UNIVERSITY OF SILESIA
FACULTY OF SCIENCE AND TECHNOLOGY

International Exhibition of Innovation

IEI 2023

Functional Grade Material based on titanium and titanium-based alloys produced for potential individual implants

Izabela Matula[1*], Grzegorz Dercz[1**], Adrian Barylski[1], Piotr Duda[2]

[1] Institute of Materials Engineering, University of Silesia in Katowice, 75 Pułku Piechoty Street 1 A, 41-500 Chorzów, Poland;
[2] Faculty of Science and Technology, Institute of Biomedical Engineering, University of Silesia in Katowice, Będzińska Street 39, Sosnowiec, 41-200, Poland

* izabela.matula@us.edu.pl, **grzegorz.dercz@us.edu.pl

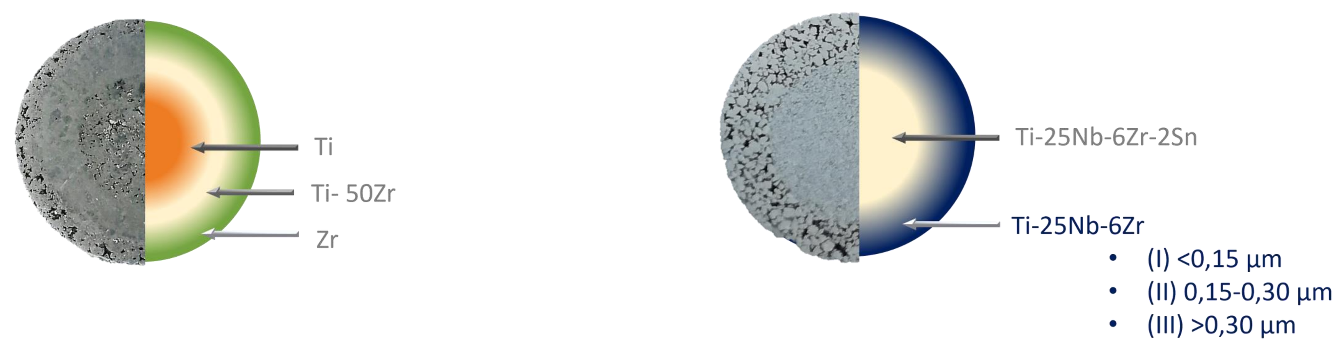
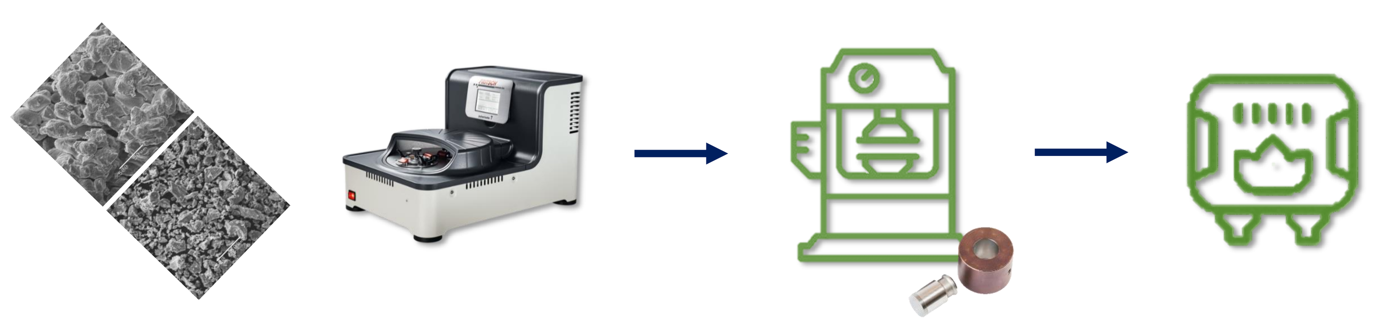


Fig. 1. A representation of samples construction

FABRICATION



The production process innovation

The small addition of tin (3 wt.%) as the PCA in powder metallurgy proces is effective method to control mechanical alloying processes. First, that addition improved the nanocrystallation of titanium phases and simultaneously, led to a considerable particle refinement and their homogenization by controling the cold-welding and agglomeration of particles.

