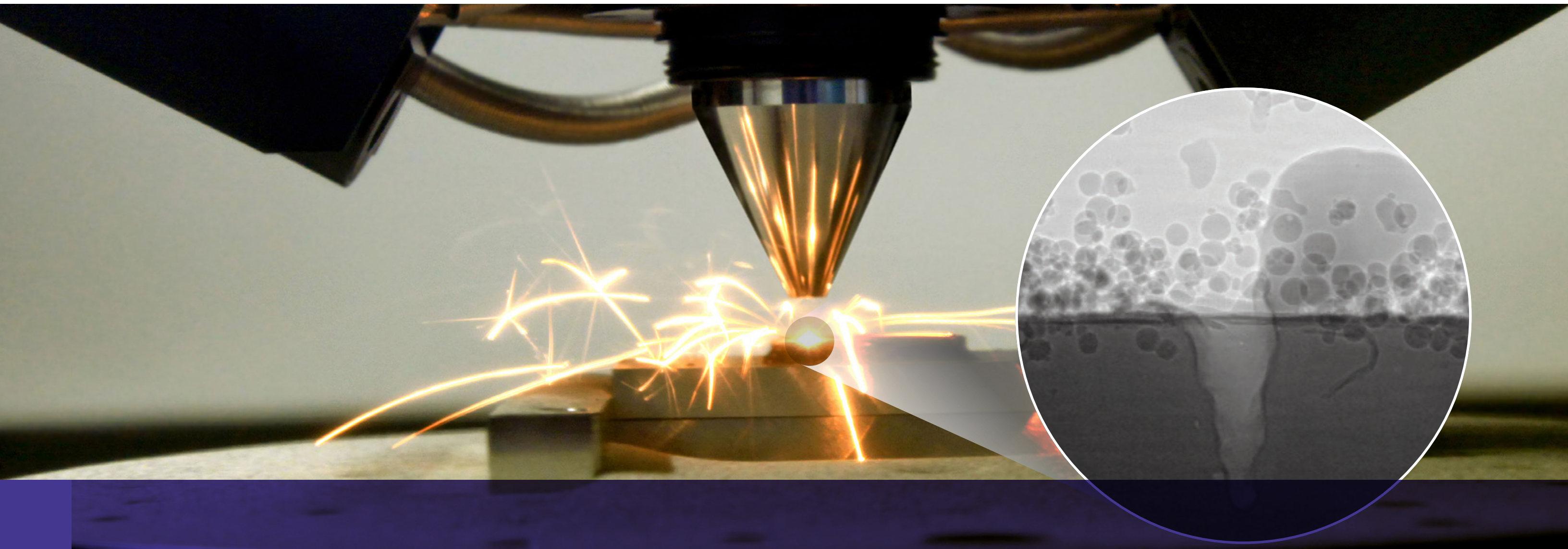
Argonne NATIONAL LABORATORY



IMPROVING PART RELIABILITY AND PROCESS EFFICIENCY

As a multidisciplinary science and engineering research center, Argonne provides an integrated approach to solving the materials challenges of metal additive manufacturing.

THE CHALLENGE

Currently, trial and error consumes much of the time expended in the metal AM design and production process. This is inefficient, expensive, and often results in parts that vary in quality. Because AM techniques are new and are comprised of highly dependent, related technologies, manufacturers would benefit from scientifically integrated, cross-disciplinary technology and access to advanced research facilities to deliver:

- More reliable material behavior prediction
- Reduced parameter variation
- Faster synthesis
- Less material excess and waste
- Defect-free, certifiable parts

ARGONNE DELIVERS SCIENTIFIC EXPERTISE AND RESEARCH CAPABILITY

Argonne National Laboratory is helping those who rely on metal additive manufacturing improve part quality/reliability and process efficiency. As a multidisciplinary science and engineering research center, Argonne is uniquely positioned to provide an integrated approach to solving the materials challenges of metal AM. The lab's capabilities include:

- Materials design and AM process modeling powered by the supercomputing capabilities of the Argonne Leadership Computing Facility
- Very bright and high-resolution X-ray imaging and scattering for materials analysis at the Advanced Photon Source
- Materials synthesis, characterization, and modeling at the nanoscale at the Argonne Center for Nanoscale Materials
- Materials synthesis and process scale-up at the Materials Engineering Research Facility

