Development of DLC dopped with B using trimethyl borate as precursor

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Abstract: In this work, we developed a B-DLC by PECVD using TMB as a precursor at a low treatment temperature. The precursor added to the treatment introduced boron and oxygen in the film due to the precursor composition, influencing the structure and hardness behavior of the film.

1. Introduction

DLC doped with boron (B-DLC) has interesting properties such as better sanguine compatibility, physical stability, high thermal resistance, lower internal tension, low friction coefficient, and better electrical conductivity [1]. However, its industrial production is limited due to the toxic, explosive, and poisonous precursors used in this process, as for example, B_2H_6, BF_3, and BCl_3. The trimethyl borate (TMB, $B(CH_3O)_3$) is an alternative to this process, once it is cheap, a highly volatile, nontoxic, and non-explosive organic liquid [2, 3].

Therefore, a comprehensive study needs to be carried out to develop the treatment using the TMB as a precursor and determine the effectiveness of adding boron to the properties of the DLC films.

2. Methods

The DLC and B-DLC films were deposited on a titanium substrate by PECVD using a pulsed DC-power supply in three steps, starting with an ablation process using 80% Ar and 20% H_2 for 1 h, followed by the deposition of the organosilicon interlayer using 70% HMDSO and 30% Ar for 15 min, and ending with the film deposition. The DLC film was deposited using 0.27 torr of CH_4 and 0.03 torr of Ar for 2 h. The B-DLC films were deposited using the parameters defined in Table 1.

Table 1. Parameters of B-DLC films deposition

	Pressure (torr)			Temperature (°C)
	CH_4	Ar	TMB	
500 V	0.27	0.03	0,025 0,05 0,075	200 - 105
550 V	0.27	0.03	0,025 0,05 0,075	200 - 110
600 V	0.027	0.03	0,025 0,05 0,075	200 - 125

3. Results and Discussion

It is possible to observe from WDS by SEM analysis that the DLC film showed a percentage of the oxygen content of 0.6% wt, while the B-DLC film showed a percentage of the oxygen content of 14.3 % wt, 13.6 % wt, and 5 % wt for 500V, 550V, and 600V respectively, independent of TBM quantity added to the treatment. The higher percentage of oxygen and lower presence of boron promoted a less hard film formation, while the lower percentage of oxygen and higher presence of boron promoted a harder film formation (Figure 1).

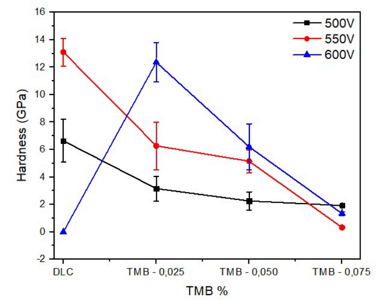

Fig. 1. Nanohardness result for the DLC and B-DLC

The spectra obtained from FTIR analyses (Fourier Transform Infrared Spectroscopy) showed the formation of B-C or C-C bond in 1100-1280 cm^{-1} for the 0.025 torr of TMB, and the formation of B-B-C bond in 1570 cm^{-1} for the 0.075 torr of TMB, independent of the tension applied in the treatment.

4. Conclusion

It was possible to dope the DLC film with boron using a TMB as a precursor. The presence of oxygen and boron content influenced the hardness of the films. The higher amount of TMB was more promising in doping the film.

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