Metal Oxides Nanowires for Chemical Sensing and Solid Oxide Fuel Cell Applications

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The demands of portable, low-cost, and efficient sensing devices and renewable energy resources is continuously increasing for environmental monitoring, production of sustainable clean energy and health care. To fulfill these demands, nanostructured metal oxides can be a potential candidate due to their high crystallinity, remarkable physical/chemical properties, ease of synthesis, and low cost. In particular, (1D) one-dimensional metal oxide nanowires (NWs), exhibit a fast response, selectivity, and stability due to their high surface-to-volume ratio, well-defined crystal orientations, and controlled unidirectional electrical properties. As far as their applications for solid oxide fuel cell (SOFC) is concerned, nanowires exhibit suitable electrical, morphological and mechanical properties for novel electrode developments that can further be used miniaturization of SOFC.

For chemical sensors, the surface of the active materials determines the sensor sensitivity toward specific gas analytes. The enhancement in the sensor response can be achieved by increasing the active surface area of the sensor. Various strategies have been used to increase the gas response and selectivity, including modulating the sensing temperature, morphological control, catalyst doping/loading and catalytic filtering of interference gases, and construing a junction between two materials. Herein, we are presenting the novel preparation and characterization of different nanostructures and heterostructures morphologies such as NiO, WO_3, Bi_2O_3 and ZnO NWs, TiO_2 nanotubes and NiO/ZnO, NiO/$NiWO_4$/WO_3 branched heterostructures and NiO/SnO_2, CuO/ZnO Core-shell, SnO_2/GO and WO_3-doped with Nb fabricated using different techniques, their characterization and chemical sensing performance towards different compounds. Further, the sensing properties of ZnO NWs were improved by functionalizing with different self-assembly monolayers such as (3-aminopropyl)trimethoxysilane (APTMS), 3-glycidoxypropyltrimethoxysilane (GLYMO) and tetraethyl orthosilicate (TEOS) for acetone detection.

Even though SOFC exhibits highest efficiency as compared to other fuel cell types, its small-scale application such as small electrical generator, micro-CPH (combined heat and power system) is still in question due to its high operational temperature, slow-startup and high cost. Indeed, for miniaturization, nanostructured materials such as nanowires can be among the best options due to their compact size, suitable transport properties and better electrical properties. Herein, we are proposing novel NiO-GDC (NiO- gadolinium doped ceria) nanowires synthesized via vapor liquid solid (VLS) mechanism for its application as an anode. NWs were grown at two different evaporation temperatures and the deposition time was kept constant. According to the best of our knowledge, NiO-GDC has never been grown before in the form of nanowires morphology especially with VLS mechanism. The nanowires were characterized to investigate their surface morphology, structure and electrical properties via different characterization techniques. Finally, the nanowires were grown on commercial single electrode (cathode only) button cell to investigate the cell and its electrochemical performance. Detail investigations reveal that the NiO-GDC nanowires have the potential to be used as an anode for SOFC.

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