NanoProof® Series
Improved IP-X7 Waterproof Technology

WEBINAR November 2016
Edward Hughes
CEO of Aculon, producers of NanoProof Series

Mario Gattuso
Senior Business Development Manager, Electronics
AGENDA

• Overview
• NanoProof Series Overview
• Introduction of NanoProof 7.0 & 8.0
• Application methods
• Competitive Comparison
• Case Studies
• Q&A
Aculon is a leading provider of surface modification technologies

- **Surface Solution Experts** – develop & produce technologies to modify a broad variety of surfaces (metals, glass, polymers).
- **Treatments include** - create hydrophobic, oleophobic, hydrophilic, adhesion promoting treatments.
- **Treatments are very thin**, easy to apply and need minimal equipment.
- **3 Units**- Electronics, Oil & Gas, Specialty
- **Business Model**: produce chemistry
- **Location**: San Diego Headquarters, worldwide distribution
In real life, consumers too often damage their devices

- Unit exposed to outdoor environment – rain, irrigation, humidity
- Consumer electronics exposed to splashing water
- Equipment (industrial and medical) exposed to wet working
- Device dropped in pool or even toilet
Aculon NanoProof® Series provides water protection from humidity to full water immersion

- Utilize proprietary technology
- Surpass competitive coatings in performance and ease of use
- Application equipment affordable and readily available
- Range of treatments available to meet performance, thickness, application and economic needs.
1. Reduce Product returns due to water damage
2. Improve yields as rework is possible after coating
3. No or minimal masking required
4. Coatings are safe, non toxic and can be used in factory environment
5. Affordable
The IPX standards provide a waterproofing scale and possibly design changes.

<table>
<thead>
<tr>
<th>IPX Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Protected against continual water submersion in under water conditions.</td>
</tr>
<tr>
<td>7</td>
<td>Protected against water immersion for 30 minutes at a depth of up to 1 meter.</td>
</tr>
<tr>
<td>6</td>
<td>Protected against high pressure water stream from any angle.</td>
</tr>
<tr>
<td>5</td>
<td>Protected against low pressure water stream from any angle.</td>
</tr>
<tr>
<td>4</td>
<td>Protected against splashing water from any angle.</td>
</tr>
<tr>
<td>3</td>
<td>Protected against spraying water when tilted up to 60 degrees vertically.</td>
</tr>
<tr>
<td>2</td>
<td>Protected against spraying water when tilted up to 15 degrees vertically.</td>
</tr>
<tr>
<td>1</td>
<td>Protected against condensation or dripping water falling vertically.</td>
</tr>
<tr>
<td>0</td>
<td>No Protection</td>
</tr>
</tbody>
</table>
Achieving higher levels of IPX has been challenging—like Mountain climbing.
<table>
<thead>
<tr>
<th>LEVEL 1</th>
<th>LEVEL 2</th>
<th>LEVEL 3</th>
<th>LEVEL 4</th>
<th>LEVEL 5</th>
<th>LEVEL 6</th>
<th>LEVEL 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dripping Water</td>
<td>Dripping water 15°</td>
<td>Spraying water</td>
<td>Splashing water</td>
<td>Waterjets</td>
<td>Power waterjets</td>
<td>Immersion Up to 1 m</td>
</tr>
<tr>
<td>Clothes-dryer</td>
<td>Clothes-washer</td>
<td>Telephone</td>
<td>Hearing Aids</td>
<td>Camera</td>
<td>Air-conditioner</td>
<td>Cell phone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clock</td>
<td>Doorbell</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Computer</td>
<td>Outdoor lighting</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>Electric Drill</td>
<td>Junction Boxes</td>
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<td></td>
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<td></td>
<td>Headphones</td>
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<td></td>
<td>Laptop</td>
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<td>Printer</td>
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<td></td>
<td>Television</td>
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<td></td>
<td>Automotive-electronics</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bluetooth headsets</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flashlight</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Devices with high customer expectation

**Aculon**
INTRODUCING NANOPROOF® 7.0 & 8.0

1. Offers extreme level IPX7 protection – often on the first round

Devices Treated with NanoProof 7.0 or 8.0 Survive 30+ minutes of submersion in water!
NanoProof 7.0 and 8.0 provides a fast route to IPX-7 and beyond.
INTRODUCING NANOPROOF® 7.0 & 8.0

1. Offers extreme level IPX7 protection – often on the first round of optimization

2. Thixotropic Formulation allows 7.0 & 8.0 to coat complicated geometries with no slumping or areas of thin coating which could lead to failure

