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ELECTRICAL PROPERTIES OF MULTILAYER TiO_2 NANOCOATED GLASS WITH Au METAL CONTACT

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Abstract
This article reports on the electrical properties of TiO_2 nanocoated glass that was varied on the number of TiO_2 layer. In this studies, TiO_2 has been investigated its electrical properties and resistivity for multilayer TiO_2 nanocoated glass application via current-voltage (I-V) measurement system while it's physical structural properties of TiO_2 was investigated using atomic force microscopy (AFM-XE100). In support this results, Raman spectroscopy was used to examine the structural properties and phase structure of TiO_2.
Keywords: TiO_2 nanocoated; electrical properties;

I. INTRODUCTION

Titanium dioxide (TiO_2) has excellent optical properties [1] make it suitable for coated mirror application. However the suitability of coating especially when exposing in air moisture condition need suit to the electrical properties of materials. Coating is means of covering of the materials surface [2] to enhance lifetime, increase protection, and became as insulator. Multilayer TiO_2 nanocoating has been applied to achieve this purpose via repetition of sol-gel spin coating technique [3]. The electrical properties need to be fixed in order to study each of coating layer electrical behavior by using one type gold metal contact. Based on my reading knowledge, there are very few reports on electrical properties of multilayer TiO_2 up to eighteen layers. In this study, we have done on investigating the effect of TiO_2 coating layer on electrical properties.

II. EXPERIMENTAL WORKS

The starting material, titanium butoxide (TTiB Sigma Aldrich) was used to synthesize TiO_2 in sodium hydroxide (NaOH) as solvent with stabilizer triton-x. This chemical reaction was accelerated using glacial acetic acid (GAA) within distilled water. The mixture was stirred under continuously stirring for 24 hours. The deposition of the coating layer was done under condition in nitrogen gas (1 mbar) with 3000 rpm speed of spin coater. After that, the coated glass was dried for 10 minutes at 150^{o}C and was annealed at 450^oC for 2 hours. The method was repeated for next coating layer until eighteen layers. The metal contact was took place after those samples coated has gone thru spin-coating process using gold metal sputtering. Figure 1 shows the schematic diagram of the sample coated TiO_2 and sputtered with gold metal contact.

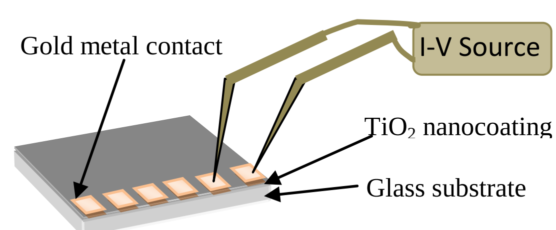
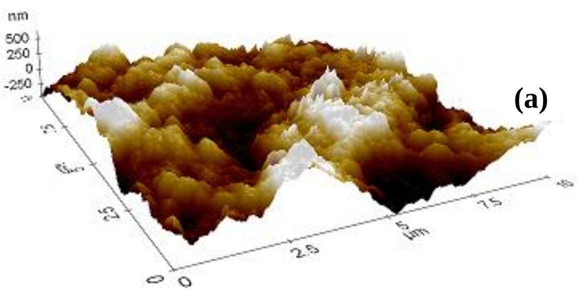


Figure 1: Schematic diagram of two probes I-V measurement with direct current.

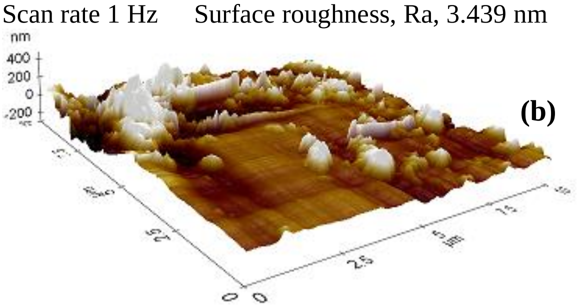
III. RESULT AND DISCUSSION

III.1 Surface topography 3-dimensional images

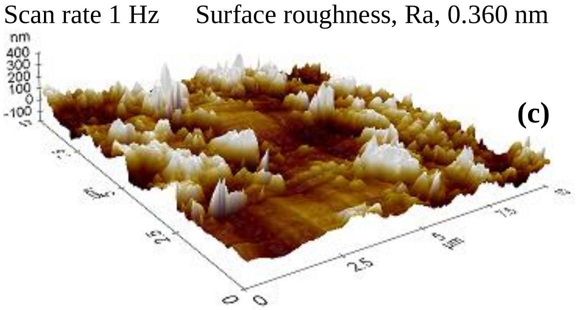
Atomic force microscopy (AFM XE-100 Park Systems) was used to investigate the physical structure of multilayer TiO_2 nanocoated glass. Figure 2 shows the physical structure AFM images in three-dimensional imaging.



