Linking DFAM, Design Optimization, and Generative Design

Allin Groom

EngD Research Engineer | @UniS_Materials

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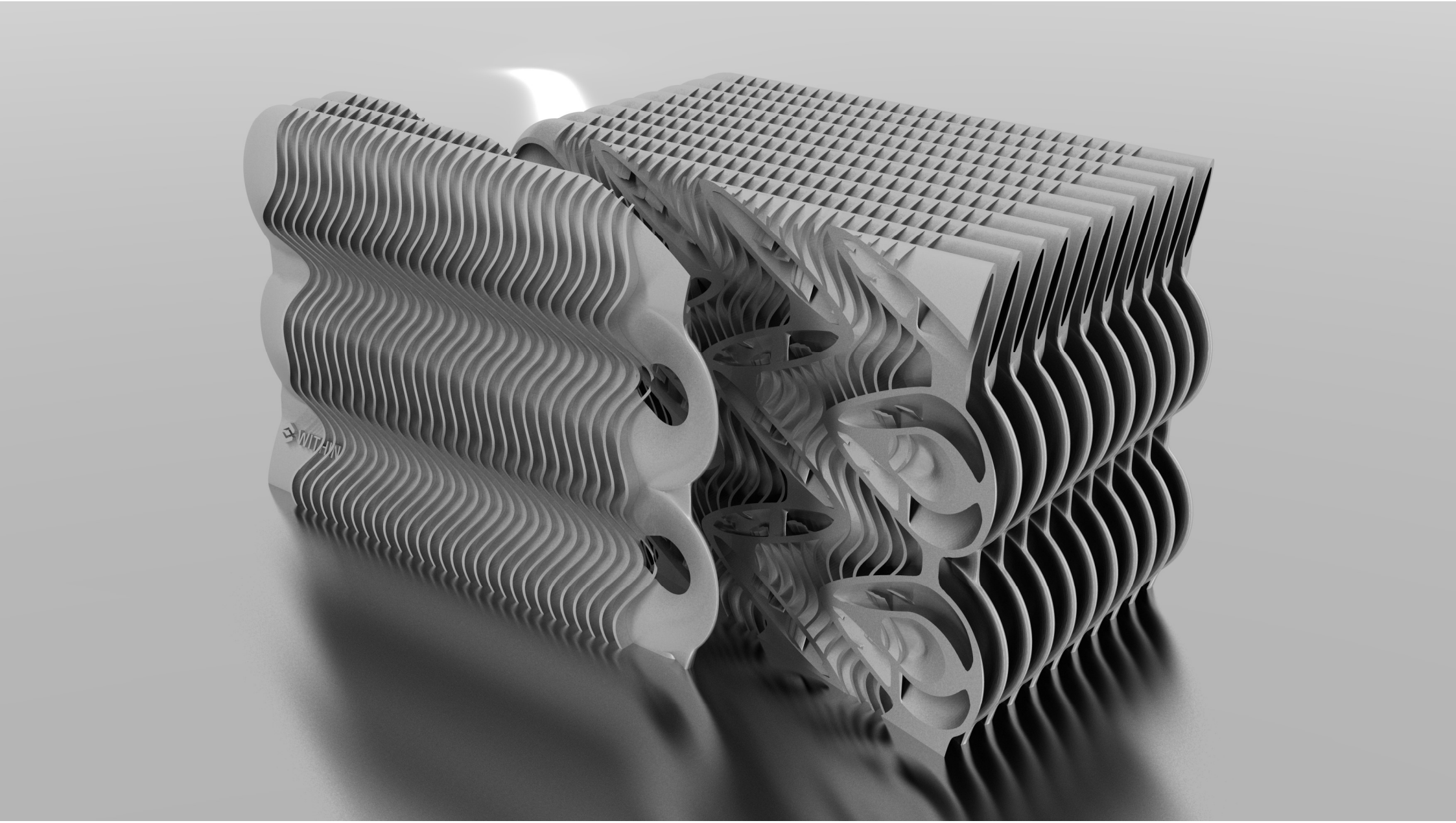
Engineering and Physical Sciences Research Council

Scope

- Introduction
- DfAM
- Laser Powder Bed Fusion
- The Challenge
- Practical Research
- Future Research
- Conclusion

About the Speaker

- MEng in Materials Science and Engineering from Queen Mary, University of London.
- Background in Polymer Nano-Composites for use in ballistic armour applications.
- Commissioned Officer in the British Army – Royal Electrical and Mechanical Engineers.
- Now pursuing an Engineering Doctorate with University of Surrey sponsored by Autodesk.
- Autodesk Research – Manufacturing Industry Futures, London


WITHIN

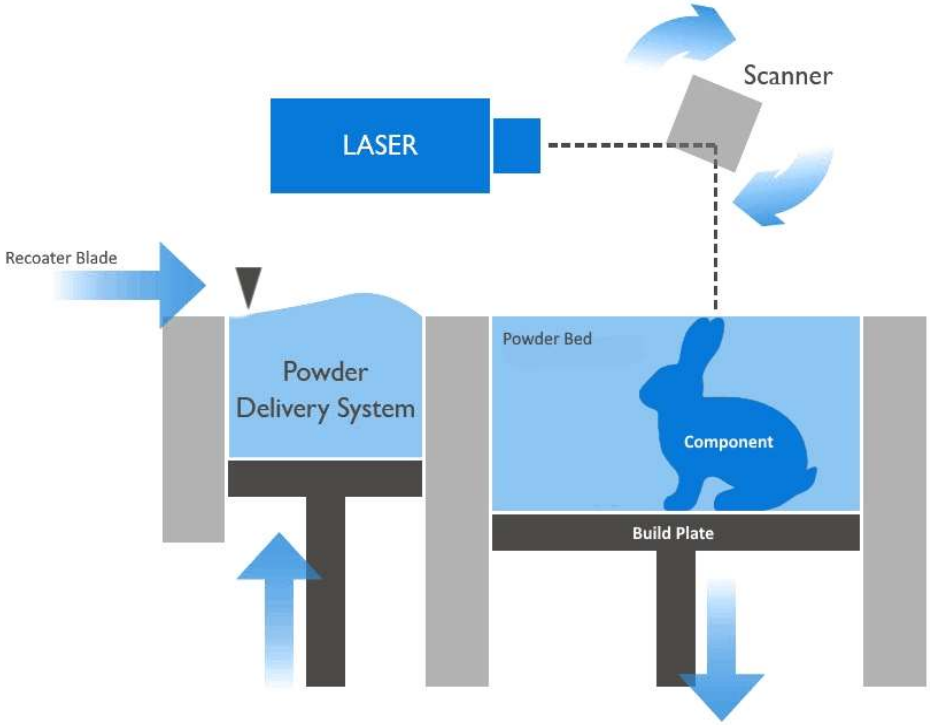
Additive Manufacture

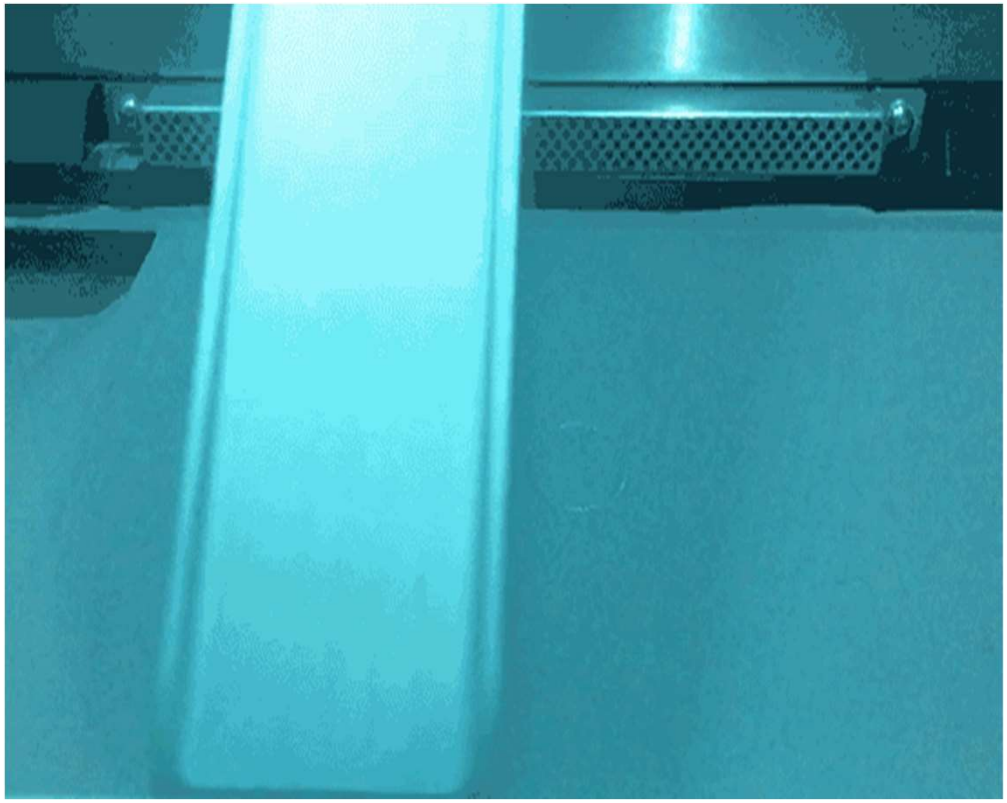
Design for Additive Manufacture (DfAM)

