A Bulk, Low Energy Surface Treatment for 3-Dimensional Substrates via CVD Processing
Taking Control of Surfaces

• Silicon (Si) naturally prevents unwanted chemical reactions (adsorptive or corrosive) with substrate

• Functionalization further enhances silicon’s advanced properties for demanding applications

• Chemical Vapor Deposition (CVD) process provides robust and repeatable outcomes
SilcoTek® Introduction

- Born in chromatography
- SilcoTek launched in 2009
- Focused exclusively on CVD coatings
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What we do

- Thermal chemical vapor deposition (CVD) “coatings”
- Amorphous silicon (a-Si)-based
- Functionalization for advanced properties
The CVD Process

Part to be coated

Processing Chamber (vacuum)

Gas Supply

Up to 450°C
Advantages of CVD

• Non-line-of-sight; uniformly treats 3D, high aspect ratio part geometries

• Molecular adhesion to base substrate

• Scalable, versatile, and highly reproducible
Coating Adhesion (Pull Strength)

- Adhesive Strength to Dursan® Fails Before Coating Adhesion to Substrate (>200-300 PSI)
Elemental Composition

* - Auger Electron Spectroscopy depth profile of Dursan® on 304 S.S.
Coating Properties

1. Chemical inertness
   – Accurately analyze trace (as low as parts-per-trillion) H2S, mercury, ammonia, etc.

2. Corrosion resistance
   – Longer life, less maintenance, lower costs

3. Low energy
   – Hydrophobicity, anti-stiction, anti-coking, etc.
Chemical Inertness

Preventing adsorption to allow chemical detection at trace (<ppm) levels
Inert Barrier Stops Reactivity

Methyl Mercaptan (CH₃SH) Recovery

CH₃SH Response (millions of counts)

Retention Time (min)

0.5 ppmv CH₃SH in helium

Sample 1: Standard RVS weldless
Sample 2: TrueTube EP
Sample 3: TrueTube EPS

*Data courtesy of Shell Research Technology Centre, Amsterdam and O’Brien Corp.

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Corrosion Resistance

Increasing usable lifetime of ideal materials of construction
Corrosion Resistance

- ASTM G31 Guidelines
- 15% NaClO Exposure
- 72 hrs at Room Temperature

- ASTM G31 Guidelines
- 6M HCl Acid Exposure
- 24 hrs at Room Temperature
Salt Spray

- 24 weeks of acidified salt spray per ASTM G85-A2. Total exposure time: 4032 hours.

- Uncoated coupons: moderate rust on all faces

- Duplex alloy 2205 showed rust on edges

- Dursan-coated coupons: no visual rust or weight loss
Dursan® shows dielectric stability over 220+ days in salt water, demonstrating sustained corrosion resistance.
Low Energy

Increasing efficiency by preventing adhesion of unwanted media
Low Energy, High Potential

- Substantially reduce coking/fouling
  - Improve fuel efficiency in auto applications

- Prevent sticking
  - Biomaterials, chemicals, etc.

- Improve hydrophobicity
  - Needed in process monitoring, sampling, and other analytical applications
Hydrophobicity

<table>
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<th>Material</th>
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<th>Rough Coupons</th>
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<tr>
<td>SN 1000</td>
<td>49</td>
<td>Rough: 120 grit; 58 rms (µin.)</td>
</tr>
<tr>
<td>SN 2000</td>
<td>101</td>
<td>Smooth: mirror-like #8; 10 rms (µin.)</td>
</tr>
<tr>
<td>Dursan</td>
<td>121</td>
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<tr>
<td>FluoroDursan</td>
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Oleophobicity

SilcoTek-Coated

- Hexadecane on rough: 92.6°
- Hexadecane on smooth: 66.0°
- 10W40 oil on rough: 95.5°
- 10W40 oil on smooth: 70.2°

PTFE

- Hexadecane on PTFE: 29.7°
- 10W40 oil on PTFE: 48.5°
Stability of Low Energy Surface

FluoroDursan on 316
Contact Angle Change vs. Thermal Oxidation Exposure

- DI Water
- Hexadecane

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Summary

• Functionalized silicon coatings provide ideal properties not attainable with base metals

• 3D CVD coating process is robust regardless of part complexity or tolerances

• Whether in the field or lab, SilcoTek coatings offer advanced surface performance
Questions?