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Characterization of TiO_2 Thin Films Prepared by Vacuum Evaporation

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Abstract. The TiO_2 thin films were prepared by vacuum evaporation on glass using TiO_2 powder 99.99% as coating material and with varying deposition speed. The TiO_2 thin films were characterized by a-step device, X-ray diffraction (XRD), atomic force microscope (AFM). The influence of deposition rate were discussed. The results indicated that thickness of the TiO_2 thin film was prepared under the deposition rate of 4Å/sec was 200 nm at room temperature, with amorphous structure. The film changed to anatase crystal structure when was annealed at 450 ℃ for one hour and the TiO_2 thin film was uniform and well combined with the glass substrate.

1. Introduction

TiO_2 has high chemical activity, good dispersion, high visible light transmittance and ultraviolet absorption properties such as excellent property. TiO_2 can be used as an important functional thin film materials. It is widely used in the field of solar cell, a photoelectric converter, sewage treatment, air purification, cleaning and sterilization etc.. There are three kinds of crystal types of typical TiO_2: rutile, anatase and brookite. At present, there are a variety of methods for the preparation of TiO_2 films, such as sol-gel method[1-2],chemical vapor deposition[3], chemical spray pyrolysis [4] sputtering [5], pulsed laser deposition [6]. The structure, appearance and performance of different preparation techniques of thin films, such as the film thickness uniformity, and the glass substrate binding firmness, surface topography, has a different effect of crystal structure.

In this paper, TiO_2 thin film was prepared by using vacuum evaporation method. The TiO_2 thin films were characterization by a-step device, X-ray diffraction (XRD), atomic force microscope (AFM) and UV-VIS spectrophotometer.

2. Experimental

A schematic of vacuum evaporation system is shown in Fig.1. TiO_2 thin films were prepared by electron beam evaporation, ion assisted reaction, TiO_2 powder 99.99% as coating material. The glass plate after cleaning fixed on the aluminum plate, the workpiece holder suspending hanging in the coating machine. Before coating, high vacuum pumping to 5×10^{-3}Pa, coating operation can be carried out. The deposition rate were 2 Å /sec, 4 /sec, 5 Å /sec Å respectively. In the process of coating, ion beam ion sources continue to substrate bombardment, the surface of the glass sheet increases, the generated TiO_2 can be combined closely with the glass sheet. In order to make the evaporation of TiO_2 thin film form a stable crystal , coating after the end of the sample, the sample, using different temperature annealing heat treatment 1h from 300-500 ℃ and measured the crystal structure of TiO_2 thin film by X-ray diffraction(XRD D/MAX-2200PC ,Japan). Thickness of TiO_2 thin films measured by a-step device (DektakXT German Brook). The surface structure of TiO_2 thin film were measured by atomic force microscopy (AFM CSPM5500 Benyuan).

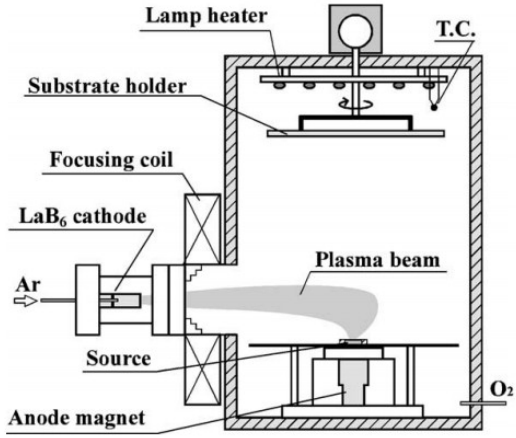

Fig.1. Schematic of vacuum evaporation system

3. Results

Table 1 shows the different thicknesses of TiO_2 thin films measured by a-step device at different deposition rate. It is showed from table 1,the thickness of TiO_2 thin films are increased with the increase of the deposition rate.

Table 1 The thicknesses of TiO_2 thin films under different deposition rate

No.	Thickness of TiO_2 [nm]	Deposition rate [Å/sec]
sample1	100	2
sample2	200	4
sample3	400	5

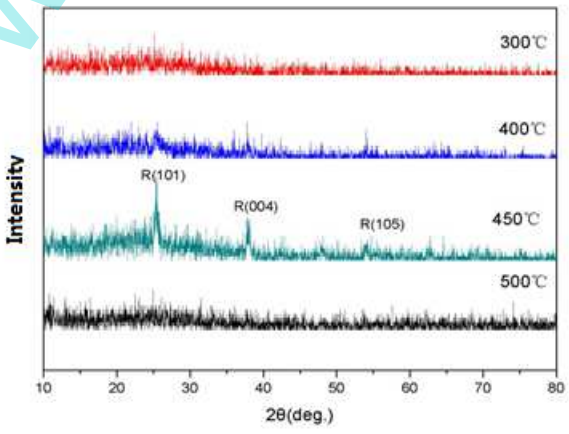

Fig.2. XRD image of TiO_2 thin films annealed 1h at different temperatures

The TiO_2 film on the above three kinds of thickness were annealed at a temperature of 300 ℃, 400 ℃, 450 ℃, 500 ℃ for one hour, and measured by XRD. The results show that the thickness 200 nm of TiO_2 film is anatase phase in the annealing temperature of 450 ℃ (Fig. 1). There is strongly

diffraction peak at 25.3 ° , corresponding to the anatase R (101) . There are two weak diffraction peak, at weak 37.8 °and 54.1 ° , corresponding to the anatase R (004) and R (105) peak respectively.

Fig.3. AFM image of TiO_2 thin film without annealing

Fig.3 shows the AFM image of TiO_2 thin film without annealing, It can been seen that TiO_2 thin film surface are amorphous and uniform.

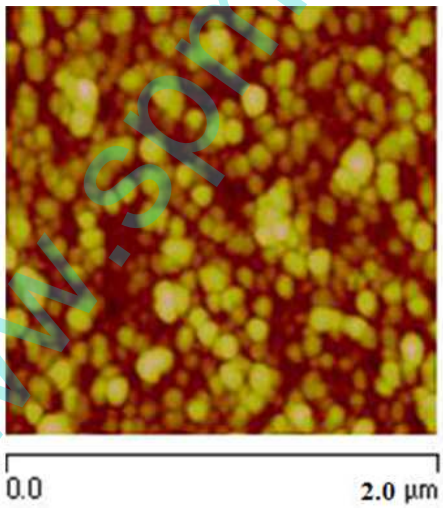

Fig.4. AFM image of TiO_2 thin film annealed at 450℃

Fig.4 shows the AFM image of TiO_2 thin film annealed at 450℃, It can been seen that the particle size of TiO_2 thin film is increased And high purity.

4 Summary

The amorphous TiO_2 thin film is obtained by ion beam assisted electron beam evaporation method. The thickness of TiO_2 thin films is changed with deposition rate. The results show that TiO_2 films is anatase in deposition rate of 4 Å /sec and annealing at 450 ℃ for one hour. TiO2 thin films were prepared by vacuum evaporation method is unform compared with other prepared method.The TiO2 thin films closed because the surface activity and atomic energy increased.

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