SuperChrome™ PVD Coating

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Vergason Technology, Inc.

- Design, assembly, process development and commissioning of PVD/PECVD plasma equipment and turn key solutions
- Service and Distribution partners in Europe, Asia, Central/South America
- Job Coating Services available in USA
- First Rapid Cycle Coater built: 1988
  - 37 second cycle time, LEAN manufacturing
- > 200 Systems installed worldwide
- 35 Years experience in PVD technology
  - Tribological, shielding, reflective, decorative coatings
- Sales & Service in Europe provided by jobaTEC GmbH
Physical vapor deposition (PVD) describes deposition methods used to deposit thin films by the condensation of a vaporized form of the desired film material (e.g. aluminum, chrome) onto the substrate surfaces (e.g., automotive plastic parts).

The coating method involves physical processes such as high-temperature vacuum evaporation with subsequent condensation, or plasma sputter bombardment. Includes: thermal, sputtering and cathodic arc deposition.
Advantages of PVD

- **REACH-conform:** both in production and disposal avoiding Cr3+, Cr6+ and Ni
- **Environmentally-friendly:** clean technology, few waste issues
- **Color flexibility:** broad spectrum of color shades and effects in chrome from bright chrome to dark chrome and colored PVD
- **Corrosion resistance:** applies to automotive test requirements in combination with or without top coat
- **Safety aspect:** The thin PVD coating and the use of flexible substrates enables safety-relevant applications e.g. impact protection airbag emblems and others
PVD Metallizing versus Chrome Plating

Chrome Plating

- Base (Plastic)
- Electroplated Cu + Ni ~ 35 μ
- Bright Nickel
- Semibright Nickel
- Acid Copper
- Copper strike
- Metallizing electroless

0.2 - 0.3 μ

PVD Metallizing

- Base (Plastic)
- UV / Thermal Primer Base Coat
- UV / Thermal Top Coat
- PVD Metal Coating
- Bright Chrome
- Microporous Nickel
- High “S” Nickel

Traditional Triple Stack:
Base Coat/PVD/Top Coat
SuperChrome™ PVD versus Triple Stack Coating

PVD Metallizing

Traditional Triple Stack:
Base Coat/PVD/Top Coat

- UV / Thermal
  - Top Coat 15 – 25 μm
- UV / Thermal
  - Primer Base Coat 15 – 25 μm

Base (Plastic)

Top Coat Darkens, Color Loses Depth

SUPERCHROME PVD Coating

Double Stack:
Base Coat/PVD
No Top Coat necessary

- UV / Thermal
  - Primer Base Coat 15 – 50 μm

Base (Plastic)

SUPERCHROME

0.3 – 1.15 μm

True Deep Chrome Color
Functionality and Design Choices

- **Large variety on substrate materials:** PC/ABS, PC, ABS, PPE, PA, ASA, PC/PBT, BMC
- **Day/Night Design** with Laser etching
- **Radar-Transparency** metalized components to not block crash avoidance and lane changing monitoring systems
- **Light Transparency:** based on partially transparent PVD coatings
- **Integration of Capacitance Sensing**
- **Temperature range:** 40° to 85°C
- **Full integration** into paint lines using UV-cured base coat
- **Variety of metal targets:** aluminum, chrome, titanium, stainless steel, nickel chrome, copper, silver, gold, brass etc.
SuperChrome: Versatile & Durable

Two Layer Decorative Coating for Automotive Interior/Exterior Parts

- Substrate + UV-Base Coat + SUPERCHROME PVD Coating: No top coat necessary
- Possibility to apply on different plastics and metal alloys
- Several UV-cured base coats (Mankiewicz) for different SUPERCHROME PVD Coating finishes tested and approved
- No corrosion risk, excellent adhesion, thermal stability and humidity resistance
UV Base Coat for SUPERCHROME PVD Coating

• Superior product properties
  • Specification-compliant properties: mechanical and chemical resistance
  • Excellent surface for support and adhesion of PVD coatings

• Short process times
  • CYCON® UV coatings are fully cured within seconds
  • Complete elimination of oven drying

• Low capital expenditure requirements:
  • Requires less production floorspace

• Shorter processing saves energy and investment costs

• Low VOC
SuperChrome: Versatile & Durable

Two Layer Decorative Coating for Automotive Interior/Exterior Parts

• Environmentally compatible alternative to galvanic Chrome (REACH – conform)

• Can be altered in appearance to achieve certain design effects (bright/medium/dark Chrome)

• SUPERCHROME PVD Coating meets major test requirements for automotive interior and exterior parts.
UV Streamlines Manufacturing for Profitability

- Short, fast processing time
- Low scrap rate
- Smaller footprint than thermal cure paint lines
- Integrates into LEAN synchronous manufacturing

Cleaning ➔ Spraying UV paint ➔ Flash-off ➔ UV Curing ➔ PVD Coating

3 – 5 min
Technical Performance: Met or Exceeded

- Formal Specifications
  - Appearance
  - Adhesion
  - Weathering
  - Mechanical
  - Chemical resistance

