

The Effect of the (Nd-YAG) Laser on Some Structural Properties of Thin Film Nan Scale Zinc Oxide Prepared by Sol-Gel Method and its Applications in Renewable Energy Sources

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Abstract. In the current research, ZnO films were prepared on glass bases using the gel-liquid technique, with different thicknesses (150-300 nm), and at different temperatures. The prepared films were baked in a convection oven at 400°C - 500 - 600 degrees, respectively, for half an hour.

Introduction

Thin films receive great attention for their use in the manufacture of many components of thin electronic devices, detectors, and interference filters. They are used in a large number of optical fields, such as the manufacture of mirrors and glass panels sensitive to the electromagnetic waves. They are also can be used in the manufacture of the integrated electrical circuits [1]. Thin films possess properties and features that may not be present in other types of material, as their thickness being extremely small gives it a rare crystalline structure that is close to the characteristics of a monocrystalline structure [2]. Thin films have been used in magnetic memory devices and in integrated circuits, and they have been used in open and closed circuits, and in the manufacture of rectifiers, transistors, amplifiers, and detectors. Solar cells, and bolometers. With the increase in scientific and technological progress, methods for preparing thin films have developed and become highly accurate in determining the thickness and homogeneity of the film, and each method has its own specificity and privileges to fulfill the purpose for which it was created [4].

The experimental work

The sol-gel method was used to prepare the models by dissolving aqueous zinc acetate in distilled water. The films were deposited on glass substrates at room temperature with a thickness of (150,300 nm). The films were annealed at a temperature of (400-500-600). And for a while. 60 minutes in a convection oven (traditional annealing), after which annealing was done using a green (Nd-YAG) laser with a wavelength of 532 nm and a power of 1000 milliwatts, with different time periods (20-30-40 sec).

Results and discussion

The structural properties of any semiconductor material are among the important properties that must be known in order to be able to use this material in industrial applications. These properties include

measuring the structural properties, and the structural properties are represented in the results obtained from X-ray diffraction examinations (XRD) and the scanning electron microscope (SEM).

1- X-Ray Diffraction (XRD): This spectroscopic technique was used to identify the crystalline structure and structural parameters by providing us with a spectrogram of the diffraction when it passes through the prepared films annealed in a thermal oven, as well as annealed with a laser, to determine the extent of the effect of laser annealing on these films.

Crystal structure of zinc oxide thin films

The results of the diagnosis using (XRD) technology for the prepared (ZnO) films showed that they have a polycrystalline structure of the stacked hexagonal type, and for all films annealed in the oven as well as by laser, as in the sources [5][6], and they match to some extent when compared with the cards of the American Standard for Testing Materials Corporation. To examine materials, we notice the appearance of diffraction peaks corresponding to the planes (100), (002), (101), (102) and (110) with a small displacement of some of these peaks. The reason for this may be due to mechanical microscopic stress resulting from various sources such as impurities, defects and voids inherent in The membrane even after heat treatment, as the dominant direction in the membranes depends on the coating method used, [7] so we notice that the dominant direction varies from one membrane to another, as the directions differ from each other, and the reason for this tendency in crystallization is due to the model of survival of the fastest, where I assume that the process of surface formation is more than A direction in the early stages of membrane growth. Then these directions begin to compete during its growth, so the faster molecules of matter continue to grow while the growth of other nuclei stops. [8] We can also notice from the XRD pattern of laser-annealed films the presence of additional peaks at a number of angles that do not belong to the crystalline structure of the material used, and the number of these values increases with increasing annealing time. This indicates that the high laser energy led to the formation of effective scattering centers and may work to create sniping levels at the grain boundaries. It works to trap charge carriers and stop them from moving in their positions, especially since the annealing took place without air, and thus affects the structural properties of the membrane.

ZnO	2 θ °	Int.	(hkl)
Rad: CuKα1	31.769	57	(100)
λ: 1.5405981	34.421	44	(002)
a=3.249	36.252	100	(101)
c=5.206	47.538	23	(102)
Mineral name: Zincite, syn	56.602	32	(110)

Figure (1): Part of the international card for ZnO, card number (ASTM/36-).

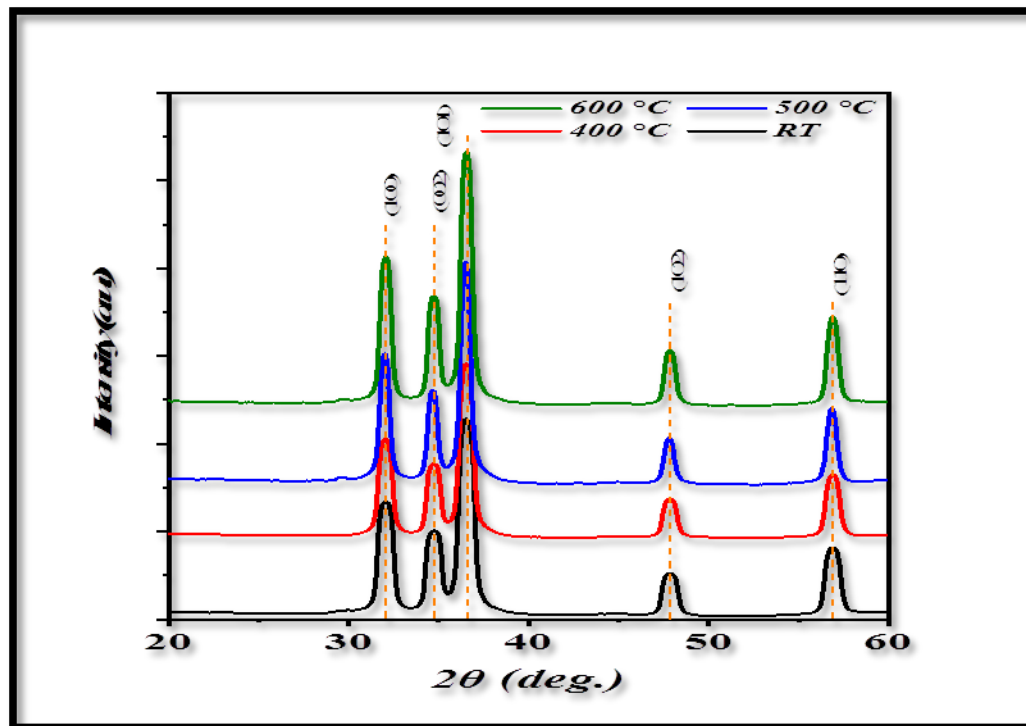


Figure (2) shows an XRD scan without an annealed laser at different temperatures.

Table (1): showing an explanation for the examination without a laser.

Sample	2θ	Cos θ	FWHM	d-spacing [Å]	βhkl	t(nm)
RT	36.5341	0.950	0.876	2.45955	0.015	9.573
400 °C	36.5475	0.950	0.788	2.45868	0.014	10.639
500 °C	36.4819	0.950	0.668	2.46295	0.012	12.548
600 °C	36.5236	0.950	0.620	2.78931	0.011	13.521

The inter planar distance (d) between the levels was calculated from Bragg's law and the width of the diffraction peaks (FWHM) was calculated, as well as the grain size was calculated from the Scherrer relationship as in the table above, which shows that the values of (d) between the levels remain approximately constant with increasing the annealing temperature as well as increasing the annealing time. With laser. Which indicates that the laser ranges did not affect these values for these membranes? Increasing the annealing temperature in the oven led to a reduction in the FWHM values and thus the grain size would increase. Also, increasing the duration of the laser annealing led to similar results in terms of improving the degree of crystallization of the material, narrowing the diffraction peaks, and increasing The granular size is consistent with the source [5], as increasing the annealing duration at high energy leads to an increase in temperature and thus an increase in the granular size of the membranes. From these results, the annealing duration (30) minutes can be considered relatively the best under the conditions for preparing the membranes.

