Mechanics

Production and Evaluation of Lightweight Metamaterials Using AM Technology

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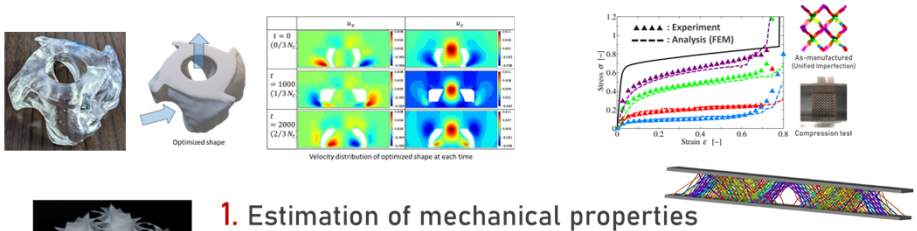
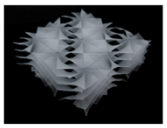
Purpose of Research

In recent years, a novel approach that combines **topology optimization with additive manufacturing (AM)** has attracted significant attention as a new paradigm in design and fabrication. Numerous research studies and practical implementations have been reported both in Japan and internationally. Among the complex structures that can only be produced by AM, those offering enhanced functionality are often referred to as lightweight metamaterials. Our laboratory focuses on **the design and analysis of such lightweight metamaterials** that achieve both **high functionality and low weight**. Specifically, we investigate how to produce such materials, how potential geometric imperfections may affect their performance, **and how to incorporate manufacturability constraints into topology optimization**. These studies are conducted through comprehensive numerical simulations.

Summary of Research

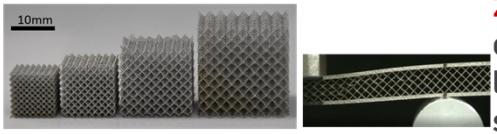
Our laboratory is conducting research on the following three key topics:
Development of a Database for Optimal Manufacturing Conditions (Process Recipes):
Establishment of Reliable Performance Evaluation Techniques:
Exploration of Practical Applications:





1. Estimation of mechanical properties of lattice core and sandwich panels
Stiffness and strength(quasi-static, dynamic), plastic yielding, buckling,

2. Topological optimization of lattice sandwich panels



3. Proper Fabrication conditions and existing geometrical imperfections in lattice

4. Multi-functional properties of lattice core aimed at leveraging the full potential of lattice structures

Comparison with Conventional or Competitive Technologies

- Derivation of optimal process parameters for fabricating lightweight lattice structures
- Development of stiffness and strength evaluation methods that account for measured geometric imperfections

Expected Applications

- Capability to propose optimal fabrication recipes tailored to the required mechanical properties
- Identification of internal structural defects using a database of numerical simulation results

Challenges in Implementation

- High-precision three-dimensional defect identification is required
- Extraction of optimal process recipes that account for variations and uncertainties in the type and quality of metal powders is

What We Expect from Companies

We welcome your inquiries at any time.

Points

- Capable of fabricating finer and more complex lightweight structures
- Capable of designing lightweight structures using topology optimization
- Not only improvements in stiffness and strength, but also controllability of vibration, sound absorption, and heat

Future Developments

- Presentation of research outcomes at academic conferences
- Submission of papers to academic journals
- Development of software covering the entire process from design to fabrication

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