Ion Bean Etching on Ti-30Ta Alloy for Biomedical Application

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Abstract

Titanium and titanium alloys are currently being used for clinical biomedical applications due to their high strength, corrosion resistance and elastic modulus. However, these materials have recently been shown to exhibit ion release and poor physiological integration that may result in fibrous encapsulation and further biomaterial rejection. In order to be a successful replacement for bone current approaches for enhancing the mechanical and biological properties of Ti was alloyed Ti with Ta due to it provides greatly improved mechanical properties which include fracture toughness and workability. Studies have shown techniques such ion beam etching, heat and alkaline treatment, SBF coatings and anodization to promote altered cellular response on Ti and Ti-alloys. In this study Ti-30Ta alloy was investigated ion beam etching. The SEM was used to investigate the topography, EDS the chemical composition, and surface energy was evaluated with contact angle to analyze due to the topography have effect on protein adsorption, platelet adhesion, blood coagulation and bacterial adhesion. This study concludes Ti-30Ta alloy substrate with ion beam etching was not favorable for biomedical application.

Introduction

Metallic materials have been used as implantable for orthopedic and dental implants. The interaction between the implant surface and the tissue plays an important role on the success of this implantable device. Several studies have shown that by modifying the surface at a nanoscale or a microscale can alter cellular response. Studies have shown techniques such ion beam etching to promote altered cellular response on Ti and Ti-alloys. One effective parameter to evaluate the biological response of the metallic biomaterials is investigated the wettability of the surface of this material due to the topography have effect on protein adsorption, platelet adhesion, blood coagulation and bacterial adhesion.

In this study, the substrate surface of the Ti-30Ta alloy was altered by topographical surface modification. The Ti-30Ta alloy substrates were modified with ion beam etching. Following techniques were used for characterized all groups: scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS) and contact angle analyze.

Materials and Method

Ti and Ta were combined by a melting process, homogenized in a vacuum, cold-worked by a rotary swaging process and cut in discs. The Ti-30Ta modified by etching the alloy surface to oblique angle oxygen ion beam by increasing the oxygenation of the near surface regions. Etching was done with a 16 cm ion source in a low-pressure environment (approximately 1.6 x 10^{-7} Torr). Gas flow rates through the source and neutralizer were 20 sccm O\textsubscript{2} and 8 sccm Ar respectively. An
energetic ion beam of 1200 eV ions with a beam current of 200 mA was used for a 3 hour etch. This beam consisted primarily of oxygen ions though it is possible that minute amounts of background Ar gas could diffuse into the source, ionize and be included. The substrates were placed on an inclined holder so the resulting angle of ion incidence was approximately 75 degrees from the surface normal.

**Physical characterization**

The Ti-30Ta alloy substrates surfaces were examined before and after the surface modification. The surface topography of the substrates was characterized using a JEOL JSM-6500FESEM. The surface elemental composition of the Ti-30Ta alloy substrates was further characterized with energy-dispersive X-ray spectroscopy (EDS, JSM- 6500F SEM). Wettability of the modified surfaces were determined by measuring water contact angle (FTA1000B Class, First Ten Angstroms, Inc). A 2 µl droplet of distilled water was dropped on the surface. Immediately after this the droplet images captured using a camera. The image were then processed with the accompanying Fta32 software determine give contact angle and the droplet volume. All the studies were conducted for minimum 6 samples to ensure appropriate statistical variability.

**Results and Discussion**

Figure. 1 shows SEM images and EDS. The results show formation of nano-scale spheroids with a wavy surface architecture.

![Figure 1 – SEM images (left) Ti30Ta and (right) Ti30Ta etched at 1200eV with a beam current of 200mA. The samples were placed on a 75 degree incline meaning the angle of incidence was ~75 degrees from normal. Coating gold 10 and 5 nm respectively](image)

Further, the results indicate that the ion etching did not significantly alter the surface. It seems that etching at 1200eV was not enough to significantly change the surface topography. EDS spectra for both group shows peaks for titanium and tantalum. The Figure. 2 shows contact angle measurements Ti-30Ta control group and Ti-30Ta etch. The results indicate following order of surface hydrophilicity:

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\text{Group 2} > \text{Group 1}
\]

This behavior is extremely important since cell and bacterial adhesion, protein adsorption, platelet adhesion and activation and blood coagulation may be affected. The materials for biomedical application need to be more hydrophilic since they have higher surface energy which is desirable for biological interaction.
Conclusion

In this study, the Ti-30Ta alloy substrates were modified by ion beam etching. SEM results show different structure on the surface. EDS spectra identified similarity on Group 1 and 2. The results presented here a little alteration in the topography on the substrate surfaces. Overall the contact angle shows Ti-30Ta etch more hydrophobic than Ti-30Ta control. This study concludes Ti-30Ta alloy substrate with ion beam etching was not favorable for biomedical application.

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