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Green Process for Functional Trivalent Chromium Electroplating

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Faraday will discuss recent work on the development of a functional chromium plating process from a trivalent-based electrolyte to replace hexavalent chromium plating. Hexavalent chromium plating has been used for many years to provide hard, durable coatings with excellent wear and corrosion resistance properties. However, hexavalent chromium has come under increasing scrutiny due to the toxic nature of the bath, effects on the environment, and workers' health. Faraday will present material property results comparable to existing hexavalent chromium plating for functional applications.

Faraday has demonstrated that the chrome coatings prepared using the FARADAYIC℠ Process have equivalent functional properties to the coatings produced with a hexavalent chromium bath (Table 1). These data demonstrate equivalent or superior: 1) plating rate, 2) Knoop hardness, 3) current efficiency, 4) hydrogen embrittlement behavior, 5) adhesion, 6) corrosion resistance, 7) porosity, 8) thickness, 9) Taber Abrasion, Ball on Flat Reciprocating and Dithering wear resistance (Figure 1), and 10) no hexavalent chromium formation over a 1400 A-hr processing window. These data demonstrate the feasibility of the process and provide the basis for further technical qualification and prototype design. This paper will discuss the demonstration and development of a FARADAYIC℠ Chromium Electrodeposition process for hard to access, complex shapes, such as the interior of cylindrical shafts.

The FARADAYIC℠ Process was designed to mimic existing commercial plating process so that installation would simulate a true drop-in replacement. This effort ensured the development of the process to industrial standards. Mr. Steve Gaydos (Technical Fellow at Boeing Research and Technology) noted the following:

1. Changing from conventional hexavalent chromium plating to the trivalent chromium electrolyte would only require the additional expense of a new power supply and dimensionally stable anodes,
2. Coating the ID of a pipe 8" x 1½" ID is practical and inexpensive (compared to other ID coating processes) with this non-line-of-sight process.
3. The process appears to produce coatings that are potentially easily scalable,
4. The chrome produced from this process has previously demonstrated the desired hardness, corrosion resistance, thickness, adhesivity, and wear resistance, and
5. This process has the potential to negate the need for additional drawings or specification to be developed before implementation.

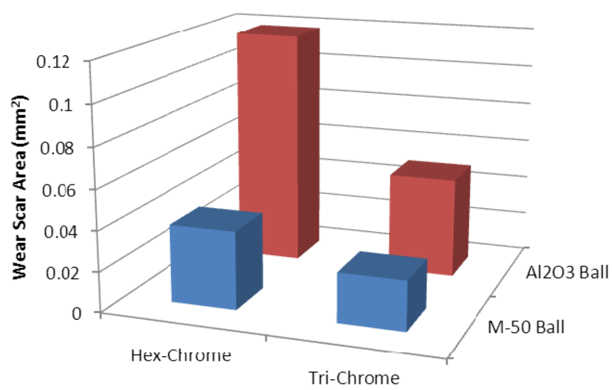

Figure 1: Data from Ball on Flat Dithering Wear tests: top) wear scar depth, and bottom) wear scar area.

Acknowledgement

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Table 1: Data comparison of a current hexavalent chromium process and Faraday's trivalent chromium process

Characterization Test (per Standard)	FARADAYIC℠ Trivalent Chromium Plating
Thickness (per AMS 2460, 3.4.1)	Comparable to hexavalent chromium plating
Knoop Hardness (per AMS 2460, 3.4.3)	Comparable or superior performance to hexavalent chromium plating (800-1000 KHN) [Average 947 KHN]
Hydrogen Embrittlement (per ASTM F519 1a.1)	Comparable performance to hexavalent chromium plating
Porosity (per AMS 2460, 3.4.4)	Comparable performance to hexavalent chromium plating
Adhesion (per ASTM B 571)	Comparable performance to baked hexavalent chromium plating
Corrosion Resistance (ASTM B117)	Comparable performance to baked hexavalent chromium plating
Plating Rate	3.5 mils/hr compared to 1 mils/hr
Current Efficiency	42% compared to 15%
Hexavalent Chromium Formation	After 1400 A-hr, no observed Cr^{6+} formation
Taber Abrasion Test (ASTM D4060)	Comparable performance to baked hexavalent chromium plating
Reciprocating Ball on Flat (ASTM G133)	Comparable performance to baked hexavalent chromium plating
Oscillation (Dithering Wear Test)	Comparable performance to baked hexavalent chromium plating