IMPROVEMENT ON THE PHOTOCURRENT OF TITANIUM DIOXIDE FILMS BY PATTERNED SUBSTRATES

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Abstract

In this study, the effects of patterned substrates on the photocurrents of coated TiO_2 films were investigated. The mask size include lines with width of 4 μm and space of 24 μm, and holes with diameter of 4μm and space of 24 μm. A 500 nm stainless steel film was deposited onto the patterned glass substrates as a conduction layer by RF sputtering. TiO_2 films were then deposited on the conduction layer by atomic layer deposition technique. The morphologies of patterned substrates were observed by a scanning electron microscopy. The photocurrents were determined to be 59.2 μA/cm^2 for plain structure, 64.5 μA/cm^2 for patterned line structure with line width of 20 μm and space of 8 μm, and with 147.5 μA/cm^2 for patterned hole structure with hole diameter of 17.6 μm and space of 10.5 μm.

Keywords: Photocurrent, patterned structure

1. Introduction

Nanosize titanium dioxide (TiO_2) has many important applications such as solar cells, [1] photocatalysts for water photolysis, [2] degradation of environmental pollutants in air and waste waters, [3,4] and as an oxygen- and gas-sensor material [5]. In previous study, plain structure TiO_2 films with photocurrents of 60~70μA/cm^2 under UV-light illumination have been developed. In this study, line and hole structures were patterned on the glass substrates by the photo-lithography and wet etching technique to increase TiO_2 films photocurrent.

2. Experimental

Line and hole structures were patterned on the glass substrates by the photo-lithography and wet etching technique .The experimental parameters referred to Table 1. The solution for wet etch of glass is BOE consists of HF(6%) and NH_4F(16%) . A 500 nm stainless steel film was then deposited onto the patterned glass substrates as a conduction layer by RF sputtering. Finally, TiO_2 films were deposited on the conduction layer by atomic layer deposition technique. The photocurrents were measured by the potentiostat technique at zero applied potential as shown in Fig.1

Table 1 Photo-lithography parameters

Process items	Process condition	Process time
HMDS Spin coating	Step 1 6000rpm	10s
Bake	110℃	5min
PR Spin coating	Step 1 1000rpm	10s
	Step 2 1500rpm	20s
Soft bake	100℃	5min
Time of exposure	100/19.33	5.1s
Development	At room Temp	10s
Hard bake	110℃	10min
Etching time	At room Temp	160s

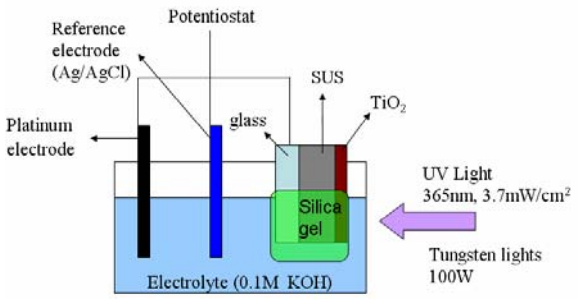

Fig.1 Photocurrent measurement system

3. Results and discussions

The SEM images in Fig.2 shows the (a) top view and (b) cross section of hole patterned glass with hole diameter of 17.6 μm and hole space of 10.5 μm. The SEM images in Fig. 3 shows the (a) top view

and (b) cross section of line patterned glass with line width of 20 μm and line space of 8 μm. The photocurrents of TiO_2 films with plain structure, line structure and hole structure are shown in Table 2. The photocurrent for plain structure was 59.2 μA/cm^2. Whereas the photocurrents for line and hole patterned structures were 64.5 and 147.5μA/cm^2 respectively, due to higher effective surface area of 0.31 and 0.51 cm^2 compared with the plain surface area of 0.25 cm^2 . The photocurrent of TiO_2 has been increased by the patterned structure with higher effective surface area

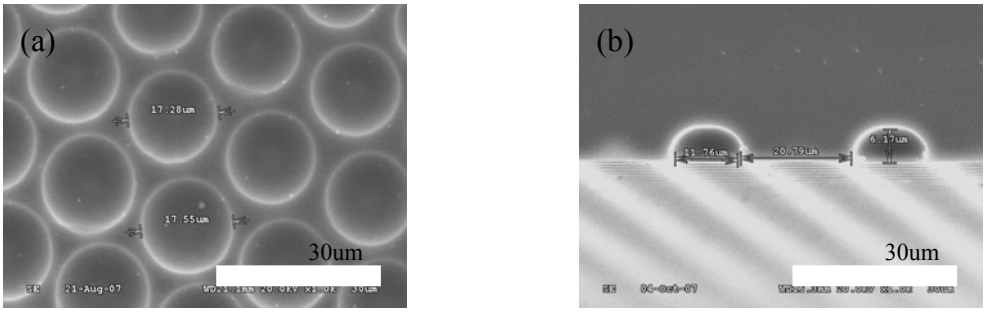

Fig.2 SEM images of (a) top view and (b) cross section of patterned glass.

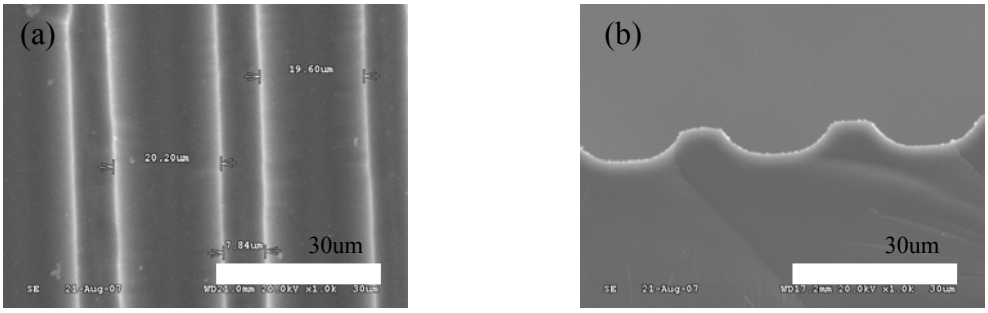

Fig.3 SEM images of (a) top view and (b) cross section of patterned glass.

Table.2 photocurrents of TiO_2 films with lines and holes

Sample structure (width & space)	Illumination area (cm^2)	Effective surface area (cm^2)	Photocurrent (μA/ cm^2)
Plain structure (without pattern)	0.5	0.5	59.2
Line pattern (4μm & 24μm)	0.25	0.31	64.5
Holes pattern (4μm & 24μm)	0.25	0.51	147.5

4.Conclusions

The photocurrents were determined to be 59.2 μA/cm^2 for plain structure, 64.5 μA/cm^2 for line structure, and 147.5 μA/cm^2 for hole structure. In the future, we will decrease line width and hole diameter to fabricate high aspect ratio structure for further increase on photocurrent.

5. REFERENCES

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