NanoProof® Series
PCB Water Protection Technology
Agenda

Aculon Overview
Aculon Technology Overview
NanoProof™ Series - PCB Waterproofing
NanoProof™ Series – Devices
NanoProof™ Coating Equipment
Summary
Questions
Edward Hughes
  ➢ CEO of Aculon, producers of NanoProof® Series

Eric Hanson PhD.
  ➢ Vice President of Technology and inventor of NanoProof Series

Mario Gattuso
  ➢ Senior Product & Business Development Manager, Electronics
Overview

Aculon is a leading provider of surface modification technologies.

- Surface Solution Experts who supply treatments to large markets including oil & gas, consumer products & electronics – over 25 commercial programs
- Strong IP – 28 granted patents and 15 in process
- Provide repellency technology that modifying surfaces in seconds with little or no capital.
- Electronics - NanoClear® – award winning stencil technology
NanoClear Stencil treatment:

- #1 Global Stencil NanoCoating Since 2013
- Modify stencil contact surfaces with a **flux-repellent** nanocoating in minutes
  - Increase yields and output on SMT assembly lines
  - Improve print quality and reduce variation
  - Lower Cost
Aculon is a leading provider of surface modification technologies.

- Surface Solution Experts who supply treatments to large markets including oil & gas, consumer products & electronics – over 25 commercial programs
- Strong IP – 28 granted patents and 15 in process
- Provide repellency technology that modifying surfaces in seconds with little or no capital.
- Electronics - NanoClear – award winning stencil technology
- NanoProof™ Series for PCB water protection launched in May 2015
NanoProof Series:

- Modify PCBs surfaces to be **water repellent** in minutes
  - Reduce product failure
  - Improve product life & reduce returns
  - Improve yields as enable rework
  - Reduce cost

- Utilize proprietary technology
- Surpass competitive coatings in performance and ease of use
- Application equipment affordable and readily available
About Aculon

- Specializes in developing and supplying easy to apply surface modification treatments
- Treatments Include: Hydrophobic, Hydrophilic, Oleophobic
- Headquarter in San Diego, CA
- Distribution partners in Asia
- www.aculon.com
Portfolio of Technologies

Other Surface Modification

Transition Metal Complexes

Polymeric Organometallics

SAMP & Organometallic
Expertise & Platforms

Specialty - Particles

- Optical
- Sapphire
- Watch

Surface Modification

NEW
- Medical Diagnostics

Oil & Gas
- Anti Fouling
- Proppant
- Rock Formation

Electronics
- PCB protection

Electronics
- Stencils
Agenda

Aculon Overview

Aculon Nanotechnology

NanoProof™ Series - PCB Waterproofing

NanoProof™ Series – Devices

NanoProof™ Coating Equipment

Summary
Why do you need waterproofing?

In real life, PCB’s are often damaged by water

- Device dropped in pool or even toilet
- Unit exposed to outdoor environment – rain, humidity
- Household appliances exposed water during operations
- Equipment (industrial and medical) exposed to wet working
A Fast Start......

Aculon NanoProof qualified in variety of applications

- Mobile Device
- Wearable Electronics
- Exterior “Smart” Home Electronics
- Outdoor Fitness Electronics
- Many others electronics in test......including automotive, appliances, lighting
Benefits include:

- Aculon NanoProof Series provides water protection from humidity to full water immersion
- Reduce product returns due to water damage
- Improve yields as rework is possible after coating
- No or minimal masking required
- Coating is safe, non toxic and can be used in factory environment
Aculon NanoProof™ Series offerings utilize proprietary coating that makes objects hydrophobic

Series Features
- Series of formulations available (from nanoscale to microns)
- Economical
- Application options including dipping, spraying or dispense
- Limited equipment required
- Provide UV tracer for QC processes

Aculon NanoProof™
- Hydrophobic +100° water contact angle
- Ability to protect a wide number of surfaces on PCB
- Liquid at room temperature
- Thin (nanometers to microns)
- No impact on conductivity
- Thermal stable to 200°C
- Easy to rework after coating
# NanoProof™ Series Comparison

