Effect of ultra - violet laser treatment on multi - wall carbon nanotube surface

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Abstract

Well-aligned multi-wall carbon nanotubes (MWCNTs) have been grown on both Corning glass and silicon substrates at about 400 ℃ by a modified plasma - enhanced chemical vapor deposition system. We have investigated laser irradiation effect on carbon nanotube surface by using an ultra - violet laser. The laser operated to modify structural defect of was carbon nanotube and to ablate possible contamination of carbon nanotube surface. The morphology and surface transformation of MWCNTs as analyzed by a SEM. In addition, the field emission measurement was also carried out in a vacuum chamber with a 10^{-7} Torr base pressure by applying bias voltages up to 1000V.

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1. Introduction

Carbon nanotubes have recently been attracted much attention because of its remarkable physical properties of effective field emission characteristic [1]. In this letter, MWNTs were grown by modified plasma enhanced chemical vapor deposition (PECVD). Laser irradiation effect on carbon nanotube surface with an ultra - violet laser source was investigated inside a high vacuum chamber to improve electrical performance of MWCNTs.

2. Experimental

We have reported the letter that well – aligned MWCNTs have been synthesized on substrates at low temperatures of 400℃ using a slightly modified PECVD [2]. Laser irradiation effect on carbon nanotube surface was carried out inside a high vacuum chamber. The laser wavelength used was 355nm with various parameters, such as laser power, and scanning time etc. Using laser irradiation processing on the MWCNT's surface their emission properties of MWCNTs were studied. The field emission measurement was carried out in a vacuum chamber with a 10^{-7} Torr base pressure by applying bias voltages up to 1000V.

3. Result and discussion

Figure 1 shows experimental setup for the laser treatment [2]. Figure 2 shows typical SEM images of well-aligned carbon nanotubes grown on Si substrates at 400°C. Figure 3 shows SEM images of CNTs after laser irradiation on carbon nanotube surface. It was clear that the length of MWCNTs was shorter than that shown in Figure 2. The morphology and surface transformation of the MWCNTs was slightly charged after the treatment. Also the laser irradiation eliminated contamination of MWCNT's surface, such as amorphous carbon. It exhibited that the surface length could be controlled by laser power, and scanning time. Turn - on voltage of the MWCNTs were also decreased after the treatment.

