Advances in Laser Coating Removal for Shipbuilding and Repair

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National Shipbuilding Research Program
Surface Preparation and Coatings Panel Meeting
June 2011

Navy Metalworking Center A ManTech Center of Excellence

NMC Photos

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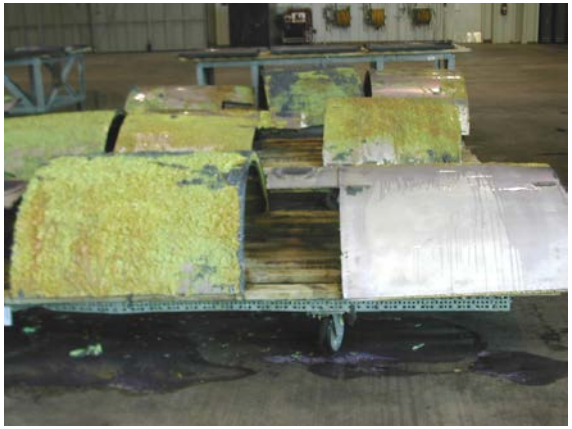
Outline

- Introduction
- Project Objectives
- Introduction to Laser Ablation
- Project Results
- Health and Safety
- Substrate Evaluation
- Cost Benefit Analyses
- Other Potential Applications
- Summary

Issue Description

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

Chemical Stripping



Power Sanding

Hand Scraping

Needle Gunning

Photos courtesy of Adapt Laser

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.**
- **Navy Metalworking Center (NMC) 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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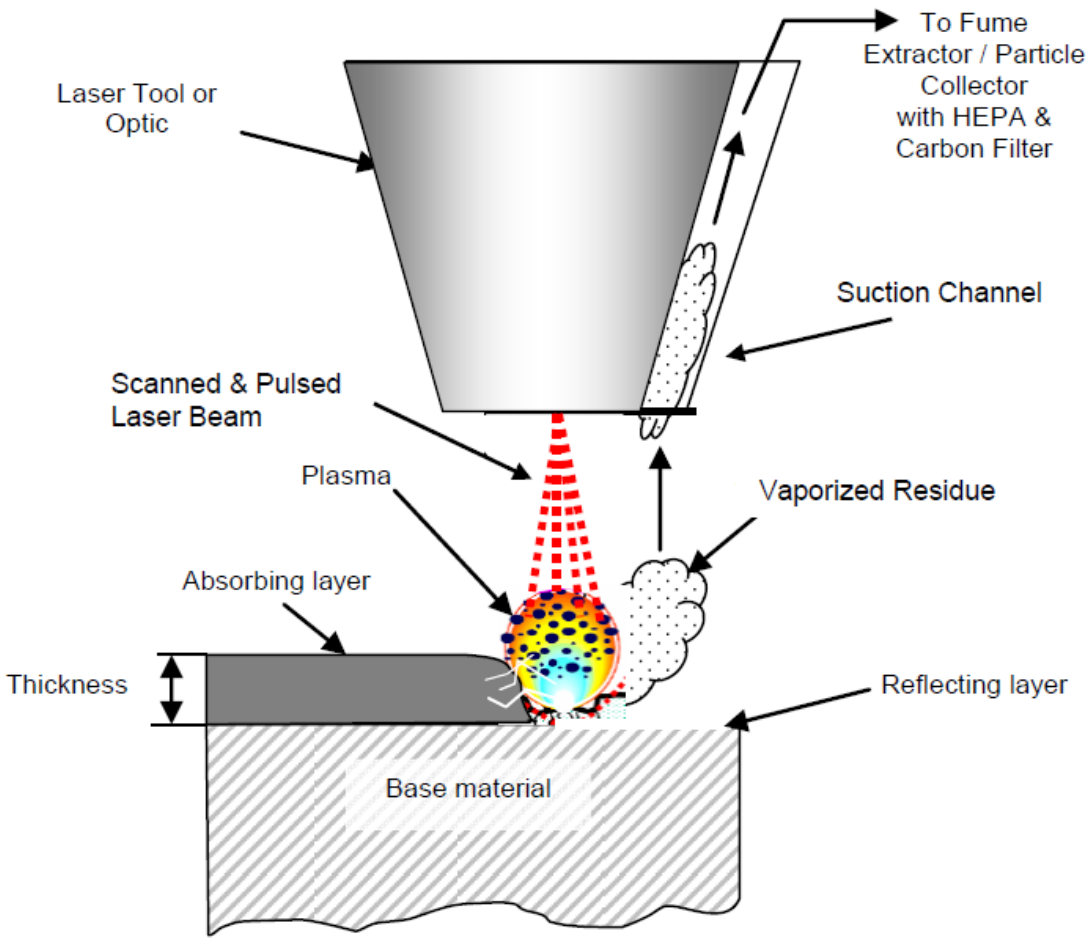
Project Objectives

