Development and Qualification of Laser Ablation for Naval Coatings

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(for the Integrated Project Teams)

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ONR Revolutionary Research . . . Relevant Results

NAVY MANTECH manufacturing technology program

CTC Concurrent Technologies Corporation

Outline

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Issue Description

Current processes are expensive, time-consuming and create large amounts of secondary hazardous waste and emissions

Chemical Stripping

Power Sanding

Hand Scraping

Needle Gunning

Introduction

- Laser ablation can replace time-consuming coating removal techniques and result in shorter process times and less waste.
- The best candidates for laser ablation are those which now use chemical stripping or hand sanding.
- The Navy Metalworking Center conducted two ManTech projects to develop and evaluate laser ablation for removing common Navy coating systems from structural steel and propulsion shafts.

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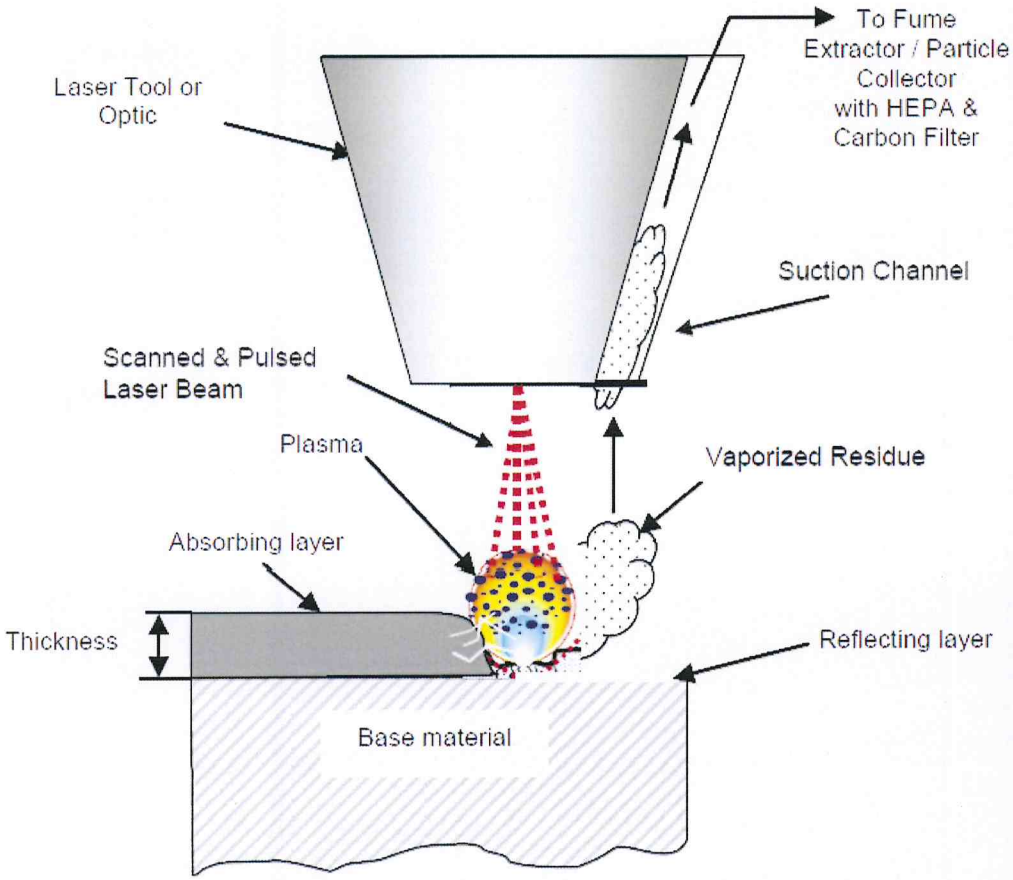
Project Objectives

- <u>Naval Application of Laser Ablation Paint Removal Technology</u> - Evaluate and qualify a state-of-the-art, self-contained, laser de-painting and cleaning system for maintenance activities with a reduced overall cost and comparable ease of use/removal rate to existing methods
- <u>Submarine Shaft Coating Removal</u> - Reduce shaft refurbishment cost and duration by eliminating the waste associated with moving submarine propulsion shafts. This will be done by replacing the grit-blasting operations currently performed in another building with operations that can be performed in the machine shop.

