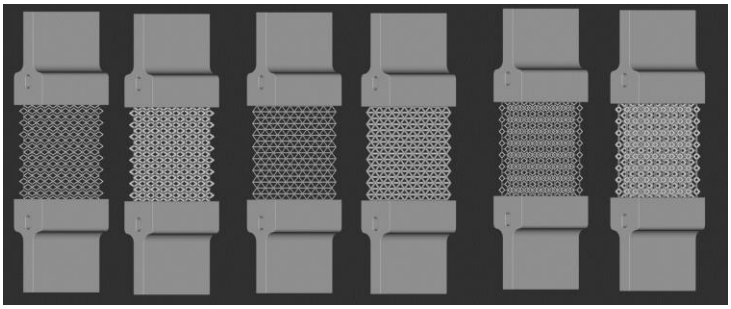
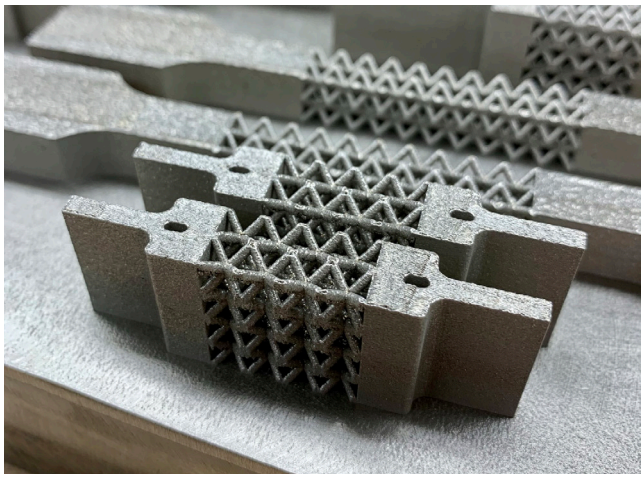
Tensile Behavior of AM Lattice Structures

Demonstrate and validate tensile test coupon geometry for the assessment of AM printed metal lattice structures



Proposed tensile test geometry with multiple lattice designs created using nTopology software.



PROBLEM

Complex cellular and lattice structures are an exciting field of materials development offering revolutionary opportunities in medical devices, light weighting, and impact protection. Additive manufacturing (AM) is uniquely suited to produce lattice structures and there has been a synergistic development cycle between the lattice design community and AM. There is, however, an unmet need for a standard approach to mechanical testing and evaluation of these lattice structures to support their introduction into demanding applications for defense and commercial use.

OBJECTIVE

The objective of this effort is to develop a standard approach to mechanical testing and evaluation of lattice structures. The program seeks to deliver an ASTM work item style final report proposing a test geometry and supported with a technical data package including tensile results and digital image correlation (DIC) imaging from a design of experiment (DOE) matrix of lattices.

AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:

MATERIAL

ASTM PROCESS CATEGORY
Powder Bed Fusion

EQUIPMENT
Concept Laser M2

MATERIAL
3016L

TECHNICAL APPROACH

The Ohio State University's Center for Design and Manufacturing Excellence (CDME) is leading the effort. The technical approach includes lattice demonstration geometry created using nTopology, printed in 316L using laser powder bed fusion on a Concept Laser M2, then evaluated using multiple approaches for tensile testing and measured using DIC. The core of the technical approach is defining and measuring the specific dimensions of the tensile bars as a function of lattice unit cell and strut size that produces a low scatter, uniform mechanical evaluation. This technical approach is envisioned to be translatable to other materials such as Ti64 and can be used to develop lattice coupons for compression and shear loading conditions as well.

The proposed tensile test geometry consists of a lattice structure in the gauge section with printed solid material for gripping. The initial geometry is a nominal 1cm x 2cm x 2.5cm gauge section specifically sized so that only complete lattice unit cells are within the gauge section (no partial cells "clipped" at the grip sections) with grips sized to interface with the lattice gauge section. Lattice designs are being produced using nTopology software. Samples are printed using a Concept Laser M2 in 316L stainless steel and then stress relieved before tensile testing with the as printed surface finish. Mechanical testing is being performed using mechanical test frames and 3D DIC hardware and software.

PROJECT START DATE

December 2020

EXPECTED END DATE

April 2021

EXPECTED DELIVERABLES

- Test artifact designed to characterize AM metal lattices
- Technical data package including all mechanical test data, build plans, and post-test inspection
- Draft standard for tensile testing of metal printed lattices
- Final report detailing material and process parameters used during the project and outlining all results from each task

FUNDING

$150K total project budget
($120K public funding/$30 private funding)

PROJECT PARTICIPANTS

Project Principal:
Ohio State University

Public Participants:
U.S. Department of Defense