Images courtesy of Renishaw and The MTC

Laser Powder Bed Fusion

L-PBF



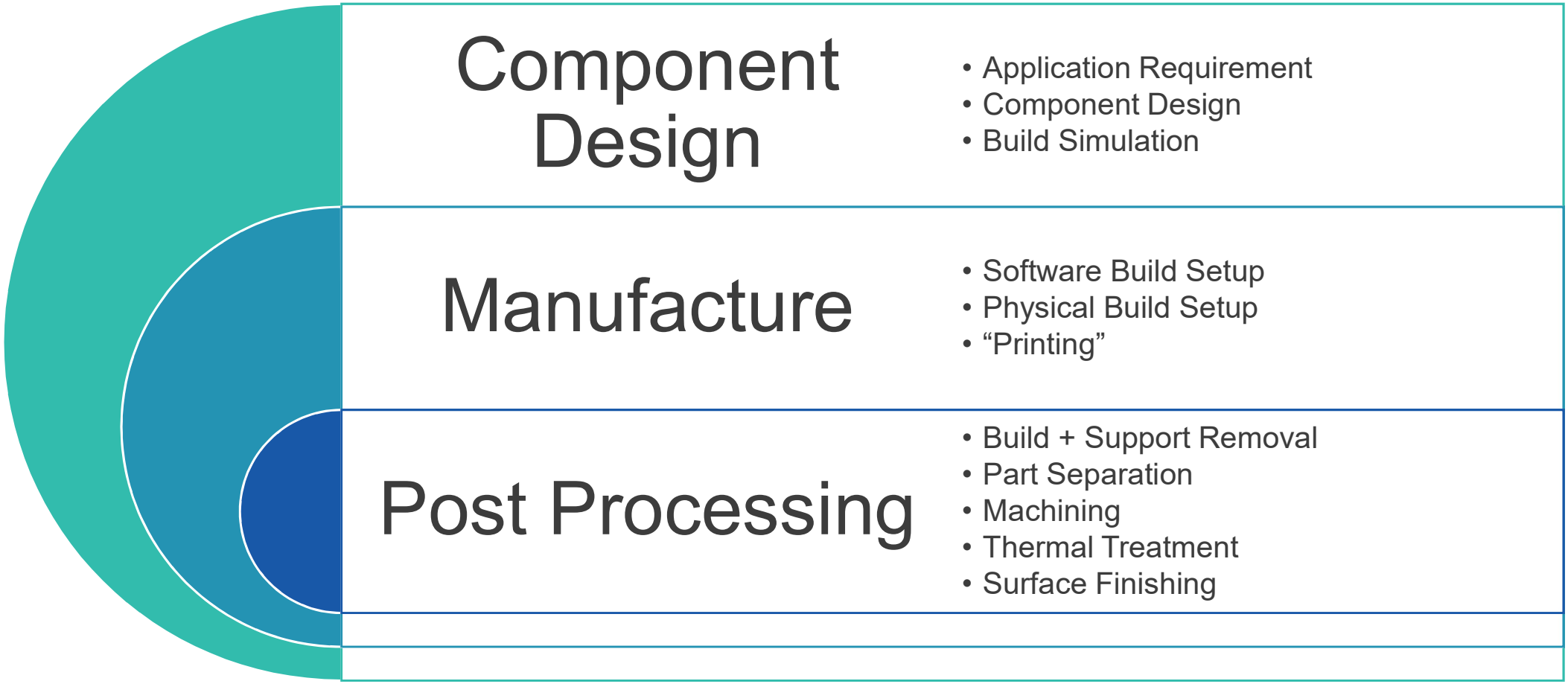


GIF courtesy of The MTC

Image courtesy of General Motors

Workflow

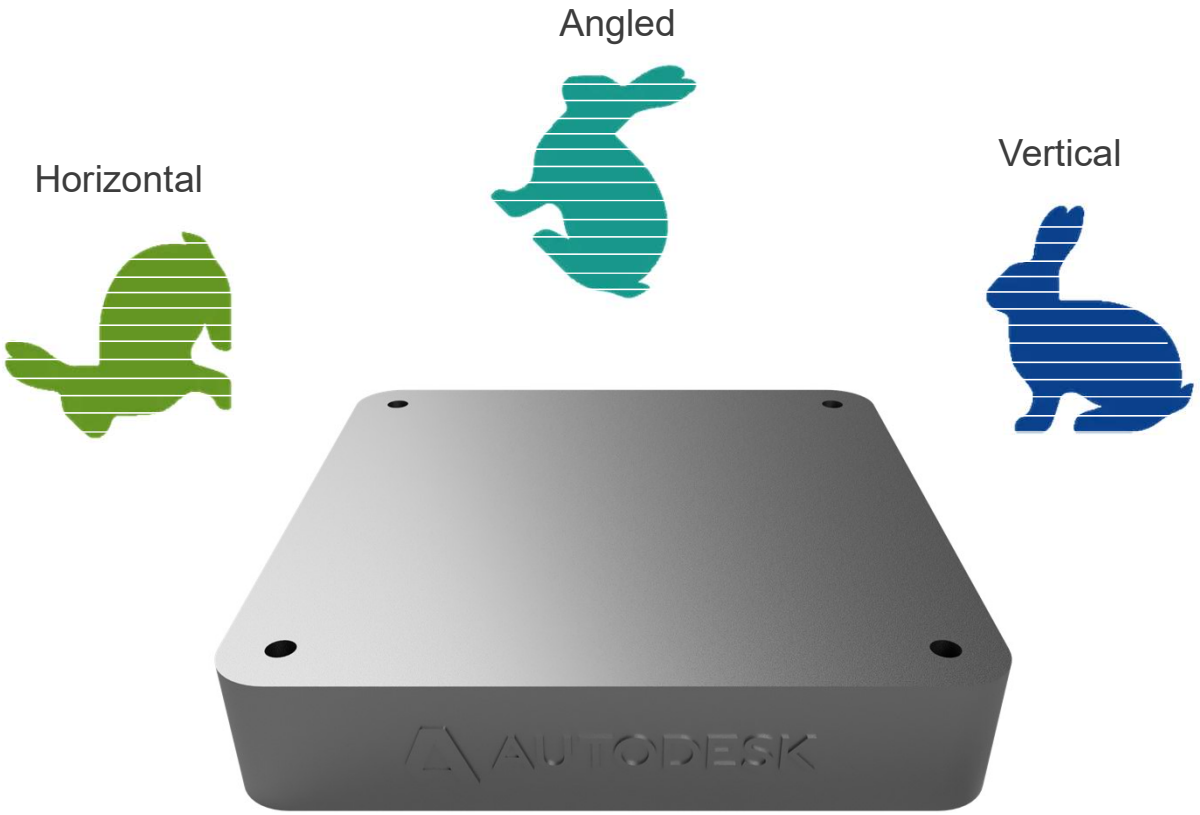
Considerations down stream.



