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Magnetron Sputter Deposition of Ti-Nb Coatings on AISI 316L Stainless Steel

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The most important criteria to develop metallic materials for manufacturing biomedical implants are the absence of toxic elements and a low modulus of elasticity. The metallic biomaterials mostly used as implants are stainless steel (SS), Co-Cr alloys, and Ti-based alloys due to their good mechanical properties, biocompatibility, high corrosion and wear resistance, and osseointegration. The comparison of titanium and its alloys with SS and Co-Cr alloys shows that although Ti alloys are significantly more expensive than SS and Co-Cr alloys, they are more biocompatible and their elastic modulus values are more compatible with those of the human bones (10-40 GPa). The elastic modulus values for AISI 316L, Cr-Co alloys, and pure titanium are 190 GPa, 210-253 GPa, and 105 GPa, respectively. The β-Ti (body cubic centered structure) alloys can have an elastic modulus even lower than 55 GPa. Niobium has been used as a nontoxic β-stabilizing agent, and its addition to Ti causes a decrease in the elastic modulus. An interesting option to overcome the costly use of bulk β-Ti-Nb alloys would be to coat an implant with a β-Ti-Nb thin film having adequate composition and thickness so that the coating would enhance the material biocompatibility. In this work, β-Ti-Nb coatings were deposited on AISI 316L SS substrate by magnetron sputtering, and four compositions were produced: Ti85Nb15 (Ti-26 wt. % Nb), Ti80Nb20 (Ti-33 wt.% Nb), Ti70Nb30 (Ti-45 wt. % Nb), and Ti60Nb40 (Ti-56 wt. % Nb). The coatings were characterized by atomic force microscopy (AFM), scanning electron microscopy SEM), energy-dispersive X-ray spectroscopy (EDS), transmission electron microscopy (TEM), and X-ray photoelectron spectroscopy (XPS). The mechanical properties were assessed by nanoindentation and scratch tests. The elastic modulus and the hardness values were in the ranges of 91.8-95.4 GPa and 5.4-7.4 GPa, respectively. No detachment of the coatings was detected.

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