Team Members

Naval Application of Laser Paint Ablation Paint Removal Technology	Submarine Shaft Coating Removal
Office of Naval Research	
NAVSEA 04X	
NAVSEA 05P23, 05P24	NAVSEA 05Z22
Portsmouth Naval Shipyard	
Norfolk Naval Shipyard	
Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility	
Puget Sound Naval Shipyard and Intermediate Maintenance Facility	
Navy Metalworking Center	
Northrop Grumman Shipbuilding – Newport News	

Ablation Using Pulsed Lasers



Laser Coating Cleaning Process Illustration
(Not to Scale)

Graphic courtesy of Adapt Laser

- **Laser ablation converts the coating into particulate and/or vapor.**
- **A vacuum system captures and filters the particulate.**
- **The substrate reflects the laser energy and is minimally affected.**

NMC Photo

Portable Laser Equipment

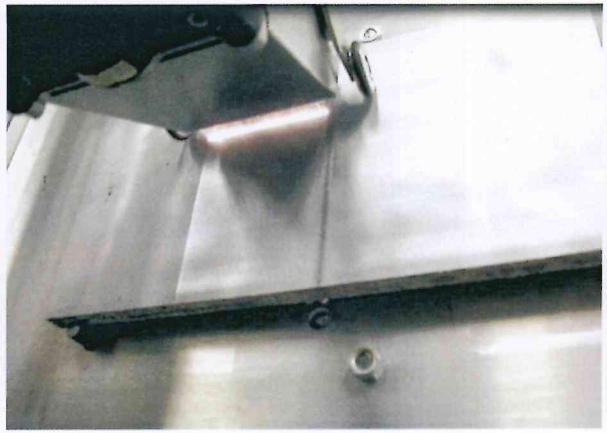
OSH 80

- The CleanLaser CL1000 Q-switched Nd:YAG laser was used with the OSH80 end effector and the TEKA CM500 fume and particle extractor.
- 1000 W average power and 800kW peak power per pulse
- 150 ft fiber length
- Integrated cooling system
- 55 in. x 30 in. x 63 in.

Photographs courtesy of Adapt Laser

Project Results

Glass Reinforced Polymer



Resin

Rust

Pre-construction primer

Mare Island and ultra-high solids epoxies

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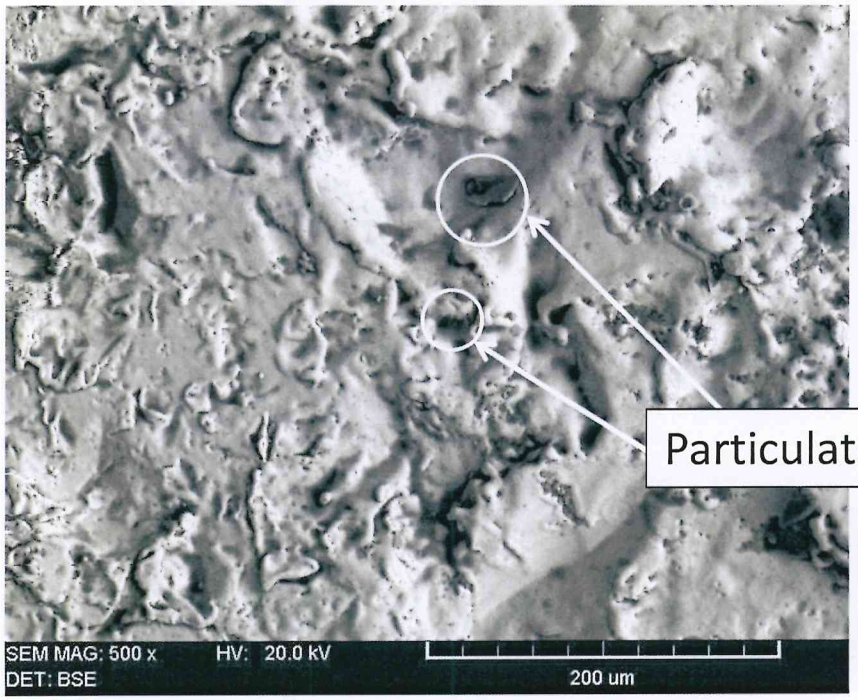
Comparison to Baseline Processes

Process	Baseline Process	Baseline Rate	Laser Ablation Rate	Savings
Epoxy removal	Needle gunning	72 MSI/min	328 MSI/min	16 min/ft^2 for a 10 mil coating
Pre-construction primer removal	Power disk sanding	144 MSI/min	180 MSI/min	0.2 min/ft^2 for a 1 mil coating

