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Structural Properties of Carbon Nanotube thin Film Deposit by Pulsed Laser Depositions

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Abstract
This paper reports the structural properties of carbon nanotubes prepared with pulsed laser depositions. The films deposited on siliconssubstrated usedNd:YAG lasers (1064 nm) as the light source. The structured properties were characterize by X-ray diffraction, atomic force microscopy and FSEM measurements. That films grown have a polycrystalline structure at three energies 300J, 400J, 500J, from the X– ray diffraction spectra of carbon nanotube that there are three peaks at three energies and at 400 J the peak little shitted off, AFM result showed increased of roughness and root mean square with increased of energy, and FESEM showed a homogenous pattern and formation.
Keywords: carbon nanotube, pulse laser deposition, X-Ray Diffraction, Morphological Properties.

1.Introduction

Carbon nanotubes were discovered in 1991 by the Japanese electron microscopes SumioIijima. He found that the central core of the cathode deposit contained a variety of closed graphitic structures including nanoparticles and nanotubes with outer diameters of 4 - 30 nm and length of 1 µm.10 Since these tubes consisted of multiple shells where many tubes are arranged in a coaxial fashion and tube diameter is of the order of nanometer he called these tubes multi - wall nanotubes (MWNTs). (1)

Since their discovery in 1991, carbon nanotubes have been the subject of extensive study. They have outstanding mechanical, thermal, and electrical characteristics. They have a high modulus, are stronger than steel, are thermally stable in vacuum up to 2800°C, have twice the thermal conductivity of diamond, and have 1000 times the electric current carrying power of copper wire. All of these properties open up the broad application areas for carbon nanotubes. (2) Some of the excellent properties of carbon nanotubes are a result of their high aspect ratio. The carbon nanotubes have long cylindrical structure with diameter at nm level and length at µm level, which makes their aspect ratio as high as 1000 or larger. The aspect ratio has significant effect on the properties of carbon nanotubes and their composites, which has been investigated theoretically and experimentally. Young' modulus of carbon nanotubes for axial deformation was studied by use of a non-orthogonal tight binding formalism. The results show that the modulus depends on the diameter when the tubes are small. (3,4)

Pulse laser deposition PLD is powerful and important technique for the growth of thin films of complex materials. It consists of three parts, laser, vacuum system and chamber. (5)

Aim of the work: Study the structural properties of carbon nanotube.

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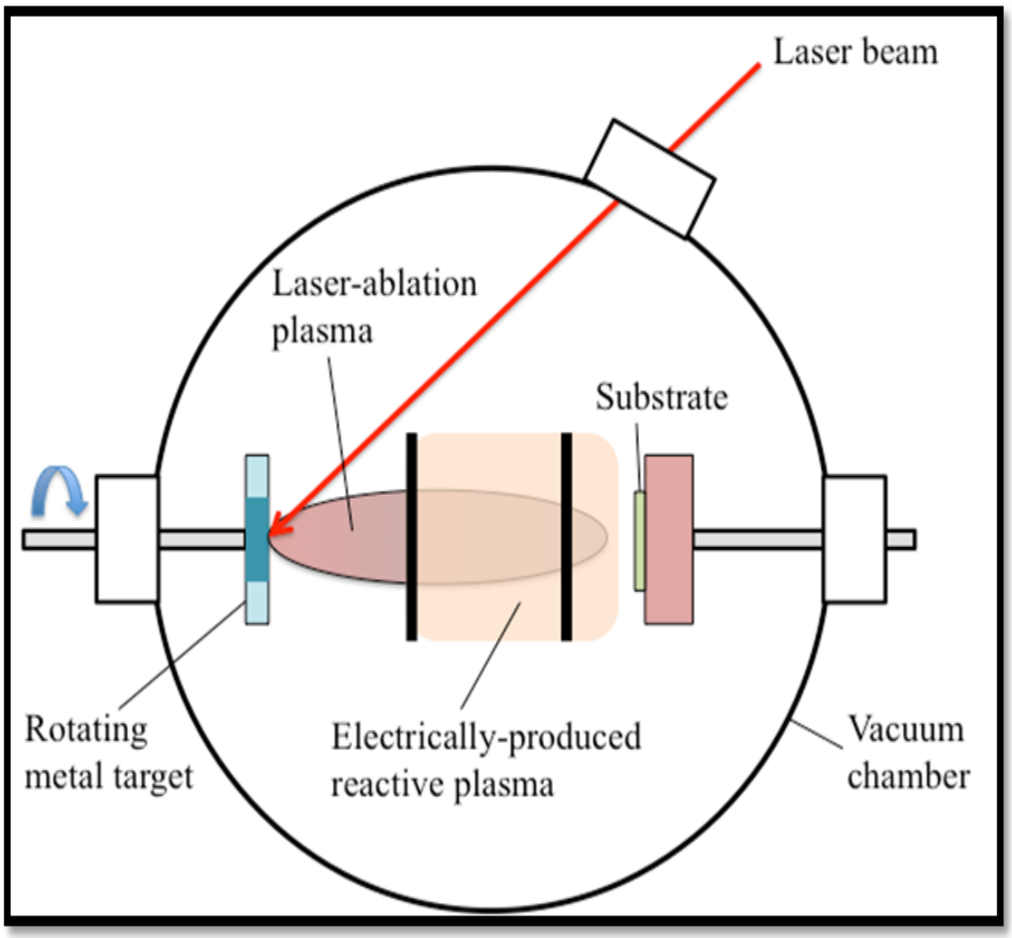
2. Experimental details