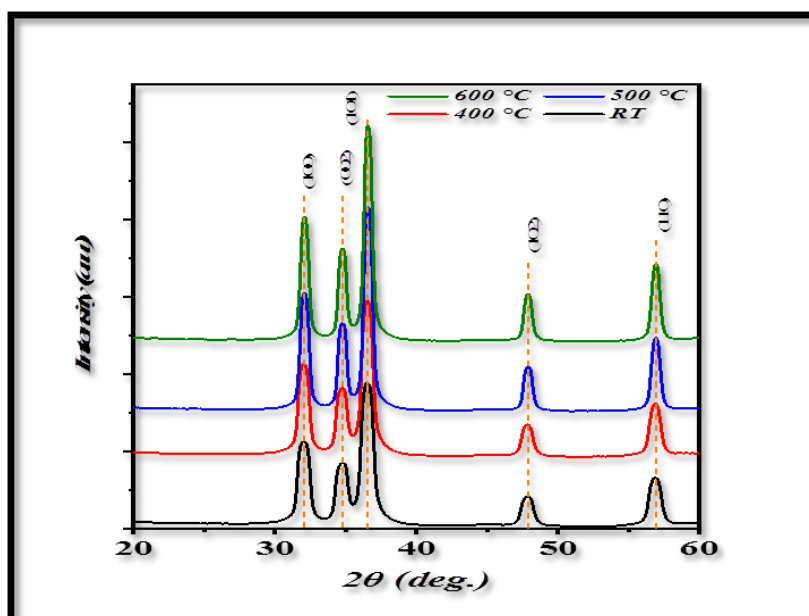


Figure (3) shows the XRD examination of films annealed in a furnace and irradiated with a blue laser.

Table 2: In-depth XRD parameters of the prepared nanoparticles with blue laser effect.

Sample	2θ	Cos θ	FWHM	d-spacing [Å]	βhkl	t(nm)
RT	36.5064	0.950	0.93874	2.46135	0.016	8.930
400 °C	36.6326	0.949	0.84865	2.45316	0.015	9.881
500 °C	36.5773	0.949	0.67215	2.45674	0.012	12.474
600 °C	36.5836	0.949	0.63311	2.47543	0.011	13.243

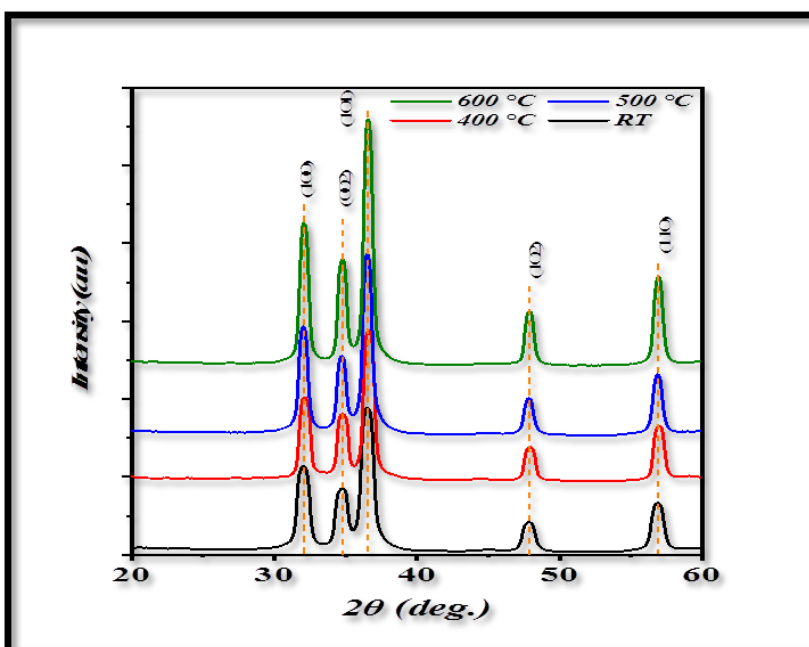


Figure (4) shows the XRD examination of films annealed and irradiated with green laser.

Table3: In-depth XRD parameters of the prepared nanoparticles with green laser effect.

Sample	2 θ	Cos θ	FWHM	d-spacing [Å]	β hkl	t(nm)
RT	36.5064	0.950	0.93872	2.46135	0.016	8.930
400 °C	36.5641	0.950	0.79136	2.4576	0.014	10.594
500 °C	36.5139	0.950	0.7235	2.46086	0.013	11.586
600 °C	36.5036	0.950	0.67216	2.45921	0.012	12.471

2-Scanning electron microscope (SEM)

It is one of the powerful techniques used in studying the surfaces of prepared materials. This technique produces images of the materials as their surfaces are scanned with focused electronic beams. The electrons will interact with the atoms of the material and thus we obtain a signal that contains information about the morphology of the surface and the components of the material it is made of [9]. The SEM has high accuracy due to its high-energy, short-wavelength electron beam. It gives high-resolution images of material surfaces at a size of less than one nanometer, due to very narrow electron beams. The scanning electron microscope also has a wide range of magnification power from 10-500,000 times, compared to better magnification power than another optical microscope. As for the samples that must be examined with an SEM, they must usually be dry and hard, such as wood and bones. The reason for this is that the samples placed inside the device's chamber are exposed to high vacuum. As for soft samples, such as living cells and tissues, chemical stabilizers must be used to preserve and stabilize their structures. [10].

The outer surface of zinc oxide was studied using a scanning electron microscope. We found that the prepared films were all nano-structured and had a spherical surface for the films prepared from ZNO after annealing. Figure (5) (6) shows the thin films prepared by the sol-gel method, annealed at a temperature of 600 degrees Celsius and irradiated with a laser. Green: We conclude from all the shapes that the particles have nanoscopic diameters and spherical shapes, and the interaction between the laser and the prepared films was demonstrated.

Figures (7) (8) of the prepared films annealed at a temperature of 500 C. We note that the particles are nano-diameters and spherical in shape. We notice an increase in the diameter of the particles when exposed to the green laser, which indicates the occurrence of an accumulation of particles under the influence of laser rays.

As for the shapes (9) and (10) of the films prepared from ZNO, annealed at a temperature of 400 C and irradiated with a green laser, these images show the shape of the nanoparticles and it becomes clear that they are spherical in shape and their diameters range from 9.03 to 13 nanometers.

Figures (11) and (12) of films prepared from ZNO material without irradiation and without annealing. The films in the picture do not show the shape of the particles and the nature of the surface.

