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CONCLUSIONS

Using Atomic Force Microscopy device is useful method to study Characterization of SiO_2 nano Films .

The SiO_2 nano thickness increases with increasing applied potential .

Nanotopography of the SiO_2 nano film vary with the change SiO_2 nano thickness.

All of the following characteristics ,the nanotopography of the SiO_2 nano film , root mean square RMS surface roughness of the SiO_2 nano film , grain area , grain volume and grain length increases with the increases of SiO_2 nano thickness.

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The study of the relation between grain length and SiO_2 nano thickness shows in Fig. (16). From this figure grain length increases with the increases of SiO_2 nano thickness.

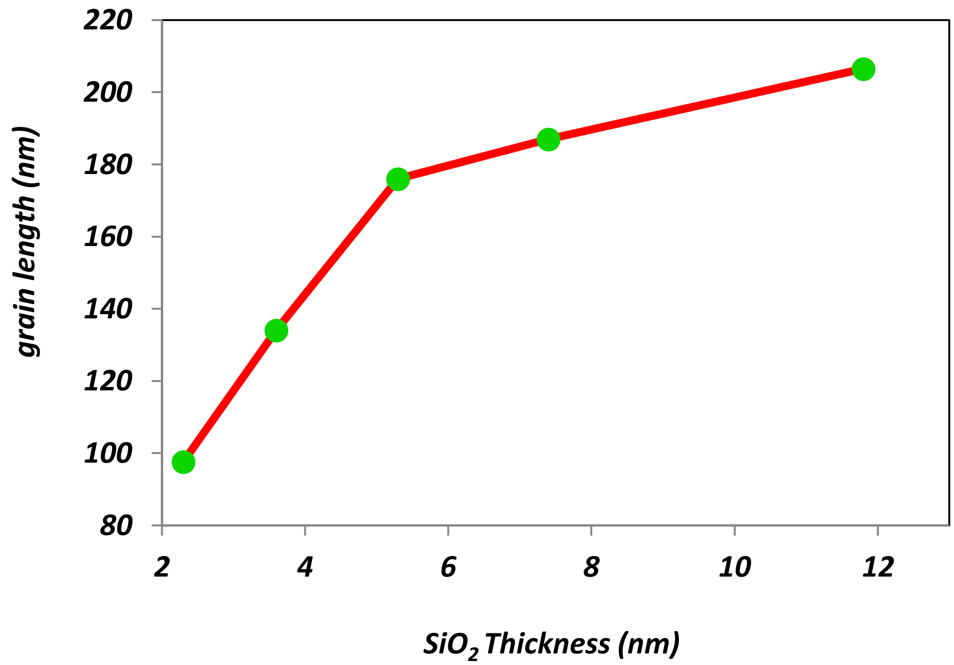

Fig. 16 : The relation between change grain length (measured by AFM) with change SiO_2 nano film thickness

The study of the relation between grain volume and SiO_2 nano thickness shows in Fig. (15). From this figure grain volume increases with the increases of SiO_2 nano thickness. Upon coalescence of the surface nuclei to form a continuous film, the nucleation process of film deposition is complete . (Kaiyong et al., 2005)

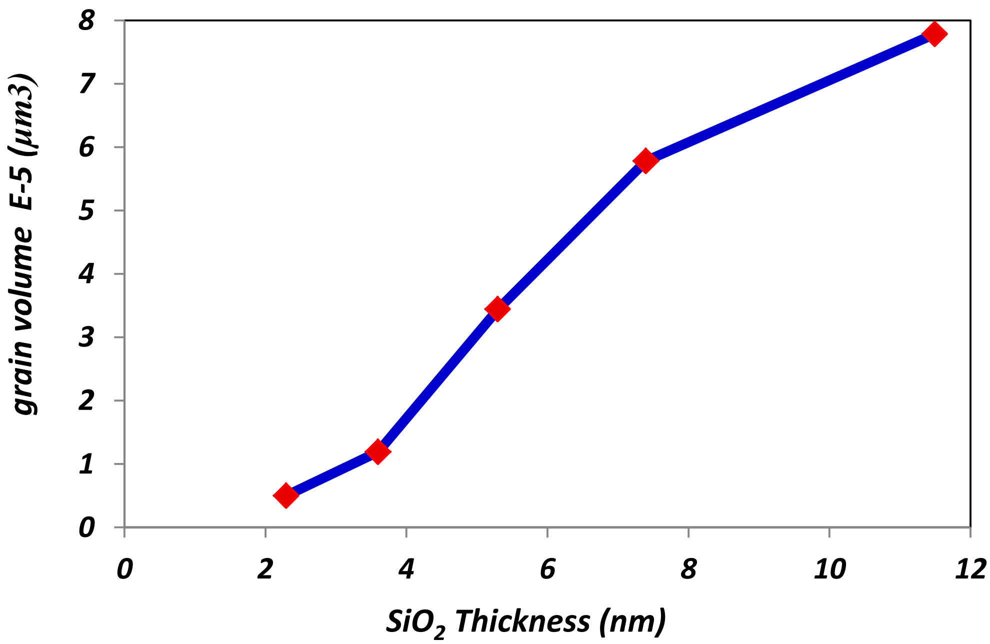

Fig. 15 : The relation between change grain volume (measured by AFM) with change SiO_2 nano film thickness

Study change grain volume , grain area and grain length with SiO_2 film thickness

AFM was used to count the number of grains and calculated the area , volume and length of each grain on the surface of the SiO_2 nano film .

