Department of the Navy SBIR/STTR Transition Program

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Topic # N18A-T005

Innovative Processing Techniques for Additive Manufacture of 7000 Series Aluminum Alloy Components

Product Innovation and Engineering, LLC

WHO

SYSCOM: NAVAIR

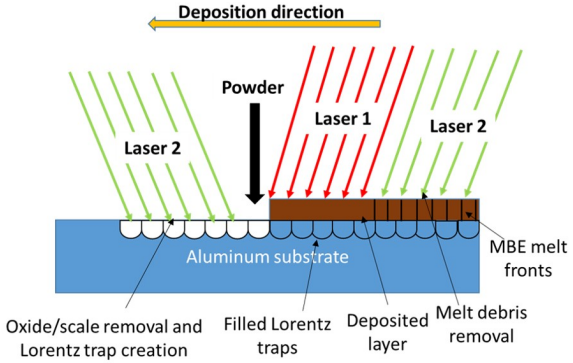
Sponsoring Program: PMA 201 Precision Strike Weapons

Transition Target: PMA 201 Precision Strike Weapons

TPOC:
(301) 342-0297

Other transition opportunities: 7XXX aluminum and other reflective metals are extensively used throughout the Navy and the military. They are also used in aerospace, automotive, and general industry. The rapid repair and return to service benefits of our technology are particularly important for the military.

Notes: Image contains the concept of the MBE-DED system, some of the results achieved like oxide layer removal and secondary meltpool formation; and deposition and parts made using different aluminum alloys like Questek, and Scalmalloy.



WHAT

Operational Need and Improvement: Naval aircraft components are commonly produced with 7000 series (e.g., 7075 and 7050) aluminum alloys due to their weight, strength, and fatigue properties. Current additive manufacturing (AM) methods fall short of successfully producing 7000 series aluminum alloys due to the reflective nature of the material. In addition, current AM methods, lacking ideal thermal control, produce inherently defective products with such issues as poor surface finish and high residual stresses.

Specifications Required: An innovative AM process is sought to successfully produce 7000 series aluminum alloy aircraft components. The novel process should accurately control the thermal profile locally and globally during component fabrication and reduce defects due to oxidation. Resulting components should demonstrate microstructural, mechanical and dynamic properties that are at least equivalent to, but preferably better than, traditionally produced parts and have minimal to no distortion per drawing tolerances. An innovative AM process has the potential to improve operational readiness, reduce total ownership cost, and enable on-demand parts manufacturing for naval aviation.

Technology Developed: A Multi-Beam Energy (MBE) Directed Energy Deposition (DED) system is used to process aluminum alloys. The system utilizes multiple laser energy sources to create a hybrid system that can both deposit and remove material. PINE is establishing that using a highly Gaussian beam, achieved through dynamic beam shaping (DBS), can quickly create and stabilize a melt pool even in highly reflective alloys, such as aluminum. Implementation of the system has led to the successful deposition of four aluminum alloys: Questek, Scalmalloy®, Gamma Alloy and ADDAlloy™ . A second laser, operating in a pulsed mode, is employed to remove surface oxides and melt pool debris. The pulsed laser also enables the creation of a secondary solidification front trailing the primary laser, thereby allowing the MBE system to alter the cooling rates of some parts of the deposit. The advantage of this system is that ablation minimizes contamination in the form of melt ejecta and oxides which could detrimentally affect the metallurgical bonding of the next layer.

Warfighter Value: Fast repair and replacement of 7XXX parts for military aircraft, vehicles, and equipment is needed to maintain battle readiness and an "unfair advantage" for our warfighters. Fast part repair and replacement in depots and other non-battleground facilities will provide cost savings.

WHEN

Contract Number: N68335-20-C-0029 **Ending on:** January 7, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
MBE/ DBS DED system completion	Med	Completed system with full capability of Multiple Beam, and Dynamic Beam shaping demonstration in a Directed Energy Environment	TRL 6	October 2021
Process paramter development for MBE?DBS	Med	Ideal paramter optimization for both primary and secondary lasers	TRL 6	November 2021
Aluminum alloy deposition and characterization	Med	Deposition and mechanical performance characterization of high performance aluminum alloys	TRL 6	December 2021
Computational model development	Med	Development of models to aid DED	TRL 5	December 2021

HOW

Projected Business Model: The intention is to manufacture and market fully operational systems in industries that work with reflective materials like aluminum alloys and others, like copper and titanium alloys. We also plan to offer repair and replacement parts from our St. James, MO factory to aid the refurbishment or replacement of legacy components. We are also keen to pursue partnership opportunities with companies that require small batch and custom components to manufacture and repair components in the above mentioned alloy systems to augment profits and increase business opportunities. Leveraging our existing partnerships with industrial contacts will be pursued for these service opportunities.

Company Objectives: Having earned a reputation as a technology leader in additive manufacturing (AM) and having successfully licensed AM software, we are now ready to market and sell AM and hybrid subtractive/additive machining systems we have developed. We have funded most of our work through SBIR and STTR grants, and will continue using this funding mechanism to expand our technology. Adding system sales and repair services will provide the revenue to expand our manufacturing facility and grow our business. Our 19 years of collaboration with Missouri University of Science and Technology has allowed us to employ outstanding scientists and engineers. Growing as a manufacturing company will allow us to provide career growth for our current employees and further contribute to local economic development.

Potential Commercial Applications: Aerospace and automotive applications are the immediate industrial applications we are pursuing. We have working relationships with Boeing, Toyota, and others where our initial commercial sales are expected. Besides aluminum alloys, PINE's system can be used for other reflective materials like copper and titanium that exhibit similar problems to aluminum. There is a vast potential market for AM components and repair in these alloys in the aviation and medical industries where we would also like to pursue system sales and servicing opportunities.

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