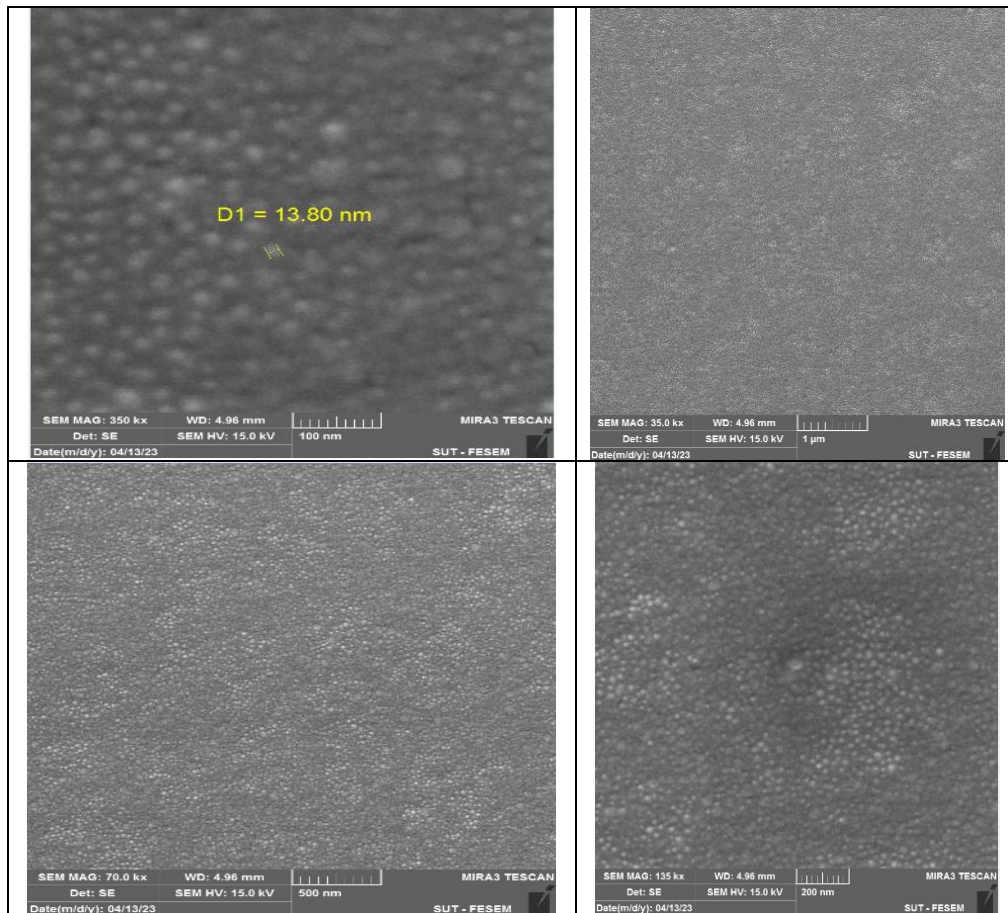
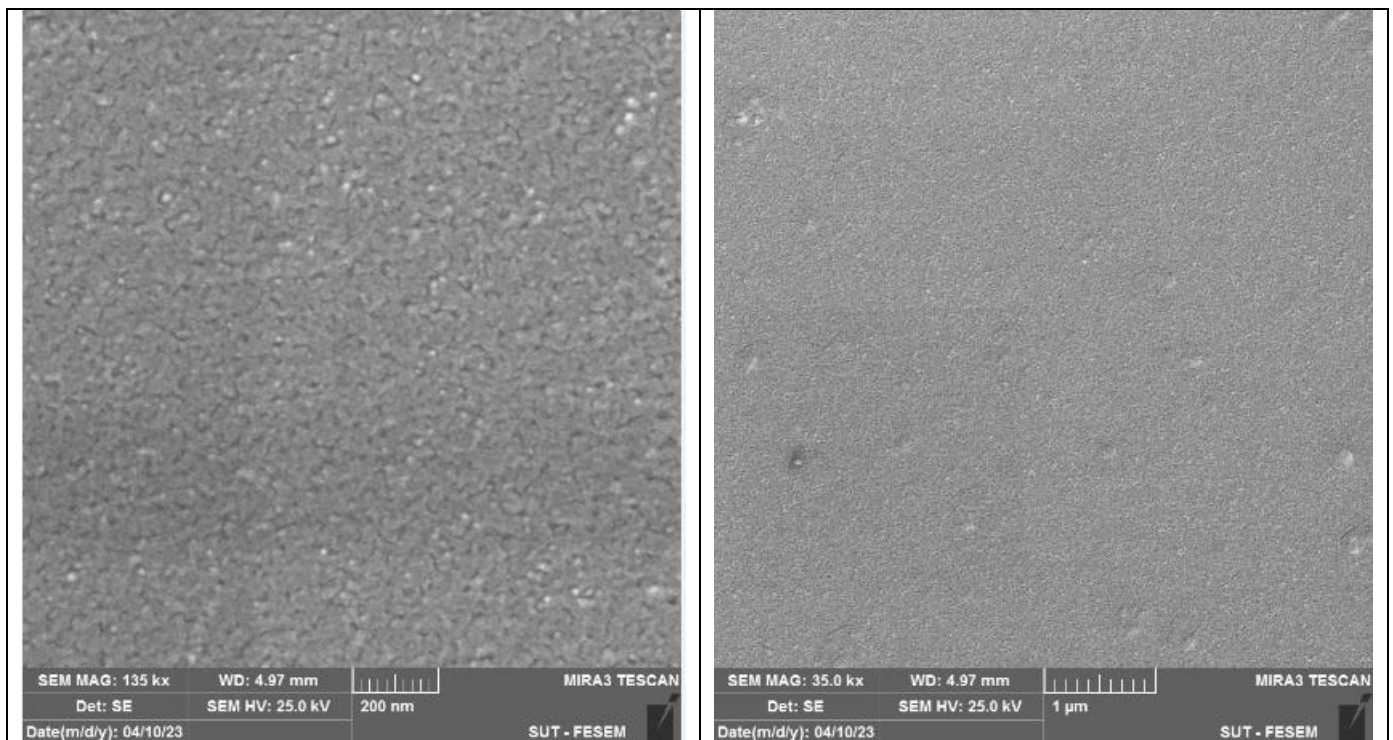


Figure (5) shows an SEM examination of a C600 annealed membrane irradiated with a green laser



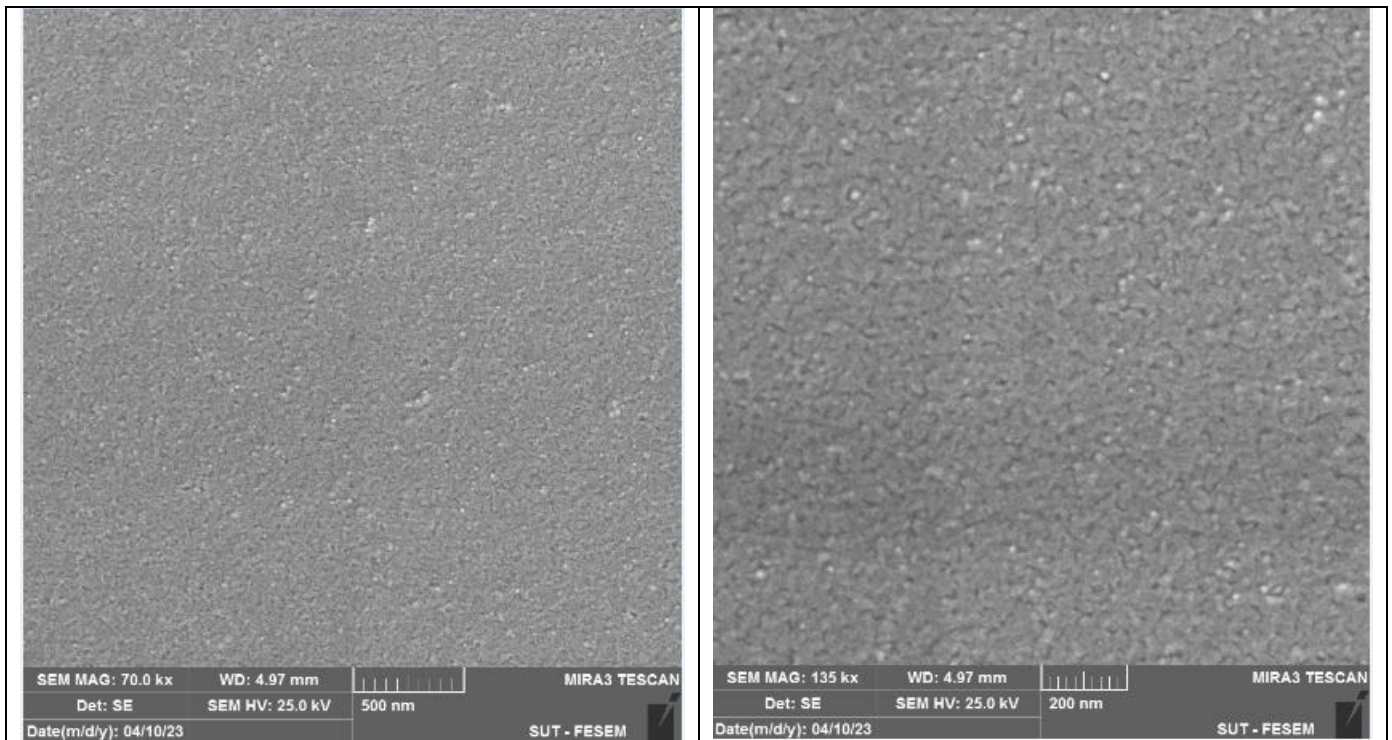
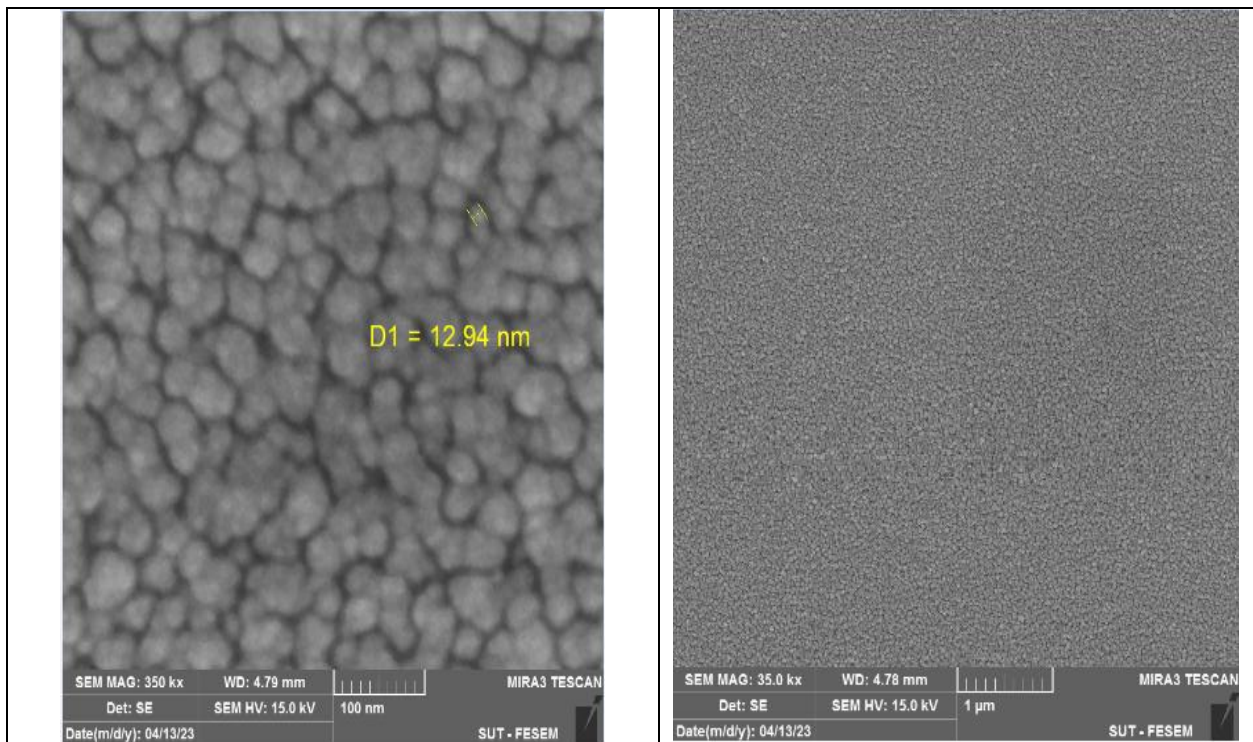


