Mechanical Behaviour of Materials

Course Project Report

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Project Title - Microstructural Analysis of Titanium Beta 21S alloy

Introduction

Pure titanium melts at 1670°C and has density of 4.51g/cc, hence it is suitable for high temperature applications where high strength to weight ratio is required. Titanium can catch fire and cause severe damage in circumstances where it rubs against other metals at elevated temperatures. This is what limits its application in the harsh environment of aeroengines, to regions where the temperature does not exceed 400°C.

The crystal structure of titanium at ambient temperature and pressure is close-packed hexagonal (α) with a c/a ratio of 1.587. At about 890°C, the titanium undergoes an allotropic transformation to a body-centred cubic β phase which remains stable to the melting temperature.

Ti alloys are known for the following characteristics –

1. Excellent strength to weight ratio.
2. Oxidation and corrosion resistance at high temperatures.

Applications- Titanium alloys are used in front stage compressor of the turbine blade in aeroengines.

Composition of Alloy

The following is the composition for 50gms of Titanium Beta 21S Alloy

Element	Atomic Weight (in gm)	Weight %
Titanium	39.4	78.8
Molybdenum	7.5	15
Aluminium	1.5	3
Niobium	1.5	3

Silicon	0.1	0.2

Methodology

Alloy Casting

The raw materials for the Ti Beta 21S were prepared and cast using a vacuum arc furnace. Casting under vacuum helps prevent oxidation and contamination, ensuring a purer alloy.

Sample Preparation

Cutting

The sample was cut and mount using Hot Mounting Press

Grinding

The sample was initially grinded using emery papers (silicon carbide papers) with grit size of 600, 800, 1200, 1500, and 2000 to smoothen the surface.

