ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY

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

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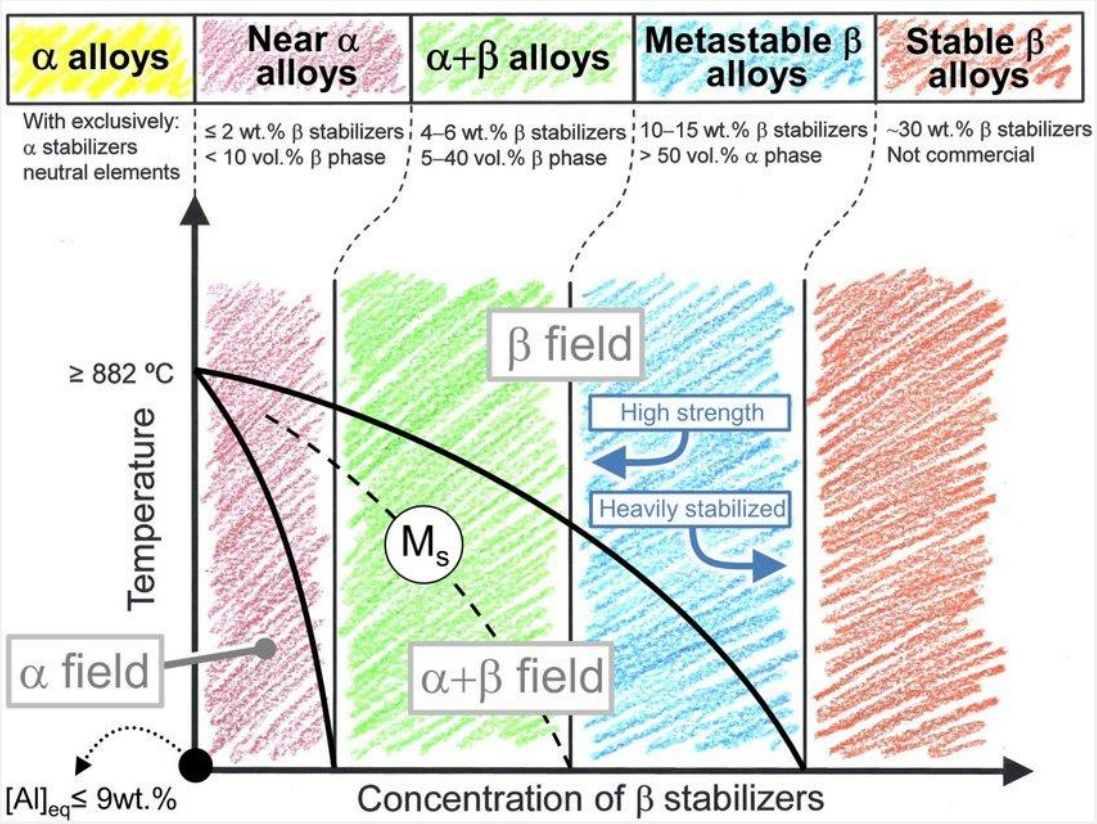
TITANIUM AND ITS ALLOYS

- Was discovered in 1790
- Properties including: light weight, high strength, high corrosion resistance, biocompatible

3 phases of titanium alloy		
α titanium	β titanium	(α+ β) titanium
- Single phase alloy composed of α - Still maintain its strength and creep resistance at 500 to 600 °C - Cannot be strengthened by heat treatment	- Single phase alloy composed of β - High strength before heat treatment - Further strengthened after quenching and aging (1372~1666 MPa)	- Two phase alloy - Strength after heat treatment is about 50% to 100% higher than that of annealed state - Can work for a long time at a temperature of 400 to 500 °C

TITANIUM AND ITS ALLOYS

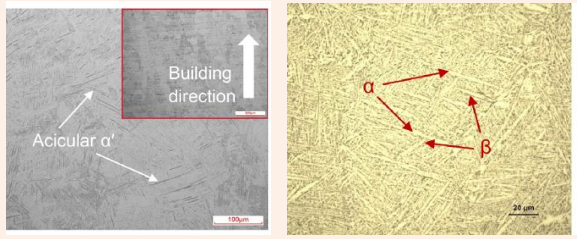
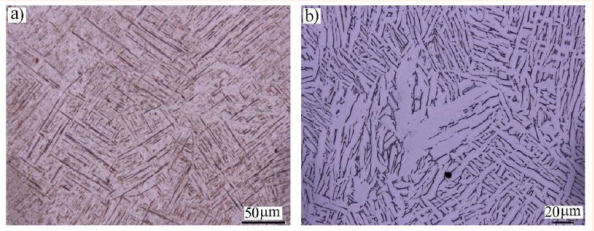


Source: Barriobero Vila, P. (2015)

HEAT TREATMENT

- Consists of heating of the material at a predefined temperature to achieve the desired characteristics
- To increase the mechanical strength, fracture toughness, creep strength, and fatigue strength
- To improve the wear resistance and frictional performance
- To enhance the ductility, thermal and dimensional stability, and creep resistance
- Type of heat treatment: annealing, aging, solution treating