The Challenge

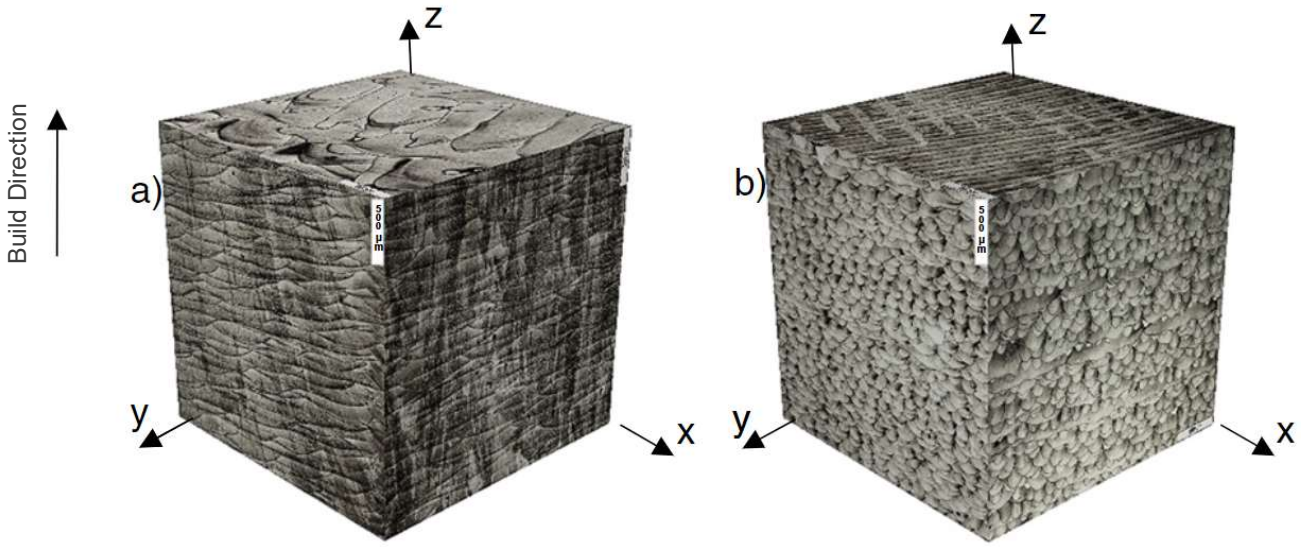
Build Orientation

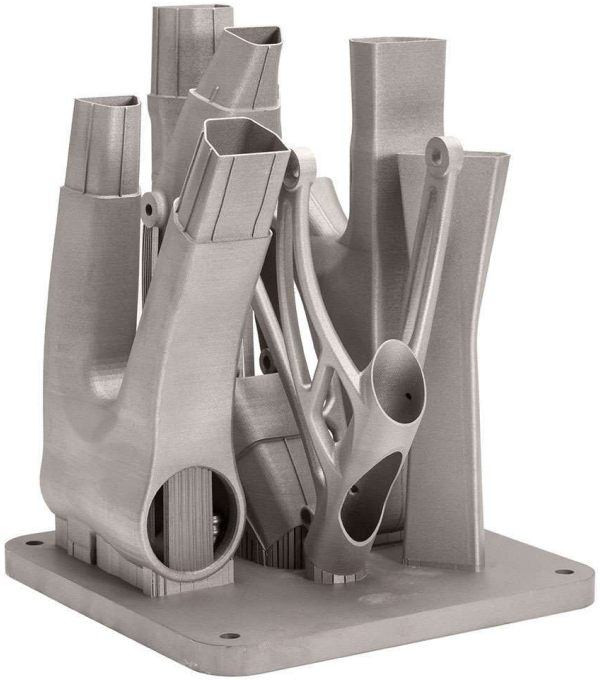
How will this affect part performance?