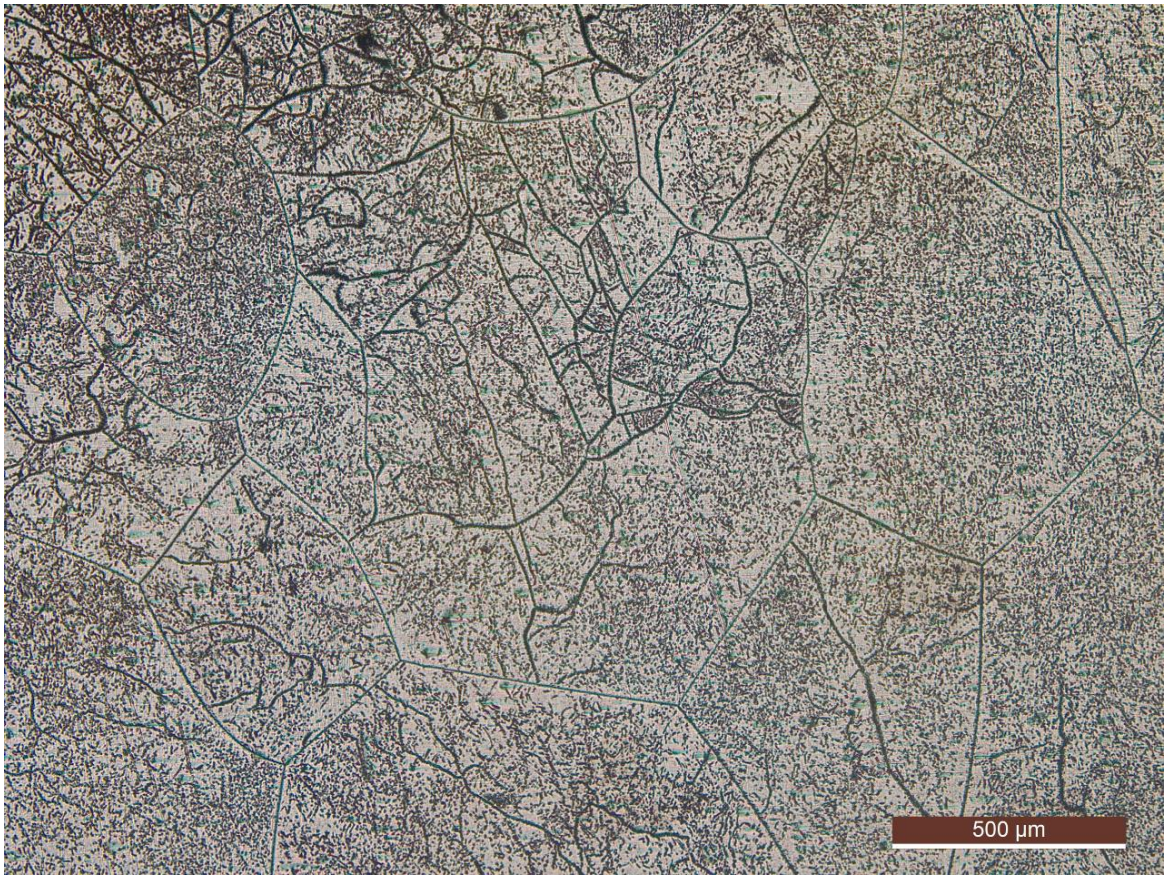
Polishing

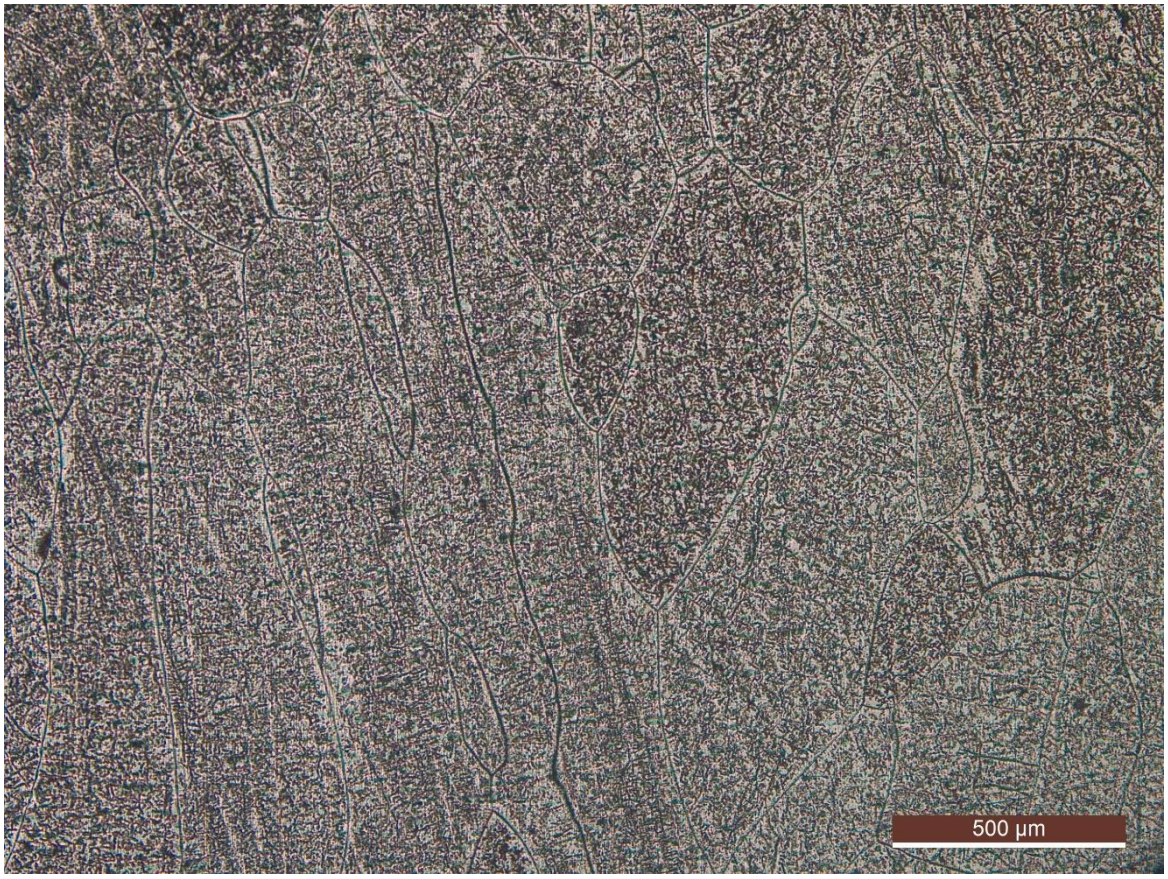
Following grinding, cloth polishing was performed to obtain mirror finish.