The study of the relation between grain area and SiO_2 nano thickness shows in Fig. (14). From this figure grain area increases with the increases of SiO_2 nano thickness.

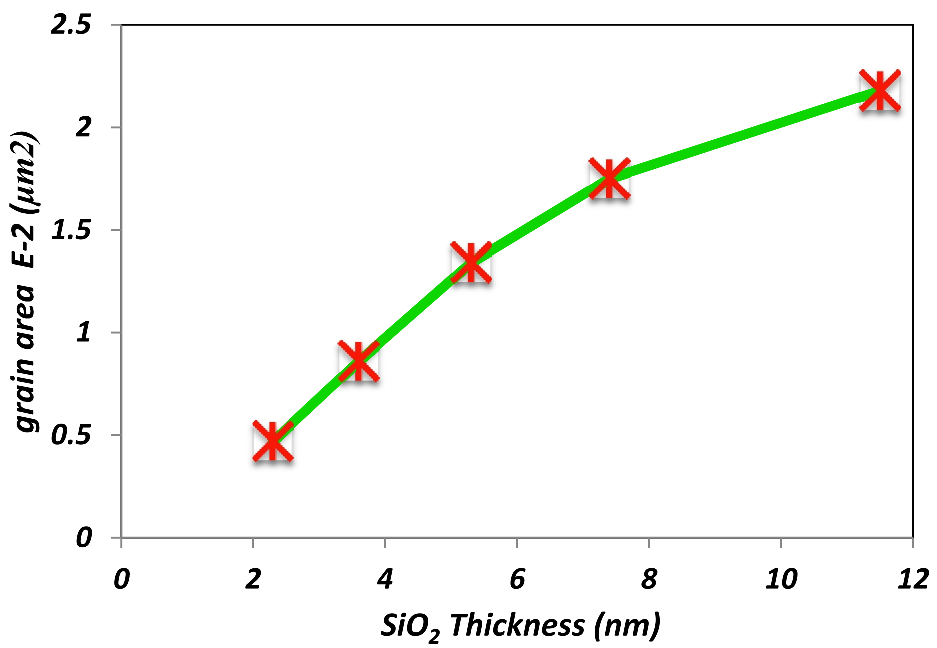

Fig.14: The relation between change grain area (measured by AFM) with change SiO_2 nano film thickness

Relation between (RMS) surface roughness and SiO_2 film thickness

From results AFM measurement Figurers (3,5,7,9,11) were Showed the relation between (RMS) surface roughness and SiO_2 nano film thickness as show in Fig (13). From this figure the RMS surface roughness of the SiO_2 nano film increases with the increases of SiO_2 thickness. the relation is liner up to 7.4 nm and break above thickness 7.4 nm . Upon coalescence of the surface nuclei to form a continuous film , the nucleation process of film deposition is complete . (Issa, 2010 ; Sulaiman et al., 2012; Kaiyong et al., 2005)

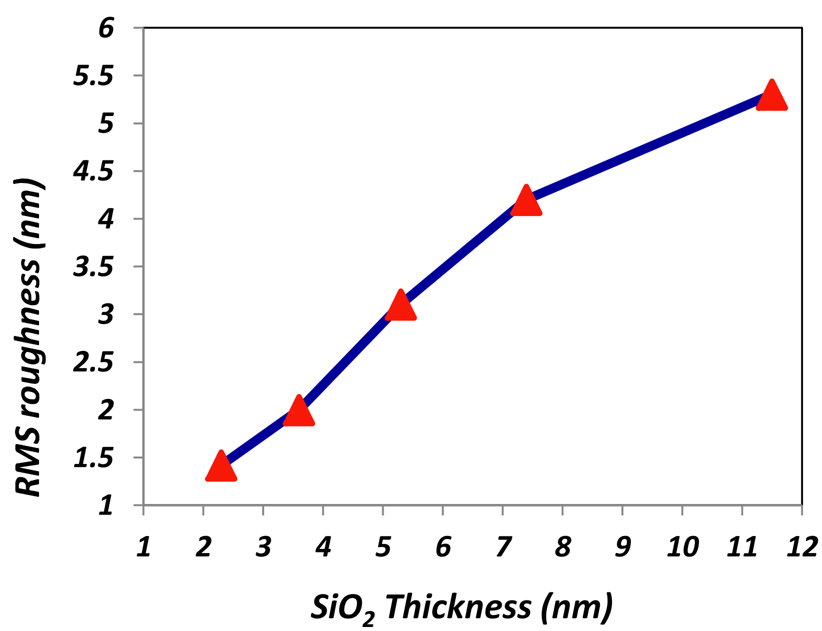

Fig.13: Relation between the RMS surface roughness of the SiO_2 nano film (measured by AFM) with thickness of the SiO_2.

