# Development of Laser-aided Additive Manufacturing Processes (LAMP)

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## Objective

As the demand for more technologically advanced systems increases, issues begin to arise concerning the production and assembly of these systems. Traditional methods of machining and subtractive manufacturing have been used for years, but they have many stubborn downsides, like speed and complexity limitations. The solution to these issues being addressed by LAMP labs is the use of Additive Manufacturing to embed complex features directly into fewer components, rather than using traditionally manufactured parts, which would require more parts.

## Methods

LAMP labs focuses on both the development of various methods of Laser-aided Additive Manufacturing Processes, and the materials-testing of material deposits made on these machines. These manufacturing processes and testing methods are outlined below:

- Blown Powder Fusion (Manufacturing)
  - Powder feeder blows powders of various metal alloys.
  - Material is fused together with laser.
- Wire-fed AM System (Manufacturing)
  - Metal alloy wire is preheated by welder.
  - Preheated wire is guided by Delta-XYZ framework.
  - Material is melted by laser to fuse to deposit.
  - Similar to traditional FDM AM methods.
- Mini-Tensile System (Material Testing)
  - LAMP deposits are cut into MT-2 specimens by Electrical Discharge Machining (Wire-EDM)
  - MT-2 Specimens are stretched and analyzed with load-cells and a Linear Variable Differential Transformer Sensor (LVDT).

## Results

Due to unforeseeable issues with sourcing and repairing components, not much progress was made in the development of the wire-fed AM system, which was the project Daniel and Jack were primarily working on. These issues are outlined below:

- Preheating welder malfunction
- Coaxial laser optic malfunction
  - Coaxial laser optic splits laser beam into three, lower power beams which converge at the melt-pool.
  - Coaxial laser optic not supplying sufficient power to melt-pool. Loss of power transfer between laser output and input means unwanted, dangerous heat is absorbed in places that cannot tolerate that heat.
  - This is visible by shining a flashlight through the optic and analyzing visually. Darkness in the upper prism indicates inadequate transfer of light. This is shown in figure (1).

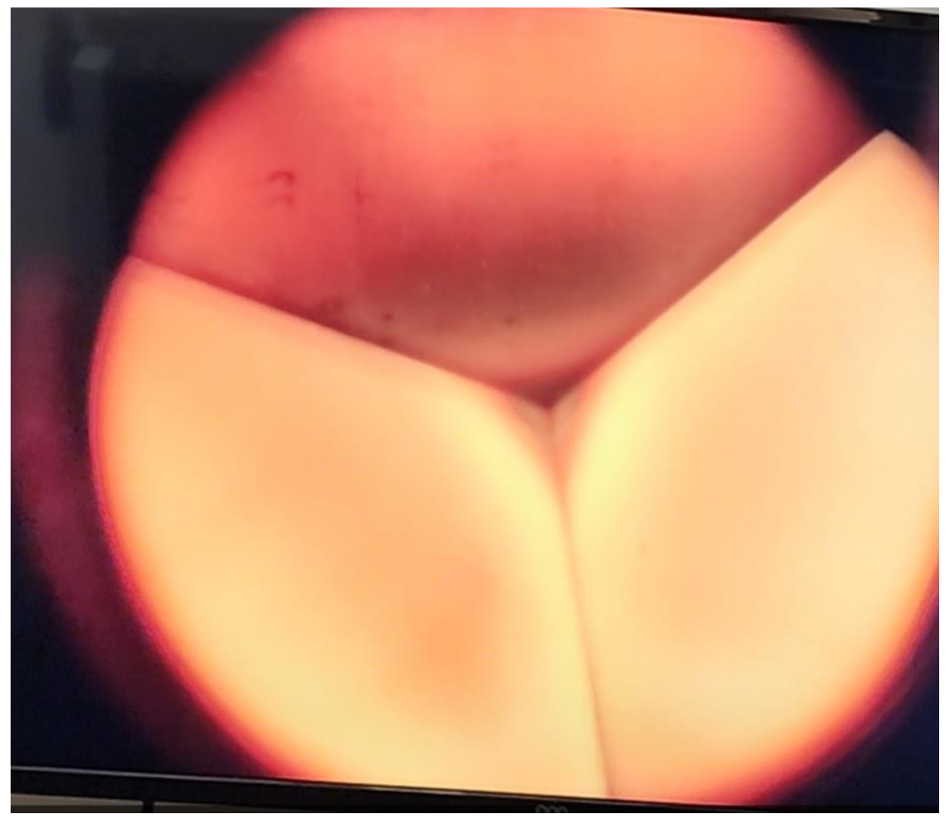

Figure (1)

The primary focus of the students working on the wire-fed system since August 2022 was the implementation of a welding camera to more clearly monitor the system as it deposits material. Figures (2) and (3) show:

- (2) a CAD drawing of the Cavitar Welding Camera in the FDM-printed two-piece mount.
  - Printed mount fits to ThorLabs 30mm optical cage components.
  - ThorLabs components are mounted at an adjustable angle to extrusion-assembly.
- (3) a sample image produced by the Cavitar Welding Camera during a deposit
  - Cavitar camera is integrated into liquid-cooling system to maintain acceptable temperature range.
  - Welding camera can filter certain wavelengths of light to produce such a clear image.