Etching

Etching is necessary for distinction of various regions in the microstructure, for example to distinguish grains, grain boundaries, precipitates from each other. Etching reveals the microstructure of the sample. An etchant (46ml H_2O + 3ml HNO_3 + 1ml HF) was prepared and the sample was etched for 90 seconds.

Microstructure and Hardness testing


500 µm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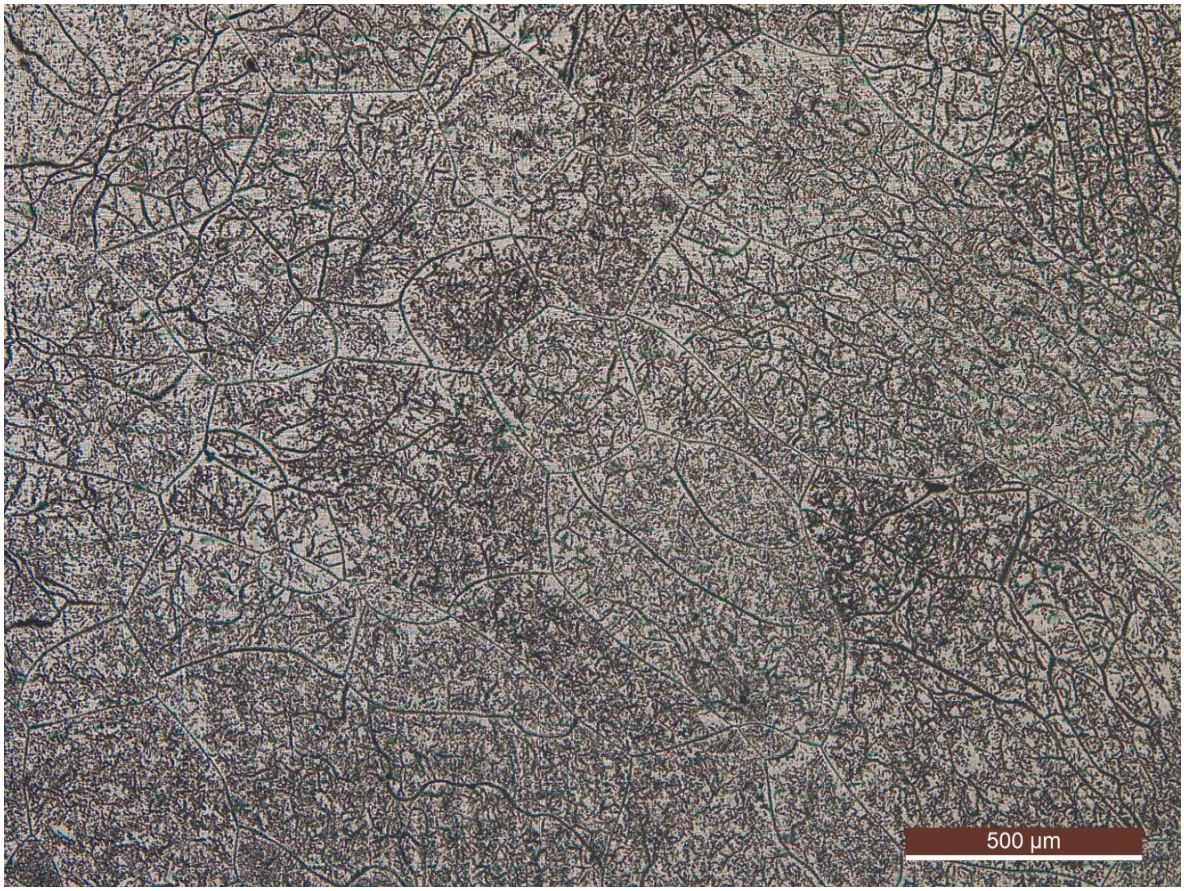
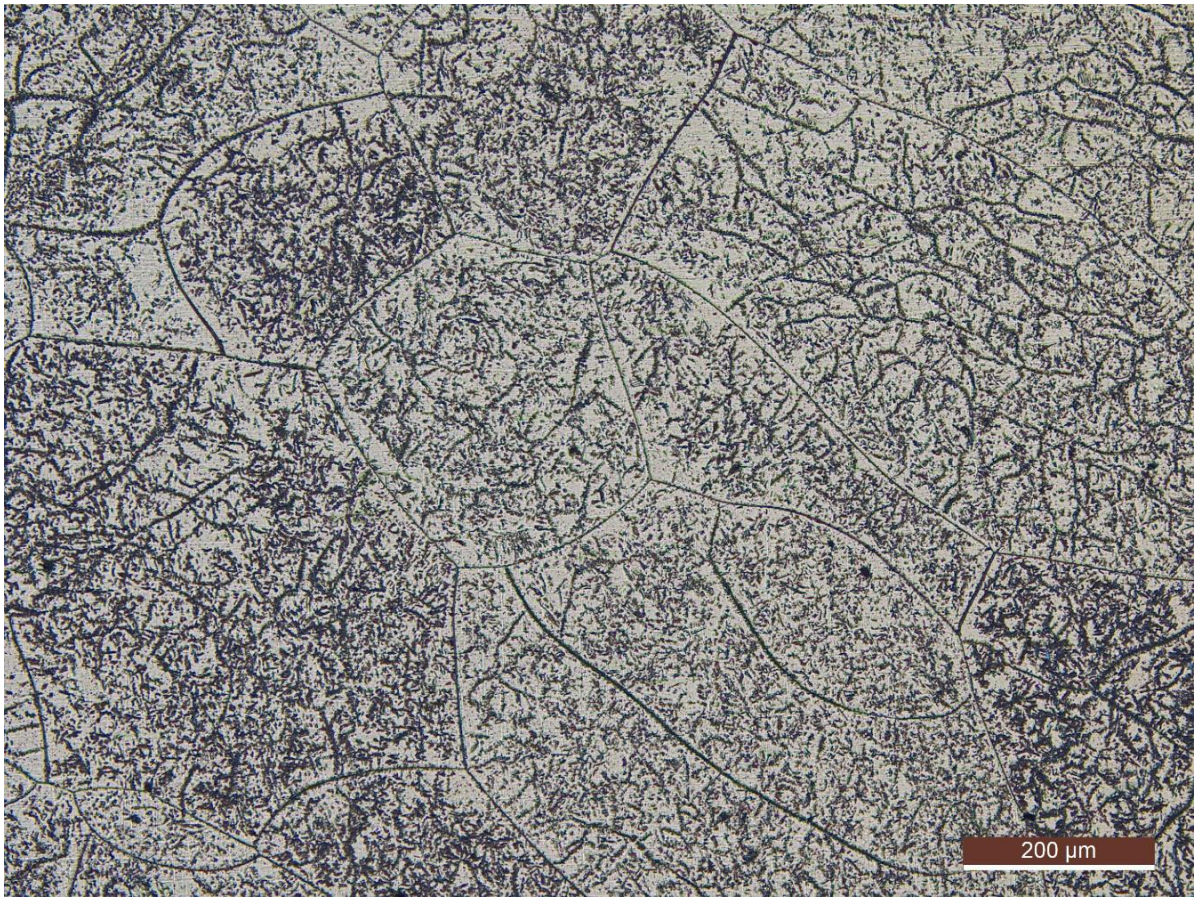
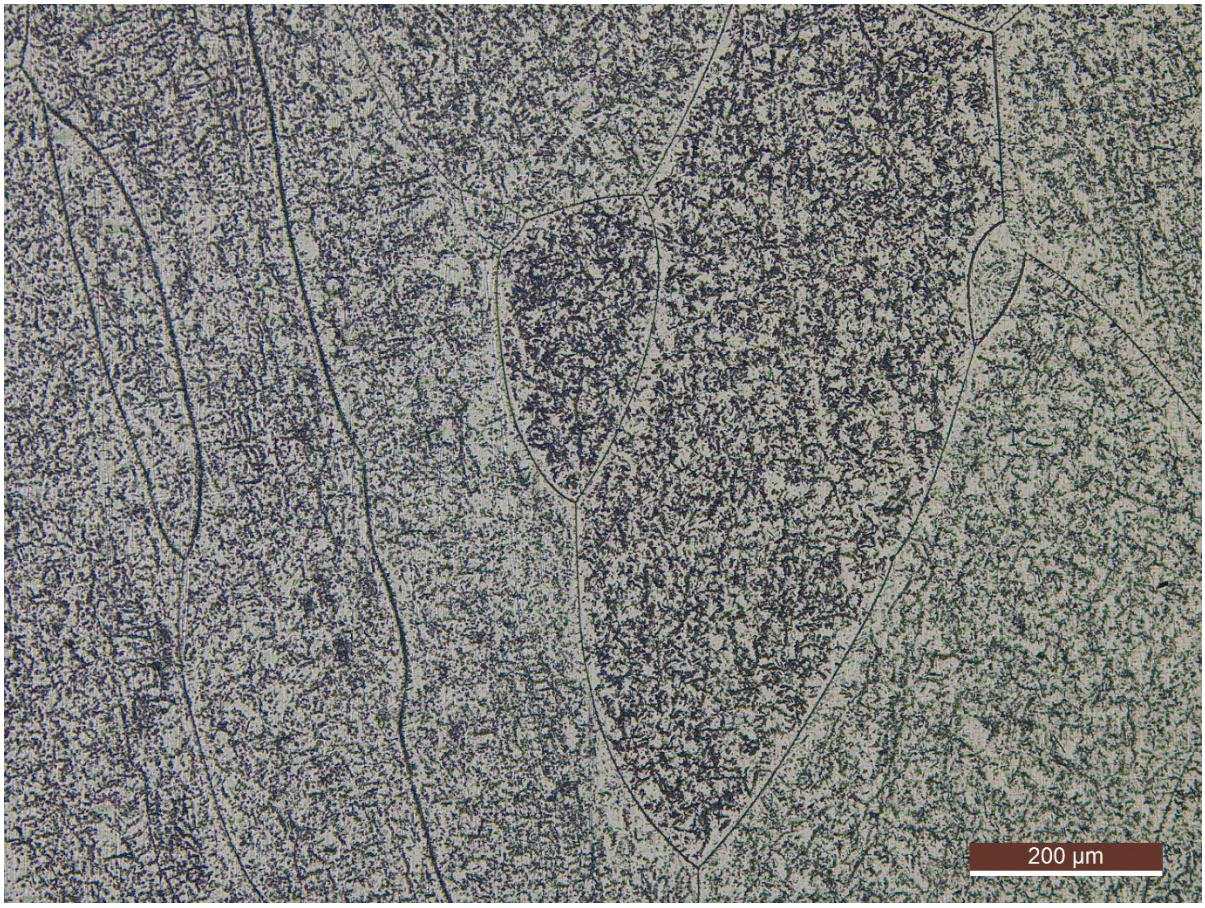

