“Working from Home” Webinar Series: Adhesion Promotion Surface Treatments

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THANK YOU FOR JOINING US

Presenters

- Edward Hughes CEO
- Eric Bruner PhD President & Founder
- Mario Gattuso Sr. Business Development Mgr.

Logistical

- Recorded
- Ask questions via GoToMeeting question tab

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THANK YOU FOR JOINING US

- Hope everyone is well and safe
- Pandemic – scope, speed, stakes
- Ability to adapt –”WFH”
- Essential company
- Be there for you when we come out of this

OUR GOAL

Aculon enables customers to make better products

by being an innovative, responsive and fast

developer and producer

of best in class

surface modification technologies.

Together we create winning products!

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AGENDA

- Aculon Overview
- Technology Platforms
- Surface Modification Options
- Adhesion Promotion Applications
  - Electronics
  - Oil & Gas
  - Specialty
- Lab Services
- Q&A

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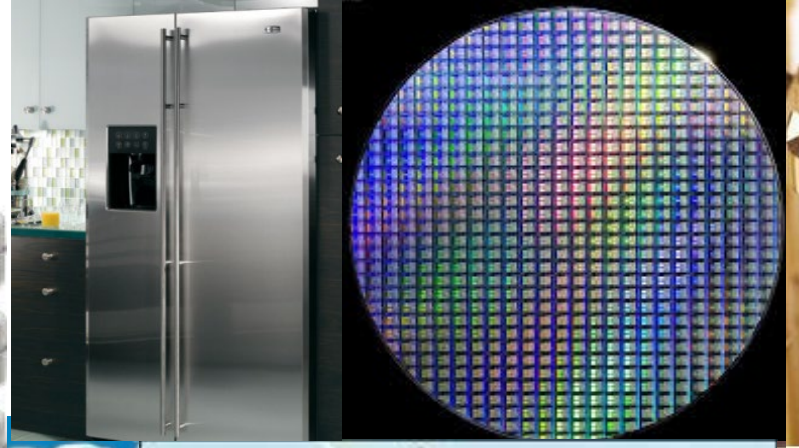

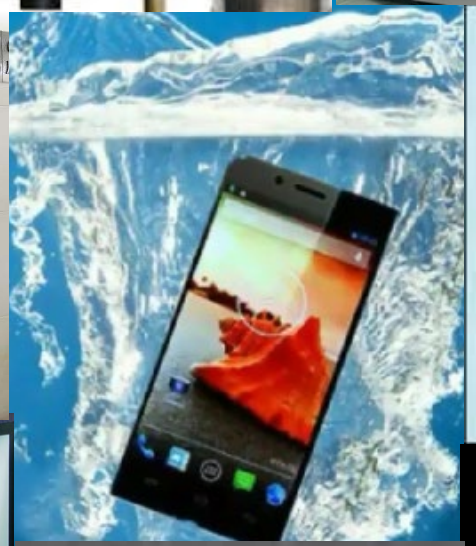

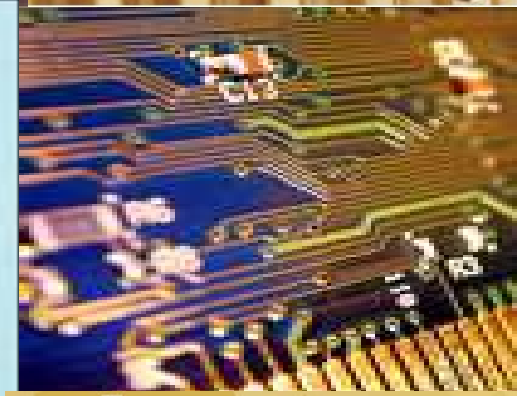

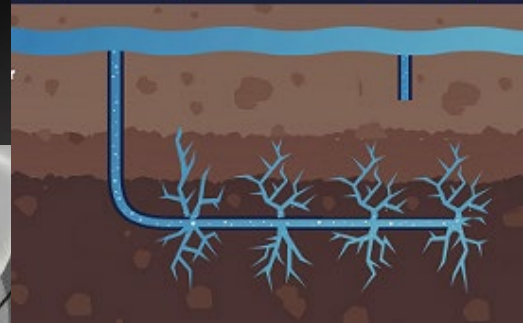
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ACULON OVERVIEW

