Ultra-sensitive NH_3 Gas Sensor based on Electrospinning SnO_2-CuO Nanowires

Univ. of Tokyo, Chuanlai Zang, Chihiro Okutani, Yasuo Yano,

Hiroyasu Yamahara, Tomoyuki Yokota, Hitoshi Tabata

E-mail: zang@bioxide.t.u-tokyo.ac.jp

Gas sensors play an important role in industrial safety, environmental protection and human health monitoring in recent years. Gas sensors based on one-dimensional (1D) semiconducting metal-oxide (MOX) exhibit inspiring sensitivity, fast response time and low power consumption [1]. When the diameter of nanowires is close to or less than double thickness of the space charge layer, the gas sensing performances such as sensitivity, response speed, will be increased remarkably. Thus, significant interest has emerged in nanowires MOX gas sensor. Ammonia (NH_3) is one of the most important pollutants or gaseous metabolites of the human body. In this work, NH_3 gas sensing performance based on electrospinning SnO_2-CuO nanowires was studied. The response to NH_3 can be understood in the framework of the well-known CuO-SnO_2 p–n junction mechanism. the interface of SnO_2-CuO will form a larger depletion region and a larger potential energy barrier, this so-called "built-in voltage" potential V_{bi}, which gives rise to higher resistance in air and thus leads to a more significant response for reducing gases.

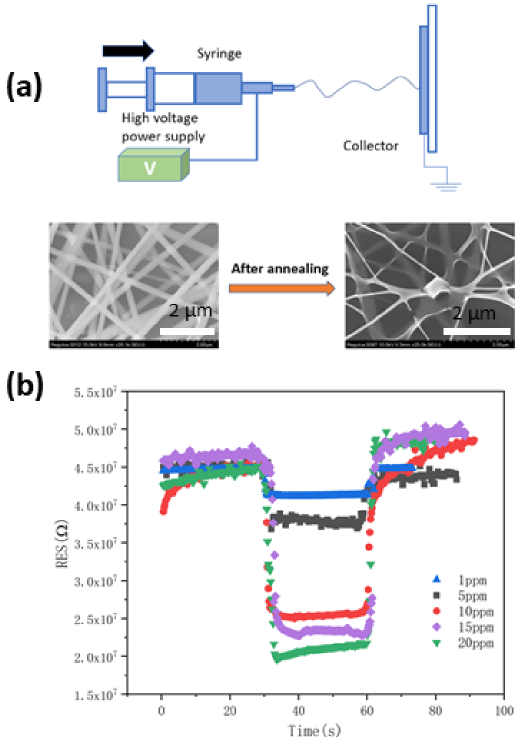

Figure 1. (a) Schematic diagram of electrospinning and SEM images of SnO_2-CuO nanowires before and after annealing. (b) Resistance change of SnO_2-CuO nanowires exposure to different NH_3 concentrations at room temperature

Platinum interdigital electrode was deposited on the Si/SiO_2 wafers firstly. Subsequently, a precursor solution contained tin chloride dihydrate ($SnCl_2 \cdot 2H_2O$), Copper chloride dihydrate ($CuCl_2 \cdot 2H_2O$), and polyvinylpyrrolidone (PVP) was applied to electrospinning experiment at 15 KV. As-spun fibers were distributed over prepared Si/SiO_2 wafer. The as-spun nanowires were subsequently annealed at 500 °C for 3 h in air. As shown in Figure 1(a), the diameter of the as-spun nanowires was around 200 nm and show a general feature of smooth and fibrous morphology. After annealing, it is evident that the fibers shrank down to around 90 nm in diameter due to the decomposition of PVP and the conversion of the precursors to SnO_2 and CuO. As shown in Figure 1(b), when the sensors fabricated from the SnO_2-CuO nanowires were exposed to NH_3 gas, their resistance decreased immediately. When the NH_3 supply was stopped, the resistance completely recovered to the initial value quickly. The SnO_2-CuO heterojunction nanowires exhibit high sensitivity towards ammonia down to 1ppm at room temperature. Furthermore, when the operating temperature increased to 100 °C, a seven times higher responds was shown compared to the room temperature.

Reference:

[1] Chen X, Wong C K Y, Yuan C A, et al. Nanowire-based gas sensors[J]. Sensors and Actuators B: Chemical, 2013, 177: 178-195.