Figure (6) shows a film at a temperature of 600 C without irradiation



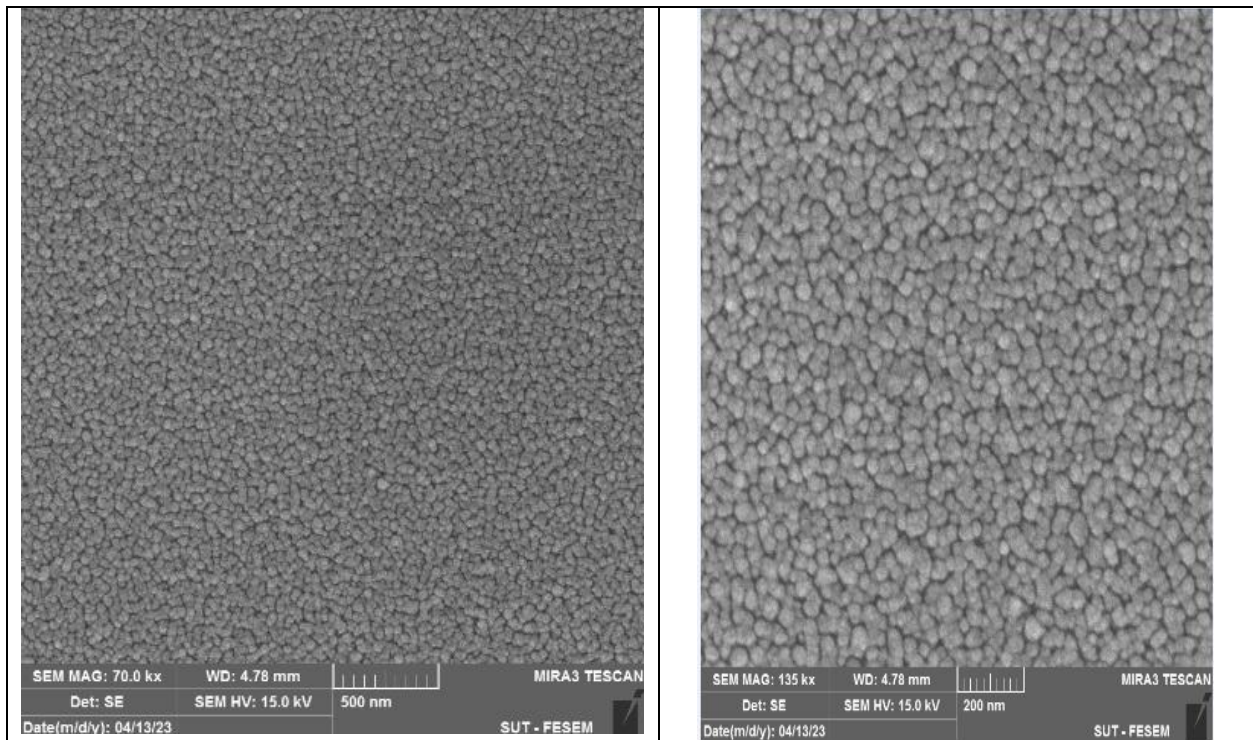
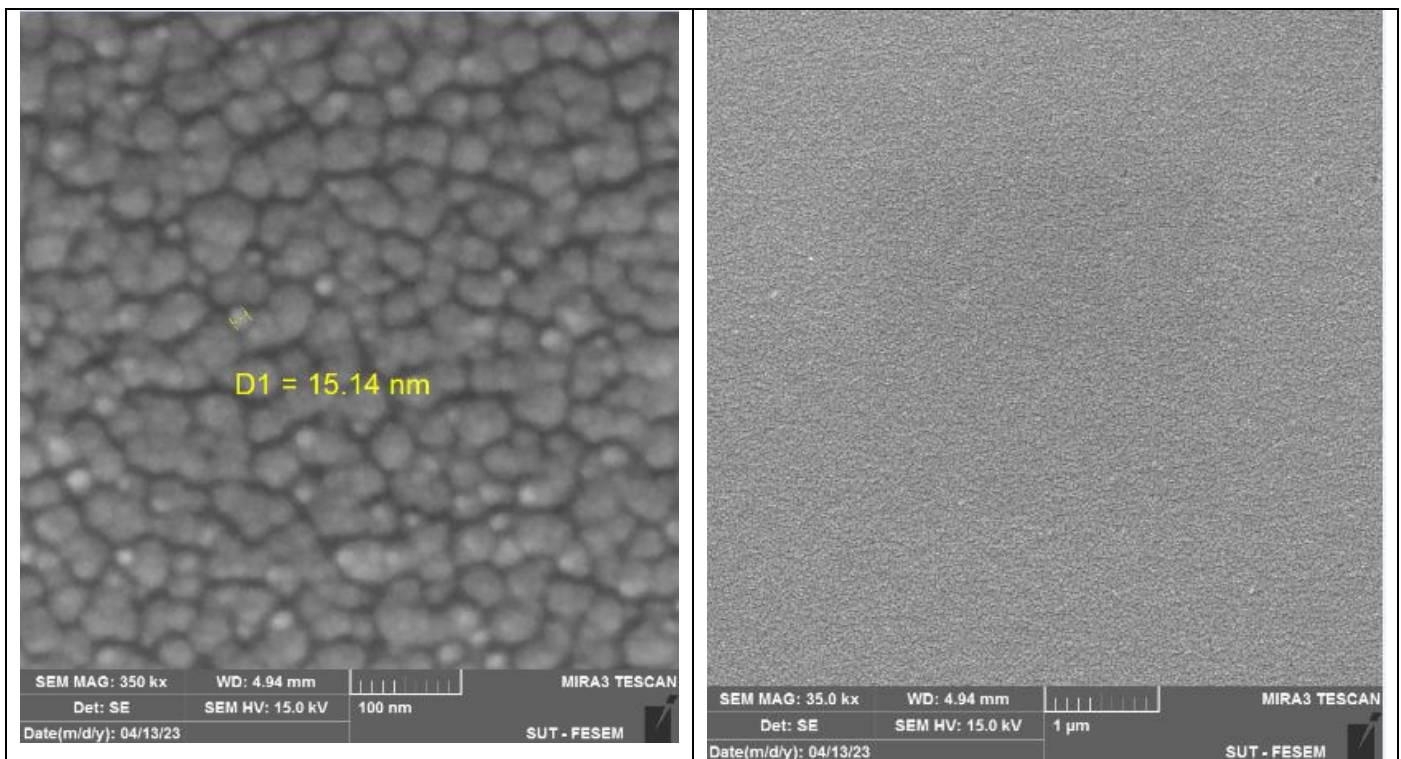


