------ Raf. J. Sci., Vol. 25, No.2 pp. 74-86, 2014------

The Effect of Annealing on Nano-Topography of SiO_2 Film

Assim A. Issa
Department of Physics
College of Science
University of Mosul

(Received 24 / 4 / 2013 ; Accepted 26 / 6 / 2013)

ABSTRACT

This research studies the effect of annealing in temperature range (300 - 600)°C on nano-topography of SiO_2 film. SiO_2 nano film growth on Si (100) p-type substrates, by using the anodic oxidation technique using (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as supporting electrolyte and applied potential is 5 volts. The chemical analysis of the surface of SiO_2 has been done by (EDAX) shows the presence of O and Si elements. (AFM) is used to study the nanotopography of SiO_2 nano film. However, it has been found that all of the following characteristics, root mean square RMS surface roughness of the SiO_2 film, grain area, grain volume and grain length increase with the increase of annealing temperature.

Keywords: AFM, annealing, nanotopography of SiO_2 film.

تأثير التلدين على الطوبغرافية النانوية لغشاء SiO_2

الملخص

في هذا البحث تمت دراسة تأثير درجة حرارة التَلْدين للمدى من300°C الى 600°C على الطوبغرافية النانوية لغشاء SiO_2. تم أنماء غشاء نانوي من SiO_2 على أرضية Si (100) نوع p-type وذلك باستخدام تقنية الأكسدة الانودية وباستعمال محلول (%75H_2O+%25 isopropanol) بوجود 0.1N KNO_3 كالكتروليت مساعد وجهد مسلط 5 فولت. ولوحظ من التحليل الكيميائي لسطح SiO_2 باستخدام (EDAX) وجود عنصر الأوكسجين (O) وعنصر السليكون (Si). تم استخدام تقنية AFM لدراسة الطوبغرافية النانوية لغشاء SiO_2 و لوحظ أن كلاً من الخصائص التالية، الطوبغرافية النانوية لغشاء SiO_2، معدل خشونة، مساحة الحبيبة، حجم الحبيبة وأخيرا طول الحبيبة تزداد مع درجة حرارة التلدين.

الكلمات الدالة :التلدين، AFM، الطوبغرافية النانوية لغشاء SiO_2

INTRODUCTION

Nano films of oxides play essential roles in a wide range of nanoelectronic and optoelectronic applications such as sensors, solar cells, transistors, switching devices, voltage regulation, and MOSFET (Metal Oxide Semiconductor Field Effect Transistor).

Electrochemical oxidation of silicon at room temperature can produce thin oxide layer on silicon surface. (Bardwell and Draper, 1996; Nakhei and Bahari, 2009; Karamdel *et al*., 2011). Therefore, the 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).

Several properties of the films are related to their surface morphology and their stability under different conditions. For example, the optical loss of a waveguide depended 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 provide surface images at close to atomic resolution. (Karthikeyan and Almeida, 2000).

The atomic force microscopy (AFM) belongs to a series of scanning probe microscopes invented in the 1980s.The AFM allowed the imaging of the topography of conducting and insulating surfaces, in some cases with atomic resolution. This technique resolves surface structure down to the nanometer scale. (Robert and Heather, 2012 ; Nakhei and Bahari, 2009; Philipsen, 2007). AFM is also be used to provide valuable information on local material properties such as hardness, study the structure of surfaces of films prepared by different technologies, adhesion and surface charge densities. They also enable us to evaluate the surface roughness and the smoothness of the metal films. For this reason the measurement of force curves has become essential in different fields of research such as surface science, materials engineering, and biology (Morihide *et al*., 2006; Klapetek *et al*., 2003; Greding *et al*.,2010).

The grain size was controlled by annealing at various temperatures AFM images showed an improvement in grain size and surface roughness of nano structured films (Vipin *et al*., 2012 ; Weeranut *et al*., 2008).

This research focuses on the analyses of the grain and roughness of SiO_2 nano films by annealing at different temperatures. SiO_2 nano films grow on Si (100) p-type in (%75H_2O+%25 isopropanol) solution containing 0.1N KNO_3 as supporting electrolyte by using anodic oxidation technique. The AFM was used to scan and analyze the grain of SiO_2 nano films at each annealing temperature.

EXPERIMENT

The wafer used is Si(100) p-type (0.5- 1.5) Ω. cm. Before the sample was oxidized, the sample was 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 nano film growth on Si (100) by using the anodic oxidation technique at constant potential using Potentiostat (Wenking, HP 72, Germany) (5) volts in which three electrodes cell were used: a (1X1) cm Silicon wafer as a working first electrode, the second was the reference electrode 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 supporting electrolyte. The SiO_2 nano film on Si(100) p-type film was annealed in vacuum at different temperature (300°C, 400°C, 500°C and, 600°C). For 2 hours. (EDAX-Genesis) Energy Dispersive Analysis X-Ray was used to analyze the 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 involves the results and discussion of elements analysis of SiO_2 surface using (EDAX), and the surface roughness and morphologies of the SiO_2 nano films obtained at different annealing temperatures were evaluated by atomic force microscopy (AFM).

• 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).

