Engineering Laboratory

Additive Manufacturing at NIST

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The Science of Digital Manufacturing
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NIST
National Institute of Standards and Technology
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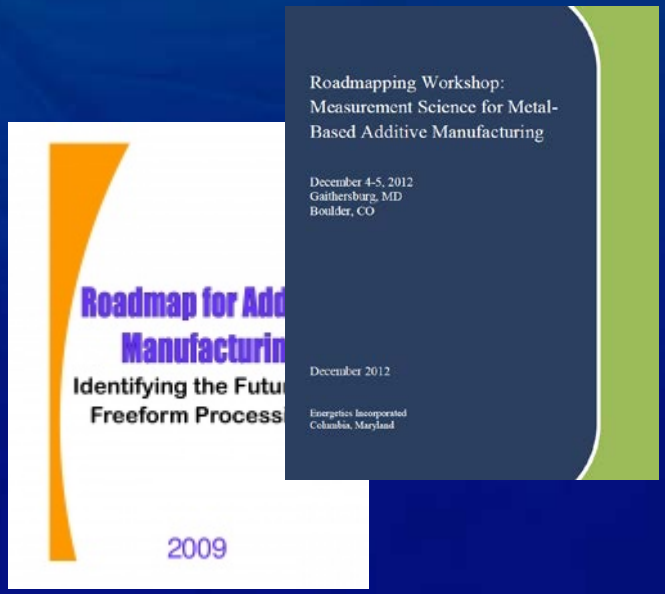
Measurement Science for Additive Manufacturing

- Additive Manufacturing is a major thrust in NIST's *Smart Manufacturing Processes and Equipment Program*
- Substantial NIST expertise in manufacturing domains is being applied to AM:
  - equipment and process metrology, process optimization and control, advanced sensor systems, materials characterization, data formats, standards development, design of experiments & statistical analysis, etc.
- Primary focus is **metal-based** AM processes (EOS M270 DMLS) but we also utilize 3D printers and modest polymer-based systems
- Improved measurements and standards will help overcome existing AM limitations and barriers

NIST Work Is Focused…

- On Existing Barriers and Limitations:
  - Materials Properties and Qualification
  - Process Understanding, Improvements, and Qualification
  - A Lack of Standards
  - Part Accuracy
  - Process Speed
  - Surface Finish
  - Limited Materials
  - Data Formats
- Using Input from:
  - AM Roadmapping efforts
  - Stakeholders and Partnerships
  - Standards Development Organizations



NIST Has Substantial Stakeholder Interactions and Partnerships

- Additive Manufacturing Consortium (AMC)
- Interagency Working Group on AM (OSTP, NASA, Army, Navy, Air Force, DOE, NIST)
- Federal agencies: LLNL, ORNL, AFRL, FBI, ARL, NRL
- Industry: Morris Technologies (OH), GE, ExOne, others
- Universities: CMU, Virginia Tech, Louisville, NCSU, UTEP
- Other: ASTM F42, ISO/TC 261, NAMII, JDMTP, Workshops, Conferences, Symposia, National Research Council

NIST Projects in Additive Manufacturing

Powder

Uncertainties in the Input Materials

Process

Uncertainties in Equipment and Process Performance

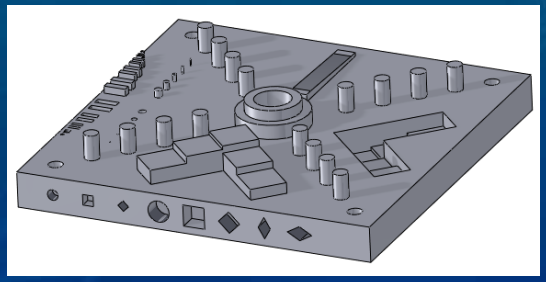
Part

Uncertainties in the Final Parts

1. Fundamental Measurement Science for Additive Processes
2. Materials Standards for Additive Manufacturing

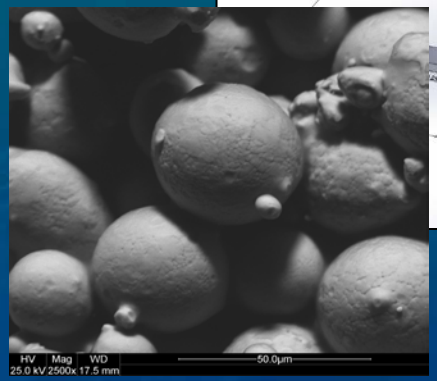
Project #1: Fundamental Measurement Science for Additive Processes

Develop first-ever standard test methods and validated models that allow industry to evaluate and improve the performance of additive manufacturing (AM) systems to make better parts more quickly and more economically.



- Physics-based models of metal additive processes to enable process control for improved product quality assurance
- Standard Test Artifact to determine process accuracy and capabilities – submitted to ASTM
- Real-time measurements of additive processes
  - High-speed thermal
  - High-speed vision
  - *In-situ* porosity sensor

Project #2: Materials Standards for Additive Manufacturing



Develop enhanced measurement techniques that support new, standardized methods for quantifying the material properties of both the powders used for additive manufacturing and the resulting manufactured parts.

- Foundational Work Already Exists:
  - Background Studies for state of the art in mechanical property testing and powder characterization (NISTIR 7847 and NISTIR 7873)
  - Assessed applicability of existing mechanical property and powder standards for AM parts and powder (Published Shortly)
- Powder Characterization:
  - Size, size distribution, morphology, chemical composition, flow, thermal properties…
  - Study of effects of recycling on powder characteristics and variability in nominally identical powders
- Setting up powder characterization lab to:
  - Develop appropriate measurement techniques and standards
  - Compare those techniques to more advanced measurement methods (SEM, laser diffraction, energy-dispersive X-ray, X-ray computed tomography…)
- Properties of AM Parts:
  - Two round robins to develop test protocols and procedures for industry accepted design allowable property data are underway
  - Residual stress (ORNL and NIST Center for Neutron Research)

Summary

- Two NIST AM projects focus on AM material properties and AM metal processes
- Recent roadmapping workshops highlighted technical needs in metal AM
- NIST AM work contributes to AM standards, and to qualification and certification issues

Questions?