11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

Influence of growing temperature of interference thin films on the mechanical properties of colored stainless steel evaluated by depth-sensing nanoindentation

A.P.A., Manfridini[(1)],C.R.O., Loureiro[(1)], M.S., Andrade [(1)], R.M.R., Junqueira [(1)] *

[1] Fundação Centro Tecnológico de Minas Gerais - Av. J.Cândido da Silveira 2000, 31170 000-BH/MG-Brasil
(*) **Corresponding author:** rosa.junqueira@cetec.br

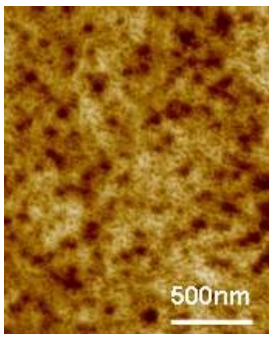
Abstract: Specimens of AISI 304 stainless steel were electrochemically colored by interference in a sulphuric solution containing CrO_3 in a temperature range of 25 to 75°C. The aim was to evaluate the influence of processing conditions on the nanomechanical behavior of the interference films. The morphology and hardness of these films were affected by the temperature of coloration process.

Growing colored interference thin films on the surface of stainless steels is an alternative for enhancing the decorative and architectural application of this material. The coloration can be conducted by electrochemical method using sulfuric solutions containing CrO_3.

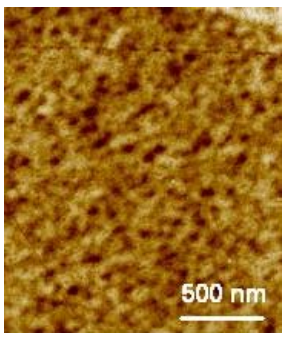
In this work, the aim was to evaluate the influence of processing conditions on its mechanical behavior. It has been already demonstrated that the mechanical resistance of interference films is affected by the coloration process, and an inverse linear correlation was found between hardness and film morphology [1]. In order to evaluate the performance of the interference films colored at 25°C, 35°C, 55°C e 75°C, the mechanical properties of these films were measured by depth sensing nanoindentation.

Specimens of mirror finishing (MF) type AISI 304 stainless steel were electrochemically colored in a sulphuric solution containing 70g/L CrO_3 by alternating pulse current method, as described before [1]. The coloration was conducted in a temperature range of 25 to 75°C. The film morphology was evaluated by atomic force microscopy (AFM) images. Depth sensing nanoindentations (DSI) experiments were performed using a Hysitron-Triboscope head attached to an AFM from Digital Dimension 3000. It was applied a 1000 µN load, under a diamond Berkovich indenter. The values of the elastic modulus and hardness of the interference films were calculated using load-displacement curves and the Oliver & Pharr approach. [2].

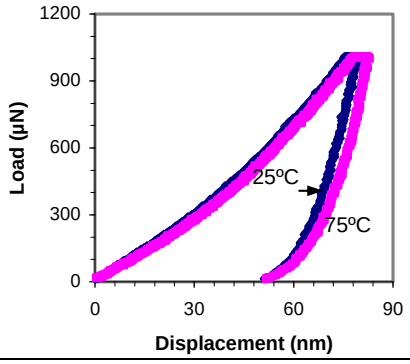
The results obtained are illustrated in Fig.1. Differences in the morphology of interference film obtained in 25 and 75°C can be observed in the AFM images: (a) and b).The mechanical behavior showed on the load-displacement curves (c) for same temperatures are also different. The values of hardness and elastic modulus of the interference films obtained in 25, 35, 55 and 75°C are shown in (d). The lowest hardness value was obtained at 75°C. It is concluded that the morphology and hardness of these films are affected by the temperature of coloration process.



(a) 25°C



(b) 75°C



(c)

T (°C)	H (GPa)	E (GPa)
25	5,9	158,0
35	6,1	150,5
55	6,0	159,5
75	5,5	157,9

(d)

Figure 1: MFA images (z = 40nm) of interference film obtained in 25°C (a) and 75°C (b) and related load-displacement curves (c) and values of hardness and elastic modulus of the interference films obtained in 25, 35, 55 and 75°C (d).

References

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Acknowledgments: The authors thank Fapemig for financial support and for the scholarships to RMRJ, MSA and CRO and Fundação Gorceix for the scholarship for APAM.