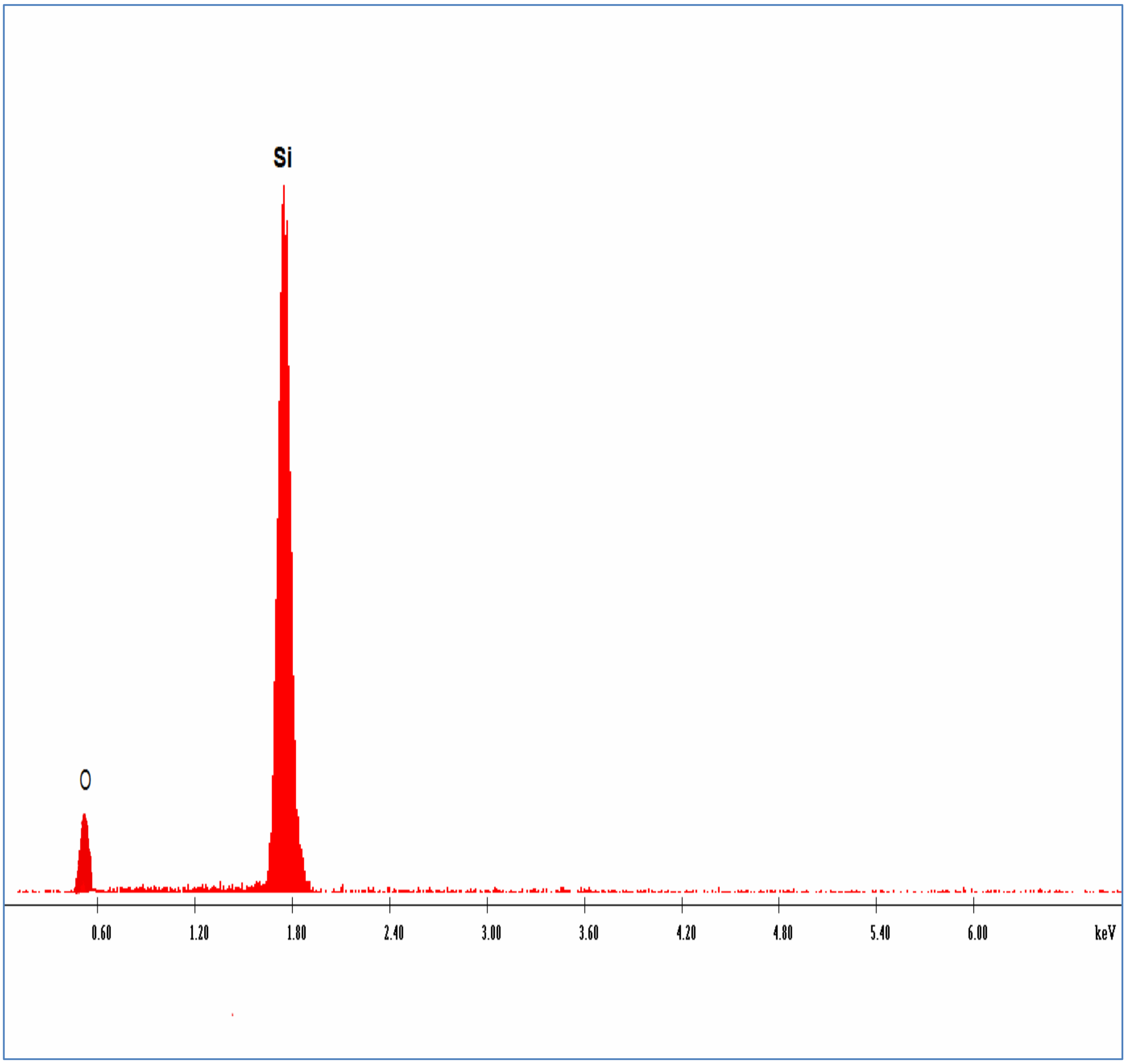

Fig. 1: Element analysis using (EDAX) of the surface of SiO_2 nano film growth on the surface of Si(100) p-type.

• Results of AFM measurements of the SiO_2 nano film annealed at various temperatures.

AFM was used in study of the nanotopography of SiO_2 nano film surfaces, which annealed at various temperatures: 300°C, 400°C, 500°C and 600°C for 2 hours.

1- SiO_2 nano film before annealing(as grown):

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 5.3 nm before annealing (growth at 25 ºC) as shown in (Fig. 2) and the root mean square (RMS) surface roughness equals 3.124 nm. (Fig .3) shows number and distribution of grain on the surface of the SiO_2, before annealing measured by using AFM. AFM was used to count the number of grains and calculate the area, volume and length of each grain on the surface of the SiO_2 nano film and the results were recorded in the Table (1).

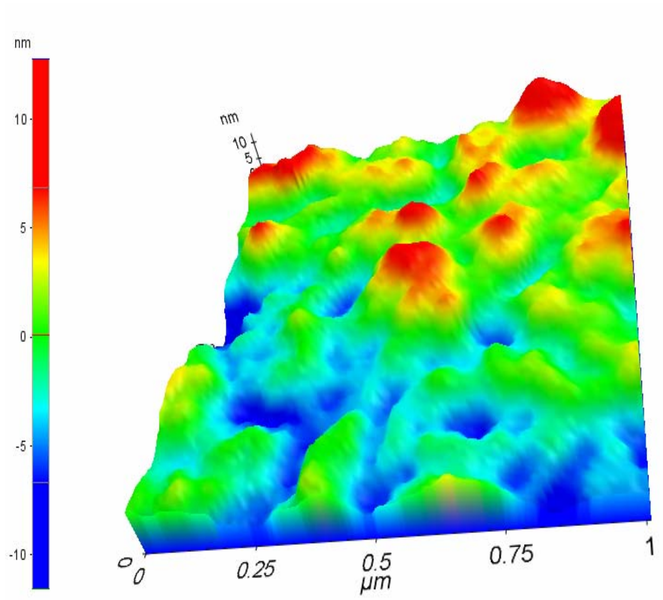

Fig. 2: The (3D) nanotopography AFM images of SiO_2 nano film surface, before annealing and RMS surface roughness equal 3.124.nm.

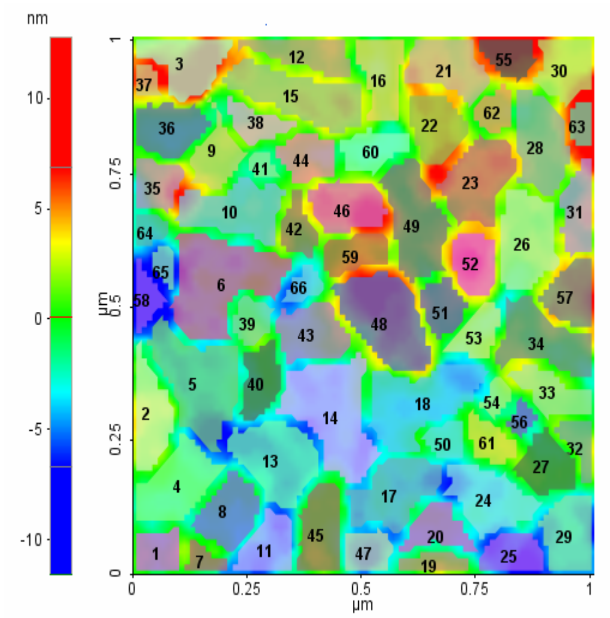

Fig. 3: number and distribution of grains on the surface of the SiO_2 before annealing measured by using AFM, RMS surface roughness equal 3.124.nm.

