Sub Gap Optical Absorption Characterization of CVD Diamond Thin Films

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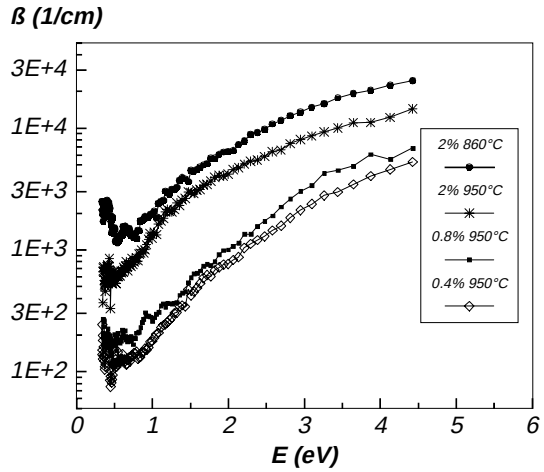
In this work we report on the characterization of thin films of CVD diamond (0.25 - 10 µm) by sub gap optical absorption measurements which enable the detection of structural or stoichiometric defects in the material. The measurements were carried out by Photothermal Deflection Spectroscopy, a highly sensitive technique, which enabled the detection of low levels of absorption even in very thin layers of diamond and in the spectral range 0.25 - 3.5 µm (4.4 - 0.35 eV) deep into the sub gap region of diamond. The films were thus characterized from the early stages of growth. The absorption in the films was typically 3 to 4 orders of magnitude larger than in bulk 2A diamond. The defects responsible for the sub gap absorption are substantially associated with sp^2 carbon, whose concentration increases with the methane content (shown in percentage in the figure) relative to hydrogen in the gas mixture. The films, grown on Si substrates, show a highly defective interface layer on the Si side. Measurements performed on films of increasing thickness and same growth conditions showed that the sp^2 interface defects propagated in an initial layer of thickness of up to a couple of microns while the remainder of the material was substantially less defective. Such an effect was less pronounced when increasing the substrate temperature thus leading to lower absorption in films. Such results were confirmed by SEM observations of the films.



The shoulder like feature in the spectra down to about 1 eV could well be accounted for with a Gaussian like energy distribution of defects in the gap, symmetric about the Fermi level, typical of the π electrons of sp^2 carbon. However, defects of different nature giving rise to localized states in the gap would be necessary to account for the smoother decrease of the absorption found at lower energies.