Figure (7) shows a film at a temperature of 500 without irradiation



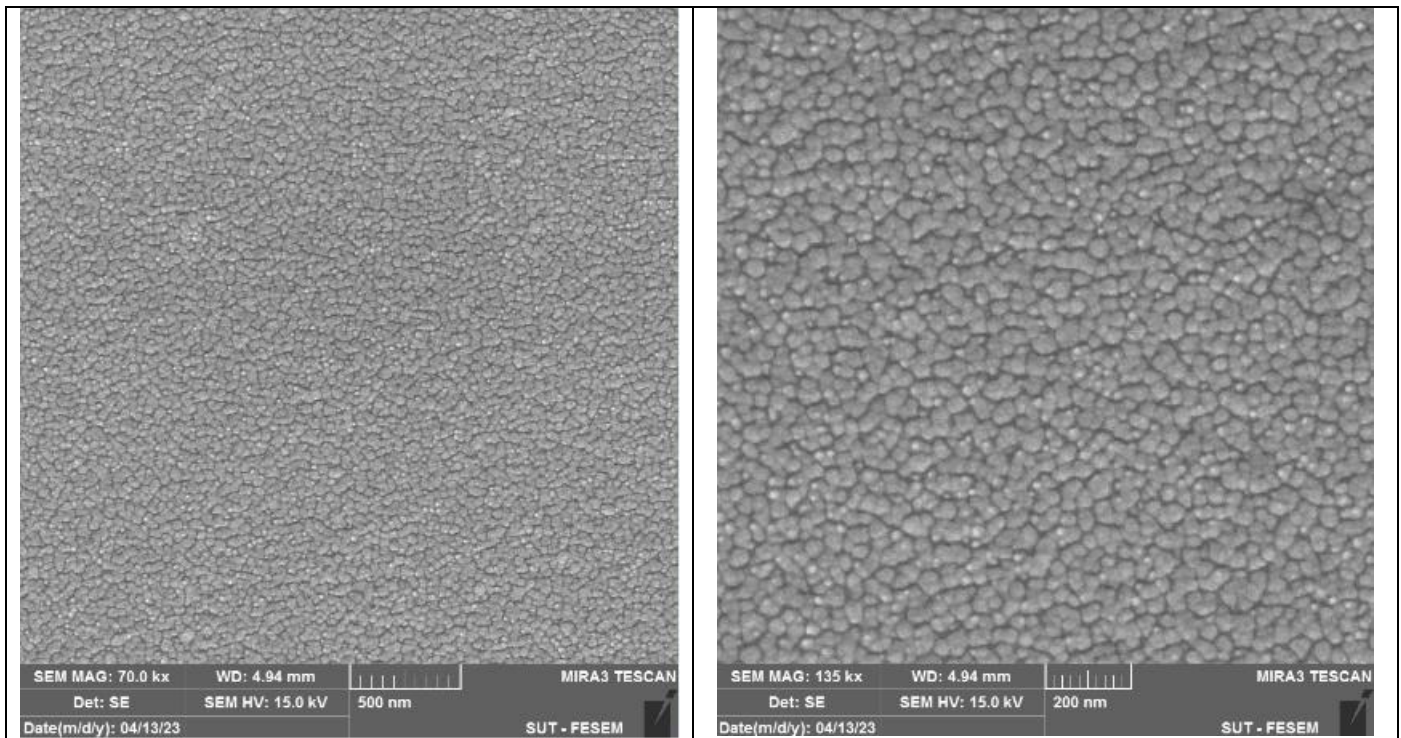
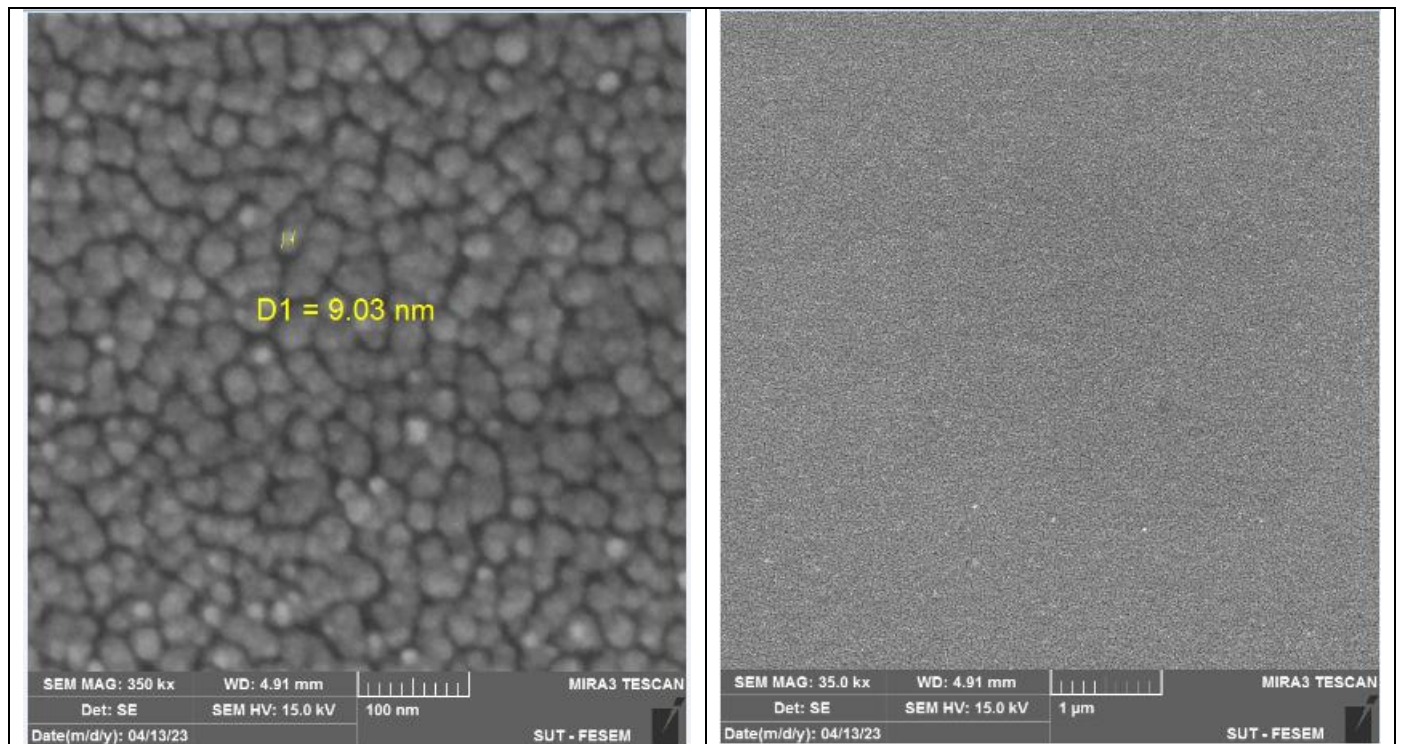