500 µm


200 µm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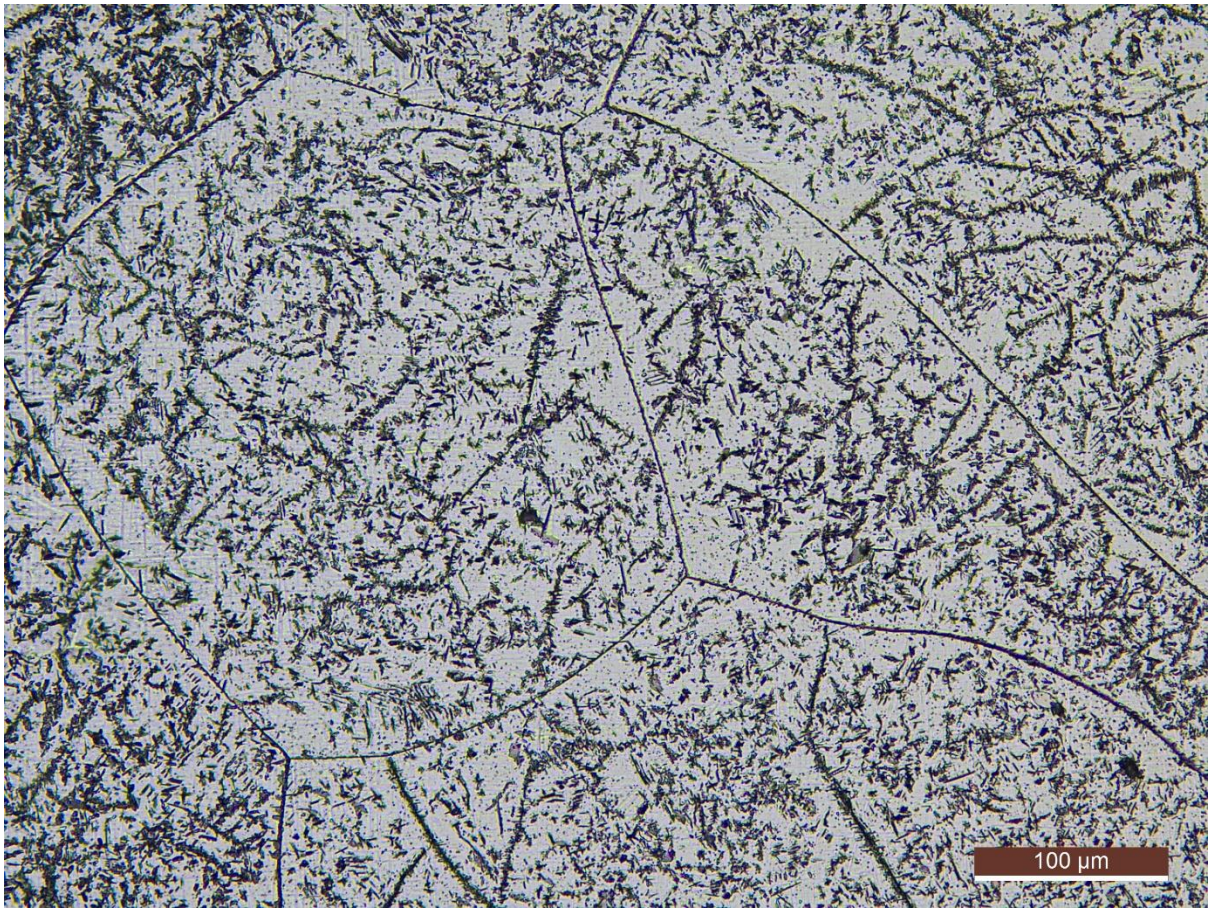
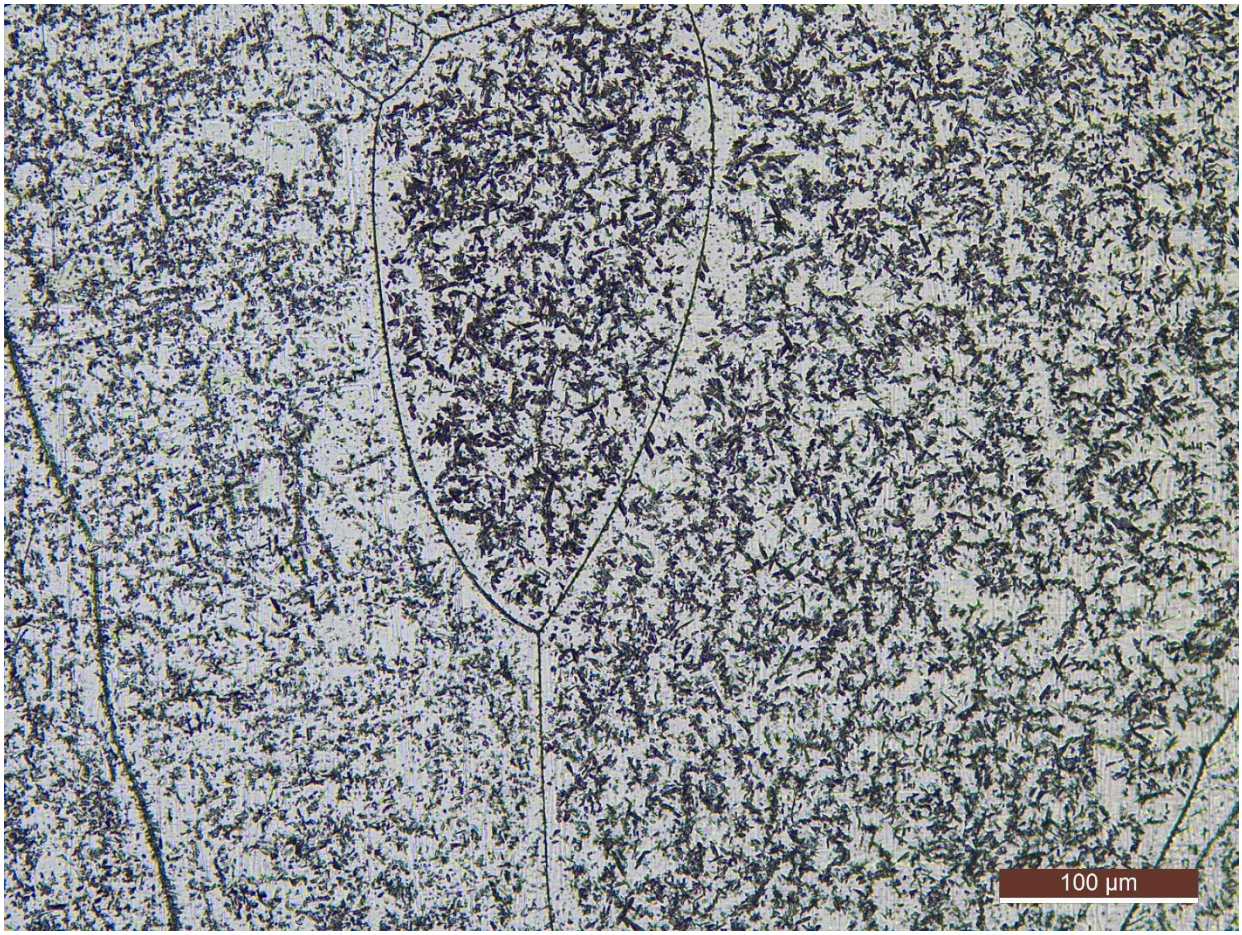

100 µm



Hardness Observed on Vickers Hardness tester:

1. 391HV
2. 405HV
3. 408HV
4. 403HV
5. 410HV

The final hardness is the obtained as the average of all.

Hardness = 403.4HV

Observations

1. Beta transus temperature refers to that temperature at which a titanium alloy transitions from a two-phase alpha-beta structure to a single-phase beta structure.

2. Beta transus temperature for Timetal 21S (Ti Beta 21S) is around 807°C (Source: Paper on Timetal 21S from “TIMET” – World’s leading titanium manufacturer).
3. We observe from the above microstructures that only the primary matrix phase, i.e., only the beta phase is present, there are no signs of precipitation of the alpha phase in the microstructure. Hence, we conclude that during casting process the temperature used is more than 807°C.
4. We also observe presence of fine needle shaped grains, hence the conclusion that after casting, the cooling process used is quenching.