

Nanowires of semiconducting metal-oxides and their gas-sensing properties

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Quasi 1-dimensional nanostructures of semiconducting materials such as zinc or indium oxides are presently investigated in order to produce a novel class of sensing devices. These fascinating nanostructures may be produced in several unusual arrangements such as nanowires, nanorods, or nanocombs, resulting in great potential for fundamental study and application. The evaporation-condensation (EC) process, with Vapor-Phase (VP) or Vapor-Liquid-Phase (VPS) growth mechanism, is highly promising as deposition technique. Such a preparation method consists of thermally-driven evaporation of bulk metal oxides followed by condensation in controlled thermodynamic conditions. Un-catalyzed and size-controlled growth of ZnO nanocombs and nanowires, down to 10 nm in size, has been achieved by EC process.

Microstructural investigation of the nanowires and the analysis of the electrical properties is a key-feature for profound knowledge of growth process and for the exploitation of the unique properties of 1-D nanostructures. Electron microscopy techniques have been carried out in order to determine the degree of chemical homogeneity and crystalline arrangement. High-resolution TEM analysis and electron diffraction revealed the regular arrangement and orientation of the wires. The atomically sharp crystal facets and the termination of the wires were revealed. Compositional imaging techniques such as STEM Z-contrast were used for the investigation of impurities and local variations in the composition.

Quasi one-dimensional nanostructures are expected to show a variety of quantum confinement effects as two of their dimensions are comparable to the wavelengths of the electronic wave-function. The effect of reactive gases on the electrical conductance of semiconducting metal-oxides nanowires is the basic mechanism for the development of nanodevices with enhanced sensing performance. The electrical and optical properties of nanowires have been investigated. Nanowires have been tested towards different gases, such as CO, O₃, NO₂ for environmental applications or vapors such as ethanol, methanol, acetone interesting for breath analyses and food quality control. Photoluminescence (PL) spectroscopy was performed over a wide temperature and frequency range for the purpose of investigating the behavior of PL spectrum in presence of reactive gases.

The experimental evidences foresee the development of innovative metal-oxide gas sensors based on the modulation of the size of the space charge region and capable of operation in liquid environment and at room temperature. Among the possible applications in the field of biotechnology, sensitive DNA and protein detection is presently under investigation.