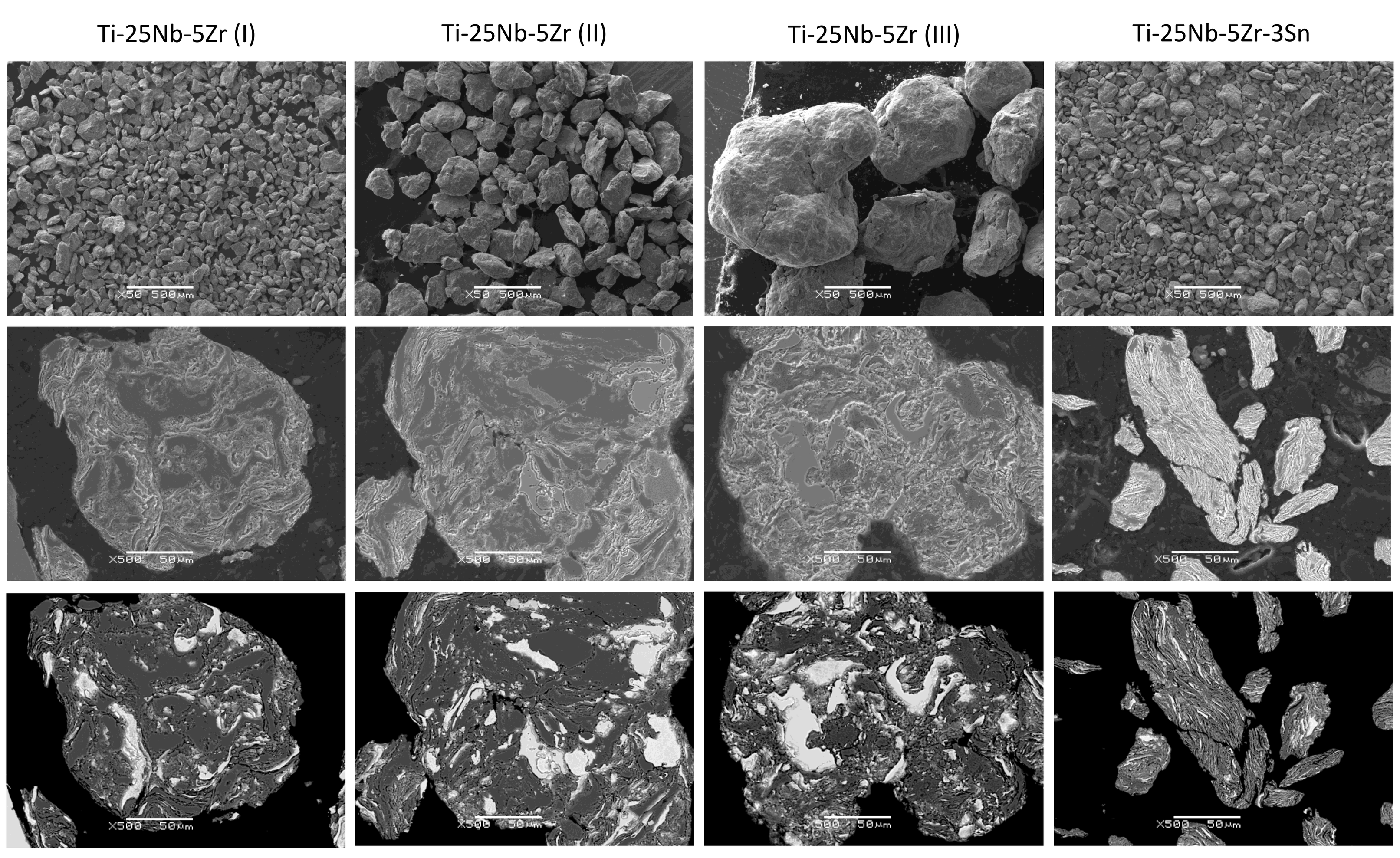
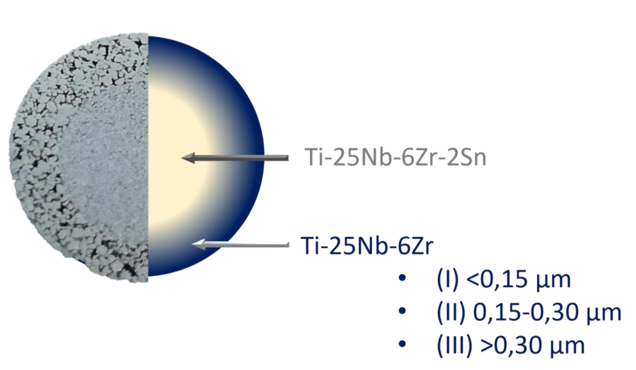


