Effect of Argon Purge Amonut on the Photoelectrochemical Properties of Nitrogen-doped TiO2 Films Grown by Atomic Layer Deposition

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Abstract

N-doped TiO2 films were grown on n^+ Silicon substrates at 400℃ by atomic layer deposition (ALD) with $TiCl_4$ and NH_4OH as the precursors. The effect of Ar purge amount on the film properties was investigated. The surface morphology, crystal structure, and photocurrent density of N-doped TiO_2 films were characterized by XRD, SEM, and Potentiostat, respectively. The results show that the deposited films are visible-light active at the wavelength up to 500 nm. The photocurrent density increases with the increase of Ar purge amount.
Keywords: Photocurrent, ALD

Introduction

Titanium dioxide (TiO_2) is an efficient semiconductor for various photodriven applications such as in photoelectronchemical cell and photocatalysis[1]. However, the bandgaps of TiO_2 films, around 3.0 eV for rutile and 3.2 eV for anatase, only allow ultraviolet (UV) absorption. In order to extend the light absorption of TiO_2 films towards the visible light region, the N-doped TiO_2 has been developed[2-3]. In this study, the effects of Ar purge amount on the photocurrents of N-doped TiO2 films grown by ALD were studied.

Experimental

N-doped TiO2 films were grown on n+ silicon substrates by ALD system. The experimental parameters were shown in Table 1.The substrates were cleaned in an ultrasonic bath sequentially using acetone, methanol, and deionized water for 5 min separately.The photoelectrochemical properties were measured by the potentiostat at zero applied potential as shown in Fig.1.

Table 1 Parameters for ALD N-doped TiO2

Process items	Process conditons
Temperature of $TiCl_4$	30℃
Temperature of NH_4OH	5℃
Temperature of growth	400℃
Deposition time	1000 cycle (1 cycle = 8 s)
r purge amount	1.59、4.18、6.43 cm^3/purge

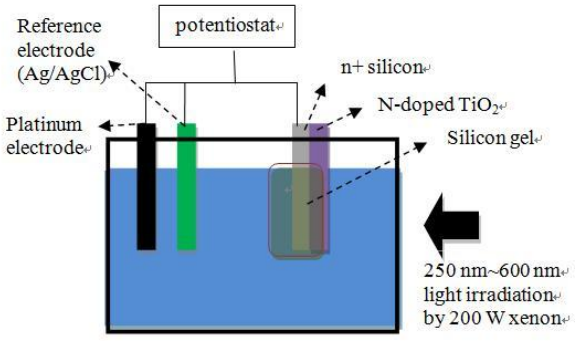

Fig. 1 Photocurrent measurement system

Results and Discussion

The FESEM images in Fig.2a,b,c shows that the surface morphologies of N-doped TiO_2 films are independent of the Ar purge amount. The corresponding X-ray diffractograms in Fig. 2d, verify the presence of anatase and rutile TiO_2. The photocurrent density in Fig. 3 shows the visible-light activity at the wavelength up to 500 nm. The photocurrents were determined to be 0.08 μA cm^{-2} for 6.43 cm^3/purge, 0.02 μA cm^{-2} for 4.18 cm^3/purge, and 0.01 μA cm^{-2} for 1.59 cm^3/purge.