3. Easy to apply via film coat equipment or dip/flow coating options

4. Maintains numerous benefits of the pre-existing NanoProof products
   - No/minimal Masking
   - Rework Possible,
   - Safe
   - Affordable
Mario Gattuso
Senior Business Development Manager, Electronics
Aculon NanoProof® Series provides water protection from humidity to full water immersion

- 6 treatments (1.0-8.0) available to meet performance requirements
- Barrier properties increase
- All application equipment affordable and readily available – all spray / film coat

Winner 2016 Circuits Assembly
New Product Introduction Award
<table>
<thead>
<tr>
<th>Technology</th>
<th>NanoProof 1.0</th>
<th>NanoProof 3.5</th>
<th>NanoProof 4.0</th>
<th>NanoProof 5.1</th>
<th>NanoProof 7.0</th>
<th>NanoProof 8.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Hydrophobic TMC based coating in hydrocarbon solvent</td>
<td>Hydrophobic / oleophillic siloxane based coating in hydrocarbon solvent</td>
<td>Hydrophobic siloxane based coating in hydrocarbon solvent</td>
<td>Hydrophobic / oleophobic fluoroacrylate based coating in fluorosolvent</td>
<td>Hydrophobic/ oleophobic fluoroacrylate based coating in fluorosolvent</td>
<td>Hydrophobic polyolefin based in toluene solvent</td>
</tr>
<tr>
<td>Water Contact Angle</td>
<td>100° - 115°</td>
<td>110°-115°</td>
<td>115°-120°</td>
<td>120°-125°</td>
<td>120°-125°</td>
<td>110°-115°</td>
</tr>
<tr>
<td>Oil Contact Angle</td>
<td>&lt;20°</td>
<td>&lt;20°</td>
<td>&gt;20°</td>
<td>&gt;80°</td>
<td>&gt;80°</td>
<td>&lt;20°</td>
</tr>
<tr>
<td>Barrier Effectiveness</td>
<td>Good</td>
<td>V Good</td>
<td>Better</td>
<td>Better</td>
<td>Best</td>
<td>Best</td>
</tr>
<tr>
<td>Thickness</td>
<td>1µm</td>
<td>5-10µm</td>
<td>5-10µm</td>
<td>5-10µm</td>
<td>50-100µm</td>
<td>50-100µm</td>
</tr>
<tr>
<td>Includes UV Tracer</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>During solvent evaporation</td>
<td>During solvent evaporation</td>
<td>Yes</td>
</tr>
<tr>
<td>Deformable?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>During solvent evaporation</td>
<td>During solvent evaporation</td>
<td>Yes</td>
</tr>
<tr>
<td>Sprayable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No (film coat)</td>
<td>No (film coat)</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Make electrical contact through barrier</td>
<td>Allows for push through connectivity</td>
<td>Allows for push through connectivity</td>
<td>While drying allows for push through connectivity</td>
<td>While drying allows for push through connectivity</td>
<td>Allows for push through connectivity</td>
</tr>
<tr>
<td>Handling Post treatment</td>
<td>Ok</td>
<td>Carefully</td>
<td>Carefully</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>
All NanoProof material on the PCB can be inspected by UV inspection system (UV fluorescent bulb).
The coating process depends on the application and including:

1. Spray
   - Preferred for 1.0, 3.5, 4.0, & 5.1

2. Film Coat
   - Preferred for 7.0 & 8.0

3. Dispense

4. Dip
Aculon NanoProof does not impact key components......

<table>
<thead>
<tr>
<th>Component</th>
<th>Fully Functional After NanoProofing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna</td>
<td>Yes</td>
</tr>
<tr>
<td>Headphone* &amp; Microphone*</td>
<td>Yes</td>
</tr>
<tr>
<td>Push buttons</td>
<td>Yes</td>
</tr>
<tr>
<td>Camera*</td>
<td>Yes</td>
</tr>
<tr>
<td>Speakers*</td>
<td>Yes</td>
</tr>
<tr>
<td>Sealed LCD Display</td>
<td>Yes</td>
</tr>
<tr>
<td>Unsealed LCD Display</td>
<td>NO – Don’t coat</td>
</tr>
</tbody>
</table>

* Excluding Nanoproof 5.1, 7.0, 8.0
Types of Treatment  Aculon Treatments 3.5, 4.0, 5.0, 7.0, 8.0

Voltages Tested: 3v, 6v, 12v

Time: 60 minutes i.e. 2X IPX-7

Conditions: Water and Salt Water

Board: IPC Multi-Purpose Test Board

Additional Testing for MIR, Salt Spray & Sweat Solutions

- **Moisture & Insulation Resistance**
  - IPC-CC-830B, AM1

- **Salt Spray (Fog) Exposure**
  - ASTM B117-11

- **Sweat Solution**
  - IBM-H6-0440-105
  - 24 hours at 10V to D and F combs
  - Resistance measured pre and post-test
NANOPROOF® – IPX TESTING

Uncoated fails

NanoProof performs well even at 12 Volts!