<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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></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>
</tr>
<tr>
<td><strong>Water Contact Angle</strong></td>
<td>100°</td>
<td>100°</td>
<td>115°</td>
<td>115°</td>
</tr>
<tr>
<td><strong>Barrier Effectiveness</strong></td>
<td>Good</td>
<td>Better</td>
<td>Even Better</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>&lt;200nm when sprayed</td>
<td>10-15µm thick when spray applied, 20-25µm when dispensed</td>
<td>10-15µm thick when spray applied, 20-25µm when dispensed</td>
<td>15µm when sprayed</td>
</tr>
<tr>
<td><strong>Includes UV Tracer</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Deformable?</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>During solvent evaporation</td>
</tr>
<tr>
<td><strong>Sprayable</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Dip/Dispense/Spray options</td>
</tr>
<tr>
<td><strong>Conductivity</strong></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>
</tr>
<tr>
<td><strong>Handling Post treatment</strong></td>
<td>Ok</td>
<td>Carefully</td>
<td>Carefully</td>
<td>OK</td>
</tr>
</tbody>
</table>
Aculon will work with you to determine best application process...

- **Spraying**: RECOMMENDED
  - Process duration is approximately 5 sec per board (Often no masking required)
  - Drying varies from 10 seconds NanoProof 1.0 to 30 minutes for NanoProof 5.1
  - 1.0-1.5 ml per Board (3” by 5”)
  - Multiple applications will build additional thickness for challenging areas

- **Dispensing**:  
  - Can be very effective in terms of use of chemistry
  - Allows for varying application amount for sensitive areas

- **Dipping**:  
  - Process duration is approximately 30 sec per dip
  - Dipping environment is 1.0 atm & room temperature
  - Dipping cycle time is depending on dipping machine
  - Drying varies from 30 seconds NanoProof 1.0 to 30 minutes for NanoProof 5.0
  - Recirculating bath with filter
  - <1ml per Board per side (3” by 5”)

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Comparison with Conformal Coating

Top 10 Advantages

1. Rework possible – improve yields
2. No masking required – even coats batteries
3. Minimal capital equipment – no chamber or oven required
4. In Line production (Not batch)
5. Fast Cycle Time (minutes versus 1-5 hours)
6. Push through connectivity
7. Flexible – Spray, Dispense, Dip
8. Spray whole board
9. Safe – non Toxic
10. It is not a conformal coating
Aculon NanoProof series has many advantages over Parylene coatings.

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

- Compatible with key components
- Can deliver IPX-7 performance and beyond

But:

- Each device is unique
- Needs to be tested
**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
### IPX Standards the New Benchmark

Aculon NanoProof Series can provide up to the **highest** level of water protection for real-life water exposure scenarios

<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>
## Aculon NanoProof Series vs. IPX

Aculon NanoProof Series can provide up to the **highest** level of water protection for real-life water exposure scenarios.

<table>
<thead>
<tr>
<th>IPX Level</th>
<th>Definition</th>
<th>Recommended NanoProof Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Protected against continual water submersion</td>
<td>NanoProof 5.1</td>
</tr>
<tr>
<td>7</td>
<td>Water immersion for 30 minutes at a depth of up to 1 meter.</td>
<td>NanoProof 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>6</td>
<td>Protected against high pressure water stream from any angle.</td>
<td>NanoProof 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>5</td>
<td>Protected against low pressure water stream from any angle.</td>
<td>NanoProof 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>4</td>
<td>Protected against splashing water from any angle.</td>
<td>NanoProof 1.0, 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>3</td>
<td>Protected against spraying water (tilted up to 60 degrees)</td>
<td>NanoProof 1.0, 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>2</td>
<td>Protected against spraying water (tilted up to 15 degrees)</td>
<td>NanoProof 1.0, 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>1</td>
<td>Protected against condensation or dripping water</td>
<td>NanoProof 1.0, 3.5, 4.0, 5.1</td>
</tr>
<tr>
<td>0</td>
<td>No Protection</td>
<td>NanoProof 1.0, 3.5, 4.0, 5.1</td>
</tr>
</tbody>
</table>
Types of Treatment
- Aculon Treatments 3.5, 4.0, 5.1

Voltages Tested: 3v, 6v, 12v

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

Conditions: Water and Salt Water

Board: IPC Multi-Purpose Test Board
NanoProof™ - IPX Results

Uncoated fails

NanoProof 4.0 performs well even at 12 Volts!

