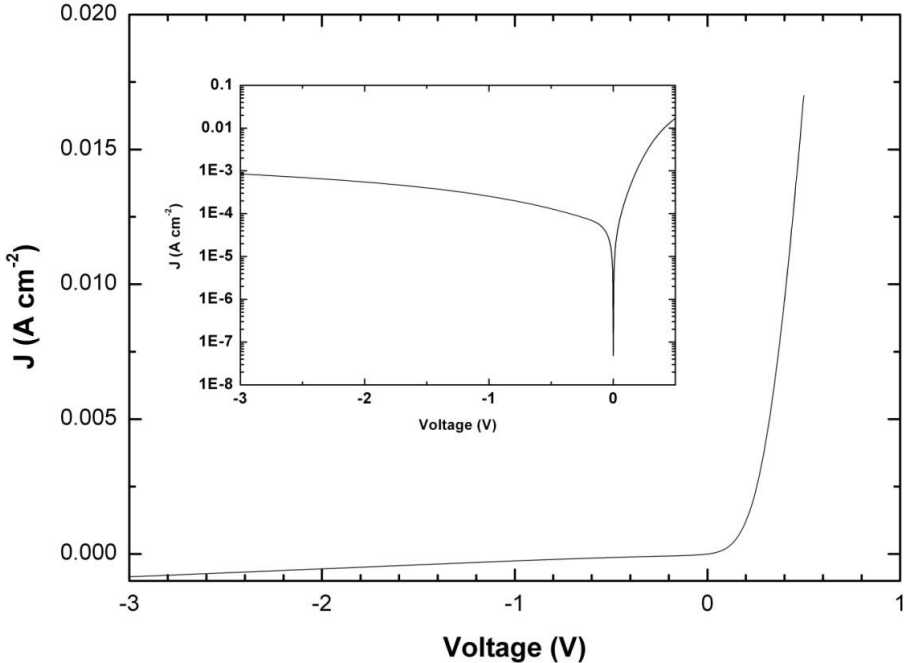


Figure 1: I-V characteristic of the graphene-based Schottky diode.

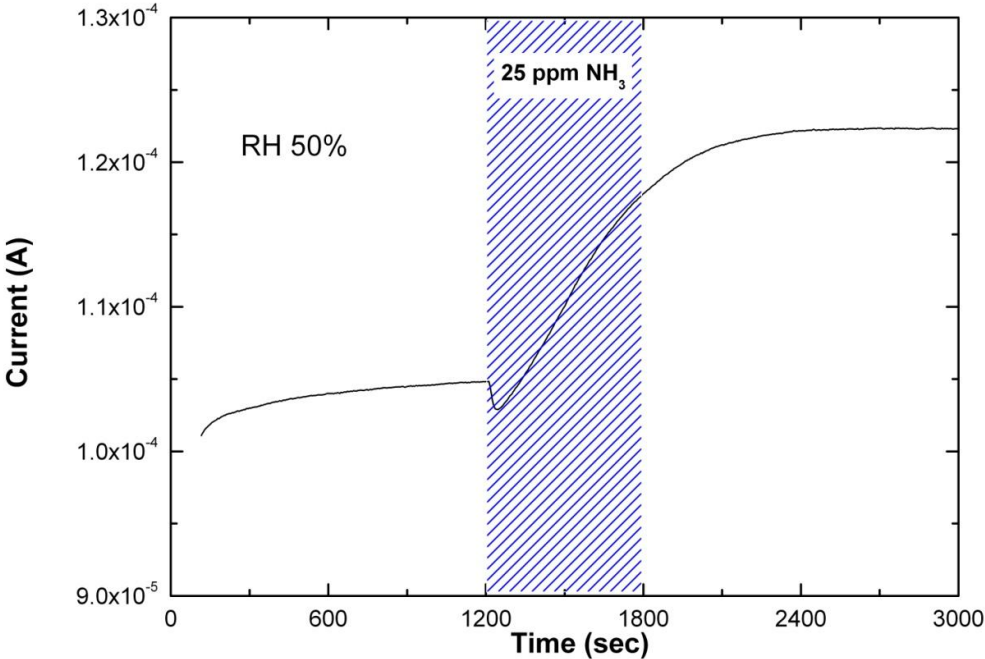


Figure 2: Current response (I) vs. exposure time to 25 ppm of NH_3 for the Schottky graphene/Si diode