Atmospheric Plasma (AP): Surface Analysis of Depaint Process for Military Aerospace Coating Materials -- Preliminary Analysis

Diane Buhrmaster
Air Force Research Laboratory (AFRL) (USA)

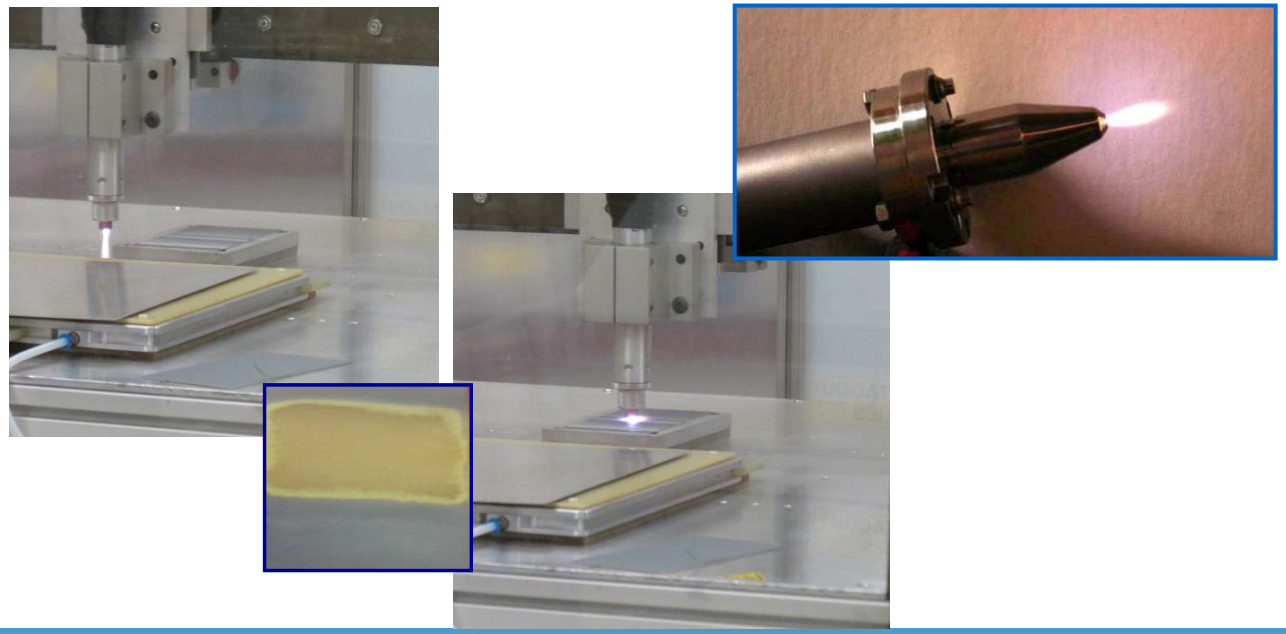
Presentation to

AVT-302 Paint Removal Technologies for Military Vehicles

Ludmila ''t Hoen-Velterop
Co-Chair (the Netherlands)
Marko Yanishevsky
Co-Chair (Canada)

Outline

- **Early Development (SBIR, SERDP)**
- **Initial Atmospheric Plasma Post-Treatment Surface Analysis**
- **Current Development and Evaluation**
- **Future Efforts**



