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Al_2O_3-TiN nanostructured multilayer thin films obtained by ion-plating

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Abstract – In this work, we report a new approach for nanostructured multilayer thin films. Taking into account the excellent mechanical properties of TiN (relative high hardness) and the high temperature resistance of ceramic oxides such as TiO_2 and Al_2O_3, a Al_2O_3-TiN nanostructured multilayer system (thin film) is developed. The Al_2O_3 and TiN are deposited by ion-plating. High deposition rates with stoichiometric thin films were obtained. Hardness and crystalline structure depend on deposition rate and process temperature.

Nanostructured multilayer thin films are widely used in plasma surface engineering. Nowadays, specific nanostructures can be achieved for different application in the metal-mechanic industry. Hard and toughness thin films improve the lifetime of cutting tools, moulds and dies. On one hand, hard coatings such as TiN and TiC can be used up to a temperature limit due to thin film oxidation. On the other hand, ceramic oxides such as TiO_2 and Al_2O_3 have been tested as hard thin films with high temperature resistance[1,2]. Furthermore, ion-plating is an established technique for surface modification leading to evaporate solid elements and compound at high vacuum condition with or without plasma. This versatile technology allows the deposition of metallic oxides at relative high rates.

In this study, Al_2O_3 and TiN thin films were obtained by ion plating. In the case of Al_2O_3, alumina pellets were evaporated only by the action of the electron beam. In the case of TiN, titanium is evaporated and a nitrogen plasma atmosphere produces the reactive nitrogen in order to form TiN. The samples were characterized by Rutherford backscattering spectrometry (RBS), X-ray diffraction (XRD), nanoindentation tests and scanning electron microscopy (SEM).

Figure 1 shows a typical RBS spectrum of Al_2O_3 thin film deposited on C. By analyzing these results, one can conclude that the Al_2O_3 deposition rate is 3.1 μ $m.h^{-1}$ with an atomic O/Al ratio of 1.5 (stoichiometric value). Nanoindentation experiments yield hardness values from 10 to 20 GPa depending on deposition parameters. The crystalline structure depends strongly on deposition rate and process temperature. Finally, our strategy is to grow different Al_2O_3-TiN nanostructured multilayer systems with variable periodicity X (see Figure 2) in order to reach a hybrid compound with both high hardness and high temperature resistance.

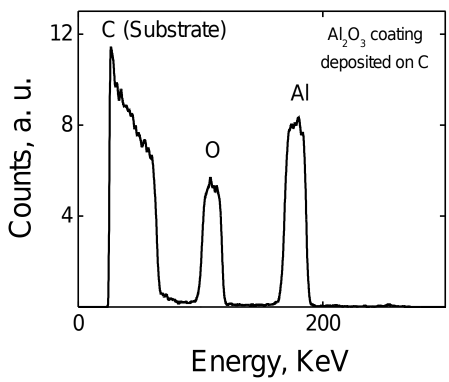

Figure 1: RBS spectrum of a typical Al_2O_3 deposited on carbon (substrate) by evaporation.

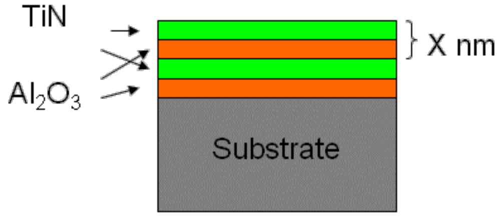

Figure 2: Al_2O_3-TiN nanostructured multilayer system where X is the Al_2O_3-TiN bilayer periodicity in the thin film.

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[2] J. Musil, V. Šatava, R. Čerstvý, P. Zeman, T. Tölg, Surf. Coat. Technol. 202, 6064 (2008).