ENHANCEMENT OF THE BOND STRENGHT OF Ni-Cr AND Co-Cr ALLOYS ON THE CERAMIC FILMS IN DENTAL RESTORATIONS

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Introduction

The aim of the paper was to give novel solutions for enhancement of the bonding metal-ceramic dental restoration through introduction of a biocompatible and corrosion resistant thin film between metal and ceramic. In the present work, two types of coatings were selected, namely TiSiN and TiSiON. The coatings were prepared by cathodic arc method and were characterized in terms of microchemical, structural, morphological, mechanical, and anticorrosive properties.

Methods

NiCr or CrCr alloys were coated with thin films using the cathodic arc technique [Vladescu, 2013], in a reactive atmosphere consisted of N_2 and O_2 gases. The coating thickness and O_2/N_2 mass flow ratio were controlled for all depositions to be of about 2 μm and 1, respectively. The arc current and the negative substrate bias were of 90 A and 100 V, respectively. The thin films' elemental composition was determined via EDS Spectroscopy (XL-30 – ESEM). Phase composition and texture were studied by XRD analysis, with Cu Kα radiation. The surface morphology was investigated by Innova AFM. Because these coatings are intended to be used for dental applications, the corrosion experiments were conducted in Fusayama saliva solution. The potentiodynamic measurements were done by using a Parstat 4000 Potentiostat, at a scanning rate of 0.4 mV/s. After deposition, low-fusing dental ceramic film was fired on alloys coated with TiSiN and TiSiON thin films, using a dental furnace, according to the manufacturer recommendations. To evaluate the bond strength of the metal-coating-ceramic system, a 3-point bending test (3PB) was undertaken according to the ASTM D790-10.

Results

X-ray diffraction patterns showed (111) preferred orientations for all the coatings. The initial roughness of NiCr alloy is smaller than the one of CoCr alloy, probably because the last is harder than first one. The AFM analysis showed that the films exhibit a low roughness (Ra ~ 10 nm) independent to the type of substrates or coatings. As compared with TiSiN coatings, lower roughness (2 times) was measured for TiSiON coatings, whatever the substrates. The coated surfaces are less rough than the uncoated ones. From electrochemical test, the corrosion potential (E_{corr}) and current densities (i_{corr}), were determined. The E_{corr} and i_{corr} values of the coatings are lower than those of the bare metal, as a result of the beneficial barrier effect of the coatings. The results of the 3PB test are given in Table 1. The coatings improve significant the adhesion between NiCr alloy and ceramic films. In the case of CoCr alloy, no significant change was observed. In both cases, TiSiON coatings exhibited more bond strength, whatever the alloy type.

Substrate	Coating	τ_b (MPa)	sd (MPa)
CoCr	-	36.93	1.53
	TiSiN	36.23	0.24
	TiSiON	37.15	2.48
NiCr	-	27.86	2.89
	TiSiN	31.95	2.04
	TiSiON	32.64	2.37

Table 1 Results of the 3PB test (τ_b-fracture toughness; sd-standard deviation).

Discussion

The introduction of the coatings between NiCr or CoCr alloys and ceramic significantly improves the bond strength of metal–ceramic systems in comparison to the metal substrate after sandblasting only. The highest bond strength was obtained by the TiSiON coating on CoCr substrates. The research carried out confirms that the proposed coatings (TiSiON), could be a good solution to coat the metallic surfaces of dental restorations, in order to increase the bond strength of the ceramic films.

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References

A.Vladescu et al, http://dx.doi.org/10.1016/j.matchemphys.2012.12.010, 2013.