Medium Entropy Alloy (MEA)-based Cubic Shell Lattice Metamaterials for Lightweight, Impact Resistance Applications

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Introduction

Lattice metamaterials are highly ordered 3D architectures composed of repeating unit cells, whose effective properties are governed by microstructural design and constituent materials. Recent advances in additive manufacturing enable precise fabrication of complex shell lattices that combine lightweight design with superior mechanical performance.

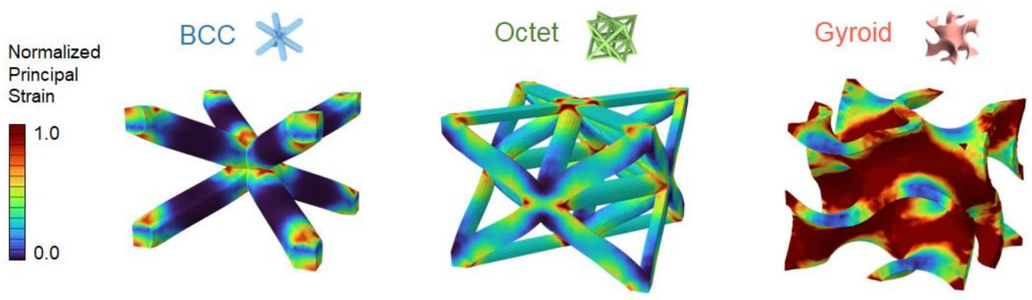
By integrating novel topologies with advanced multicomponent alloys like CoCrNi MEAs, known for exceptional strength, toughness, and cryogenic resistance, these metamaterials unlock unprecedented property spaces for aerospace, thermal management, and extreme-condition applications.

Objectives

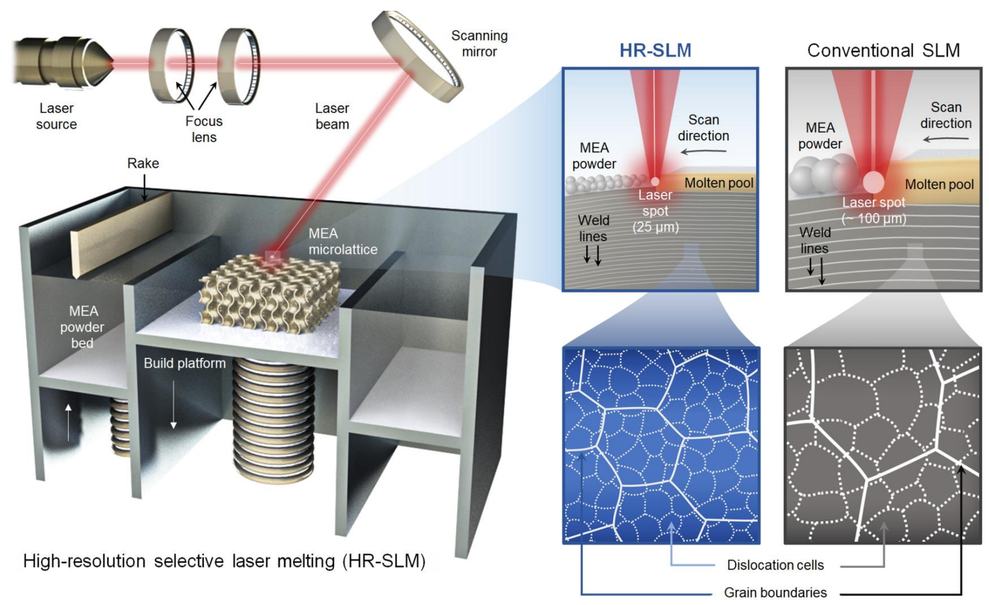
1. **Design novel cubic shell lattices:** develop geometric modeling, optimization tools, new unit cells to achieve superior properties.
2. **Optimize a CoCrNi-based medium-entropy alloy (MEA)** using high-throughput computational and experimental methods to enhance elastic, plastic, and impact responses.
3. **Scalable fabrication of MEA shell lattices** via micro-selective laser melting minimizing defects and distortion while ensuring lightweight, high-performance structures.
4. **Characterize multiscale mechanical behavior** and demonstrate industrial applications in aerospace for lightweight, high-toughness components.

