THE EFFECTS OF PROCESS PARAMETERS ON THE PHOTOCURRENT OF WO_3 THIN FILMS GROWN BY REACTIVE MAGNETRON SPUTTERING

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Abstract

Tungsten trioxide (WO_3) is a promising material as a photoelectrochemical anode for water splitting [1]. In this research, WO_3 thin films were deposited onto ITO glass by radio frequency magnetron sputtering. We changed process pressure, oxygen partial pressure and thickness of WO_3 thin films to find out an optimum sputtering condition for growth of WO_3 electrodes. The relationships among the process parameters, film structures, and photocurrent responses were explored in this study.

The sputtering target was a 3 inch disk of W metal (99.99% purity). Corning glass was used as substrate. Reactive sputtering was carried out in a mixed gas of argon and oxygen. The oxygen flow ratio was varied from 5% to 50%. The process parameters of total gas flow ($Ar+O_2$), distance between target and substrate, and RF input power were fixed at 60 sccm, 60 mm, and 200W, respectively. The total gas pressure in the sputtering chamber was monitored by a capacitance manometer and the flow rates of argon and oxygen gases were controlled by mass flow controllers. The film thickness and crystal structures of the films were determined by α-step profilometer and X-ray diffraction (XRD) with CuKα (λ=0.15418nm) radiation, respectively. The photocurrents of WO_3 thin films were measured by potentiostat under illumination of 365 nm UV light with intensity of 3.7mW/cm^2. The compositions of WO_3 thin films were examined by energy dispersive X-ray (EDX).

Fig.1 shows the influence of oxygen partial pressure on the photocurrent of WO_3 thin films deposited at room temperature. The photocurrent has a maximum at oxygen partial pressure of 20%. Fig.2 shows the XRD patterns of these WO_3 thin films. They are all crystalline with monoclinic structure and the crystalline intensity is not related to the oxygen partial pressure. Fig.3 shows the transmittance of WO_3 thin films deposited at various oxygen partial pressures. The transmittances are almost independent on oxygen partial pressure. Fig.4 shows the EDX patterns of WO_3 thin films grown at various oxygen partial pressures. The oxygen ratio in the films increases slightly with increasing oxygen partial pressure. The results from Figs. 2, 3 and 4 indicate that the photocurrent is almost independent on the crystalline intensity, transmittance and oxygen content in this study.

Fig.5 shows the influence of thickness on the photocurrent of WO_3 thin films grown at 300℃. We can see that the photocurrent has a maximum with the thickness of WO_3 thin films. For film thickness beyond 330 nm, the photocurrent tends to decrease with the increase in thickness because of carrier blocking effect. Lower carriers were drawn from the surface of films in thicker WO_3 thin film. However, for film thickness below 330 nm, the lower absorption efficiency caused by the thinner film of WO_3 made the generated carriers not enough to achieve for a sufficient photocurrent. A maximum photocurrent of 1.46×10^{-5} A/cm^2 was obtained for the WO_3 films with thickness of 330 nm.

Conclusion

WO_3 films were prepared by reactive magnetron sputtering system. The oxygen partial pressure in deposition and the deposited film thickness have a significant effect on the photocurrent of WO_3 electrodes. The results show that the photocurrent density has a maximum with oxygen partial pressure and WO_3 film thickness.

ACKNOWLEDGMENTS

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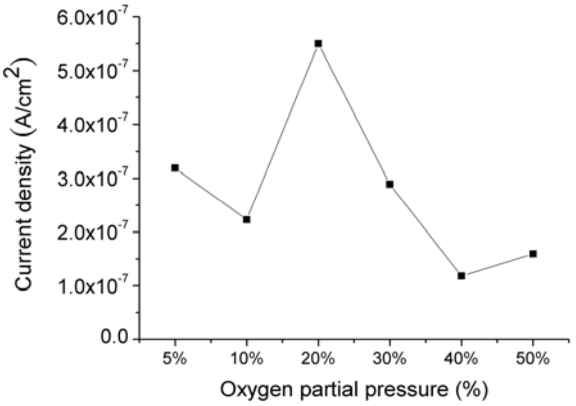

Fig.1 Influence of oxygen partial pressure on the photocurrent of WO_3 thin films grown at room temperature with a thickness of 450nm.

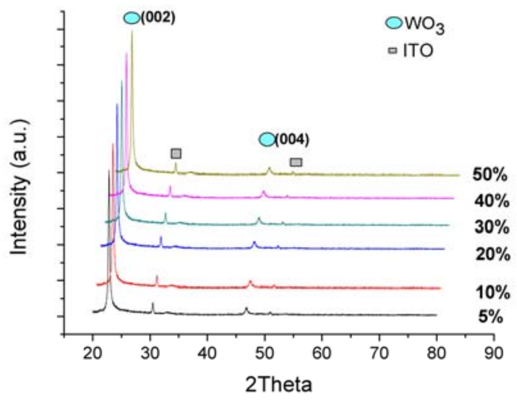

Fig.2 XRD patterns of WO_3 thin films deposited at various oxygen partial pressures

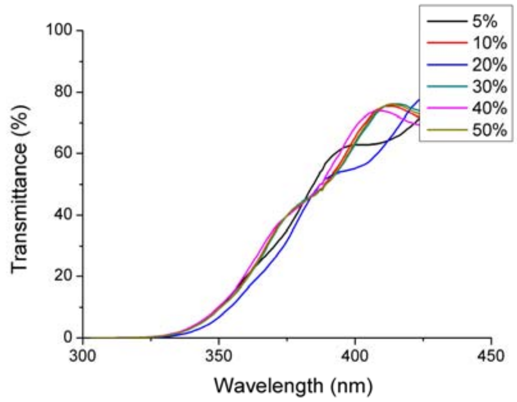

Fig.3 Transmittance of WO_3 thin films deposited at various oxygen partial pressure

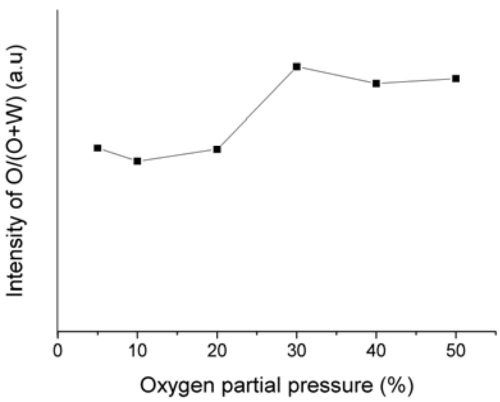

Fig.4 Effect of oxygen partial pressure on the ratio of EDX intensity of oxygen to oxygen and tungsten (O/(O+W))

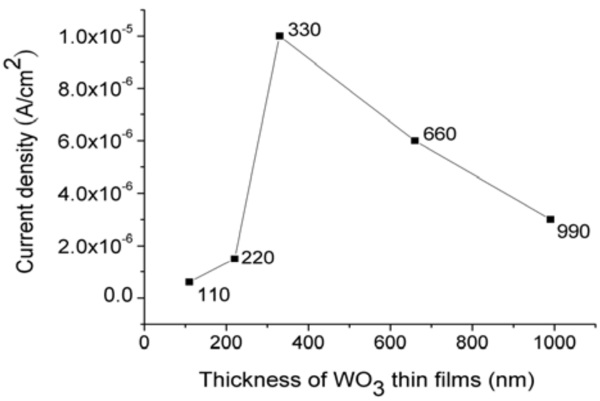

Fig.5 Influence of thickness on the photocurrent of WO_3 thin films grown at 300℃ with RF power of 200W and oxygen partial pressure of 20%