Plasma electrolytic oxidation of β-TiZr alloy in Ca-P solution with ZnO nanoparticles

O. Oleshko[1],V. Deineka[1], I. Liubchak[1], J. Michalska[2], W. Simka[2,3], O. Mishchenko[3], M. Pogorielov[1,3]

[1]Sumy State University, Sumy, Ukraine. [2]Silesian University of Technology, Gliwice, Poland, [3]Osteoplant R&D, Dębica, Poland

INTRODUCTION: Dental implant surface quality is a crucial factor for osteointegration and clinical success. Sandblasted, SLA, anodizing etc. surfaces are already used in clinical practice but clinical outputs reported up to 12% fails during 15 years after implantation. Plasma Electrolytic Oxidation (PEO) is a method that can provide one-step generation of protective and multifunctional bioceramic coatings with improved wear and corrosion resistance, enhanced protein absorption, accelerated osseointegration. Incorporation of some ions into implant coatings can refine implant bioactivity. New alloy (e.g. β-Ti-based) was investigated to prevent stress-shielding effect and increase implant success rate. However, the influence of different PEO parameters on surface modification of low-modulus Ti-based alloys remains unclear.

Current research aimed to assess structure and cell response to PEO-modified β-TiZr alloy in Ca-P bath with addition of ZnO nanoparticles.

METHODS:

β-TiZr alloy (Ti50%-Zr50%) in a form of disks with 6 mm diameter and 4 mm high was used in experiment. PEO was performed in a solution of 0.1 M $Ca(H_2PO_2)_2$ with or without ZnO nanoparticles (NPs). Process voltage was from 300 to 500 V, and current density was equal 50 mA/cm^2. Based on SEM and contact angle measurements, samples were selected for cell culture experiment provided in primary rat osteoblast culture.

RESULTS: Voltage increase (more than 400 V) in pure $Ca(H_2PO_2)_2$ solution leads to formation of flat surface with no porous structure, in the case of $Ca(H_2PO_2)_2$-ZnO bath - to development of cracks affected the porous sample surface (Fig. 1). It must be noted, that addition of ZnO NPs to electrolyte provide formation of rough mesoporous surface compare the pure $Ca(H_2PO_2)_2$ solution.

Contact angle of samples after PEO in $Ca(H_2PO_2)_2$ bath ranges between 51.9 ± 10.3 and 57.1±8.3 with or without any significant relation to voltage. In ZnO NPs-contained solution contact angle increased with voltage elevation from 58.2±47.6 at 350 V to 123.1±6.2 at 450 V.

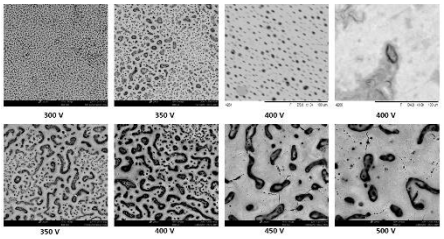

Fig. 1: SEM images of anodized surface in $Ca(H_2PO_2)_2$ solution (upper row) and $Ca(H_2PO_2)_2$-ZnO solution (lower row).

Based on the SEM and contact angle investigations four surfaces were selected for cell culture – pure Ca-P (300 and 350 V) and Ca-P with Zn-O (350 and 400 V). Resazurin reduction assay did not show difference in cell attachment and proliferation in 1st and 3rd days but in 7th day we can see acceleration of osteoblast proliferation on ZnO-contained surfaces (Fig. 2).

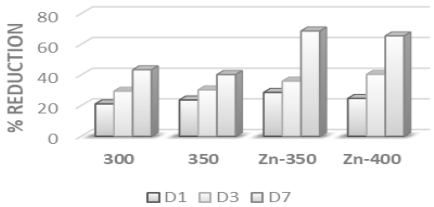

Fig. 2: Resazurin reduction assay in 1-7 days of osteoblast cultivation on PEO-coated β-TiZr *alloy.*

DISCUSSION & CONCLUSIONS: PEO of β-TiZr alloy in $Ca(H_2PO_2)_2$ solution leads to formation of porous layer at lower voltages (300-350 V). ZnO NPs addition provide formation of advanced mesoporous surface at voltages 350 and 400 V and lead to cracks formation with voltage increase. Mesoporous surface support cell attachment and facilitate osteoblast proliferation within 7 day of cultivation.

ACKNOWLEDGEMENTS: This research was supported by H2020 MSCA, grant NanoSurf 777926.