Table 1: AFM characterization of SiO_2 nano film (as grown)

Grain	Area(μm²)	Vol(μm³)	Length(nm)
Mean	1.327E-2	3.493E-5	172.161
1	7.69E-3	2.438E-7	124.572
2	1.566E-2	2.528E-5	247.207
3	1.566E-2	9.56E-5	213.847
4	2.101E-2	4.742E-5	235.835
5	2.994E-2	1.181E-4	298.771
6	3.598E-2	9.737E-5	285.370
7	4.395E-3	7.283E-7	100.809
8	1.538E-2	1.5E-5	163.223
9	1.236E-2	1.014E-5	177.337
10	2.197E-2	2.13E-5	252.973
11	1.126E-2	5.216E-5	159.392
12	1.154E-2	2.1E-5	267.229
13	2.348E-2	1.226E-4	211.263
14	3.447E-2	1.176E-4	267.229
15	2.554E-2	8.557E-5	318.784
16	1.332E-2	2.268E-6	185.290
17	2.019E-2	6.61E-5	231.130
18	2.911E-2	6.642E-5	300.375
19	5.356E-3	1.243E-6	154.136
20	1.099E-2	2.538E-5	176.171
21	1.62E-2	5.557E-5	188.959
22	1.346E-2	5.441E-5	157.224
23	2.129E-2	7.307E-5	195.039
24	1.95E-2	6.644E-5	222.964
25	1.03E-2	5.461E-5	144.953
26	2.197E-2	2.389E-5	196.442
27	1.236E-2	2.911E-6	144.953
28	1.978E-2	3.725E-5	215.447
29	1.414E-2	5.742E-5	169.010
30	1.208E-2	4.912E-5	152.794
31	1.016E-2	2.122E-5	193.271
32	5.081E-3	7.714E-6	136.663
33	1.167E-2	1.526E-5	200.250
34	2.06E-2	1.403E-5	250.792

Grain	Area(μm²)	Vol(μm³)	Length(nm)
35	9.613E-3	1.801E-5	126.758
36	1.442E-2	6.241E-6	170.628
37	3.433E-3	1.999E-5	82.864
38	9.064E-3	8.326E-6	196.442
39	7.278E-3	1.833E-6	104.816
40	1.099E-2	1.158E-5	167.787
41	3.021E-3	5.175E-6	78.612
42	7.828E-3	1.003E-5	137.164
43	1.566E-2	2.042E-5	170.628
44	1.003E-2	9.952E-7	141.598
45	1.36E-2	2.471E-6	183.427
46	1.579E-2	7.208E-5	181.924
47	8.652E-3	3.981E-5	117.188
48	2.856E-2	1.434E-4	263.346
49	2.458E-2	3.985E-5	235.544
50	6.18E-3	9.037E-6	111.174
51	1.057E-2	1.429E-5	156.348
52	1.003E-2	4.866E-5	136.663
53	8.789E-3	1.243E-5	152.794
54	3.983E-3	6.918E-6	82.864
55	7.553E-3	5.242E-5	133.614
56	4.257E-3	5.04E-6	82.864
57	1.112E-2	4.793E-5	143.046
58	6.866E-3	6.094E-5	141.112
59	9.476E-3	2.252E-5	152.344
60	1.085E-2	1.075E-5	165.728
61	8.24E-3	4.465E-6	133.614
62	6.042E-3	1.235E-6	100.809
63	3.708E-3	3.209E-5	89.247
64	3.845E-3	1.031E-5	84.505
65	3.159E-3	2.138E-5	96.635
66	4.807E-3	2.013E-5	100.809

2- SiO_2 nano film was annealing at temperature 300°C:

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 5.3 nm was annealed at temperature 300 °C as shown in (Fig. 4) and the root mean square (RMS) surface roughness equals 3.792 nm. (Fig. 5) shows the number and distribution of grain on the surface of the SiO_2 which annealed at temperature 300°C measured by using AFM. AFM was used to count the number of grains and calculate the area, volume and length of each grain on the surface of the SiO_2 nano film and the results were recorded in the Table (2).

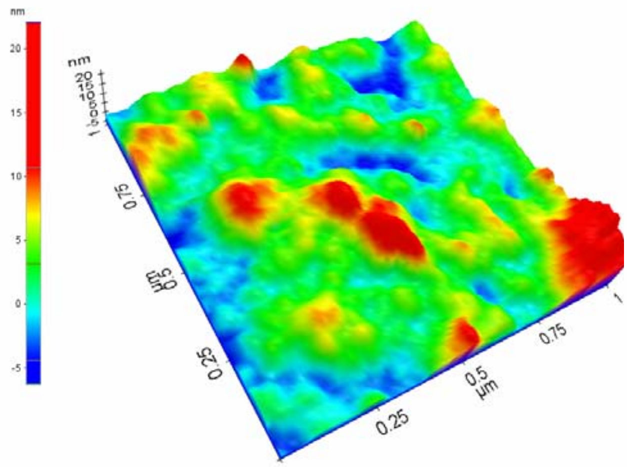

Fig. 4: The (3D) nanotopography AFM images of SiO_2 nano film surface annealed at temperature 300°C, RMS surface roughness equal 3.792 nm.

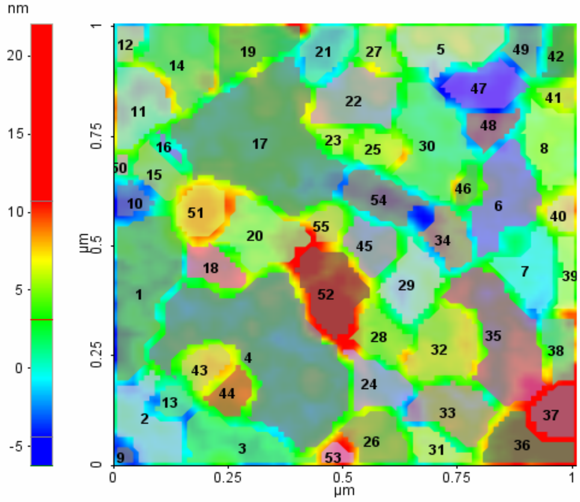

Fig. 5: number and distribution of grains on the surface of the SiO_2 , which annealed at temperature 300°C measured by using AFM, RMS surface roughness equal 3.792 nm.

