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Investigating the synthesis and growth of titanium dioxide nanoparticles on a cobalt catalyst

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ABSTRACT

A new deposition process working inthe pressure of 1torr has been created for the growth of titanium dioxide layers composed of nanoparticles. The Growth of TiO_2 nanoparticles has been investigated by scanning electron microscopy (SEM), EDX, and Raman scattering.Respectively, the particles sizes are about D_1=124nm,D_2=108.85nm,andD_3=97.94nm.And Raman peaks are in 132.36, 182.85, 27.82, 392.59, 458.41, 503.74, 512.45, 600.92, 623.24, 631.28, and 809.08.cm^{-1}

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1.Introduction

It is increasingly interested in Nano-sizedmaterialsduetotheirunique structure and properties. Recently, the focus of most works conducted in thisfieldis on important metal oxides such asZno , Al_2O_3, V_2O_5, TIO_2, WO_3, and SIO_2,, which are known for their catalytic behaviors, sizeeffects,non-linear optical properties, unusual luminance, and so forth [1-5].

In the last 20 years, the production of titanium dioxide coatingshas attracted a lot of attention due to the high advantages and chemical-physical characteristics [6].Nano Titanium Dioxide (TiO_2) has been widely studied in recent years due to its high applications such as photovoltaic batteries[7],semiconductor photocatalysts[8],and gas and humiditysensors[9].There are several methods for the synthesis of one-dimensional nanostructures such as chemical vapor deposition (CVD), plasma-enhanced chemicalvapor deposition (PECVD), and sol-gel [10-17]. The main drawback of this method is that the process almost takes a long time to be performed (for example, several hours) and often done under very low pressure. Such problems cause the method to be expensive [6].

Over the past few years, many approaches have successfully produced Nano titanium dioxide from nanoparticles [18], thin films [19], nanotubes [20-21], and nanowires [22]. In this study, it is attempted to provide an efficient method for shaping on the scale of one-dimensional nanoparticles using hot filament chemical vapor deposition (HFCVD). Actually, the idea of growing TiO_2 nanoparticles using HFCVD apparatus has been never done so far.

2. The experiment

In this process, the experiment is performed on a silicon substrate whose contaminants has been removed using ultrasonic treatment and then the cobalt catalyst has been overlaid on the substrate using PECVD device. It should be noted that before growth stage, the operations of preparing the substrate are conducted using HFCVD apparatus under an atmosphere of hydrogen and ammonia at a pressure of 5torr and the temperature of 550^0C. Then, using the precursor of titanium tetra iso-propoxide (TTIP), and Argon and ammonia gas, under a hot filament at the pressure of 1torr and the temperature of 550^0C , it is transferred into the chamber and stays there (15min) for the growth of nanoparticles. After the growth process, the samples are ejected from the chamber to be identified and analyzed by electron microscope, Raman spectroscopy, and EDX. Figure 1 shows an HFCVD apparatus.

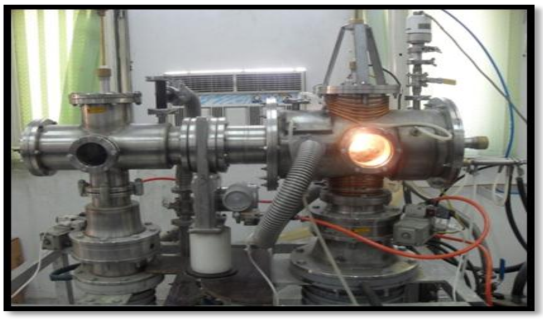

Figure 1: an HFCVD apparatus

3. Results

Figure 2 shows an SEM image of TiO_2 nanoparticles growth on a silicon substrate which has been overlaid with cobalt catalyst for 15 min at the temperature of 550^0C . The size varieties of nanoparticles are respectivelyas D_1=124nm,D_2=108.85nm,andD_3=97.94nm.

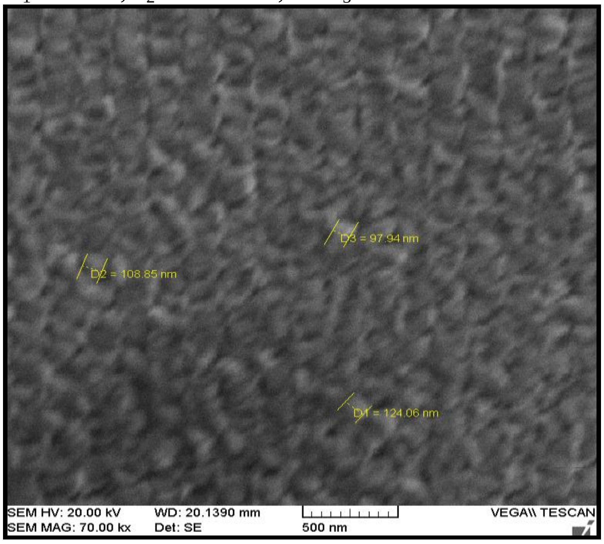

Figure 2: the SEM image of TiO_2 nanoparticles for 15 min at the temperature of 550^0C

Figure 3 shows Raman spectroscopy of TiO_2 nanoparticles for 15 min at the temperature of 550^0C , which it has determined 11 Raman peaks in132.36,182.85,27.82,392.59, 458.41,503.74,512.45,600.92, 623.24, 631.28, and 809.08 cm^{-1}. The peaks respectively in 132.36, 182.85, 392.59,503.74,512.45,623.24, 631.28, and809.08cm^{-1}. show the anatase peaks and the peaks in 600.92 and 458.41 cm^{-1}. show the rutile peaks.