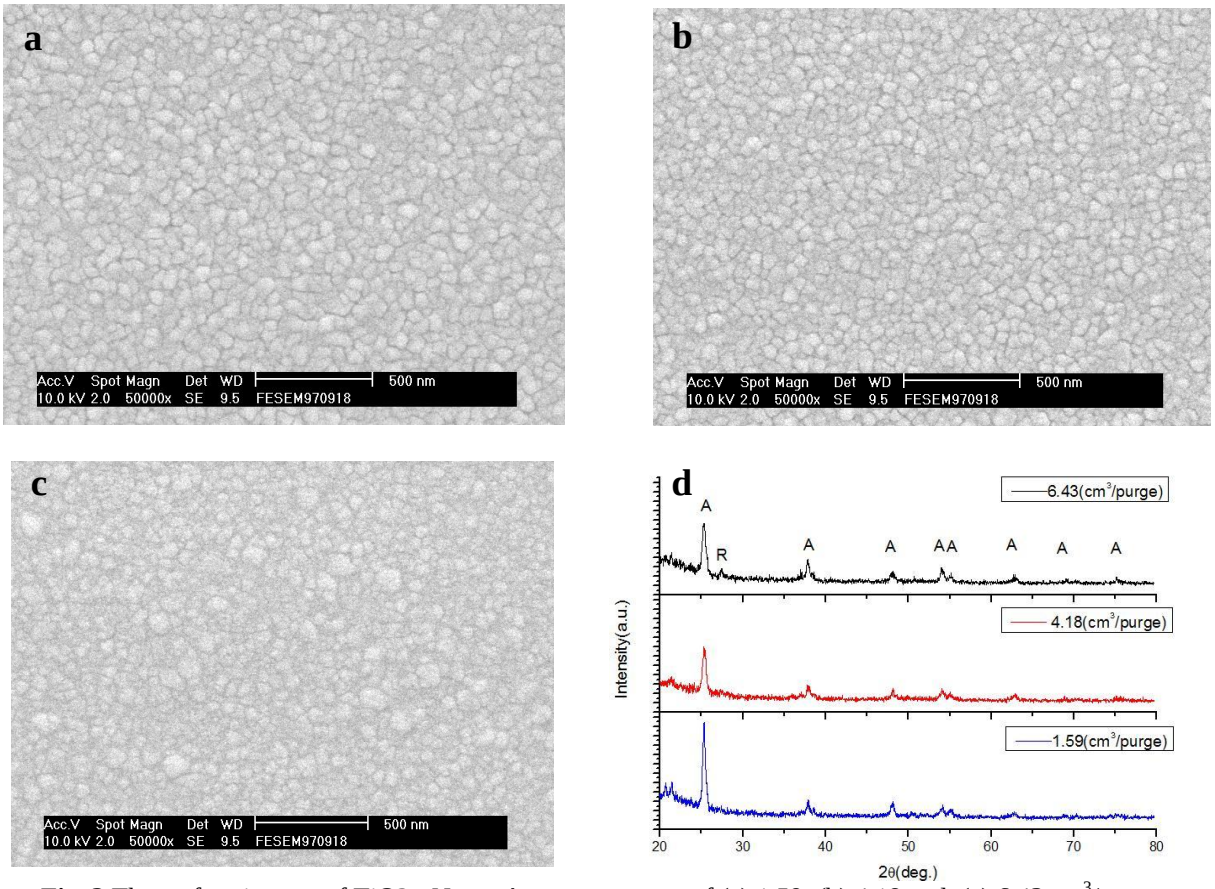

Fig. 2 The surface images of TiO2-xNx at Ar purge amount of (a) 1.59 ,(b) 4.18,and (c) 6.43 cm^3/purge. The corresponding X-ray diffractograms were shown in d.

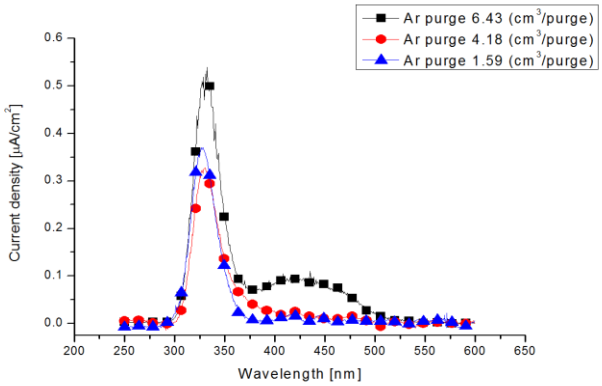

Fig.3 The wavelength-dependent of N-doped TiO2 films.

Conclusion

The photocurrents under 0.16 mW/cm^2 430 nm light irradiation were determined to be 0.08 μA cm^{-2} for 6.43 cm^3/purge, 0.02 μA cm^{-2} for 4.18 cm^3/purge, 0.01μA cm^{-2} for 1.59 cm^3/purge.Further investigation to increase the optical absortion effciency is on going.

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