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Enhanced properties of photocatalytic thin films via doping during magnetron sputter deposition

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Titanium dioxide is a well-known photocatalytic material with a wide range of applications such as self-cleaning and anti-microbial hygienic surfaces. Due to its band gap of 3.2 eV it is activated by ultraviolet radiation and much attention has been focused on means of shifting the photocatalytic activity into the visible range, including transition metal ion doping and doping with nitrogen. This would significantly extend the range of applications for this material, particularly if these enhancements could be achieved at processing temperatures that are not detrimental to the integrity of commodity substrates, such as glass or polymers. In the present work, TiO₂ coatings doped with various transition metals (Mo, Nb, Ta, W) and TiO₂ coatings doped with N₂ have been investigated and compared. As-deposited coatings and coatings annealed at both 400°C and 600°C were characterized by X-ray Diffraction (XRD), Raman spectroscopy and energy dispersive X-ray spectroscopy (EDX). The band gap values were determined from optical data for all samples. The photocatalytic properties of the coatings were studied by the degradation of methylene blue dye under both ultra-violet and visible light sources. The results of the study showed that doping titania coatings with Mo, W and Nb ions in low concentration significantly improves their photocatalytic properties in both the UV and visible ranges. For example, titania coatings doped with 2.4at% Mo showed a 26% increase in activity in the UV and a 69% increase in activity in the visible range, compared to pure titania coatings prepared under the same conditions. Similarly, low levels of nitrogen doping can also be beneficial, whereas doping with Ta was detrimental. The crystal structure of all coatings with high photocatalytic activity was predominantly anatase. Excessive transition metal doping leads to the formation of electron-hole recombination centres at dopant sites, and hence reduces the photocatalytic activity.

Keywords

titania coatings

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dopants