In-situ Data Analysis and Tool Development for Additive Manufacturing Metal Powder Systems

DE-EE00032038
SLAC, LLNL Ames
Q3FY16-Q4FY18

Michael F. Toney, SLAC National Accelerator Laboratory
Christopher J. Tassone, SLAC National Accelerator Laboratory

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
July 17-19, 2018

Overview Slide

Timeline

- FWP Award made in September 2017
- Projected End date September 2018
- Project 95% complete

Budget

	FY 16 Costs	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	_	2.364M	1.98M	$4.34M
Project Cost Share	_	-	-	-

Barriers

- Experimental observations are needed to vet existing models and identify new physical processes.
- Metrology tools are needed which can accelerate process development and characterize part quality

Partners

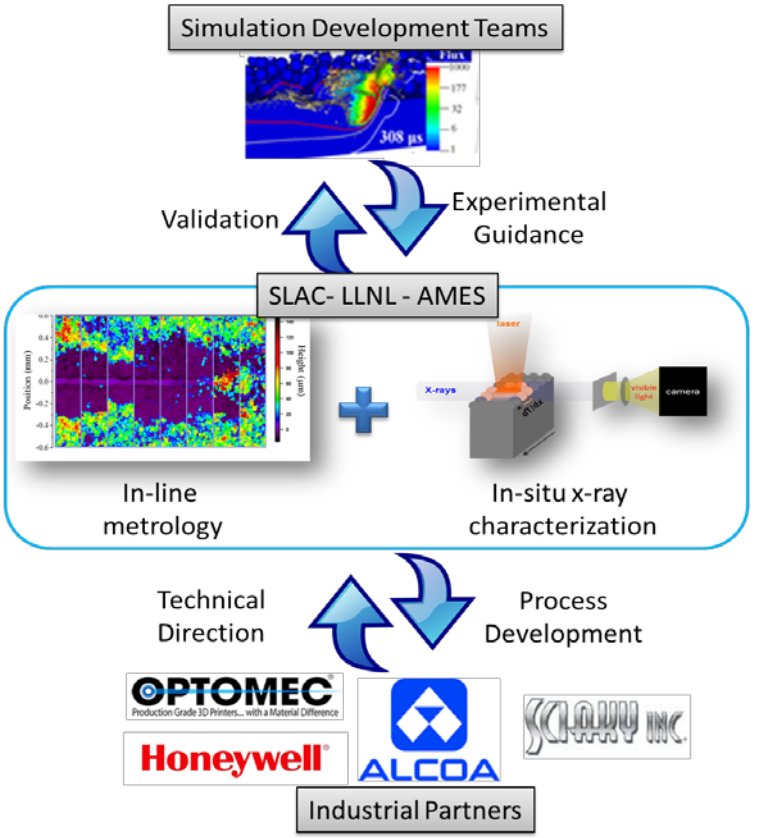
- Lawrence Livermore National Laboratory brings expertise in the development of additive processing, metrology tool design, and process characterization
- Ames National Laboratory brings expertise in the development of powder feed additive processes, synthesis and characterization of precursor powder, and part level characterization

Project Objective

Goal: Accelerate adoption of AM for metallic components by developing advanced AM testbed to enable rapid process development and qualification of the AM components

Problem Statement: Current models are inadequate for processing design and limit wide spread adoption of AM.

- Experimental observations are needed to vet existing models and identify new physical processes.
- Metrology tools are needed which can accelerate process development and characterize part quality

