Highly Sensitive and Selective Room Temperature NO_2 Sensor Based on Ohmic Metal–Semiconductor Interfaces of Electrolytically Exfoliated Graphene/Flame-Made SnO_2 Composite Films

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Abstract: In this work, flame-made undoped SnO_2 nanoparticles were loaded with 0.1–5 wt% electrolytically exfoliated graphene and systematically studied for NO_2 sensing at low working temperatures. Characterizations by X-ray diffraction, transmission/scanning electron microscopy, Raman and X-ray photoelectron spectroscopy indicated that high-quality multilayer graphene sheets with low oxygen content were widely distributed within spheriodal nanoparticles having polycrystalline tetragonal SnO_2 phase.The 10–20 μm-thick sensing films fabricated by spin coating on Au/Al_2O_3 substrates were tested towards NO_2 at operating temperatures ranging from room temperature of 25°C to 350°C in dry air. Gas-sensing results showed that the optimal graphene loading level of 0.5 wt% provided an ultra-high response of 26,342 towards 5 ppm NO_2 with a short response time of 13 s and good recovery stabilization at a low optimal operating temperature of 150°C. In addition, the optimal sensor also displayed high sensor response of 171 towards 5 ppm NO_2 at room temperature (25°C). Furthermore, the sensors displayed very high NO_2 selectivity against H_2S, NH_3, C_2H_5OH, H_2 and H_2O. Detailed mechanisms for the drastic NO_2 response enhancement by graphene were proposed based on the formation of graphene-undoped SnO_2 ohmic metal-semiconductor junctions and accessible interfaces of graphene–SnO_2 nanoparticles [1,2]. Therefore, the electrolytically exfoliated graphene-loaded FSP-made SnO_2 sensor is a highly promising candidate for fast, sensitive and selective detection of NO_2 at low working temperatures.

References

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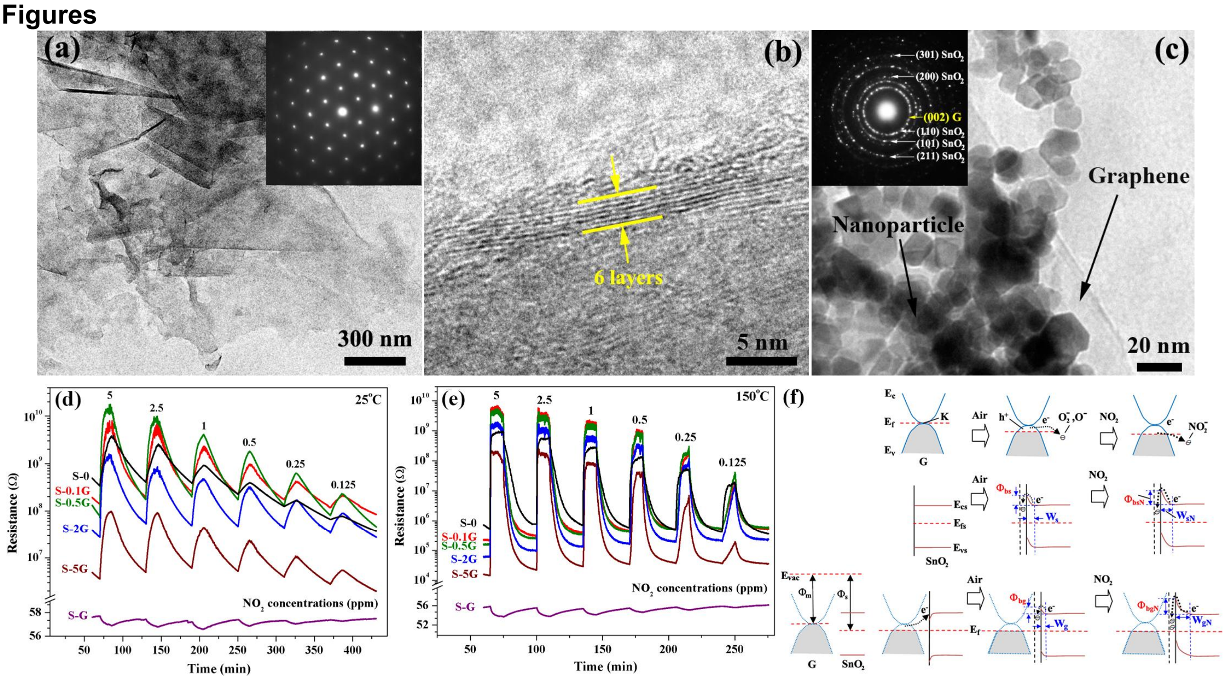
Figures



RESULTS: (a, b) HR-TEM images of graphene (G), (c) BF-TEM images of 0.5 wt%G/SnO_2, change in resistance under exposure to NO_2 (0.125 to 5 ppm) of G, SnO_2, 0.1-5 wt%G/SnO_2 sensors at (d) room temperature (25°C) and (e) the optimal working temperature (150°C), and (f) the energy band models for NO_2 sensing mechanisms of multilayer G, SnO_2 surface, G−SnO_2 interface.