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TRIBOLOGICAL BEHAVIOR OF THICK AND SOFT DLC COATINGS

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INTRODUCTION

Austenitic stainless steels are widely used in industry due to their good corrosion resistance; however, they present poor mechanical properties.

*Different coatings such as DLC "Diamond Like Carbon" can be used in order to improve surface properties. According to the sp3/sp2 ratio and the hydrogen content, DLC coatings can be classified in hard DLC or soft DLC. These coatings have low friction coefficient, good wear resistance and chemical inertia; however, they present adhesion problems when they are deposited on metallic substrates. For this reason, the plasma nitriding previous to the DLC coating deposition could be convenient. Although there are several publications about DLC coated and nitrided stainless steels, not many contributions have been found in the literature about soft and thick coatings. In this work, the tribological behavior and adhesion of thick and soft DLC coatings deposited on nitrided and non-nitrided austenitic stainless steels were studie*d.

MATERIALS AND METHODS

Disk-type samples of 25 mm in diameter and 6 mm in height were cut from 316 L austenitic stainless steel bar. Plasma nitriding treatments were carried out in an industrial reactor by means of a pulsed DC discharge, for 14 hours at 400 ºC, with a gas mixture 20 % N_2 and 80 % H_2. The DLC coatings, which are in fact a:C-H-Si films (silicon containing amorphous hydrogenated carbon), were deposited by the Plasma Assisted Chemical Vapour Deposition technique (PACVD) in the same reactor used for nitriding with HMDSO and acetylene as precursor gas. The DLC coatings were deposited on austenitic stainless steel (named coated samples) and on nitrided austenitic stainless steel (named duplex sample) and the control group was the austenitic stainless steel (untreated samples). The films were characterized by EDS and Raman, hardness was assessed with nanoindenter and microstructure was analyzed by OM and SEM. The pin on disk tests were performed with alumina as counterpart and a hertzian pressure of 0.87 GPa. The abrasive wear resistance was tested using the ASTM G65-95 Dry Sand/Rubber Wheel test; where the applied load was 45 N, and the duration of the test was 8.5 min, using a mixture between parameters suggested in Procedures A and D of this standard.

RESULTS AND DISCUSSION

In the Raman spectrum, the films presented the D and G bands with an intensity ratio (ID/IG) of 1.08. The hydrogen content was about 43 % which was calculated from the background of the Raman spectrum1.

The coating thickness was about 36-37 m in both samples (Figure 1).

The nitrided layer thickness was 12 m. The hardness was about (12 2) GPa and the Young's Modulus was (72 10) GPa, though it can be considered a soft DLC film.

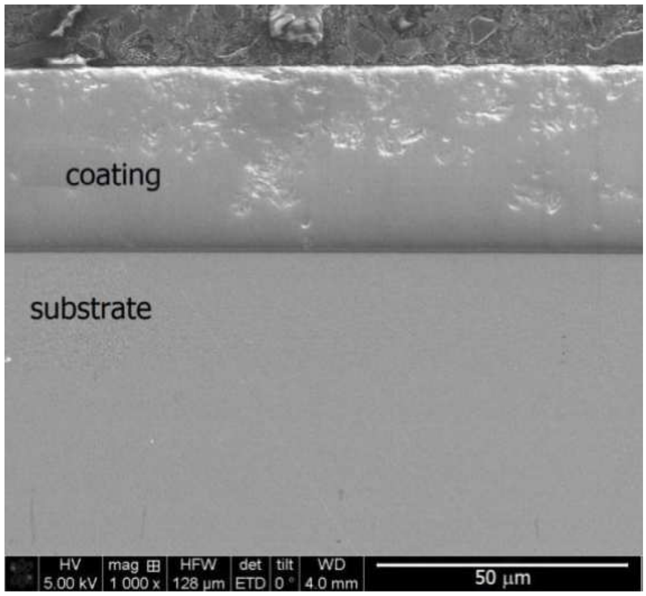

Fig. 1: SEM Image of the coated sample The surface morphology of the coatings in the coated and the duplex sample was different (Figure 2). In both samples, the coating presented defects in the form of holes and protuberances as it was reported by some of the authors2.

However, the protuberance size and the density of the defects were higher in the duplex sample than in the coated sample, probably due to the higher roughness produced by the nitriding process. The roughness (Ra) in the untreated sample was 0.040 m and in the nitrided sample was 0.070 m.