Carbon nanotubes thin film were deposit silicon substrate by Pulse laser deposit techniquesin three energy 300J, 400J, 500J as shown in Fig (1), where CNT pellets prepare with solids states reactions route methods which use as that targets materials (6). The film are deposit in a vacuums chambers use a 1064nm Nd:YAG laser. the pulsed repetitions rates is set at (6) Hz and the Energy densities of that lasers beams was (500) mJ/cm^2. The vacuums chambers was pump downs to a base pressure of(4x 10^{-2})mbar and the partial pressure of oxygen was 4 x 10^{-1}mbar. The target to substrate distance maintained at (10 cm). Crystalline quality and crystal orientation of prepared thin films were investigated by the X-ray diffraction technique (7).



Fig(1): Schematic diagram of a typical laser deposition set-up. (8)

3. Results and discussions

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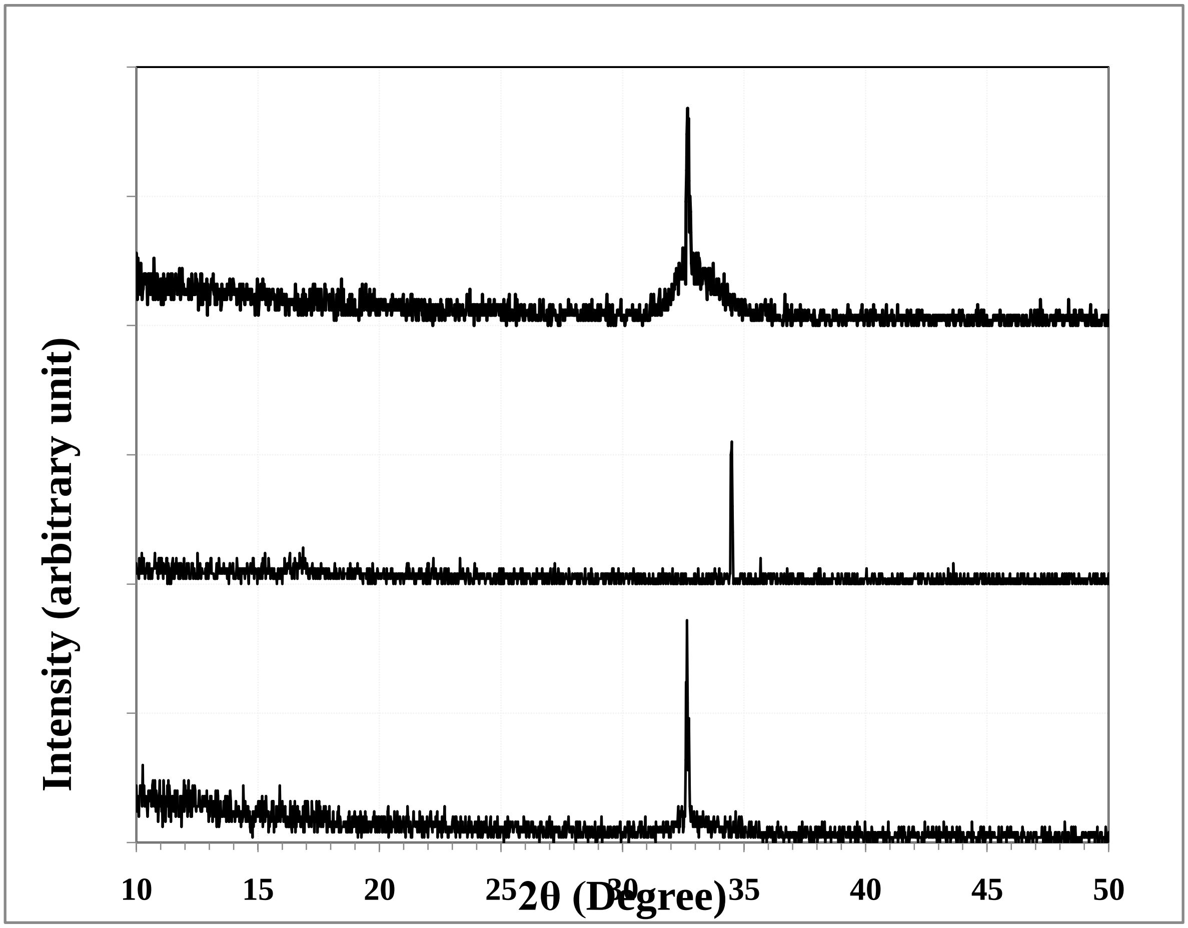
X-Ray diffraction

