Enhancement of Gas Sensing Properties through Branch Formation and Metal Catalysts

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Abstract
Nanowires have been studied and used as sensing materials because of their outstanding sensitivity and selectivity. Also decorating nanomaterials with branches and metal nanoparticles has been done for using their heterointerfaces’ reactions and catalytic effects. In this experiment, we report a novel method to improve the gas sensing properties of metal oxide nanowires through the interactions of metal oxide branches and metal nanoparticles.

Key words: Nanowires, branches, metal nanoparticles, gas sensing

Background
Recently, there are several environmental threats and especially problems with toxic gases are important social issues. To solve the problem, researchers have experimented gas sensors using many kinds of semiconductors. Also to detect the low concentration of toxic gases, lots of experiments have been concentrating their focus on manipulating morphologies of sensing materials [1,2]. In here, we fabricated SnO2 stem nanowires and metal-oxide branches were grown on the surface of SnO2 nanowires. Furthermore, metal nanoparticles were attached on the surface of as fabricated nanowires. For sensing tests, interdigitated Au top electrode was deposited on the specimens. Gas sensing properties of as-fabricated sensor were enhanced by their resistance modulation by the branch formation and catalytic effect by metal nanoparticles.

Experimental
The fabrication of Au functionalized TeO2-branched SnO2 nanowire is as follows. First, we fabricated SnO2 nanowires by thermal evaporation of Sn powder. Sn powder (purity: 99.9 %, Sigma-Aldrich) was used as the source material. The substrate temperature was set to 900°C for 1hr to heat 3nm-Au coated Si substrates. A mixture of Ar and O2 gases (O2: 3 %; Ar: 97 %) was set at a fixed 2 Torr pressure. To fabricate TeO2-branched SnO2 nanowires, 3nm-Au was coated again onto as-fabricated SnO2 nanowires. Then we fabricated TeO2-branched SnO2 nanowires by thermal evaporation of Te powder (purity: 99.99%, Sigma-Aldrich). At 370°C, Te powders were evaporated and combined with oxygen. Finally to fabricate Au nanoparticles, Au thin film (3nm) were sputtered on the surface of as fabricated TeO2-branched SnO2 nanowire and annealed at 300°C with Ar gases.

Results
Figure 1 shows SEM images of SnO2 nanowire, TeO2-branched SnO2 nanowire, and Au nanoparticle functionalized TeO2-branched SnO2 nanowire. TeO2 branches and Au nanoparticles were grown randomly on the surface of SnO2 nanowires. Figure 2 shows gas response of SnO2 nanowire, TeO2-branched SnO2 nanowire, and Au functionalized TeO2 branched SnO2 nanowire to NO2 gas. Gas response of branched SnO2 nanowires is higher than that of bare SnO2 nanowires. Also with metal functionalization, gas response was increased.
Fig. 1. SEM images of (a) SnO$_2$ nanowire, (b) TeO$_2$-branched SnO$_2$ nanowire, and (c) Au functionalized TeO$_2$-branched SnO$_2$ nanowire.

Fig. 2. Gas response of (a) SnO$_2$ nanowire, (b) TeO$_2$-branched SnO$_2$ nanowire, and (c) Au functionalized TeO$_2$-branched SnO$_2$ nanowire to NO$_2$ gas.

References