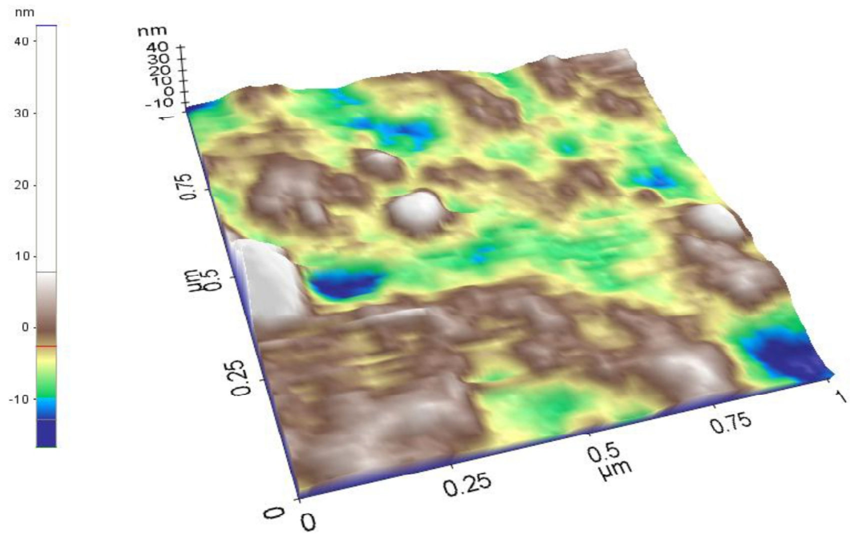

Fig.11 : The (3D) nanotopography AFM images of SiO_2 nano film surface , SiO_2 thickness 11.5 nm and RMS surface roughness equal 5.269 nm.

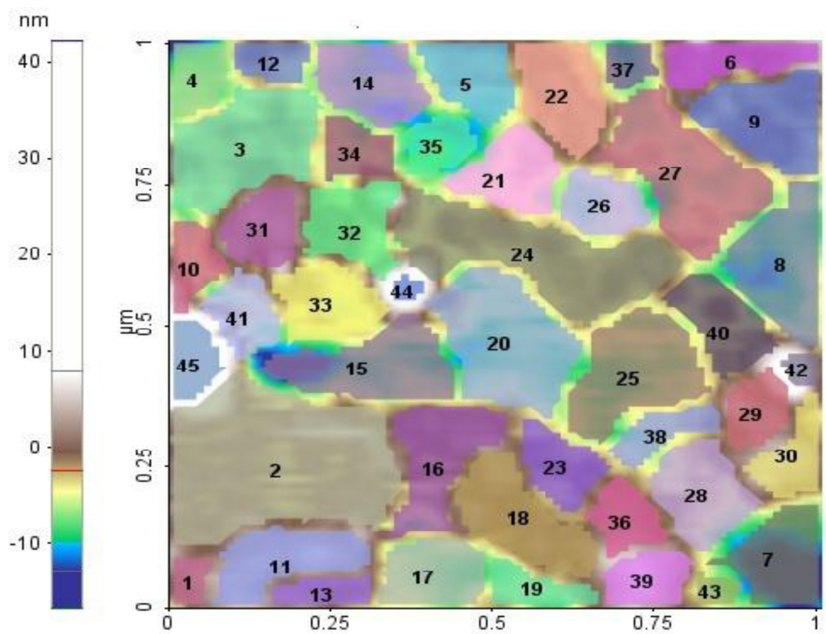

Fig.12 : number and distribution of grains on the surface of the SiO_2 measured by using AFM ,SiO_2 thickness 11.5 nm and RMS surface roughness equal 5.269 nm.

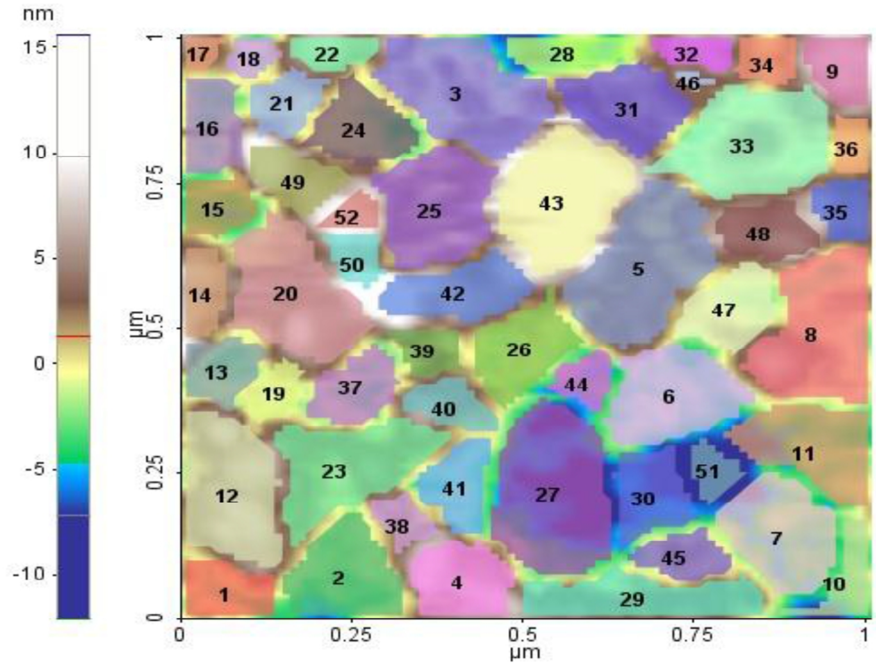

Fig. 10 : number and distribution of grains on the surface of the SiO_2 measured by using AFM , SiO_2 thickness 7.4 nm and RMS surface roughness equal 4.302 nm .

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SiO_2 film thickness 11.5 nm

A three-dimensional (3D) nanotopography image of the SiO2 nano film thickness 11.5 nm show in Fig. (11) and root mean square (RMS) surface roughness equal 5.269 nm . Fig .(12) shows number and distribution of grain on the surface of the SiO2 measured by using AFM .

