

Atmospheric Plasma Depainting

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Report Documentation Page

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Overview

- Problem Statement
- Define Plasma
- Define Atmospheric Plasma
- Describe Atmospheric Plasma Coating Removal (APCR)
- Benefits of APCR
- Introduce the PlasmaFlux™ system
- Aerospace Depainting Efforts
- Navy Ship Depainting Efforts

Problem Statement

- Annual cost of corrosion for DoD ~ \$20 Billion
- Virtually every weapon system across all segments of DoD require periodic maintenance of coating systems



Plastic Media Blasting



High Pressure Water Jet



Grit blasting

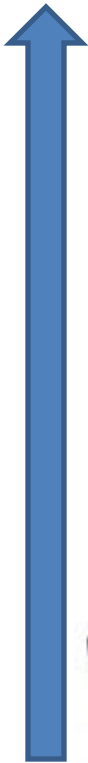
Problem Statement, cont.

- Conventional media-based coating removal technologies generate large volumes of solid waste, are labor intensive, and hazardous to maintenance personnel.
 - High environmental impact
 - High cost of waste disposal
- Atmospheric Plasma Coating Removal (APCR) provides an environmentally benign and safe means of removing coatings and sealants.

What is Plasma?

Plasma: Fourth State of Matter

Increasing Energy



Solid



Liquid



Gas



Plasma



State of Matter

What is Atmospheric Plasma?

Plasma occurring at Atmospheric Pressure

Plasma in open air with
no special chamber
needed

Atmospheric Composition
requires only compressed
air as the feed-gas

Atmospheric Plasma Coating Removal (APCR)



+



=



Atmospheric
Plasma

Paint / Sealant

Carbon
Dioxide

Water

- APCR requires no media
- Atmospheric plasma produces highly reactive gas
 - Cold plasma \Rightarrow high chemical energy, low thermal energy
 - Vaporizes organic portion of coatings to CO_2 and H_2O
 - No damage to temperature sensitive substrates

Features and Benefits of APCR Technology

Feature	Benefit
No Media Required	Cost - Reduced procurement, storage, and disposal costs
	Safety - Reduced exposure to hazardous materials
	Environmental – Reduced environmental impact
Atmospheric Pressure Operation	Non-damaging removal, preserves surface profile
	Selective layer-by-layer removal
	Simple technology requires compressed air and electricity
	Safety – No special safety equipment or procedures
	Cost – Eliminates need for “hot work” zones, faster maintenance cycle
Compact size, low weight	Controlled manually or by robotics
	Reaches areas that are inaccessible to other technologies