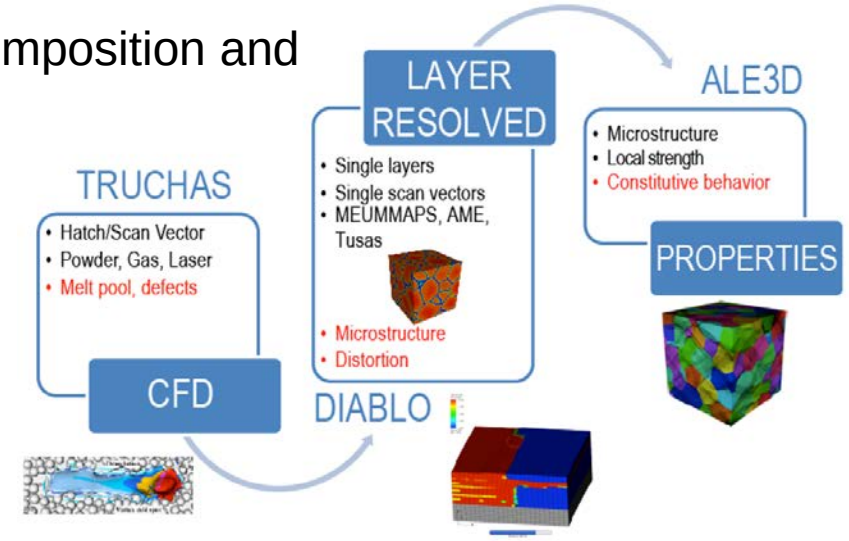


Challenges: Mutli-modal measurements at high spatial and temporal resolution.

- High energy X-Rays and in-line metrology integrated into process simulation tools with near-real time feedback.

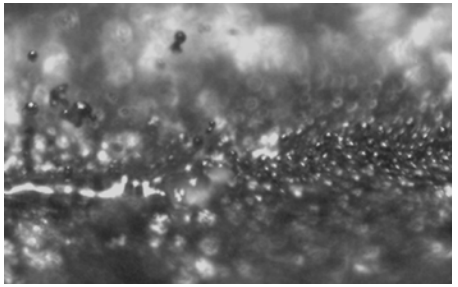
Technical Innovation

AM processing parameters and evolution of composition and microstructure are not well understood.

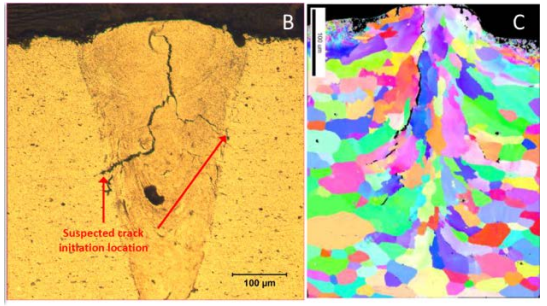


- Current models lack validation, poorly link processing parameters to build

- Current in-situ probes are surface sensitive and limit visualizing melt pool shape, porosity, and structural evolution, internal strain