Table 2: AFM Characterization of SiO_2 nano film was annealed at temperature 300°C

Grain	Area(μm²)	Vol(μm³)	Length(nm)
Mean	1.618E-2	5.769E-5	179.824
1	3.983E-2	3.519E-5	392.884
2	2.074E-2	3.205E-6	225.110
3	2.307E-2	1.421E-5	296.464
4	9.38E-2	2.599E-4	475.874
5	2.046E-2	4.539E-5	241.588
6	2.747E-2	3.235E-5	281.738
7	1.579E-2	8.515E-6	200.593
8	1.826E-2	4.842E-5	227.537
9	1.236E-3	3.632E-6	49.718
10	6.454E-3	1.687E-5	126.215
11	1.936E-2	1.335E-4	196.442
12	4.395E-3	3.42E-6	100.809
13	4.944E-3	4.786E-6	89.247
14	2.142E-2	8.984E-5	211.263
15	9.888E-3	1.342E-5	148.232
16	1.785E-3	1.323E-6	94.480
17	8.253E-2	1.865E-4	409.318
18	1.085E-2	4.044E-5	159.392
19	1.607E-2	8.498E-5	225.110
20	2.321E-2	1.677E-4	211.263
21	1.126E-2	1.954E-5	159.392
22	2.307E-2	7.768E-5	225.415
23	3.433E-3	1.439E-5	94.480
24	1.414E-2	4.966E-5	185.290
25	7.828E-3	3.333E-5	115.416
26	1.414E-2	7.627E-5	167.787
27	7.965E-3	3.986E-5	141.112
28	1.236E-2	6.641E-5	152.344
29	1.854E-2	1.447E-5	211.263
30	3.227E-2	5.598E-5	285.370
31	8.926E-3	8.263E-6	163.223
32	2.17E-2	1.144E-4	192.202
33	2.101E-2	4.337E-5	212.236
34	1.181E-2	1.602E-5	156.348

Grain	Area(μm²)	Vol(μm³)	Length(nm)
35	4.065E-2	1.755E-4	331.663
36	1.689E-2	1.813E-4	204.659
37	9.476E-3	1.51E-4	133.614
38	8.24E-3	4.805E-5	159.392
39	5.63E-3	1.775E-5	170.628
40	4.257E-3	2.946E-5	89.247
35	4.065E-2	1.755E-4	331.663
36	1.689E-2	1.813E-4	204.659
37	9.476E-3	1.51E-4	133.614
38	8.24E-3	4.805E-5	159.392
39	5.63E-3	1.775E-5	170.628
40	4.257E-3	2.946E-5	89.247
41	2.747E-3	1.684E-5	94.480
42	6.729E-3	1.819E-5	136.663
43	8.514E-3	5.326E-5	120.652
44	8.514E-3	3.959E-5	131.020
45	1.208E-2	3.699E-5	148.232
46	3.571E-3	2.007E-5	104.816
47	1.648E-2	5.087E-5	199.219
48	8.926E-3	1.574E-5	143.046
49	7.278E-3	1.56E-5	131.020
50	1.099E-3	1.645E-6	52.408
51	1.099E-2	1.037E-4	133.614
52	2.348E-2	2.751E-4	218.924
53	3.021E-3	2.989E-5	74.116
54	1.579E-2	3.208E-5	193.271
55	5.356E-3	3.734E-5	94.480

3- SiO_2 nano film annealed at temperature 400°C :

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 5.3 nm was annealed at temperature 400 °C shown in (Fig. 6) and the root mean square (RMS) surface roughness equals 4.054 nm. (Fig.7) shows the number and distribution of grain on the surface of the SiO_2 which annealed at temperature 400 °C measured by using AFM. AFM was used to count the number of grains and calculate the area, volume and length of each grain on the surface of the SiO_2 nano film and the results were recorded in Table (3).

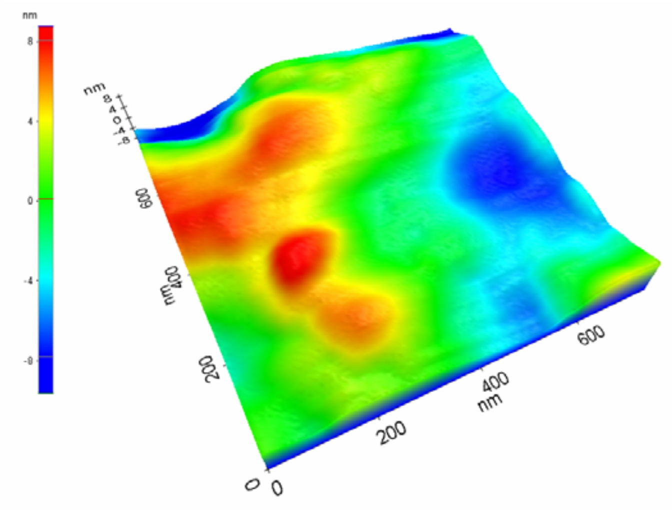

Fig. 6 : The (3D) nanotopography AFM images of SiO_2 nano film surface annealed at temperature 400°C, RMS surface roughness equal 4.054 nm.

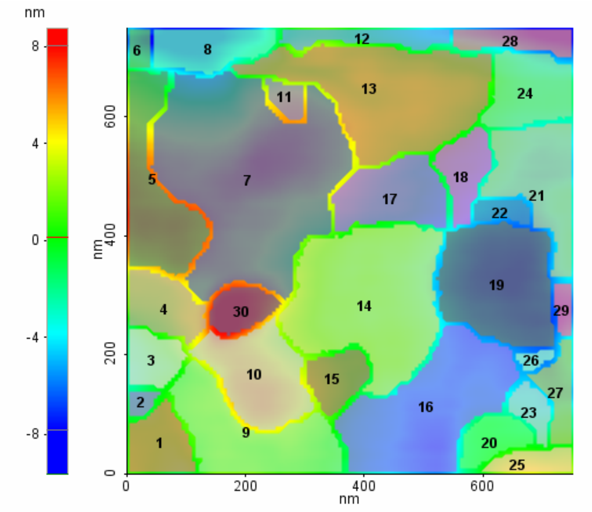

Fig. 7 : number and distribution of grains on the surface of the SiO_2 which annealed at temperature 400°C measured by using AFM, RMS surface roughness equal 4.054 nm.

