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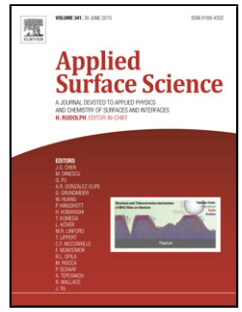

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Author: Chi-Wai Chan Seunghwan Lee Graham Smith Gianluca Sarri Chi-Ho Ng Ahmed Sharba Hau-Chung Man

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Enhancement of Wear and Corrosion Resistance of Beta Titanium Alloy by Laser Gas Alloying with Nitrogen

Chi-Wai Chan[1], Seunghwan Lee[2], Graham Smith[3], Gianluca Sarri[4], Chi-Ho Ng [1,5], Ahmed Sharba[4], Hau-Chung Man[6]

1 School of Mechanical and Aerospace Engineering, Queen's University Belfast, BT9 5AH, UK

2 Department of Mechanical Engineering, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark

3 Department of Natural Sciences, University of Chester, Thornton Science Park, Chester, CH2 4NU, UK

4 School of Mathematics and Physics, Queen's University Belfast, Belfast BT7 1NN, UK

5 Laser Engineering and Manufacturing Research Centre, Faculty of Science and Engineering, University of Chester, Thornton Science park, Chester CH1 4BJ, UK

6 Department of Industrial and Systems Engineering, Faculty of Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Corresponding Author: c.w.chan@qub.ac.uk

Abstract

The relatively high elastic modulus coupled with the presence of toxic vanadium (V) in Ti6Al4V alloy has long been a concern in orthopaedic applications. To solve the problem, a variety of non-toxic and low modulus beta-titanium (beta-Ti) alloys have been developed. Among the beta-Ti alloy family, the quaternary Ti-Nb-Zr-Ta (TNZT) alloys have received the highest attention as a promising replacement for Ti6Al4V due to their lower elastic modulus and outstanding long term stability against corrosion in biological environments. However, the inferior wear resistance of TNZT is still a problem that must be resolved before commercialising in the orthopaedic market. In this work, a newly-developed laser surface treatment technique was employed to improve the surface properties of Ti-35.3Nb-7.3Zr-5.7Ta alloy. The surface structure and composition of the laser-treated TNZT surface were examined by grazing incidence x-ray diffraction (GI-XRD) and x-ray photoelectron spectroscopy (XPS). The wear and corrosion resistance were evaluated by pin-on-plate sliding test and anodic polarisation test in Hanks' solution. The experimental results were compared with the untreated (or base) TNZT material. The research findings showed that the laser surface treatment technique reported in this work can effectively improve the wear and corrosion resistance of TNZT.

Keywords: Laser Surface Treatment, Beta Titanium, TNZT, Wear, Corrosion, Surface Hardening

Introduction

Ti6Al4V alloys have long been considered as the workhorse in orthopaedic applications due to their excellent mechanical properties and corrosion resistance. However, their elastic modulus is still larger than that of human bone causing the problem of "stress-shielding" or osteopenia. The stress shielding effect which originates from the disparity of elastic modulus between implant materials and human bones causes a reduction in bone density and results in the loosening of implants in the long term (M.R. Prince, E.W. Salzman, F.J. Schoen, A.M. Palestrant, M. Simon, 1988). Moreover, the presence of the toxic vanadium (V) element in the Ti6Al4V alloy also creates the concern of toxic ion release near the implanted area (F. Kasano, T. Morimitsu, 1997). Recently, advances in materials technology have led to the development of beta-titanium (beta-Ti) alloys. Beta-Ti alloys possess desirable properties over the conventional Ti6Al4V alloy, such as lower elastic modulus, super-elastic behaviours, and no concern of toxicity/allergy problems (J. Ryhanen, M. Kallioinen, W. Serlo, P. Peramaki, J. Junila, P. Sandvik, E. Niemela, J. Tuukkanen, 1999). A variety of beta-Ti alloy systems constituted by different combinations of non-allergic/toxic beta-stabilising elements (Zr, Nb, Ta, Mo,