Figure (8) shows a film at 500 degrees Celsius irradiated with a green laser



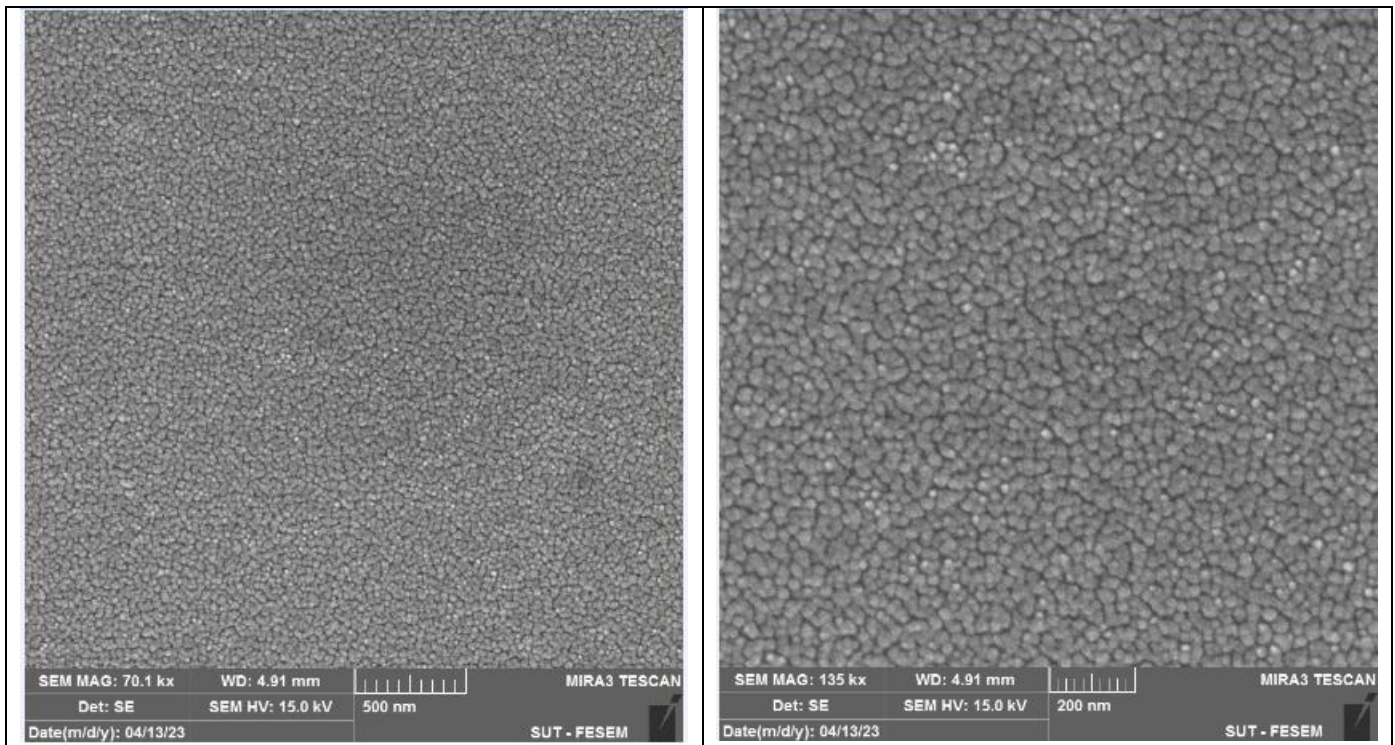
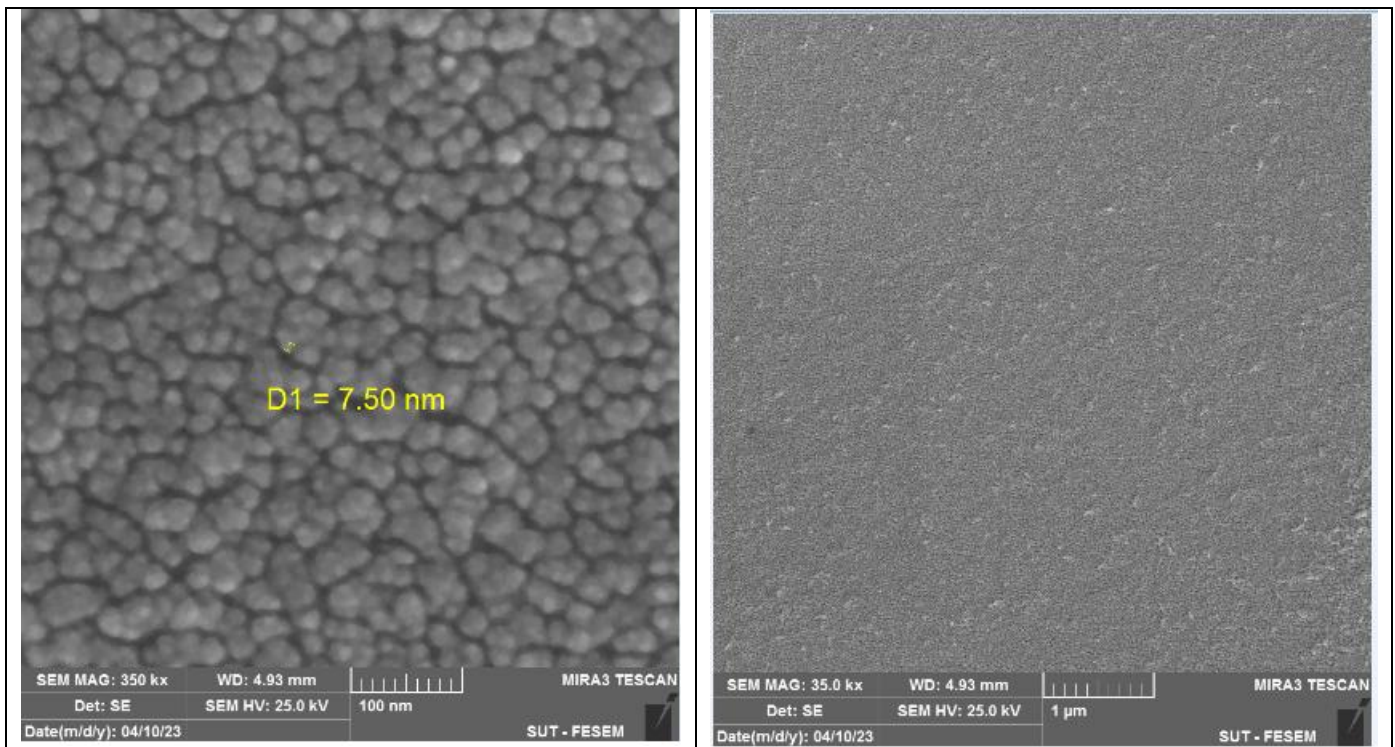


Figure (9) shows a film at a temperature of 400 and without irradiation.



