Cirrus Hybrid™ Technology

An innovative coating system for light metal substrates

Chris Goode | chris.goode@cirrusmaterials.com
Hybrid coating system

Conductive, anti-corrosion, nano-structured coatings

Acc.V  Spot Magn  Det  WD | 1 \mu m
20.0 kV  5.0  50000x  BSE 5.4
Why of Hybrid coating

- Compared to traditional anodising
- Compared to electroless NiP
- Compared to primer and paint systems

Low cost, Non-toxic, non-hazardous!

Many Important Product Attributes are Controlled by the Coating System
- Wear resistance
- Tribology
- Magnetic Properties
- Solderability
- Weldability
- Hardness
- Thermal properties
- Corrosion Resistance
- Appearance
How does Hybrid coating work

Cirrus Hybrid™ - patented coating process
How does Hybrid coating work

Anodising

Electrodeposition

Deposition

Alloy Part

Nanotube Array

Deposit Growing Up Nanotube

Functional Coatings

Images: Scanning Electron Microscope (SEM) images of hybrid coatings.
How does Hybrid coating work

1. **Alloy Part**
2. **Anodising**
3. **Nanotube Array**
4. **Electrodeposition**
5. **Deposit Growing Up Nanotube**
6. **Functional Coatings**
Advantages of Hybrid coating

- Low cost
- High performance from thin coating
- Simple process
- Uses existing production processes & equipment
Hybrid™ Properties

Early performance data
Corrosion Properties of Hybrid coating

Neutral Salt Spray - ASTM B117

6 micron duplex Hybrid Ni
- Anodising 2 microns
- Columnar nickel 4.5 microns
- Laminar nickel 1.5 microns

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Conductivity mΩ/in²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
</tr>
<tr>
<td>&gt; 120</td>
<td>0.3</td>
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</table>

10 micron duplex Hybrid Ni
- Anodising 2-3 microns
- Columnar nickel 7 microns
- Laminar Nickel 3 microns

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Conductivity mΩ/in²</th>
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<tbody>
<tr>
<td></td>
<td>Pre</td>
</tr>
<tr>
<td>&gt; 500*</td>
<td>0.25</td>
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* > 75 hours CASS
Electrical Properties of Hybrid coating

Thermal Cycling - Mil-Std-883 Method 1010 Condition F

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<tr>
<th>Temperature</th>
<th>Duration</th>
<th>5 Cycles</th>
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<tr>
<td>-65°C</td>
<td>30 minutes</td>
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<tr>
<td>+25°C</td>
<td>2 Minutes</td>
<td></td>
</tr>
<tr>
<td>+175°C</td>
<td>30 Minutes</td>
<td></td>
</tr>
<tr>
<td>+25°C</td>
<td>2 Minutes</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Hybrid Coating Thickness</th>
<th>Conductivity Pre</th>
<th>Conductivity Post</th>
<th>Crack or Peel</th>
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<tbody>
<tr>
<td>6 micron</td>
<td>0.3 mΩ/in²</td>
<td>1.2 mΩ/in²</td>
<td>No</td>
</tr>
<tr>
<td>10 micron</td>
<td>0.3 mΩ/in²</td>
<td>0.9 mΩ/in²</td>
<td>No</td>
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</tbody>
</table>
Mechanical Properties of Hybrid coating

Adhesion - ASTM B571

- Samples tested:
  - As coated
  - After Thermal Shock Testing
  - After NSS testing
- Tests Performed
  - Scribe grid test
  - Mandrel bend test
Aesthetic Properties of Hybrid coating

Can produce an hemispherical Surface Morphology

Tune-able surface morphology allows creation of hydrophilic, hydrophobic, or unique surface aesthetic.
Surface Properties of Hybrid coating

Cirrus Hybrid™ HMSC

Typical Bright Nickel Coating on Aluminium
Optical Properties of Hybrid coating

UV-Vis-infrared light absorption properties

The Surface Morphology of the Hybrid Black Nickel Coating

UV-Vis-infrared light absorption properties

Hybrid™ Black Ni (red) versus standard Black Ni.
Hybrid Titanium

Acc.V  Spot Magn  Det  WD  1 μm
5.00 KV  2.0  50000x  TLD 5.4  TiO2 60V - 40V/30min
Hybrid Ti: deposit of Cu Nano-particles

Electro-polishing ➔ Anodizing ➔ Post-treatment ➔ Electroplating

- Ethanol washing & HF activation
- Copper Pyrophosphate

- Short plating time supports formation of copper nanoparticles with interesting bacteriological properties
- Nano particles can facilitate plating of other metals
- Low adhesion between substrate and anodized layer
- Longer plating produces uniform copper with poor adhesion
Hybrid Ti: Nickel coating

- Anodizing
- Oxide removal
- Anodizing
- Post treatment
- Annealing
- Plating

- Duplex nickel plating provides best results
- Annealing increases wettability and improves pore filling
- Adhesion between anodising film and plated coating excellent
- Adhesion of annealed film to substrate excellent
- Problems exist with bending adhesion after plating
Functional Top Layer

Hardened & nano-structured multi-layer coating
Use of Cirrus Dopant™ with Hybrid coating

Hard surfaces: Cirrus Hybrid™ + Cirrus Dopant™

Functional upper layer can be any material, plated or coated directly onto the protected light metal substrate.

Gold, Silver, Nickel (NiB, NiCo, NiP), Cobalt (CoP, CoW), Cr, Cu, Zn, Sn ...

Or combined with a Cirrus Dopant™ to create a nano-structured, hardened composite functional upper layer.
• Liquid to liquid – forms sub 20nm particles which do not agglomerate
• Designed to be stable and highly dispersed in the bath
• Safe to handle
Cirrus Hybrid™ plus Cirrus Dopant™
Co-efficient of Friction

Cirrus Hybrid Black Ni

Cirrus Hybrid Black Ni with Cirrus Dopant™
Cirrus Hybrid™ coating system for light metals

Low cost, high efficiency coating system that utilises existing production processes

Excellent conductivity, corrosion resistance, adhesion, thermal stability.

Hemispherical functional coatings creates aesthetic, mechanical & optical properties.

Can be combined with nano-structured and hardened composites, or ultra black upper layers.