Enhanced acetone gas sensing of activated carbon functionalized graphene nanoribbon FET in the real-air environment

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Detection of gas species from exhaled breath as biomarkers leads to early disease diagnosis in human beings [1]. The exhaled breath contains gas molecules such as like acetone, NH_3, H_2S, and volatile organic components (VOCs) which are considered as primary and key biomarker gases in the detection and diagnosis of numerous diseases like diabetes, asthma, renal disease, halitosis, and lung cancer. Among the above-mentioned biomarkers, acetone is a key indicator for diabetes mellitus. Based on the medical reports and findings, the acetone concentration of a healthy person is about 300-900 ppb, an increase of acetone above 1.8 ppm indicates the presence of diabetes in humans [2]. Recently, graphene has attracted much attention as a promising material in the detection of toxic gases due to its excellent physical and chemical properties such as high carrier mobility, single-atom thickness, and large surface area. These properties drive graphene as an ideal material for the field-effect transistor (FET) sensor. Herein, we report the fabrication of activated Carbon Functionalized chemical vapor deposition (CVD) grown graphene nanoribbon FET (aCF-GNR) to detect acetone gas in the real air environment. The real-time shift of charge neutrality point of GNR FET was measured under the presence of acetone at 110 °C. GNR FET showed a higher sensitivity even towards a lower concentration (50 ppb) of acetone.

Fig.1a shows the schematic illustration of the graphene nanoribbon FET sensor, which was exposed to acetone gas molecules during the measurements. Fig.1b shows the Helium ion microscope (HIM) image of the fabricated device with 200 nm × 200 nm CVD aCF-GNR on SiO_2/Si substrate. The image clearly reveals the formation of activated carbon on the surface of graphene. Fig. 1 c displays the I_d vs V_g measurement of aCF-GNR sensor under vacuum and 50 ppb concentration of acetone at 110 °C. These results revealed that the physically adsorbed acetone gas molecules act as acceptors and as a result shift in the charge neutrality point towards the positive gate voltage was observed. The higher sensitivity of the gas sensor, especially for acetone gas molecules may be caused by the formation of C=O and C-O bonds in the activated carbon. In addition, these bonds resist the adsorption of water and oxygen molecules in the air. Details of acetone concentrations and sensing mechanisms will be discussed during the presentation.

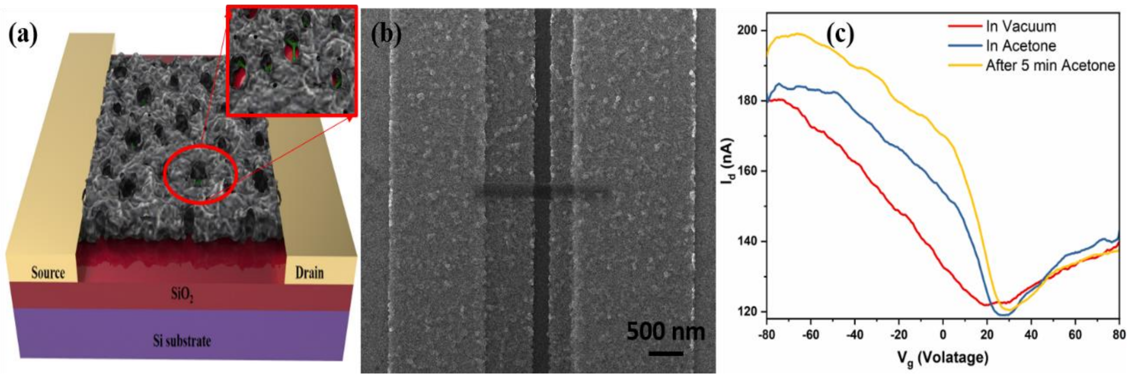

Fig. 1 Schematic illustration of aCF-GNR sensor, (b) HIM image of aCF-GNR device (c) I_d-V_g characteristics under Acetone gas

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