Table 3: AFM Characterization of SiO_2 nano film was annealed at temperature 400°C

Grain	Area(μm²)	Vol(μm³)	Length(nm)
Mean	1.775E-2	5.849E-5	202.135
1	1.088E-2	2.676E-6	138.906
2	1.82E-3	1.696E-6	71.523
3	8.034E-3	7.018E-6	115.565
4	1.222E-2	3.357E-5	162.907
5	2.537E-2	1.425E-4	353.995
6	2.266E-3	1.104E-5	73.418
7	8.782E-2	3.876E-4	429.776
8	1.219E-2	7.549E-5	214.968
9	2.87E-2	5.406E-5	322.479
10	2.379E-2	1.153E-4	233.274
11	3.296E-3	1.422E-5	91.526
12	7.107E-3	3.792E-6	288.064
13	5.098E-2	9.383E-5	440.078
14	5.572E-2	6.446E-5	318.623
15	8.617E-3	1.046E-5	123.186
16	4.491E-2	1.668E-4	343.361
17	1.885E-2	1.771E-5	208.646
18	9.991E-3	1.771E-5	176.269
19	3.529E-2	2.279E-4	265.294
20	7.484E-3	8.682E-6	136.286

Grain	Area(μm²)	Vol(μm³)	Length(nm)
21	2.242E-2	8.54E-5	280.578
22	3.193E-3	1.536E-5	100.125
23	4.978E-3	1.569E-5	124.158
24	1.603E-2	3.129E-5	182.018
25	5.562E-3	1.028E-5	191.934
26	1.751E-3	9.715E-6	66.807
27	6.66E-3	2.468E-5	185.012
28	6.935E-3	3.915E-5	204.659
29	2.266E-3	1.248E-5	92.645
30	7.313E-3	5.413E-5	127.971
21	2.242E-2	8.54E-5	280.578
22	3.193E-3	1.536E-5	100.125
23	4.978E-3	1.569E-5	124.158
24	1.603E-2	3.129E-5	182.018
25	5.562E-3	1.028E-5	191.934
26	1.751E-3	9.715E-6	66.807
27	6.66E-3	2.468E-5	185.012
28	6.935E-3	3.915E-5	204.659
29	2.266E-3	1.248E-5	92.645
30	7.313E-3	5.413E-5	127.971

3- SiO_2 nano film annealed at temperature 500°C :

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 5.3 nm was annealed at temperature 500 °C shown in (Fig. 8), and the root mean square (RMS) surface roughness equals 4. 543 nm. (Fig. 9) shows the number and distribution of grain on the surface of the SiO_2 which annealed at temperature 500 °C measured by using AFM. AFM was used to count the number of grains and calculate the area, volume and length of each grain on the surface of the SiO_2 nano film and the results were recorded in the Table (4). Mean area, mean volume and mean length have also been calculated and results were recorded in Table (4).

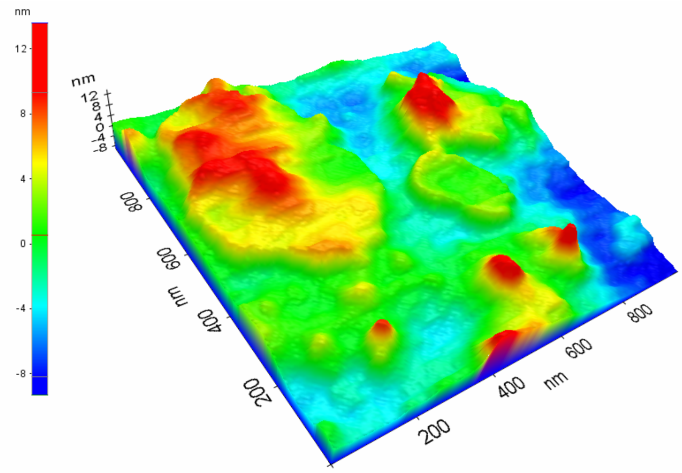

Fig. 8: The (3D) nanotopography AFM images of SiO_2 nano film surface annealed at temperature 500°C, RMS surface roughness equal 4. 543 nm.

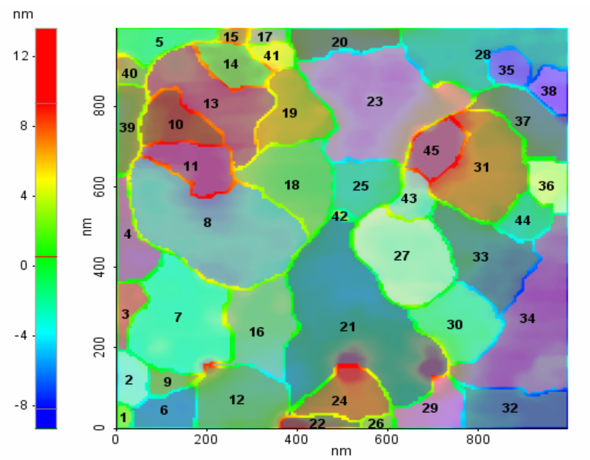

Fig. 9: number and distribution of grains on the surface of the SiO_2 which annealed at temperature 500°C measured by using AFM, RMS surface roughness equal 4.543 nm.

Table 4: AFM characterization of SiO_2 nano film was annealed at temperature 500°C

Grain	Area(µm²)	Vol(µm³)	Length(nm)
Mean	2.107E-2	7.008E-5	214.023
1	1.545E-3	1.15E-6	57.708
2	7.759E-3	2.784E-5	139.276
3	6.969E-3	1.271E-5	174.802
4	1.346E-2	4.853E-7	264.257
5	1.15E-2	6.606E-6	224.575
6	1.109E-2	3.745E-5	171.130
7	4.817E-2	4.709E-5	311.485
8	7.642E-2	3.985E-4	432.881
9	5.116E-3	1.011E-5	120.794
10	1.603E-2	1.273E-4	191.934
11	1.734E-2	1.563E-4	217.745
12	2.798E-2	4.225E-5	223.886
13	3.543E-2	2.209E-4	331.663
14	1.315E-2	1.019E-4	183.895
15	1.888E-3	1.119E-5	70.799
16	2.87E-2	5.468E-6	273.137
17	2.575E-3	6.816E-6	89.247
18	2.997E-2	5.293E-5	247.831
19	2.184E-2	6.385E-5	220.876
20	1.336E-2	2.918E-5	242.793
21	9.582E-2	2.508E-5	504.621
22	4.601E-3	3.155E-5	170.829

