Electrochemical Phenomena of TiN/ZrN Coated Ti-35Ta-xHf Alloys

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Ti and Ti based alloys have been used as implant materials in dental and orthopedic applications. However, it can cause potentially serious health problems because they release toxic metal ions. Thus, there are efforts for developing new titanium alloys with non-toxic elements. Current research is specially focusing on new β-type Ti alloys, using non-toxic elements such as Nb, Ta, Zr, and Hf, which exhibit lower elastic modulus and improve biocompatibility. Especially, Ta is found to reduce the modulus of elasticity when alloyed with Ti, and Hf belongs to the same group as Ti in the periodic table of elements, this element will likely have good corrosion characteristics. It is important to use appropriate surface modifications to increase the corrosive resistance and biocompatible properties of Ti alloys for long-term clinical applications. In recent years, the application of protective coatings for implants has been attracting considerable attention. Titanium nitride (TiN) film is an interesting choice for implants due to its useful properties, including chemical stability, high hardness, excellent wear properties, electrical properties and intrinsic biocompatibility. Also, zirconium nitride (ZrN) film has been attracting interest for its excellent corrosion resistance, biocompatibility, high hardness, good lubricity, and ductility properties, thereby making it potentially useful in biomedical engineering. ZrN film have been reported to exhibit better corrosion protection ability compared to TiN and have been used to improve the corrosion resistance of some biomaterials. Magnetron sputtering is one the most important growth techniques in thin film realization. The sputtering deposited films had a uniform and dense structure, especially on complex implant designs, like threaded implants. In this way, multilayer coatings have many virtues, especially the compact microstructure and good corrosion resistance. In this study, we investigated the electrochemical phenomena of TiN/ZrN coated Ti-35Ta-xHf alloy.

The Ti-35Ta-xHf alloys(x=0 ~ 15wt.%) were prepared by vacuum arc-melting furnace. Commercially high purity Ti, Ta and Hf were employed for the purpose. The specimens were group up to 2000-grit SiC paper and then polished using 1 μm aluminum oxide powder. The polished specimens were sonicated successively in acetone and ethanol, and then rinsed with deionized water and dried. A commercially pure Ti target and Zr target were used as coating source. The Ti-35Ta-15Hf alloys were used as substrates. The sputtering chamber was evacuated to a base pressure lower than 10^{-5}torr, then back-filled with high purity argon and nitrogen until a working pressure of 10^{-2} torr was obtained. Prior to deposition, the substrate surface was first sputtering-cleaned for 20 min at RF mode. The TiN and ZrN target were in the side-by-side configuration. The magnetron sputtering deposition for TiN was performed in the RF mode for 2h. And then, ZrN was performed in the RF mode for 2h. The corrosion test of the uncoated and TiN/ZrN multilayered Ti-35Ta-15Hf alloy were studied in 0.9% NaCl at temperature of 37 ± 1℃.

Ti-35Ta-xHf alloy showed α"+β phase structure. The coating layer is about 64nm thick. No pore and cracks can be observed throughout the coating surface and layer. A blurred interface between the coating and substrate can be seen and it should provide good adhesion between the coating and substrate. The specimens showed an active to passive transition behavior. Apparently, when compared to Ti-35Ta-15Hf alloy, the TiN/ZrN multilayered film substrate exhibited a reduced corrosion current for all of the potentials measured, confirming the significantly improved corrosion resistance of the TiN/ZrN multilayered film(Supported by NRF-2009-0074672).