- New Attributes
  - Weight savings
  - Flexibility
  - Laser etch ➤ day/night
  - Capacitive sensing
# Test Results – Visual, Adhesion, Weathering

<table>
<thead>
<tr>
<th>Standards Tested - Visual, Adhesion, Weathering</th>
<th>SuperChrome™ with UV Base Coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Appearance Interior VW TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>Initial Adhesion Interior VW TL226 &amp; Exterior VW TL211/528</td>
<td>PASS</td>
</tr>
<tr>
<td>Visual Appearance after 2d 60°C Interior VW TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>Adhesion after 2d 60°C Interior VW TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>Visual Appearance after 24 h 90°C Interior TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>Visual Appearance after Constant Climate 240h 40°C, &gt;96% relative humidity Interior VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Adhesion after Constant Climate 240h 40°C, &gt;96% relative humidity VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Artificial Aging UVB Procedure A PSA B72 0200/2013-04</td>
<td>PASS</td>
</tr>
<tr>
<td>Water Absorption BAC FORD PSA B72 0200/2013-04</td>
<td>PASS</td>
</tr>
<tr>
<td>PV1200 Climate Change Test VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Neutral Salt Spray VW TL528</td>
<td>PASS</td>
</tr>
<tr>
<td>Salt Spray ASTM B117-11</td>
<td>PASS 1000 Hours</td>
</tr>
<tr>
<td>CASS</td>
<td>PASS 120 Hours</td>
</tr>
<tr>
<td>PV3930 Florida Sunshine VW TL211</td>
<td>PASS 2400 Hours</td>
</tr>
<tr>
<td>Russian (CaCl2)Mud per ASTM B995</td>
<td>PASS 336 Hours</td>
</tr>
<tr>
<td>Hydrolysis 95°C, 95% RH, 72 hour</td>
<td>PASS</td>
</tr>
</tbody>
</table>
# Test Results - Mechanical

## Standards Tested - Mechanical

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to Gritting Renault 47-03-003/L-2013</td>
<td>PASS</td>
</tr>
<tr>
<td>Stone Chipping, VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Stone Chipping, PSA B72 0200/2013-04</td>
<td>PASS</td>
</tr>
<tr>
<td>Gravelometer/70 CASS</td>
<td>PASS</td>
</tr>
<tr>
<td>Resistance to Scratching byAbrasion Renault 47-03-003/L-2013</td>
<td>PASS</td>
</tr>
<tr>
<td>Crockmeter BMW Exterior</td>
<td>PASS</td>
</tr>
<tr>
<td>Car Wash Brush Resistance VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Abrex</td>
<td>PASS</td>
</tr>
<tr>
<td>Martindale</td>
<td>PASS</td>
</tr>
</tbody>
</table>
# Test Results - Chemical

<table>
<thead>
<tr>
<th>Standards Tested - Chemical</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream A Interior VW TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>Cream B Interior VW TL226</td>
<td>PASS</td>
</tr>
<tr>
<td>High Pressure Cleaning VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Hydrolysis Interior BMW</td>
<td>PASS</td>
</tr>
<tr>
<td>FAM test fuel VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Gasoline E10 VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Diesel B7 VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Isopropanol VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Ethanol/Water Exterior BMW</td>
<td>PASS</td>
</tr>
<tr>
<td>Sodium Hydroxide 5% VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Sulfuric Acid 10% VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Hydrochloric Acid 10% VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Hydrochloric Acid 30% Suspended in Vapors</td>
<td>PASS 24 Hours</td>
</tr>
<tr>
<td>Bird Droppings VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Liquid Tree Pitch VW TL211</td>
<td>PASS</td>
</tr>
<tr>
<td>Vomit Exterior BMW</td>
<td>PASS</td>
</tr>
<tr>
<td>Deionized Water Exterior BMW</td>
<td>PASS</td>
</tr>
<tr>
<td>Wheel Cleaner Exterior BMW</td>
<td>PASS</td>
</tr>
<tr>
<td>Underbody Sealant BMW</td>
<td>PASS</td>
</tr>
</tbody>
</table>
SUPERCHROME PVD Coating System
Integrated production - Batch

SUPERCHROME 660 PVD Coating System

- Batch-type rapid cycle metallizer
- sputter-coating
- Deposit metals such as chromium, aluminum, brass, copper, stainless steel, nickel - chrome alloys, etc.
SUPERCHROME PVD Coating System
Integrated production - Batch

SC 660 PVD Coating System

Single-point loading and safety enclosure
Robotic load/unload available
Conclusions

- PVD process and equipment technology is making strong headway for safe replacement of some applications of electroplated chromium on plastic substrates.
- Key work for chromium coatings on plastic substrates with no top coating was started four decades ago.
- SUPERCHROME PVD Coatings are gaining acceptance for internal and external automotive applications as well as for use in sanitary and appliance markets.
- Batch and Inline-Systems available.
- Job coating services available in USA.