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Surface modification of NiTi by carbon plasma immersion ion implantation(C-PIII)

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Introduction: Plasma immersion ion implantation (PIII) is commonly used to improve the corrosion behavior, biocompatibility and tribological surface properties of biomaterials [1-2]. NiTi alloys are widely used in biomedical application [1-3] because of unique properties such as super-elasticity and shape memory effects. The good biocompatibility is due to the formation of a thin passive film under natural conditions but it can be destroyed byan external corrosion medium leading to leaching of Ni [2-3]. To overcome this problem which depends on the corrosion resistance of the metal, surface modification can be implemented to improve the biological properties of NiTi alloys[1-3]. In this study, carbon plasma immersion ion implantation (C-PIII) is adopted to modify NiTi alloys to improve the corrosion behavior.

Materials and Methods: Ni50.8Ti49.2 (at%) disks were polished to a mirror finish and ultrasonically cleaned in acetone, absolute ethanol, and deionized water. The NiTi alloys were treated by carbon plasma immersion ion implantation (C-PIII) in a vacuum chamber witha carbon plasma generated by a pulsed cathodic arc plasma source.The phase, structure, and morphology of the surface were examined by glancing-angle X-ray diffraction (GIXRD), field-emission scanning electron microscopy (FE-SEM), and atomic force microscopy (AFM), respectively. The thickness of the coating was determined by XPS depth profiling. The corrosion behavior was evaluated by performing electrochemical impedance and potentiodynamic polarization tests in a cell composed of the working, reference, and auxiliary electrodes in 250 ml of 3.5% NaCl on the Zennium Electrochemical Workstation potentiostat galvanostat using the ZView analysis software.

Results and Discussion: The results confirm the formation of a uniform, smooth, and crack-free coating with a thickness of 50 nm by carbon plasma immersion ion implantation coating for 2 h. C-PIII changes the roughness, hardness, and elastic module from 17.4 nm, 64.31 GPa, and 2.74 GPa for the pristine NiTi alloy to 6.1 nm, 89.27 GPa, and 4.77 GPa for the C-PIII NiTi, respectively. The Nyquist curves indicate that C-PIII improves the corrosion resistance and hardness of NiTi without forming defects and also obstructs the release of Ni from the materials.

Conclusion: C-PIII is utilized to modify the surface of NiTi alloys to increase the corrosion resistance and hardness. It also promotes the biocompatibility of NiTi by obstructing the formation of defects and out-diffusion of Ni from the substrate.

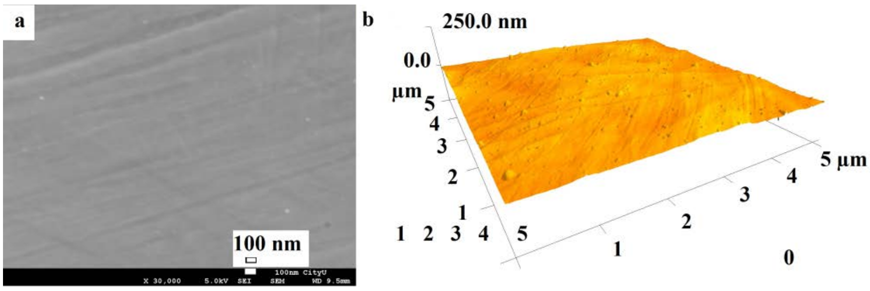

Figure 1(a) FE-SEM image an, (b) AFM image of the sample after carbon plasma immersion ion implantation (C-PIII).

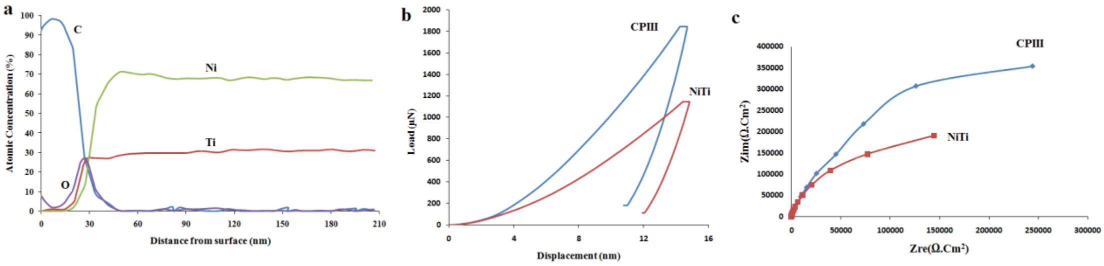

Figure 2 (a) XPS depth profile of the surface coating formed carbon plasma immersion ion implantation, (b) Nanoindentation test, and (c) Nyquist plot of NiTi after carbon plasma immersion ion implantation.

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