Early Development

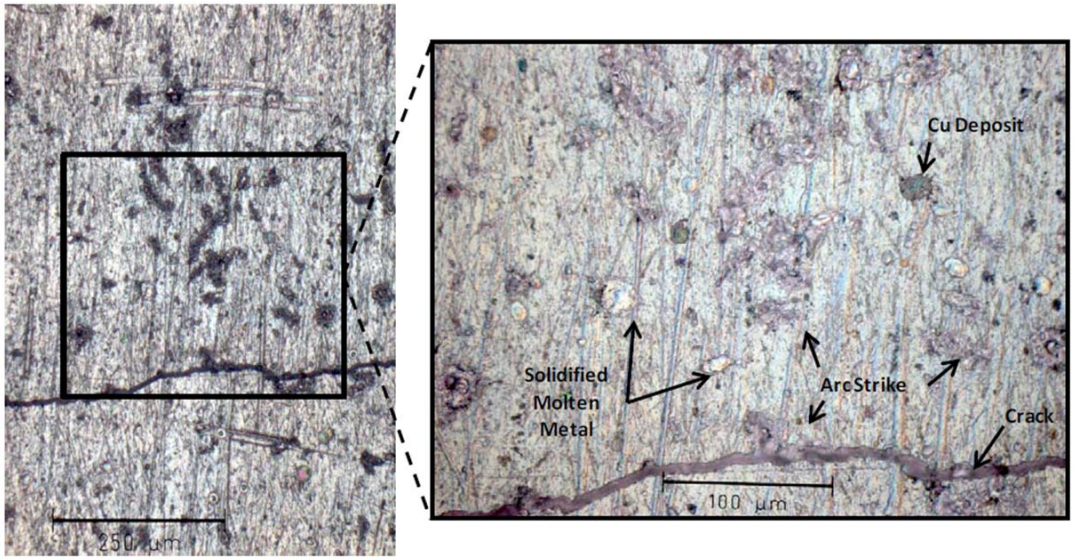
- **Early development was done under the Department of Defense Small Business Innovation Research (DoD SBIR) program (2008 – 2011) with AFRL**
  - Demonstrated feasibility of removing conventional military aerospace coating materials as well as sealant materials commonly found on the outer moldline (OML) of legacy aircraft
  - Developed an automated removal system (single AP pen) for substrates as large as 12 x 12 inches (approx. 30 x 30 cm) and maximum traverse speed of 1200 in/min (30.5 m/min)
  - Characterized surface temperature profile during coating removal on AA2024-T3 and AA7075-T6 (0.032-inch) substrates, carbon fiber & radome composites

Early Development

- **Additional characterization and development performed through the Strategic Environmental Research and Development Program**
  - North Carolina State University, AP Solutions Inc., U.S. Naval Air Systems (NAVAIR), U.S. Naval Sea Systems (NAVSEA), and AFRL
  - Determined capability of atmospheric plasma to remove coatings for Navy applications
  - Developed and characterized large area plasma devices
    - Optical emission & mass spectroscopy; SEM/EDAX
  - Investigated environmental and process hazards, waste mitigation, operational safety, and integration/transition of the atmospheric plasma process for NAVSEA

Initial AP Post-Treatment Surface Analysis

- **Initial evaluation of the uncoated samples showed plasma-induced surface phenomena**



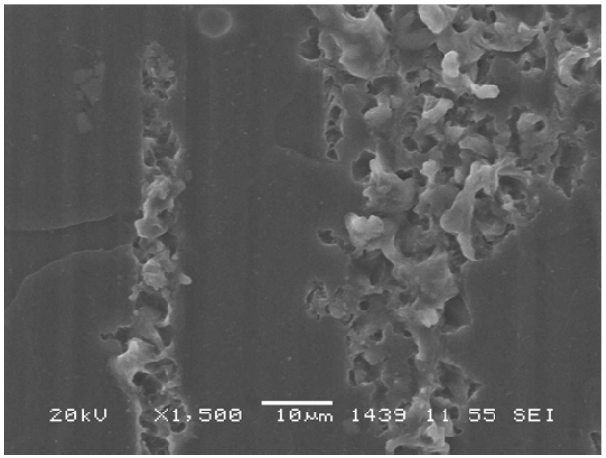
- **Further inspection determined these phenomena to be minor substrate material removal, likely from arc strikes between the sample and the nozzle**

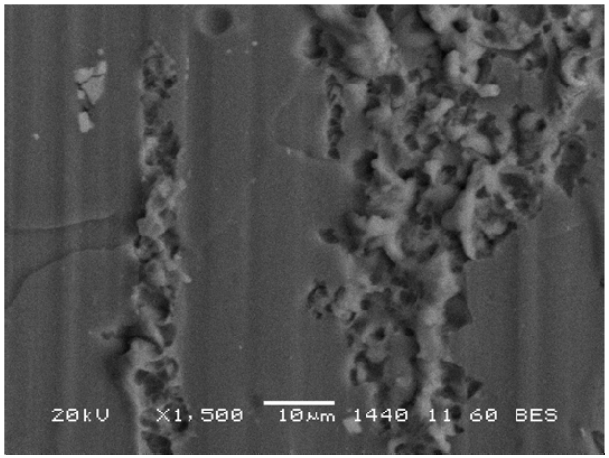
Current Development and Evaluation

- **Investigate AP treatment induced surface phenomena**
  - ➢ Characterize surface phenomena
    - Vary stand-off distance, travel speed, number of continuous passes, spacing between passes
    - Vary coating removal and type of coating, validate there are no deleterious changes to the type/frequency surface phenomena
  - ➢ Identify coating removal process for coating systems on aerospace aluminum
    - Cr-free OML coatings (Rare earth system, Mg-rich system)

