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Pulsed Nd:YAG laser-deposition carbon thin films: Effect of the laser fluency

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Abstract – In the last decades, studies of structurally disordered carbon films deposited by laser ablation methods, in vacuum or at low ambient gas pressure, were widely studied. The wide spectrum of the atomic structure and properties of amorphous carbon stems from the capability of carbon to form different hybridizations. Depending on the short-range environment, physical and mechanical properties of carbon films can be different between the two crystalline extrema of carbon, i.e., graphite and diamond [1]. In this work we report the characterization of carbon thin films deposited by pulsed *Nd:YAG* laser-deposition (λ = 1064 nm) on cleaned (100) silicon substrates at room temperature.

Carbon thin films have been synthesized by pulsed laser deposition (PLD) of a rotating graphite target using 1064 nm (*Nd:YAG*) laser, operating in vacuum (10^{-4} Pa) onto cleaned (100) silicon substrates. For a fixed distance of 3 cm between the target and substrate, samples of carbon films were prepared for different fluencies varying the laser energies (Laser lamp Voltages were varied) per pulse in the system. Raman Spectroscopy, as a standard nondestructive technique for the characterization of crystalline and amorphous carbons [2], was employed in order to obtain detailed information about chemical bonding environment in the carbon thin films. The results showed typical D and G bands in their Raman Spectra. Then, Raman spectroscopy indicates an increase in the quantity of sp^2 clustering with the highest laser energy per pulse and a commensurate increase in the internal stress measurements. Nanoindentation measurements were carried out on various films prepared under different laser energies per pulse to study the effect of the fluency on the elastic modulus and nanohardness. It was found that reduced laser energies per pulse leads to formation of amorphous carbon films with increased hardness.

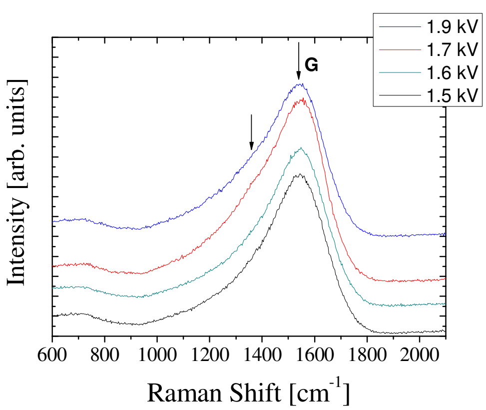

Figure 1: Variation of Raman Spectra of carbon films for different laser energies.

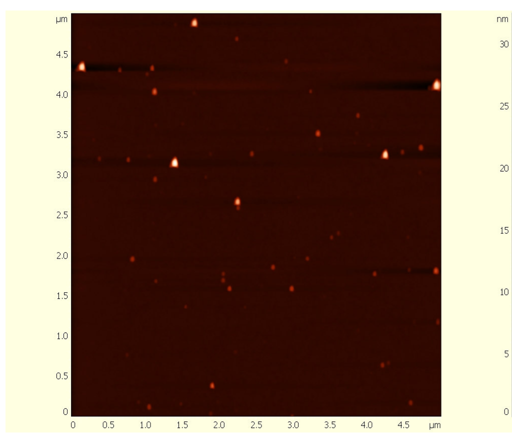

Figure 2: AFM image obtained from a carbon film. (5μm x 5μm)

Samples	Lamp Voltage	I_D/I_G	Internal Stress (GPa)	Hardness (GPa)	Average Roughness (nm)
1	1.5	0.42	2.71	26.9	0.22
2	1.6	0.44	5.73	24.2	0.20
3	1.7	0.64	8.38	11.1	0.24
4	1.9	0.56	6.75	18.4	0.19

References:
[1] E. Capelli, et.al., Appl. Phys. A ***79****, 2063 (2004).*
[2] Seong-Shan Yap et al., Vacuum xxx(2008)1-3.