Methodology

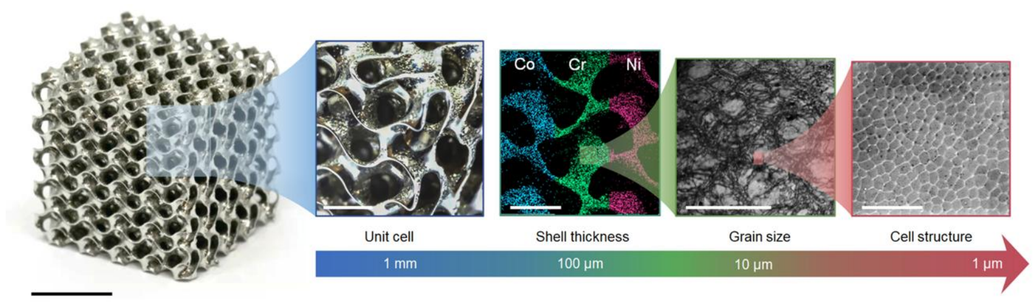
1. Geometric/Structural Design/Optimization of Cubic Shell Lattices



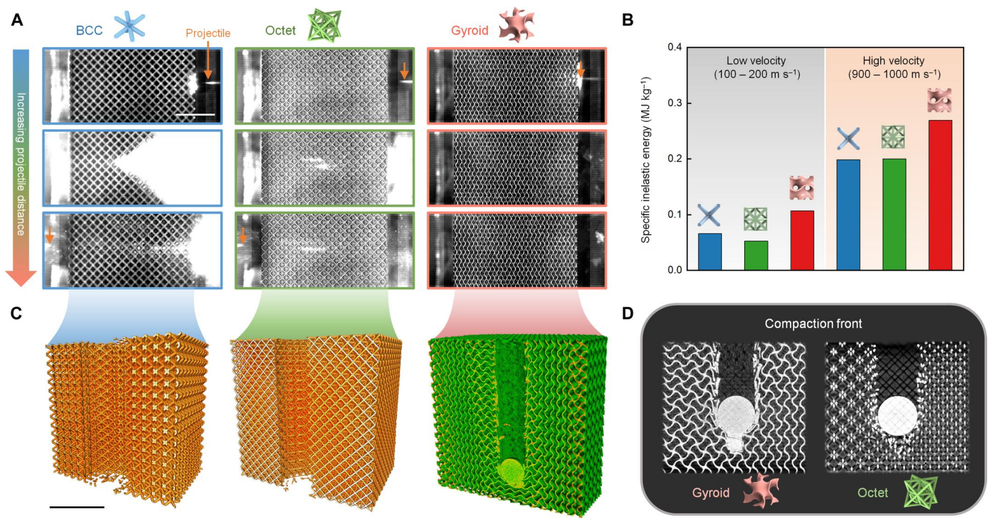
2. Design/Optimization of Microalloyed CoCrNi-based MEA System



