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Additive Manufacturing and Testing of High Metal Content High Performance Ramjet Grains

Gunduz, Ibrahim E.; Dausen, David F.; Smith, Walter

Monterey, California: Naval Postgraduate School

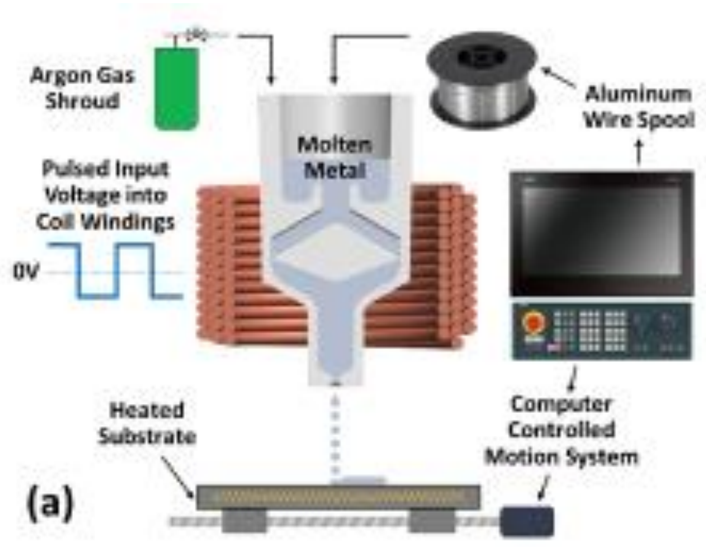
Additive Manufacturing of High Density Solid Fuels for Air Breathing Combustion Applications

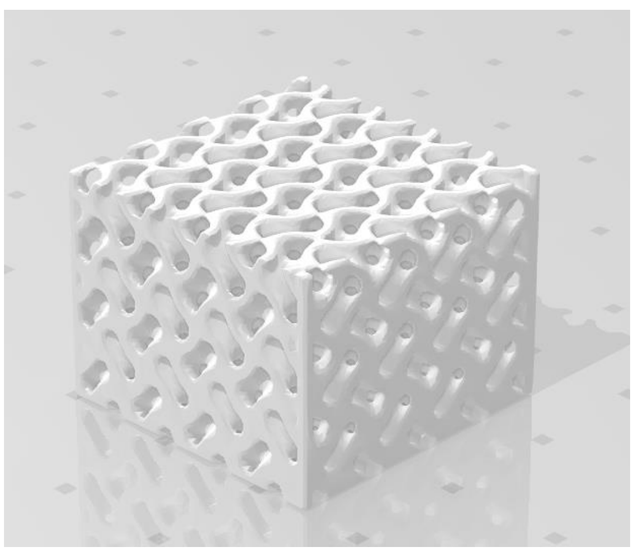
Naval Postgraduate School

AM of Lattices using Aluminum Alloys

Fuels with good combustion efficiency and high energy densities are needed to maximize the range and speed of future air-breathing systems. Metals are used to achieve a higher energy density. Fly out calculations show that this could increase range by up to 4X as compared to a non-air breathing munitions, but the fabrication of these parts has been challenging. This work will leverage recent advancements in additive manufacturing (AM) of aluminum alloys and evaluate 3D printed lattices.

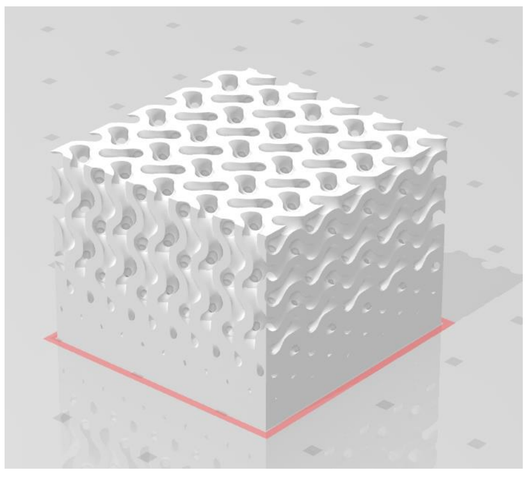
In this study, we utilized the XEROX ElemX that uses liquid metal printing (LMP) approach to 3D print lightweight aluminum alloy lattices with varying geometries. Our results show that gyroid infills with feature sizes down to 0.4 mm can be 3D printed using ElemX, with further possible improvements in resolution, on par with powder bed fusion AM at lower cost and no powder hazards.

