Chemiresistor-type NO gas sensors based on ZnO nanorods

Lin, C. Y.; Feng, W. I.; Lin, C. W.; Tunney, J.; Ho, K. C.

cwlinx@ntu.edu.tw

Surface plasmon resonance (SPR) is an optical resonance phenomenon that occurs on the surface of thin metal films and it is very sensitive to changes of the refractive index near the surface. It can therefore be used for the detection of molecular adsorption. SPR has been efficiently employed for chemical- and bio-sensing in numerous fields such as molecular biology, medicine, biotechnology, drug and food monitoring, environmental monitoring. Nanocomposite thin films formed by noble metal nanoparticles embedded in a dielectric matrix also show attractive SPR phenomenon due to collective excitations of conduction electrons (particle plasmons) in metal nanoparticles when photons are coupled to the metal particle–dielectric interface. Replacing thin metal films by metal-dielectric composite films in an SPR sensor not only simplify its design, and but also offers the possibility to measure very small changes in the refractive index of media caused by molecular adsorption. This presentation describes the detailed processes on the fabrication of gold/tungsten-oxide ($Au-WO_3$) nanocomposite thin films by pulsed laser deposition (PLD) technique. The content of Au in the $Au-WO_3$ nanocomposite films was varied by altering the relative laser ablation time on Au and WO_3 targets. The SPR phenomenon of the $Au-WO_3$ films is evaluated for various gold percentages and film thicknesses. A SPR sensor based on $Au-WO_3$ composite films was fabricated and evaluated for the detection of gas adsorption.

Keywords: pulsed laser deposition (PLD), metal-dielectric nanocomposite film, and surface plasmon resonance (SPR)

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Parallels between Environmental Gas Sensing and Bionanotechnology: Optimized Performance Through the Nanostructural Control of Thin Films

J. J. Tunney[1], C. J. Jeffrey[1], X. Du[1], A. Majid[1], K. Darcovich[1], M.L. Post[1], C.Y. Lin[2], K.C. Ho[2]

[1] National Research Council of Canada, Institute for Chemical Process and Environmental Technology, Ottawa, Ontario, Canada

[2] Department of Chemical Engineering, National Taiwan Unviersity, Taipei, Taiwan

Many of the same trends in materials science, microelectromechanical structures (MEMS) and information and communication technologies (ICT) are driving technological developments in both environmental chemical sensing and bionano science and technology. Part of the research efforts at the Institute for Chemical Process and Environmental Technology (ICPET) is focused on the development of new sensor materials for industrial gas detection which are amenable to device fabrication. Reducing and controlling the dimensionality of metal oxide materials from the micron(s) to the nanometer (< 10 nm) regime has been a major goal, since this allows the novel catalytic, absorptive, electronic and optical properties of these nanostructured materials to be exploited for chemical sensing applications. This talk will focus mainly on aspects of our chemical sensing related research activities which are potentially applicable or have parallels in the field of bionano science. Examples will be taken from our efforts to optimize the conductometric gas sensor response of electroceramic thin films and more recently, conductive polymer films.

Keywords: gas sensing, electroceramics, thin films

13:40-13:55 10086

Chemiresistor-type NO Gas Sensors Based on ZnO Nanorods

C. Y. Lin[1], W. I. Feng[2], C. W. Lin[2,3], J. Tunney[4], K. C. Ho[1,5,]*

[1] Department of Chemical Engineering, National Taiwan University, Taipei 10617, Taiwan

[2] Institute of Biomedical Engineering, National Taiwan University, Taipei 10617, Taiwan

[3] Institute of Electrical Engineering, National Taiwan University, Taipei 10617, Taiwan

[4] Institute for Chemical Process and Environmental Technology, National Research Council of Canada, Ottawa K1A 0R6, Canada

[5] Institute of Polymer Science and Engineering, National Taiwan University, Taipei 10617, Taiwan, e-mail: kcho@ntu.edu.tw

The synthesis of ZnO nanorods and their sensing properties with respect to NO gas were studied. The ZnO nanorods were synthesized onto a ZnO thin film (~150 nm), which was first sputtered on the Au interdigitated electrode, as the seeds for growing ZnO nanorods. After depositing the ZnO thin film, the growth of ZnO nanorods was carried out via the hydrothermal method.

During the initial growth stage (6~18 h), the length and diameter of the first uniform ZnO nanorods are about 2 m and 200 nm, respectively, as judged by the SEM images. The subsequent growth of ZnO nanorods, which was noticed after 18 h, was characterized by a less uniform and larger diameter. The second layer of ZnO nanorods grew preferentially on the top of the first layer. The non-uniformity in diameter at the latter stage of the reaction can be explained by the non-uniform local concentration distribution of the precursor, which was mentioned in the literature.

The optimal operating temperature of the ZnO thin film and ZnO nanorod for sensing the NO gas were found to be 200°C. When the operating temperature was higher than 200°C, the response signals for 10 ppm NO gas were not fully recovered and reached only about 50% and 35% of their original values for the ZnO thin film and ZnO nanorods, respectively. On the other hand, when operating below 200°C, not only did the response not recover, but the sensitivity was lower. Besides, the sensitivity of the ZnO nanorods for sensing NO was 45 times higher than that of the ZnO thin film, presumably larger surface area is provided by the ZnO nanorods. Although the response signal could be recovered at 200°C, the recovery time took about 3.5 h. Works are in progress to dope ZnO with GaO and examine the sensing properties of the modified material.

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