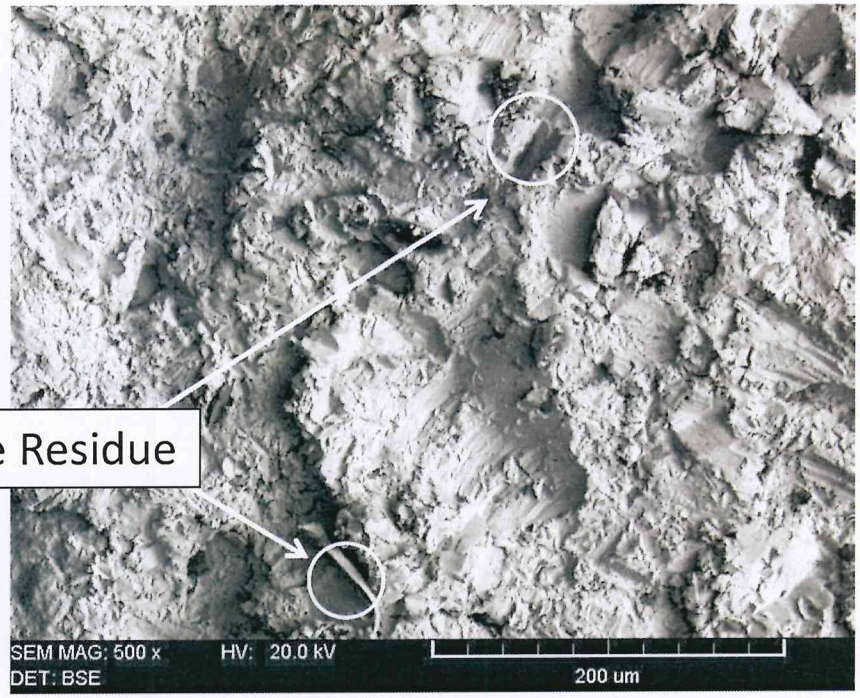
MSI = mil square inch. For example, 10 MSI represents a 10 mil coating on one square inch or a 1 mil coating on 10 square inches.

- Additional benefits include
  - No secondary waste
  - Reduced cycle time
  - Reduced cost
  - Selective small area removal

SEM Comparison of Grit Blasting and Laser Ablation



Particulate remaining in HY-80 substrate after laser ablation



Particulate remaining in HY-80 substrate after abrasive blasting

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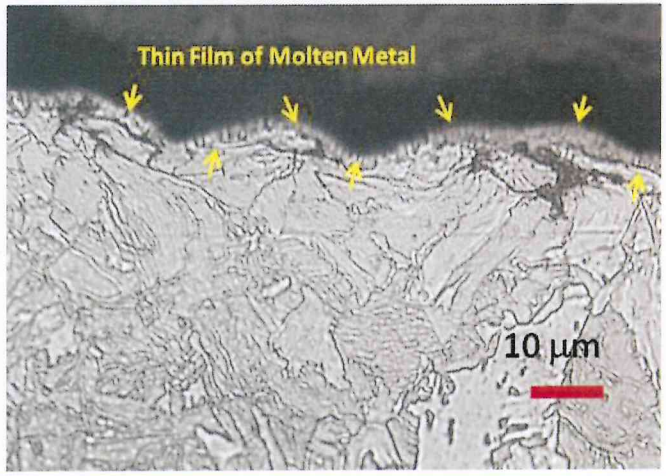
Metallurgical Evaluation

- Laser ablation did not adversely affect yield strength, tensile strength, surface profile, paint adhesion or corrosion resistance.
- Laser ablation did result in:
  - 3-4 µm fused surface layer with no other microstructural effects
  - minor increase in surface hardness.