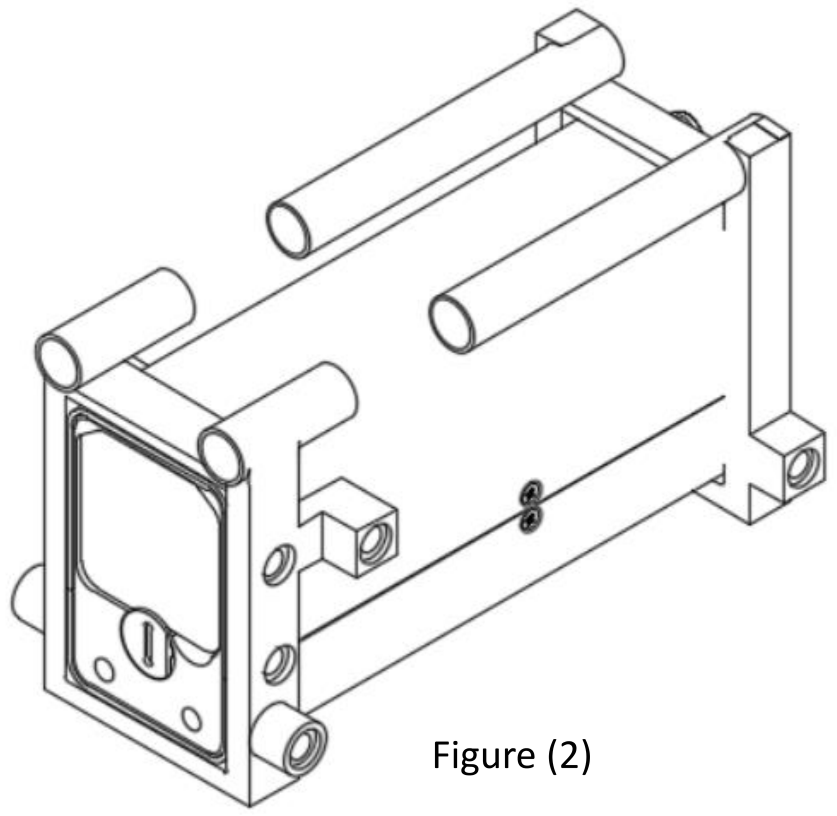

Figure (2)

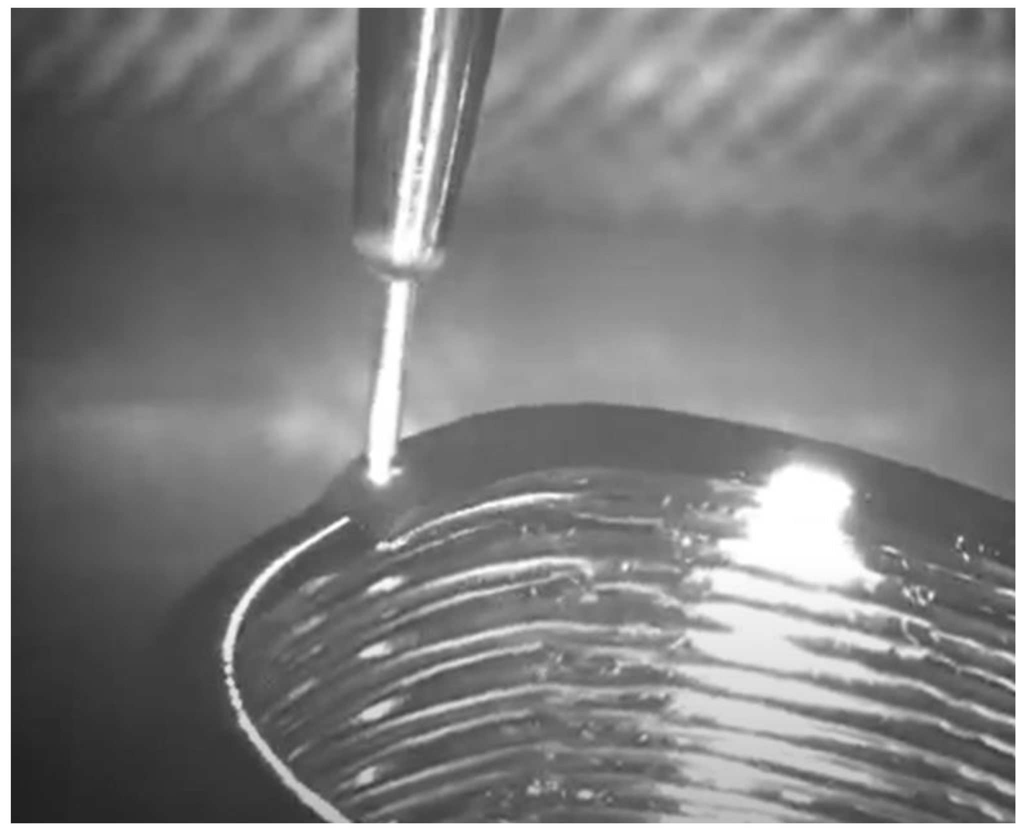

Figure (3)

## Summary

- Cavitar Welding Camera mount has been printed and fitted to camera. The system is nearly fully functional.
- Coaxial laser optic has been confirmed faulty by the manufacturer, Fraunhofer, and has been sent to Germany, where it will be tested and ultimately brought back to working order. LAMP labs expects this component to return to the lab sometime in the next few months.
- Miller welder has been fully repaired. A significant amount of time was required to determine that the cause of the malfunction was corrupted firmware. After replacing the main-board and performing a firmware update, the machine returned to working order.
- Mini-tensile tests indicate that deposits produced by Blown Powder Fusion and the wire-fed system are feasible solutions to the ever-increasing demand for more complex components. LAMP labs continues to research these methods of AM to innovate manufacturing technologies in the Mechanical and Aerospace Engineering field.

## References

Y. Chen et al., "TiNi-Based Bi-Metallic Shape-Memory Alloy by Laser-Directed Energy Deposition," Materials, vol. 15, no. 11, article no. 3945, MDPI, Jun 2022.