Fig. 2 SEM micrographs in secondary electrons (SEI) and backscattered electrons (BSE) contrast of powders (top line) and powder crossection after milling and sieve separation

GRADIENT SAMPLES II



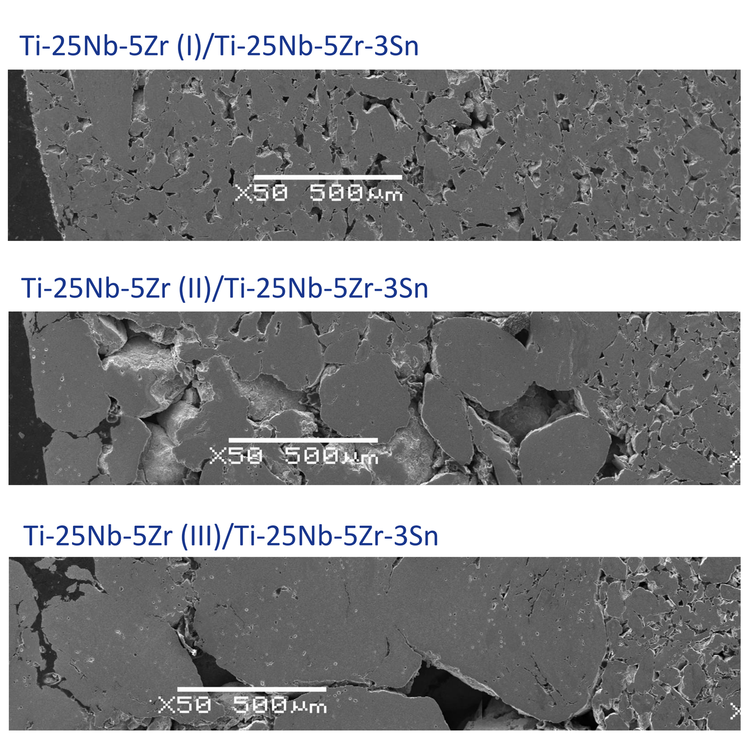


Fig. 3 SEM micrographs of sintered samples in both configuration

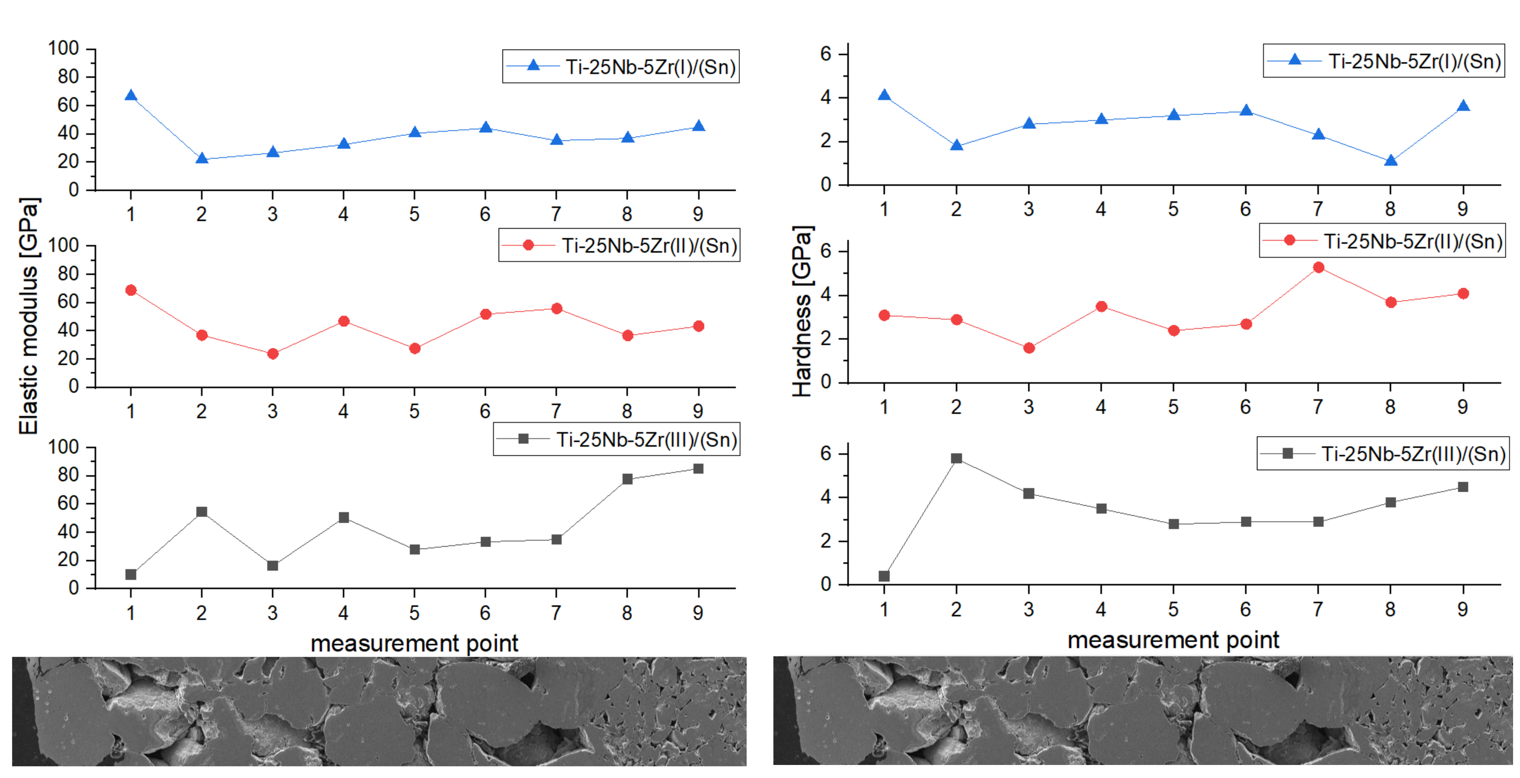
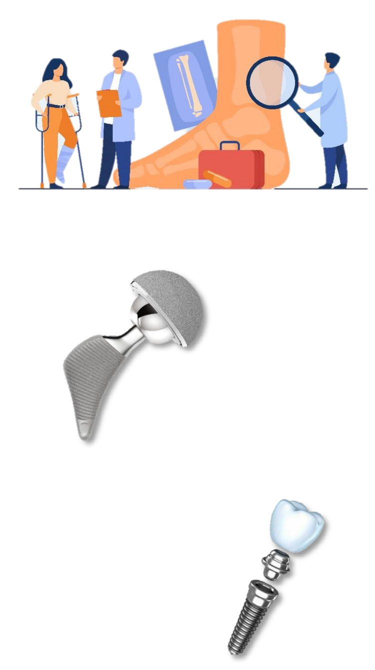


