Printability of Titanium Alloy TA6V4 by MELD Friction Stir Additive Manufacturing Process:

Study of process-microstructure-macroscopic properties links and optimization of post-printing heat treatments

Ismail Zabeeullah Kolimi

Thesis Supervisors:
S. Bouvier & J. Marteau

Co-supervision :
Auguste Pierre(CETIM)

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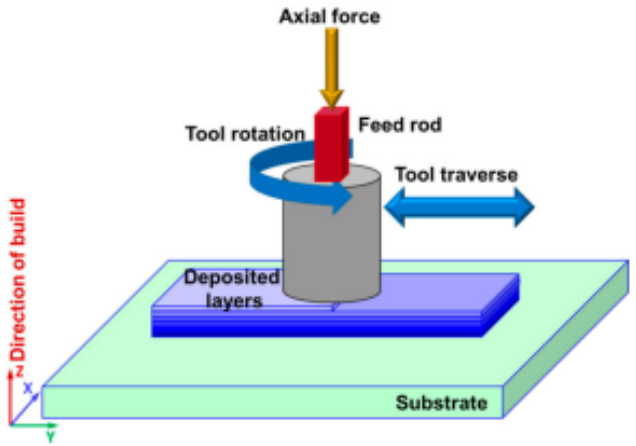
CONTEXT – SCIENTIFIC INTEREST

MELD : Innovative process for the additive manufacturing of metal alloys in the solid state by friction stir deposition

Advantages :

- Solid state metal fabrication process(No melting)
- Wide range of capabilities(coating, component repair, metal joining etc.)
- High deposition rate (up to 13kg/h for Al alloys)
- No risk of hot cracking, high residual stress and porosities
- Possibility to cool the manufacturing plate
- Homogeneous recrystallized microstructure



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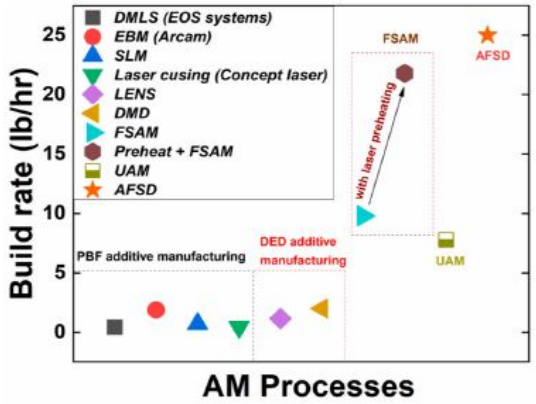
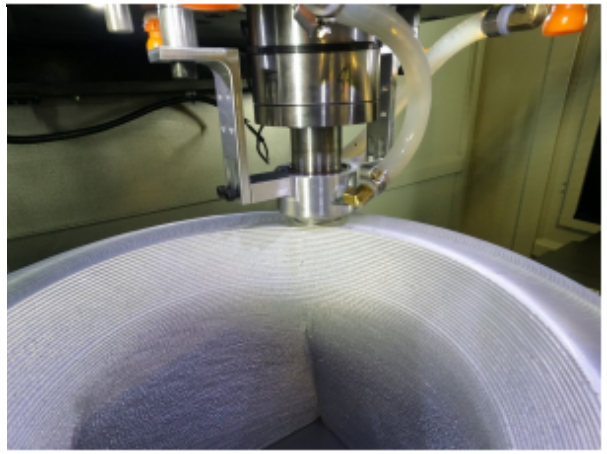




Source : MELD Manufacturing Corporation, Christiansburg, Virginia, USA

Déposition conditions :

- $1 - 10^3\ s^{-1}$
- $0.6 - 0.8\ T_f$
- $\varepsilon \sim 40$!

ismail-zabeeullah.kolimi@utc.fr

OBJECTIVES

1. **Optimization** of the MELD process parametrization in the case of TA6V4.

2. Understanding the **links between process parameters and microstructure evolution**.

3. Study of the relationship between **microstructure and mechanical properties** under monotonic loading.

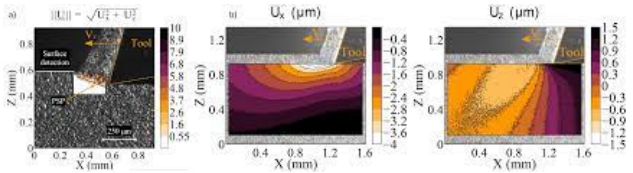
4. **Improvement of mechanical performances** and properties by ad hoc post-fabrication heat treatments .

