PD DOPED GRAPHENE-WO_3 FILMS PREPARED BY SOL GEL METHOD FOR HYDROGEN SENSING

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Hydrogen is a colorless, tasteless gas and has a large diffusion coefficient of 0.61 cm2/s in air. Unlike fuels such as gasoline or diesel, hydrogen burns cleanly without release of pollutants or greenhouse gases. As a result, more attention is needed to be paid to hydrogen as a clean fuel in household and transportations applications. In other side hydrogen is flammable and explosive in concentrations higher than 4% in air, So monitoring hydrogen leaks in the process of manufacturing, transporting, storage and in the filling station is essential. Tungsten trioxide is an n-type semiconductor and a good candidate for gas sensing applications [1]. The electrical properties of tungsten trioxide are greatly changed by means of physisorption, chemisorptions and catalytic reaction of gaseous molecules. in spite of good selectivity, the main problem of semiconductor based gas sensors is high working temperature because of considerable band gap and so high electrical resistivity. in other side graphene as a new member of carbon nanostructures family is an excellent candidate for gas sensing. graphene with maximize volume exposed to analytes, high conductivity and low crystal defects can act as a sensitive sensors with minimized noises. Minimizing of noises such as johnson and excess noises caused by thermal switching, leads to maximize the signal-to-noise ratio[2]. In this work, we describe a new graphene-WO_3 hybrid thin film, which is more sensitive to hydrogen than pure WO_3 thin film in lower working temperatures.
At first, Peroxopolytungstic acid (P-PTA) sol was prepared according to Kudo rout and then mixed with Graphene oxide (GO) suspension. GO suspension was prepared by Hummer's method and the molar ratio of mixing for W:GO was 1:100 . Then $PdCl_2$ was added to sol with 1% molar ratio relative to tungsten. The sol was coated on Al_2O_3 substrate by spin coating technique as thin film. All films were annealed at 400°C for 2 h in argon atmosphere. For measuring electrical resistance, Ti/Au comb-like inter digitated electrodes as electrical contacts with 150 nm thickness were evaporated on the sample surface through a mask. The samples were placed in a small stainless steel chamber with several electrical feed-throughs, gas inlet and gas outlet. For measuring sensitivity a constant dc voltage of 4 V was applied between our sensor. The gas sensing performance was tested at different hydrogen concentrations in the range of 30150°C by means of a heater located on the back of the substrates.
The AFM image in figure(1), confirms the existence of single layers(about 0.8 nm thickness) of GO sheets in prepared suspension. After thermal annealing, in addition to crystallization

of WO_3 nanoparticles, GO sheets in composite thin films reduce to graphene and resistivity of films reduce to KΩ from MΩ. Figure (2a) show The SEM images the surface morphology of fabricated hybrid thin films. So reduced graphene sheets can be have as a conductor role in transferring of carriers and less cracks in thin films in during of solvent evaporation.
Gas sensing test results are shown in figure (2b). In comparison with, electrical resistivity, response time and working temperature of graphene-WO_3 thin films were lower than pure WO_3 thin film[3]. The proposal mechanism is the formation of water molecules from the reaction of atomized hydrogen on the surface with pre-absorbed oxygen ions and change in carrier concentrations. graphene sheets act as fast transporter of these carriers to electrodes. In conclusion, Our results present a new group of graphene-metal oxide hybrid thin films for facile and sensitive gas sensors that have better and more efficient working parameters as well as smart sensing.

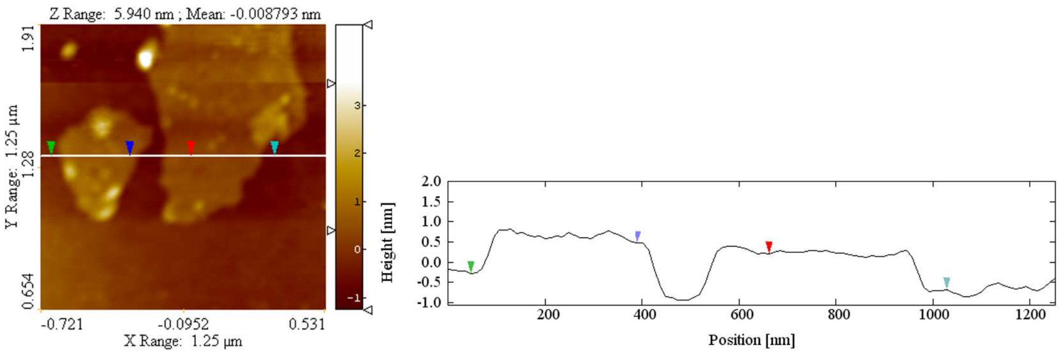

Figure 1: The AFM image from GO sheets on Si substrate and corresponding height profile.

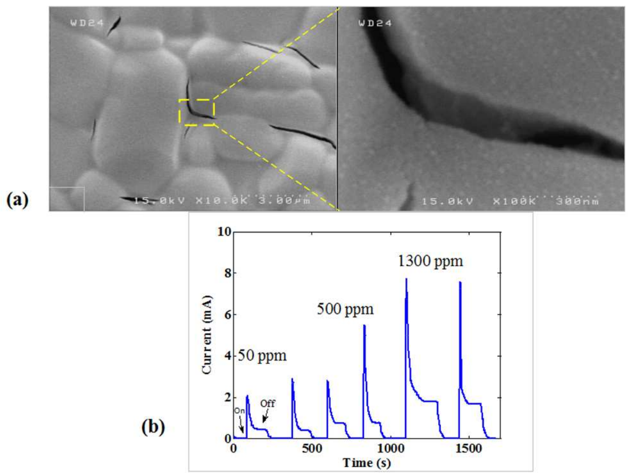

Figure 2: SEM images from surface of thin film sensor and (b)the current variations of W:GO = 1% film in presence of H_2 (two cycle for different concentrations) in 150°C.

References

[1] O. K. Varghese *et al.*, Sensor Letter, 4 (2006) 120.
[2] F. Sherdin *et al.*, Nature Materials, 6 (2007) 652.
[3] S. Fardindoost, A. Iraji zad, F. Rahimi, R. Ghasempour, International Journal of Hydrogen Energy, 35 (2010) 854.