The chemical composition of resulted nanoparticles is analyzed using EDX. Here, two EDX profiles have been used: 1) the spot profile and 2) the linear profile. The direction of linear profiles is parallel and perpendicular to the axis of the nanoparticles.

Figure 4a and 4b respectively show the results obtained from EDX linear and spot profiles. Signals of cobalt, oxygen, titanium, and tungsten have been detected in the spot and linear profiles. Figure 4a shows the EDX diagram of TiO_2 nanoparticles for 15 min at the temperature of 550^0C , in which a signal of cobalt, oxygen, titanium, and tungsten has been observed. In figure 4a, the weight percent of titanium, oxygen, and cobalt are respectively 0.2%, 17.37%, and 0.5%. Figure 4b shows a signal of oxygen, cobalt, titanium, and tungsten, whose weight percent are respectively 17.11%, 0.47%, 0.05%, and 82.37%.

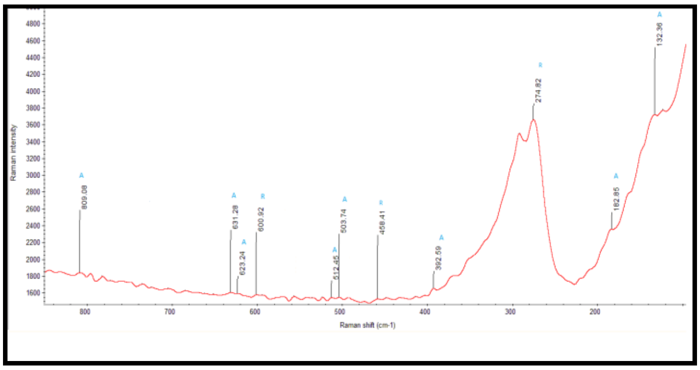

Figure 3: theRaman spectroscopydiagram of TiO_2 nanoparticles for 15 min at the temperature of 550^0C

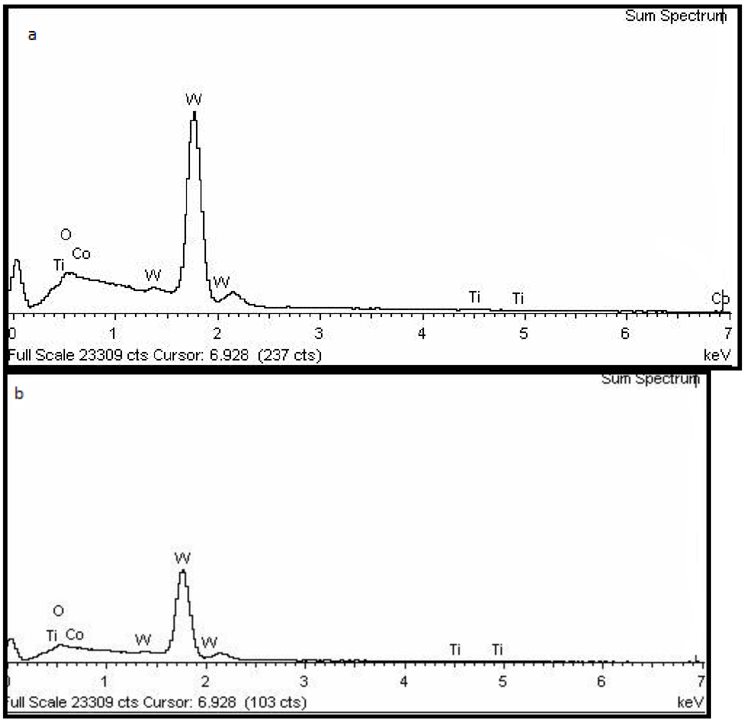

Figure 4: the EDX diagram of TiO_2 nanoparticles for 15 min at the temperature of 550^0C

4. Conclusions

The hot-filament deposition process was described in this article, which is a flexible method for combining titanium dioxide coatings with nanostructures. The growth of TiO_2 nanoparticles on the surface of Co at the temperature of 550^0C (for 15 min) was explained. The smallest and the largest particle size were respectively reported equal to 97.94 and 124nm. The results of Raman spectroscopy showed the peaks in132.36, 182.85, 27.82, 392.59, 458.41, 503.74, 512.45, 600.92, 623.24, 631.28, and 809.08 cm^{-1}.

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