Uncoated in Water at 3, 6, 12V

NanoProof™ 4.0 vs Uncoated in Water at 3, 6, 12V
NanoProof™ - IPX Testing

- Aculon tested at 3 volts, 6 volts, 12 volts.

Minimization of electronic circuitry places tremendous pressure on manufacturers to develop new methods and technologies. Among the many challenges currently faced by PCB manufacturers is incorporating water resistance. Traditionally, thick encapsulating coatings or mechanical gasketing have been used, however continued miniaturization has made these technologies difficult/costly to incorporate as many parts of the board must be masked to avoid melting pre-fit connector or damaging sensitive components such as microphones. Aculon® NanoProof™ surface treatments offer protection from liquids without gasketing or masking.

Water-resistance product offerings generally fall into three categories: no-mask solution based hydrophilic coatings applied without the need to protect sensitive parts of the boards, conformal solution based hydrophobicics which repel fluids but require some level of masking or "keep-out" areas, and vacuum-deposited coatings (which also require masking) such as polymide-based treatments. Aculon® NanoProof™ surface treatments are no mask solution based hydrophobic coatings eliminating the need for costly capital investment and avoiding the bottlenecking of vacuum based manufacturing or masking operations.

To demonstrate the effectiveness of Aculon® NanoProof™ surface treatments, we coated standard PCB test patterns (IPC-B-25A) with three different Aculon® surface treatments: Aculon® NanoProof™ 4.0, 3.5 and 5.0. IPC-B-25A boards meet the guidelines for testing conformal coatings (IPC-CC-836B) and solder masks (IPC-SM-844). Aculon® NanoProof™ 4.0 and 3.5 are hydrophobic polymer-based coatings that repel water and provide inhibition of ion migration/electromigration. They are also designed to avoid the need to mask keep-out areas simplifying the manufacturing process. Aculon® NanoProof™ 5.0 is an oleophobic fluoropolymer coating that offers an increased level of protection by also repelling fluids with lower surface tensions.

**Experiment Overview**

The coatings were applied to printed circuit boards with electrical test patterns than the circuit boards were connected to an external power supply and maintained at a constant voltage while using a digital ammeter to measure current across the electrodes.

Using a modification of the IPX1-3 testing standard (see IPX Test Method and Aculon® Modifications and Test Results), powered test boards were immersed in water or salt water for an extended time period at a variety of voltages. The circuit's current was measured and recorded periodically over time.
NanoProof™ - IPX Testing Results

- Aculon NanoProof™ 1.0 exceeds IPX-4
- Aculon NanoProof™ 3.5 exceeds IPX-7
- Aculon NanoProof™ 4.0 exceeds IPX-7
- Aculon NanoProof™ 5.1 exceeds IPX-7/8
- Aculon NanoProof™ treatments outperform competitive products
- Easily detect NanoProof via 365 nm UV light
- All NanoProof products standard with UV Tracer
- Automated inspection possible utilizing post application inspection equipment
Performance Considerations

Every device is different and needs testing!

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

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

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

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

* Excluding Nanoproof™ 5.1
Agenda

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NanoProof™ Coating Equipment
Summary
The coating process depends on the application and including:

1. Spray
2. Dispense
3. Dip

Spraying
Dispensing
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 
  • Mexico
  Finland 
  • Singapore
  UK 
  • China
  Brazil
• All systems manufactured in-house in New York
• PVA has Representatives in over 30 countries
• Standard lead times 4 weeks
• Custom lead times 6 weeks
NanoProof Coating Equipment

Equipment required meets a variety of needs. From handheld to batch to inline to high volume automation.

