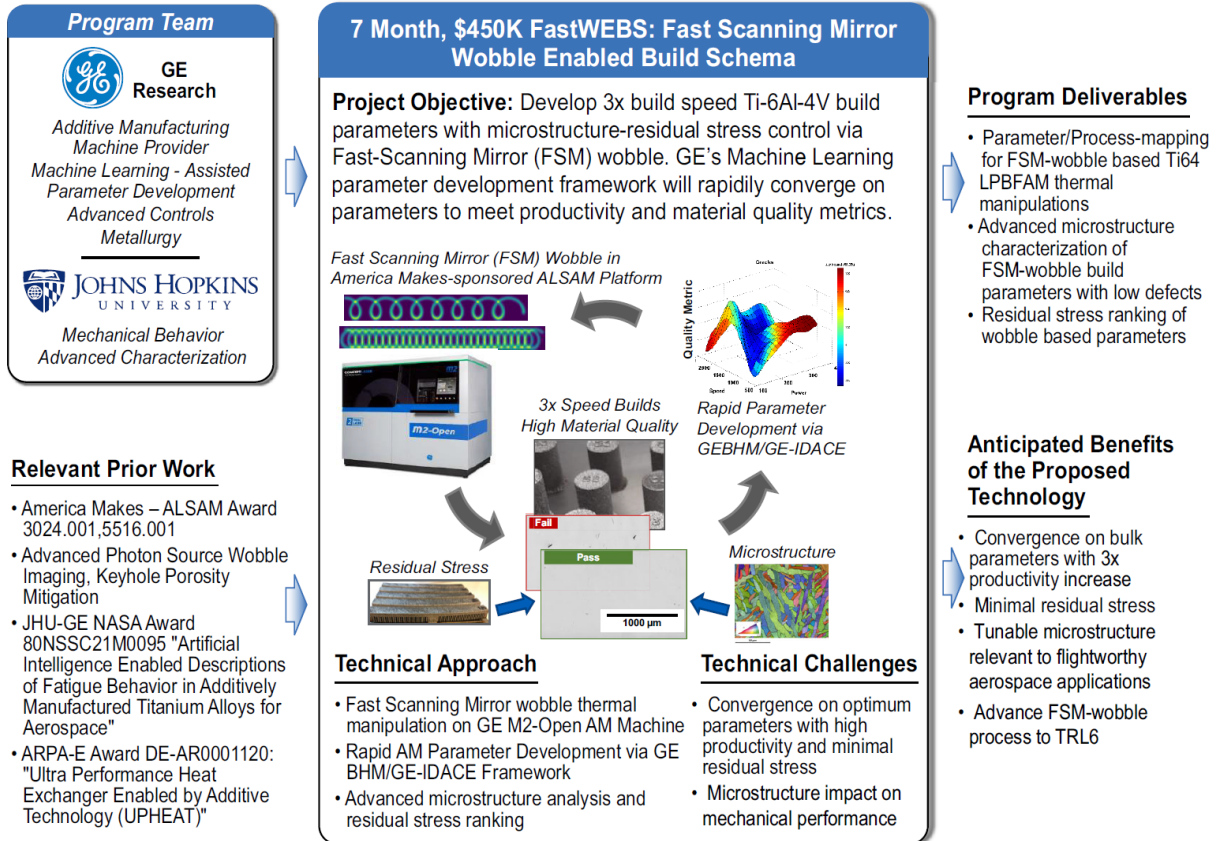


Fast-Scanning-Mirror Wobble-Enabled Build Schema (Fast-WEBS)



Relevant Prior Work

- America Makes – ALSAM Award 3024.001.5516.001
- Advanced Photon Source Wobble Imaging, Keyhole Porosity Mitigation
- JHU-GE NASA Award 80NSSC21M0095 "Artificial Intelligence Enabled Descriptions of Fatigue Behavior in Additively Manufactured Titanium Alloys for Aerospace"
- ARPA-E Award DE-AR0001120: "Ultra Performance Heat Exchanger Enabled by Additive Technology (UPHEAT)"

