ABSTRACT

The objective of this thesis is to study the structural, optical and gas sensing properties of tungsten trioxide and molybdenum trioxide thin films and nanoparticles and make structure-property correlations. Thin films of amorphous tungsten trioxide and amorphous molybdenum trioxide are grown by thermal evaporation and crystallized by post-deposition annealing in air. Thin films of different thicknesses were deposited on fused silica, microscopy glass slide, single-crystal silicon wafer and alumina substrates and analyzed by Grazing Incidence X-ray Diffraction, UV-visible absorption and specular reflectance spectroscopy, AFM, FESEM and Raman spectroscopy. The interference fringes in the UV-visible transmittance and reflectance spectra are used to determine simultaneously, the thicknesses and refractive indices of amorphous and crystalline film samples. The gas sensing properties of films are studied for 50 to 150 ppm concentration of H₂S, and 1000 to 2000 ppm concentration of C₂H₅OH as a function of sensor operating temperature.

Nanoparticles of tungsten trioxide and molybdenum trioxide are prepared by hydrothermal method. Nanoparticles of both the materials; WO₃ and MoO₃ grow into the same crystalline phases as their corresponding thin film and starting polycrystalline powder samples.

High resolution Raman studies revealed for the first time, that the short-range structure of amorphous WO₃ and MoO₃ are very similar to that of their respective bulk crystalline phases. Raman spectroscopy is found to be an excellent technique for determining the stoichiometry of sub-stoichiometric MoO₃₋ₓ. It is shown that the Raman peaks intensity ratios: I₁₁₇/I₁₃₀ and I₂₈₅/I₂₉₁ are proportional to each other and correlate directly with Mo-O stoichiometry. Higher the value of these intensity ratios, greater is the Mo-O stoichiometry in thin film and powder samples. WO₃ nanoparticles are found to have better response towards H₂S as compared to MoO₃. Thin film and nanoparticle sensors were continuously tested towards H₂S and C₂H₅OH for a period of 2 to 3 months and the sensor characteristics i.e. response, response time and recovery times are found to be high stable.