- Manual Dispensing
- Batch Automation
- In-line Automation
- High Volume Manufacturing
- Custom Automation
UV Inspection Available

- Apply and inspect coatings in the same machine
- NanoProof coatings glow under UV "black" light.
- Only for selective areas: top of component, ground plane, test points, etc…
- Detect presence or absence of coating
- Same camera can be used for path programming
In summary

- Leading supplier of NanoScale Repellency Technology
- NanoProof Series provides options based on performance requirements
- Samples available on the website
  www.aculon.com/nanoproofpcbrepellency.php
- Easy to apply
- Equipment readily available
- Cost reduction
- Proven to outperform competitive technology
- Aculon supply chemistry globally
Performance • Surface • Solutions

Thank you
Contact Info:

Mario Gattuso, Aculon

gattuso@aculon.com

Edward Hughes, Aculon

hughes@aculon.com
Appendix
• Low to medium volume applications
• Batch process only, manual load / unload
• Benchtop design
  – Available with rolling bench
• PC interface optional
• 3 or 4 axis motion
• List Price $XXXXXX
• Specifications
  – Repeatability = +/-0.025mm
  – Resolution = 0.005mm
  – Work Area = 400x400x100mm
    • (Area is reduced with additional valves)
  – Payload = 11.4 kg
  – Travel Speed = up to 500mm/sec
  – Max Component Height = 50mm
  – Air Requirements = 80psi (5.5bar)
  – Power Requirements
    • 120 VAC +/- 10%, 50-60Hz
    • 220 VAC +/- 10%, 50-60Hz
• Medium to high volume applications
• Conveyorized or manual load/unload
• PC interface
• 3 or 4 axis motion
• List Price $XXXX

Specifications

  • Repeatability = +/-0.025mm
  • Resolution = 0.005mm
  • Work Area = 537x485x100mm
    • (Area is reduced with additional valves)
  • Payload = 11.4 kg
  • Travel Speed = up to 500mm/sec
  • Max Component Height = 50mm
  • Air Requirements = 80psi (5.5bar)
  • Power Requirements
    • 120 VAC +/- 10%, 50-60Hz
    • 220 VAC +/- 10%, 50-60Hz
  • Footprint = 847x1137x1606mm
• Medium to high volume applications
• Conveyorized or manual load/unload
• PC Interface
• 3 or 4 axis motion
• Maximum Size Workspace
  – 621x595x100 mm
• List Price $XXXX
• Specifications
  – Repeatability = +/-0.025mm
  – Resolution = 0.005mm
  – Work Area = 621x595x100mm
  • (Area is reduced with additional valves)
  – Payload = 11.4 kg
  – Travel Speed = up to 500mm/sec
  – Max Component Height = 100mm+
  – Air Requirements = 80psi (5.5bar)
  – Power Requirements
    • 120 VAC +/- 10%, 50-60Hz
    • 220 VAC +/- 10%, 50-60Hz
Board Handling / Conveyors

- Queue conveyors for part staging, inspection, assembly
- Board inverter for double side processing of circuit boards
- Line shuttles for dual lane transfer
- Choice of chain or edge belt conveyors
The Preferred Nozzles can be used for spray or dispense applications...

<table>
<thead>
<tr>
<th>Series</th>
<th>Type</th>
<th>Application</th>
<th>Materials</th>
<th>Viscosity Limit*</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCS</td>
<td>Atomized Spray</td>
<td>Dot, Line</td>
<td>Coatings</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>
Bench Top Operations

- Valve Stands
- Shot Timers
- Small Volume Tanks
- Gun handle mounts
- Custom Workstations
Fluid Handling options

Reservoirs
- Syringe
- 6–20oz Cartridge
- Liter Tank
- 10gal Tank

Pumps
- Cartridge
- 5 gal Pail
- 55 gal Drum
- Gear
- Progressive Cavity
- Specialty