Fast-WEBS project overview

PROBLEM

Increased build speed results in higher part production throughput, one of the main barriers to entry for the additive manufacturing (AM) industry. While speed is important, maintaining high material quality is critical to meeting the performance requirements for the part and is challenging when printing at higher speeds. Among alloys explored for laser powder bed fusion additive manufacturing (LPBFAM) processability, Ti64 is typically not considered "difficult to process." However, residual stress build-up is a known factor contributing to part distortion and cracking across many alloy systems.

As the upper limit on power availability in lasers increases over time, the AM industry has plateaued in the utilization of that laser power. Delivery of high power to the AM powder bed is challenging while maintaining reasonable material quality (e.g. keyhole porosity). LPBFAM machines only use a fraction of the available phase space of other AM techniques due to the difficulties of delivering power into the powder bed. The Fast-Scanning Mirror (FSM) -based wobble is a solution to deliver this power to the powder bed with rapid build speeds. It allows fine resolution when needed and broad resolution for increased productivity that is selectable on the fly to deposit energy efficiently where needed.



AMERICA MAKES TECHNOLOGY DEVELOPMENT ROADMAP

This project aligns to:



ASTM PROCESS CATEGORY
Powder Bed Fusion

EQUIPMENT
GE Concept Laser Powder Bed Fusion M2-Open

MATERIAL
Ti-Al-4V

OBJECTIVE

The objective of this project is to demonstrate the ability to increase the bulk build rate of LPBFAM Ti64 by 3x, using high-frequency wobble-based thermal manipulation developed by GE Research (GE) under the recent ALSAM Program (projects 3024.001 and 5516.001).

TECHNICAL APPROACH

GE, together with Johns Hopkins University, will demonstrate 3x build speed productivity while maintaining high material quality in the Ti-6Al-4V (Ti64) alloy. High-frequency wobble-based thermal manipulation, via a fast-scanning mirror (FSM), will be used to manipulate the thermal energy distribution from a single beam to support high power and scan speeds.

Given the thermal manipulations of a wobble-based scan path, this project will demonstrate the potential for wobble to modify microstructure features known to affect mechanical performance (e.g. grain size, texture). Finally, the hypothesis to modify residual stress using wobble-based thermal manipulation will be tested. This is a key technical hurdle to enabling improved geometric and dimensional control, as well as LPBFAM of large, complex parts and difficult-to-process materials.

To reduce the cycle time for project execution, GE will leverage a previously demonstrated framework that utilizes probabilistic machine learning (ML) and intelligent sampling and optimization protocols to accelerate the parameter development process for LPBFAM. The framework consists of a Bayesian Hybrid Model (GEBHM) as the probabilistic ML technique, GE-IDACE as the intelligent sampling framework, with optimization along with high-throughput automated characterization. By combining GE's expertise in AM and advanced controls with Johns Hopkins' experience in microstructure/mechanical performance relationships, this program will demonstrate a disruptive improvement to achieve cost-effective, energy-efficient AM capabilities. This project will showcase LPBFAM build productivities that have never been realized while meeting key performance parameters required to demonstrate material quality and control.

PROJECT START DATE

December 2023

EXPECTED END DATE

June 2024

EXPECTED DELIVERABLES

- Parameter/process-mapping for FSM-wobble-based Ti64 LPBFAM thermal manipulations
- Advanced microstructure characterization of FSM-wobble build parameters with low defects
- Residual stress ranking of wobble-based parameters
- Final report

FUNDING

\$299,732 total project budget

(\$149,732 public funding/\$150,000 private funding)

PROJECT PARTICIPANTS

Project Principal:

GE Research

Other Project Participants:

NCDMM/America Makes
Johns Hopkins University

Public Participants:

U.S. Department of Defense