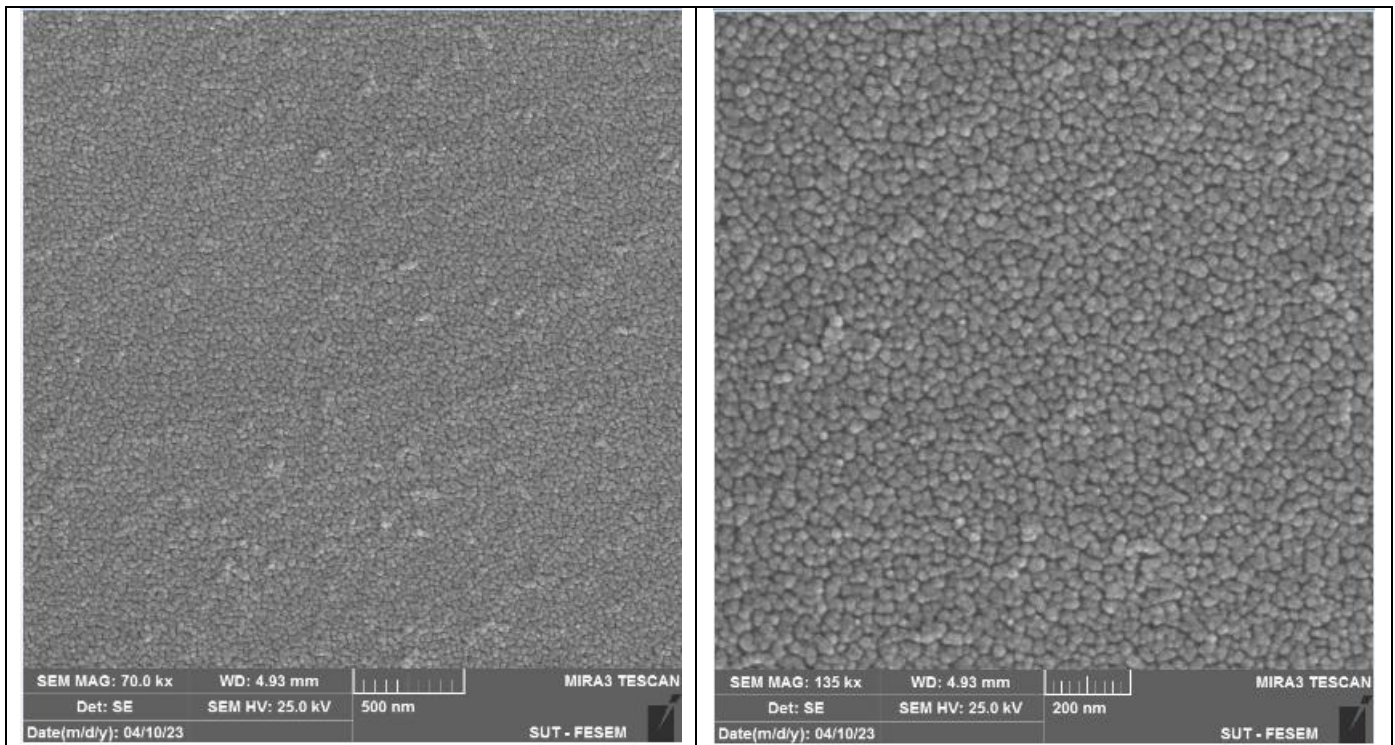
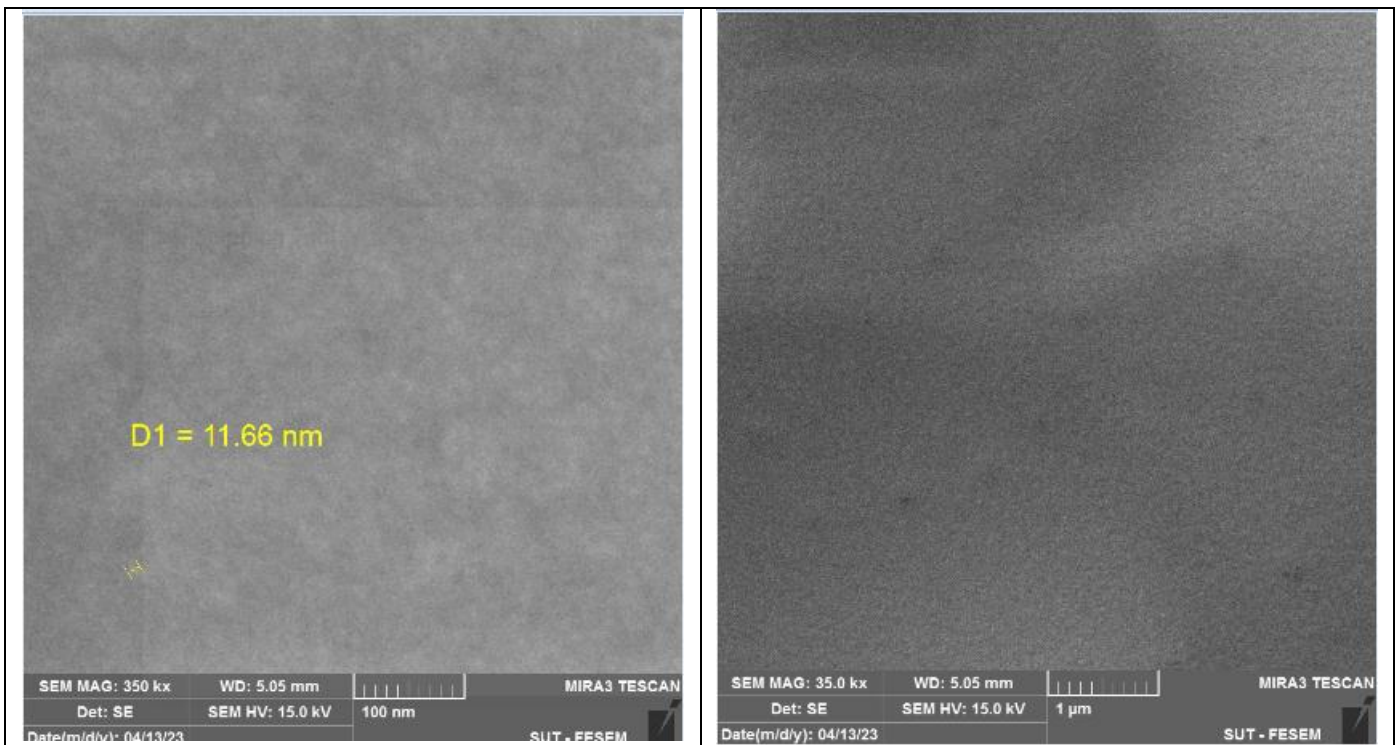