3. Scalable AM of MEA Shell Lattice with μSLM

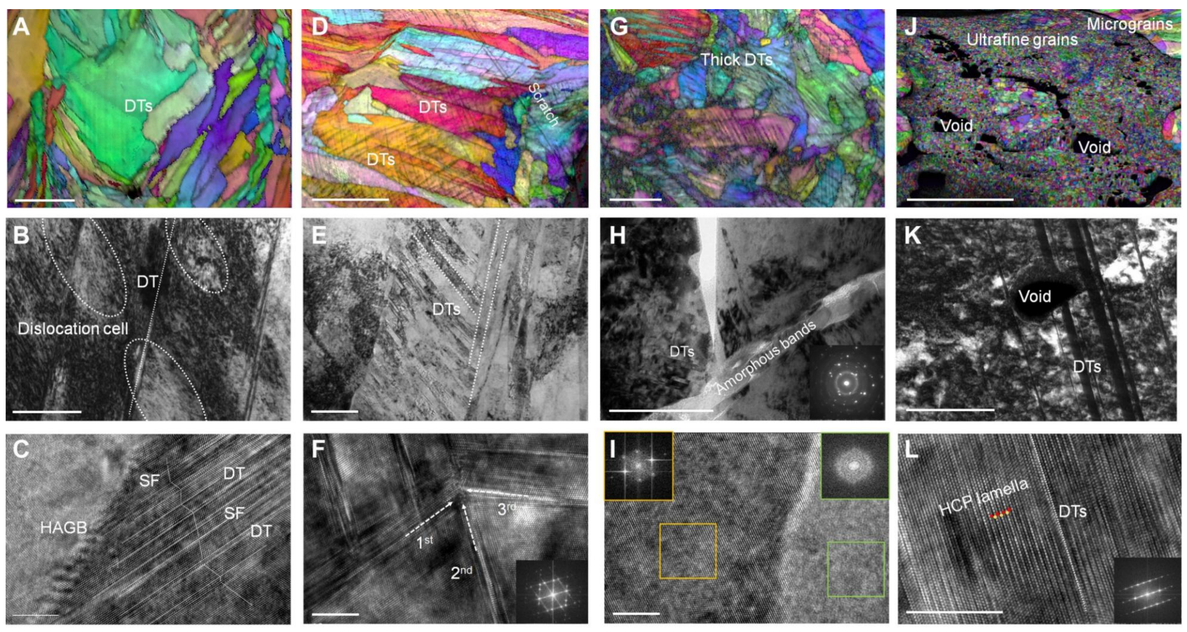


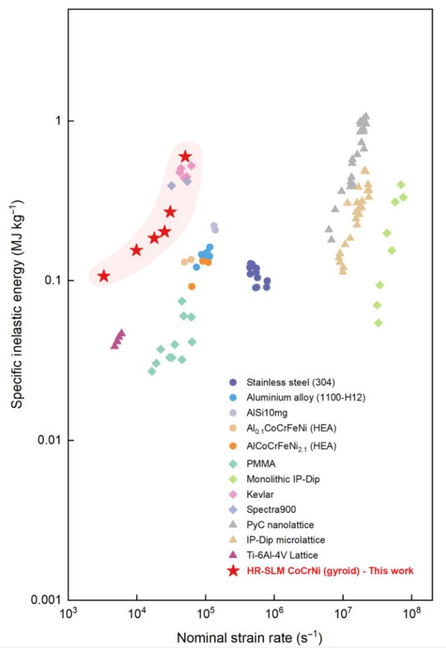
4. Characterization and Applications Demonstrations of the MEA Shell Lattices under Service Conditions

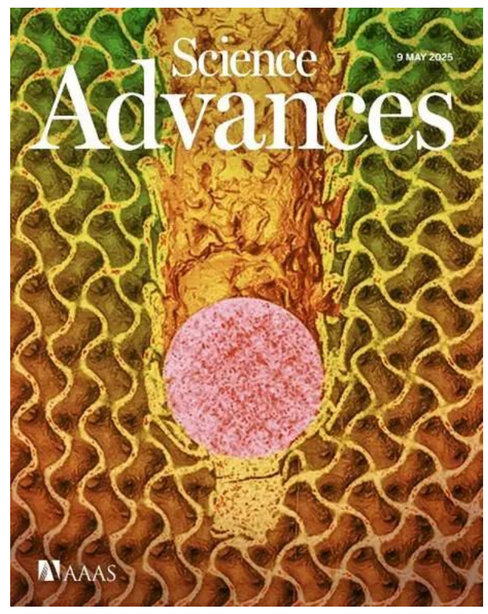


Research accomplishments

Pioneered MEA-based lattices







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Impact & Outlooks

- **Industry Impact:** Develop printable, high-performance MEA cubic shell lattices for aerospace applications, enabling lightweight, impact-resistant components.
- **Design Revolution:** Establish a comprehensive design framework and database for metamaterials, advancing and industry adoption.
- **Education & Innovation:** Train next-gen AM talent through courses, competitions, and prototypes, boosting Hong Kong's role in advanced manufacturing.
- **Long-Term Vision:** Partner with aerospace leaders to certify and deploy MEA lattices in rockets/satellites, driving re-industrialization in Greater Bay Area.