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Corrosion resistance of the biocompatible nitride and carbide thin films

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INTRODUCTION: In the last few years considerable research effort was directed to deposition of biocompatible thin films in order to increase the wear and corrosion resistance and life of various implants and prostheses [1]. In this paper, synthesis and characterization of TiN, TiC, Ti(C,N), ZrN and (Ti,Zr)N films prepared under different deposition conditions by a cathodic arc system are presented.

METHODS: The thin films were deposited using cathodic arc technique using Ti and Zr cathode targets [2]. These coatings were prepared in a reactive atmosphere of N_2 and CH_4+N_2, respectively. Hard coatings deposition was performed on Si and stainless steel substrates. The overall thickness of all coatings was approx. 2 µm. Elemental composition was investigated by Auger electron spectroscopy (AES). Phase composition and texture were determined by X-ray diffraction. Microhardness measurements were performed using a microhardness tester at 15 g load. Scratch tests under standard conditions were undertaken to determine the coating adhesion. The electrochemical test was used in order to determinate the corrosion resistance by measuring the corrosion current and the critical current for passivation. The test consisted of potentiodynamic polarization from -1100 to +1100 mV with a scan speed of 20 mV/s of the coated samples in artificial physiological solution.

RESULTS: The AES analysis showed that the layers are formed by almost stoichiometric layers (N/Ti≈N/Zr≈C/Ti≈(N+C)/Ti≈N/(Ti+Zr)≈1). For the (Ti,Zr)N film, Zr content is significantly higher that Ti content (Ti/Zr= 0.45). All types of coatings exhibited a strong (111) preferred orientation. For the (Ti,Zr)N coating, the diffraction lines were located nearby the positions of the lines found for the ZrN film, but with a slight shift ($0.5\text{-}0.7^0$) towards higher Bragg angles. This shows, as it was evidenced by the analysis of the elemental composition, that the Zr concentration in the film is substantially higher than that of Ti. One may conclude that the investigated layer crystallized in a face centered cubic ZrN lattice with reduced lattice parameters. Microhardness HV values were in the range 22÷26 GPa - TiN, 26÷28 GPa - TiC, 28÷35 GPa - TiCN, 25÷28 GPa – ZrN and 27÷34 GPa - TiZrN. A good adhesion of all films was found, critical loads of 40 – 57 N being measured. The best corrosion resistance was measured for the TiCN and TiZrN coatings followed by ZrN, TiC and TiN. It can be seen that the coatings improved the corrosion resistance of the uncoated specimens, by decreasing value of the critical corrosion current, as previously reported for some transition metal nitride and carbide coatings [3,4].

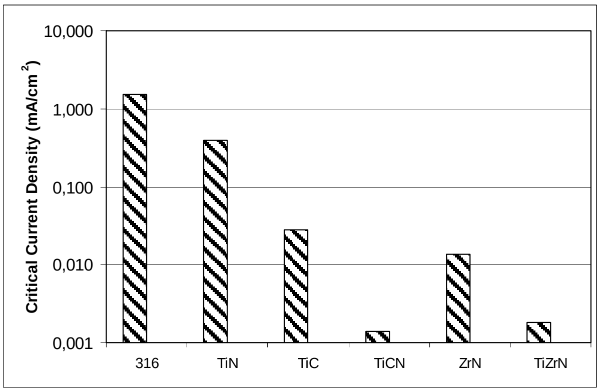

Fig. 1: Critical current densities of the coatings and substrate.

DISCUSSION & CONCLUSIONS: Coatings of transition metal nitrides (TiN, ZrN, TiZrN) and carbides (TiC, TiCN) were deposited on 316L substrates in order to enhance the corrosion resistance in artificial physiological solution of austenitic stainless steels. All coatings have shown the highest corrosion protection, exhibiting the lowest value of the critical corrosion current. Since the TiCN and TiZrN coatings were found to have the highest microhardness and adhesion and also a good corrosion behavior, these types of films would be an appropriate solution to enhance the performance of the stainless steel implants.

REFERENCES: [1] S. Black, (1999) *Biological performance of materials: fundamental of biocompatibility*, 3rd edition, Ed. Dekker, New York. [2] M. Braic, M. Balaceanu, V. Braic, A. Vladescu, G. Pavelescu, M. Albulescu (2005) Surf.Coat.Technol. **200**, 1014-1017. [3] M. Ürgen, A.F. Çakir (1997) Surf.Coat.Technol. **96**, 236-44. [4] E. Kelesoglu, C. Mitterer, M. Ürgen (2002) Surf. Coat. Technol.**160**, 82-86.

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