OR1308

The Effect of Nitrogen Partial Pressure and Substrate Temperature on the Characteristics of Photocatalytic N:TiO2 Thin Films deposited by Filtered Vacuum Arc Deposition

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Nitrogen doped Titanium Oxide (N:TiO_2) thin films were deposited using filtered vacuum arc deposition, and their structure, composition and morphology were studied as functions of the total pressure, N_2/O_2 gas ratio and the substrate temperature. The XRD patterns of the TiO_2 thin films deposited in a pure oxygen environment indicated that films were polycrystalline in the anatase phase, while films deposited in an atmosphere in which the N_2 fraction was greater than 9% were amorphous, for substrate temperatures up to 500°C. Annealing at 400°C in N_2 for one hour generated polycrystalline films with anatase phase independent of $\%N_2$ fraction during deposition. AFM analysis of films deposited in a 41% N_2 atmosphere indicated that the surface roughness increased from 0.5 up to 3.2 nm when the substrate temperature was increased from RT to 500°C, and it was higher for films deposited at 23% N_2 partial pressure (~5.7 nm) compared to films deposited on RT substrates at 23% N_2. XPS analysis indicated that all films deposited in 0%N_2 were stoichiometric TiO_2. N content in the films increased with $\%N_2$ in the deposition atmosphere, however the N-content in the film, 1-3at.%N, was much less than that in the gas mixture (9-69%N_2). Annealing decreased the N-content in these films to <1at.%. In addition, the XPS revealed that all N:TiO_2 films had two main N 1*s* components, at 396-397 eV and at 399-400eV, associated with substitutional and interstitial nitrogen, respectively. Optical transmission measurementsindicated that the average film transmission was approximately 80% in the visible spectrum for films deposited at lower N_2 partial pressures (<41%), and it decreased to ~50% for higher $\%N_2$. The absorption edge of the films shifted to longer wavelengths with increased substrate temperature and $\%N_2$, from ~380 nm up to ~485 nm for films deposited with 41%N_2 and a substrate temperature of 500°C. The deposited nano-structured films were tested for a water treatment application using a photocatalytic activity test and it is found that the photocatalytic activity of samples which had lower N content was higher.

Keywords
Photocatalytic Titanium Oxide Coatings
Microstructure
Optical Characterization