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Research Article

Comparison of Surface Properties of B_2O_3-Doped TiO_2 and Non-Doped Thin Films with Sol-Gel Method

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Abstract

Titanium dioxide (TiO_2) is a widely used material in nanotechnological applications. Especially in photocatalytic and optical applications, TiO_2 thin films are an indispensable material. Metal-doped thin films are of interest to researchers for the development of these properties.

In this study, the effect of boron oxide (B_2O_3) additive on surface properties in coating TiO_2 thin films on soda-lime glasses was investigated. In the experimental study, alkoxide solutions with a source of boron and titanium were used. TiO_2 sol was prepared with Sol-Gel method. In addition, the sol was prepared by adding Triisopropyl borate. Condensation and polymerization steps were completed in acid catalysis and the solution was obtained. In the home-made dip coater device, the solution is coated on the surface.
The substrate was immersed in solution at constant speed for a specified time (approximately 30 seconds). It was then withdrawn at the same speed. The surface properties of dried thin films have been characterized by applying morphological analysis (Scanning Electron Microscope) and contact angle measurement tests. The surface shows hydrophilic properties, as an angle of less than 90 degrees occurs on the uncoated glass surface. As is seen contact angle image of TiO_2, an angle of 11.83 degrees has occurred on the surface of TiO_2 coated glass. As is seen contact angle image of boron oxide coated glass, an angle of 24.12 degrees has occurred on the surface of B_2O_3 coated glass. As is seen contact angle image of TiO_2 and boron oxide coated glass, an angle of 6.12 degrees has occurred on the surface of TiO_2 and B_20_3 coated glass. So, although the surface is very close to the superhydrophilic degree, it is hydrophilic as the contact angle of the surface is greater than 5 degrees.
As a result, the B_2O_3-doped TiO_2 coated surface was found to have better hydrophilic properties than the non-doped TiO_2 surface. It has been observed that the boron oxide-doped TiO_2 coated glass material has a superhydrophilic value.

Keywords: B_2O_3-Doped TiO_2, Sol-Gel, Superhydrophilic.

B_2O_3-Katkılı TiO_2 ve Katkısız İnce Filmlerin Yüzey Özelliklerinin Sol-jel Yöntemi ile Karşılaştırılması

Öz

Titanyum dioksit (TiO_2) nanoteknolojik uygulamalarda yaygın olarak kullanılan bir malzemedir. Özellikle fotokatalitik ve optik uygulamalarda, TiO_2 ince filmler vazgeçilmez bir malzemedir. Metal katkılı ince filmler, bu özelliklerin geliştirilmesi için araştırmacıların ilgisini çekmektedir.

Bu çalışmada, bor oksit (B_2O_3) katkısının, TiO_2 ince filmlerinin soda-kireç camları üzerine kaplanmasında yüzey özellikleri üzerindeki etkisi araştırılmıştır. Deneysel çalışmada, bor ve titanyum kaynağı olan alkoksit çözeltileri kullanılmıştır. TiO_2 sol, Sol-jel

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yöntemi ile hazırlandı. Ek olarak, Sol, Triizopropil Borat eklenerek hazırlanmıştır. Asit katalizinde yoğuşma ve polimerizasyon aşamaları tamamlanmış olup çözelti elde edilmiştir. Ev yapımı sol-jel daldırma kaplama cihazında, çözelti yüzeye kaplanmıştır. Kullandığımız mekanik düzenek, taşıyıcıyı belli bir düşey hızla çözeltiye daldırıp aynı hızla (yaklaşık 30 saniye) çıkarma işlevi görmektedir.

Kurutulmuş ince filmlerin yüzey özellikleri, morfolojik analiz (taramalı elektron mikroskobu) ve temas açısı ölçüm testlerinin uygulanmasıyla karakterize edilmiştir. Cam kaplanmamış durumdayken 90 dereceden küçük olduğu için hidrofilik bir özellik göstermektedir. TiO_2 kaplanmış cam örneğinde ise 11.83 derecelik bir açı yaparak 0 dereceye yakın olduğundan bu hidrofilik bir özellik göstermektedir. B_2O_3 kaplı camın yüzeyinde 24.12 derecelik bir açı meydana geldiği için yüzey hidrofilik özellikler göstermiştir. TiO_2-Boroksit kaplı cam örneğimiz ise 0 dereceye yakın bir özellik göstererek süperhidrofiliktir. TiO_2 ve B_20_3 kaplı camın yüzeyinde 6.12 derecelik bir açı meydana gelmiştir. Bu nedenle, yüzey süperhidrofilik dereceye çok yakın olmasına rağmen, yüzeyin temas açısı 5 dereceden büyük olduğu için yüzey hidrofiliktir.
Sonuç olarak, B_2O_3 katkılı TiO_2 kaplı yüzeyin, katkısız TiO_2 yüzeyinden daha iyi hidrofilik özelliklere sahip olduğu bulunmuştur. Bor oksit katkılı TiO_2 kaplamalı cam malzemenin süperhidrofilik bir değere sahip olduğu gözlenmiştir.
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Anahtar Kelimeler: B_2O_3-Katkılı TiO_2, Sol-Jel, Süperhidrofilik.

