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Effects of the deposition pressure on the chemical and structural properties of a-SiC:H thin films deposited by PECVD

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Abstract – In this work amorphous hydrogenated silicon carbide thin films were deposited by plasma enhanced chemical vapor deposition, at the "silane starving plasma" conditions, using a gaseous mixture of silane and methane, with and without hydrogen dilution. The radio frequency power and gas flows were fixed for each series of samples, and only deposition pressure was varied as deposition parameter, in order to better understand the pressure effects on the chemical and structural properties of a-SiC:H thin films deposited.

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 the effects of the deposition pressure on the chemical, optical and structural properties of the films. Two series of a-SiC:H samples were deposited (see table 1), the first one without hydrogen dilution and the second one with 300 sccm hydrogen dilution during deposition process, in order to improve the structural characteristics of the films [4,5], breaking weak bonds (C-H and Si-H) in the growing film and enhancing the density of Si-C bonds. The films were analyzed by FTIR, UV-Vis and RBS techniques, in order to obtain their structural, optical and chemical properties.

The experimental results show that an increase in deposition pressure promotes silicon incorporation in the solid phase, and that very high pressures may be deleterious to the structural and chemical properties of the deposited material. Particularly, for the non-hydrogenated samples, the continuous increase of the deposition pressure generate a very high density of Si-CH_n and Si-H_n bonds that, together with the very strong lowering of the Si-C peak intensity, is a clear evidence of a structurally poor and less homogeneous material. Also, it is clear from the experimental data that hydrogen dilution is important to avoid some of the deleterious effects of the deposition pressure on the structural properties of the films.

Table 1: Deposition Conditions.

Sample	SiH_4 flow (sccm)	CH_4 flow (sccm)	H_2 flow (sccm)	RF power (W)	Deposition Pressure (mtorr)
1	3.6	14.4	0	20	14
2	3.6	14.4	0	20	50
3	3.6	14.4	0	20	220
4	3.6	14.4	0	20	1000
5	3.6	36.0	300	100	120
6	3.6	36.0	300	100	290
7	3.6	36.0	300	100	1000

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