Founded 2004

- **Expertise** Develop & produce surface solutions to modify a broad variety of surfaces (metals, glass, polymers).
- **Functionality** Hydrophobic, superhydrophobic, oleophobic, hydrophilic, anti-fingerprinting, adhesion promotion
- **Treatments** Thin, easy to apply (no vacuum chambers), often no cure, safe, non-toxic and offer green options.
- **Differentiation** Create proprietary innovative treatments & willingness to work with customer to solve problems.
- **Focus areas** Electronics, Oil & Gas, Specialty (Medical +other)
- **Business Model** Produce chemistry & treat parts
- **IP** Over 35 Patents granted. Worked with 1000's applications, invested 100,000's hours
- **Products:** > 100
- **People:** Smart (numerous Chemists with PhD's & Masters Degrees, Electrical & Mechanical Engineers)
- **Global** Locations San Diego (HQ, Lab & Manufacturing) Shanghai, Singapore, Dallas, Amsterdam,
  Distributors > 12 in Asia

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WHY SURFACE ADHESION MATTERS?

Interaction with surfaces can create problems.
Adhesion promoting technologies can be used to address a wide variety of problems. Examples include:

1. Adhesion between substrate and adhesive is poor
2. Desire to eliminate surface roughening
3. Traditional adhesion techniques are not viable
4. Part is experiencing undesirable failure mode
5. Current adhesion promotion process is too labor intensive
6. Desire to move to substrate with difficult bonding characteristics

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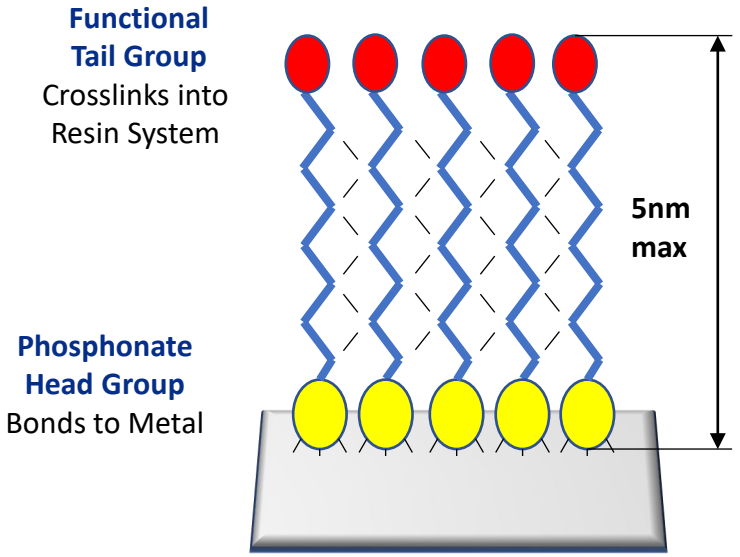
ORIGINAL TECHNOLOGY