5. Study of the **behavior under fatigue loading** on optimized configuration.

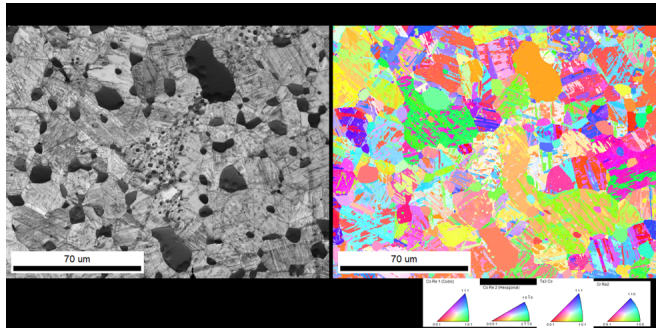
TIMELINE

Component Production

Characterization of Mechanical Behaviour at Macroscopic Level

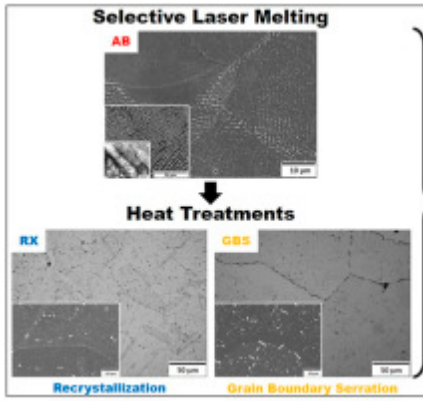


Microstructural characterization

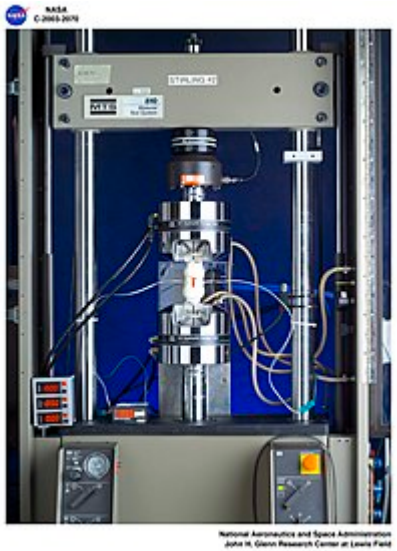


Observation in microscopy (optical, electronic, transmission)

Post-Manufacturing Heat Treatment Optimization



Characterization of Fatigue Behaviour



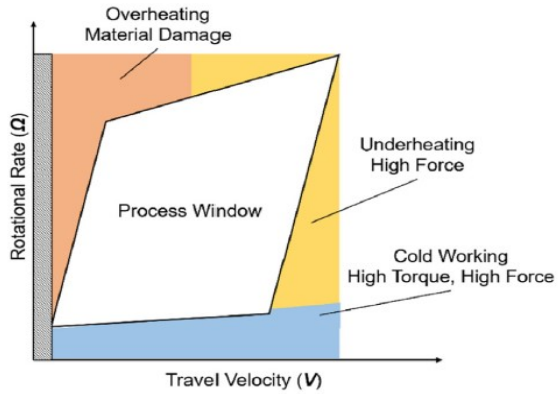
ismail-zabeeullah.kolimi@utc.fr

PROGRESS(Since November 2022)

Bibliography

1. Literature Review is being undertaken on
   - MELD process
   - Evolution of Microstructure of Ti-Based Alloys
   - Hot deformation for Ti-based alloys
   - Study of Recrystallization and recovery mechanism
   - Fatigue and related phenomenon

2. Understanding and Optimization of Process Parameters



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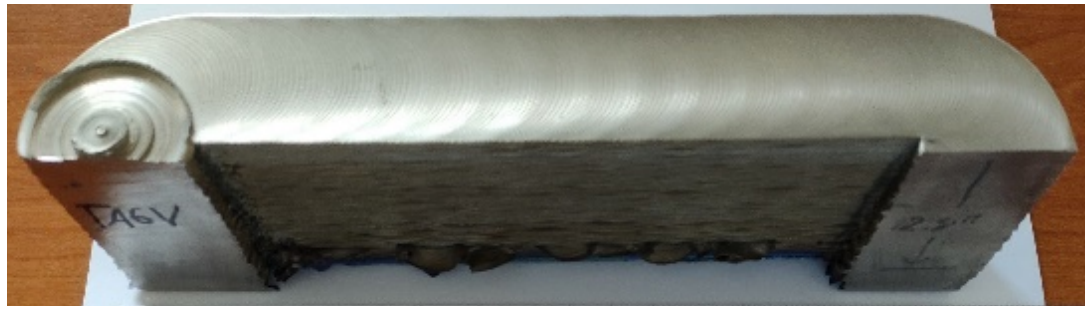
Experimental Work

1. Training on various experimental methods.
2. Microscopic (Optical) as well as XRD analysis is being carried out on the samples provided by CETIM.