Current Development and Evaluation

- **Investigate AP treatment induced surface phenomena**
  - Current evaluation of the uncoated samples (post atmospheric plasma treated) showed plasma-induced surface phenomena
  - Determined these phenomena to be minor substrate material removal, likely from arc strikes between the sample and the nozzle

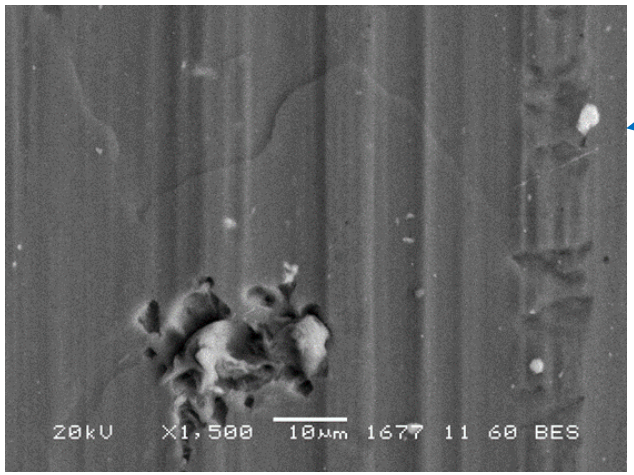




Distance: 0.051 inch
Speed: 500 in/min
Passes: 3
Spacing: 0.045 inch

Current Development and Evaluation

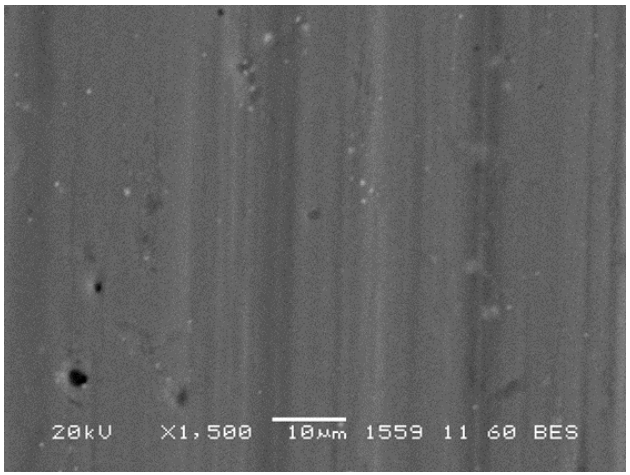
- **Investigate AP treatment induced surface phenomena**
  - SEM images showed that arc strikes occurred regardless of stand-off distance, travel speed, number of passes, or spacing of passes
  - However the severity of the arc strike damage phenomena was reduced when the stand-off distance was increased from 0.051 to 0.15 inches