Build Geometry

Microstructural Anisotropy

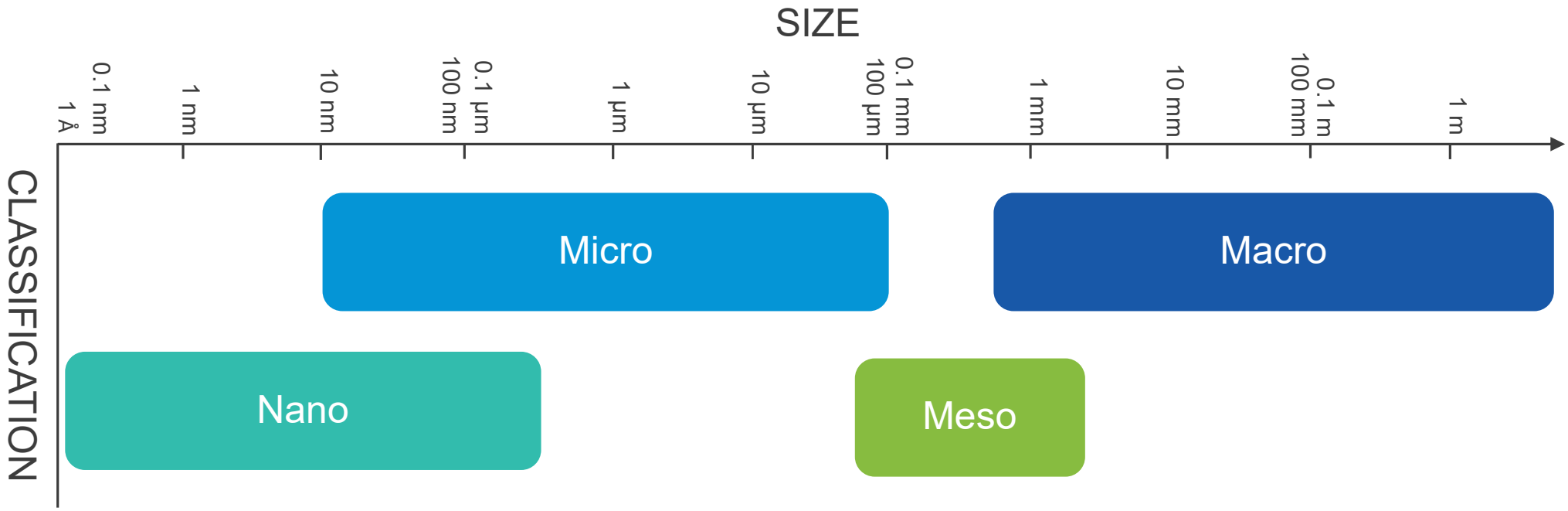




V.A. Popovich et al, Materials and Design (2016)
Image courtesy of Renishaw

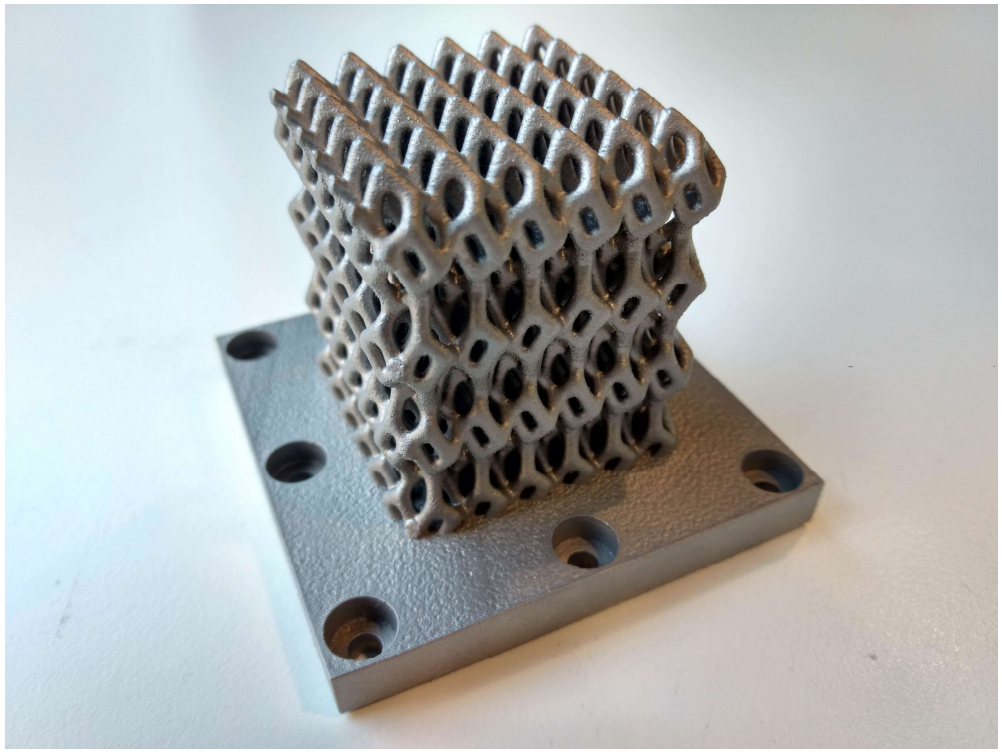
Manufacturing Scale

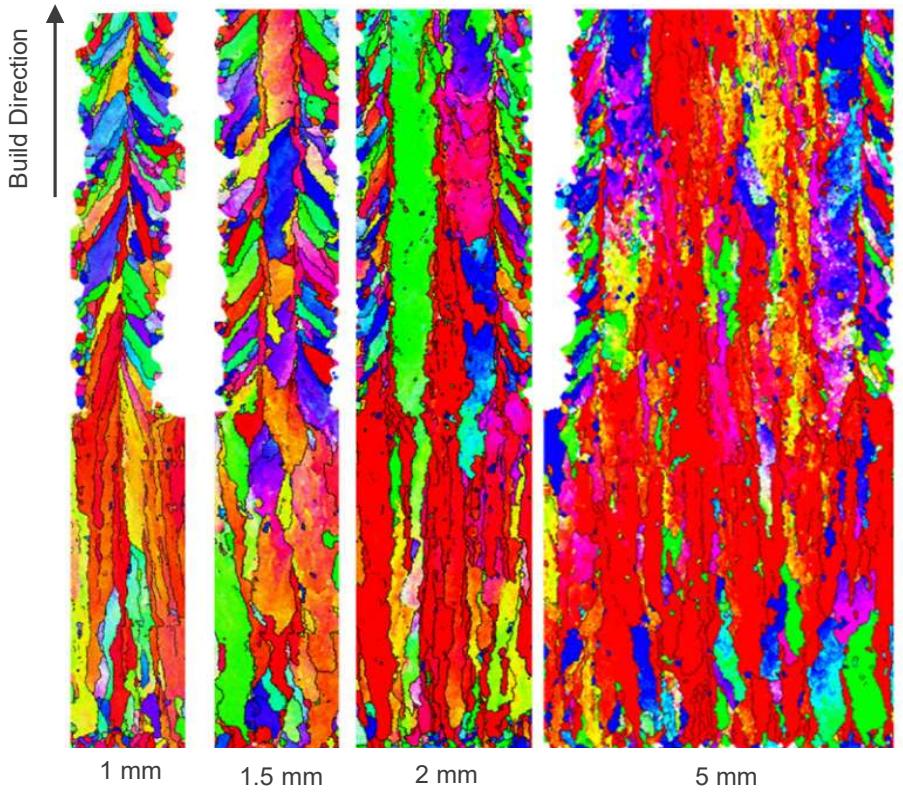
Mesoscale 0.1 – 5 mm



Feature Thickness

Bulk vs Surface Influence





Alphons Antonysamy et al, Materials Characterisation (2013)

Practical Research
Approach

Experimental

Representative Testing

- Representative sample design.
- Mechanical testing – Uniaxial tensile and fatigue.
- Compositional and microstructural analysis.
- Fracture surface analysis.
- Post process impact.

