ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

THE DIFFERENT HEAT TREATMENT EFFECTS FOR THE NITRIDATION EFFICIENCY OF THE 3D-PRINTED TITANIUM ALLOY

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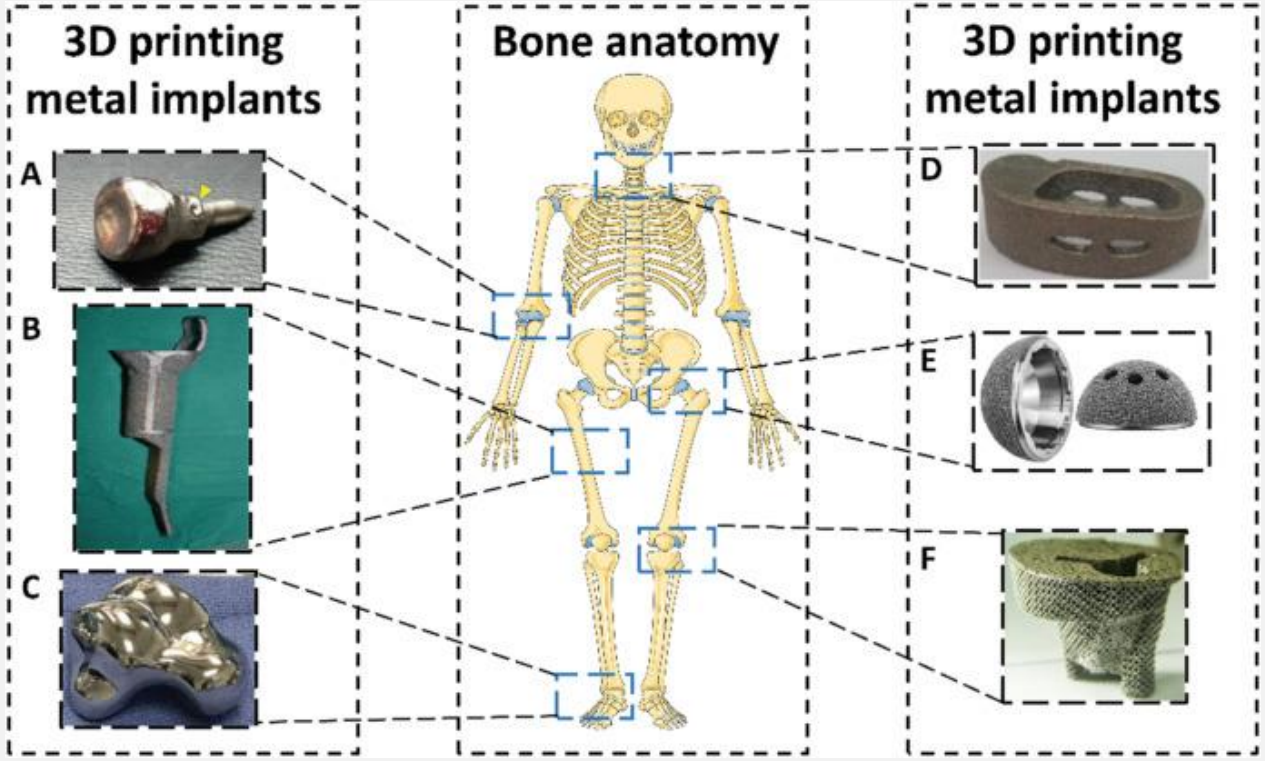
Semester 3 (2024/2025)

TITANIUM IN BIOMEDICAL INDUSTRY



Source: Meng et al. (2023)

TI6AL4V VS ZRTINB

- The unique and adaptable qualities of titanium alloy make it an excellent material for the biomedical sector
- Ti6Al4V is widely used for medical applications, but there has been ongoing research for alternatives
- ZrTiNb alloys such as ZTM14N is a safer option over time as the absence of vanadium and aluminium in this alloy addresses the concerns about potential cytotoxicity associated with these elements in Ti6Al4V
- Due to the lack of clinical data supporting the use of ZrTiNb alloys, extensive research needs to be done, in order to further validate the potential of ZrTiNb alloys as a safer and more effective alternative in the future

CHEMICAL COMPOSITION

- Alpha phase stabilizer – aluminium
- Beta phase stabilizers – vanadium and niobium

