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a-SiC:H thin films deposited by PECVD with very low silane flow

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Abstract – This work reports studies on the chemical and structural order of amorphous hydrogenated silicon carbide thin films deposited by PECVD at the "silane starving plasma" conditions, using a gaseous mixture of silane, methane and hydrogen. The radio frequency power and silane flow were varied as deposition parameters. Very low silane flow (down to 0.9 sccm) was used, in order to explore deposition conditions deeply inside the "silane starving plasma" conditions. Particularly, the ratio between the number of Si-C and Si-H (or C-H) bonds was analyzed for all the samples.

The deposition of amorphous hydrogenated silicon carbide thin films (*a*-$Si_{1-x}C_x$:H) by plasma enhanced chemical vapor deposition (PECVD) has been extensively studied due to the ability of this technique to control the carbon content, *x*, in the solid phase and, therefore, the optical gap (E_g). The increase in the optical gap, following the increase in the carbon concentration, is desirable for many device strategies [1,2]. The growth of *a*-$Si_{1-x}C_x$:H thin films with very low conductivity ($< 10^{-14}\ \Omega^{-1}.cm^{-1}$) and high optical gap (higher than 3 eV) is particularly important for thin film transistor (TFT) technology based on amorphous materials [1-3]. Several works of the group [4,5] showed that advantageous electrical, optical, mechanical, structural and chemical properties of these films are achieved at the so-called "silane starving plasma" [6] conditions, a special case of the low power density regime.

The experimental strategy in the present work was to explore new limits of deposition conditions, as very low silane flow (down to 0.9 sccm), aiming to improve the chemical and structural order in hydrogenated silicon carbide films deposited by the group using PECVD technique. Hydrogen dilution (300 sccm) was used during deposition to improve the structural characteristics of the films [4,5], due to the fact that the hydrogen ions contribute to break weak bonds (C-H and Si-H), enhancing the density of Si-C bonds, as well as they sputter the film's surface, making it smoother. Methane concentration during deposition process was kept in 90% for all samples. Other deposition conditions are shown in table 1 for some of the samples studied in this work.

All the samples deposited in this work are carbon rich ($x \geq 0.5$), a characteristic property only achieved for a-SiC:H thin films deposited by PECVD inside the "silane starving plasma" conditions. For the silane flow variation series, the experimental FTIR data shows that ratio between the number of Si-C and Si-H bonds in the film increases with the increasing of the silane flow during deposition process, in order that stoichiometric sample presents the highest values for both ratios. In addition, for the RF power variation series, the FTIR analysis show that [Si-C]/[C-H] ratio decreases with the increasing of the carbon content, at the same time that [Si-C]/[Si-H] ratio increases. These results clearly shows that the better way to increase carbon content in the films without increase significantly the density of C-H bonds is lowering silane flow without raise RF power, that is, maintaining the condition depositions at the low power density regime and, more than that, going deep at the "silane starving plasma" conditions.

Table 1: Deposition Conditions.

Sample	silane flow (sccm)	methane flow (sccm)	RF power (W)
36906h2p	3.6	32.4	100
27906h2p	2.7	24.3	100
09906h2p	0.9	8.1	100
09906h4p	0.9	8.1	200

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