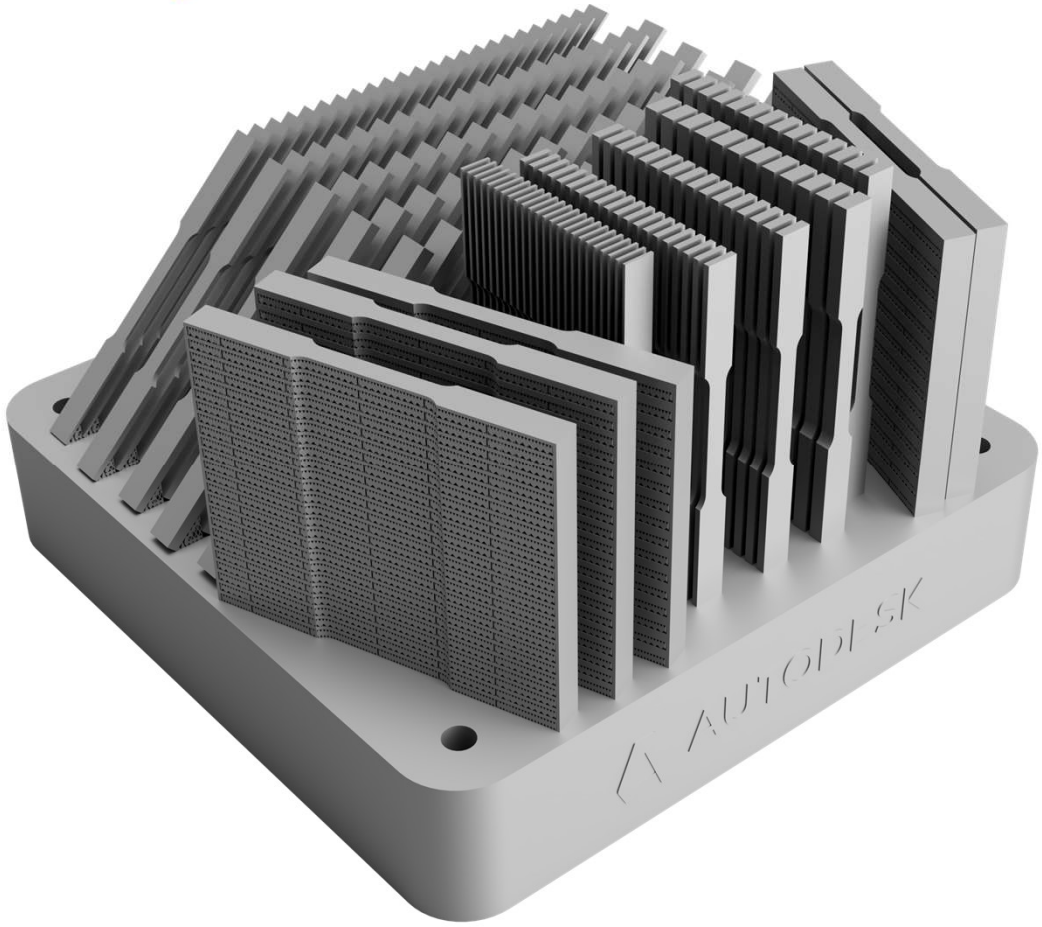
Materials

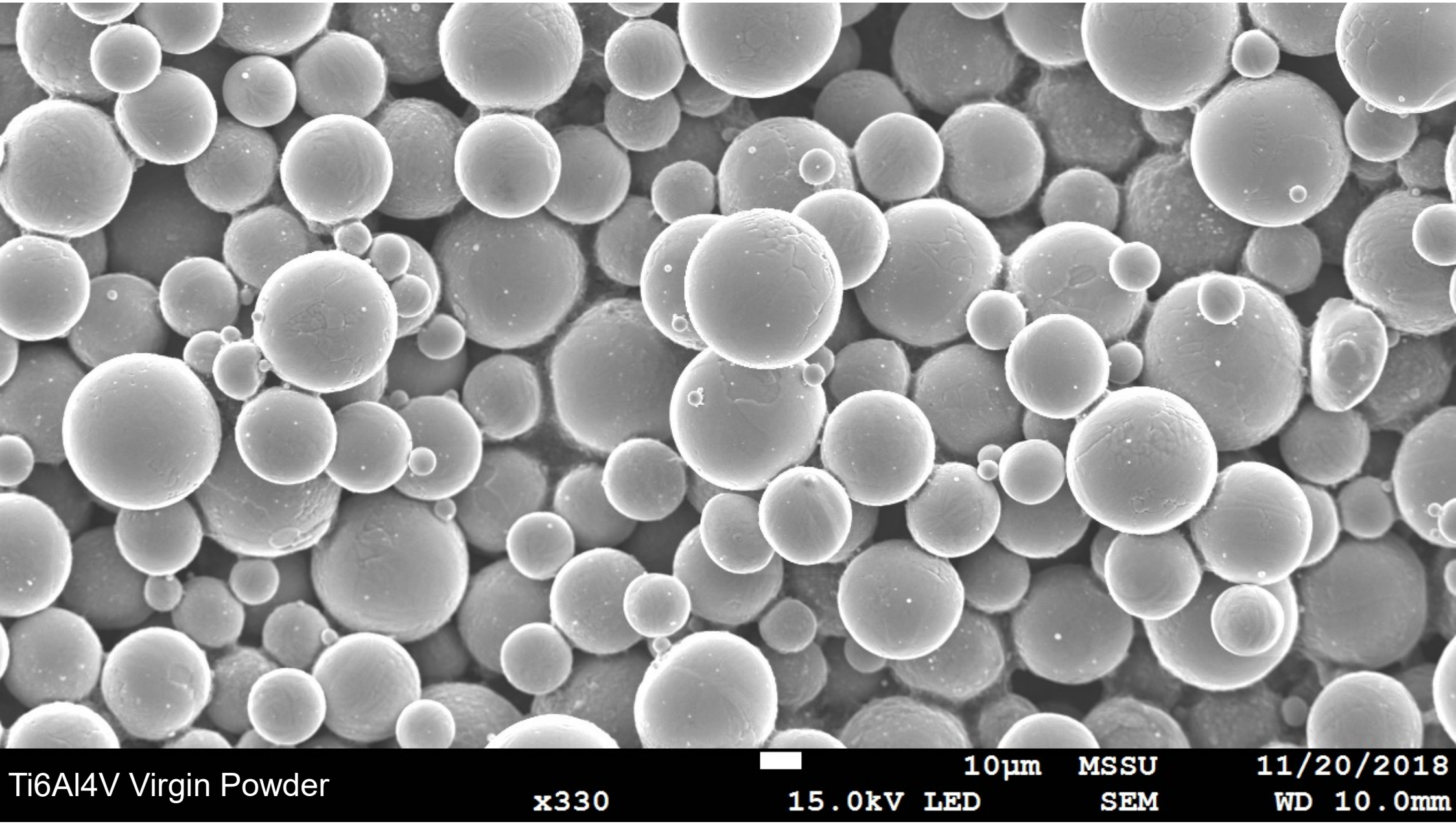
Additive Alloys

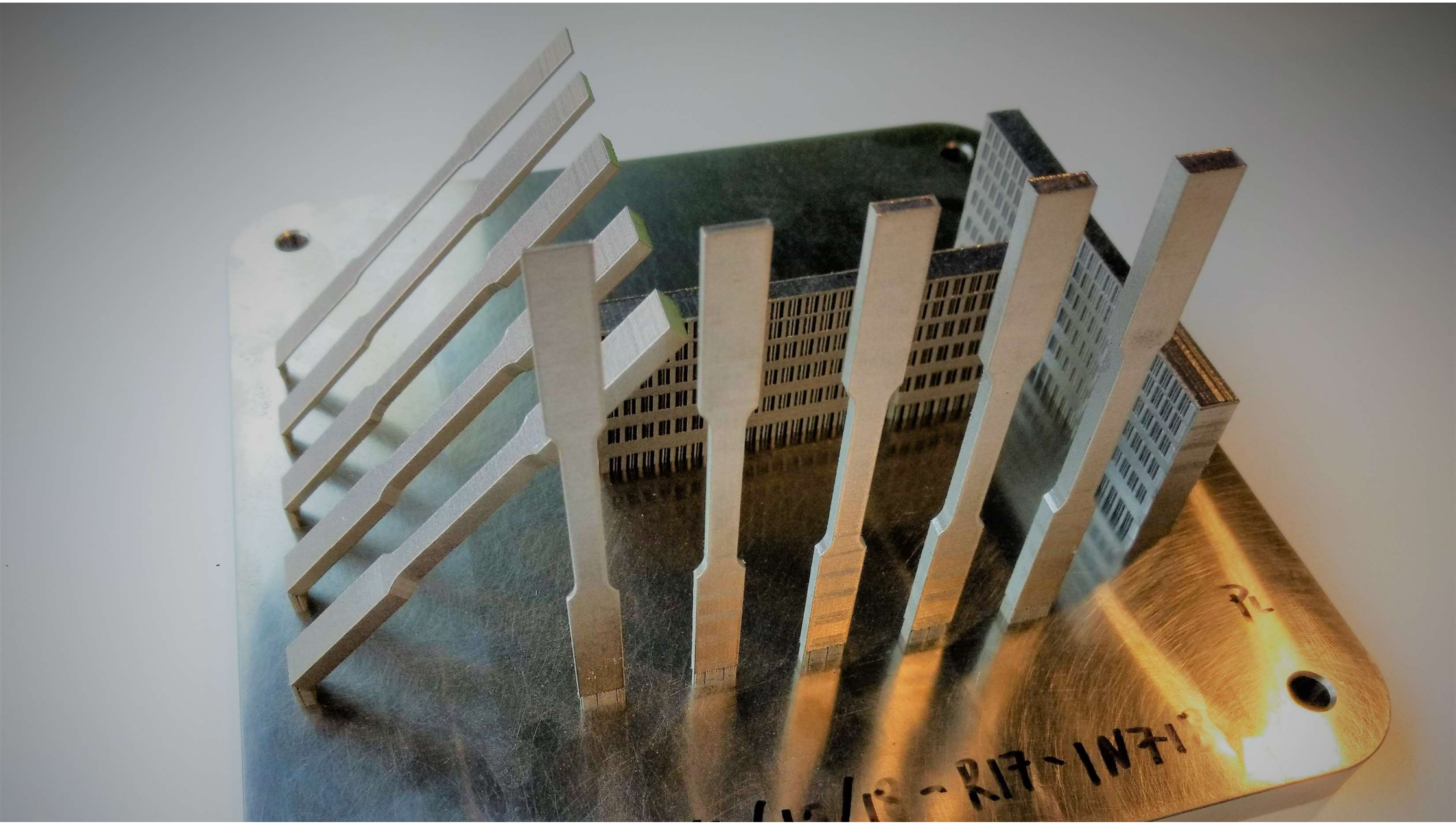
- Ti-6Al-4V
- Al-Si-10Mg
- Inconel 718
- Maraging Steel M300

