Chemical Sensing with ZnO nanowires

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Zinc oxide (ZnO) is a wide band gap (3.37 eV) semiconducting material with broad applications such as optical waveguide, transparent conducting layer, surface acoustic wave device. ZnO nanowires (NWs) has been regarded as a promising material for nanoscale ultra-violet (UV) lasing, light emitting and photodetection. In our research, single crystal ZnO NWs are synthesized using a vapor trapping chemical vapor deposition method. SEM shows NWs are typically 30~150 nm in diameter and ~40μm in length. TEM shows single crystal structure and NWs are grown along (001) direction. Individual ZnO NWs are configured as field effect transistors (FET) (Fig. 1a). Electrical transport studies show that ZnO NWs behave as typical *n*-type semiconducting material.

It has been observed that oxygen (O_2) ambient has considerable effect on the performance of ZnO NW FETs. Because surface absorbed O_2 molecules capture free electrons in NW channel by the process $O_2 + e^- \rightarrow O_2^-$, charge carriers in the NW channel are depleted (Fig. 1b inset), thus conductance is suppressed. Fig. 1b shows that thinner ZnO NWs exhibit higher sensitivity to O_2 ambient due to their larger surface to volume ratio. Here, $\Delta G/G_0$ is the relative conductance change from atmosphere to 10^{-2} torr. Fig. 1c shows the conductance change when varying the O_2 concentration. A concentration as low as 10 ppm can be detected. Fig. 1d illustrates the dependence of relative conductance change on the gate voltage from 0 ppm to 10 ppm O_2. These results demonstrate that ZnO NW has far better O_2 sensing performance than its thin film counterpart and other metal-oxide bulk material O_2 sensors at room temperature.