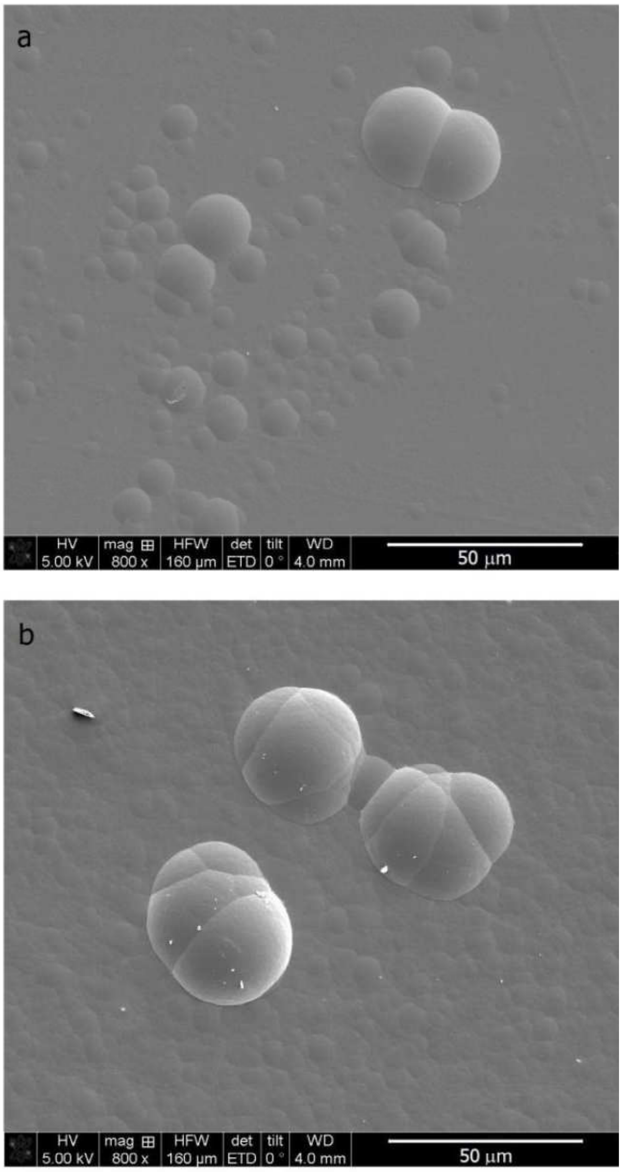

Fig. 2 SEM image of surface of the coated and duplex samples.

In the pin on disc tests, the friction coefficient was 0.09 for the only coated sample and 0.11 for the duplex sample (Figure 3), similar values as others have already reported 3. These values were considerable lower than the friction coefficient in the untreated sample. Wear tracks were undetectable, probably due to the low elastic modulus E of these films.

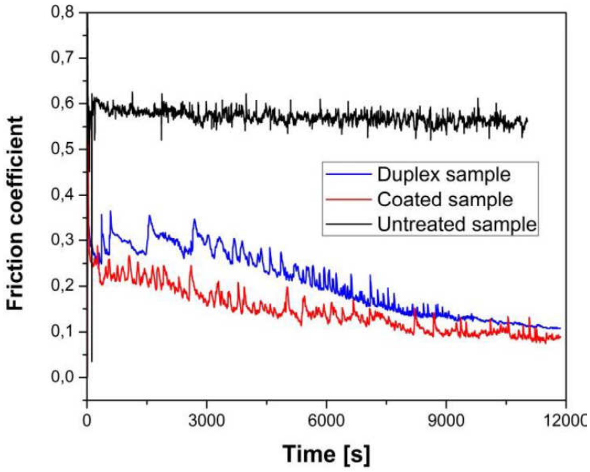

Fig. 3: Friction coefficients registered in the pin-on-disc tests for different samples.

In the abrasive test, the results were also very good for the coated samples, as they showed no damage, mass loss was undetectable and so were the tracks profiles. Anyway, as the wear tracks were visible, it could be observed that the defects were cracked and holes appeared in their place. It was determined that these holes did not pass through the coating thickness.

In the Scratch test, the critical load was higher in the duplex sample (13 N) than in the only coated sample (9 N). In the Rockwell C indentation, the behavior was similar in duplex and coated samples. In these thick coatings, the test did not evaluate the adhesion but the fracture toughness. The nitriding as previous treatment allows improving the adhesion of the coatings but affect their topography, resulting with more defects, which affect the tribology behavior.

CONCLUSIONS

These thick and soft DLC coatings had low friction coefficient and outstanding abrasive and sliding wear resistance. Probably a polishing process previous to the coating could be convenient in order to reduce the roughness.

REFERENCES

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