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Nanocrystalline Tellurium Films: Fabrication and Gas Sensing Properties

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Abstract

A brief review of achievements in the fabrication of nanostructured tellurium thin films for applications in sensor technology is reported, paying particular attention to physical growth of nanocrystalline films in vacuum. The structure, growth and properties of Te films are determined by fabrication parameters such as the microstructure of the substrate, the growth rate or post-deposition UV irradiation. As shown by SEM, AFM and XRD, the rate most strongly influences the microstructure of the films and their gas sensing properties. An increase of the rate results in the transformation of the microcrystalline structure of the film to a nanostructured one, or even to an amorphous state. The gas sensing mechanism is explained in terms of a model that involves hole accumulation at the Te nanocrystallites surfaces due to interactions of dangling bonds and a lone-pair electron of the chalcogen. This model can explain, for instance, the "strong" chemisorption of nitrogen dioxide, which results in an increase of the work function $\Delta\Phi > 0$ and the electrical conductivity $\Delta\rho > 0$ as a consequence of the additional charging of the surface and band bending. In ultrathin (<40 nm) amorphous tellurium thin films, a damping of the sensitivity induced by high gas (NO2) concentration was observed for the first time. The sensitivity of an ultrathin Te film decreases near linearly with increasing concentration between 150 and 500 ppb nitrogen dioxide which needs to be taken into consideration by the sensor technology.