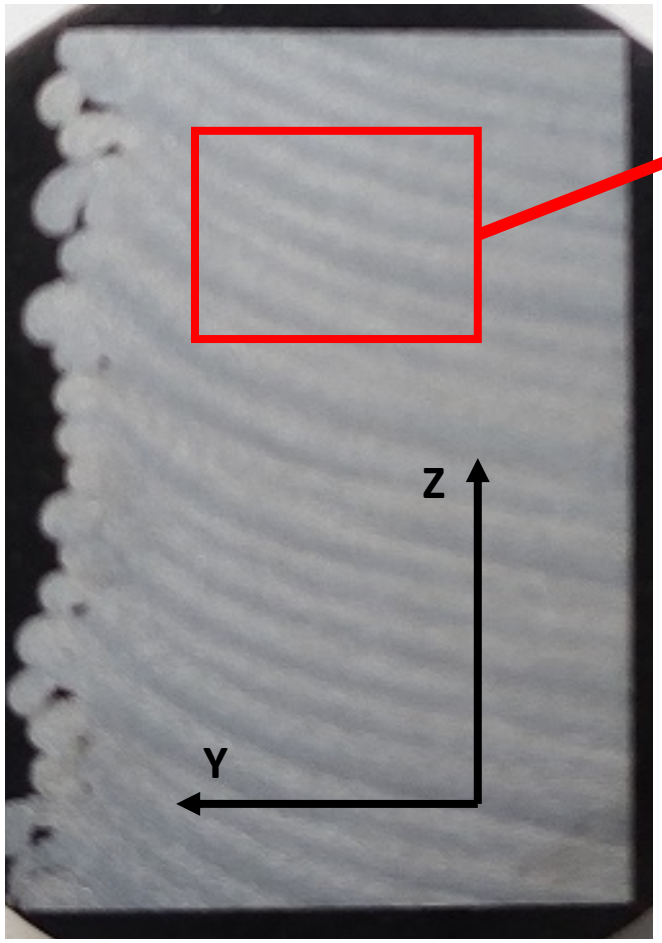


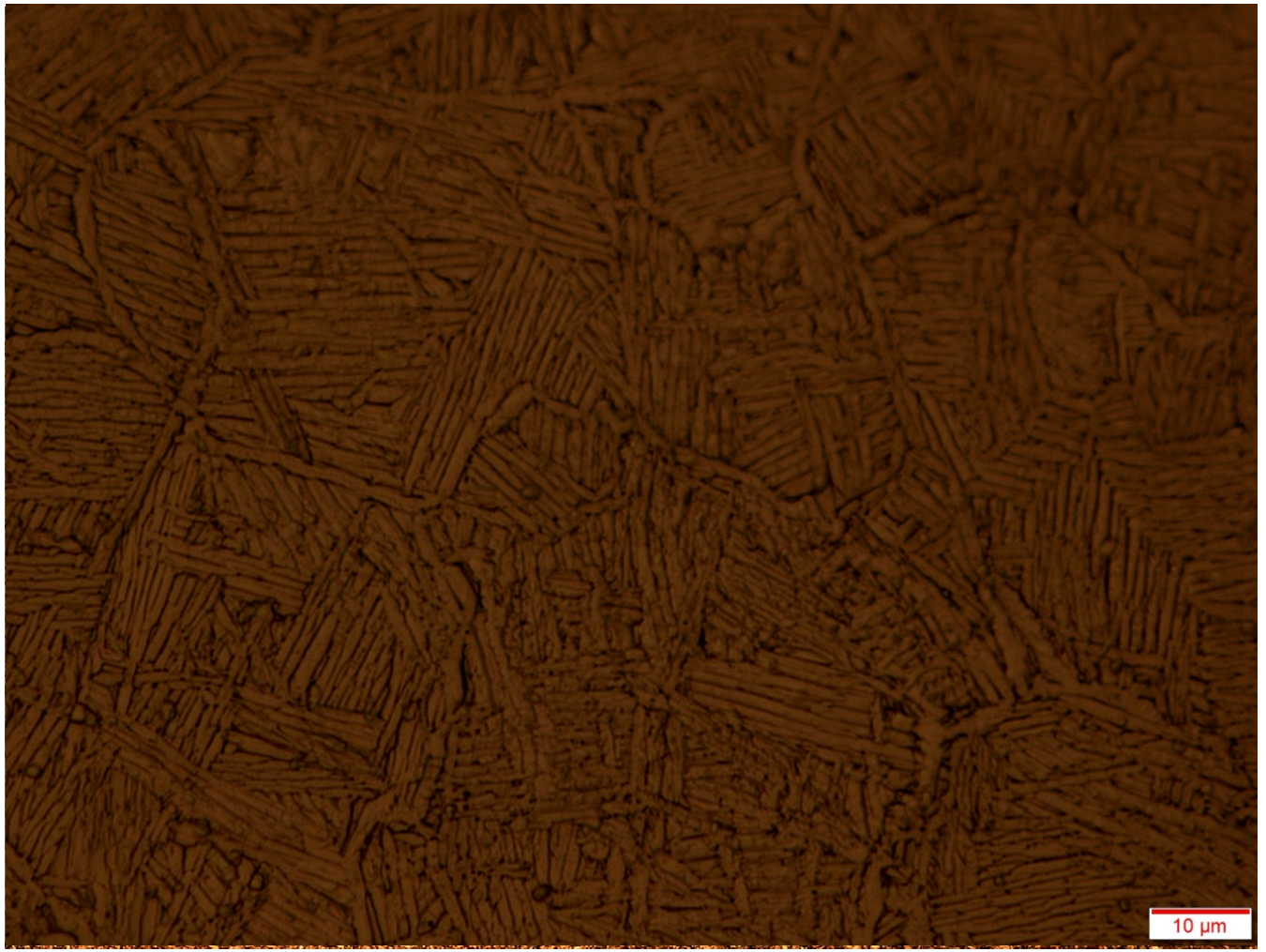
ismail-zabeeullah.kolimi@utc.fr

State of the Art

The advent of Industrial Revolution 4.0 has made significant technologies impact in the field of additive manufacturing that offer a low-energy pathway to achieve net-shaping or near-net shaping with less heat input, thermal gradients, and residual stresses. A major attraction towards the solid state based Additive Stir Friction Deposition(AFSD) has been noticed lately due to process producing defect free and homogenous microstructure when compared to other Additive Technologies. A significant amount of research has been undertaken on AFSD technology especially with respect to the equipment,mechanism,heat input, material flow as well as the