Current Leakage!

No Current Leakage!
Spray (Recommended): Conformal Coating spray equipment is highly recommended.
Recommended Equipment:
• Spray & Dispense Valve - The PVA FCS300 Valve recommended - utilized with a manual or automated system seen below.
• Automated & Selective Coating - The PVA Delta 8 Selective Coating / Dispensing System recommended

Dispensing: Effective use of NanoProof for spot application to sensitive areas.

Dipping: Effective for economical applications requiring coverage of entire board with no keep out areas.
Aculon will work with you to determine best application process...

**Film Coat (recommended):** Film Coating can yield a uniform and repeatable process.

**Recommended Equipment:**
- Film Coat Valve - The [PVA FC100-CF](#) recommended.
- Automated & Selective Coating - The [PVA Delta 8 Selective Coating / Dispensing System](#) recommended.

**Dispensing:** Effective use of NanoProof for spot application to sensitive areas.

**Dipping or Flow Coat:** Effective for economical applications requiring coverage of entire board with no keep out areas.

**Spray:** Not Compatible
Equipment required meets a variety of needs. From handheld to batch to inline to high volume automation.
1. Conformal Coatings
2. Parylene
ADVANTAGES OVER CONFORMAL COATINGS

- Provides effective water protection - full submersion → reduce return rate
- Flexible application process – spray, dip, dispense
- Minimal capital equipment required
- Production is continuous process, not batch.
- Treatment allows push through conductivity
- NanoProof treatments enables rework → lowers internal reject rate
- No masking required*. Can even coat batteries
- Fast cycle times < 1 minutes versus 1 – 5 hours in a chamber
- Safe - Non-toxic
# COMPARISON WITH PARYLENE

## Aculon NanoProof series has many advantages over Parylene coatings.

<table>
<thead>
<tr>
<th>Category</th>
<th>Aculon</th>
<th>Parylene</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance</strong></td>
<td>IPX 4-7+</td>
<td>Often IPX 3</td>
</tr>
<tr>
<td><strong>Application methods</strong></td>
<td>Multiple—Dip, spray wipe</td>
<td>Vacuum Deposition only</td>
</tr>
<tr>
<td><strong>Long Lasting Hydrophobicity</strong></td>
<td>Yes</td>
<td>Depends</td>
</tr>
<tr>
<td><strong>Enables Rework</strong></td>
<td>Yes—easily</td>
<td>No</td>
</tr>
<tr>
<td><strong>Capital Equipment</strong></td>
<td>Minimal</td>
<td>Yes &amp; Expensive</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>Continuous</td>
<td>Batch</td>
</tr>
<tr>
<td><strong>Cycle time</strong></td>
<td>Fast: &lt;1 minute</td>
<td>Slow: 1hr-5 hrs. depending on part size and thickness</td>
</tr>
<tr>
<td><strong>Ability to treat complex parts</strong></td>
<td>Yes—low surface energy solution</td>
<td>Maybe—depends on throwing capability</td>
</tr>
<tr>
<td><strong>Masking required</strong></td>
<td>No</td>
<td>Yes and must be “gas tight”</td>
</tr>
<tr>
<td><strong>Lowers Internal reject rate</strong></td>
<td>Yes—can rework</td>
<td>No—cannot rework</td>
</tr>
<tr>
<td><strong>Energy Usage in Production</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Part Size</strong></td>
<td>No limit</td>
<td>Large chambers up to 40”</td>
</tr>
<tr>
<td><strong>Treat Batteries</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Case studies:

1. Bluetooth headsets
2. Wearable devices
3. Outdoor home electronics
4. Hearing aids
5. Cellphone
BLUETOOTH HEADSETS

**Requirement:** Protection from sweat and splashing water, full immersion proofing not required. IPX3 required, IPX4 desired.

**Collaboration:** Aculon treated customer test parts in addition to evaluations at customer site to finalize process.

**Time:** 6 months

**Material selected:** NanoProof 4.0

**Application:** Excluding audio speaker, all electronics sprayed utilizing PVA FCS300 Valve

**Performance:** Passes customer IPX4 Qualification
WEARABLE DEVICES

**Requirement:** Protection from sweat and splashing water, full immersion proofing not required. Needs to protect from rain and shower exposure. IPX4 required, IPX5 desired

**Collaboration:** Aculon treated customer test parts via spray for initial testing. Customer testing identified high voltage components needing additional protection solved by application of spot treatment to reach spec.