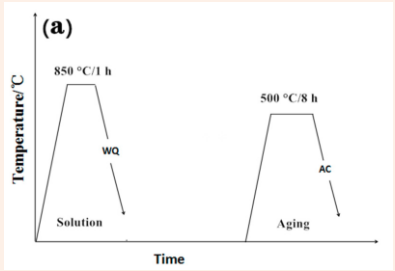
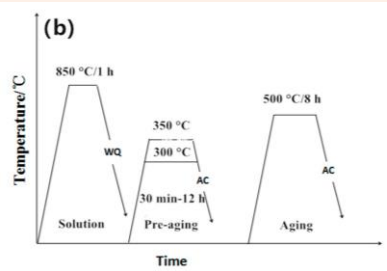
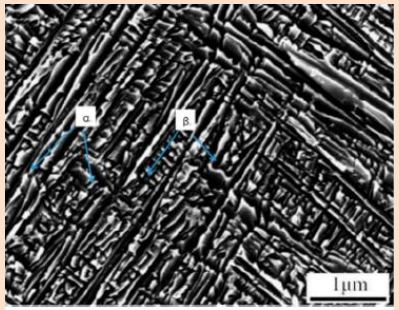
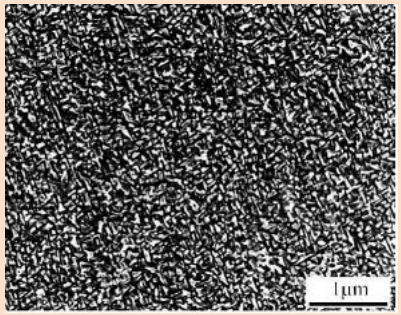
HEAT TREATMENT: ANNEALING

	Chang et al. (2020)	Rautio et al. (2020)
Parameter	800 °C for 2h	940 °C for 4h
Microstructure	Acicular α' martensite to α+β 	Acicular α' martensite to α platelets with interlamellar β 
Mechanical properties	YS: 960 MPa to 941 MPa EL: 7.4% to 16.7%	YS: 937 MPa to 939 MPa UTS: 1129 MPa (no change) EL: 8.8% to 8.3%

HEAT TREATMENT: AGING

- Also known as precipitation hardening
- Used to increase the yield strength of materials
- Precipitation of α phase occurs through decomposition of β phase. The α precipitates finely distributed in β matrix lead to increase in strength of material
- 3 types of aging: high temperature aging, low temperature aging, and duplex aging

HEAT TREATMENT: AGING

Ti-3.5Al-5Mo-4V	Ji et al. (2021)	
Type	Single-stage aging	Double-stage aging
Parameter		
Microstructure	Consists of α+β 	refined α phase and β phase 
Mechanical property	-	Hardness: 350 Hv (pre aging) to 524 HV

HEAT TREATMENT: SOLUTION TREATMENT

- In which alloy is being heated at an appropriate temperature for the specific duration so that the required constituent enters the solid solution followed by fast cooling
- Consists of 3 steps:

  (a) heating the material to a high temperature to take the alloying elements into solution in the β phase,

  (b) holding at this temperature to achieve homogenization

  © fast cooling to room temperature

RESEARCH OBJECTIVES

- To study the suitable heat treatment processes for 3D-printed Ti6Al4V alloy via SLM printing method
- To evaluate the effects of heat treatment on the microstructure, physical and mechanical properties of Ti6Al4V samples
- To analyze the relationship between heat treatment and nitridation efficiency of 3D-printed Ti6Al4V alloy
- To optimize technological parameters to obtain suitable mechanical and tribological properties of 3D-printed Ti6Al4V parts

RESEARCH SCOPE

- Addresses the challenges of corrosion resistance associated with Ti6Al4V alloy
- Investigates the application of heat treatments and nitridation to enhance corrosion and wear resistance properties
- Understanding the relationship between heat treatment parameters and nitridation efficiency for 3D-printed Ti6Al4V alloy

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 - Nitridation experiments on heat-treated Ti6Al4V alloy
- Semester 4 - Analysis on heat treatment and nitridation process
- Semester 5 - Validation experiment using optimal parameter
- Semester 6 - Control study (if needed)
- Semester 7 - Thesis writing
- Semester 8 - Public defense

EXPECTED OUTCOMES

- Determination of the heat treatment parameters of the Ti6Al4V alloy to achieve the wanted phases
- Understanding the relationship between the mechanical performance and corrosion resistance achieved by heat treatment and nitriding
- Determination of the optimal microstructure for the properties to be achieved

FUTURE WORKS

- This semester: literature review on heat treatment of Ti6Al4V alloy
- Heat treatment processes on 3D-printed Ti6Al4V alloy
- Corrosion test on 3D-printed and heat-treated Ti6Al4V samples
- Publication of corrosion test and heat treatment result

GANTT CHART

	2023		2024		2025		2026		2027
Planned / Current stage	I	II	I	II	I	II	I	II	II
Literature review	■	■	■	■	■	■	■		
	▒	▒							
Heat treatment processes on 3D printed Ti6Al4V alloy			■	■					
Nitridation experiments on heat-treated samples			■	■					
Parameters optimization based on relationship between heat treatment and nitridation efficiency					■	■			
Publication and conference		■	■	■	■	■	■	■	
Thesis writing				■	■	■	■	■	■

THANK YOU FOR YOUR ATTENTION

Presented by: Minhalina Binti Ahmad Buhairi