Microstructural Evolution and Mechanical Properties of Ti–25Nb–8Sn–4Ta Beta Titanium Core–Shell Structures Fabricated by Ball Milling and Spark Plasma Sintering

Jan Blažek[1], David Nečas[1], Jiří Kubásek[1]

[1]*University of Chemistry and Technology in Prague, Faculty of Chemical Technology, Department of Metals and Corrosion Engineering, Prague, Czech Republic*

E-mail: blazekb@vscht.cz

Beta titanium alloys have gained significant attention in biomedical and structural applications due to their unique combination of properties. They exhibit a low elastic modulus, closely matching that of human bone, which helps to reduce the stress shielding effect in medical devices. Additionally, their excellent corrosion resistance and biocompatibility ensures long-term stability in physiological environments further enhancing their suitability for medical devices and orthopaedic implants. Furthermore, the core–shell structures enhance mechanical properties by increasing strength while maintaining a good plasticity.

Core–shell structures composed of coarse-grained β-phase cores surrounded by ultrafine-grained α+β-phase shells were successfully prepared by combining mechanical milling and spark plasma sintering (SPS). In these materials, the degree of deformation of the powder precursors affected the volume fraction of the fine-grained phase, which significantly contributed to the increase in both flexural and compressive strength (σ_{YC} = 950 ± 28 MPa) as well as hardness (290 ± 17 HV_1), compared to the reference material prepared solely by SPS (σ_{YC} = 712 ± 6 MPa and 194 ± 8 HV_1). Increased oxygen content and embedded deformation promoted the nucleation of fine-grained (<1 µm) α-Ti along β-Ti matrix grains, as revealed by EBSD, SEM, and EDX analyses. With a higher content of fine-grained regions, which serve as the primary sites for crack propagation during bending tests, the ductility decreases. Overall, the Ti-25Nb-8Sn-4Ta core–shell structures were successfully prepared, but the results indicate that processing parameters must be carefully optimized to balance the trade-off between strength and ductility.

This research was funded by project "Mechanical Engineering of Biological and Bio-inspired Systems", funded as project No. CZ.02.01.01/00/22_008/0004634 by Programme Johannes Amos Comenius, call Excellent Research.