SiO_2 film thickness 7.4 nm

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 7.4 nm show in Fig. (9) and root mean square (RMS) surface roughness equal 4.302 nm . Fig .(10) shows number and distribution of grain on the surface of the SiO2 measured by using AFM .

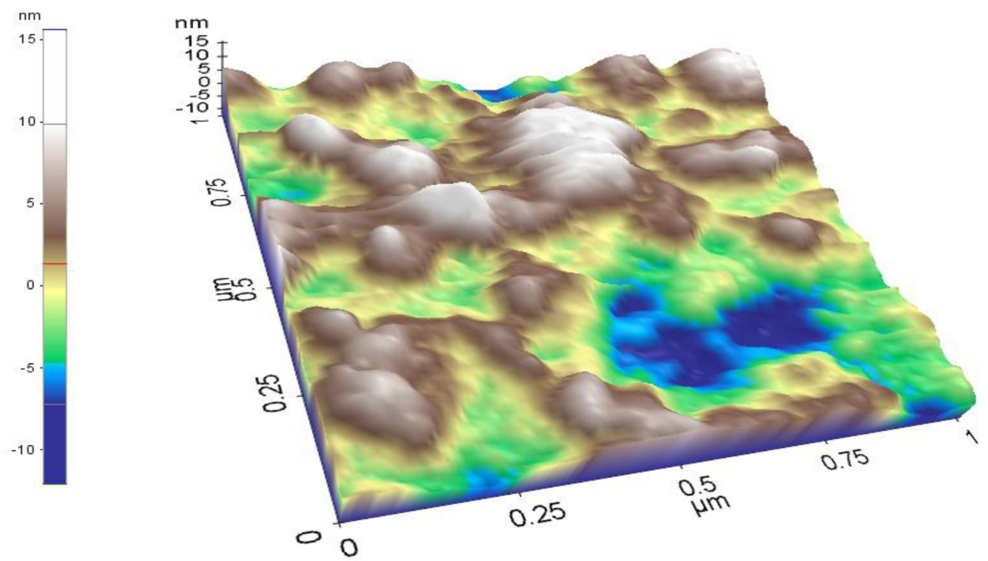

Fig 9 : The (3D) nanotopography AFM images of SiO_2 nano film surface , SiO_2 thickness 7.4 nm and RMS surface roughness equal 4.302 nm .

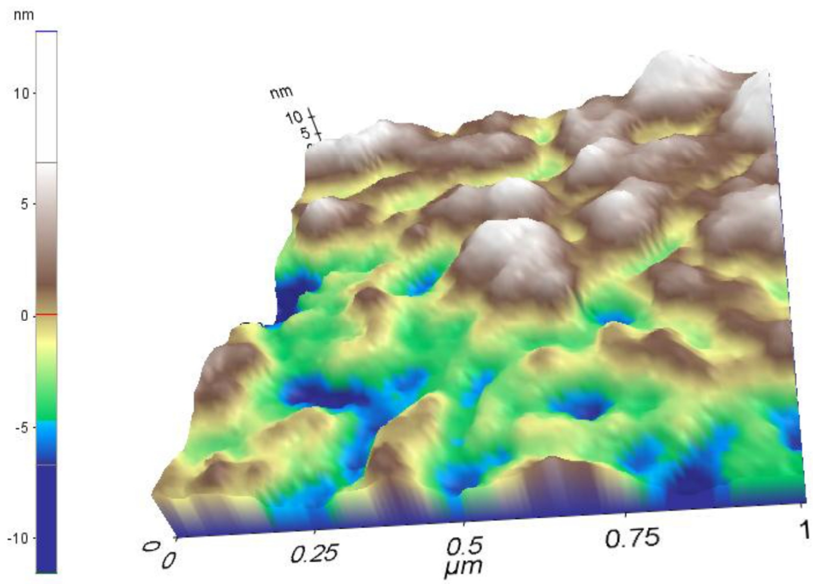

Fig.7: The (3D) nanotopography AFM images of SiO_2 nano film surface , SiO_2 thickness 5.3 nm and RMS surface roughness equal 3.124.nm .

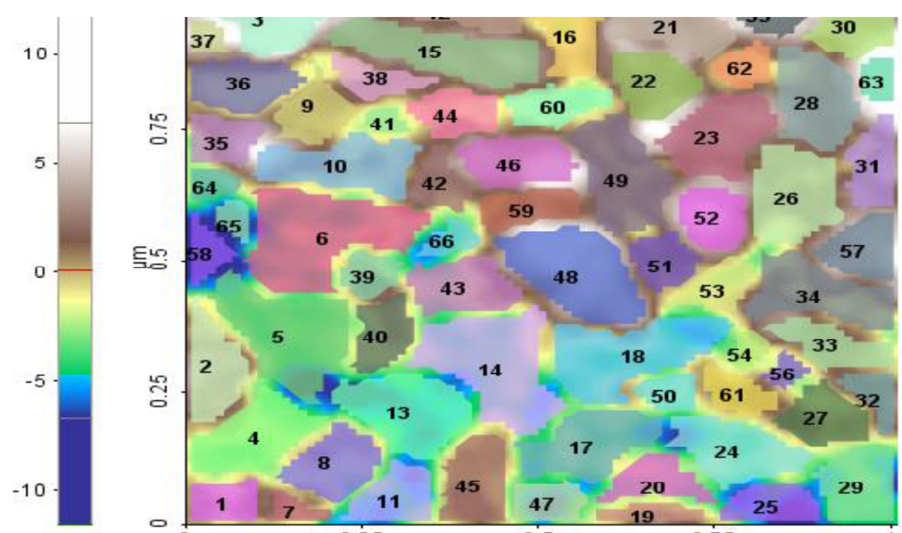

Fig.8 : number and distribution of grains on the surface of the SiO_2 measured by using AFM ,SiO_2 thickness 5.3 nm and RMS surface roughness equal 3.124.nm .