**Time:** 6+ Months

**Material selected:** NanoProof 4.0 & NanoProof 5.1 combo

**Application:** All electronics sprayed with 4.0 utilizing PVA FCS300 Valve. Spot application of 5.1 on sensitive components.

**Performance:** Passes customer IPX5 Qualification
OUTDOOR HOME ELECTRONICS

**Requirement:** Protection from splashing water from rain and irrigation equipment, full immersion proofing not required. IPX5 required, IPX6 desired

**Collaboration:** Aculon/Customer collaboration determined most robust option (5.1) needed to protect high voltage components.

**Time:** 9 months

**Material selected:** NanoProof 5.1

**Application:** Excluding audio speaker, and optical components all electronics sprayed utilizing PVA FCS300 Valve with NanoProof 5.1. Electrical connections made using diluent solvent.

**Performance:** Passes customer IPX5 Qualification Required
HEARING AIDS

**Requirement:** Protection from sweat and splashing water, full immersion proofing not required. IPX3 required, IPX4 desired.

**Collaboration:** Customer obtained and tested samples successfully

**Material selected:** NanoProof 4.0

**Application:** Excluding audio speaker, all electronics sprayed utilizing PVA FCS300 Valve

**Performance:** Passes customer IPX4 Qualification
**Requirement:** Protection from sweat, splashing water, high pressure water & full immersion proofing. IPX6 or IPX7

**Collaboration:** Working with several cell phone manufacturers for IPX7 success.

**Time:** 6 months + estimated 3 months

**Material selected:** NanoProof 7.0 & 8.0 in test.

**Application:** Several process options in test.
Every device is different & needs testing!

- Selecting IPX performance requirement drives selection of which NanoProof
  - Impacts coating thickness
  - Impacts costs
  - Handling requirements & manufacturing process

- In general we have experienced no impact on the following
  - Signal strength, WIFI, Bluetooth.
  - Speakers and MIC.*
  - Camera
  - Antenna

- Application method available
  - Spray vs. Dip vs. Dispense

- Board Cleaning – Cleaner is better!
  - Use available PCB cleaning solutions

* Excluding Nanoproof® 5.1
Aculon will work with you to determine best application process...
Flexible approach designed to increase your probability of success...

- **Customer Trial (Good)**
  - Customer buys NanoProof to test on products
  - Customer run tests

- **Aculon Trial (Better)**
  - Customer sends aculon devices to treat.
  - Customer tests

- **Customer & Aculon Collaboration (Best)**
  - Set up Design of Experiments to determine best treatments for application
  - Review results and iterate
Presentation
• Will be emailed to all attendees and will be hosted on the Aculon.com NanoProof page

To discuss collaboration or order samples of NanoProof
• Contact Mario Gattuso  gattuso@aculon.com

For questions and volume quotes for NanoProof
• Contact Mario Gattuso  gattuso@aculon.com
In summary

- Leading supplier of NanoScale Repellency Technology
- Qualified and in production on numerous applications
- Easy to apply & cost effective
- NanoProof® Series provides options based on performance requirements
- Proven to outperform competitive technology
- Aculon supply NanoProof series globally
Questions
Please contact: gattuso@aculon.com

Aculon tested at 3 volts, 6 volts, 12 volts.
NANO COATING THICKNESS MEASUREMENT ON COATED WITNESS COUPON

Blank stainless steel substrate

NanoProof 1.0 coating thickness on stainless steel substrate

NanoProof 4.0 coating thickness on stainless steel substrate

NanoProof 5.1 coating thickness on stainless steel substrate
NANO COATING THICKNESS MEASUREMENT ON COATED PCBA
Aculon’s preferred choice of equipment vendor is PVA, one of the world leaders in spraying and dispensing automation:

- Founded in 1991
- Located in Cohoes, New York, 15 miles north of Albany
- Currently has Demo and Service Centers located in:
  - US
  - Finland
  - UK
  - Brazil
  - Mexico
  - Singapore
  - China
- All systems manufactured in-house in New York, USA
- PVA has Representatives in over 30 countries including South Korea
### Contact Angle Post Measurement

<table>
<thead>
<tr>
<th>Part Description</th>
<th>NanoProof Material</th>
<th>Deposition Method</th>
<th>Average WCA</th>
<th>Average OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB (no clean prior to coating)</td>
<td>Nanoproof 5.1</td>
<td>Spray</td>
<td>121°</td>
<td>82°</td>
</tr>
<tr>
<td>PCBA (clean prior to coating)</td>
<td>Nanoproof 5.1</td>
<td>Spray</td>
<td>124°</td>
<td>88°</td>
</tr>
</tbody>
</table>

Legend:  
WCA = Water Contact Angle  
OCA = Oil Contact Angle

**Contact angle instrument**