Ti6Al4V		ZrTiNb	
Element	%	Element	%
Al	5.5 – 6.5	Zr	21.46
V	3.5 – 4.5	Nb	27.12
C	0.08	C	0.039
O	0.13	O	0.15
Others	0.79	Others	0.019

MECHANICAL PROPERTIES

- Surfaces of Ti6Al4V fabricated using selective laser melting (SLM) have hardness values that vary from 362 HV to 387 HV
- Formation of martensitic and majority alpha phase microstructure add to the hardness
- Ti6Al4V can also achieve tensile strength exceeding 1100 MPa
- ZrTiNb alloys are designed to address the stress-shielding syndrome, by providing a lower Young's modulus (27.27 GPa to 34.85 GPa) while maintaining the mechanical integrity
- ZrTiNb also suitable for hard tissue replacements due to their mild yield stress between 854 MPa and 1080 MPa, and compressive strength between 1044 MPa and 1325 MPa

BIOCOMPATIBILITY AND CORROSION RESISTANCE

- Surface treatments such as ZrO_2 coatings increase Ti6Al4V's biocompatibility and corrosion resistance while also promoting cell adhesion and proliferation
- By adding ZrO_2 and hydroxyapatite (HA) to Ti6Al4V greatly improves the cell viability, with values surpassing 70%, which is the biocompatibility standard
- Addition of elements such as niobium and zirconium also lower the possibility of cytotoxicity and allergic reactions
- In simulated body fluids, the Ti-19Zr-11Nb-4Ta alloy exhibits greater corrosion resistance and a low rate of ion release during the 21-day period.
- When TiO_2 nanotubes are coated to the Ti-29Nb-13Ta-7.1Zr alloy, the alloy exhibits improved corrosion resistance due to increased hydrophilicity and reduced wear

RESEARCH OBJECTIVES

- To analyze the corrosion resistance of ZrTiNb in simulated body fluid environment, in comparison to Ti6Al4V
- To evaluate the mechanical properties of ZrTiNb alloy, such as tensile strength and fatigue strength, and compare them with those of Ti6Al4V
- To optimize the 3D printing process of ZrTiNb alloy, including surface modifications and coating methods, to enhance their bioactivity for medical application

RESEARCH PLAN

- Semester 1 - Literature review on corrosion behavior of Ti6Al4V alloy
- Semester 2 - Literature review on heat treatment of 3D-printed Ti6Al4V alloy
- Semester 3 – Literature review on comparison between usage of Ti6Al4V and ZrTiNb in medical applications
- Semester 4 – Optimization of 3D printing process for ZTM14N
- Semester 5 - Validation experiment using optimal parameter
- Semester 6 - Control study (if needed)
- Semester 7 - Thesis writing
- Semester 8 - Public defense

EXPECTED OUTCOMES

- Comprehensive understanding of the corrosion behaviour of ZrTiNb alloy, and comparing its performance to that of Ti6Al4V
- Development of an optimized parameter set for 3D printing process of ZrTiNb alloy
- Determination of optimal surface modification and coating techniques to improve the bioactivity of 3D-printed ZrTiNb alloy, tailored for medical applications

FUTURE WORKS

- This semester: literature review on usage of Ti6Al4V and ZrTiNb alloy for biomedical applications
- Corrosion test on 3D-printed ZrTiNb samples
- Mechanical test and microstructural characterization of ZrTiNb samples
- Optimization of process parameters for 3D printing of ZrTiNb
- Publication of corrosion test and mechanical test result

SUBJECTS TAKEN IN SEMESTER 1 - 3

Semester I	Semester II	Semester III
- Scientific paper writing (OATTUMI1ND) - Titanium and titanium alloys (OATTET01ND) - Analysis of damage failures for structural materials (OBTSZAK1ND) - Fundamentals of materials science (OATANTA1ND) - Hungarian as foreign language and culture I (RMSMID1BNE) - Research project I (OATKUTP1ND) - Research report I (OATBESZ1ND)	- Powder technology (OATPOT11LD) - Biomaterials for medical applications (OATBIOA1ND) - Hungarian as foreign language and culture II (RMSMID2BNE) - Research project II (OATKUTP2ND) - Research report II (OATBESZ2ND)	- Experimental design (OATKITE1ND) - Selected chapters of material testing methods I (OATVFAM1ND) - Research project III (OATKUTP3ND) - Research report III (OATBESZ3ND)