PlasmaFlux™ Technology

Power Supply

Plasma Source



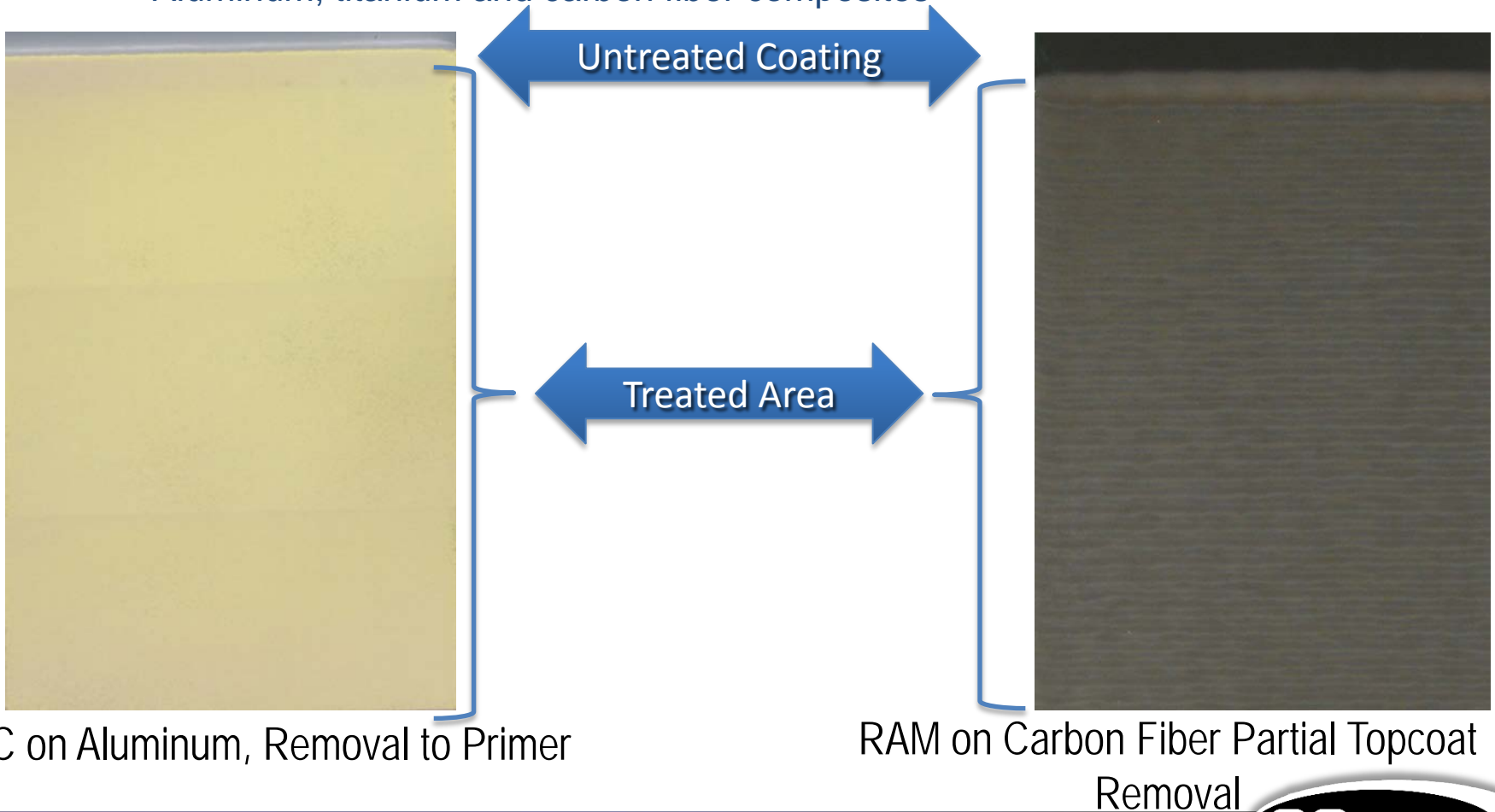
- The power supply produces a high frequency electric field to generate cold plasma
- Depot compatibility: Requires only compressed air and electrical power

Aerospace Depainting Efforts

- APC (Advanced Performance Coating), RAM (Radar Absorbing Material), and Sealant removal
- Aluminum, Titanium, Composite substrates
- Accessing confined spaces where other technologies struggle

Aerospace Coating Removal

- Selective layer-by-layer removal demonstrated on temperature sensitive substrates
 - Aluminum, titanium and carbon fiber composites



Sealant Removal



- Rivets were initially covered with about 4 mm of sealant
- Rivets completely uncovered by hand held plasma pen

Hand Held Removal of Polysulfide Sealant

AC-240-B2 Sealant (2-5 mm thick)
applied to aluminum lap joint with
protruding rivets



~15 second handheld removal
around rivet leaving bare metal
and powdery residue

Aerospace Coating Removal Transition Programs

- AFRL (WPAFB)
 - Evaluation of high power atmospheric plasma process for aircraft coating removal
 - Evaluation of handheld APCR for Sealant removal
- NAVAIR (Cherry Point)
 - Evaluate adhesion promotion of AP on surfaces
- Ongoing projects with prime contractors
 - Evaluating APCR for surface treatment of aircraft fasteners and sealant removal
 - Evaluating removal of specialty LO coatings on composite substrates

