Symposium EM04: Wide- and Ultra-Wide-Bandgap Materials and Devices

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EM04.10: Oxide Materials and Devices I

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9:15 AM - EM04.10.04
Humidity Sensors from Individual Gallium Oxide Nanowires—Synthesis, Characterization and Sensing Properties

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Hide Abstract

The monoclinic phase of gallium oxide (Ga_2O_3) is a wide band gap semiconductor material that has been widely studied for its oxygen sensing properties at high temperatures, above 600 ^{0}C and for its sensitivity towards reducing gases at temperatures above 450 ^{0}C. At lower temperatures, the sensing mechanisms that contribute to the bulk oxygen-vacancies diffusion and consequently to the gas sensing, is deactivated. However, gas sensing can continue taking place at the defect sites of the material surface. The high surface-to-volume ratio attributed to the nanowire (NW) morphology can help to overcome this limitation and decrease the sensing temperature increasing the surface interactions. In our study, single Ga_2O_3 NW, that offer less power consumption and more convenient material study than meshes of NWs, are studied for humidity and oxygen sensing.
In this work, Ga_2O_3 NWs have been fabricated via carbothermal reduction following a vapor-liquid-solid (VLS) mechanism using a chemical vapor deposition (CVD) furnace. The precursor material is heated at 950 ^{0}C and the gas phase is transported using a pure argon flow of 100 cm^3/min. The Si/SiO_2 substrates, covered with a 5 to 20 nm discontinuous Au layer, are positioned downstream and heated up to 800 and 950 ^{0}C to promote the NW growth.
The grown nanowires have been structurally, chemically and optically characterized using X-ray diffraction, scanning and transmission electron microscopy and related techniques as well as photoluminescence, XPS and Raman spectroscopy. Correlation between shape, crystallinity and optical properties of the formed nanostructures and their chemical composition will be discussed and justified based on the known properties of the pure forming materials.
The Ga_2O_3 NWs were subsequently removed from the substrates applying sonication in order to fabricate gas sensors from individual NWs. The next step involves the deposition of the Ga_2O_3 NWs on suspended microhotplates and their contact using a combination of Focused Electron- (FEBID) and Focused Ion-Beam Induced Deposition (FIBID) techniques. The fabricated nanosensors devices have been tested towards different gases relevant in air quality monitoring, like NO_2 and CO, as well as towards O_2 and water vapor at different concentrations and operating temperatures. The sensing properties will be discussed and the relation to the structural and chemical properties of the nanomaterials will be established.