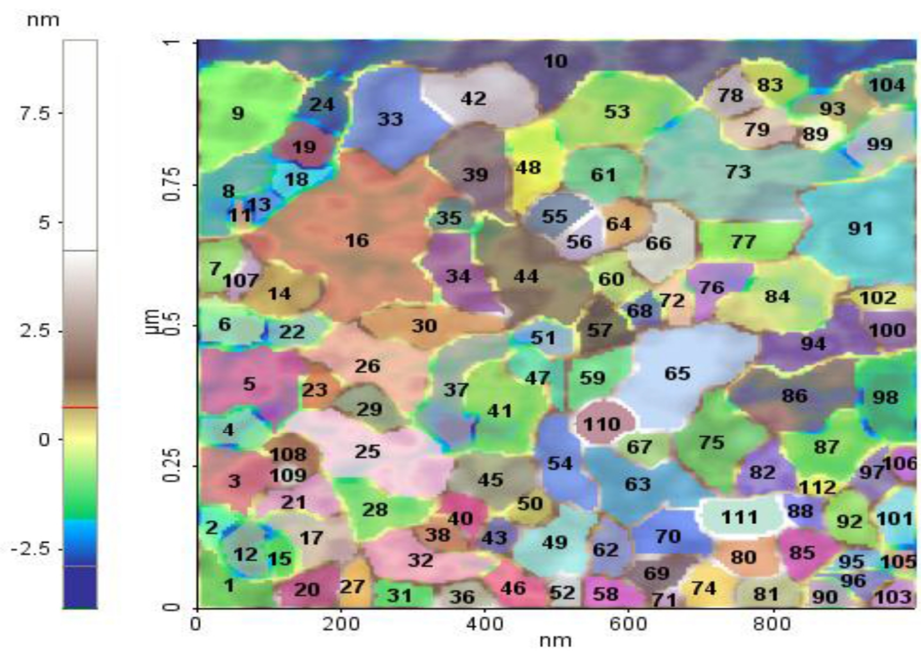

Fig.6: number and distribution of grains on the surface of the SiO_2 measured by using AFM , SiO_2 thickness 3.6 nm .

SiO_2

film thickness 5.3 nm

A three-dimensional (3D) nanotopography image of the SiO2 nano film thickness 5.3 nm shown in Fig. (7) and root mean square (RMS) surface roughness equal 3.124 nm . Fig (8) shows number and distribution of grain on the surface of the SiO2 measured by using AFM .

SiO_2 film thickness 3.6 nm

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 3.6 nm show in Fig. (5) and root mean square (RMS) surface roughness equal 1.995 nm . Fig (6) shows number and distribution of grain on the surface of the SiO_2 measured by using AFM.

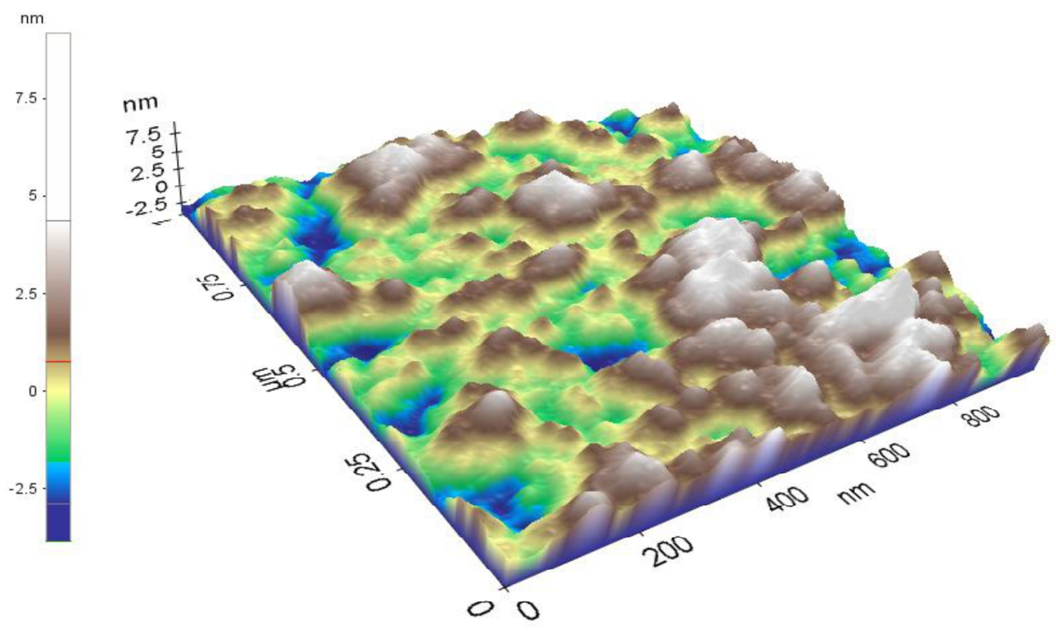

Fig.5:The (3D) nanotopography AFM images of SiO_2 nano film surface , SiO_2 thickness 3.6 nm and RMS surface roughness equal 1.995 nm .

