Desktop FFF Fabrication of Metal-Filament Gyroid TPMS Structures

Process Optimization and Preliminary Characterization

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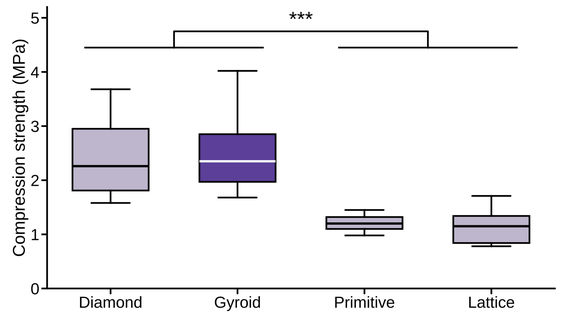
ABSTRACT

This project developsand optimizes a workflow for fabricating Gyroid TPMS structures using TVF 316L stainless steel filament on a desktop FFF printer (Bambu Lab X1-Carbon). Specimens at 30%, 40%, and 50% relative densities were designed (26.7×26.7×53.3 mm) and printed successfully after iterative parameter optimization. As-printed parts show good geometric fidelity and consistency across replicates. This work demonstrates the feasibility and repeatability of accessible metal FFF for lattice structures relevant to bone-scaffold applications.

WHY GYROID?

- ✓ Excellent mechanical performance and isotropic properties
- ✓ Competitive compressive strength and stiffness among TPMS topologies
- ✓ Efficient material distribution with high strength-to-weight ratio
- ✓ Interconnected porosity ideal for bone tissue

COMPRESSIVE STRENGTH & MODULUS BY TPMS TOPOLOGY



*Source: Compression strength of 3D-printed hydroxyapatite scaffolds. ***p < 0.005. Adapted from Maevskaia et al. (2023).*

RESEARCH CONTRIBUTION

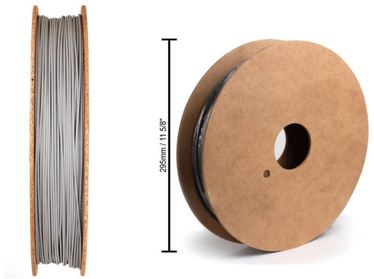
Workflow demonstrating TVF 316L metal-filament printing of Gyroid TPMS on an accessible desktop FFF platform.

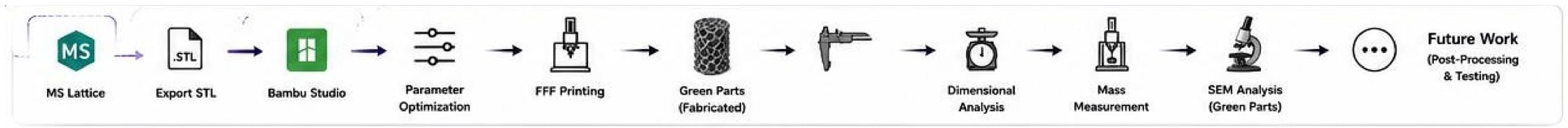
Bridges the gap between high-cost industrial AM systems and low-cost research prototyping.

Provides a repeatable, optimized process for future biomedical scaffold fabrication.

1. MATERIAL

TVF Stainless Steel 316L Filamet™

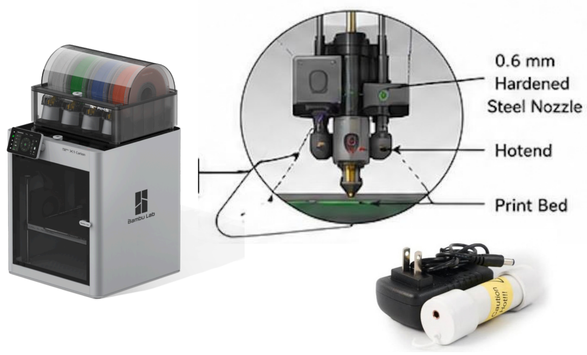




2. DESIGN PARAMETERS

TPMS Type	Gyroid
Relative Density (RD)	30%, 40%, 50%
Unit Cell Size	6 mm
Specimen Dim. (CAD)	26.7×26.7×53.3 mm
Target Sintered Dim.	24×24×48 mm
Replicates	5 per relative density

4. EXPERIMENTAL SETUP

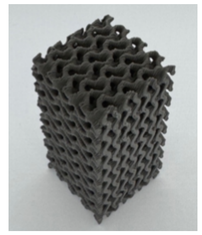


① TVF 316L Spool ② Filawarmer ③ Bambu Lab X1-Carbon

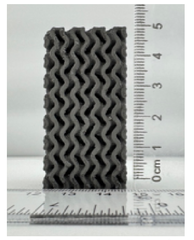
5. PRINTING PARAMETERS (OPTIMIZED)