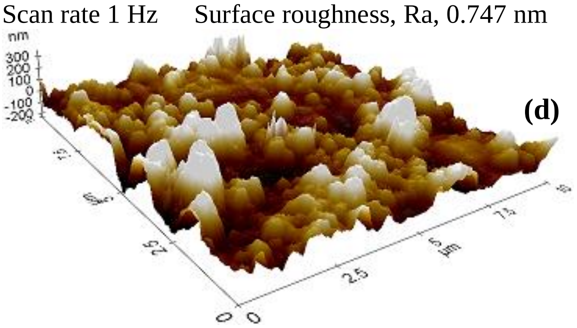
Scan rate 1 Hz Surface roughness, Ra, 3.439 nm



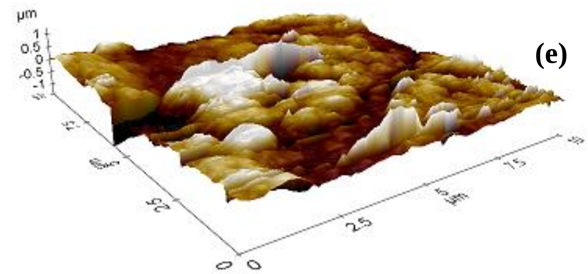
Scan rate 1 Hz Surface roughness, Ra, 0.360 nm



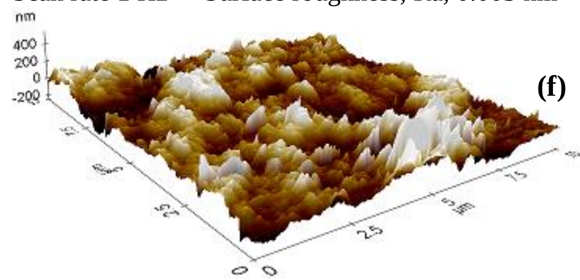
Scan rate 1 Hz Surface roughness, Ra, 0.747 nm



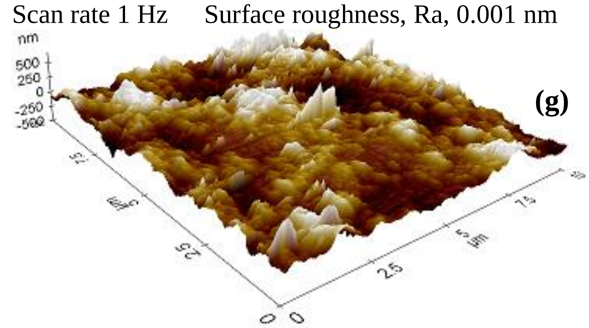
Scan rate 1 Hz Surface roughness, Ra, 0.002 nm



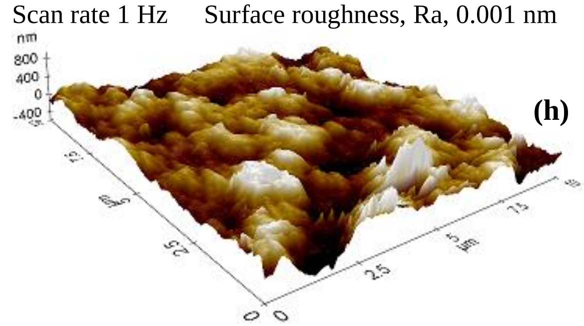
Scan rate 1 Hz Surface roughness, Ra, 0.003 nm



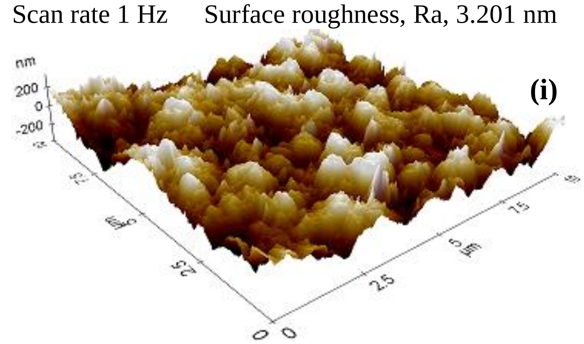
Scan rate 1 Hz Surface roughness, Ra, 0.001 nm