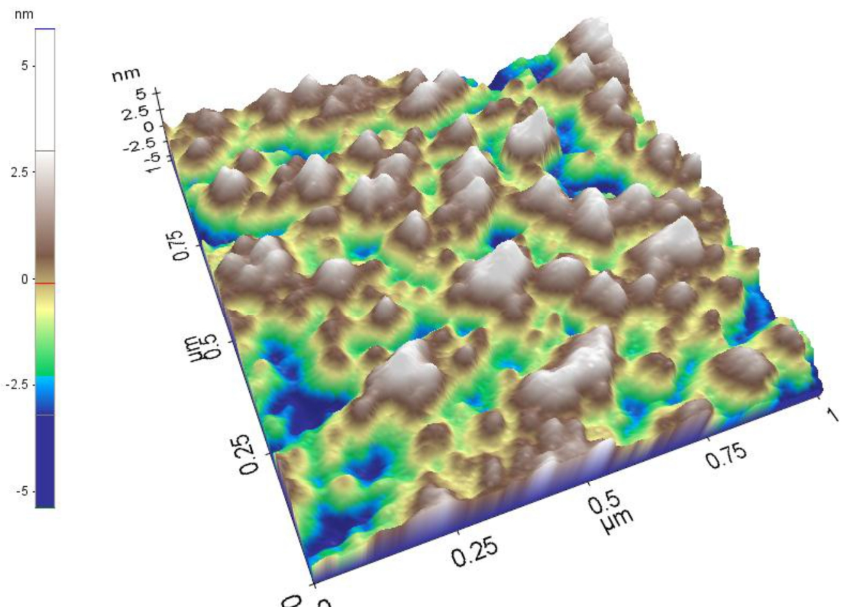

Fig.3:The (3D) nanotopography AFM images of SiO_2 nano film surface , SiO_2 thickness 2.3nm and RMS surface roughness equal 1.437 nm .

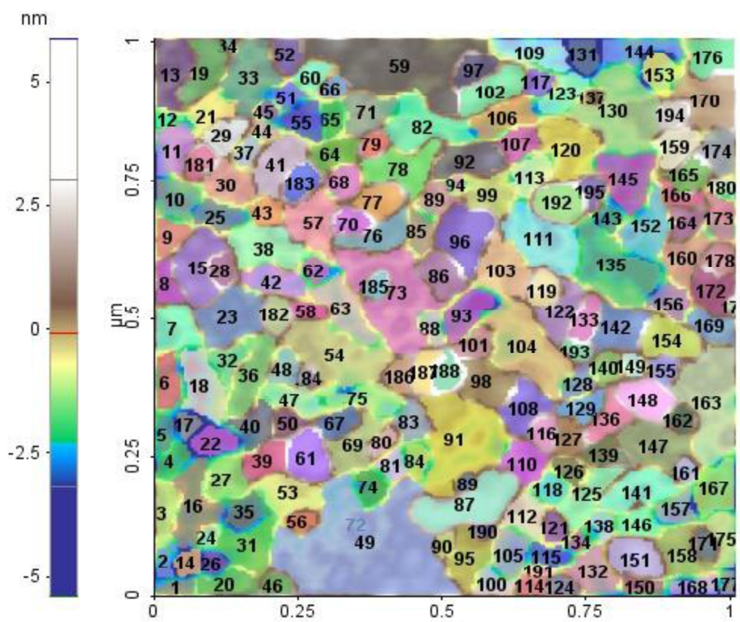

Fig.4 : :number and distribution of grains on the surface of the SiO_2 measured by using AFM , SiO_2 thickness 2.3 nm and RMS surface roughness equal 1.437 nm .

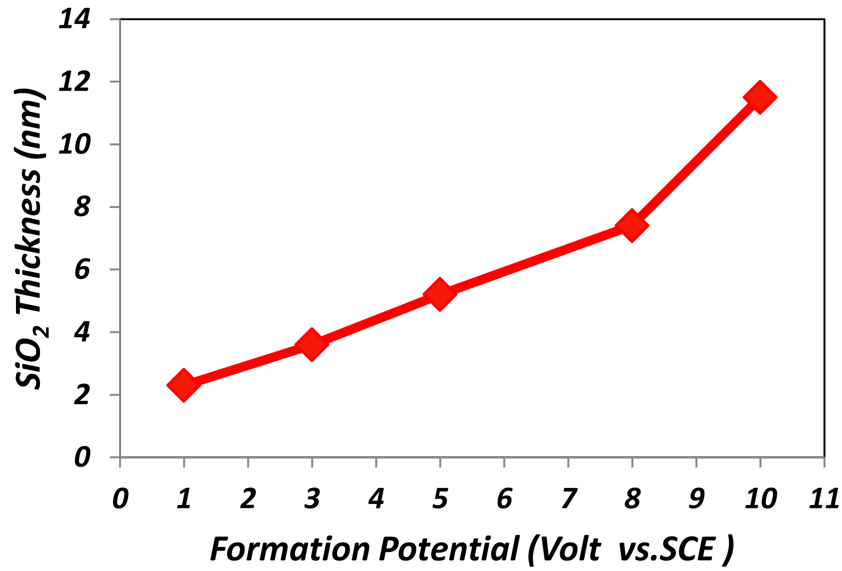

Fig. 2 : Relationship between the formation potential and the thickness of SiO2 growth on p-type polycrystalline Silicon.