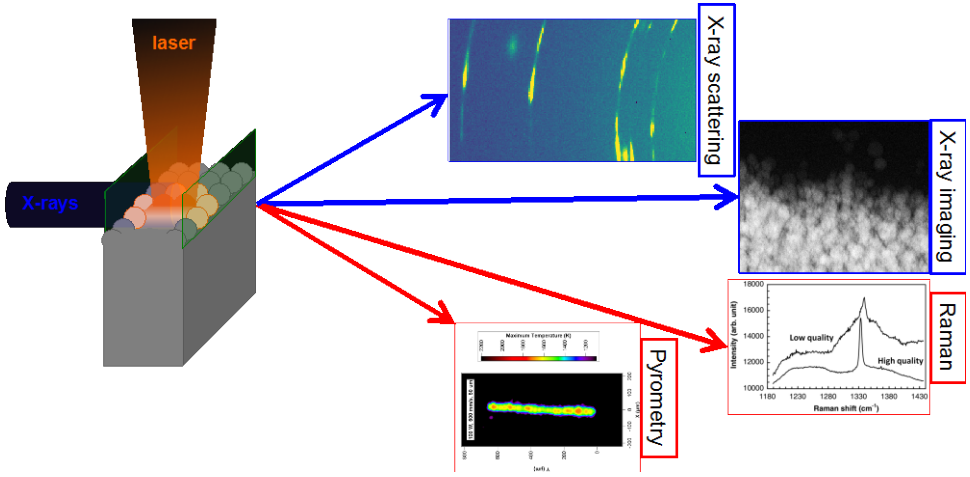


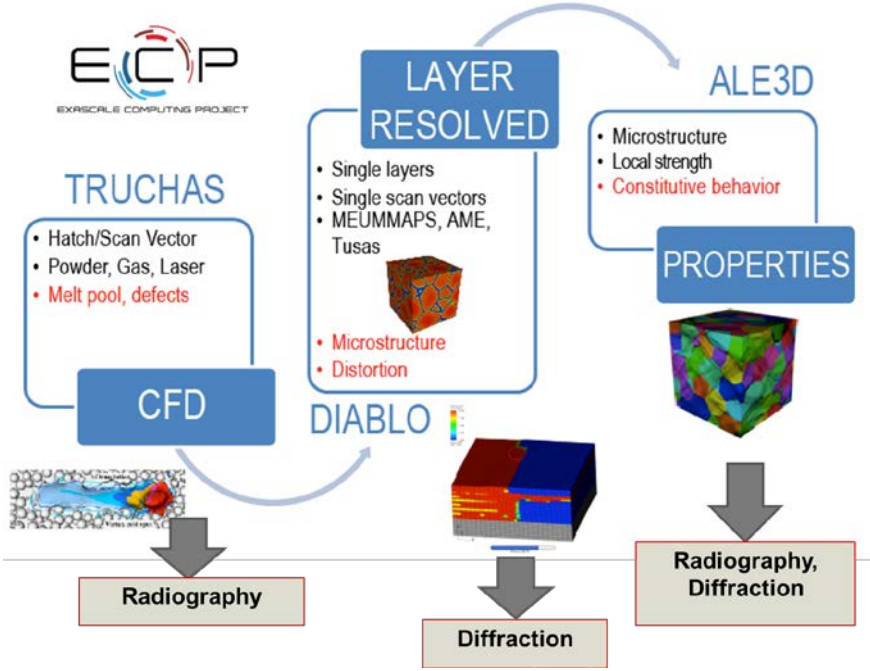
- Ex-situ cannot measure dynamics which lead to final microstructure



Technical Innovation

- In-situ X-ray characterization **coupled** to in-line metrology (e.g. ultra-fast imaging, pyrometer…) to create a testbed system for advancing AM processing.
  - Validate, inform and improve process modeling.
  - Accelerate process development.