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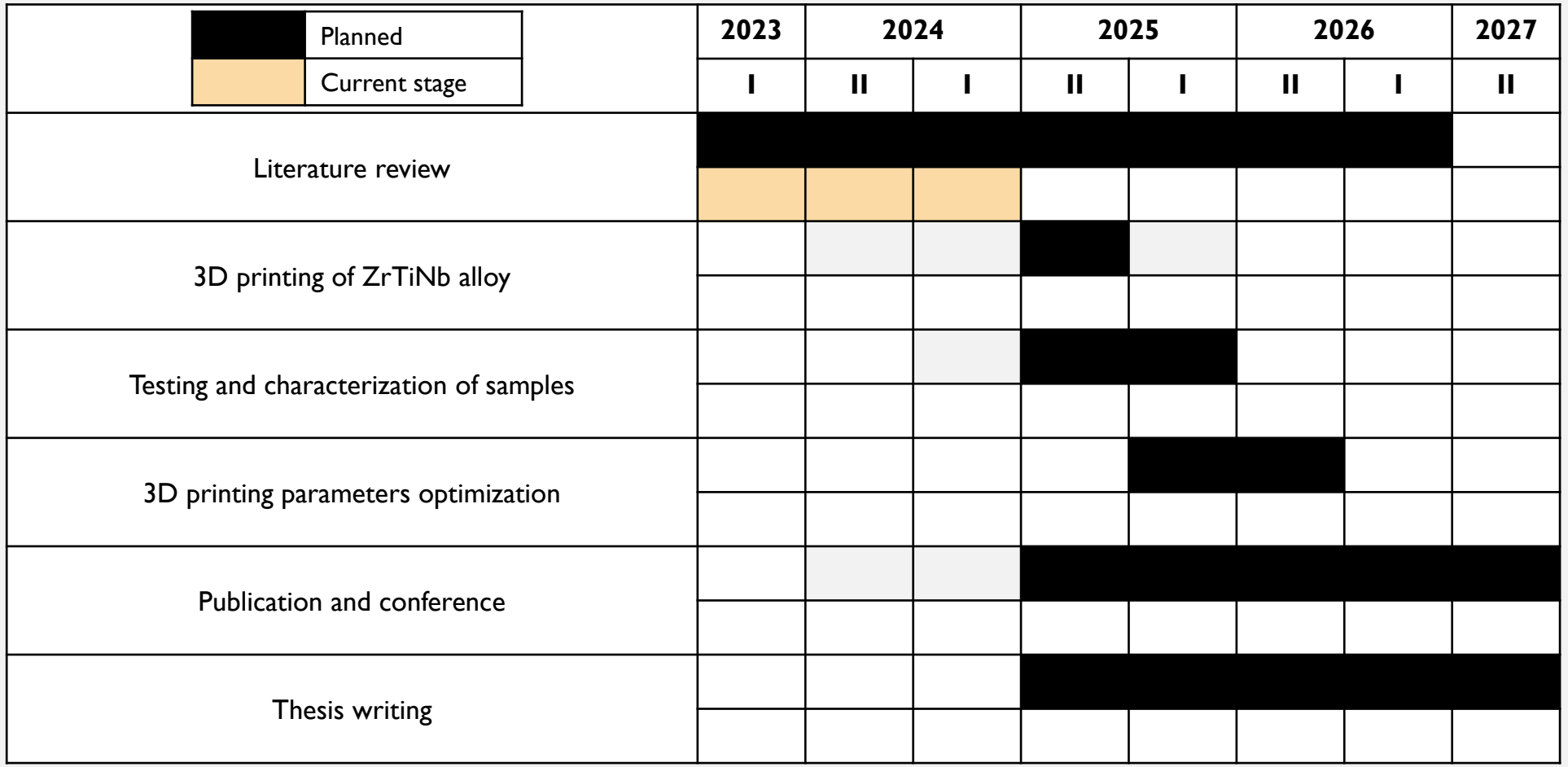
Planned
Current stage
2023
2024
2025
2026
2027
I
II
I
II
I
II
I
II
Literature review
3D printing of ZrTiNb alloy
Testing and characterization of samples
3D printing parameters optimization
Publication and conference
Thesis writing

THANK YOU FOR YOUR ATTENTION

Presented by: Minhalina Binti Ahmad Buhairi