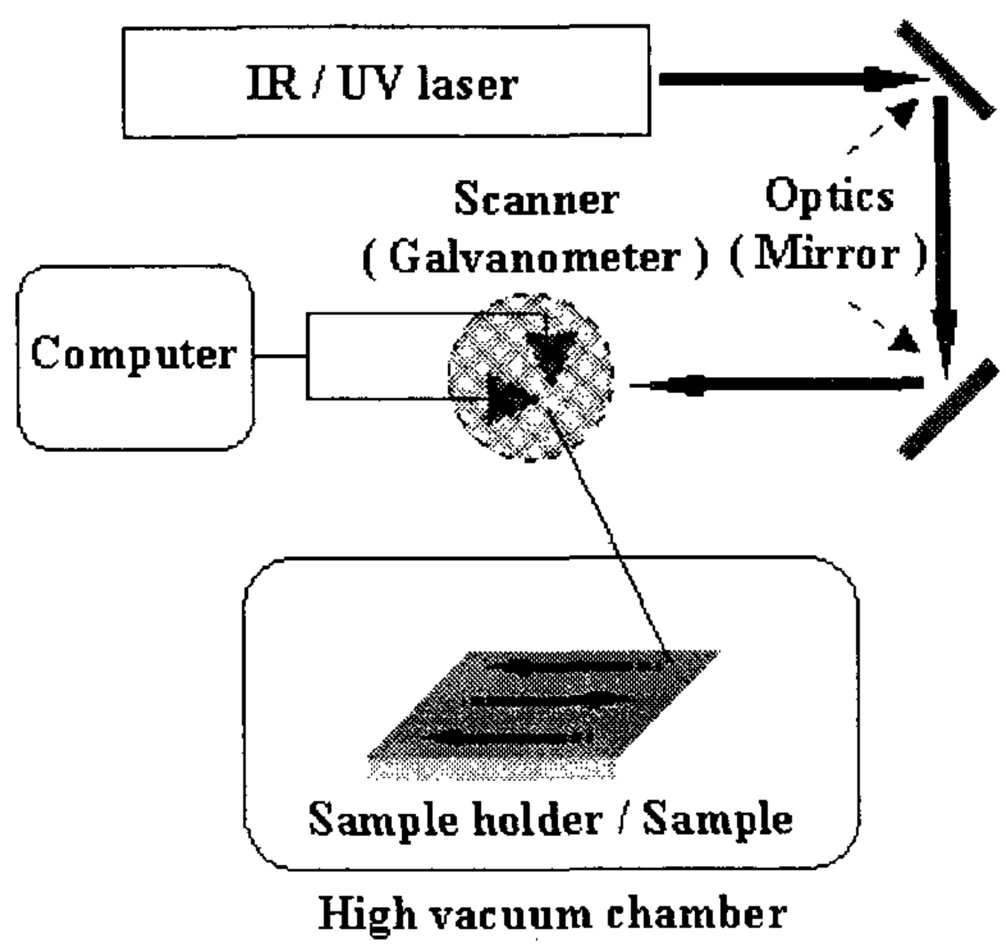

Fig 1. Experimental setup for the Laser treatment

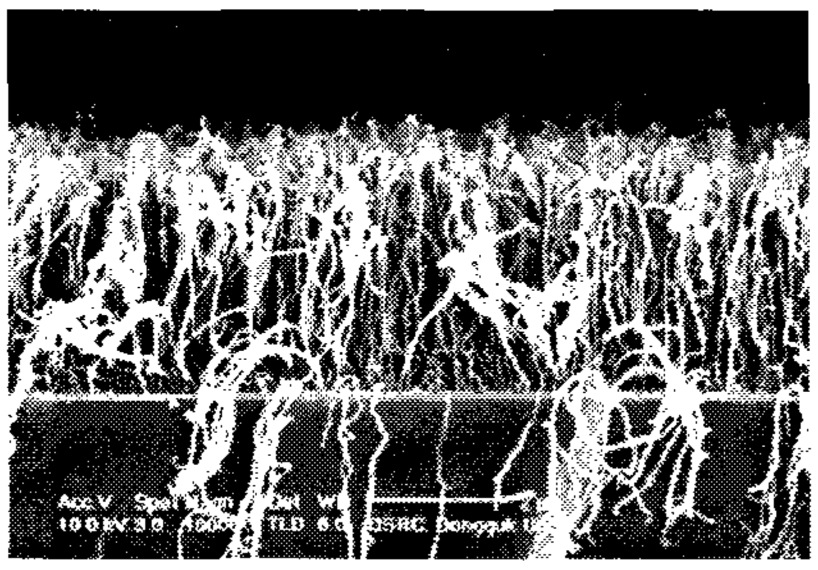

Fig 2. SEM images before the treatment

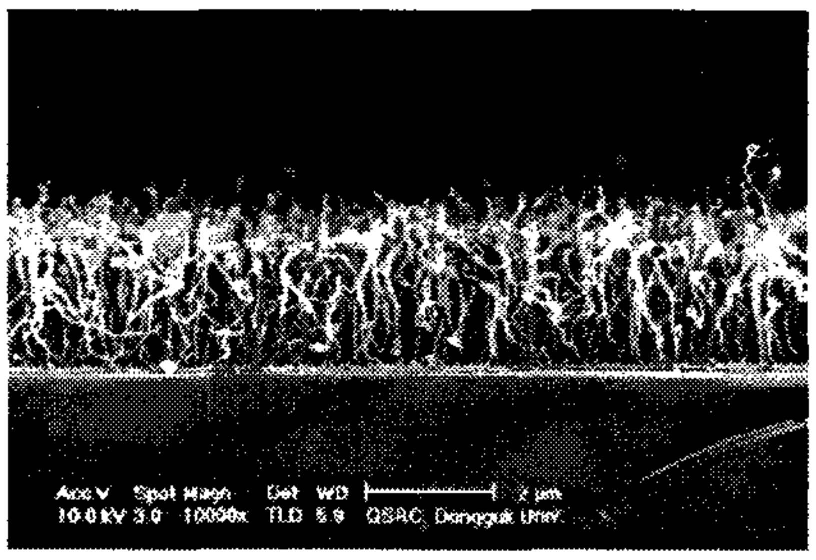

Fig 3. SEM images after the treatment

Figure 4 shows a typical Raman spectrum before laser irradiation on MWCNT's surface. Clear peaks were observed at three points - 1360 cm^{-1}, 1590 cm^{-1} .The spectrum peak at 1590 cm^{-1} (G-band) indicates one of the two E_{2g} modes of graphite crystal [3]. This means the formation of graphitized carbon nanotubes. The spectrum peak at 1260 cm^{-1} (D-band) indicates that carbonaceous particles exist near carbon nanotubes or adhere to the wall of carbon nanotubes. When the intensity of D-band (I_d) is larger than that of G-band (I_g), this means that carbon nanotubes grown at 400°C contain a large amount of carbonaceous particles. We will study Raman spectrum after laser irradiation on MWCNTs.