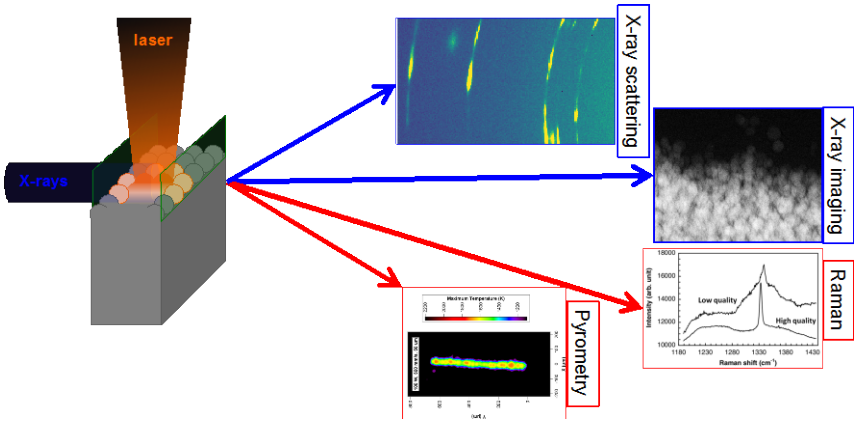


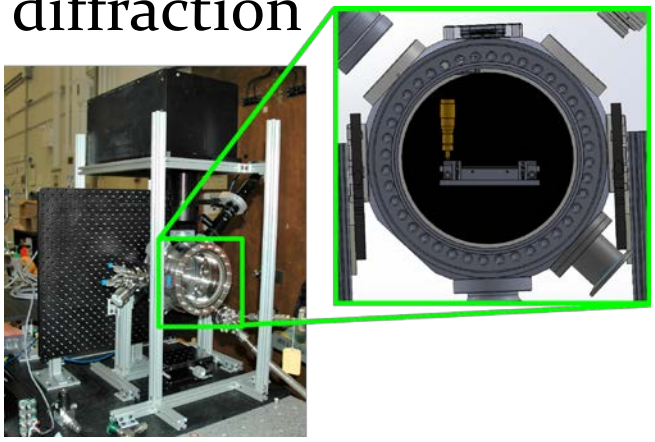


Actively engage AM community

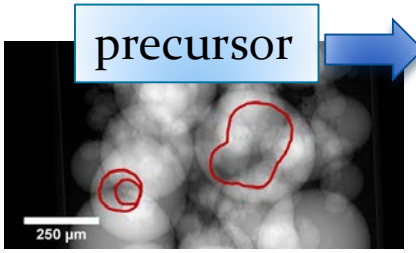
Technical Approach

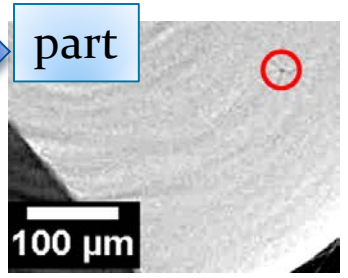
- Develop and deploy AM testbed system
  - Compatible with x-ray imaging and diffraction

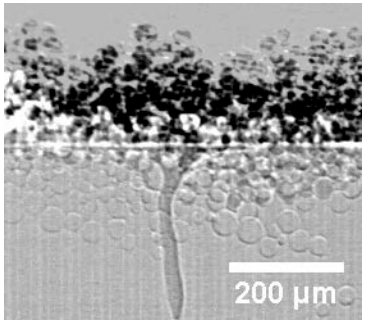


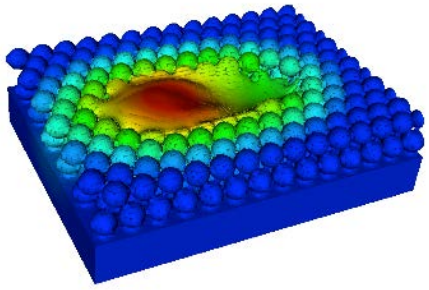


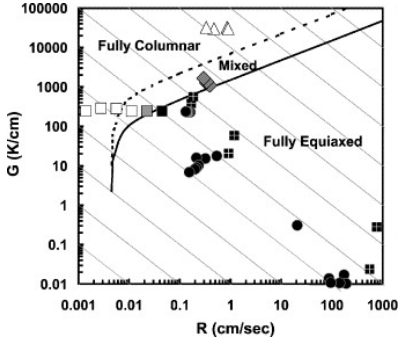
- Demonstrate value to end users
  - Relate precursor to build quality
  - Vet existing simulations