Fig.2 shown the XRD patterns of CNT nanotubes. The diffraction peaks position at 2θ=32.5°, 34.5°and 33° assigned to (111) orientation planes of carbon nanotubes with hexagonal wurtzite structure were observed. However, diffraction peak of CNT were polycrystalline.

Fig(2): XRD spectrum of carbon nanotube thin film with thickness of 100 nm grown on Si (111) substrate at (300,400,500) J.



Atomic force microscopy

The surface roughness of the thin films is an important parameter which beside describing the light scattering at the surface, gives a significant indication about the quality of the surface under investigation. The increase in surface roughness of the films leads to increase in efficiency for sensing properties, therefore, it is very important to investigate the surface morphology of the films. 2D and 3D AFM images of thin films are shown in Fig (3). It shows that the morphology of thin films has larger intensity of grain size, which indicates the crystalline nature of the films

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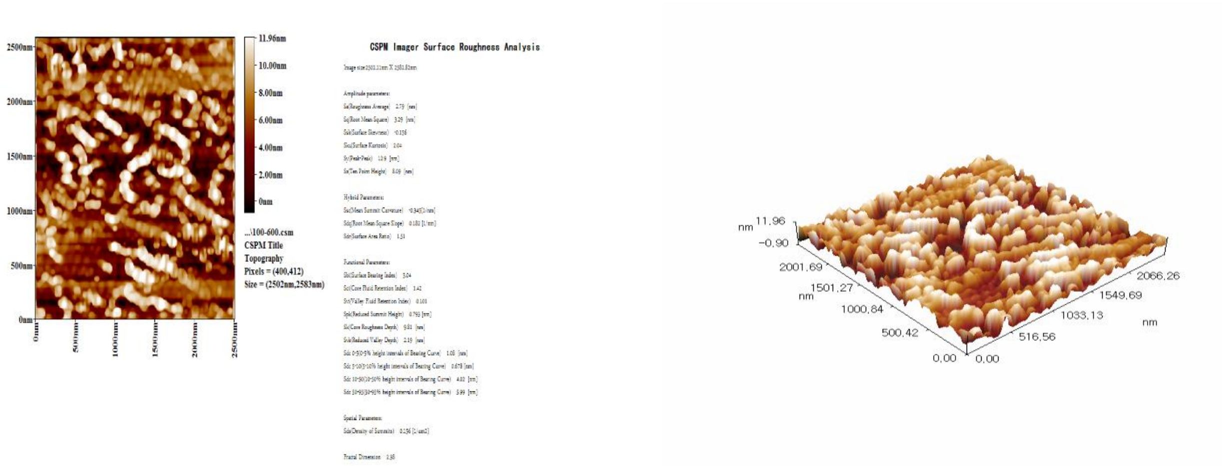
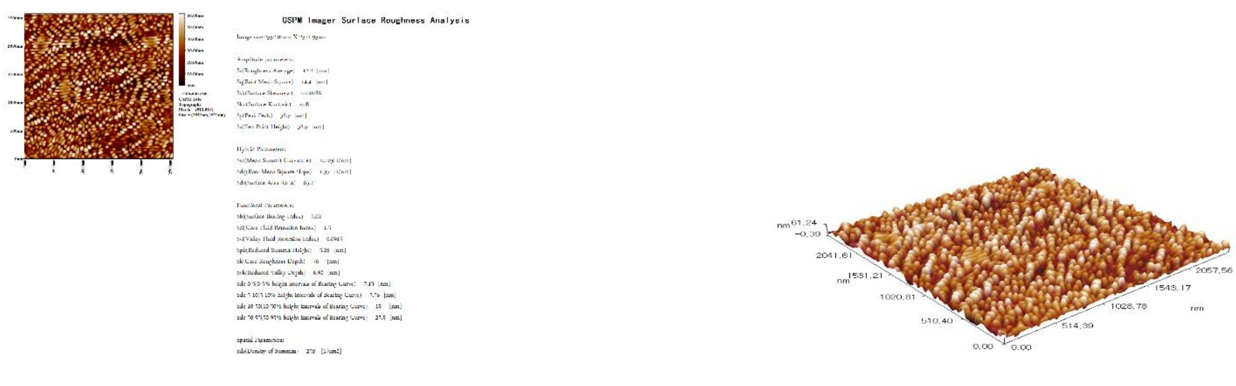
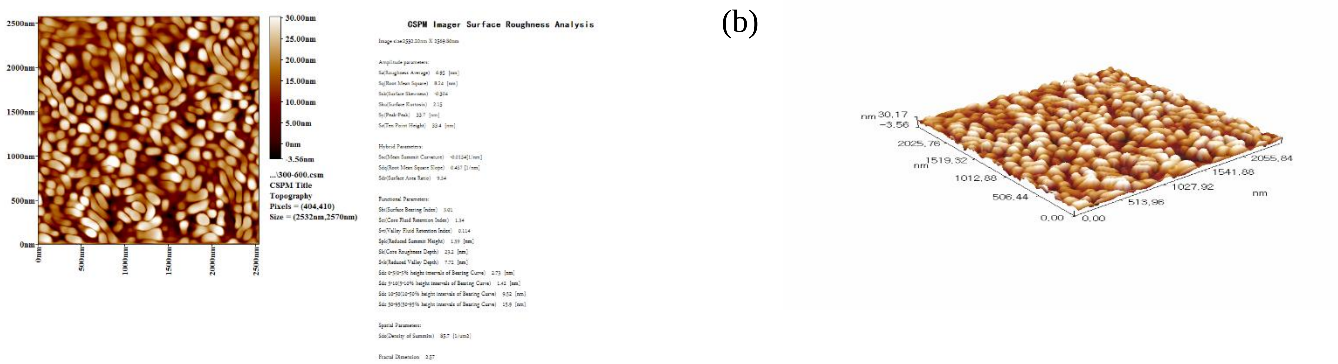


is of high crystallinity and good surface morphology. It is known that the granular thin films show higher surface area.

(a)



(b)



(c)

Fig (3): 3-D AFM images of carbon nanotube thin films grown on Si (111) substrates with three different energies a- 300 J b- 400 J c- 500 J.