Distance: 0.051 inch

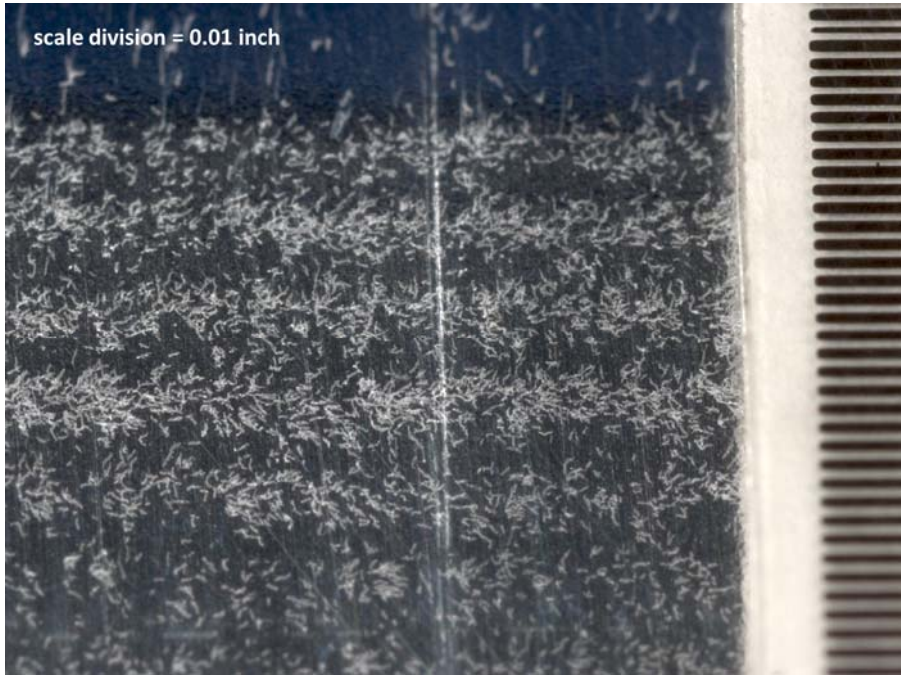
Distance: 0.15 inch

Speed: 500 in/min
Passes: 3
Spacing: 0.045 inch



Current Development and Evaluation

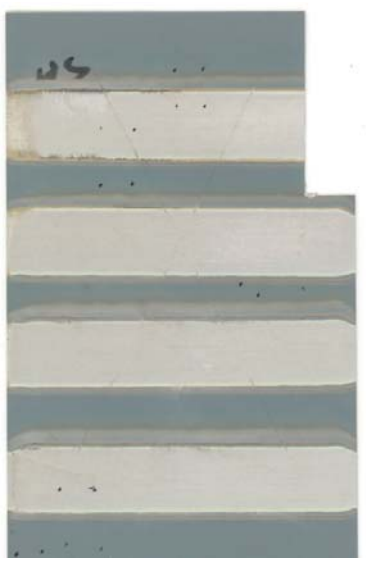
- **Investigate AP treatment induced surface phenomena**
  - Arc strike phenomena was evaluated on a mirror-finish polished sample
  - Comparison of treated and untreated topography in the section shows patterning of the plasma-induced surface phenomena



Distance: 0.051 inch
Speed: 500 in/min
Passes: 3
Spacing: 0.045 inch

Current Development and Evaluation

- **Initial Coating Removal Evaluation**
  - Arc strike phenomena was noted on both the reparability sample and the single-system sample
  - Frequency of plasma-induced surface phenomena can be decreased by increasing the stand-off distance and reducing the number of consecutive/continuous passes over an area



Initial System:
PPG EAP #9
PPG CA7236 MgO
PPG CA9311
Repaired with:
PreKote
AN 2111P001 MgO
AN Aerodur 5000

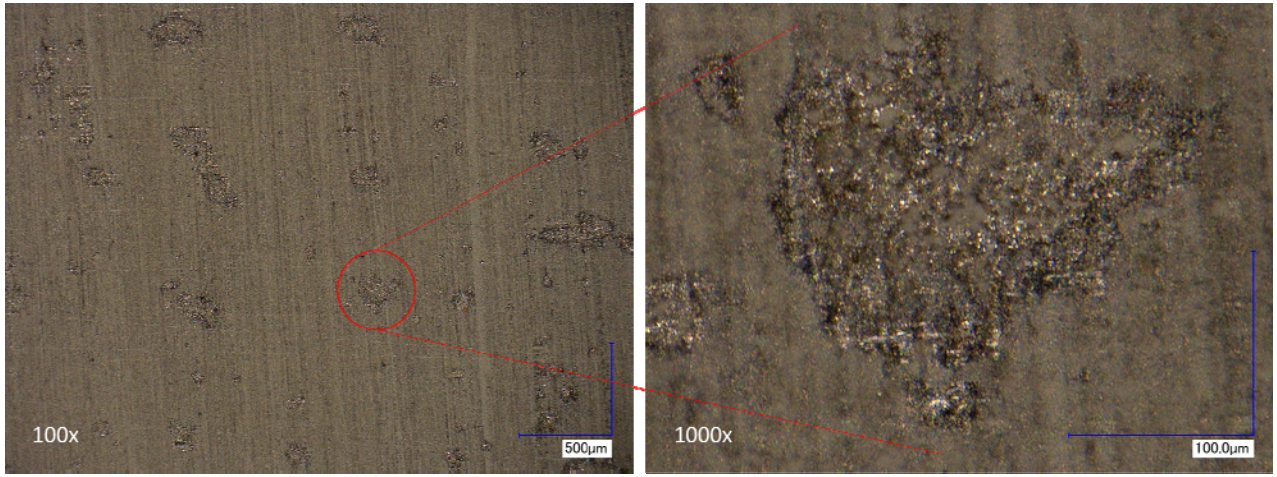
RECC 1045/3031
Pretreatment
Deft 02-GN-097
Rare-Earth
Deft 990GY001
Topcoat