Results of AFM measurements of the SiO_2 nano films

Atomic force microscopy was used to characterization of the surfaces of SiO_2 nano film in the thickness range (2.3- 11.5) nm growth by anodic oxidation in (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as supporting electrolyte.

SiO_2 film thickness 2.3nm

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 2.3 nm show in Fig. (3) and root mean square (RMS) surface roughness equal 1.437 nm Fig.(4) shows number and distribution of grain on the surface of the SiO_2 measured by using AFM.

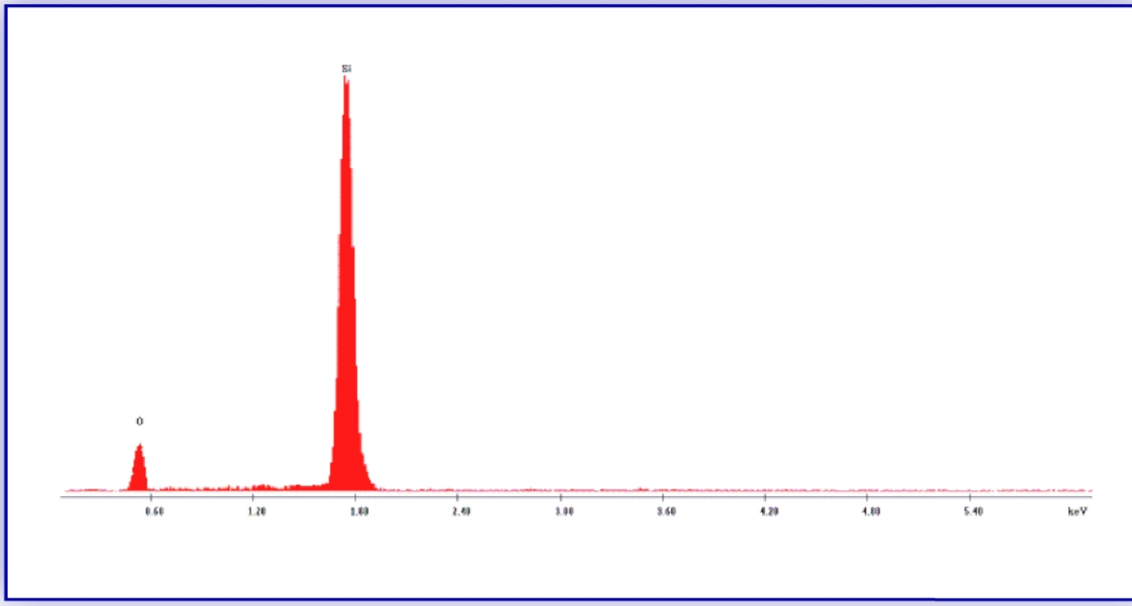

Fig. 1: element analysis using (EDAX) of the surface of SiO_2 nano film growth on the surface of Si(100) p-type .

The relation between oxide thickness and formation potential

The relation between oxide thickness and formation potential is shown in Fig. (2). It is very clear that the formed oxide increases with increasing formation potential and the relation between them is found to be liner up to (8 nm) and break above thickness (8 nm). The mechanism of oxide growth changes from lattice diffusion of ions inward at low potential to short circuit diffusion of ions inward at high potential (above the break). (Bardwell et al., 1995 ; Bardwell and Draper, 1996 ; Sulaiman et al., 2012).

supporting electrolyte . (EDAX-Genesis) was used to analyse present elements in the sample . Oxide thickness was measured by Ellipsometer (J. A. Wodllam V.VASE) . Finally Atomic Force Microscopy AFM MODEL PSIA (XE-100E) was used to analyze the SiO_2 surface nanotopography .

RESULTS AND DISCUSSION

This section present the results and discussion of growth SiO_2 nano film on Si(100) p-type (0.5- 1.5) Ω. cm. , the relation between oxide thickness and formation potential, chemical analysis of SiO_2 surface by using (EDAX-Genesis). Finally present the results of study the surface nanotopography of a SiO_2 film by using Atomic force microscopy AFM. This study is included the relation between root mean square (RMS) surface roughness of the SiO_2 and SiO_2 nano thickness, relation between area of grain and SiO_2 nano thickness , relation between volume of grain and SiO_2 nano thickness finally relation between length of grain and SiO_2 nano thickness .

Elements analysis of SiO_2 surface using (EDAX)

The analysis of the surface of SiO_2 grown on the surface of Si(100) P-type has been done by (EDAX), which shows the presence of O and Si elements as shown in the Fig. (1).

Several properties of the films are related to their surface morphology and their stability under deferent conditions. For example, the optical loss of a waveguide is dependent on the surface scattering. Therefore more detailed and quantitative measurements of the properties at a film surface are needed to develop materials for optical applications . Which provides surface images at close to atomic resolution. (Karthikeyan and Almeida, 2000).

Firstly this work involves the growth of nano-thickness film of SiO_2 on Si(100) p-type in (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as supporting electrolyte by using anodic oxidation technique. Aim of this work is to study the properties of a SiO2 surface by using Atomic force microscopy AFM . The study is included the relation between root mean square (RMS) roughness of the SiO_2 surface and SiO_2 thickness, relation between area of grain and SiO_2 thickness , relation between volume of grain and SiO_2 thickness finally relation between length of grain and SiO_2 thickness .