Navy Ship Depainting Efforts

- Freeboard and anti-fouling Naval coatings

Naval AP Depainting Development Programs

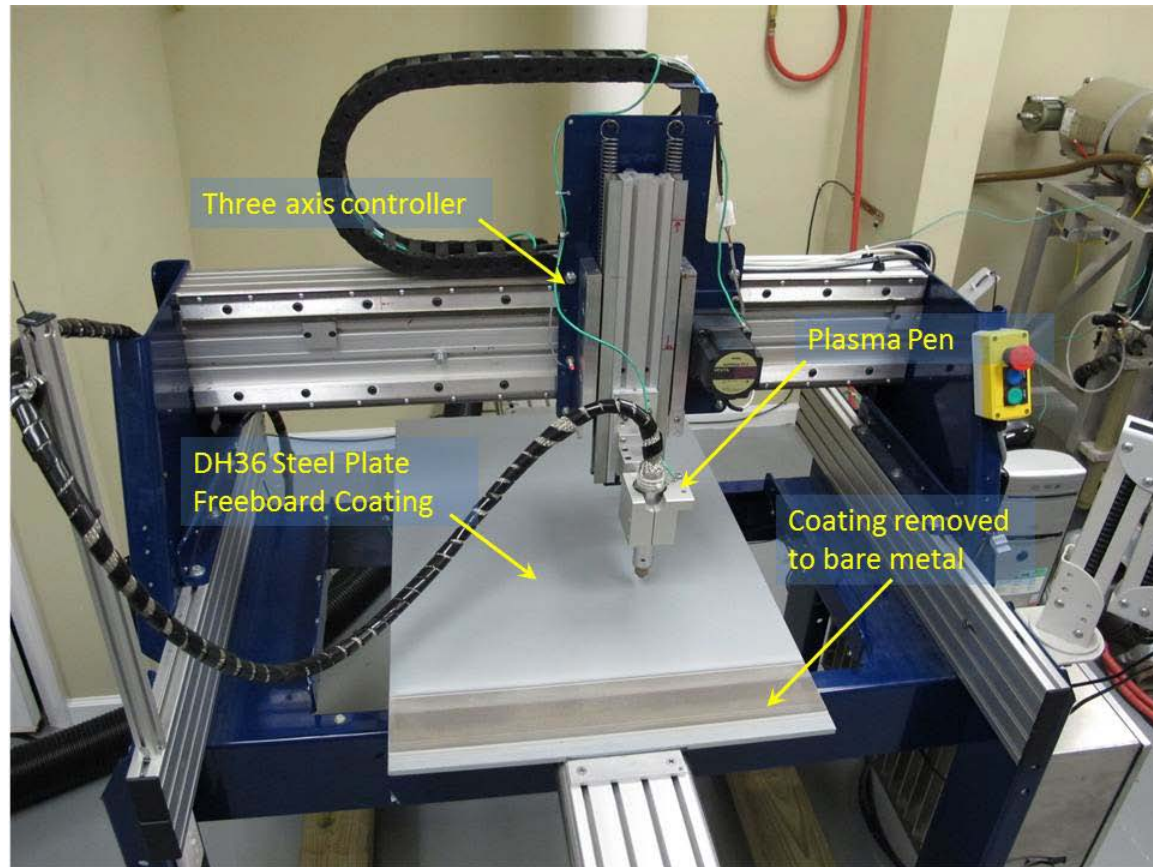
- Navy Phase I & II SBIR (N00014-10-C-0266)
 - Projects focused on engineering development challenges
 - Power supply and plasma source designs
 - Improved single and multi-pen designs
 - Ruggedization for Dry-dock environment
 - Operation using Dry-dock 480V 3-phase power

Naval AP Depainting Development Programs

- SERDP WP-1762
 - Recoating performance of APCR depainted surfaces
 - Multi-pen removal process development using SBIR designed plasma system
 - Removal rate enhancement on Naval ship coatings
 - Plasma plume-surface interaction
 - Environmental / Health characterization of the plasma depaint process

