

# Metal Additive Manufacturing

The **Metal Additive Manufacturing (MAM) Laboratory** at University of Memphis is led by Professor of Mechanical Engineering, Ebrahim Asadi. MAM studies phase transformations and microstructural evolutions using computational models synchronized with experimental measurements to predict behavior of the manufactured material and to accelerate the development of novel materials and manufacturing processes. Our ultimate goal is to develop a framework for design of materials and advanced manufacturing processes for specific biomedical devices/implants and for structures in high temperature environments.

## -Research Themes-

**Enabling Design for MAM by Revealing Process-Property-Structure Relationships** - MAM's point-wise and layer-wise material joining process results in a structure-specific (location/size dependent) property (mechanical/material) that is also a function of MAM process (laser power, speed, spacing, scanning pattern, etc.). This work is supported by Medtronic Spine and FedEx Corporation.

**Designing New Materials for MAM toward Patient-Specific Biodegradable Devices** - Next generation devices for bone disease treatments must be manufactured to match the anatomy of a specific patient, integrate proper scaffold structure into the device to allow guided bone regeneration, possess bone-like mechanical properties to avoid abnormal bone density developments, and biodegrade to eliminate risk of body rejection and secondary revision surgeries. Tapping the largely unexplored potential of magnesium, this research employs novel additive manufacturing technology that, when combined with patient-specific CT-scans will allow fabrication of patient-specific magnesium devices and offer a platform for other relevant applications such as fabrication of biodegradable vascular stents.

**Understanding Metal Processing during MAM through Advanced Predictive Computational Modeling Techniques** - Rapid solidification and subsequent nano/micro-structural evolutions (NME) are the key material processes occurring cyclically in MAM. As the performance of materials has a direct relations to their nano/micro-structures, understanding and predicting rapid NME of melt pool will open an opportunity for quality control and property optimization for additively manufactured metallic parts. In this research theme, we integrate molecular dynamics, phase-field crystals, and phase-field model to establish a quantitative multi-scale modeling framework and computational tool for non-equilibrium thermodynamics. This theme is supported by NASA and the FedEx Institute of Technology.

## -Infrastructure & Capabilities-

**Manufacturing:** (1) Small platform powder bed fusion MAM machine for new material development, (2) Medium platform powder bed fusion MAM machine capable of printing Titanium alloys, Aluminum alloys, Inconel, and variety of steels; the machine is currently dedicated to Titanium alloys, (3) Several plastic and composite material 3D printers for prototyping and education.

**Post Processing:** (1) Wire EDM for precise cutting with minimal cutting effects, (2) Stress relieving furnace, (3) Vacuum annealing and sintering furnace.

**Quality Assurance:** (1) Sonic sieving for powder size characterization, (2) Powder divider and flowmeter, (3) Combustion infrared detection for ppm level analyzing of Carbon and Sulfur content in metals, (4) Inert gas fusion for ppm level analysis of Oxygen, Nitrogen and Hydrogen content in metals.

**Materials & Mechanics Characterization:** (1) 20X-5000X optical digital microscope for quantitative 2D and 3D metallography, (2) Sub-size mechanical testing instrument with extensometer, (3) Automatic Vickers, Knoop, and Brinell hardness testing instrument with overview camera, and (4) FESEM, EDX, XPS, AFM, and XRD through UM shared facility.

**Computations:** UM operates a shared high performance computing center with several thousand of CPUs and tens of GPUs.

For more information please visit:

<https://umdrive.memphis.edu/easadi/public/Webpage/M2CRL.html>

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