IMPACTS SUBMISSION

For division/directorate use

Please use the following template to present items that would make persuasive Impacts. Information must be understandable by a lay person.

SUBJECT: Seeing from the inside out: Using neutron imaging in order to create strong, precise 3D printed metal parts for the growing U.S. advanced manufacturing industry.

CATEGORY- Chose U.S./global economy, national security or scientific knowledge:
Scientific knowledge

NSF AWARD(S) - Provide award number hyperlink:
https://nsf.gov/awardsearch/showAward?AWD_ID=1541079

OTHER SUPPORTING INFORMATION:

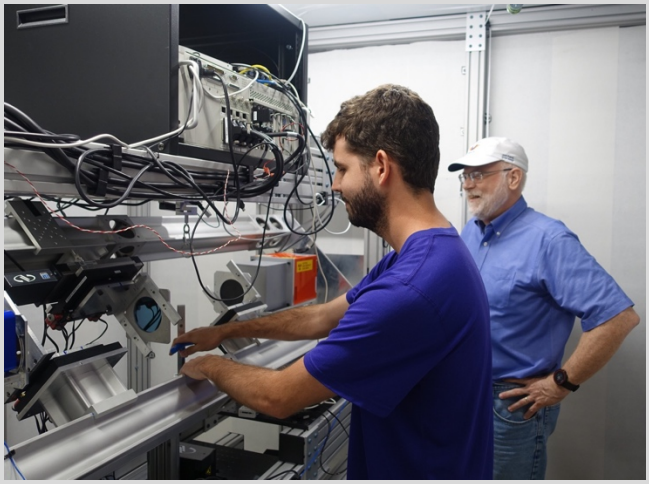
BRIEF SUMMARY OF OUTCOMES - (Why is this award compelling for use as an Impact?):
Whether manufacturing metal parts for space stations or airplanes, you need strong, precision parts that last a long time. The manufacturing industry in the U.S. is transitioning to new technologies that can rapidly 3D print strong, extremely complicated parts with less cost and waste. In particular, a technology called Selective Laser Melting (SLM), is being developed in Louisiana by a team of researchers in the Consortium for Innovation in Manufacturing and Materials (CIMM). SLM uses high-powered lasers to melt metal alloy powders layer by layer to create complicated 3D parts.

This new technology is under rapid development and still presents many challenges and opportunities. Due to the complexity of the highly dynamic SLM process, the parts can contain defects, which could lead to poor mechanical strength and a shortened service life. Researchers in Louisiana are studying the science of the phenomena at work at the molecular level to gain insights into the defects that cause failure when a specimen is subjected to stress.

To understand the fundamental science at work, a CIMM engineering research team prepared SLM printed stainless steel parts and then conducted controlled tension and fatigue tests on the parts. Then the CIMM imaging team, led by Dr. Les Butler of Louisiana State University, applied advanced neutron imaging techniques to study the effects on the molecules inside the microstructures of these test parts.

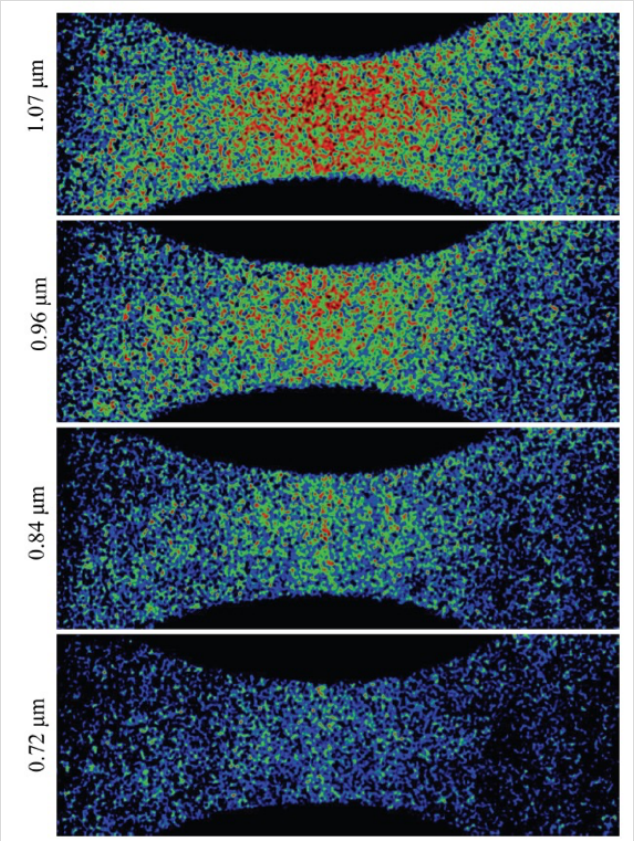
To analyze detailed microstructures within the samples, Dr. Butler's group first used extremely high-powered and high contrast x-ray technology at LSU's Center for Advanced Microstructures and Devices in Baton Rouge, Louisiana, called grating-based X-ray interferometry. They then tested the parts using a similar method that uses neutrons, called neutron interferometry, at the NIST Neutron Interferometry and Optics Facility in Maryland and the HZB research center in Berlin.

The CIMM team successfully demonstrated that neutron imaging could be used to identify the status and failing pathway of SLM 3D printed parts before the parts were pushed to the actual point of failure. The major advantages of neutron imaging are the excellent penetration capability and 3D mapping resolution. This is vital knowledge for understanding the physics at work inside these metal structures on the molecular level.



Graduate student Adam J. Brooks (front) and Dr. Les Butler (back) work on grating-based X-ray interferometer at the LSU Center for Advanced Microstructures and Devices in Baton Rouge, Louisiana. *Credit: Dr.Shengmin Guo, Louisiana State University, sguo2@lsu.edu*

Graduate student Adam J. Brooks (right) and Dr. Nikolay Kardjilov (left) of HZB Berlin neutron facility prepare samples for neutron imaging. *Credit: Dr. Les Butler, Louisiana State University, lbutler@lsu.edu*



Neutron interferometry (dark-field) imaging of a fatigued stainless steel sample showing the crack formation at micron scale. Images acquired with Dr. Dan Hussey using the NIST neutron imaging facility. *Credit: Dr. Les Butler, Louisiana State University, lbutler@lsu.edu*

THREE REASONS this award outcome impacts U.S./global economy, national security or scientific knowledge:
The team successfully conducted detailed 3D imaging of SLM parts using neutron interferometry. This tool will be valuable to Louisiana researchers as they develop an understanding the molecular physics behind the differing strengths and weaknesses of these metal structures.

This research supported new theories and computational models for understanding of process-microstructure-property-performance relationship for SLM parts.

Supports a thorough understanding vital to the growing U.S. advanced manufacturing industry.

NSF Directorate(s)/Division(s): OIA

State(s): Louisiana