Additive Manufacturing and Characterization of Topologically Designed Porous 316L Stainless Steels

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INTRODUCTION

Porous 316L stainless steels (SS) are valued for their lightweight, high strength, and corrosion resistance, making them ideal for biomedical, filtration, and energy applications. Traditional methods for making porous structures are limited in design flexibility and often generate more waste. In contrast, additive manufacturing (AM), especially Laser Powder Bed Fusion (LPBF), enables precise control over complex geometries, while also reducing material waste, making it a more sustainable option. Topological designs, such as Triply Periodic Minimal Surface (TPMS) structures, allow for the fine-tuning of porosity and mechanical properties, making AM an excellent choice for producing porous metals.

MATERIAL AND METHODS

Material: 316L Stainless Steels

Methods: Topological Design, LPBF Fabrication, Optical Microscope and SEM Characterization, Micro-CT Analysis.

RESULTS AND DISCUSSION

Laser Power (P)	180 W
Scan Speed (v)	1000 mm/s
Hatch Distance (H)	110 μm
Layer Thickness (t)	60 μm

Table 1. Printing parameters.

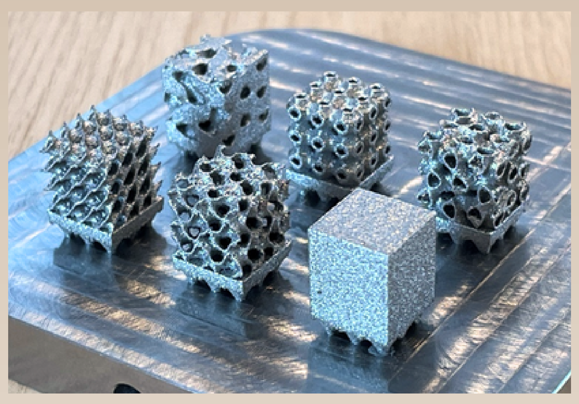

Fig 1. Print 316L structures.

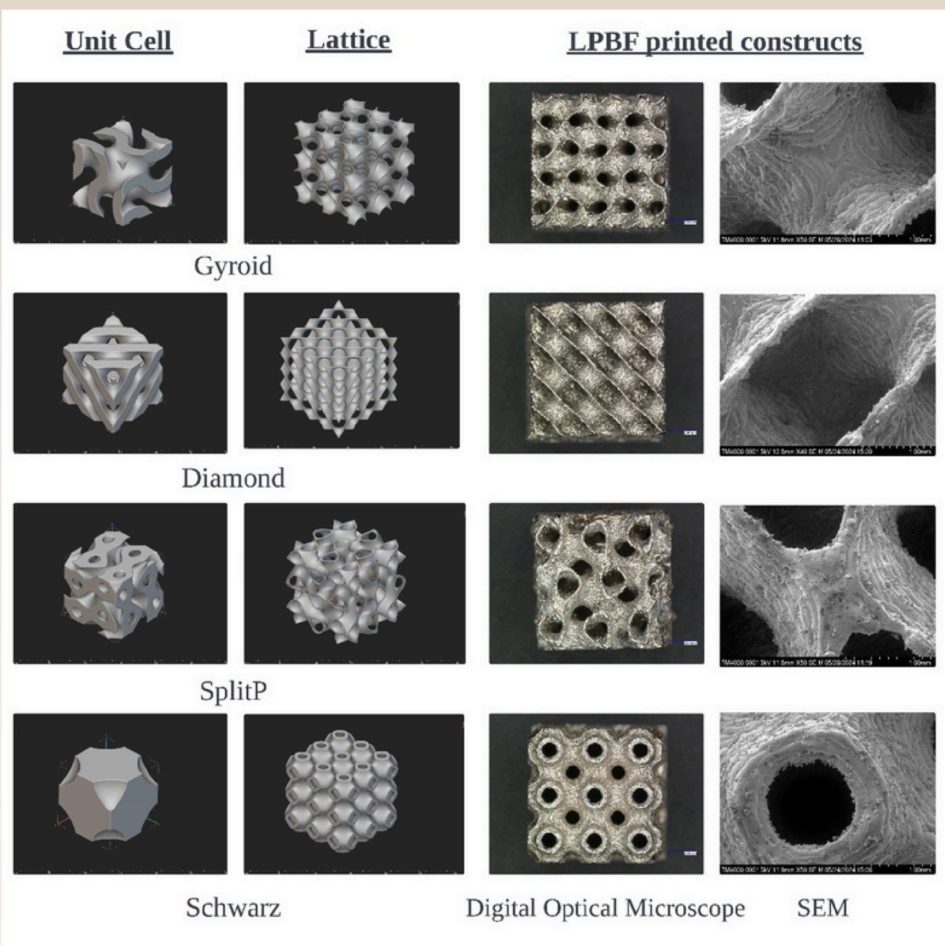

Fig 2. Optical microscope and SEM micrographs displaying the structure of porous 316L.

The LPBF process successfully produced topologically designed TPMS structures with a uniform porosity distribution and complex geometric features.

