Electrolytically Exfoliated Graphene/Flame-spray-made Vanadium-doped SnO_2 Composite Films for Nitric Oxide Sensing

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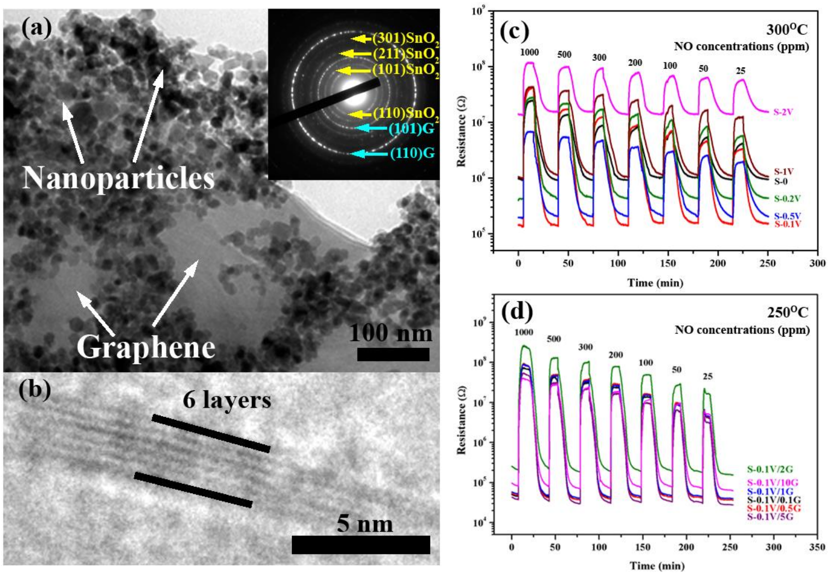
Abstract: The effect of functionalized additives of flame-spray-made SnO_2 nanoparticles on nitric oxide (NO) gas-sensing properties were systematically studied by doping with 0.1−2 wt% vanadium (V) and additional loading with 0.1−10 wt% electrolytically exfoliated graphene. Characterizations by X-ray diffraction, transmission/scanning electron microscopy and X-ray photoelectron spectroscopy significantly demonstrated that V-doped SnO_2 nanostructures had spheriodal morphology with polycrystalline tetragonal SnO_2 phase and vanadium (V^{4+}, V^{5+}) was confirmed to form solid solution with SnO_2 lattice while graphene in the sensing film after annealing and testing still retained high-quality multilayer structure with low oxygen content. The sensing films were prepared by a spin-coating technique on Au/Al_2O_3 substrates and evaluated for NO-sensing performances (25–1000 ppm) at operating temperatures ranging from 25 to 350°C in dry air. Gas-sensing results indicated that 0.1 wt% V-doped SnO_2 evidently catalyzed the highest response at 300°C. While, the additional loading of 0.5 wt% graphene into optimal 0.1 wt% V-doped SnO_2 composites led to a drastic response enhancement with shorter response times and fast recovery stabilization at optimal operating temperature of 250°C. The superior gas sensing performances of V-doped SnO_2 nanoparticles loaded with graphene may be attributed to large specific surface area of the composite, high density of reactive sites of highly porous non-agglomerated graphene-SnO_2 nanoparticle structure and high electronic conductivity of graphene, which allowed fast gas response and recovery. Moreover, detailed mechanisms for the drastic NO response enhancement by V and graphene were proposed based on the formation of graphene/V-doped SnO_2 ohmic metal-semiconductor junctions and accessible interfaces of graphene–metal oxide nanoparticles. Therefore, the graphene-loaded and V-doped SnO_2 sensor is potential for responsive detection of NO and may be useful for general environmental and biomedical applications.

Reference

[1] C. Liewhiran, N. Tamaekong, A. Wisitsoraat, S. Phanichphant, Sens. Actuators, B, **163** (2012) 51-60.

Figures



RESULTS: (a) BF-TEM image of the optimal 0.5 wt%G/SnO_2 composite, (b) HR-TEM images of multilayer graphene (G), change in resistance under exposure to NO (25-1,000 ppm) of (c) undoped SnO_2 and 0.1-2 wt%V-doped SnO_2 at the optimal working temperature of 300°C and (d) 0.1-10 wt%G/0.1 wt%V-SnO_2 sensors at the optimal working temperature of 250°C.