Grain	Area(µm²)	Vol(µm³)	Length(nm)
23	6.698E-2	2.171E-4	399.341
24	1.778E-2	7.982E-5	212.962
25	1.706E-2	4.369E-5	185.290
26	1.785E-3	4.487E-6	70.799
27	3.814E-2	6.662E-5	262.367
28	3.612E-2	1.357E-4	375.183
29	1.311E-2	2.259E-5	170.325
30	2.496E-2	5.701E-5	209.139
31	3.897E-2	1.482E-4	285.370
32	2.135E-2	1.574E-4	262.367
33	3.292E-2	1.297E-4	319.699
34	5.414E-2	3.276E-4	478.320
35	6.969E-3	3.841E-5	112.555
36	9.029E-3	7.362E-6	156.018
37	2.077E-2	2.419E-5	258.079
38	6.901E-3	5.3E-5	128.506
39	1.078E-2	7.634E-6	219.629
40	3.811E-3	1.542E-5	87.891
41	4.738E-3	1.783E-5	104.816
42	6.866E-4	1.437E-6	54.021
43	8.377E-3	3.257E-5	124.296
44	8.755E-3	1.085E-5	128.506
45	1.329E-2	1.384E-4	159.392

4- SiO_2 nano film annealed at temperature 600°C

A three-dimensional (3D) nanotopography image of the SiO_2 nano film thickness 5.3 nm annealed at temperature 600 °C shown in (Fig. 10), and the root mean square (RMS) surface roughness equal 5. 482 nm. (Fig.11) shows number and distribution of grain on the surface of the SiO_2 which annealed at temperature 500 °C measured by using AFM. AFM was used to count the number of grains and calculate the area, volume and length of each grain on the surface of the SiO_2 nano film and the results were recorded in the Table (5).

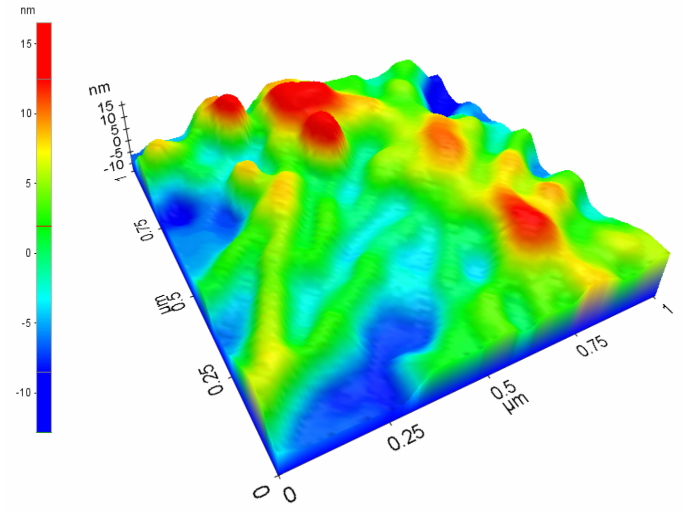

Fig. 10: The (3D) nanotopography AFM images of SiO_2 nano film surface annealed at temperature 600°C, RMS surface roughness equal 5. 482 nm.

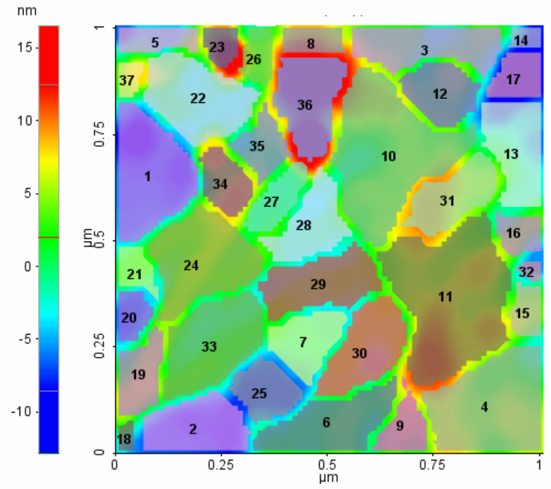

Fig. 11: Number and distribution of grains on the surface of the SiO_2 which annealed at temperature 600°C measured by using AFM, RMS surface roughness equal 5.482 nm.

Table 5: AFM characterization of SiO_2 nano film was annealed at temperature 300°C

Grain	Area(μm²)	Vol(μm³)	Length(nm)
Mean	2.476E-2	1.033E-4	229.548
1	4.697E-2	2.811E-4	331.456
2	3.09E-2	2.053cE-4	262.039
3	3.035E-2	6.195E-5	358.525
4	5.534E-2	2.604E-4	348.029
5	1.03E-2	2.585E-5	196.442
6	3.667E-2	5.561E-5	382.613
7	2.142E-2	6.639E-5	204.659
8	8.926E-3	8.82E-5	167.787
9	1.305E-2	4.887E-5	189.322
10	7.841E-2	4.024E-4	425.925
11	8.679E-2	6.014E-4	441.752
12	2.225E-2	6.283E-5	200.250
13	2.815E-2	8.762E-5	283.439
14	3.433E-3	2.562E-5	94.480
15	8.652E-3	2.561E-5	141.598
16	9.75E-3	1.401E-5	150.073
17	1.181E-2	1.293E-4	166.555
18	2.472E-3	4.974E-6	78.612
19	1.84E-2	8.266E-5	230.833
20	8.789E-3	3.954E-5	131.020

Grain	Area(μm²)	Vol(μm³)	Length(nm)
21	8.514E-3	8.601E-7	159.392
22	4.23E-2	2.302E-6	293.905
23	6.592E-3	7E-5	110.554
24	4.807E-2	1.303E-4	302.426
25	1.936E-2	1.233E-4	179.262
26	8.926E-3	3.72E-5	148.232
27	1.483E-2	2.266E-5	208.646
28	2.705E-2	7.228E-6	262.039
29	3.529E-2	4.445E-5	305.588
30	3.227E-2	2.027E-5	300.146
31	2.582E-2	1.963E-4	267.229
32	2.197E-3	8.64E-6	68.331
33	4.34E-2	3.765E-6	342.260
34	1.579E-2	9.379E-5	189.322
35	1.579E-2	5.161E-5	200.593
36	3.172E-2	4.194E-4	259.406
37	5.356E-3	2.095E-5	110.554

- **The Relation between (RMS) surface roughness of the SiO_2 nano film and annealing temperature :**

From results AFM shown in (Figs. 2, 4, 6, 8, 10) the relation between (RMS) surface roughness of the SiO_2 nano film and annealing temperature predicted and shown in (Fig. 12). (Fig. 12) shows that RMS surface roughness of the SiO_2 nano film increases with increasing in annealing temperature. This result can be attributed by island coalescence which belongs to the tetragonal crystal system, with increasing annealing temperature, there is also a loss of crystallinity (Zhang *et al.*, 2003; Simoes *et al.*, 2001; Weeranut *et al.*, 2008).