APPLICATIONS

- Nuclear energy
- Automotive
- Aerospace
- Defense
- Biomedical

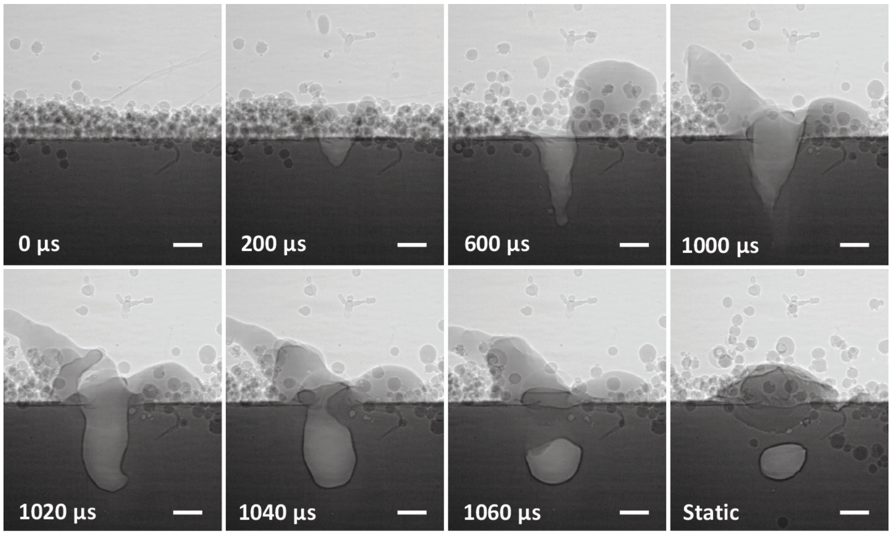
THE BENEFITS

By working with Argonne, industry partners can boost productivity and enhance their parts predictability and reliability through a deeper understanding of materials' microstructure formation and growth.

U.S. DEPARTMENT OF ENERGY

Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

December 2017



Argonne researchers have provided a first-of-its-kind *in-situ* observation and measurement of the metal additive manufacturing process. Shown here are dynamic X-ray images of a laser powder bed fusion processes of Ti-6Al-4V, with time sequence and length scale indicated. The laser is turned on at t = 0, and continues to heat the sample until t = 1000 μs. The raw data were taken with a frame rate of 50 kHz. The exposure time for each individual image is 350 ns. All the scale bars are 100 μm. "Evaluating the Effect of Processing Parameters on Porosity in Electron Beam Melted Ti-6Al-4V via Synchrotron X-ray Microtomography," The Minerals, Metals & Materials Society, 68:765-771 (2016). DOI: 10.1007/s11837-015-1802-0

The Advanced Photon Source at Argonne provides ultra-bright, high-energy storage ring-generated X-ray beams for research in almost all scientific disciplines.

CASE STUDIES

In situ observation of laser sintering process

Researchers at Argonne's Advanced Photon Source facility have developed a first-of-its-kind experimental platform for high-resolution, high frame rate X-ray observation of the metal powder laser sintering process. This capability includes both radiography imaging and scattering measurements that can enable unique insights of the material response to a range of AM processing parameters. This can include studies on the evolution of porosity and other microstructural defects, powder disruption, and melt pool dynamics for a range of laser parameters and material parameters of the powder feed stock. This *in situ* X-ray technique has already enabled researchers to gain new scientific understanding of the laser sintering process, which can lead to significant improvements to the AM process control and part quality.

Post-build characterization and analysis

Argonne scientists use a suite of unique, incisive capabilities to study unresolved questions in AM processing of different alloys. They use brilliant, high-energy X-rays to non-destructively probe up to centimeter-thick samples, using a combination of diffraction and imaging techniques. This yields information on strains and texture in every crystalline phase present, along with morphological features such as voids and cracks. These measurements can be conducted under simulated service conditions, including high temperature and applied stress, to capture material evolution. Argonne has worked with many users, including multiple aerospace companies, to characterize residual stresses in post AM-built parts.

Characterizing Fatigue Crack Growth in LENS Fabricated Titanium Printed Parts

Researchers from General Dynamics, the Air Force Research Laboratory, Worcester Polytechnic Institute, Nutonian Inc., Babcock Power and the Advanced Photon Source (APS) used high-energy absorption contrast microtomography at the 1-ID X-ray beamline at the U.S. Department of Energy's APS at Argonne National Laboratory to study fatigue cracks *in situ*.

3D microtomography was found to provide higher-resolution data of crack formation over time and with more accuracy of growth rates at earlier stages of crack growth than traditional ex-situ striation measurements.

CONTACT

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www.anl.gov/technology/capabilities/metal-additive-manufacturing