Nanostructured multilayer nitride coatings for biocompatible materials

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INTRODUCTION: Most transition metals form binary or ternary nitrides, with good mechanical, tribological, anticorrosive and biocompatibility properties [1,2]. Therefore, nitrides coatings are well suited to the protection of the medical implant surfaces. The aim of this work is to improve the characteristics of a Ti alloy (Ti5Al2.5Fe) by depositing nanometer - scale multilayered TiN/TiAlN and Ti/TiN/TiAlN hard films (with individual layer thicknesses of about 8 nm).

METHODS: The multilayer thin films were deposited using magnetron sputtering technique using Ti and Ti+Al cathode targets [3]. The multilayers were obtained by using two adequate shutters, periodically opened and closed. The overall thickness of all coatings was approx. 3 μm. Chemical composition of the films was investigated by AES (Auger electron spectroscopy). Phase composition and texture were determined by X-ray diffraction. Microhardness measurements were performed using a microhardness tester at 20 g load. Scratch tests under standard conditions were undertaken to determine the coating adhesion. The wear behavior was investigated by using a testing apparatus consisting of a coated sample pressed on a rotating steel disc.

The flow cytometry technique was used in order to determinate the biocompatibility by measuring the cell viability in Calcein-AM test. The cytotoxic effects were determined by cellular models *in vitro* (MTT test).

RESULTS: The AES analysis showed that the multilayers are formed by almost stoichiometric layers (N/Ti≈N/(Ti+Al) ≈1). In the TiAlN films, the Al/Ti ratio was of about 0.8. The both types of multilayers exhibited a strong (111) preferred orientation. In the case of Ti/TiN/TiAlN coatings, Ti peaks were also detected. Microhardness $HV_{0.02}$ values were in the range 18÷21 GPa - TiN, 24÷26 GPa - TiAlN, 25÷27.2 GPa - TiN/TiAlN and 28÷34 GPa - Ti/TiN/TiAlN. A good adhesion of all films was found, critical loads of 46 – 55 N being measured. The best wear resistance and the lowest friction coefficient were measured for the Ti/TiN/TiAlN multilayer (0.18÷0.26) followed by TiN/TiAlN (0.22÷0.28), TiN (0.26÷0.30) and TiAlN (0.28÷0.34). The biological tests had shown a relatively high cytotoxic effect of Ti5Al2.5Fe alloy (cell viability 49%). The best cell viability was found for the Ti/TiN/TiAlN coatings (75%), followed by TiN/TiAlN (68%), TiN (65%) and TiAlN (63%).

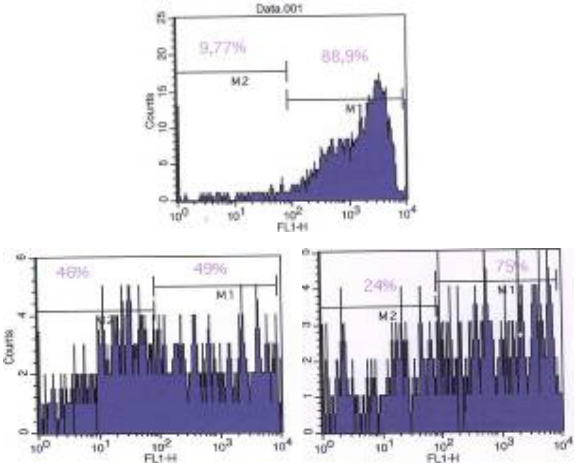

Fig. 1: Dermal fibroblasts: suspension (up), in presence of Ti5Al2.5Fe (left) and in presence of Ti/TiN/TiAlN (right).

DISCUSSION & CONCLUSIONS:
All the investigated coatings decreased the cytotoxic effects of Ti5Al2.5Fe alloy, while enhancing its mechanical, tribological properties. As compared with single layer coatings (TiN and TiAlN), the both multilayer films exhibited a superior mechanical, tribological and biocompatibility properties. Ti/TiN/TiAlN nanostructured multilayer presented the best biocompatibility properties and the higher wear resistance.

REFERENCES: [1] B. Kasemo (1998) *Current Opinion in Solid State&Materials Science*, 3, 451. [2] J. Helsen, H. Breme (1998) *Metals as Biomaterials*, Ed. Wiley, New York. [3] M.Balaceanu, M.Braic, D.Macovei, M.J.Genet, A.Manea, D. Pantelica, V.Braic, F.Negoita (2002) *J.Optoelectron. Adv. Mat*. 4 (1) 107 -114.

ACKNOWLEDGEMENTS: The work presented in this paper was supported by Romanian research project BIOTECH 4649/2004.