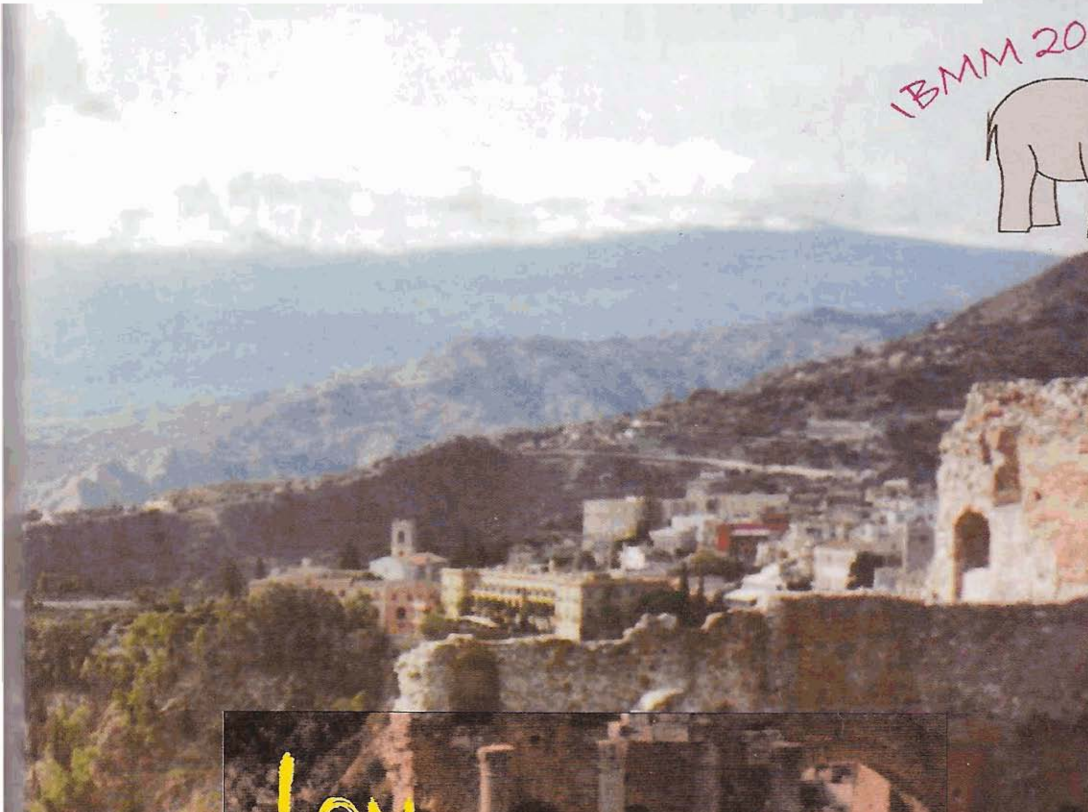
IBMM 2006



Ion Beam Modification of Materials

Program and Abstracts

15th International Conference

San Domenico Palace Hotel

Taormina - Italy

September 18-22, 2006

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Oxygen and sodium plasma-implanted nickel-titanium shape memory alloy: A novel method to promote hydroxyapatite formation and nickel suppression

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Introduction: Nickel-titanium (NiTi) shape memory alloy is a promising orthopedic biomaterial due to its memory and super-elastic properties. Their high nickel concentration is, however, a major obstacle to qualify them as surgically implantable materials. Previous studies have shown that oxygen plasma immersion ion implantation (PIII) can mitigate nickel leaching and enhance the corrosion resistance. Nonetheless, the oxygen-implanted layer is bio-inert and does not bond well to bones. This may lead to mechanical failure at the bone-implant interface when the modified NiTi is used as orthopedic implants. The use of sodium PIII has been shown to enhance the surface bioactivity of titanium. This study aims at modifying the surface bioactivity of the oxygen plasma pre-treated NiTi surface by sodium PIII.

Materials and Methods: Sodium PIII was conducted at 15 kV and 50 Hz on six oxygen PIII pre-treated samples and six untreated NiTi control samples. Their surface chemistry was examined by X-ray photoelectron spectroscopy (XPS). In order to assess the bioactivity, the samples were immersed in simulated body fluids (SBF) for 7 and 21 days. As the surface bioactivity is reflected by the ability to deposit calcium phosphate, scanning electron microscopy (SEM) was used to observe deposit formation and energy dispersive x-ray analysis (EDS) was employed to confirm the presence of calcium and phosphorous. The corrosion resistance of the materials was evaluated by potentiodynamic polarization tests.

Results: XPS results reveal that the amount of sodium implanted into the oxygen plasma pre-treated samples is higher than that in the nntreated samples. Sodium ion penetration into the oxygen pre-treated NiTi is well over 18nm while it is only 6nm in the untreated NiTi. In the SBF immersion test, deposits on both the oxygen pre-treated and untreated samples are detected by SEM. EDS confirms that these deposits consist of calcium and phosphorus. The deposit covers a larger snrface area on the oxygen pre-treated samples than the untreated samples after 7 and 21 days. No significant difference in corrosion resistance can be obsreved between the oxygen pre-treated and untreated samples after Na PIII.

Discussion and conclnsion: Oxygen PIII pre-treatment in NiTi can enhance the efficiency of subsequent sodium PIII. This phenomenon may attribute to the surface defects produced by oxygen PIII leading to easier movement of sodium ions into the modified surface and the presence of oxygen to stabilize the sodium ions. The ability to nucleate more calcium phosphate on the oxygen and sodium PIII samples is likely due to the formation of more sodium titanate caused by the higher atomic concentration of sodium. In conclnsion, with the combined use of sodium PIII and oxygen PIII pre-treatment, a bioactive diffusion barrier layer can be obtained. The new bioactive plasma treated NiTi alloys may enhance the biomechanical properties at the bone-implant interface, thereby redncing the possibility of orthopedic implant failure due to poor bone adhesion.