- **<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. The project developed a solution with reduced overall cost and comparable ease of use/removal rate compared to existing methods.**
- **<u>Submarine Shaft Coating Removal</u> - Reduce shaft refurbishment cost and duration by eliminating the time and cost 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.**

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.**
- **The vacuum system captures and filters the particulate.**
- **Most of the laser energy is reflected by the substrate.**

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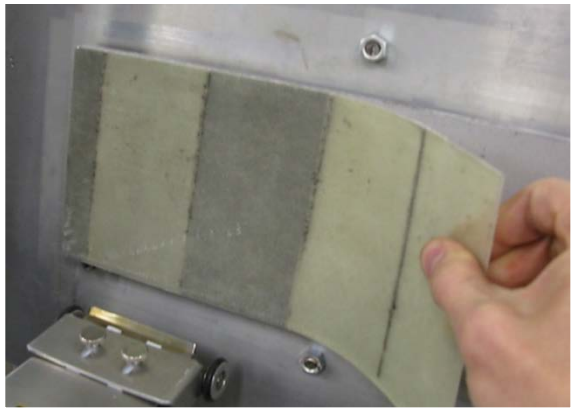
Portable Laser Equipment

OSH 80

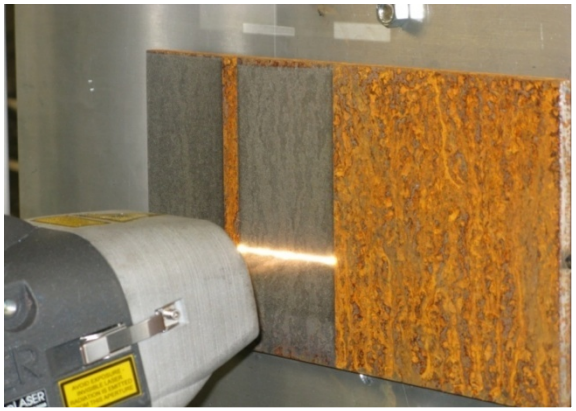
- **The CleanLaser CL1000 Q-switched Nd:YAG laser was used with the OSH80 end effector and the TEKA CM500 fume and particle extractor.**
- **1000 W average power and 800kW peak power per pulse**
- **150 ft fiber length**
- **Integrated cooling system**
- **55 in. x 30 in. x 63 in.**

Photographs courtesy of Adapt Laser

Navy Application Summary



Fiberglass comes off in one piece after one pass at 30 sec/ft^2



Rust is removed at 30 sec/ft^2

A 2-mil coating of preconstruction primer is removed at 2.2 min/ft^2

A 21-mil coating of ultra high solids epoxy is removed at 7.7 min/ft^2

A 10-mil coating of Mare Island epoxy is removed at 4.7 min/ft^2

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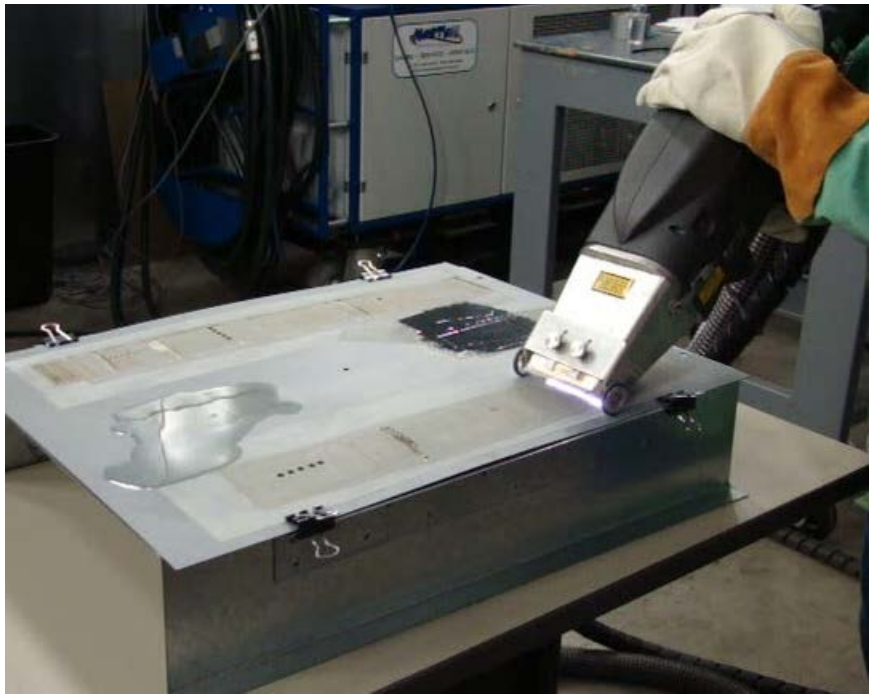
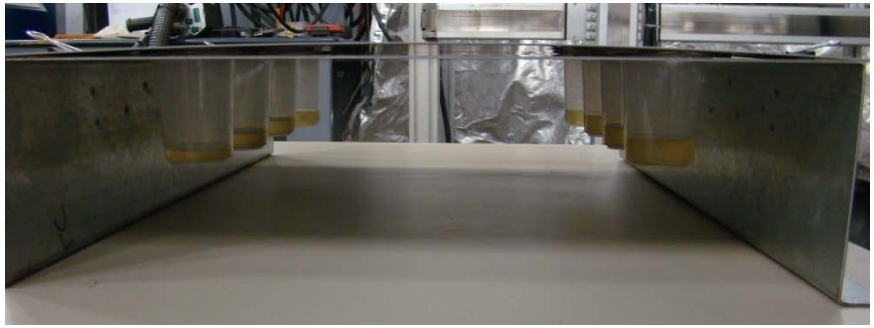
Health and Safety Testing