Current Development and Evaluation

- **Surface Evaluation, Post-Coating Removal using AP**

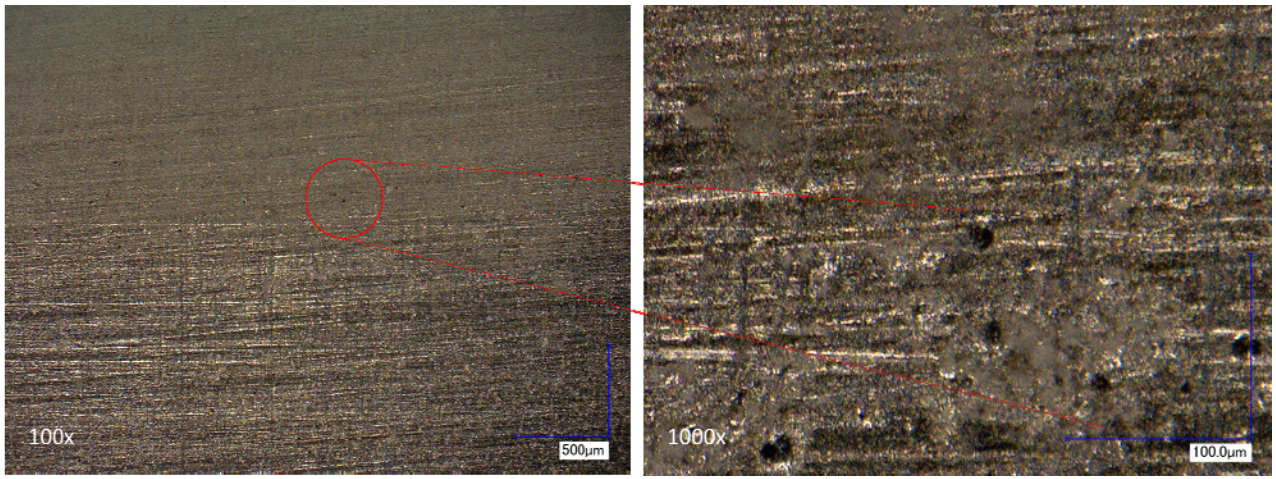
Initial System: PPG EAP 9 chromium-free adhesion promoter; PPG CA7236 chromium-free, magnesium-oxide pigmented high-solids primer; PPG CA9311 polyurethane topcoat (MIL-PRF-85285)

Repaired System: Pantheon PreKote adhesion promoter; AkzoNobel 2111P001 chromium-free, magnesium-oxide pigmented high-solids primer; AkzoNobel Aerodur 5000 polyurethane topcoat (MIL-PRF-85285)



Current Development and Evaluation

- **Initial Coating Removal Evaluation**
  - ➢ Surface Evaluation, Post-Coating Removal using Atmospheric Plasma; Coating Stack-Up -- Rare Earth Conversion Coating (RECC) 1045/3031; Deft 02-GN-097 Rare-Earth epoxy primer; Deft 990GY001 polyurethane topcoat



Future Efforts

- **Quantify any Structural Integrity Impact of AP Surface Treatment Process**
  - Preliminary data shows that the atmospheric plasma surface treatment process does cause plasma-induced surface phenomena, which is likely arc strikes
  - Depth, width, and potential impact to structural integrity is not yet quantified – will be evaluated in next phase of study
    - Aerospace substrate surface cleaning (300M)
    - Coating removal (AA2024-T3, AA7075-T6, baseline composites)

Future Efforts

- **Define removal process for other difficult to remove coatings**
  - Fuel tank coated surfaces for non-destructive evaluation
  - Coating removal on composites
- **Evaluate AP for removal of surface contaminants (i.e., silicon) on 300M high strength steel**
  - Silicon surface removal from 300M prior to landing gear plating
- **Document and Distribute Baseline Protocols**
  - Parameters for successful coating and contaminant removal
  - Surface profile protocol for structural integrity

Acknowledgements

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Questions / Comments?