SILICON INTERLAYER INFLUENCE IN ADHESION OF DLC FILM DEPOSITED ON AA 7075 SUBSTRATE USING A MODIFIED PULSED-DC PECVD TECHNIQUE

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1. Introduction

Aluminum and aluminum alloys have been widely used as structural materials in the aerospace and automotive industries because of their low density, good machinability and high mechanical strength-to-weight ratio [1, 2].

The choice for the AA 7075 aluminum alloy is due to its use in the space, aeronautics, automotive, biomedical and mainly because it is one of the most used alloys in the CBERS (China-Brazil Earth-Resources Satellite) family of the National Institute of Space Research (INPE). However, its low surface hardness as well as properties of low resistance to wear and corrosion reduces its lifetime in tribological contacts through wear and friction damage, limiting its application in several areas of surface engineering [3]. DLC (Diamond Like Carbon) is a metastable form of amorphous carbon with significant amount of sp3 bonds with high mechanical hardness, chemical inertia, optical transparency in addition to being a broadband semiconductor [4].

The focus of this study is in the silicon interlayer, seeking an interface with intermediary mechanical properties between substrate AA 7075 and DLC film, but with strong chemical bonds ensuring high adhesion.

2. Experimental

The deposition of DLC and Silicon interlayer films was made using a modified pulsed-DC PECVD technique (additional cathod) [5]. The applied self-bias voltage was -2 kV, -4 kV, -6kV, -8 kV and -10 kV, for Silicon interlayer growth. In order to increase the plasma densification of the technique an additional cathod was used [5]. All fifteen depositions was made using the same parameters as described in Table 1, the only changing parameter was the voltage for the Silicon deposition.

The film's atomic arrangements were analyzed by Raman Spectroscopy, and film adhesion was evaluated by Rockwell C Indentation with reference to VDI 3198 test (500, 1000, and 1500 N). DLC film and interlayer thickness was measured by Scanning Electron Microscopy (SEM / FEG) and Glow Discharge Optical Emission Spectroscopy (GDOES).

Tab. 1: Process parameters for all depositions.

ACTIVITIES	TIME (min)	PRESSURE (Torr)	VOLTAGE (V)	FLOW (sccm)
Sample cleaning (Argon)	25	$8{,}0\times 10^{-4}$	-600	10,0
Silicon deposition (SiH_4)	15	$1{,}5 \times 10^{-4}$	variable	3,6
$SiH_4 + C_2H_2$	2	$1{,}0 \times 10^{-4}$	-800	3,6 / 9,8
$SiH_4 + C_2H_2$	3	$1{,}0 \times 10^{-4}$	-800	2,0 / 9,8
DLC deposition (C_2H_2)	40	$8{,}0 \times 10^{-4}$	-750	9,8

3. Results and Discussions

The growth in thickness of the silicon interlayer, measured by GDOES and SEM (Fig. 1, a and b, respectively), showed a near linear behavior as a function of the increase on the applied voltage. The thickness obtained by SEM showed smaller values but with the same (near) linearity. The thickness measurements of the films by SEM / FEG were made for films grown on Silicon [100] monocrystal substrate, and not on AA 7075, as it was made for GDOES. This is because when we cut the AA 7075 sample with DLC film, it was always observed a deformation of the metal above the film.

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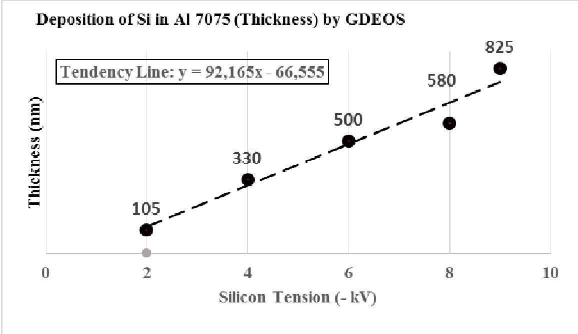

Fig. 1a. *Silicon thickness (GDOES) versus applied self-bias voltage.*

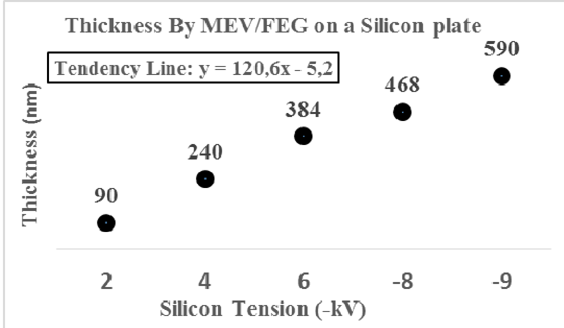

Fig. 1b. *Silicon thickness (SEM/FEG) versus applied self-bias voltage.*

The spectrum obtained through Raman spectroscopy for all processed samples is typically of a hydrogenated amorphous carbon (a-C: H) film, as it can be seen on Fig.2 for sample 23.

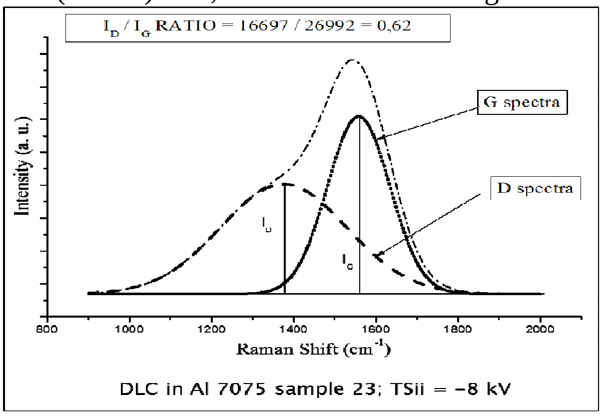

Fig.2. *Raman spectra with deconvoluted curves for sample 23.*

The adhesion results for the DLC films were satisfactory for all self-bias voltages applied in the silicon interlayer (VDI standard 3198). Fig. 4 shows the results of sample 13 -6 kV) for 1500 N.

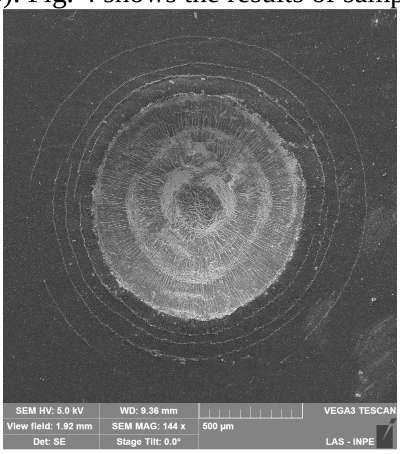

Fig.3. *Rockwell C indentation for the sample with sel-bias voltage of -6 kV.*

It can be concluded that, with the applied film growth methodology, it was possible to obtain high adherent DLC films on AA 7075 substrate, and that the silicon interlayer thickness did not affect the adhesion of the DLC film in the substrate.

4. References

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