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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 SnO_2 stem nanowires and metal-oxide branches were grown on the surface of SnO_2 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 TeO_2-branched SnO_2 nanowire is as follows. First, we fabricated SnO_2 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 O_2 gases (O_2: 3 %; Ar: 97 %) was set at a fixed 2 Torr pressure. To fabricate TeO_2-branched SnO_2 nanowires, 3nm-Au was coated again onto as-fabricated SnO_2 nanowires. Then we fabricated TeO_2-branched SnO_2 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 TeO_2-branched SnO_2 nanowire and annealed at 300°C with Ar gases.

Results

Figure 1 shows SEM images of SnO_2 nanowire, TeO_2-branched SnO_2 nanowire, and Au nanoparticle functionalized TeO_2-branched SnO_2 nanowire. TeO_2 branches and Au nanoparticles were grown randomly on the surface of SnO_2 nanowires. Figure 2 shows gas response of SnO_2 nanowire, TeO_2 branched SnO_2 nanowire, and Au functionalized TeO_2 branched SnO_2 nanowire to NO_2 gas. Gas response of branched SnO_2 nanowires is higher than that of bare SnO_2 nanowires. Also with metal functionalization, gas response was increased.

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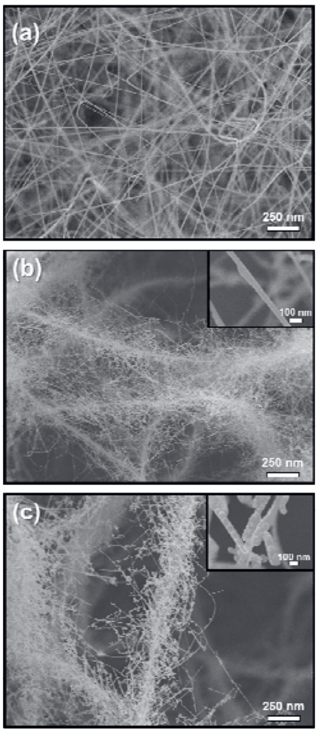

Fig. 1. SEM images of (a) SnO_2 nanowire, (b) TeO_2-branched SnO_2 nanowire, and (c) Au functionalized TeO_2-branched SnO_2 nanowire.

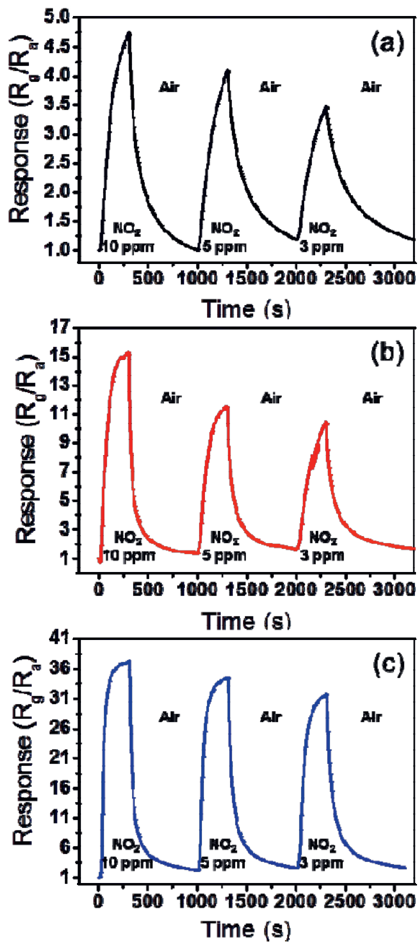

Fig. 2. Gas response of (a) SnO_2 nanowire, (b) TeO_2-branched SnO_2 nanowire, and (c) Au functionalized TeO_2-branched SnO_2 nanowire to NO_2 gas.

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