Scan rate 1 Hz Surface roughness, Ra, 0.001 nm



Scan rate 1 Hz Surface roughness, Ra, 3.201 nm



Scan rate 1 Hz Surface roughness, Ra, 2.206 nm

Figure 2: Three-dimensional imaging of multilayer TiO_2 nanocoated glass: (a) 2 layers, (b) 4 layers, (c) 6 layers, (d) 8 layers, (e) 10 layers, (f) 12 layers, (g) 14 layers, (h) 16 layers and (i) 18 layers.

Figures (2b) and (2c) show that flatten surface with surface roughness. It might due to heat treatment was applied during annealing process cause distort growth of the TiO_2 nanostructures and further flattening of the structure [7] especially at lower number of layer. At eighteen layers coating as in figure (2i), the multilayer TiO_2 have good electrical properties in consistency with I-V result compared to others multilayer as in shown figure (2a) and figure (2e-h). The reason is from the ion of O – Ti – O in sol gel solution reacts to form atom. At atomic level, form particle without enough energy possess upon during heat treatment inner layer atoms cause the particle didn't well form nanostructure became either fine grain or coarse grain results accumulation in each other atomic then form precipitation, without further agitation or mechanical action cause agglomeration as the final product. Further reaction, this is what happens on TiO_2 particle [4] deposited onto glass surface influence the surface roughness and the nanostructures were formed. Surface in nature, generally affect the electron mobility as carrier, and flatten surface [5] may miss function the ability of electron migrate.

III.2 Electrical properties of multilayer TiO_2

Manual prober ST-103A I-V Measurement direct current was used to measure the current and voltage properties of TiO_2 nanocoated glass. Gold metal contact has been used with work function around 5.11 to 5.41 as shown in figure 1. The electrical properties of TiO_2 nanocoated at different layer are shown in Fig. 3. The figure showed that the current (I) value increased as the number of layer coating increase. As reported S.Y. Lee et. al., [5] TiO_2 has weak electrical properties. In this study by increasing the number of layer TiO_2 can shown clearly the increment pattern of current properties as voltage was applied. This due to increasing of grain size cause by accumulating of TiO_2 particle in 18 layers number of TiO_2 as discussed in AFM. The current starts increase in 4 layers coated glass with slowly the value voltage increase until 10 layers while drop instantly starts 12 layers till 18 layers, from 7.25 x 10^{-4} mV to 3.22 x 10^{-4} mV respectively. The electrical properties of TiO_2 associated with the electron transport and electron migration [5], means as the conductivity of the films improved, the resistivity decrease as shown in figure 4. This result consistency with Raman spectroscopy results on the structural and crystallinity properties multilayer TiO_2.

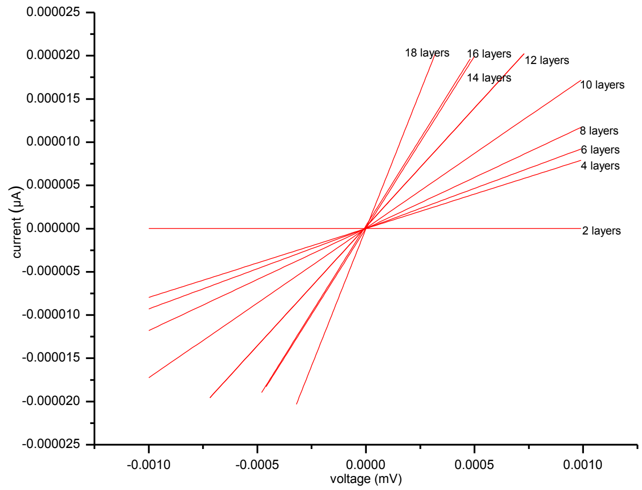


Figure 3: I-V characteristic for multilayer TiO_2 nanocoated glass substrate.

