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Ultra-thin TiO2 films by atomic layer deposition and surface functionalization with Au nanodots for sensing applications

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Abstract

The massive application requests for high-performance sensors indicate on the importance of precise controlling of the semiconducting oxide characteristics. The sensor longevity needed for the remote areas in harsh environments is mandatory and can benefit greatly from self-cleaning abilities. To serve this demand, we present in our work ultra-thin TiO2 films deposited with different thicknesses down to 15 nm on glass substrates using atomic layer deposition (ALD). The morphological, chemical, topographic, electronic and chemical properties of the fabricated films were investigated in detail, showing the presence of the anatase phase. As it is known by the literature, the UV and gas sensing properties are highly dependent on the thickness of the films, however fully reversible and capable of long term detection. Thinner films (15 nm) showed higher UV and gas sensing performances than thicker films (45 nm), which was related to the film thickness comparable to the Debye length. Further improvement in the UV sensing properties was achieved by surface functionalization of TiO2 films with Au nanoparticles. The UV response increased by about one order of magnitude after the surface functionalization with Au nanoclusters/nanoparticles. All TiO2 ultra-thin films demonstrated good selectivity to hydrogen gas, independent of the thickness. The samples with 15 nm thickness showed a response of ~ 600% to 100 ppm of H2 at 250°C operating temperature. The presented study demonstrates the importance of the film thickness and surface functionalization with noble metals nanoclusters for sensing applications of ultra-thin TiO2 layers. Such ultra-thin films could be used for the development of a series of integrated detectors and chemical field effect transistors (chemFETs) directly on highly complex chips.