EVALUATION OF CR-N THIN FILMS DEPOSITED BY REACTIVE PLASMA IMMERSION ION IMPLANTATION AND DEPOSITION (PIII&D) AND HOLLOW CATHODE DISCHARGE

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1. Introduction

The magnetron sputtering (MS) deposition of thin films allows depositing different materials on various substrates. Nevertheless, the small fraction of ions and the great variety of directions in the sputtered particles trajectory turns the deposition difficult to control [1]. The iPVD processes are alternatives to increase the ions fraction and control particles direction during film's growth. In this work, chromium nitride deposition was performed by the association of the DC reactive magnetron sputtering, hollow cathode secondary discharge and plasma immersion ion implantation and deposition. Chromium nitride coatings have high hardness and good wear, corrosion and oxidation resistances at high temperature. Studies show that its composition is generally dominated by two phases: CrN and Cr2N with different mechanical properties, as well as hardness, elastic modulus, wear resistance and friction coefficient [2]. The CrN and Cr2N phases' formation in the chromium nitride coatings are associated to the used nitrogen flow in the precursor gas mixture [2]. Each coating was deposited with a different nitrogen ratio in order to evaluate its influence on chemical composition, surface defect density, morphology and wear resistance.

2. Experimental

A high purity chromium target was used as the metallic source in MS. Negative high voltage pulses were applied in a metal tube positioned between the target and the substrate, generating a high density plasma inside it. Part of the sputtered particles that pass through the high-density plasma are ionized. The high voltage pulses were applied simultaneously to the carbon steel substrate, resulting in ion implantation. Voltage, frequency and width of the pulses were kept constant for all experiments. For comparison, two experiments were performed without the secondary discharge. The amount of nitrogen in the gas mixture was 33, 50, 66, 75 and 100%, with argon in balance. The substrate and target surfaces were cleaned with argon bombardment for 10 minutes before the film growth. The growth process took 60 minutes and the working pressure during the experiments was maintained at $3{,}5\times10^{-2}$mbar.

3. Results and Discussions

In comparison to the deposited films by reactive magnetron sputtering without secondary discharge, the proposed system with DCMS, IIIP and hollow cathode discharge resulted in coatings with better adhesion to the substrate, higher wear resistance and lower surface defect density. The low stress between coating and substrate, caused by ion implantation during the deposition may be one of the reasons for the better quality presented by these films. Both CrN and Cr2N phases were identified in the coatings by XPS analysis, but the presence of CrN phase was affected by the amount of nitrogen into the chamber until a certain extent. The grown film with 66% of nitrogen in the gas mixture presented lower friction coefficient, although the grown film with 33% of nitrogen presented higher wear resistance. The complete results obtained by characterizations in these coatings deposited with and without secondary discharge and variation of nitrogen flow will be presented at the conference.

4. References

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