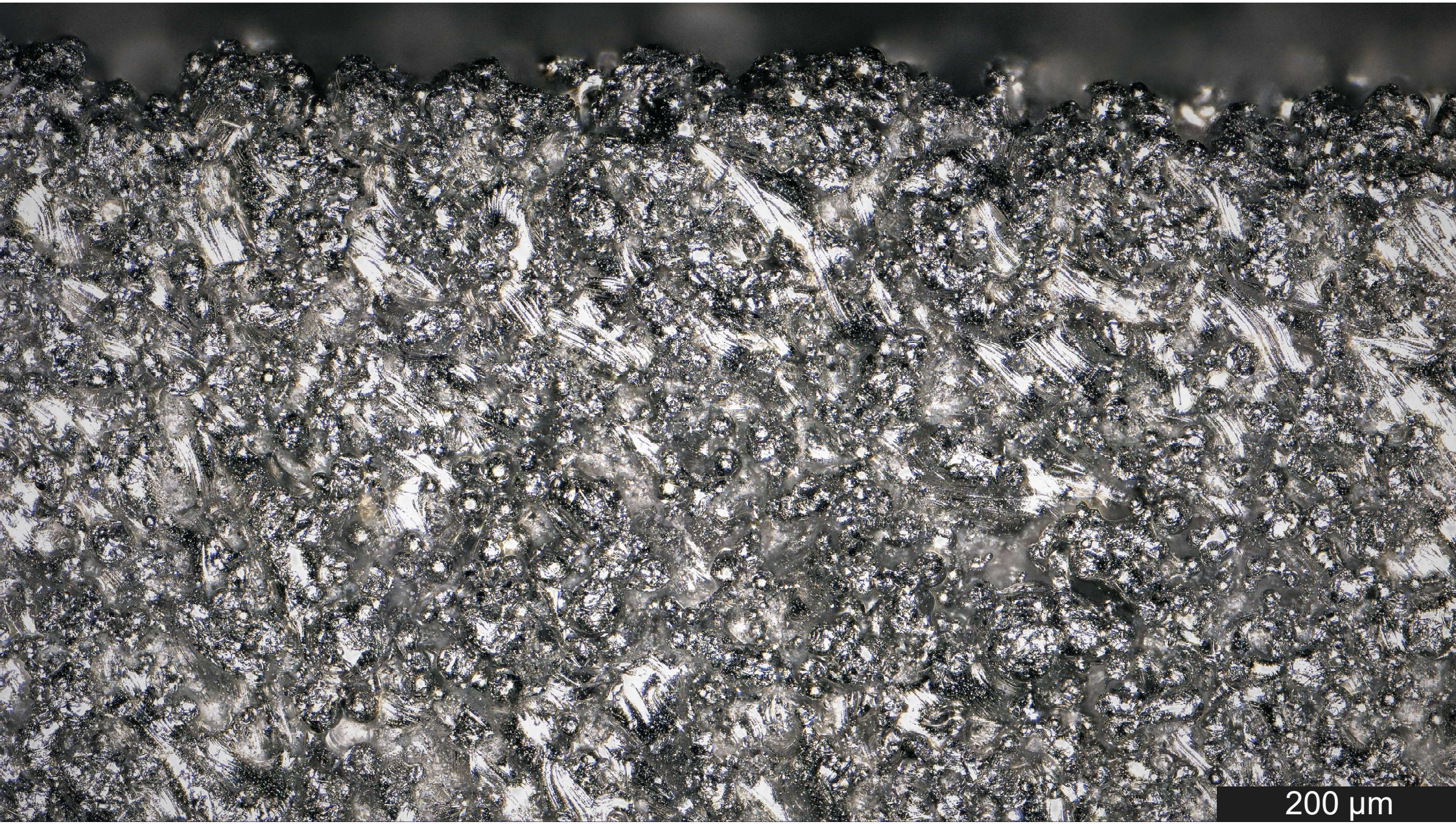
Sample Design and Build Layout

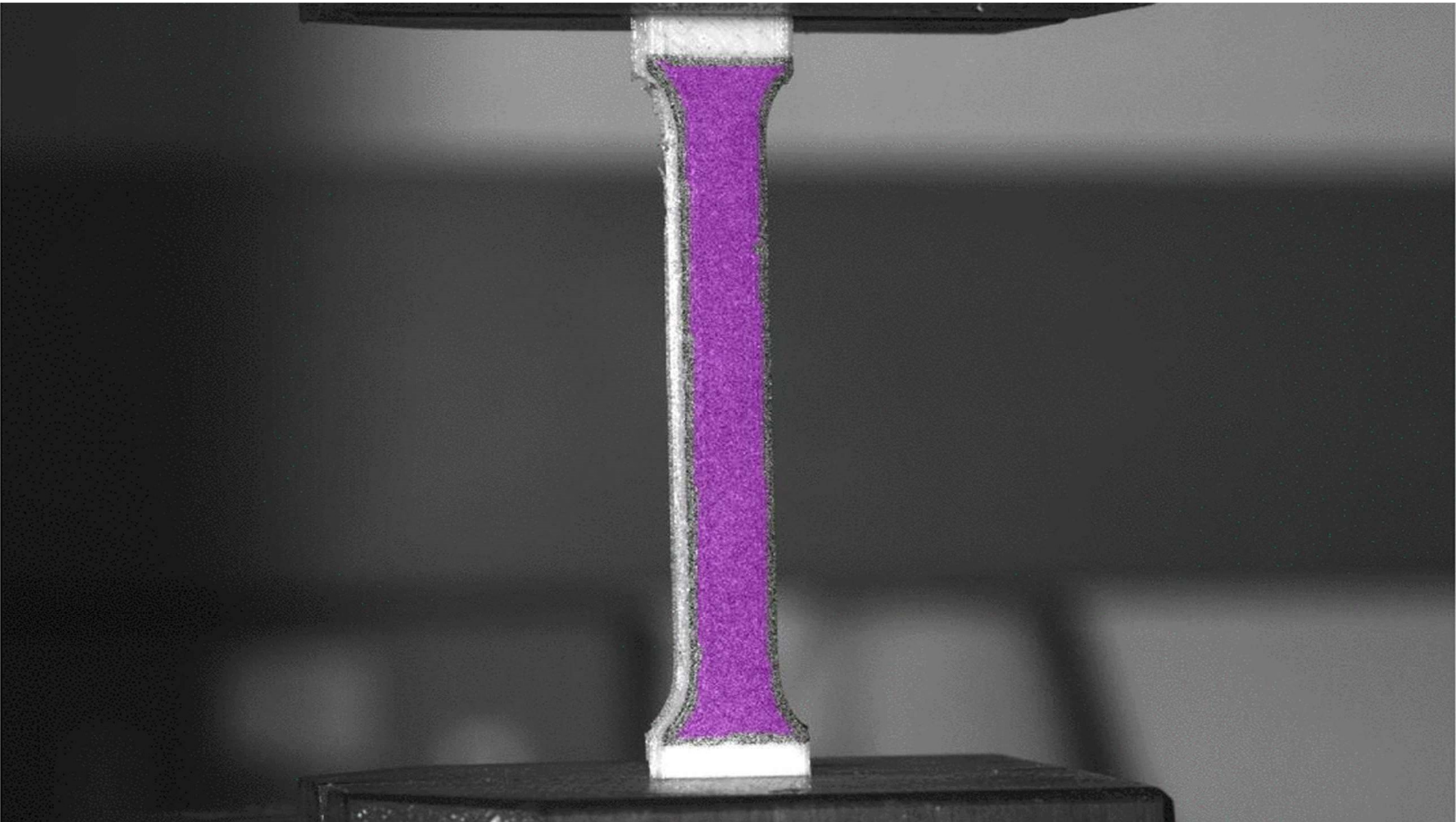
ASTM E8




Ti6Al4V Virgin Powder
x330
15.0kV LED
10µm MSSU
SEM
11/20/2018
WD 10.0mm




200 µm

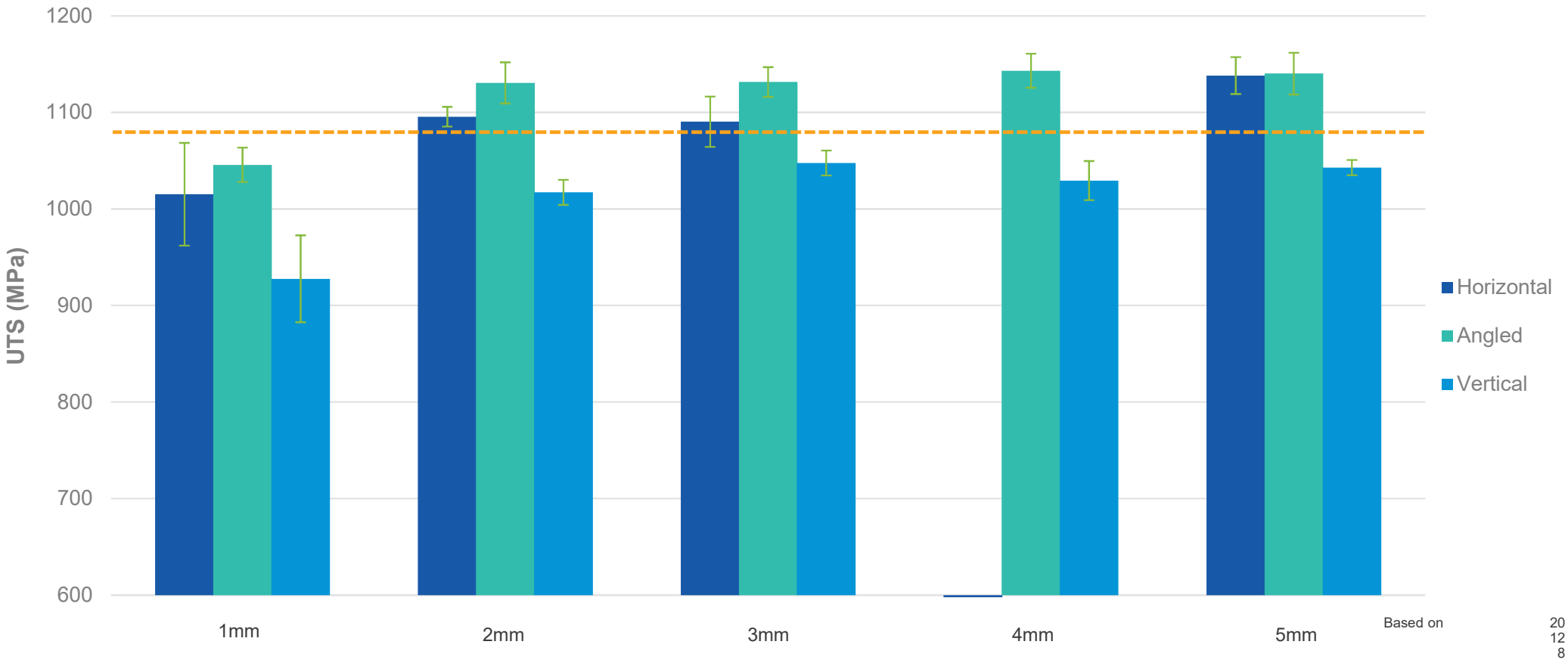


Practical Research

