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New framework for structural characterization of a-C:H films from single-wavelength optical constants

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Abstract – A new technique for characterization of a-C:H films based on optical constants determined at single wavelength is presented. The procedure is based on the assumption that a-C:H films are composite materials, made of polymer-like, diamond like and graphite-like phases. The volume fraction of each phase is obtained by the application of a three-component effective medium theory. The method was applied for films obtained from different PECVD processes at several conditions. The results are compared to previous reports on amorphous carbon characterization, showing a good qualitative agreement.

This work reports a new method for the characterization of plasma-deposited a-C:H films from their optical constants determined at fixed wavelength (633 nm). The method is based on the assumption that a-C:H films are three-phase composite materials, with a polymer-like (transparent and with relatively low refractive index), a diamond-like phase (transparent and with a high refractive index), and a graphite-like phase (absorbing and with high refractive index). The optical constants of the films were determined by in-situ laser reflectance, and analyzed with the aid of a three-component Effective Medium Theory (EMT) [1], using as reference for each phase optical constants data taken from literature.

Data from some deposition processes were analyzed, all of them operating at 50 mTorr pressure: two sets of films were obtained by usual RFPECD (methane or acetylene, 0- 1000 V bias), one set obtained from hollow-cathode rf-PECVD [2] (methane,, 0-500 V bias), and one film obtained in typical conditions for near-frictionless carbon (NFC) deposition [3] (methane 25%-hydrogen 75%, -500 V bias0. In Fig. 1 are shown the ε_1 vs ε_2 plots concerning all deposition process, compared to constant polymer-like volume fraction contours (dot-dash lines). The results obtained from the analysis are shown in Fig. 2, as volume fraction against self-bias plots. For the PECVD-deposited samples the diamond-like fraction showed very similar behavior for methane and acetylene atmospheres, with remarkable differences in the polymer-like and graphite-like volume fractions. The behavior of diamond-like fraction for these films is very similar to that reported by Tamor et al [4] from ^{13}C NMR analysis. Results from hollow-cathode PECVD-deposited samples show sharp maximum of diamond like- fraction at a lower self-bias range, characteristic of highly tetrahedral hydrogenated carbon (ta-C:H) [5], For higher self-bias, the increase of the graphite-like fraction is faster than for usual PECVD.

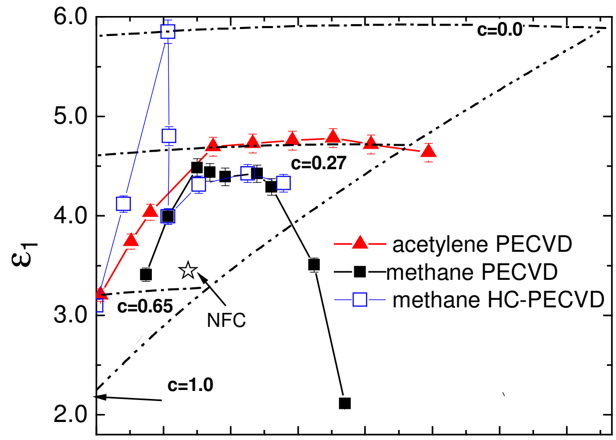

Figure 1: e1 versus e2 plots for films obtained using several deposition processes

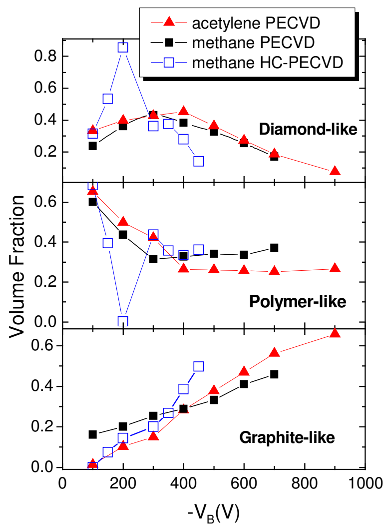

Figure 2: Phase composition against self-bias.

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