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Tribological properties and Corrosion resistance enhancement of AISI H13 hot work steel by means of Chromium Nitride (CrN)/Titanium Nitride (TiN) multilayers

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Abstract – CrN/TiN multilayer were deposited on steel AISI H13 substrates with a total thickness of 4 µm. All coatings were fabricated by the magnetron sputter technique using Cr and Ti targets under gas mixture of Ar/N_2. Thereby CrN/TiN hard coatings with 10, 40, 80 and 100 bilayers were deposited in order to study the effect of the number of bilayers on their tribological and electrochemical properties. The samples coated with $(CrN/TiN)_{100}$ exhibited a 70% higher hardness and a wear volume three order of magnitude smaller as uncoated steel. The polarization resistance of the probes coated with 100 bilayers of CrN/TiN was an order of magnitude higher and the corrosion speed 95% and 77% slower as those coated with TiN and CrN monolayer, respectively.

Steel AISI H13 is widely used for injection moulds fabrication and other hot work tools with hardness around 56 Rockwell C, however life time of this steel is limited by its relatively low wear and corrosion resistance, if it would be exposed to an aggressive environment. It is widely known that the performance of tools and mechanical parts that undergo high mechanical load can be enhanced by the use of hard thin coatings in form of monolayer. However, the used of such coatings as corrosion barriers is often unsatisfactory, since the deposition processes usually generate many small pores and pinholes, which negatively affect the electrochemical behaviour of the hard coating/substrate system. On the other hand, if a hard thin film covers a less noble material, such as steel, small anodic areas could be generated and exposed to an aggressive environment and a galvanic corrosion would take place. Therefore, it is also necessary to optimize the design of the coating system used in order to achieve the better relationship between mechanical and electrochemical properties for the whole system. The intention of the work presented here was to enhance the tribological properties and corrosion resistance of well known steel AISI H13 through the use of a CrN/TiN multilayer coatings system. All coatings were deposited by using the balanced magnetron sputtering deposition technique. The total thickness of the coatings was maintained by 4 micrometer, while the number of the CrN/TiN bilayers was varied from 10 to 100. Hardness and Young Modulus of the coatings were measured by nanoindentation, while microstructure, chemical bonds and topography were investigated by low angle X-ray diffraction (XRD), Fourier Transformer Infrared Spectroscopy (FTIR) and Atomic Force Microscopy (AFM), respectively. The electrochemical evaluation of the coatings was carried out by Electrochemical Impedance Spectroscopy (EIS) and Tafel polarization curves.

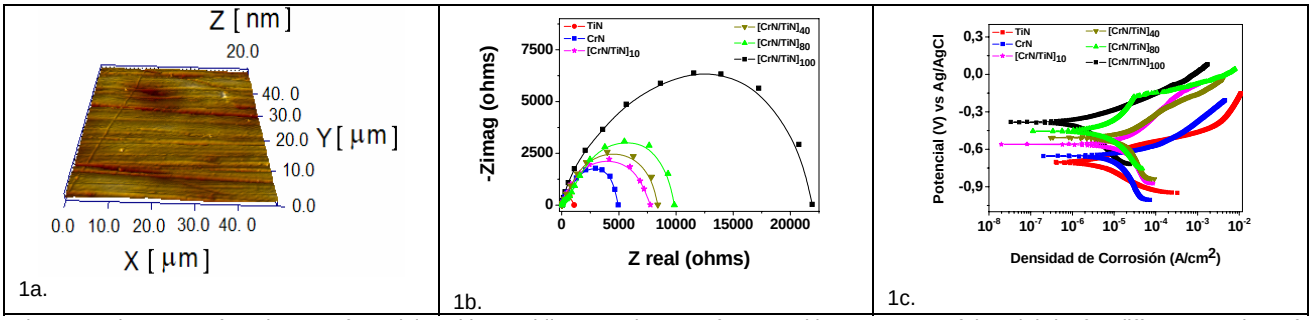

Figure 1: a) AFM surface image of CrN/TiN with 100 bilayer and a Ra of 13 nm, b) EIS curves of (CrN/TiN)n for different number of bilayers, c) polarization curves of (CrN/TiN)n for different number of bilayers

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