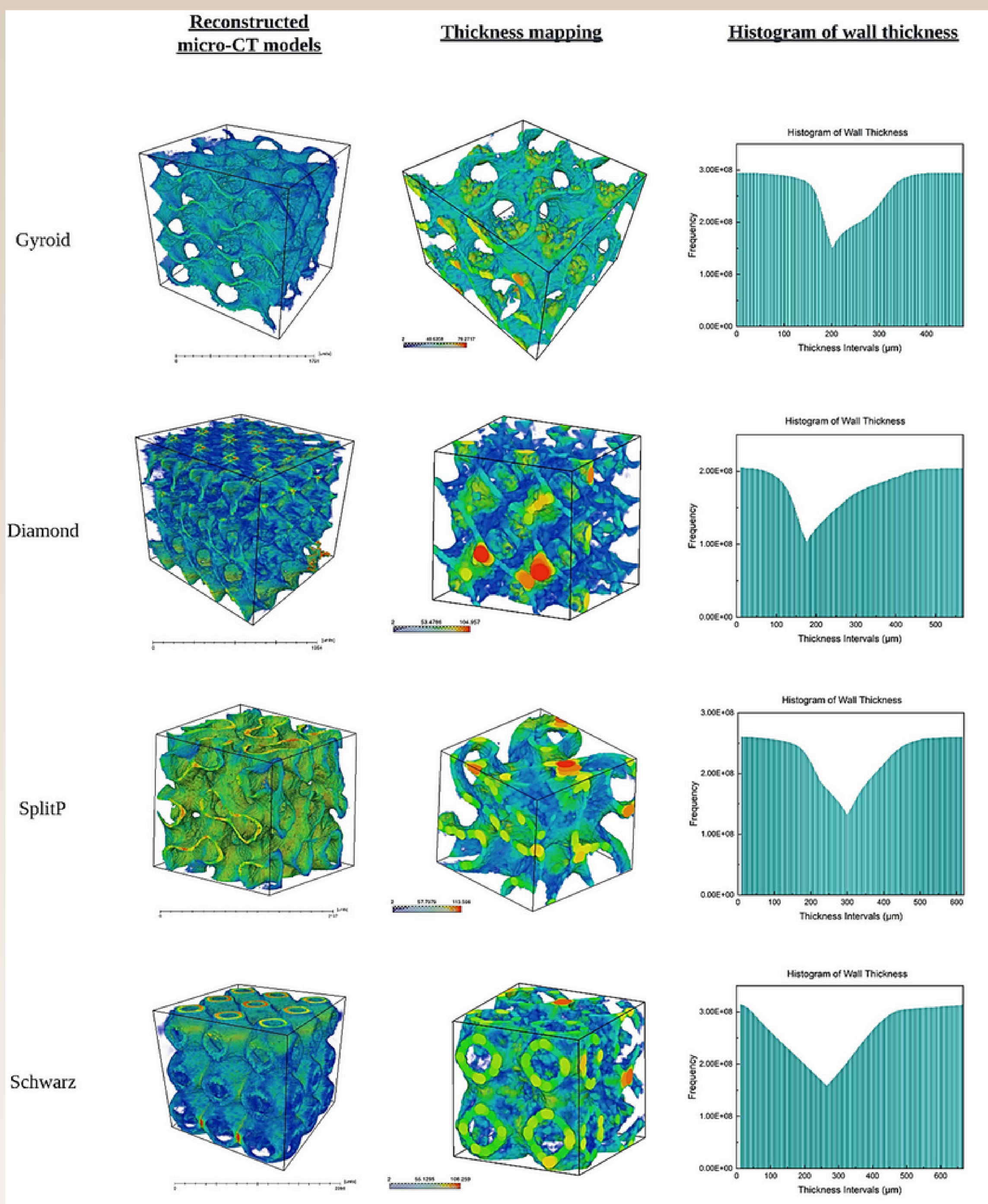

Fig 3. Micron-CT and thickness images of porous 316L.

	Gyroid	Diamond	SplitP	Schwarz
Design thickness (μm)	240	240	400	240
Printed average thickness (μm)	227	210	310	228
Design porosity	89.17 %	88.42 %	83.63 %	74.32 %
Printed porosity	85.00 %	82.76 %	80.74 %	69.53 %
Design surface area (mm^2)	1434.67	1440.56	1489.43	1368.60
Print surface area (mm^2)	1835.65	1896.15	2242.10	1718.10

Table 2. Comparison of designed and printed structure.

However, according to the micro-CT results, some deviations from the design were observed due to limitations in resolution and parameters during the printing process. CT analysis shows that the surface area of the printed samples was slightly higher than the designed values, because of the roughness introduced by the LPBF process.

CONCLUSION

- This study shows that LPBF can successfully fabricate topologically designed porous 316L with controlled porosity.
- Optimizing printing parameters is important to achieving accurate geometries.
- Future work will focus on improving sample precision by adjusting process parameters and exploring post-processing techniques.
- These findings support the use of AM in creating advanced porous materials for more applications.

REFERENCE

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