Topic: N15A-T008

Intelligent Optical Systems, Inc.

In Situ Inspection of Additive Manufactured Metallic Parts Using Laser Ultrasonics

Intelligent Optical Systems (IOS) has developed a laser ultrasonic (LUT) inspection system for additively manufactured (AM) parts. It will detect defects inside of metal AM parts during fabrication. IOS is small business that conducts research on topics ranging from laser ultrasonic testing to chemical sensing. There is a growing pull from multiple Defense agencies for AM parts and an in-line inspection solution is needed to qualify the parts. Multiple technologies exist for in-line AM part inspection, but all are indirect, as they rely on predictive algorithms. There is no other technology currently available that can provide real-time direct inspection of AM parts on a layer-by-layer basis. In its work to date, IOS has demonstrated an LUT defect detection sensitivity of 500 μm in AM parts. IOS is seeking a business partner that can provide funding to help grow/further develop our technology.

Technology Category Alignment:

Propulsion and Extreme Environments
Readiness
Structures and Protection

Contact:
Marvin Klein
mklein@intospys.com
(424) 263-6361
http://www.intopsys.com/
SYSCOM: NAVAIR
Contract: N68335-17-C-0148

Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-17-C-0148

Department of the Navy SBIR/STTR Transition Program

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NAVAIR 2017-716

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WHO

SYSCOM: NAVAIR

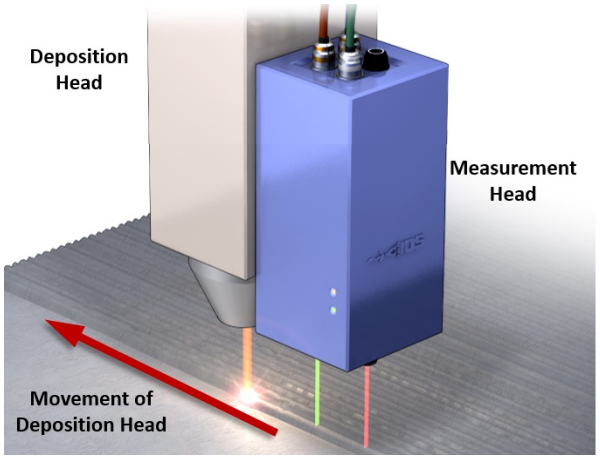
Sponsoring Program: AIR Vehicle Engineering (AIR-4.3)

Transition Target: None identified

TPOC:
(301)342-8020

Other transition opportunities: H-53K (PMA-261), F-35 (PMA-JSF), H-1 (PMA-276) and V-22 (PMA-275)

Notes: This image shows a rendering of IOS's laser ultrasonic inspection system operating inline with an additive manufacturing machine. The measurement head follows the path of the deposition head, inspecting the recently solidified material.



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WHAT

Operational Need and Improvement: Additive manufacturing (AM) is a very promising technique for rapid, low-cost production of aircraft parts. AM is especially appealing for complex parts that would be costly or impossible to fabricate by machining or casting. At the current time there are no reliable, cost-effective techniques to qualify the finished parts. Several government studies have noted this gap and urged increased efforts to develop improved techniques for part qualification.

Specifications Required: The inspection system must be able to detect common process related defects, such as increased porosity and lack of fusion. Therefore, the system must provide live feedback on the properties of the deposited material so that any deviation from ideal build characteristics can be addressed before another layer is deposited. The inspection system must be suitable for a production environment (high temperatures and dust/smoke). The system must be capable of inspecting as-built parts with rough surfaces.

Technology Developed: Intelligent Optical Systems (IOS) has developed a laser ultrasonic (LU) inspection system for AM parts. It detects defects during fabrication. The system integrates an LU measurement head that follows the deposition path of a 3D printer. As the material is deposited, a pulsed laser beam is used to generate ultrasonic waves in the deposited material. A second laser beam is used to detect ultrasonic signals as the propagate through the builds. Defects in the build will create distinct signals that are automatically detected by feature recognition algorithms in IOS's software. In its work to date, IOS has demonstrated an LUT defect detection sensitivity of 500 µm in AM parts.

Warfighter Value: The use of AM will reduce weight and cost for aircraft engines and structures. The engine industry for military and commercial aircraft is adopting additive manufacturing for complicated parts that would be difficult or even impossible to produce by conventional techniques. Key high-value components such as injection nozzles are found multiple times in a turbine engine.

WHEN

Contract Number: N68335-17-C-0148 **Ending on:** November 22, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Detection of artificial defects on AM builds	N/A	Detect ultrasonic signals of artificial defects.	3	June 2016
Detection of process related defects on AM builds	Low	Detect ultrasonic signals from process related defects in AM builds.	3	August 2017
Develop, fabricate, and test factory-ready prototype measurement head	Med	Successfully test prototype measurement head on AM machine.	4	December 2017
Integration of LUT software with 3D printer software	Low	Integrate LUT software with AM machine deposition software.	5	June 2018
Complete prototype system	High	Demo of inspection system during despoition.	6	November 2018

HOW

Projected Business Model: Upon completion of Phase III, a turnkey in-line inspection system will be offered for sale to AM machine suppliers. The system will be compatible with direct energy deposition or selective laser melting AM machines. Optech Ventures, the sister commercialization company to IOS, will manufacture the system. Optech already manufactures, sells, and supports a commercially successful line of laser ultrasonic systems for research and factory applications. Our existing product engineering capability can be leveraged by adding the proposed real-time quality monitor to our existing product line.

Company Objectives: At the Forum for SBIR/STTR Transition, IOS will seek a business partner that can provide funding to help grow/further develop our technology. Integration into commercial AM machines is key for the successful transition of IOS's inspection technology. IOS plans to further develop its LUT-based inspection system for industrial use outside of the Department of Defense and primes. Businesses with experience in both the military acquisition environment and the commercial manufacturing industry would make ideal partners.

Potential Commercial Applications: The IOS inspection system has large commercial potential outside of the military. Additive manufacturing is already well established in the commercial aircraft industry, primarily for the manufacture of engine components. The Aviation Division of General Electric is now producing fuel nozzles by AM, saving significant weight and cost. CFM International, GE's joint venture with Snecma, will incorporate 3D-printed nozzles into its LEAP jet engine. Each engine will have 19 nozzles. The estimated production of these nozzles is 8,000 per year. At the current time GE alone has over 300 3D printing machines in use. Qualification of these parts is critical for the expansion of AM in the commercial aerospace industry.

Contact: Marvin Klein, Manager, Laser Ultrasonics Products Group
mklein@intospys.com (424) 263-6361