Effect of plastic deformation on the corrosion behaviour of Ti-29Nb-13Ta-4.6Zr biomedical alloy with ultra-low stiffness

Agata SOTNICZUK[1], Donata KUCZYNSKA[1], Piotr KWASNIAK[1], Krzysztof TOPOLSKI[1], Halina GARBACZ[1]

[1] *Faculty of Materials Science and Engineering, Warsaw University of Technology, Poland*

Nowadays, much effort is being put to into creating new biomaterials with a stiffness closer to human bone (Young modulus about 30 GPa). Substantially greater stiffness of biomaterial prevents stress being transfer to adjacent bone which may result in bone resorption around implant and even implant loosening leading to revision surgery. A new group of metastable β Ti alloys such as Ti-29Nb-13Ta-4.6Zr alloy (TNTZ) responds to the above requirements, offering remarkably low stiffness. Another advantage of TNTZ alloy is relatively great β phase stability which prevents spontaneous phase transitions during plastic deformation. Thereby, beneficial ultra-low stiffness does not change during further technological processing. However, TNTZ possess relatively low mechanical strength compared to other Ti biomedical alloys such as Ti6Al4V. In case of TNTZ, enhancement of mechanical strength without loosening of ultra-low stiffness can be achieved by large plastic deformation processes such as cold-rolling. Large plastic deformation affects not only mechanical but also functional properties such as corrosion resistance. The high dislocation density in cold-rolled alloy may affect passivation process and stability of the oxide layers. Moreover, plastic deformation may influences chemical composition of protective oxide layers (contribution of Ti, Nb and Ta oxides) and thereby changes the corrosion response.

The main aim of this work was to investigate the effect of plastic deformation on the corrosion resistance of modern β Ti alloy (TNTZ) in terms of its biomedical applications. Corrosion behaviour was evaluated based on electrochemical tests (OCP, EIS – after different immersion times, potentiodynamic polarization) combined with surface analysis (XPS). Additional investigations included evaluation of the influence of plastic deformation on microstructure (OIM, TEM) and mechanical properties (microhardness and Young modulus) of TNTZ. This study provide in-depth analysis of the correlation between plastic deformation, surface chemical composition and corrosion response of modern β Ti alloy with ultra-low stiffness.

This work was supported by The National Science Centre Poland [Grant number 2016/21/B/ST8/01965].