1. Introduction

Nowadays, research and development work in the field of nanotechnology is growing rapidly, focusing on nanomaterials that include high performance and new functions [1]. Recently, TiO_2 thin films with hydrophilic properties have been attracting intense attention. TiO_2 thin films have many advanced functions and features, such as anti-decay, deodorization, sterilization and anti-fogging. Therefore, in order to increase the surface area of TiO_2 and the hydrophilicity of the surface, metals, rare elements, nitrogen or iron are doped to TiO_2 films [2-5]. In order to compare the morphology and microstructure of different films by coating, the sol-gel dip-coating method may be preferred [6-7].

Sol-gel method is one of the most widely used techniques in which glass, glass-ceramic or composite materials can be produced by preparing the solution, gelling and removing the solvent from the system [8-9]. Sol-gel dip coating method is simple, economical and functional. Furthermore, dip-coating method, the substrate to be coated is prepared it is based on the fact that it is dipped in the solution at a certain speed and withdrawn from the solution again at the same speed. This method is one of the most preferred methods among sol-gel coating methods [10].

In this study, different solutions for TiO_2 and B_2O_3 were prepared by sol-gel method. On the other hand, the prepared solutions were coated to the surface with a homemade dip-coater devices. The microstructure of the prepared surfaces was examined with scanning electron microscopy (SEM). The contact angles of the surfaces were also examined with the contact angle measurement device. As a result of the investigations, it was observed that the glass material coated with TiO_2 has a better hydrophilic property than the glass material coated with B_2O_3. In addition, it has been observed that the TiO_2 coated glass material doped with B_2O_3 has a superhydrophilic property.

2. Material and Method

2.1. Preparation of TiO_2 solution

In this study, 1,854 ml of titanium (IV) Isopropoxide and 10 ml propanol was added to the glass beaker after cleaning the material to be used. Then, the mixture was placed in the magnetic stirring apparatus and stirred for 30 minutes. 2 ml of nitric acid and pure water were added to the mixture of titanium (IV) isopropoxide-propanol. In order not to evaporate the solution, the lid of the solution was kept closed at each stage.

2.2. Preparation of B_2O_3 solution

2,298 ml of Triisopropyl borate and 10 ml propanol was added to the glass beaker after cleaning the material to be used. Then, the mixture was placed in the magnetic stirring apparatus and stirred for 30 minutes. 2 ml of nitric acid and pure water were added to the mixture of B_20_3-propanol. In order not to evaporate the solution, the lid of the solution was kept closed at each stage.

2.3. Coating of Thin Films

In our study, dip coating method was used to cover films. The thin films are carefully placed in the dip-coater devices. The substrate was immersed in solution at constant speed for a specified time (approximately 30 seconds). It was then withdrawn at the same speed. In addition, the surface plane of the solution with the carrier surface was kept perpendicular. The carrier was given an angle of 5-7 degrees without disturbing the steepness of the plane. If this slope is not given, completely drainage cannot be achieved when the lower limit of the carrier is withdrew of the solution at the same time. Therefore, in intermediate heat treatments, the solution can't be dried completely.

3. Results and Discussion

3.1. Contact Angle Measurements

The magnitude of the contact angle depends on the relative magnitude of the gravitational forces (cohesion forces) between the liquid's own molecules and the gravitational forces (adhesion forces) between the liquid and solid [11]. The greater the size of the cohesion forces than the size of the adhesion forces, the greater the contact angle between the liquid and solid.

As shown in Figure 2.1., the surface shows hydrophilic properties, as an angle of less than 90 degrees occurs on the uncoated glass surface.

Figure 3.1. Contact Angle İmage of Uncoated Glass

As shown in Figure 2.2., an angle of 11.83 degrees has occurred on the surface of TiO_2 coated glass. Therefore, since the contact angle is close to 0 degrees, the surface shows a hydrophilic property.