Fig. 4 Hardness and elastic modulus measurement of Ti-25Nb-5Zr(I)/(Sn), Ti-25Nb-5Zr(II)/(Sn) and Ti-25Nb-5Zr(III)/(Sn) samples in relation to the location of measurement point (from outer zone to the inside zone)

INFORMATION



Medical reports (including the WHO report) present alarming statistics on the development of civilization diseases and the demand for implants. Despite the many efforts of doctors, engineers and medical companies, the implant as well as the procedure are not perfect. Therefore, a high percentage of premature implantations is observed. The main problem with metal implants is the mechanical mismatch between human bone and the implant material.

One possible solution is to design a new titanium-based gradient materials for potential application to implants manufactured by powder metallurgy is development of producing method of titanium-based materials for long-lasting bone/dental implants design in a holistic way (regard to non-toxic composition, improved mechanical properties and porosity, which can improve the connection and reduce between the implant and the bone).

Production of implants with gradient porosity enable an almost personal approach to the patient's needs, e.g. osteoporosis, bone properties or demand. Moreover, the porous implant promotes bone ingrowth into the pores and allows stress to be transferred from the implant to the bone. This approach leads to possibility to create material build with different materials (composition and porosity), where each of the material zone can respond to various individual patients needs.

Functional graded materials (FGM) are materials whose structure, composition or porosity is distributed in a gradient. The above areas are characterized by microscopic areas of non-homogeneous material, which in the whole form a gradient of the analyzed factor. The whole sample is built of zones with different porosity and composition internal and external zones with radial gradient.