Results

Practical Results

L-PBF Ti-6Al-4V (As Built) Mean UTS



Based on

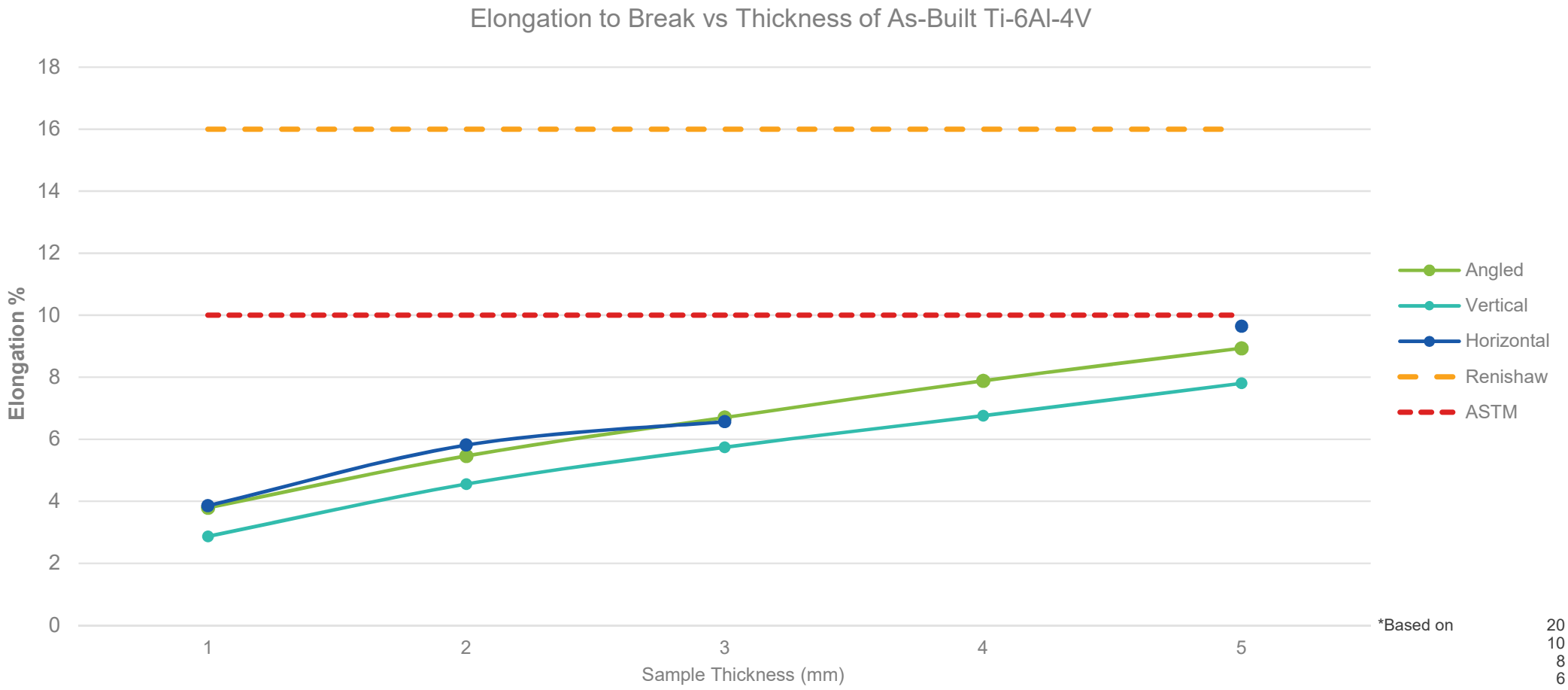
20 x 1mm
12 x 2mm
8 x 3mm
6 x 4mm
6 x 5mm

Renishaw Data
H-5800-1086-04-B

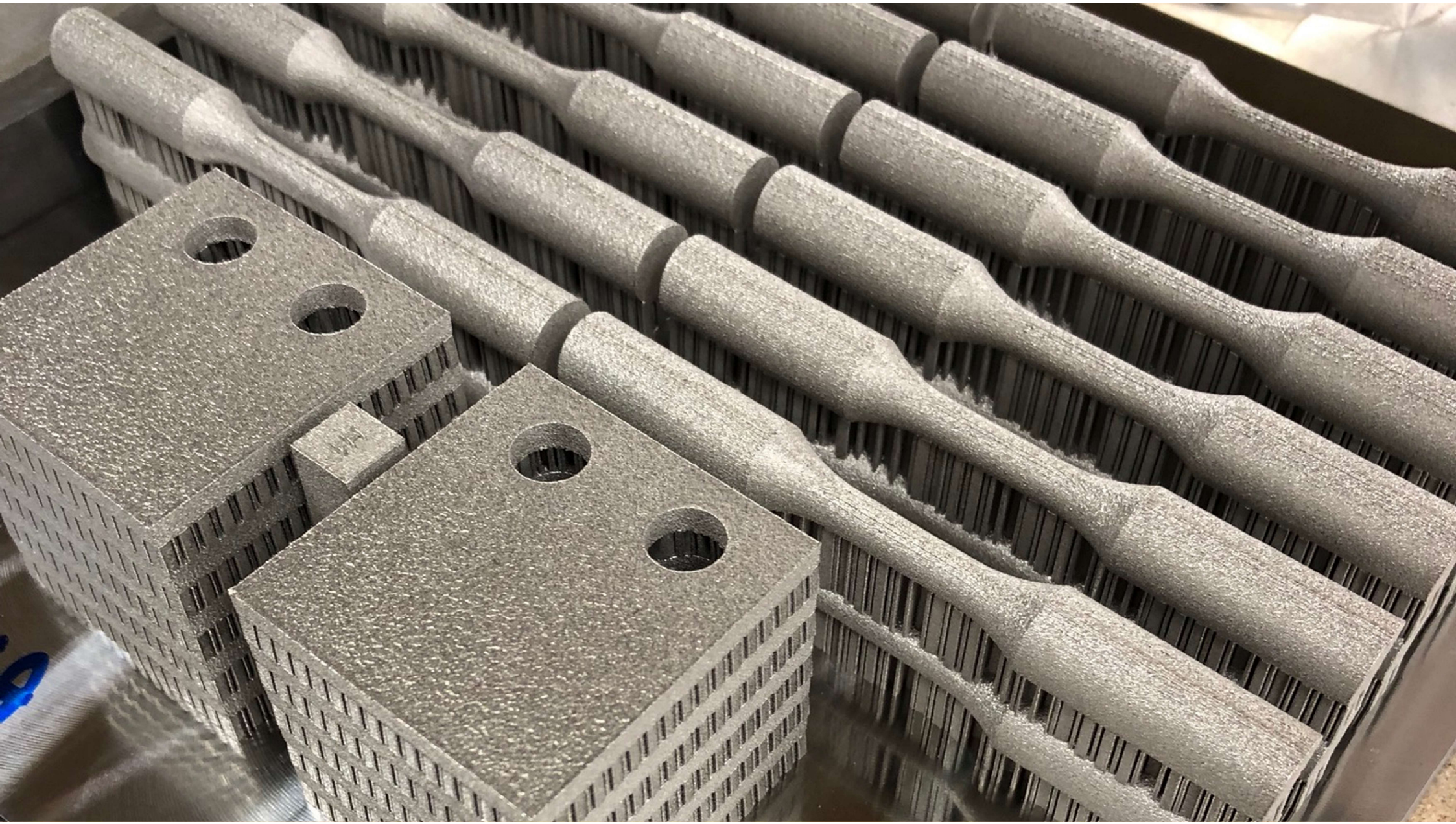
>5mm

Results

Ti6Al4V (As Built)