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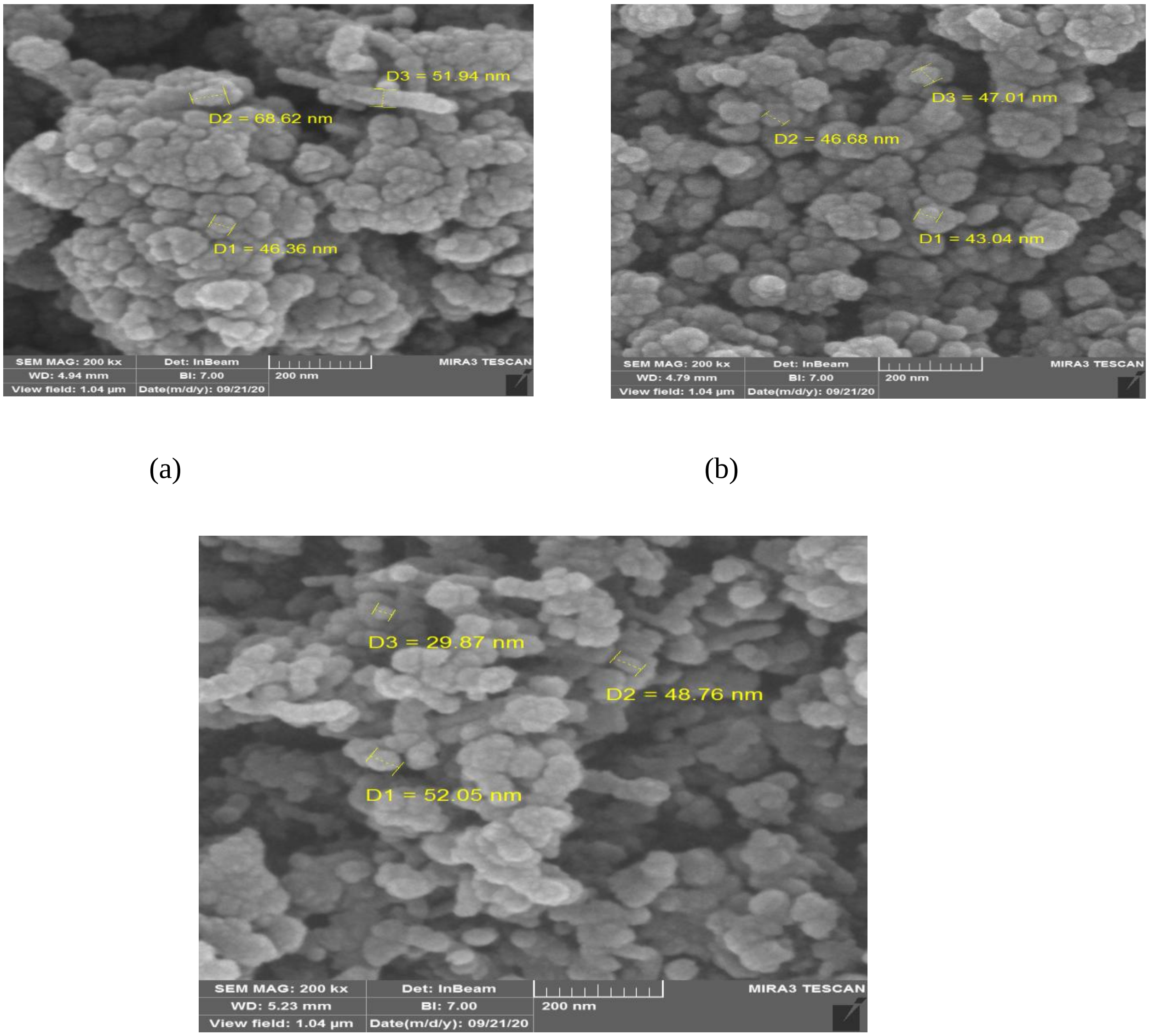
Scanning Electron Microscopy

It is clear that the particle size of pure carbon nanotube was decreased from 50 nm to 29 nm when the energy increased from 300 J to 500 J with no significant change over all the area. However as shown in Fig (4).



(a) (b)

(c)

Fig (4): SEM images of carbon nanotube thin films grown on Si (111) substratesa- at 300 J, b- 400 J, c- 500 J.

4. Conclusions

1- Carbon nanotube deposited on n- type wafer silicon with pulse laser deposition.

2- XRD spectra show the formation of multi carbon nanotube and that the structure decrease, the particle size layers is nanostructured in nature and this decrease.

3- The atomic force microscopy investigation shows the increase in roughness surface with increasing in etching time, the small pores exhibit sponge like giving rise to smaller pore diameter.

4. The Field emission scanning electron microscope (FESEM) image of PS at different etching time. shows a homogeneous pattern and confirms the formation of uniform films structures.

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