Selectively Plated Trivalent Chrome

Presented by
Chris Mance, Tinker AFB
<table>
<thead>
<tr>
<th>1. REPORT DATE</th>
<th>MAR 2005</th>
<th>2. REPORT TYPE</th>
<th>3. DATES COVERED</th>
<th>00-00-2005 to 00-00-2005</th>
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<td>4. TITLE AND SUBTITLE</td>
<td>Selectively Plated Trivalent Chrome</td>
<td>5a. CONTRACT NUMBER</td>
<td>5b. GRANT NUMBER</td>
<td>5c. PROGRAM ELEMENT NUMBER</td>
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<td>6. AUTHOR(S)</td>
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<td>5d. PROJECT NUMBER</td>
<td>5e. TASK NUMBER</td>
<td>5f. WORK UNIT NUMBER</td>
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<td>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</td>
<td>Oklahoma City Air Logistics Center, Tinker AFB, OK, 73145</td>
<td>8. PERFORMING ORGANIZATION REPORT NUMBER</td>
<td>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</td>
<td>10. SPONSOR/MONITOR’S ACRONYM(S)</td>
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<td>14. ABSTRACT</td>
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<td>15. SUBJECT TERMS</td>
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<td>16. SECURITY CLASSIFICATION OF:</td>
<td></td>
<td></td>
<td>Same as Report (SAR)</td>
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<td>a. REPORT</td>
<td>unclassified</td>
<td>b. ABSTRACT</td>
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<td>18. NUMBER OF PAGES</td>
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Background

- Developed 10 years ago by Dr. Zoltan Mathe at Liquid Development Corporation (LDC).

- Process is fully developed, but main customer interest has been for smaller, limited applications such as touch-up of existing chrome.

- Referred to as LDC-HTC³
Properties of LDC-HTC³

- Hardness (HV) 900-1200
  - As good or better than Electrolytic Hard Chrome (EHC)
- Taber Wear Index of 0.7 mg/1000 cycles
  - 3 times better than EHC
- Coefficient of friction equal to EHC
- Can build deposits 3 times faster than EHC
- Application of a nickel flash prior to LDC-HTC³ eliminates need for post bake. No hydrogen embrittlement.
- Line of sight NOT required
Repair of Existing Chrome

- LDC-HTC$^3$ can build new chrome on existing chrome.

- No need to strip existing chrome if remaining coating is acceptable.
Coating Thickness

- Can plate to thicknesses in excess of 10-mils.
- Cause of pitting seen at thicker coatings isolated and identified at Tinker AFB.

<table>
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<tr>
<th>Sample</th>
<th>Carbon Content</th>
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<tbody>
<tr>
<td>Sample-19</td>
<td>0.0%</td>
</tr>
<tr>
<td>Sample-16</td>
<td>48.7%</td>
</tr>
<tr>
<td>Sample-17</td>
<td>62.5%</td>
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</tbody>
</table>
- Carbon contamination caused by corrosion of graphite anode used in the process.

- Replacement of graphite anode with platinum niobium mesh eliminates graphite contamination.
Coating Thickness

- Coating thickness can very accurately be predicted by measuring amp-hrs during the process.
  - Thickness predictions +/- 0.00001 inches possible with selective plating.

- “Plate To Tolerance”
Coating Finish

- Surface finishes as good as 10 Ra have been measured at Tinker.
  - Surface finishes better than 16 Ra generally called for after grinding and polishing.

- “Plate To Finish”
Post Machining

- “Plate to Tolerance, Plate to Finish”
- Post grinding and polishing may be completely eliminated
To date, no micro or macro cracking has been observed in LDC-HTC$^3$ coated samples. EHC has large tensile stresses associated with it, resulting in microcracking “spider webs”.

The lack of cracking in LDC-HTC$^3$ could mean:
- Large residual stresses could remain in the coating and are not being relieved by microcracking as in EHC.
- Coating does not crack during cutting and grinding of metallurgical samples.
- Residual stresses in LDC-HTC$^3$ could be less than those in EHC.
- Selectively plated coatings in general are less porous and more dense when compared to tank plated coatings.
- Lack of cracking could mean a dramatic improvement in corrosion resistance of LDC-HTC$^3$ as compared to EHC.
Environmental/Safety Hazards

- **LDC-HTC** is
  - Non-oxidizing
  - Non-toxic
  - Non-carcinogenic
  - Non-corrosive
  - pH of 7.0

- Process is carried out in a “closed system”.
  - 6 gallons of solution contained in a closed heater/pump system.
  - Solution is passed through anode over part and returned to heater/pump.
  - No chrome rinse water is generated.
  - Solutions used to prepare parts (~65 mL per part) are segregated and collected.
  - A finding of “CATEX” is anticipated at Tinker
    - “No significant individual or cumulative effect on the human environment”
Lean Cell Applicable

LDC-HTC³ is ideally suited to the Lean Cell concept.

- Equipment is low cost
  - Less than $30,000 per station.
- Small footprint needed
  - Equipment fits on a workbench
- Very little masking of part is required
  - Taping of boundaries using plating tape
- Cleaning and preparatory steps carried out using selective plating equipment
- Parts can be completely processed in as little as 4 hours
  - Ready to be reinstalled
## Cost Comparison for Trivalent Brush Plated Chrome vs. Electrolytic Chrome Technologies

<table>
<thead>
<tr>
<th>Component</th>
<th>Trivalent Brush Plated Chrome</th>
<th>Hexavalent Chrome Plating</th>
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<tbody>
<tr>
<td>Capital and Installation (Per Trichrome Lean Cell)</td>
<td>$30,000</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Operational Costs:</strong></td>
<td></td>
<td></td>
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<tr>
<td>Consumables Cost (25 square inch area, 1500 parts annually)</td>
<td>$121,247</td>
<td>$109,875</td>
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<tr>
<td>Gas</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Labor (Including &quot;Shipping &amp; Handling&quot; and Post-Plate Machining and Polishing for HVOF and Hexchrome)</td>
<td>$29,580</td>
<td>$318,750</td>
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<td>Rinsewater treatment</td>
<td>$0</td>
<td>$500</td>
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<tr>
<td>Disposal</td>
<td>$0</td>
<td>$1,000</td>
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<td><strong>Annual Total (w/o capital)</strong></td>
<td>$150,827</td>
<td>$430,125</td>
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### Economic Analysis Summary:

- **Annual Savings for Trivalent Brush Plated Chrome:** $279,298
- **Capital Cost for Diversion Equipment/Process:** $30,000
- **Payback Period for Investment in Equipment/Process:** 0.11 Years, 1.29 Months
Current Status

- Submission of project to ESTCP complete.
  - Submitted with contributors from
    - Tinker Air Force Base
    - Oklahoma City ALC
    - Army Research Labs
    - Naval Research Labs
    - NAVAIR
    - Naval Air Systems
    - PEWG
    - HCAT
    - Boeing
    - Pratt & Whitney
- Supplementary funding obtained at Tinker AFB
  - Testing will continue during ESTCP review process.
Metallurgical properties measured to date “as good or better” than EHC
Process does not require line of sight
Could eliminate stripping of existing chrome
Could eliminate post grinding and polishing
Environmental and health concerns greatly reduced or eliminated