Highly Sensitive NO_2 Gas Sensors Based on Electrolytically Exfoliated Graphene/Au-catalyzed WO_3 Composite Films

Sathukarn Kabcum[1], Anurat Wisitsoraat[2], Chakrit Sriprachuabwong[2], Ditsayut Phokharatkul[2], Adisorn Tuantranont[2], Sukon Phanichphant[3], Chaikarn Liewhiran[1,*]

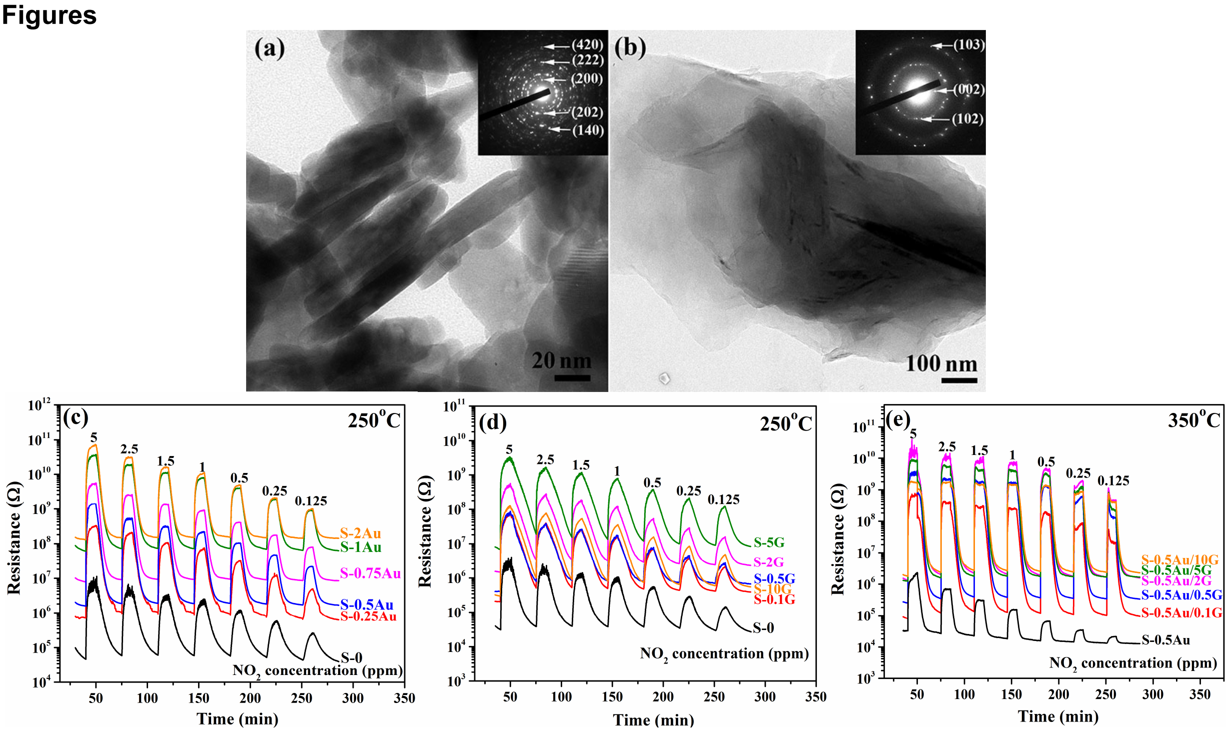
[1] Department of Physics and Materials Science, Faculty of Science, Chiang Mai University, Chiang Mai 50202, Thailand
[2] Nanoelectronics and MEMS Laboratory, National Electronics and Computer Technology Center, National Science and Technology Development Agency, Klong Luang, Pathumthani 12120, Thailand
[3] Materials Science Research Center, Faculty of Science, Chiang Mai University, Chiang Mai 50202, Thailand
*Corresponding author: chaikarn_@yahoo.com

Abstract: The effect of functionalized additives of high-aspect-ratio WO_3 nanorods on nitrogen dioxide (NO_2) gas-sensing properties were systematically studied by doping with 0.25−2 wt% gold (Au) and additional loading with 0.1−10 wt% electrolytically exfoliated graphene (G). The WO_3 nanorods were synthesized by a modified precipitation method [1] utilizing ethylene glycol as a dispersing agent while Au-doped WO_3 nanoparticles and their graphene composites were also prepared by impregnation method to achieve high responsive NO_2 sensors. Characterizations by X-ray diffraction, transmission/scanning electron microscopy and X-ray photoelectron spectroscopy significantly demonstrated that Au-doped WO_3 nanostructures had nanorod-like morphology with polycrystalline monoclinic WO_3 phase and Au was confirmed to form solid solution with WO_3 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 spin coating technique and evaluated for low detection of NO_2 (0.125–5 ppm) sensing performances at operating temperatures ranging from 25°C to 350°C in dry air. Gas-sensing measurement indicated that WO_3 sensing film with optimal 5 wt% graphene exhibited the maximum response at 250°C, while 0.5 wt% Au-doped WO_3 optimally catalyzed the highest responses and shorter response time at 250°C. Particularly, the additional loading of optimal 0.5 wt% graphene into optimal 0.5 wt% Au-doped WO_3 composites led to a drastic response enhancement with very short response time and fast recovery stabilization at 350°C. Detailed mechanisms for the drastic NO_2 response enhancement by catalyzed-Au and graphene were proposed based on the formation of graphene/catalyzed Au-doped WO_3 ohmic metal-semiconductor junctions and accessible interfaces of graphene–metal oxide nanostructures. Therefore, the G–Au/WO_3 composite has a potential for responsive low detections of NO_2 and may be useful for environmental applications.

Reference

[1] S. Kabcum, D. Channei, A. Tuantranont, A. Wisitsoraat, C. Liewhiran, S. Phanichphant, Sens. Actuators, B, **226** (2016) 76−89.

Figures



RESULTS: HR-TEM images of (a) 0.5 wt%Au/WO_3 nanorods and (b) graphene (G), change in resistance under exposure to NO_2 (0.125−5 ppm) of (c) WO_3 and 0.25−2 wt%Au/WO_3 at 250°C, (d) 0.1−10 wt%G-loaded WO_3 sensors at 250°C, and (e) 0.1−10 wt%G/0.5 wt%Au/WO_3 sensors at 350°C.