The Effect of Substrate on TiO_2 Thin Films Deposited by Atomic Layer Deposition (ALD)

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Abstract

ALD is a precision growth technique that can deposit either amorphous or polycrystalline thin films on a variety of substrates. The difference in substrate can cause a variation in the ALD process, even it is carried out using the same reactants and deposition conditions [1]. TiO_2 thin films were grown using TTIP (Titanium isopropoxide) ALD on silicon wafers, glass slides, and stainless steel plates in order to study the effect of substrates on the growth of TiO_2. The thin films were analyzed using Xray Diffraction (XRD), Raman Spectroscopy and Atomic Force Microscope (AFM). From XRD analysis were indicates the main peak for anatase (101) (2θ= 25.3) was observed from the XRD patterns for TiO_2 on all substrates. The results show that crystalline TiO_2 thin films can easily grow on a crystal substrate rather than on an amorphous substrate.

Keywords: Atomic Layer Deposition (ALD), Thin films, Titanium oxide (TiO_2) X-Ray Diffraction. Substrate

Introduction

Titanium dioxide (TiO_2) is a ceramic material with versatile applications for self-cleaning, biocompatible, sensor and corrosion resistance. TiO_2 thin films can be deposited from the reaction of Titanium isopropoxide [Ti $(OCH(CH_3)_2]_4$ (TTIP), and water (H_2O) using Atomic layer deposition (ALD). In principle, ALD is an ideal technique for the deposition of nanostructured scale thin films. ALD is a chemical gas phase thin film deposition method based on alternating and saturating surface reactions.

This feature gives ALD a supreme capability to apply precise and conformal coatings of different types of materials. However, there is a lack of work reporting the growth mechanism of TiO_2 films using TTIP and water as precursors by ALD. It is necessary to gain a better understanding on the underlaying of ALD for deposited TiO_2 using TTIP and water.

Experimental Method

The single layer TiO_2 thin films were deposited using TTIP and H_2O. The deposition was started by heating the chamber and placing the sample into the ALD chamber. The pressure of the ALD chamber was maintained at 50 kPa, and the N_2 carrier gas was set at 20 sscm. The TTIP was heated to 75°C and the water was kept at room temperature in order to provide sufficient vapour for the TiO_2 ALD process. The precursors pulse rates for TTIP and H_2O were set at 0.20 s and 0.15 s, respectively. It was important to maintain the deposition temperature below the thermal decomposition temperature of TTIP, which was reported to be above 300°C [2]. The deposition temperatures used in this study is 300°C with 3000 cycles. TiO_2 were deposited on silicon wafers, glass slides and stainless steel plate.

Results and Discussion

Figure 1 indicates the main peak for anatase (101) ($2\theta = 25.3$) was observed from the XRD patterns for TiO_2 on all substrates. As for stainless steel, besides the (101) orientation, it still has two others, namely the (200) and (211) orientation. With stainless steel the intensity of the (211) orientation increased. TiO_2 thin films deposited onto stainless steel were more crystalline than those on either silicon wafer or glass. The results show that crystalline TiO_2 thin films can easily grow on a crystal substrate rather than on an amorphous substrate (i.e. glass).

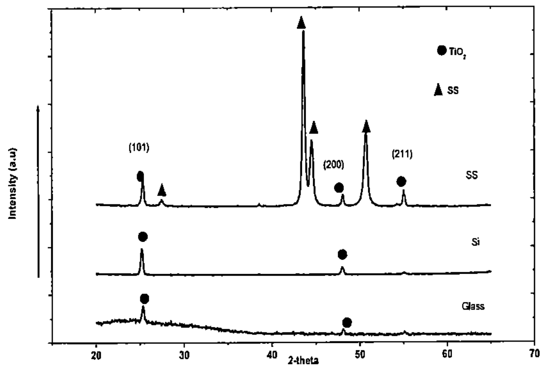

Fig. 1: XRD patterns of TiO_2 on stainless steel, silicon wafer and glass

Fig. 2 shows the AFM images indicate that the substrates affect the microstructure of the TiO_2 thin films. The TiO_2 thin films on Si wafer consist of the biggest particles than those on stainless steel and glass, which consist of fine particles. The evolution of the thin films was influenced by the surface microstructure, which was affected by the substrate type [4]. The substrates would influence the deposition rate, due to the sticking probabilities and nucleation rates, which are highly dependent on the nature of the substrate surfaces [3].

Conclusion

The combined results of XRD and AFM show that the substrate played an important role in the growth of TiO_2 thin films. The crystalline TiO_2 thin films can easily grow on a crystal substrate rather than on an amorphous substrate.

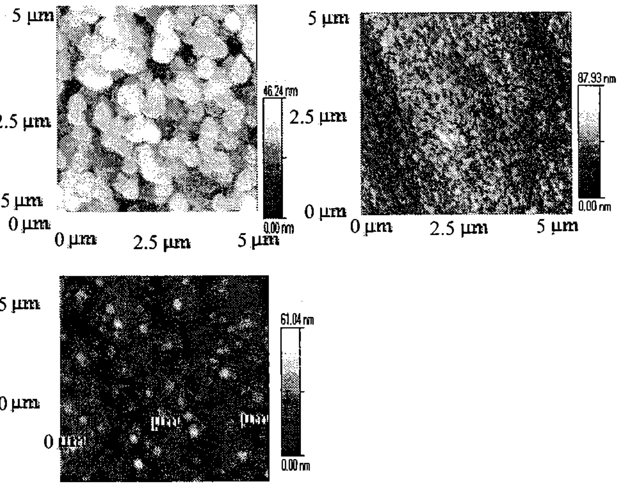

Fig. 2: AFM morphology of TiO_2 on stainless steel, silicon wafer and glass

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