effect of process parameters on micro and macro properties primarily for Al-based alloys. The research and development with regard to Ti-Based Alloys is minimal and it requires further detailed research especially on the effect of process parameters on microstructure as well as mechanical properties. An important aspect which can be clearly noticed is the lack of research with regard to effects of Heat Treatments as well as Fatigue Behaviour of the components which are produced by AFSD which also require understanding and research.

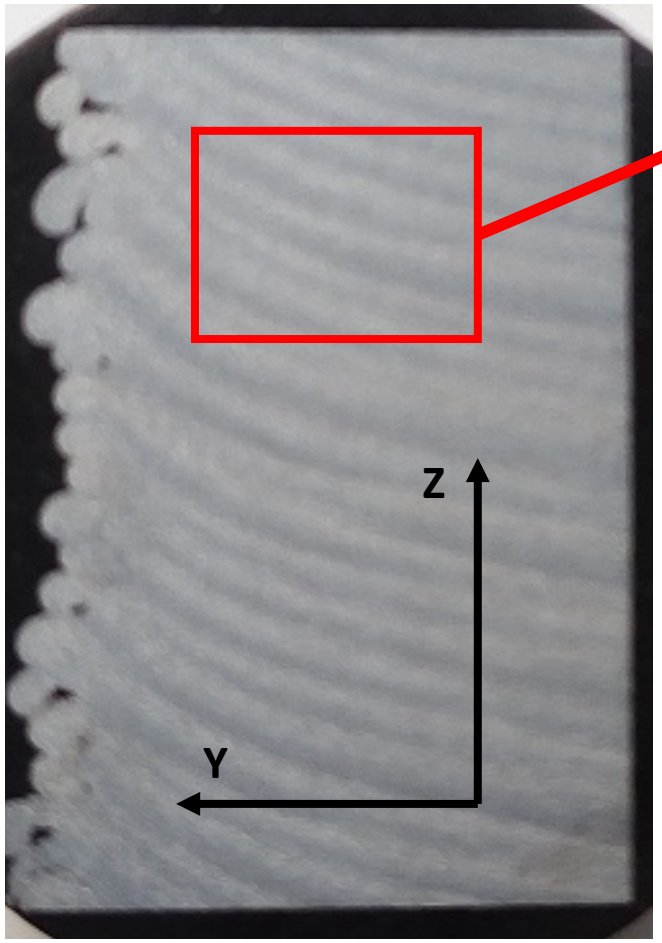
MICROSTRUCTURE





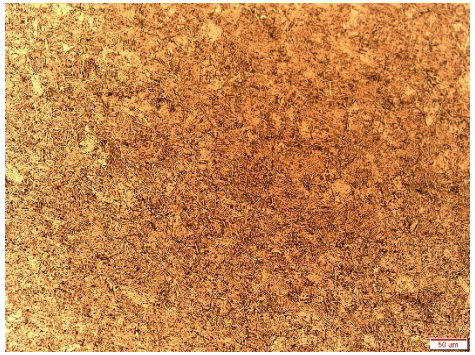
ismail-zabeeullah.kolimi_02@utc.fr

APPENDIX



200 µm

100 µm



50 µm

10 µm

20 µm

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