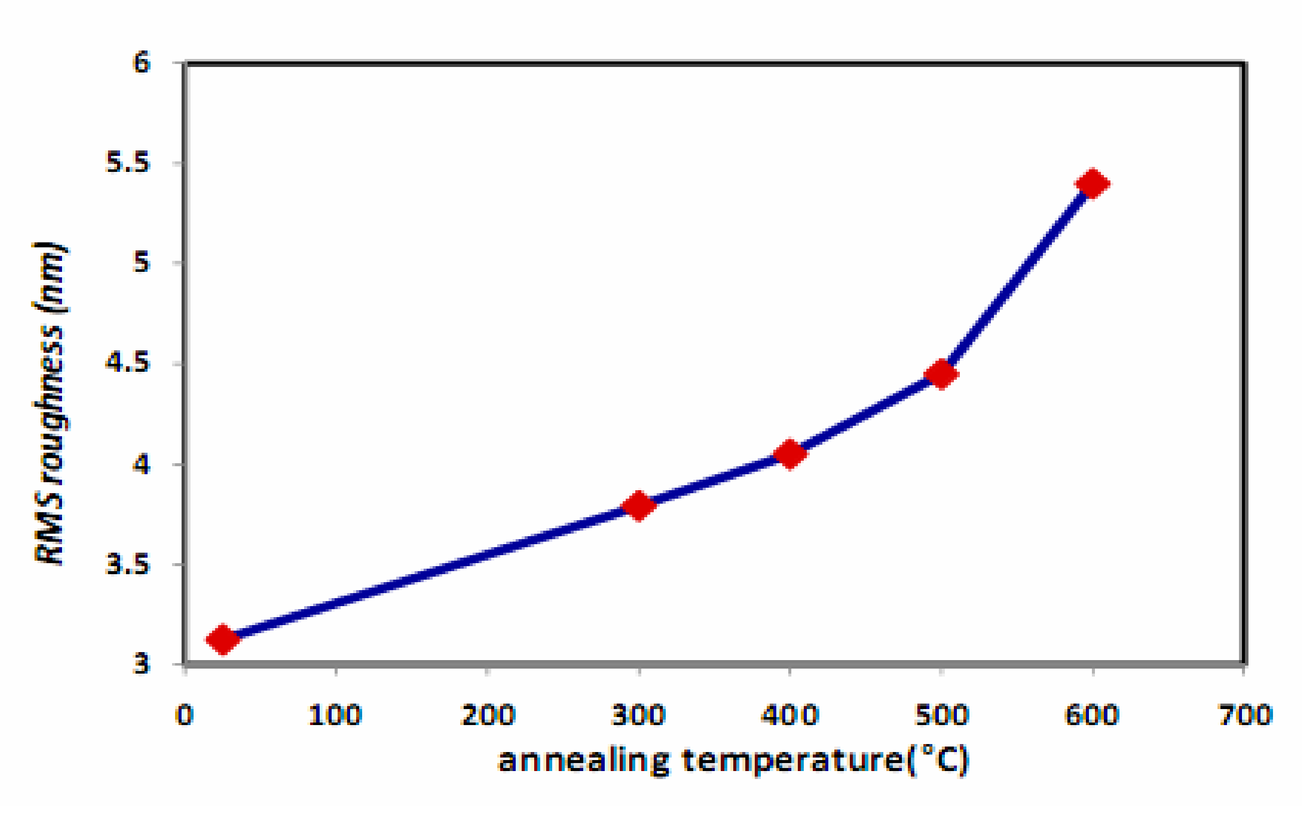

Fig. 12: Relation between the RMS surface roughness of the SiO_2 nano film (measured by AFM) and annealing temperature.

- **Study change of grain volume, grain area and grain length of SiO_2 film with annealing temperature.**

Using results AFM measurements tabulated in Tables (1, 2, 3, 4, 5) a relation between change (grain volume, grain area and grain length of SiO_2 nano film)with the annealing temperature.

(Fig. 13) shows thee relation between grain area of SiO_2 nano film and annealing temperature .Where the grain area increases with increasing in annealing temperature. This can be explained by island coalescence (Zhang *et al.*, 2003; Simoes *et al.*, 2001; Weeranut *et al.*, 2008).

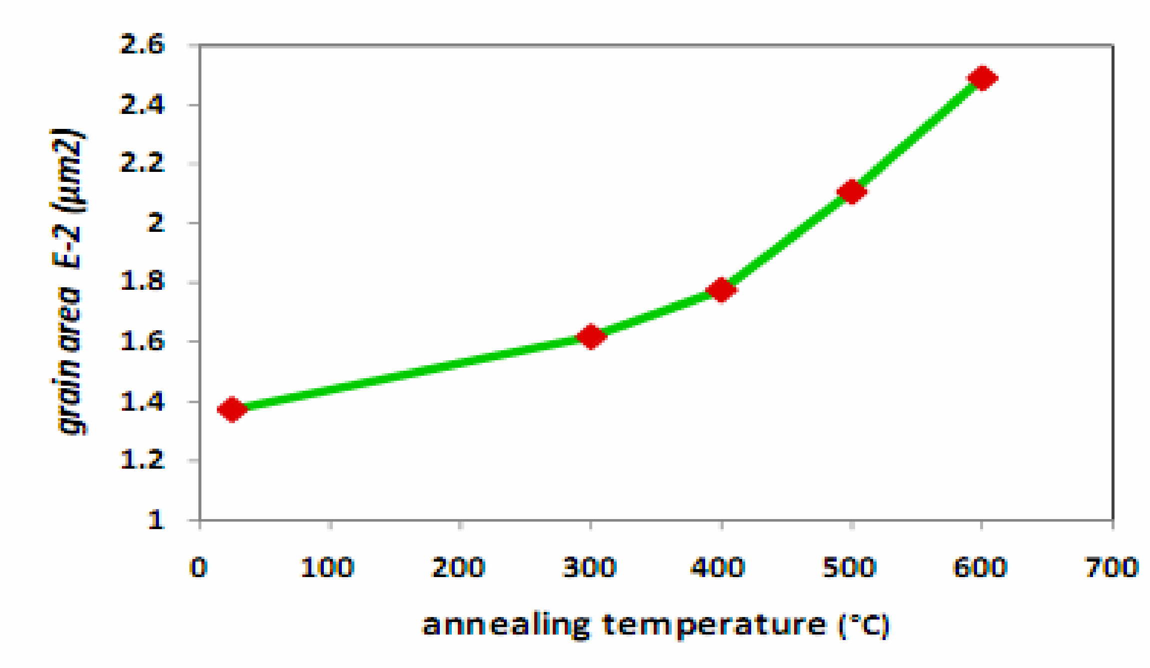

Fig. 13: The relation between grain area (measured by AFM) and annealing temperature

