Reactive Sputtering Deposition and Photocatalytic Activity of TiO_xN_y Thin Films

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Abstract – TiO_xN_y films have been fabricated at Si substrates by reactive ion assisted sputtering deposition. Chemical composition of the films was determined with X-ray photoelectron spectroscopy (XPS). Optical parameters of the films were defined with spectroscopic ellipsometry (SE).

1. Introduction

Titanium dioxide and nitrogen-doped titanium dioxide are actively developed as a promising medium with photocatalytic reactivity under sunlight [1–3].

Doping with nitrogen has been considered as one from most effective approaches to improve photocatalytic activity of TiO_2 in visible spectral region. Nitrogen-doped titanium dioxide films can be fabricated by sputtering deposition in N_2/O_2 reactive gas mixture.

The TiO_xN_y/Si film system is a basis for creation of microphotocatalytic elements. We focus our attention on how the different deposition conditions are related to the resulted chemical composition of the film and their photocatalytic properties.

2. Experiment

The TiO_xN_y films were grown using ion beam sputtering of Ti metal target. The reactive gas mixture N_2/O_2 ratio was varied within the range 0–100%.

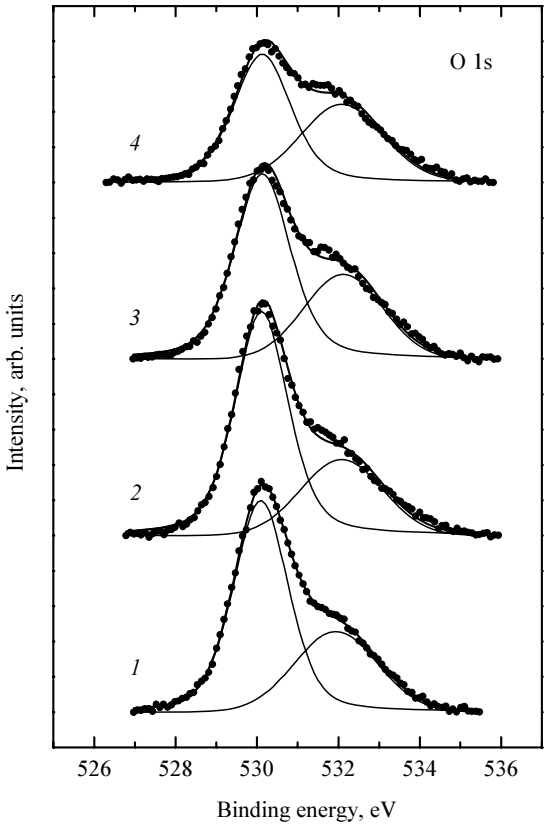

Fig. 1. Detailed photoemission spectra of O 1s core level. Samples are shown by numbers

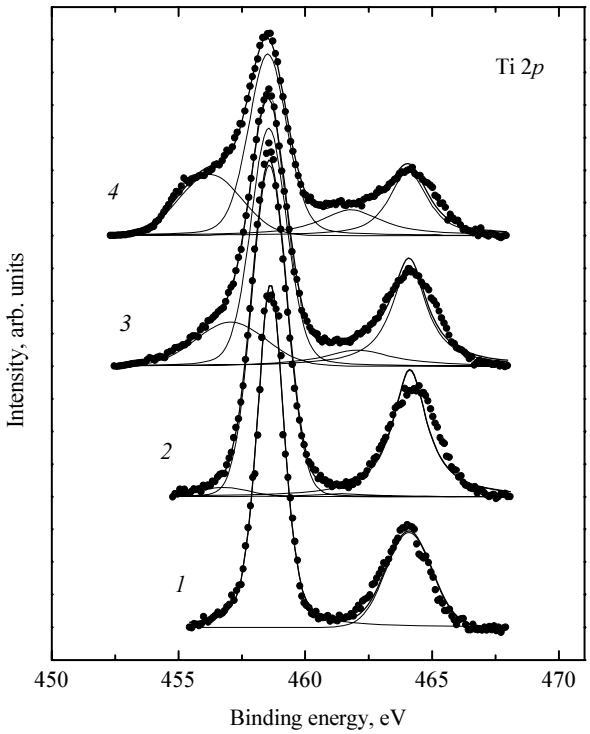

Fig. 2. Detailed photoemission spectra of Ti 2*p* doublet. Samples are shown by numbers

Chemical composition and element valency were measured with detailed observation of Ti $2p_{3/2}$, O 1s and N 1s core levels by X-ray photoemission spectroscopy (XPS) (Figs. 1, 2). Optical characteristics and film thickness were evaluated with spectroscopic ellipsometry (SE) over the spectral range 250–800 nm (Table 1).

Table I. Synthesis conditions and composition of TiO_xN_y films

Sample	1	2	3	4
Gas composition N_2/O_2, %	0/100	92/8	97/3	100/0
Film thickness, nm	96.7	92.4	67.1	64.7
Chemical composition of film surface, % at				
Ti	26.99	26.73	25.37	24.81
C	17.15	18.23	19.14	16.12
N	–	2.72	5.29	9.09
O	55.87	52.32	50.20	49.99

Photocatalytic activity was measured by acetone oxidation reaction in the homemade setup [4]. The N 1s core level shows complex bicomponent structure that confirms the presence of two different chemical states of nitrogen in TiO_xN_y films. The sharp component at binding energy ~ 396.6 eV was attributed to formation of Ti–N chemical bonds. As high extinction ratio as k = 0.02–0.04 over the spectral range 350–800 nm has been measured with SE for the films fabricated at N_2/O_2 = 97/3 and 100/0. The test for complete acetone oxidation by nitrogen-doped films shows the photocatalytic reactivity ~ 0.25 nmol/c.

References

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