Characteristics of TiO_2 Thin Films with Metal Content by Co-sputtering

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TiO_2 has been known as a material with a high refractive index, high transparency in the visible and near-infrared wavelength region, high dielectric constant, very good wear resistance and stability.[1] TiO_2 thin films has been widely used for many applications such as optical thin film device, optoelectronics, gas sensor, ceramic membrane and photocatalytic purifier.[2] Sputtering method has provide more freedom in selection of the deposition parameters and the deposition temperature could be controlled with additional heating. The doping of noble metals has been used to improve the photocatalytic activity of TiO_2 thin films.

In this study, we prepared the pure TiO_2, M/TiO_2 thin films by RF magnetron co-sputtering method and studied their physical and chemical properties. The M/TiO_2 thin films were deposited on quartz glass by RF magntron sputtering system (Hanvac HVS-380) in a high vacuum reactor with three separate-confocal sources. Ceramic titanium oxide target was prepared by pressing TiO_2 rutile powder and then sintering it in the atmosphere at 1200 ℃ for 5 h. The background pressure of the process chamber was 6×10^{-6} Torr that was obtained by employing a turbo-molecular pump backed by a mechanical pump. The optimum substrate-to-target distance was determined to be 200 mm. The rotation speed of substrate was maintained by 5 rpm and the temperature of the substrate was maintained at 250 ℃. The RF powers of the TiO_2, Ag and Pd targets were 150 W, 5 W and 5 W, respectively. The deposition pressure was fixed at 1×10^{-2} Torr. After the deposition, the as-deposited films were calcined temperature from 300 ℃ to 900 ℃ and maintained at that temperature for 1 h. The calcined thin films investigated their optical and structural properties using UV visible spectrophotometer, SEM, XRD etc. The photocatalytic activity of the films was determined by the decomposition of methylene blue dye solution.

Fig. 1 shows the XRD patterns of pure TiO_2 thin film calcined at 600 ℃and 900 ℃. No peak is observed for the as deposited TiO_2, indicating that they are amorphous. The TiO_2 thin films calcined at 600 ℃ have the anatase phase, and they also have mixed anatase and rutile phase at 900 ℃. Fig. 2 shows the photodegradation of methylene blue solution of pure TiO_2, Ag/TiO_2 and Pd/TiO_2 thin films calcined at 600 ℃. The photocatalytic activity of the Ag doped TiO_2 thin film is higher than pure TiO_2 and Pd doped TiO_2 thin films. These results relate to the grain size of thin films. Fig. 3

and 4 show the EXAFS and Ti K-edge XANES spectra of the films using 3C1 X-ray Absorption Fine Structure beam line. The XANES result shows that Ag/TiO_2 thin films calcined at 900 ℃ have the anatase phase. These results suggest that the doping-Ag particle in the TiO_2 thin films hinder the phase transformation from anatase to rutile struture.

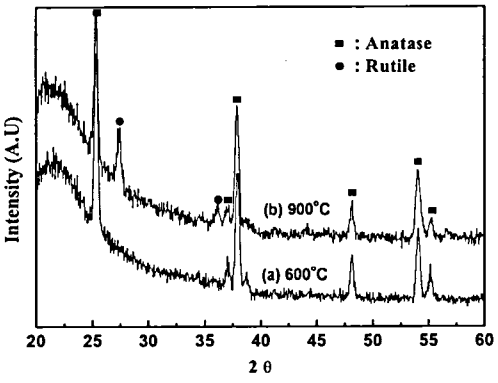

Fig 1. XRD patterns of pure TiO_2 thin film calcined at 600 ℃and 900 ℃.

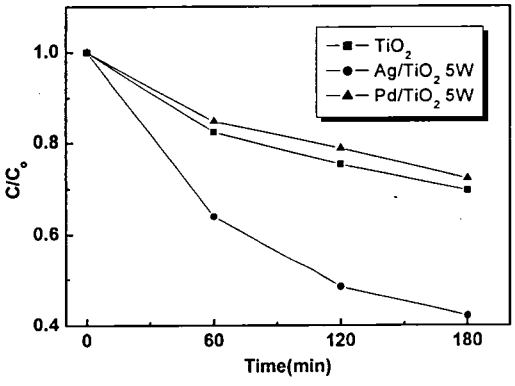

Fig 2. Photodegradation of methylene solution of pure TiO_2, Ag/TiO_2 and Pd/TiO_2 films thin calcined at 600 ℃.

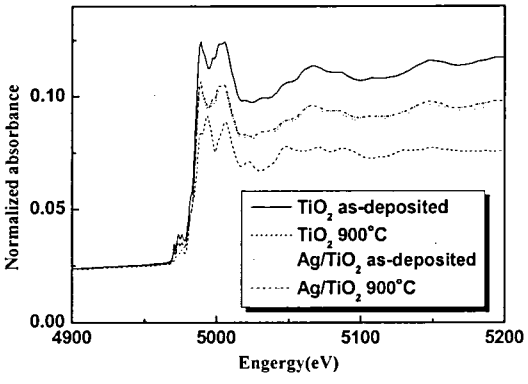

Fig 3. EXAFS spectra of the TiO_2 and Ag/TiO_2 thin films.

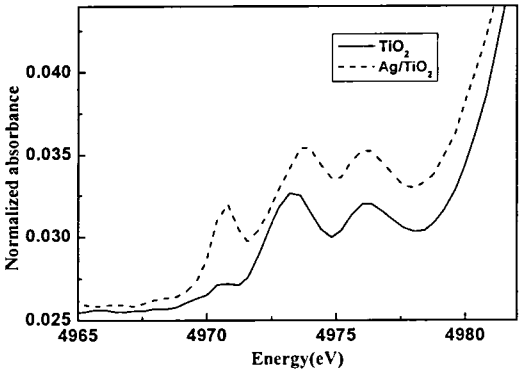

Fig 4. Ti K-edge XANES spectra of the TiO_2 and Ag/TiO_2 thin films calcined at 900 ℃.

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