GRADIENT SAMPLES I

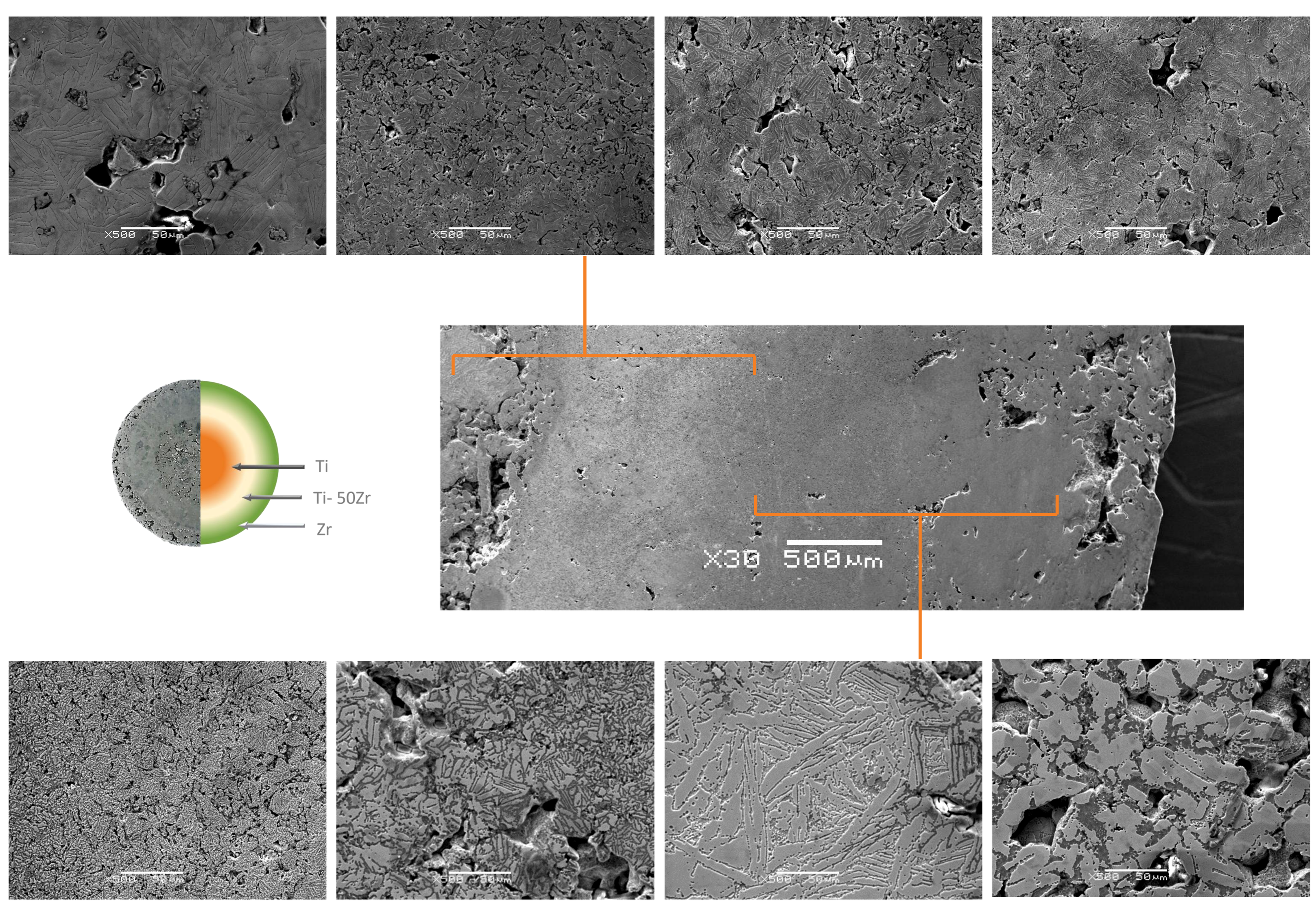


Fig. 5 SEM micrographs of sintered sample

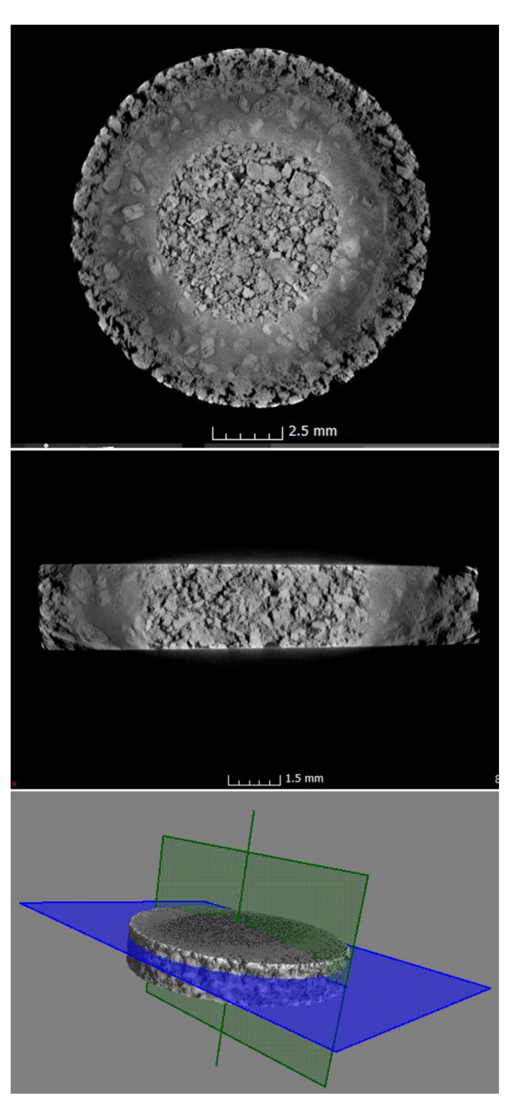


Fig.7 Microtomography observations of the Zr-Ti/Zr-Ti sample. Cross-section of the specimen and the location where the above images were taken