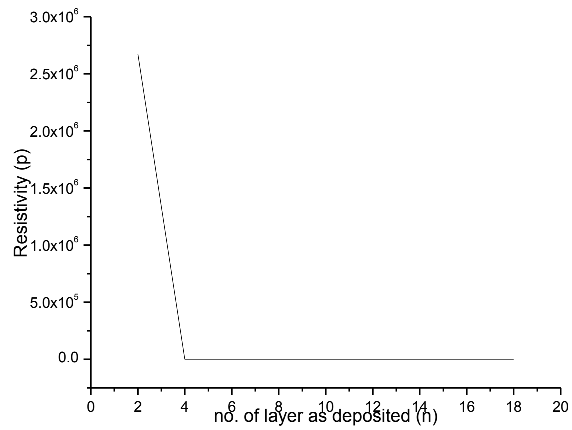


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Figure 4: Resistivity of TiO_2 nanocoated glass substrate at different number of layer.

As the number of layer increase, more TiO_2 particles were induced during deposition process increase the mobility of electron through TiO_2 coated surface via gold metal contact. Figure 4 shows that the studied of relationship between resistivity and conductivity with the electron mobility.

Multilayer TiO_2 with lower number of layer has highest value of resistivity, 2.68 x 10^6 Ω.m before became decline starts at 4 layers dropped drastically. This might due to lack of TiO_2 nanoparticles were induced. Moreover, based glass coated has been revealed the glass amorphous structure that non-conductive material. Short order of atomic arrangement in non-crystalline structure caused the electron mobility from TiO_2 particle to others particle became difficult and then lost their energy. These prove, the amorphous materials have poor electron mobility and, in this case of study the optimum number of layer have suitability coated on mirror application. This supported by Raman results shows the lower layer have revealed glass surface which is amorphous structure compared with maximum layer shows the peaks means have crystalline structure.

III.3 Structural Analysis via Raman Spectroscopy

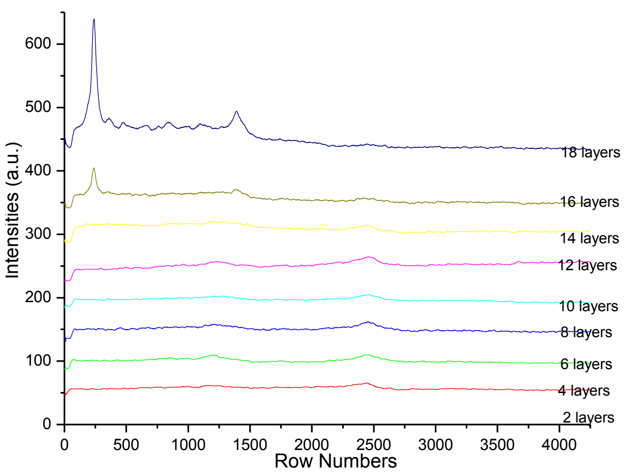

Figure 5: Structural properties of multilayer TiO_2 nanocoated glass via Raman spectroscopy.

Multilayer TiO_2 nanocoated glass was investigated its structural properties via micro-Raman spectrometer Cu-Raman, Horiba Jobin Yvon 79 DU420A-OE-325 using Ar+ ion laser at 514.32 nm wavelength sources and 20 mW powers at room temperature. The Raman spectra of the TiO_2 varied number of layer are presented in figure 5. More O – Ti – O were bonded each of TiO_2 particle as number of layer increase. The peaks at 20 layers and 18 layers were assigned to anatase phase [6] at raman band are 199.41 cm^{-1} and 694.20 cm^{-1}, respectively while Raman bands at 1150.79 cm^{-1} can be attributed to the rutile phase [8] structure. Related to I-V measurement, electron mobility associate with the crystal structure orientation which narrow raman band peaks indicate that a crystalline phase while broad peaks indicate amorphous structure. FWHM of intense peak for 18 layers and 16 layers is 12.7735 and 50.0296, respectively. As the number of layers increase, a peak appears and shifted from right to left.

IV. CONCLUSION

As the number of layer increases, more TiO_2 nanoparticles were induce boosting the capability of multilayer TiO_2 as electric device otherwise TiO_2 nanocoated glass based material with lower electrical properties of material suitable for glass coated, depend on the application. Upon subsequent of deposition of TiO_2 sol via repetition of sol-gel spin coating technique tend as electron mobility carrier clearly seen via trend of the results have anatase crystal structure phase with 3.22 x 10^4 mV in electrical properties.

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