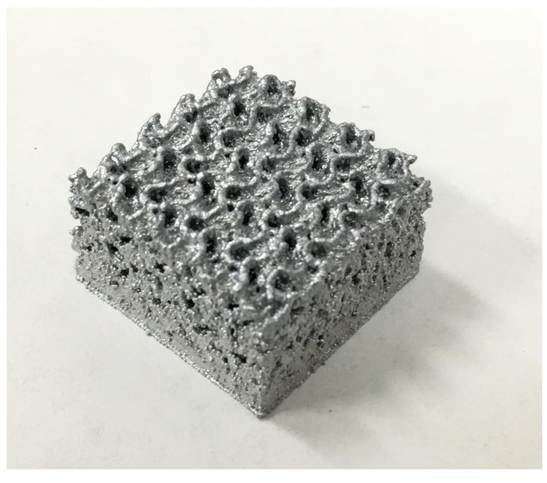




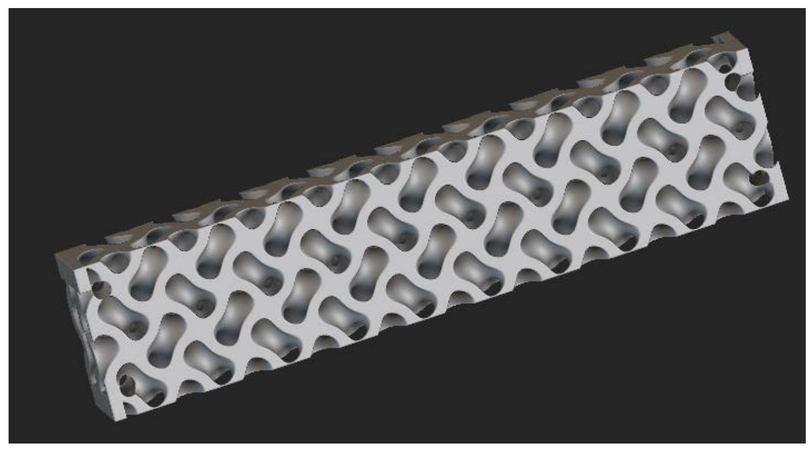
XEROX ElemX system at NPS, Conceptual Lattice with varying Void Gradient

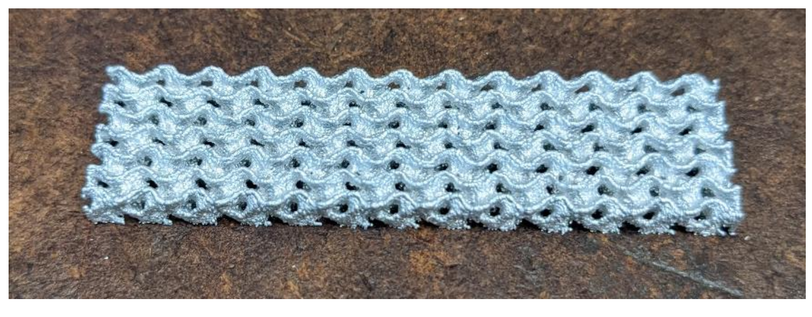
3D Printed Samples





Printed samples (1"x1"x0.75") at the resolution limit (0.8 mm) of ElemX commercial configuration





Higher Resolution (0.4 mm) sample design and print (3"x1"x0.25")

- Troubleshoot ElemX system and slicer, determine resolution limits and sample to sample variation
- Design iterations with low density
- Improve design with density gradients
- Modify nozzle to improve resolution and reduce minimum feature size down to 0.4 mm.

- These were successfully implemented and can be further improved following the approach in this work for air-breathing propulsion applications.

Researchers: Dr. Emre Gunduz (PI)
Graduate School of Engineering and Applied Sciences (GSEAS)

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