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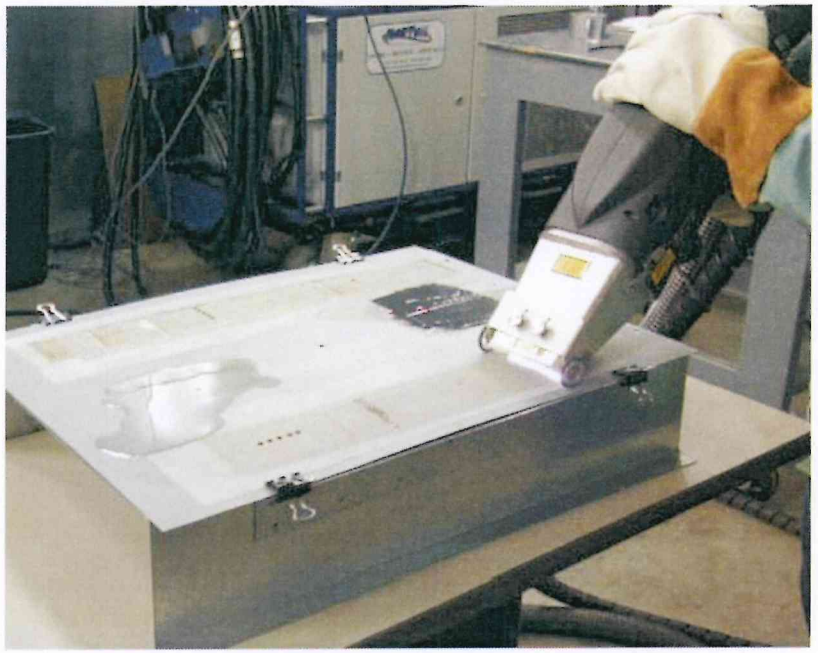
Health and Safety Testing

- The air at the operator station and the fume extractor exhaust was tested for ammonia, nitrous oxides, ozone and carbon monoxide.
- Air quality was acceptable at the laser operator station.
- Carbon monoxide and nitrous oxide levels at the fume extractor exhaust were slightly above specification.
- Noise levels were acceptable at all locations.

Flammability Testing

- Flammability testing was performed on pools and cups of
  - MIL-L-23699 (Motor Oil)
  - Methyl-ethyl Ketone (MEK)
  - Mil-Spec Grease (Molybdenum Disulfide)
  - Wet Cosmolene
  - JP-5 Fuel.
- With the vacuum system operating, minimal smoke was observed during direct laser ablation on JP-5. No other flames or smoke were detected.
- With the vacuum system secured, flames and smoke were observed during direct laser ablation of JP-5 and motor oil.



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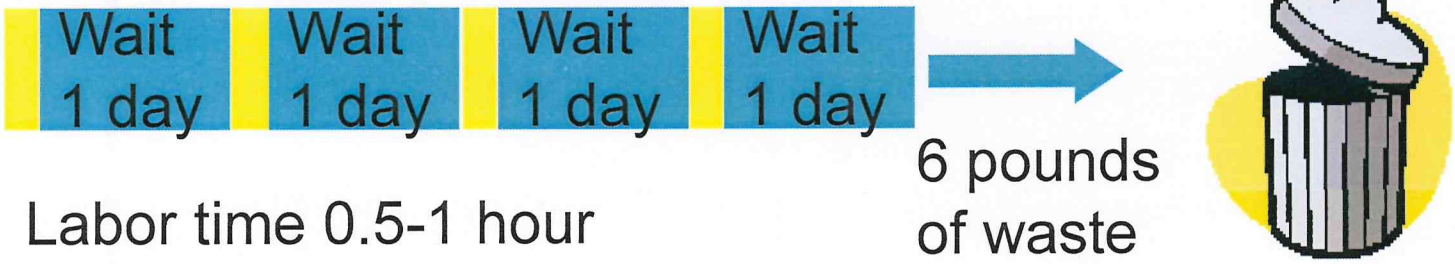
Example Payoff

- **The four-layer coating system is currently removed using a chemical stripper over 4 days.**



Labor time 0.5-1 hour

- **Laser ablation is able to strip this area in 5 minutes.**

Example Payoff

Baseline vs. Laser Coating Removal for One Linear Foot of Weld

Category	Baseline Process	Laser Process	Savings
Labor	1.5 to 5 hours	5 minutes	1.42 to 4.92 hours
Cycle Time	3 to 5 days	25 minutes	3 to 5 days
Waste Generation	6 pounds	0 pounds	6 pounds

Estimated Annual Savings

Category	Annual Savings*
Labor	$443,040 to $1.54 million
Waste Generation	$67,500
Total	$510,540 to $1.61 million

* Based on $60 per hour burdened labor rate, 100 feet of weld per week, and $1.50 per pound of hazardous waste.

Potential Applications

- Coating removal where grit blasting is not an option
- Small area coating removal
- Coating removal from composite substrates
- Cleaning joints prior to welding
- Cleaning surfaces prior to adhesive bonding.

Summary

- Laser ablation can replace time-consuming coating removal techniques resulting in shorter process times and less waste.
- The best candidates for laser ablation are those which now use chemical stripping or hand sanding.