Naval Coatings Removal

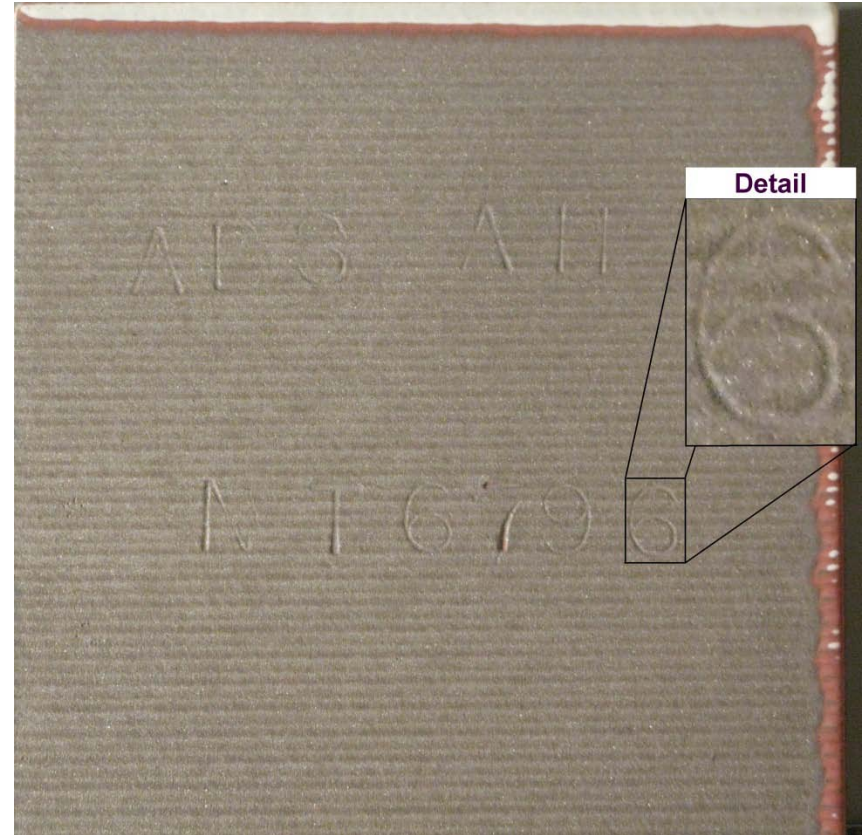
- Plasma pen integrates with COTS automated system for coating removal tests
- Sample coupons
 - 24" x 36" 3/8" DH36 steel
 - (± 2.5 mil roughness)
- Coating stacks
 - Freeboard
 - Anti-Fouling
 - 20 mils thick (nominal)



Three axis automated system

Anti-Fouling Coating Removal

- APCR produces surface with “near white metal blast cleanliness”
- Underlying surface profile is unchanged
- Uniform removal demonstrated for freeboard and anti-fouling coatings
- Demonstrated excellent adhesion of re-applied coating

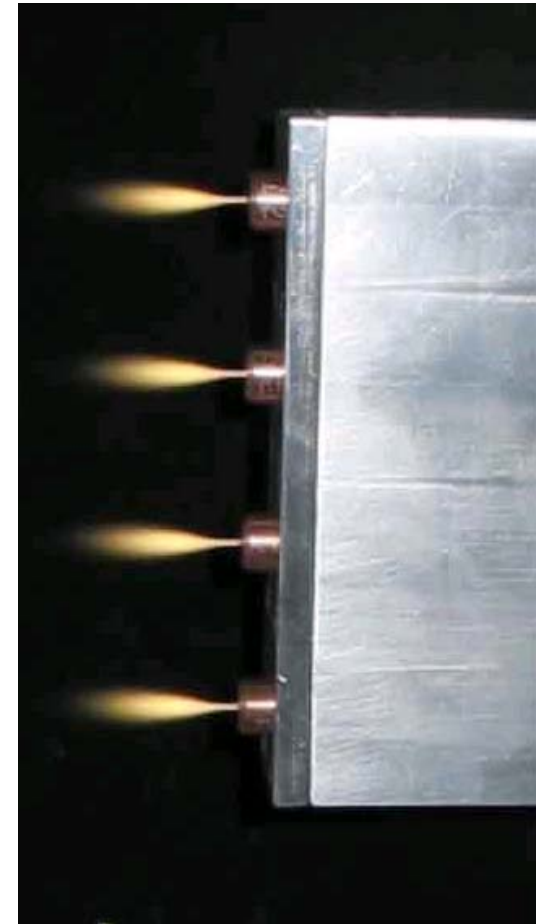


SERDP Program Findings So Far

- Comparable efficacy of APCR to conventional Naval coating removal techniques
- Test panels were depainted by grit blasting and APCR to “near white metal” conditions and then repainted
- No significant performance difference of reapplied coatings was observed between APCR and grit blast surface preparation
 - No discernible difference in surface grain size, structure, or composition.
 - Pull-off adhesion tests of re-applied coating are comparable
 - No significant coating performance difference in salt fog and cathodic disbondment testing

Technology Transition

- Scale up plasma coating removal technology to production rates
 - Increased power levels (power source and plasma pen)
 - Multiple plasma pens
- Ruggedize power supply and pen for testing under depot conditions
 - Outdoor marine environment: Category III, Pollution Degree 4
 - Compliance standards taken into consideration in design



Four Pen Array

Special Thanks

- AFRL: Jeff Kingsley, Natasha Voevodin
- ONR: Stephen McElvany
- NCSU: Jerry Cuomo, Steve Hudak
- SERDP: Bruce Sartwell