Figure 3.2. Contact Angle İmage of TiO_2 Coated Glass

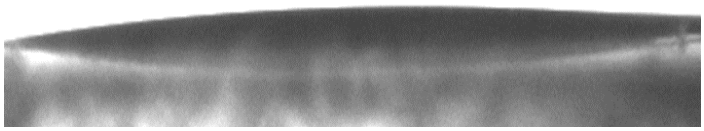
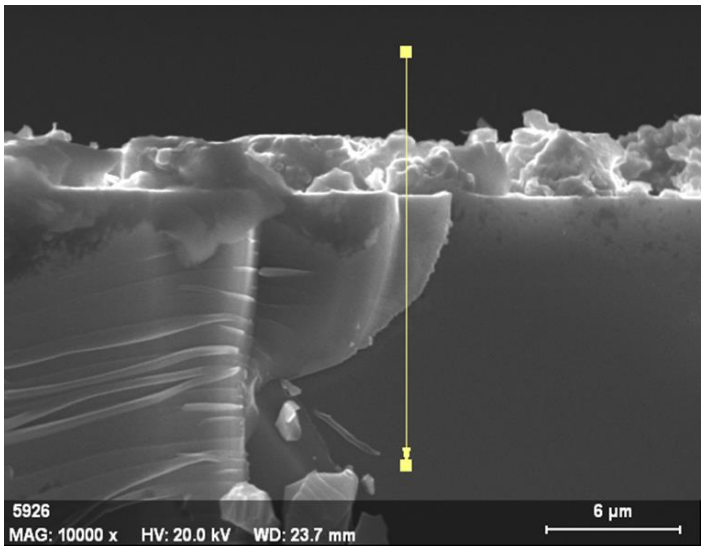


Figure 3.4. Contact Angle İmage of TiO_2 and Boron Oxide Coated Glass

3.2. SEM Analysis

Scanning electron microscope images of prepared surfaces are as follows;

As shown in Figure 3.5., the SEM image taken from the surface of the TiO_2 coated glass shows that the surface has a homogeneous structure.



As shown in Figure 2.3., an angle of 24.12 degrees has occurred on the surface of B_2O_3 coated glass. Therefore, the surface showed hydrophilic properties.

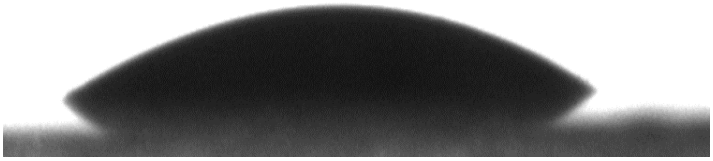


Figure 3.3. Contact Angle İmage of Boron Oxide Coated Glass

Figure 3.5. SEM İmage of TiO_2 Coated Surface on Glass

As shown in Figure 3.6., the SEM image taken from the surface of the TiO_2 coated glass doped with B_2O_3 shows that the surface has a heterogeneous structure.

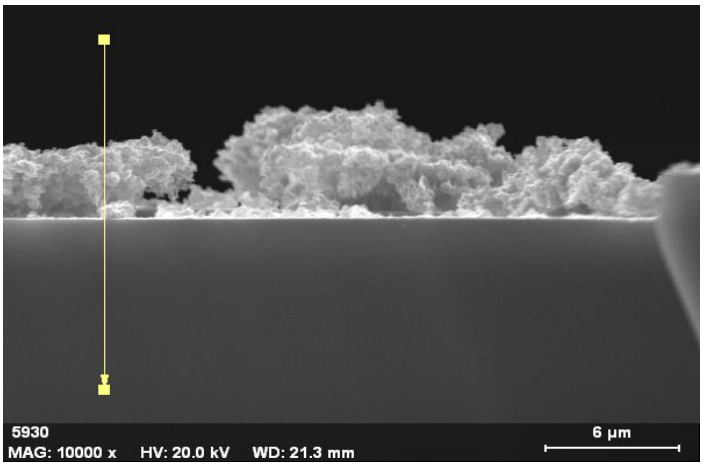


Figure 3.6. SEM İmage of TiO_2 and Boron oxide Coated Surface on Glass

4. Conclusions and Recommendations

In this study, it was observed that the glass material coated with TiO_2 has better hydrophilic properties than the glass material coated with B_2O_3. It has been observed that the surface of boron oxide and TiO_2 coated glass to the fact that material is superhydrophilic. However, differences in surface thickness were observed due the TiO_2 coated glass surface doped with B_2O_3 was not homogeneous. So, it has been a heterogeneous coating.

In future studies, the characteristics of surfaces can be studied by adding different materials to TiO_2-coated surfaces.

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