- 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
- 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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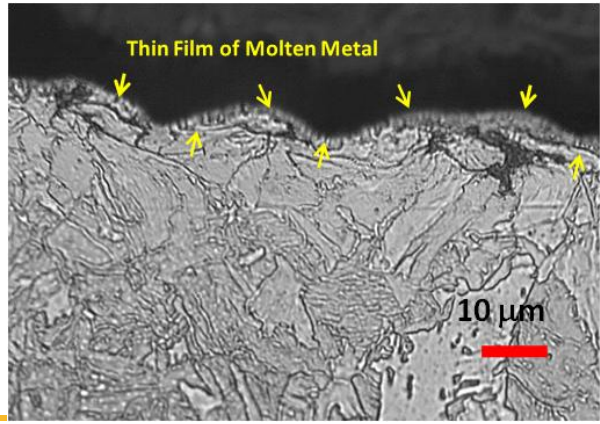
Metallurgical Evaluation

- Laser ablation processes were developed for HY-80, HSLA-65 and MIL-STD 23284A Nickel Molybdenum Steel.
- The current laser ablation processes resulted in:
  - Minor, in specification, reduction in tensile strength
  - minor reduction in surface profile (3.0 mil reduced to 2.8 mil)
  - no effect on adhesion
  - reduced fatigue life.
- Although fatigue life was affected by these process, other processes are being developed to eliminate that effect.

Fatigue Life

- The project team is trying to identify the observable indicators that correlate to reduced fatigue life.
- A 3 micron molten film is the only observed change, yet this seems to be too thin to be the cause of reduced fatigue life.
- X-ray diffraction and transmission electron micrography are being used to look for these indicators.
- They will be used to screen new process parameters.



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Cost Benefit Analysis - Paint Removal

- **Compare needle gunning to laser ablation for removing a 10-mil coating of Mare Island epoxy (MIL-DTL-24441)**
- **Removal Rates**
  - **Needle gun: 21 min/ft^2**
  - **Laser ablation: 5 min/ft^2**
  - **Savings: 16 min/ft^2**
- **Labor Cost: $65/hr**
- **Cost of laser rental: $12,000 per week**
- **Cost effective if needle gunning >780 ft^2 per week**

<u>or</u>

- **Cost of laser purchase: $550,000**
- **Payback in five years if doing 6,300 ft^2/yr**
- **Ergonomic benefits will also be significant.**

Photo courtesy of Adapt Laser

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Cost Benefit Analysis – Shaft Fiberglass Removal

- **Compare grit blasting to laser ablation for removing all coatings from submarine propulsion shafts upon initial receipt**
  - **Grit Blasting Labor (including transportation to the blast facility): 265 man-hours**
  - **Labor with Laser Ablation: 44 man-hours**
  - **Labor Savings: 221 man-hours**
  - **Cost per man-hour: $65**
  - **Labor Cost Savings: $14,365**
  - **Cost of Laser Rental: $12,000**
  - **Total Cost Savings: $2,365**
  - **Schedule Savings: 8 - 10 weeks**

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Cost Benefit Analysis – Weld Joint Inspection

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- **The paint is currently removed using a chemical stripper over four days.**

Wait 1 day | Wait 1 day | Wait 1 day | Wait 1 day → 6 pounds of waste

Labor time 0.5-1 hour

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

Cost Benefit Analysis – Weld Joint Inspection

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

Category	Chemical Stripping	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.**

Other Potential Applications

- Chloride removal
- Non-skid removal
- Decoating composites
- Small area coating removal
- Weld joint cleaning
- Cut line preparation
- Coating removal where grit blasting is not an option
- Cleaning surfaces prior to adhesive bonding.

Photo courtesy of Adapt Laser

Summary

- Laser ablation can replace time-consuming coating removal techniques resulting in shorter process times and less waste.
- The recommended candidates for laser ablation are those which now use chemical stripping, needle gunning or disc sanding.
- Laser ablation can have an adverse effect on the fatigue performance of the substrate.

Contact Information

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