EXPERIMENT

The wafers used are Si(100) p-type (0.5- 1.5) **Ω**. cm. Before the sample was oxidized, sample cleaned by rinsing in acetone, Isopropanol , methanol and finally dionized water . The native oxide was removed by etching in 1% HF for 1 min . The SiO_2 films were grown at constant potential using Potentiostat (Wenking, HP 72, Germany) (1-10) volt in which three electrodes cell were used: a (1X1) cm Silicon wafer as a working first electrode, the second was the reference electrode is Saturated Calmel Electrode (SCE), and the third counter electrode is Pt. The electrolytic medium used in (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as and with physiochemical properties of the film(Kalugasalam and Ganesan , 2010)

Atomic force microscopy AFM has developed rapidly in recent years for this purpose. AFM consists of a sharp tip on the end of a flexible cantilever across a sample surface while maintaining a small, constant force. (Nakhei and Bahari, 2009 ; Philipsen, 2007 ; Trogisch et al., 2005).

Atomic force microscopy (AFM), which is a three-dimensional topographic technique with a high atomic resolution, is based on scanning a sample surface with a probe and on imaging surface properties of the sample . (AFM) is a very useful tool for investigating the surfaces of thin solid films . This technique has been used to study a structure of surfaces of films prepared by different technologies. For example, AFM has been employed for analyzing the roughness grain structure and fractal properties of the thin film surfaces. Further, it has been employed for the thin films formed by different materials, e. g. the films formed by single crystal of semiconductors, columnar films formed by dielectrics, polycrystalline films of metals etc. (Mahmood, A.; (2016) .(Klapetek et al.,2003). (Greding et al.,2010).

Surface morphology of deposited metal thin films is successfully observed by atomic force microscopy(AFM) . AFM provide clear surface images of the films with a high spatial resolution down to nanometer and angstrom scales. They also enable us to evaluate the surface roughness and the smoothness of the metal films and characterize the surface morphology quantitatively (Morihide et al., 2006).(Muhammad et al .,2016). (Muhtade et a.l ;2017).

INTRODUCTION

The growth of SiO_2 nano film layer on Silicon surface is an important for industrial and scientific study. Over the last two decades, they have come to be used in a wide range of electronic devices, such as transistors, switching devices, voltage regulation, photocells MEMS , and photo detectors. One device most widely used in silicon based integrated circuits is the MOSFET (Metal – Oxide – Semi-conductor – Field – Effect – Transistor . Electrochemical oxidation of silicon at room temperature can produce thin oxide layer on Silicon surface. Also electrochemical technique has been the source of information on the growth and surface morphologies of semiconductors. (Clark et al., 1994 ; Bardwell and Draper, 1996 ; Issa, 1999 ; Issa, 2010 ;Nakhei and Bahari, 2009).

Recently nanotechnology plays an important role for the fabrication of the electronic devices . Therefore nanotopography of the surface of silicon wafers has been an important issue because it gives information about the uniformity of the thickness variation of dielectrics and understand how the various characters of the nanotopography of wafers impact on oxide. (Katoh et al., 2002 ; Empestl et al., 2008).

The physical properties of nano films are known to differ widely from those of bulk materials. This is evidently connected with the small size of the crystallites formation on the film and with the large number of defects such as dislocations, vacancies, stacking faults, grain boundaries, twins etc in particular. The study of the structure is particularly important when coupled with data concerning the film formation processes

Study The Surface Characterization of Anodic grow SiO_2 nano Film on Si by using AFM

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ABSTRACT:

In this work studied The surface characterization of SiO_2 nano film in the thickness range (2.3- 11.5) nm by using atomic force microscopy . SiO_2 nano film growth on Silicon (100) p-type substrates , by using the anodic oxidation technique using (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as supporting electrolyte. The chemical analysis of the surface of SiO_2 has been done by (EDAX) shows the presence of O and Si elements, The films thickness has been found that is increases as formation potential increases. The (AFM) is used to study the nanotopography of SiO_2 film . However it has been found that all of the following characteristics ,the nanotopography of the SiO_2 nano film , root mean square RMS surface roughness of the SiO_2 nano film , grain area , grain volume and grain length increases with the increase of SiO_2 nano thickness.

Keywords : AFM , SiO_2 nano film , nanotopography of SiO_2 film.

الملخص:

في هذا العمل تم دراسة خصائص السطح النانوي لغشاء SiO2 ذي سمك بحدود nm (2.3- 11.5) باستخدام المجهر القوة الذرية . تم أنماء غشاء نانوي من SiO_2 على أرضية (100) Si نوع p-type وذلك باستخدام تقنية الأكسدة الانودية وباستعمال محلول (%75H2O+%25 isopropanol) بوجود 0.1N KNO_3 كاالكتروليت مساعد . ولوحظ من التحليل الكيميائي لسطح SiO2 باستخدام (EDAX) وجود عنصر الأوكسجين (O) وعنصر السليكون (Si). وكذلك لوحظ أن سمك الاوكسيد SiO_2 يزداد بزيادة جهد الإنماء . تم استخدام تقنية AFM لدراسة طوبغرافية النانوية لغشاء SiO_2 . لقد وجد أن كل من الخصائص التالية ، طوبغرافية النانوية لغشاء SiO_2 النانوي ، معدل خشونة ، مساحة الحبيبة ، حجم الحبيبة وأخيرا طول الحبيبة تزداد مع زيادة سمك SiO_2 النانوي .