Selectively Plated Trivalent Chrome

Presented by
Chris Mance, Tinker AFB
**Selectively Plated Trivalent Chrome**

**Report Documentation Page**

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<td><strong>Oklahoma City Air Logistics Center, Tinker AFB, OK, 73145</strong></td>
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<td><strong>25th Replacement of Hard Chrome and Cadmium Plating Program Review Meeting, March 15-17, 2005, Greensboro, NC. Sponsored by SERDP/ESTCP.</strong></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-HTC$^3$
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
- LDC-HTC³ 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.

Sample-19  0.0% Carbon
Sample-16  48.7% Carbon
Sample-17  62.5% Carbon
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
Micro/Macro Cracking of Coating

- 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

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<tr>
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<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>
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<td><strong>Operational Costs:</strong></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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<td>Gas</td>
<td>$0</td>
<td>$0</td>
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<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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<td>Disposal</td>
<td>$0</td>
<td>$1,000</td>
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<td>Annual Total (w/o capital)</td>
<td>$150,827</td>
<td>$430,125</td>
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<td>Annual Savings for Trivalent Brush Plated Chrome:</td>
<td>$279,298</td>
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<td>Capital Cost for Diversion Equipment/Process:</td>
<td>$30,000</td>
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<td>Payback Period for Investment in Equipment/Process:</td>
<td>Years 0.11</td>
<td>Months 1.29</td>
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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.
Summary

- 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