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Surfaces analysis of different carbon films using Wettability, AFM and Raman

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Abstract – In this study were analyzed the effects of wettability in different carbon films (boron doped diamond - BDD, undoped nanocrystalline diamond - NCD and nanographite) that have been used as electrodes in electrochemical applications. The values contact angles were obtained using liquids with different polarities (water, diiodo-methane and ethylene glycol) to calculate the surface energy and work adhesion of these films. Considering Shuttleworth-Bailey state, it was possible to observe the relationship between surface roughness of these films and contact angle (CA). The morphology and structure characteristic of these carbon films were confirmed by SEM images and Raman spectroscopy, respectively.

The exact knowledge of the material surface is essential for optimizing various coating process and their applications. In the contact angle measurements process, which enables the determination of surface energy and work adhesion, the selection of appropriate test liquids is sometimes complicated [1-2]. The accuracy of the obtained values is essentially influenced by test liquids selected. The water and ethylene glycol have a high polarity while diiodo-methane has a low polarity. The measures of contact angles (CA) were performed using sessile drop method and the surface energy (SE) was calculated by Fowkes method [3]. The water CA values were 144°, 125° and 103° to nanographite, BDD and NCD, respectively. These results agree with the literature. The graphite presents the highest hydrophobic character in comparison with BDD and NCD. Moreover, high values of CA (θ>90°) are an indicative of low adhesion work, that means, a weak interaction between liquid and the film. The calculated adhesion work, around 60 mJ/m^2, for nanodiamond film was obtained. This adhesion work may damage the film and cause loss in its protective properties. The same behavior was not verified for other films. The surface energy is defined by the amount of uncompensated bonds on surface atoms, and is related with adsorption, adhesion, tribological and also electronic properties. The estimative of the surface energy presented some discrepancies. This discrepancy may be associated with the combinations of two liquids that did not provide coherent results mainly due to the polarity. However, the best estimative, for surface energy, was obtained with water and diiodo-methane and agree with the most used liquids in the literature for all the samples studied. This behavior may be related with the presence of the oxygen incorporated during the process of doping. Despite diamond films surfaces was different (grains size, roughness, with and without oxygen, etc.); it is believed that the similarity between the surface energy values is related with the diamond crystallographic plane <111>, that is considered a plane with low surface energy. There is also a direct relationship between wettability and roughness films. Shuttleworth-Bailey considered that the asperities on surfaces rough could mean barriers to the liquid flow and wetting liquids will be increased [4]. In this way, the films roughness was calculated and values of root mean square roughness (R_q) were 32, 289 and 111 nm to NCD, BDD and nanographite, respectively. Considering only diamond films, the surface terminations and their morphology were direct related with the liquid tested. It is possible to verify that the roughness increased with the increasing of CA [5].

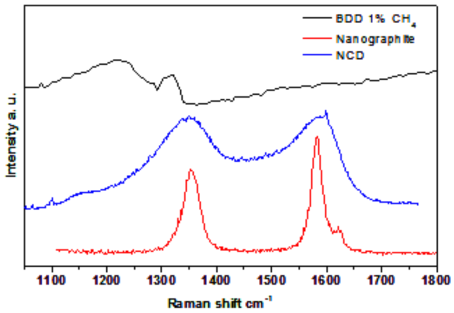

Figure 1: Raman Spectroscopy of the different carbon films

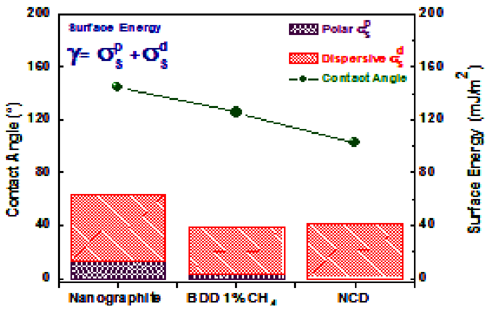

Figure 2: Contact Angle (energy surface, polar and dispersive components)

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