Figure (10) shows a 400 degree film irradiated with a green laser



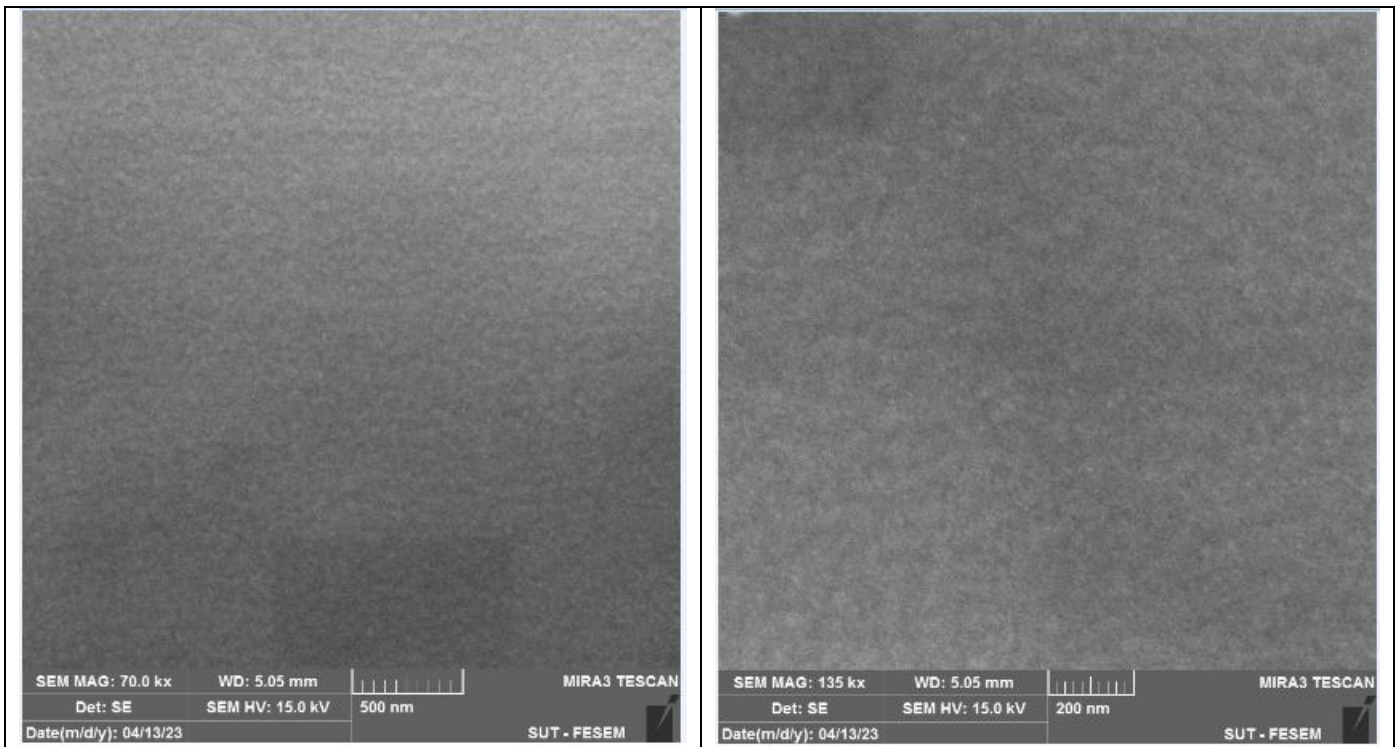
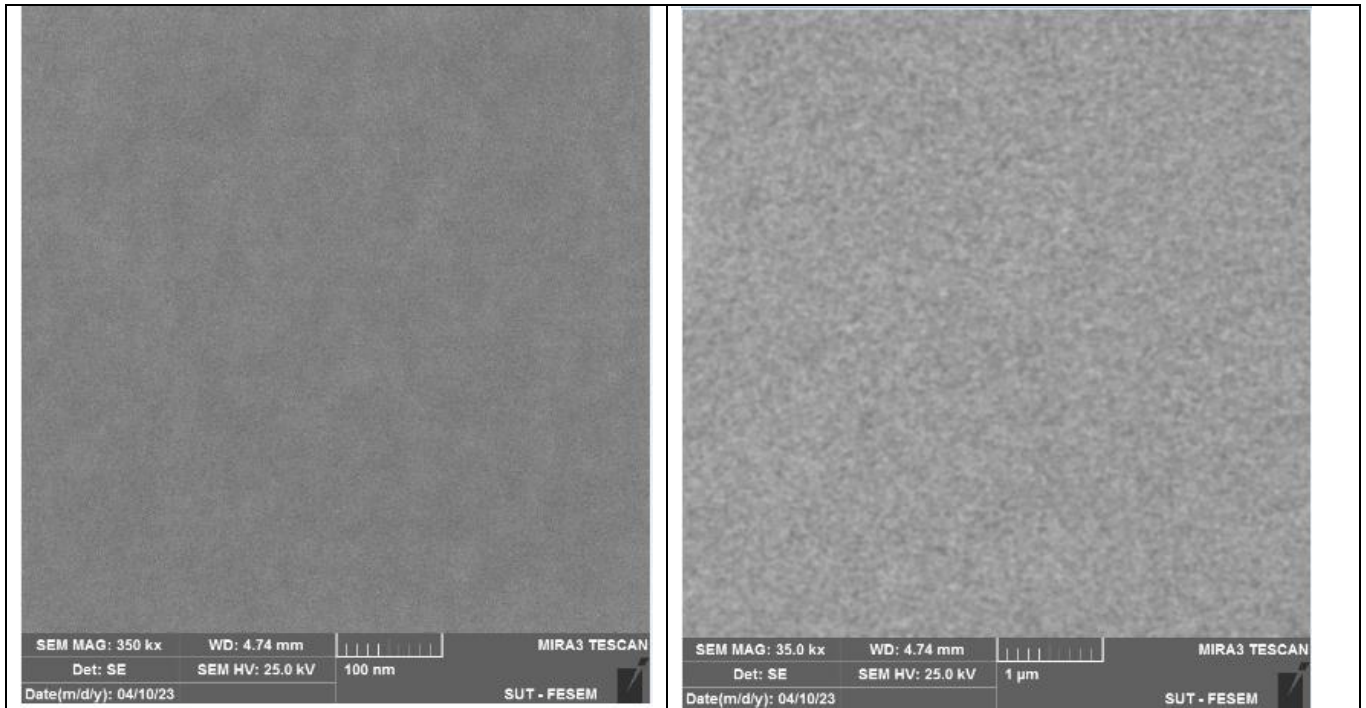


Figure (11) shows a film without annealing and without irradiation.



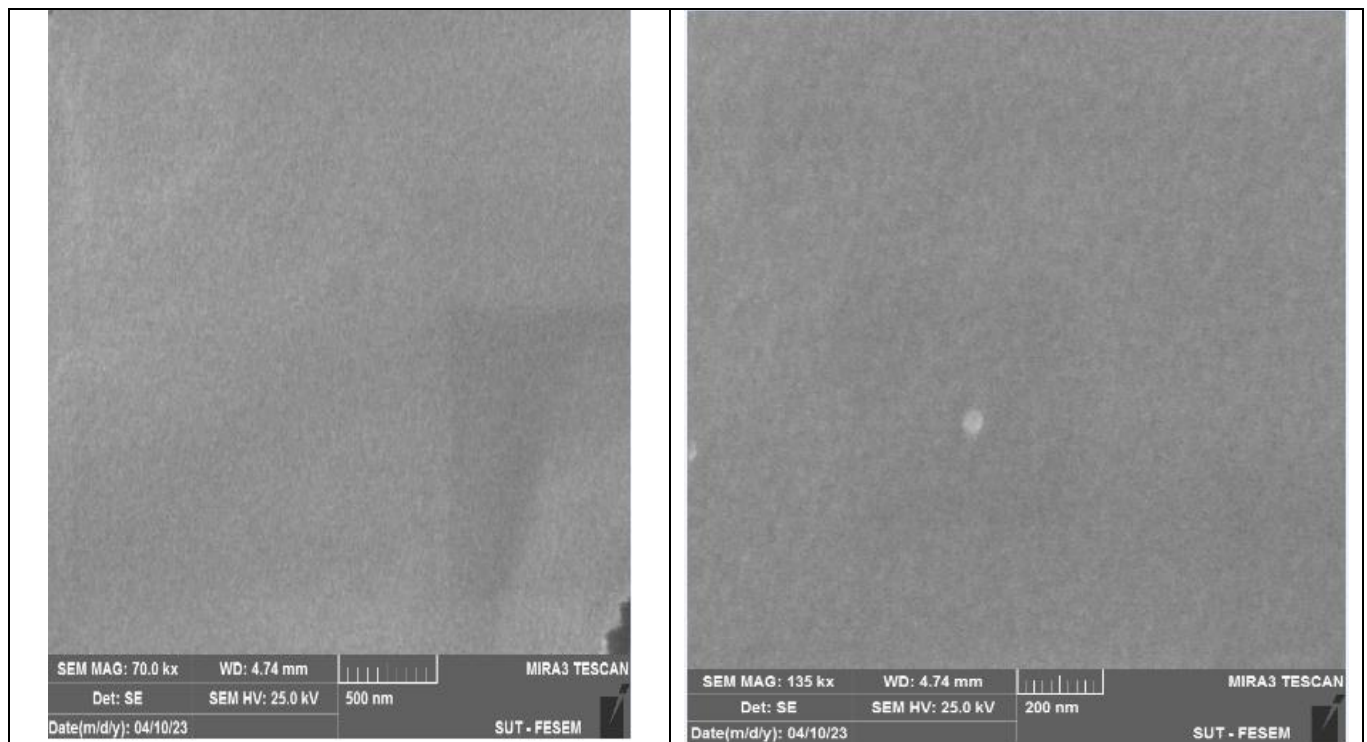


Figure (12) shows an unannealed membrane irradiated with a green laser.

Conclusions:-

In this research, it was shown that performing the annealing process and increasing the temperature together leads to improving the structural properties, which are represented by obtaining spherical surfaces with nanoscopic dimensions. Also, traditional annealing and laser annealing reduce structural defects and surface defects.

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