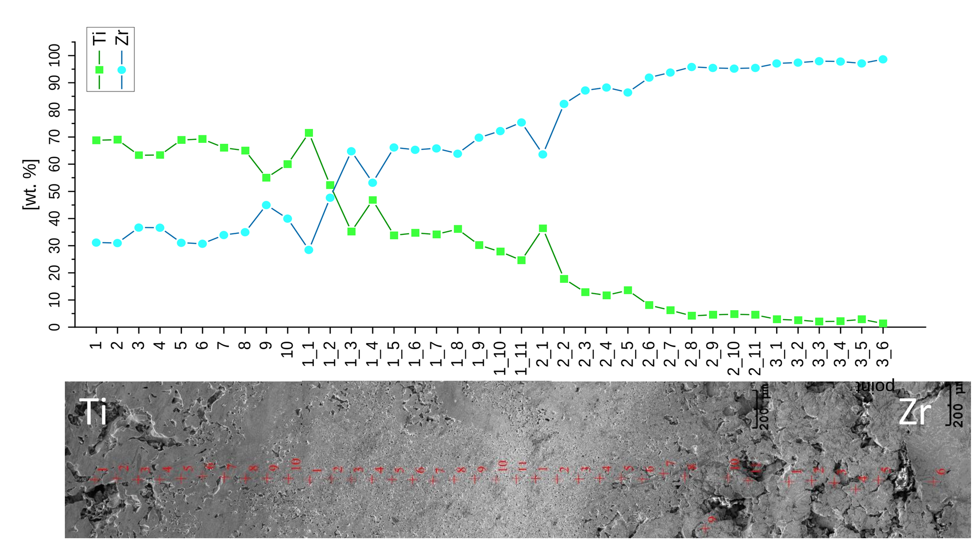


Fig. 6 Change of chemical composition across the sample crossection

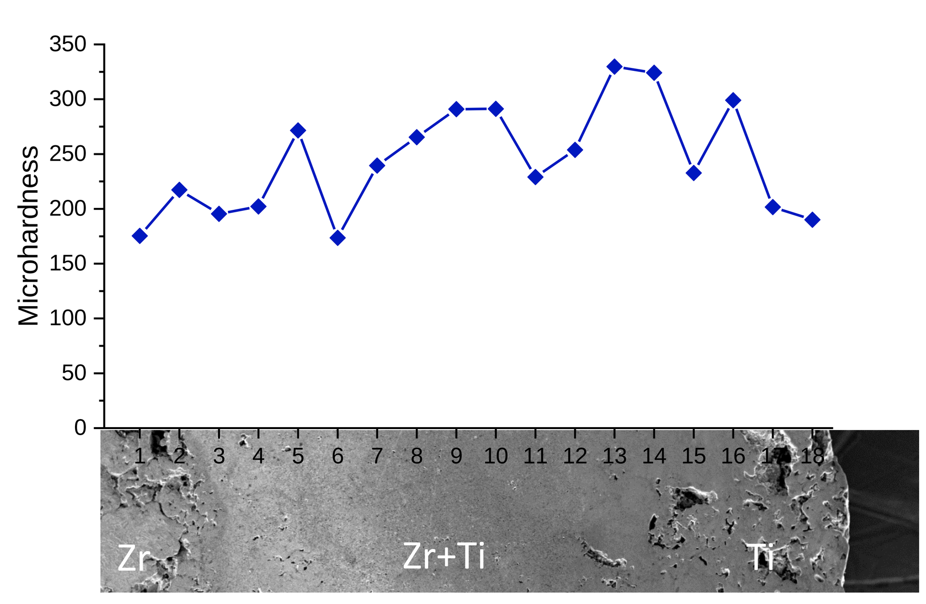


Fig. 8 Microhardness measurment across the sample