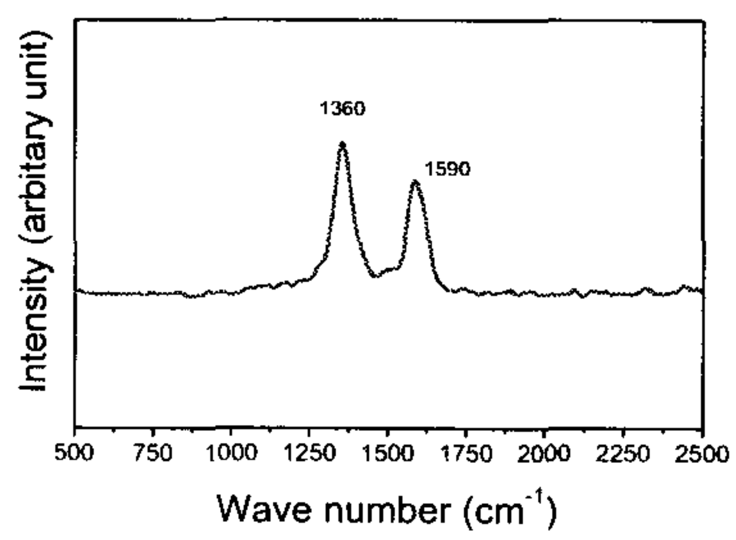

Fig4. Raman Spectrum of MWCNTs grown on silicon substrate at 400 °C

Figure 5 shows I-V curves of MWCNTs deposited at extreme low temperatures of about 400°C, shown in Fig 1. The emission area was 1cm^2, distance between CNTs and anode was 300μm and the threshold voltage was 0.7 V/μm. We will discuss field emission test after laser irradiation on MWCNTs' surface. Turn - on voltage of the MWCNTs were also decreased after the treatment.

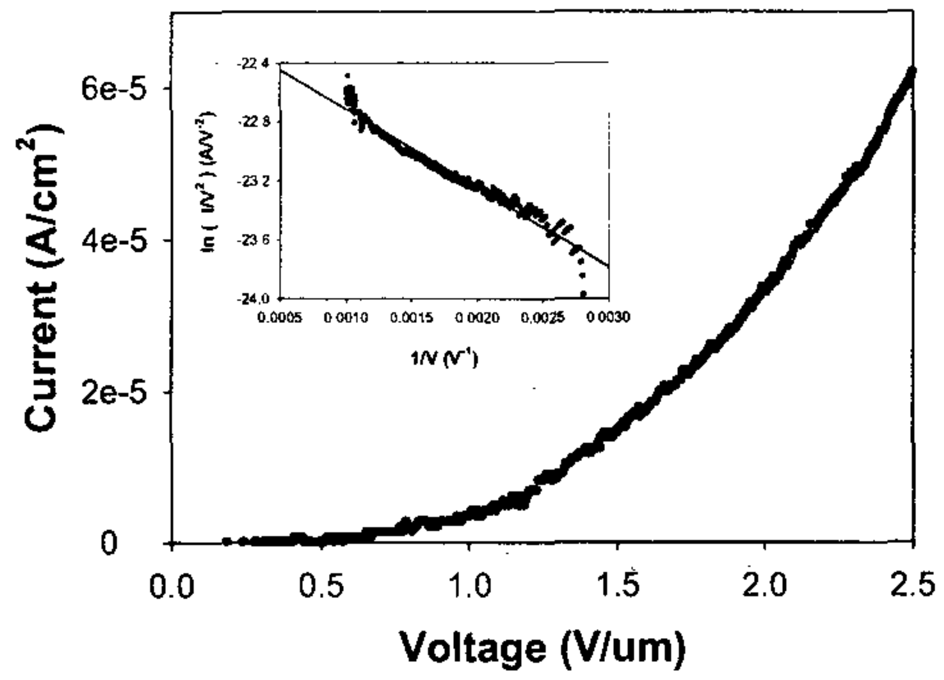

Fig5. Field emission current densities as function of the applied electric field for MWCNTs

4. Conclusion

In conclusion, MWCNTs were prepared on nickel-coated Si and Corning glass substrates at low temperatures of about 400°C. External SUS-grid was inserted to relatively increase reactive radical density during the growth. This grid was found to be the key parameter for low temperature deposition of carbon nanotubes in our case. We have investigated laser irradiation effect on carbon nanotube surface by using an ultra violet laser. The laser was operated to modify structural defect of was carbon nanotube and to ablate possible contamination of carbon nanotube surface. It seems evident that this work gives significant impact to eliminate, contamination of MWCNT's surface, such as amorphous carbon. Together with the emission improvement.

5. References

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[3] T.C. Chieu, M.S. Dresselhaus, M. Endo, Phys. Rev. B 26 (1982) 10530.