Nozzle Diameter	0.6mm (Hardened Steel)
Layer Height	0.3 –0.4 mm
Nozzle Temperature	230 °C
Bed Temperature	65 °C
Print Speed	45 –60 mm/s
Flow Rate	110 –120 %
Cooling Fan	OFF (Part & AUX)
Chamber	Enclosed (30–50 °C)
Build Plate	Textured PEI Plate

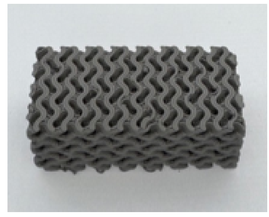
6. FABRICATED GREEN PARTS (AS-PRINTED)



30% Relative Density

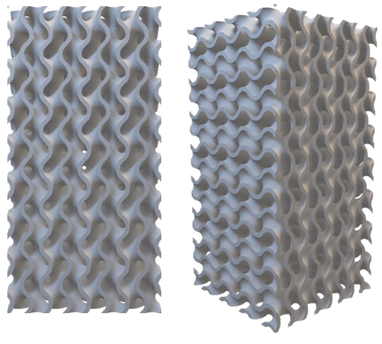


40% Relative Density

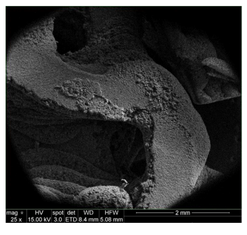


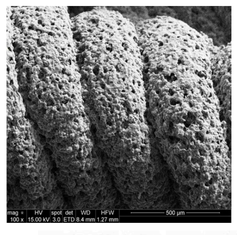
50% Relative Density

3. GYROID UNIT CELL (6 MM)



9. SEM ANALYSIS (GREEN PARTS)

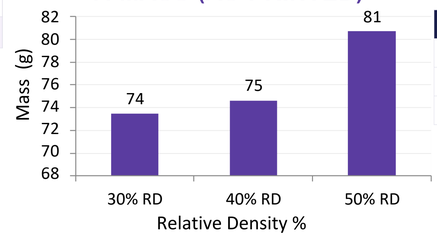




10. CHALLENGES ENCOUNTERED & SOLUTIONS

Challenge	Root Cause	Solution Implemented
Poor Bed Adhesion	Parts lifting / warping	Clean bed + glue stick + brim + enclosure
Brittle Filament	Filament breakage	Filawarmer + proper handling
Nozzle Clogging / Wear	Inconsistent extrusion	0.6 mm hardened nozzle + flow optimization
Stringing	Surface defects	Retraction tuning + cooling off
Dimensional Variation	Batch-to-batch differences during printing	Parameter tuning + enclosure temp. control

7. MASS (AS-PRINTED)

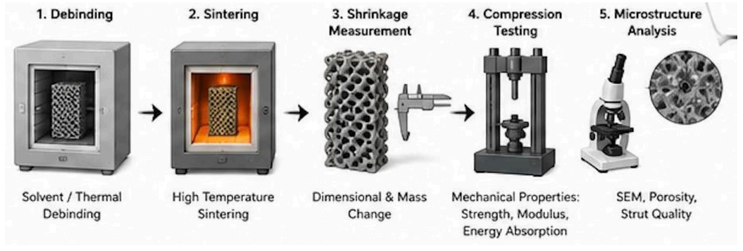


8. DIMENSIONS (AS-PRINTED)

RD (%)	L (mm)	W (mm)	H (mm)
30	26.6	26.6	53.3
40	26.6	26.6	53.3
50	26.6	26.6	53.3

CAD: 26.7×26.7×53.3 mm
Target after sintering: 24×24×48 mm

11. FUTURE WORK: POST-PROCESSING & MECHANICAL TESTING



12. IMPACT & BIOMEDICAL APPLICATIONS

- Demonstrates feasibility of metal-filament FFF for TPMS structures on a desktop platform
- Establishes a repeatable and optimized workflow for green-part fabrication
- Enables cost-effective production of lattice structures for biomedical applications
- Foundation for future mechanical and microstructural characterization

ACKNOWLEDGEMENT This research is supported by the Laidlaw Undergraduate Leadership and Research Programme at NYU Abu Dhabi.

KEY REFERENCES Mechanical behavior of Diamond/Gyroid/Primitive/Lattice TPMS scaffolds, PMC10611970 • Obadimu, E. O. & Kouroussis, K. I. (2023), anisotropic sintering shrinkage in extrusion-printed 316L SS, Int. J. Mech. Sci. •The Virtual Foundry, Filamet 316L SS print/debind/sinter guidelines