Thank You

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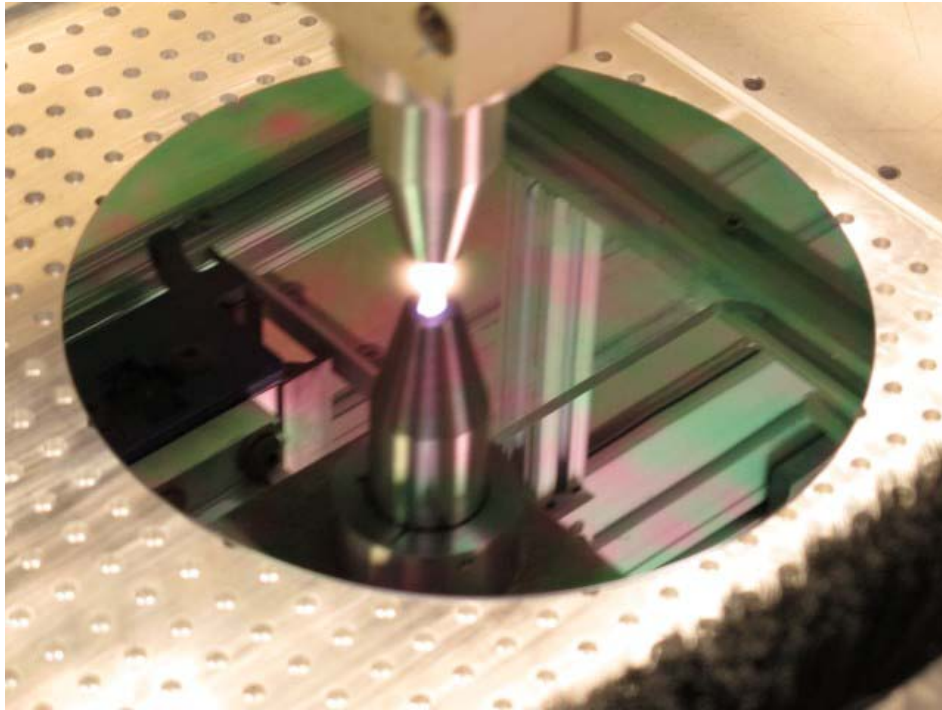
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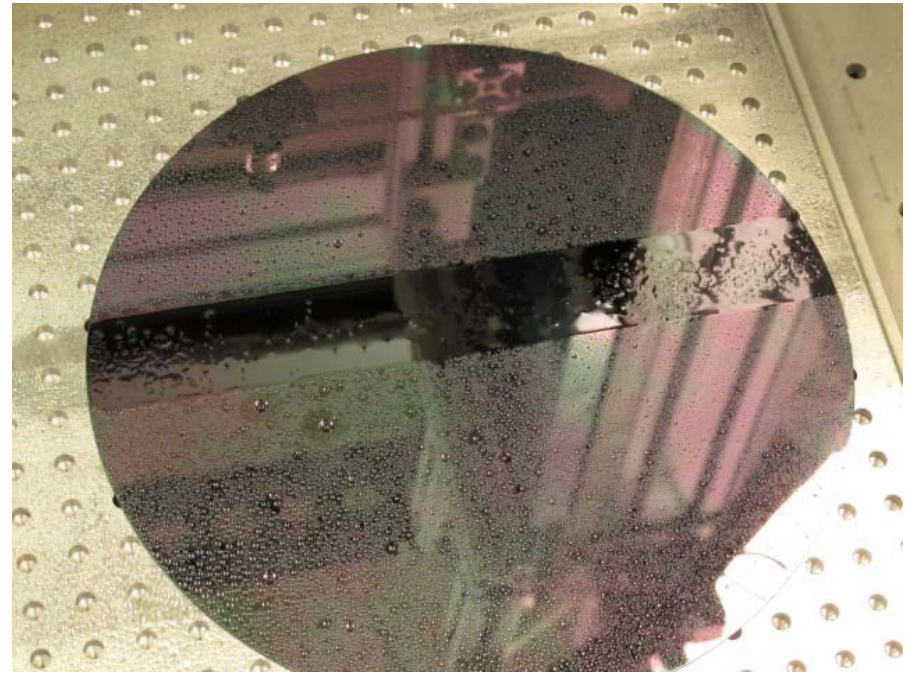
Additional Slides



Surface Energy Enhancement, Adhesion Promotion



1 second linear sweep across silicon wafer surface



Produces extremely hydrophilic, high surface energy path