(Fig. 14) Shows that grain volume increases with increasing of annealing temperature. Which also can be explained by the island coalescence. At a lower temperature are identified as cristobalite SiO_2, which belongs to the tetragonal crystal system. By increasing the annealing temperature, there is a loss of crystallinity (Zhang *et al*., 2003; Simoes *et al*., 2001; Weeranut *et al*., 2008).

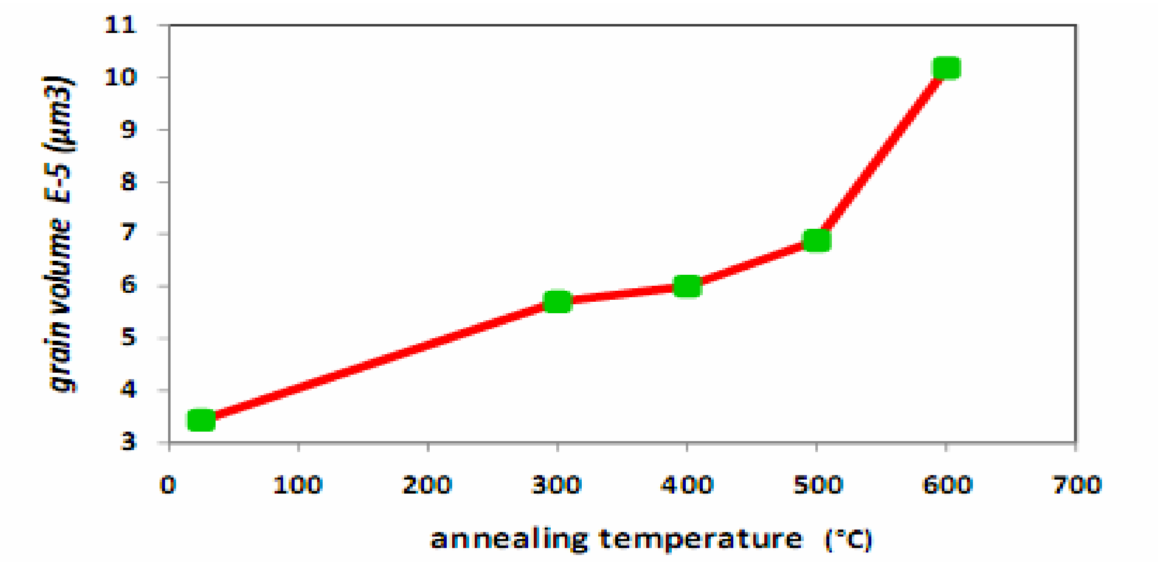

Fig. 14: The relation between grain volume (measured by AFM) and annealing temperature

The relation between grain length of SiO_2 nano film and annealing temperature as shown in (Fig. 15).Where the grain length increases with increasing in annealing temperature.

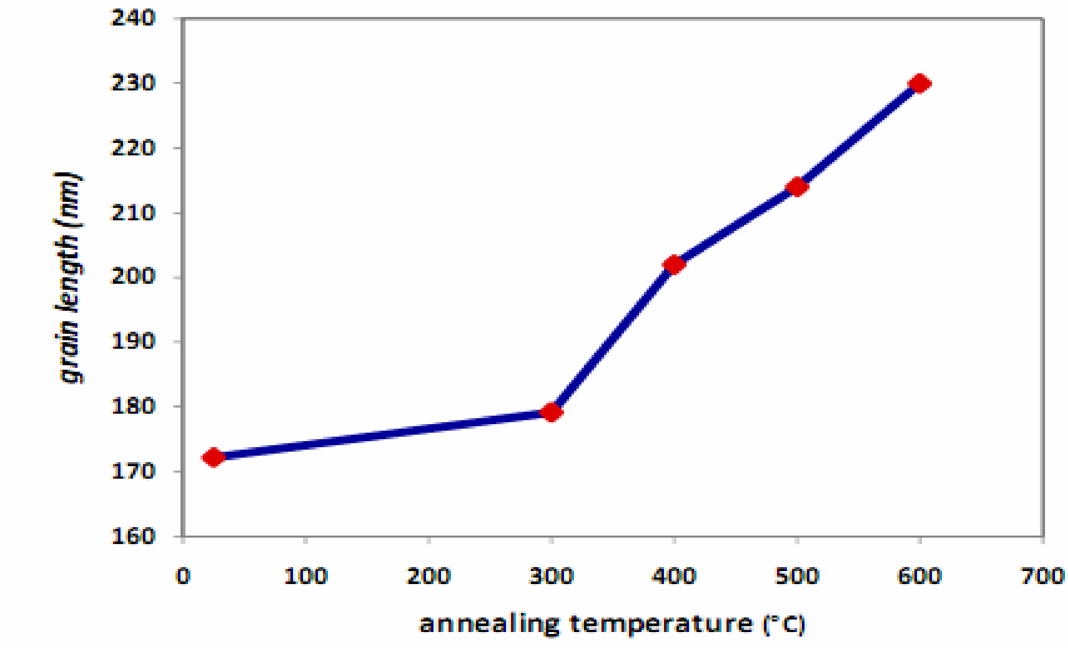

Fig. 15: The relation between grain length of SiO_2 nano film (measured by AFM) and annealing temperature

CONCLUSIONS

Using Atomic Force Microscopy device is useful method to study characterizations nanotopography of the SiO_2 nano film which vary with the change of annealing temperature. And all of the following characteristics, root mean square RMS surface roughness of the SiO_2 nano film, grain area, grain volume and grain length increases with the increasing in annealing temperature.

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