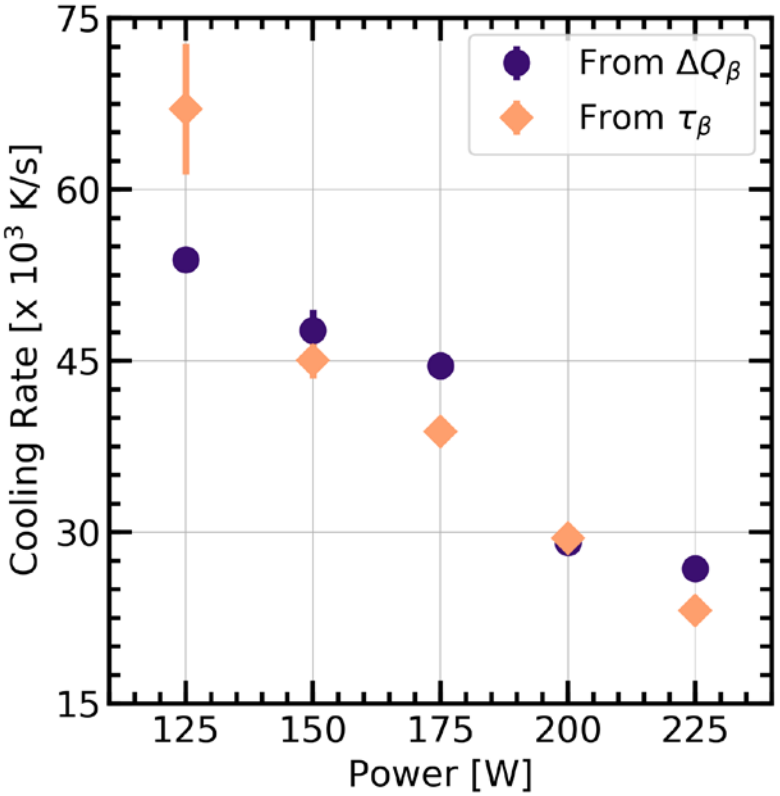


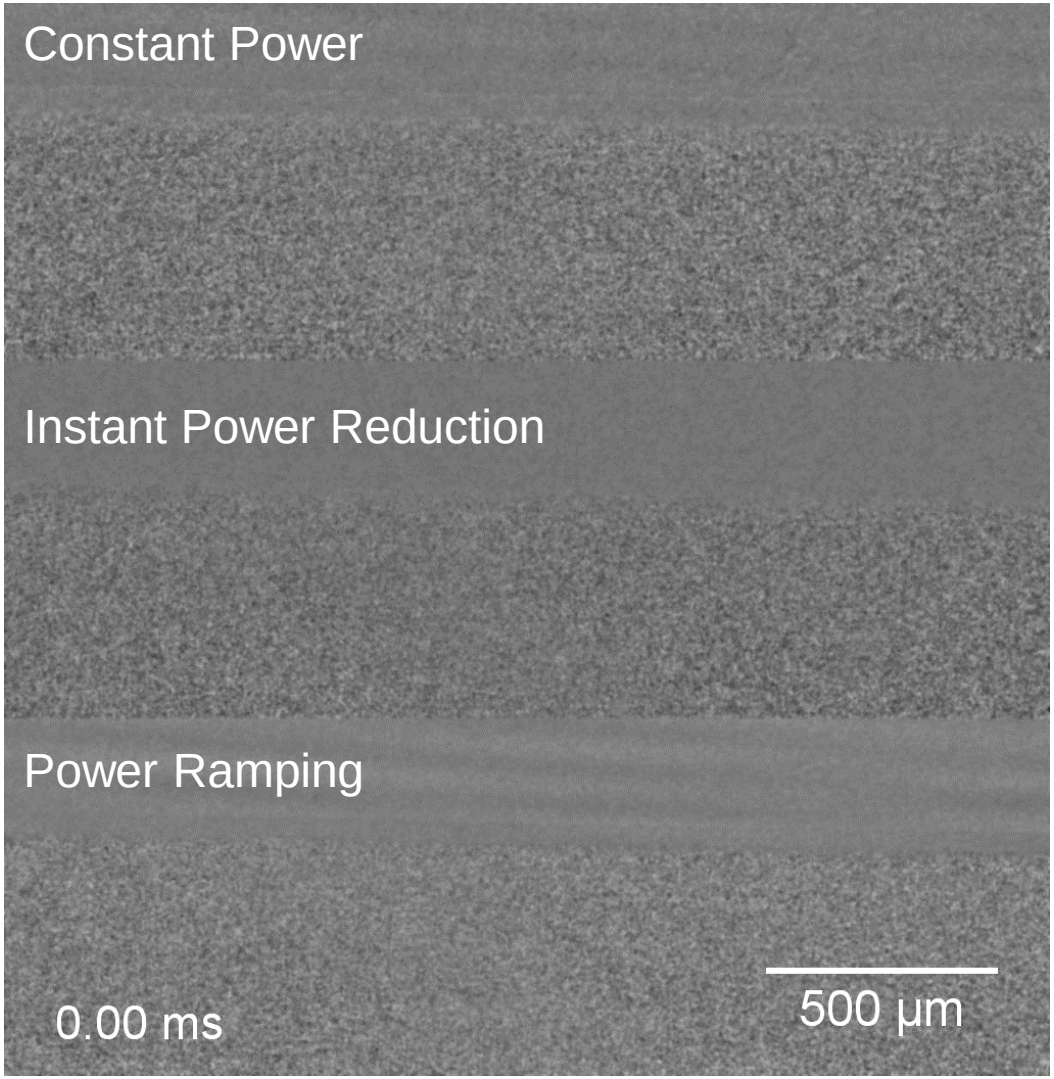




Results and Accomplishments

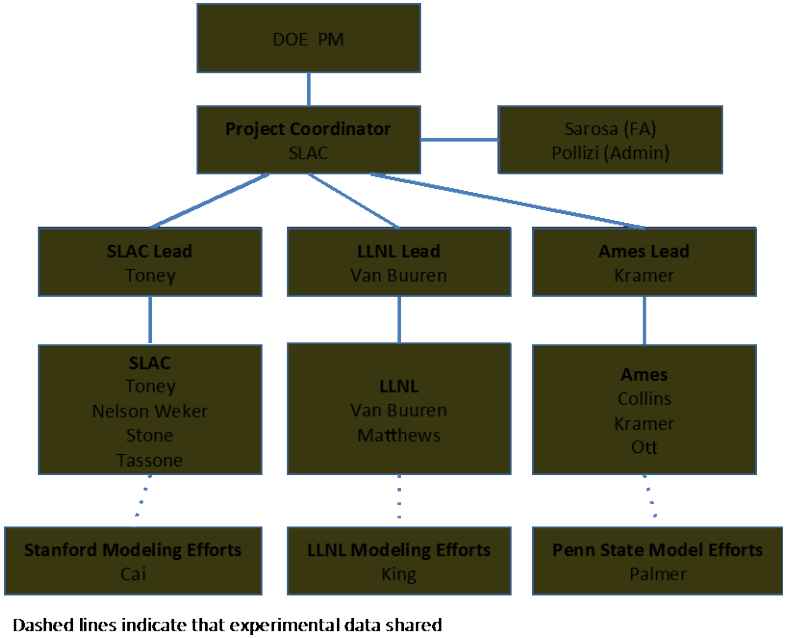
- Results
  - ✓ System commissioned
  - ✓ Relate Precursor to build quality
  - ✓ Microstructural evolution from in-situ diffraction
  - ✓ Vet simulation





Technical Approach

- **SLAC:** lead implementation of in-situ X-ray probes
  - implement X-ray imaging - kHz & 1µm
  - implement X-ray diffraction - kHz & 50µm
  - industrial outreach and for coordinating the executive council
- **LLNL:** lead design, construction, testing in-situ X-ray selective laser melting chamber
  - Package x-ray characterization data for comparison to simulation
  - Actively engage with industry and America Makes partners to ensure that test bed capabilities and experimental campaigns align well with industry needs

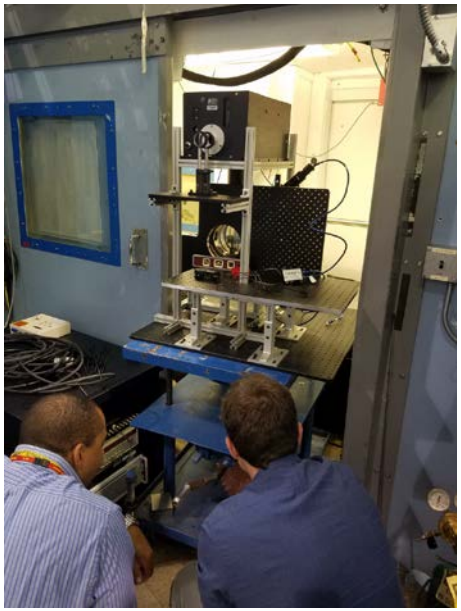


Dashed lines indicate that experimental data shared

- **Ames:** lead characterization of Ti-6Al-4V powder and design of directed energy powder feed system for in-situ x-ray studies
  - Lead planning and executing AM community workshop to prioritize the experiments that are perceived to be the greatest need by the AM community.
  - Actively engage with industry and America Makes partners to ensure that test bed capabilities and experimental campaigns align well with industry needs

Transition and Deployment

Goal: create a self-sustaining user facility for industrial partners to speed up AM process development



Targeted industrial partners include all stakeholders:

- Feedstock suppliers
- OEM Venders
- Industrial and government end users
- Modeling groups: Industry, Universities, National Laboratories

Industrial End Users	Material Suppliers	AM OEM Vendors	Software Developers
Honeywell	Alcoa	Sciaky	ITI
GE Aircraft Engineers	ATI	Optomec	UES
Boeing	Praxair	Government Users	ThermoCalc
Pratt & Whitney	Crystal Metal Powder	NASA	QuesTek
John Deere	Ametek	Air Force Research Lab	
Queen City Forging		Army Research Lab	
Quad City Manf. Lab		Oak Ridge National Laboratory	

Questions?