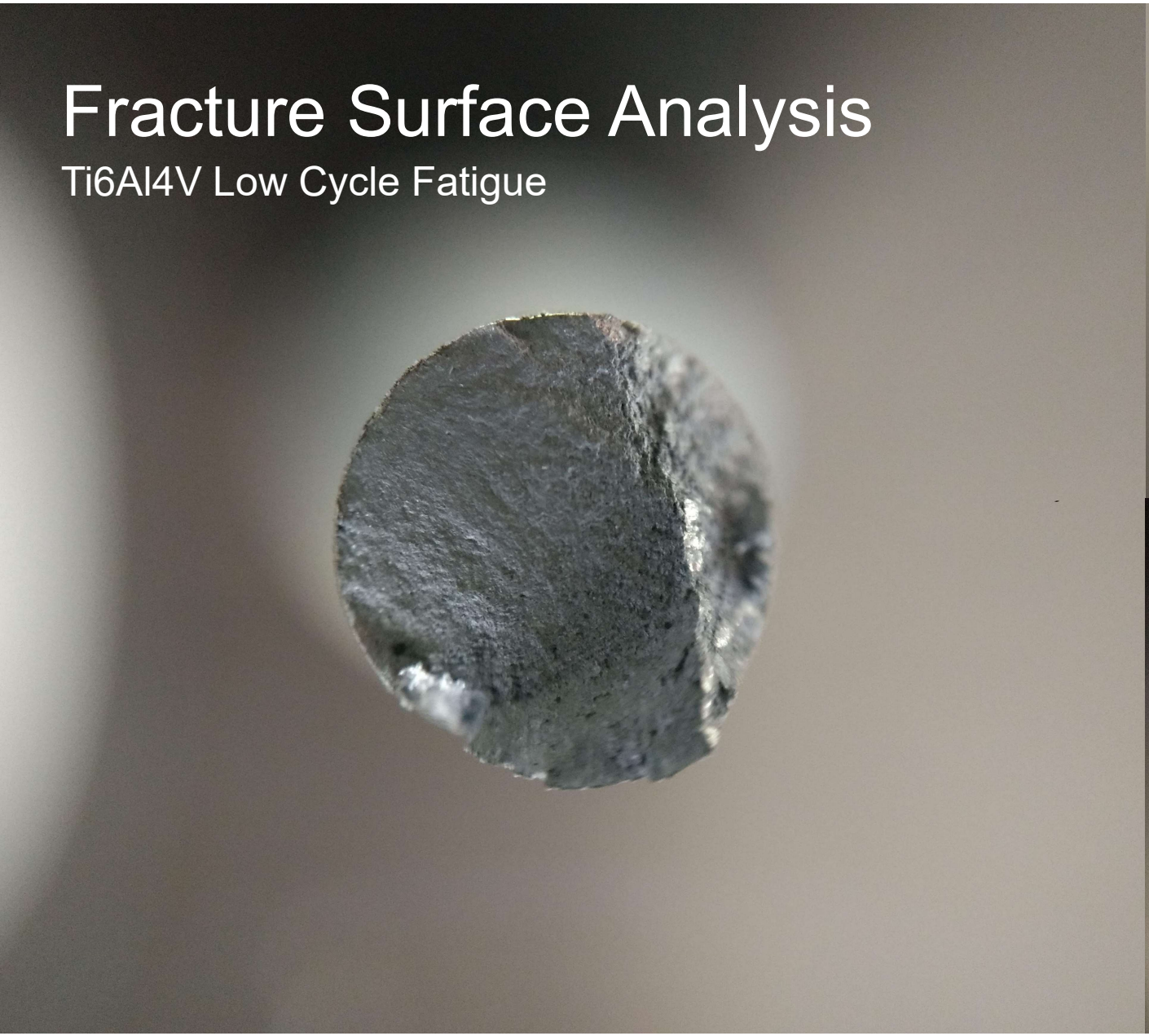


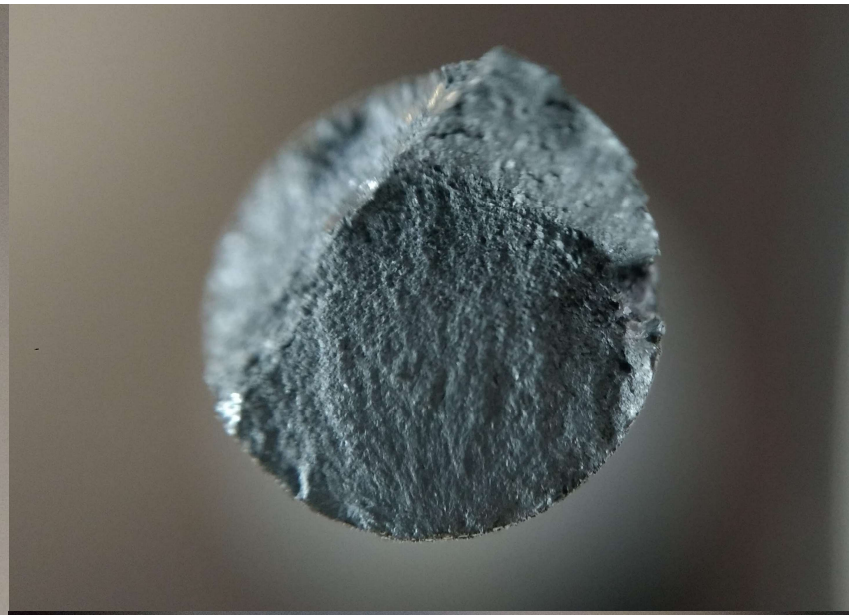
Ongoing Work



Fracture Surface Analysis

Ti6Al4V Low Cycle Fatigue

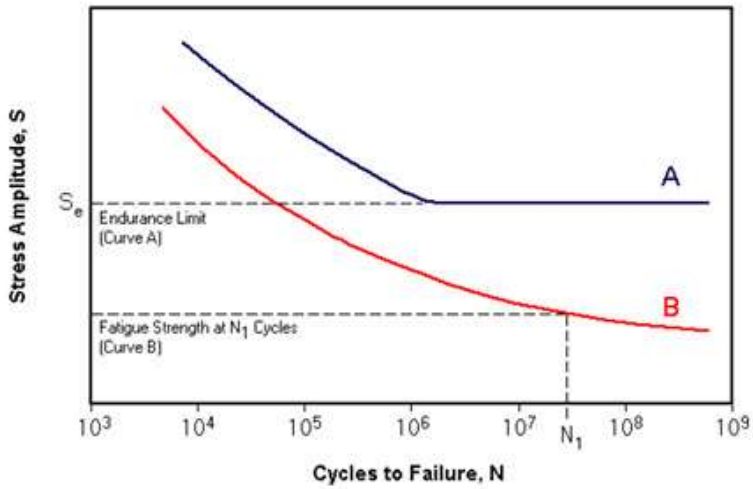




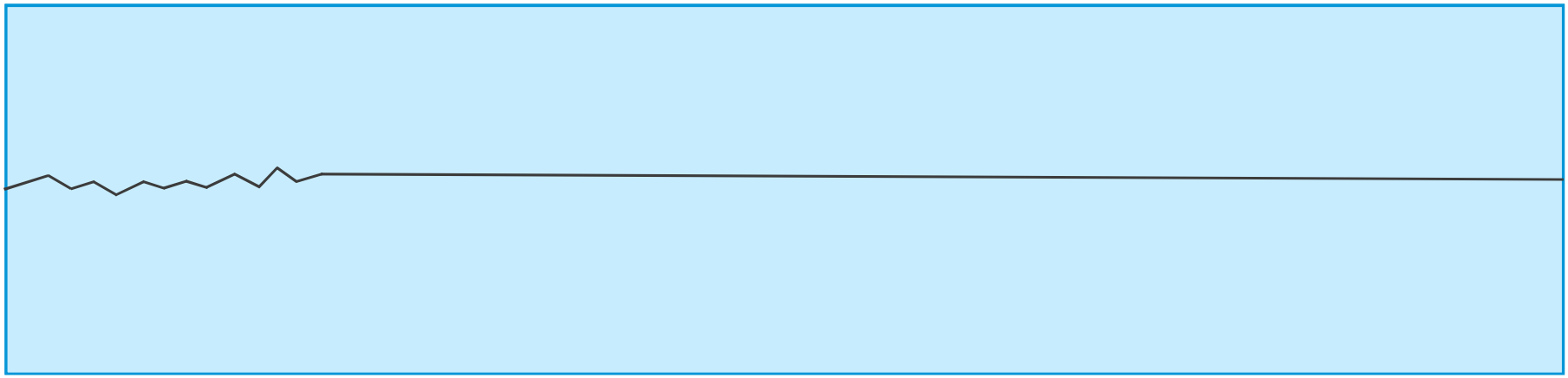
Fatigue Testing

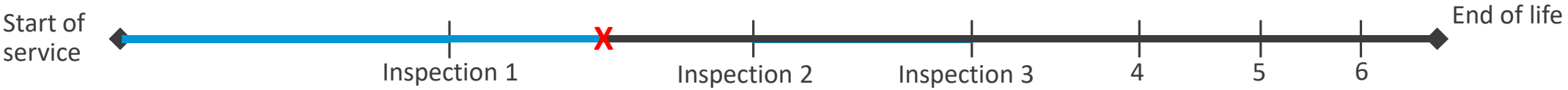
Safe Life and Damage Tolerance

- **Safe Life Fatigue Design** – specifying how long a component should last for. This is dependant on data acquired from SN Curve.
- **Damage Tolerant Design** – This assumes a flaw exists within the component but is designed not to propagate to critical length before the next maintenance inspection.



Damage Tolerant





Concluding Remarks

Design Takeaway

“So what?”

- Additive alloys will exhibit variation in mechanical properties which can significantly deviate from published data values.
- Incorporating lattices and complex geometries for structural features should consider property variation.
- Microstructural anisotropy affects mechanical performance thus build orientation must be considered for structural components with tight property tolerances.
- Fatigue testing data will enable components to be designed with both safe life and damage tolerance approaches without the need for large enveloping volumes.

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