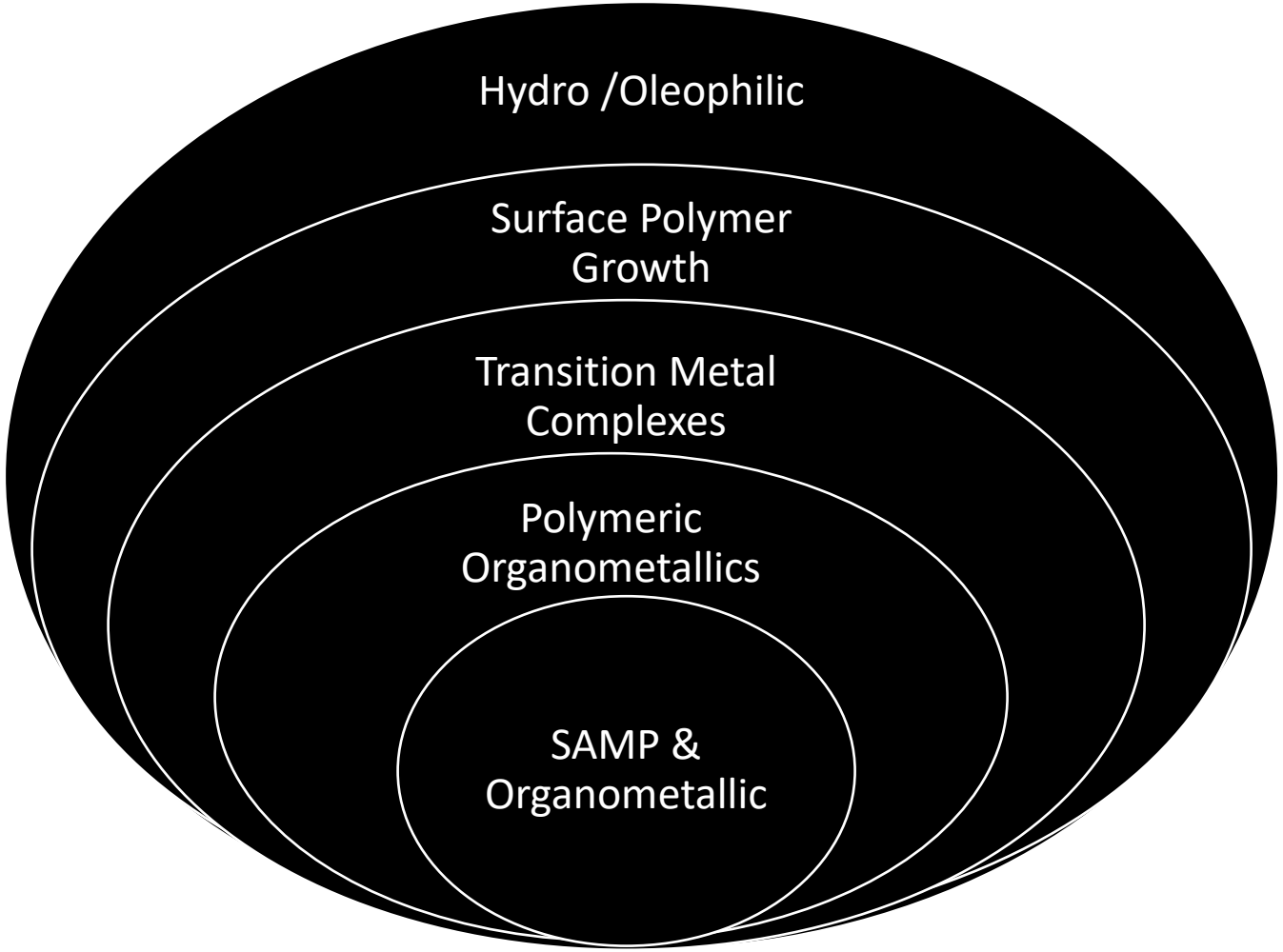
Aculon's proprietary "Self Assembled Monolayer of Phosphonates" (SAMP) can treat surfaces to impart a variety of characteristics, including increased adhesion.

The SAMP monoloayer is comprised of a phosphonic acid and a repellent, carbon-based molecule:

1. Phosphonic acid reacts with the surface and creates a covalent bond at the substrate: phosphonic acid interface
2. The carbon group connected to the phosphonic acid is the functional mono layer
3. The monolayer is less than 5 nanometers thick



MANY SURFACE MODIFICATION PLATFORMS



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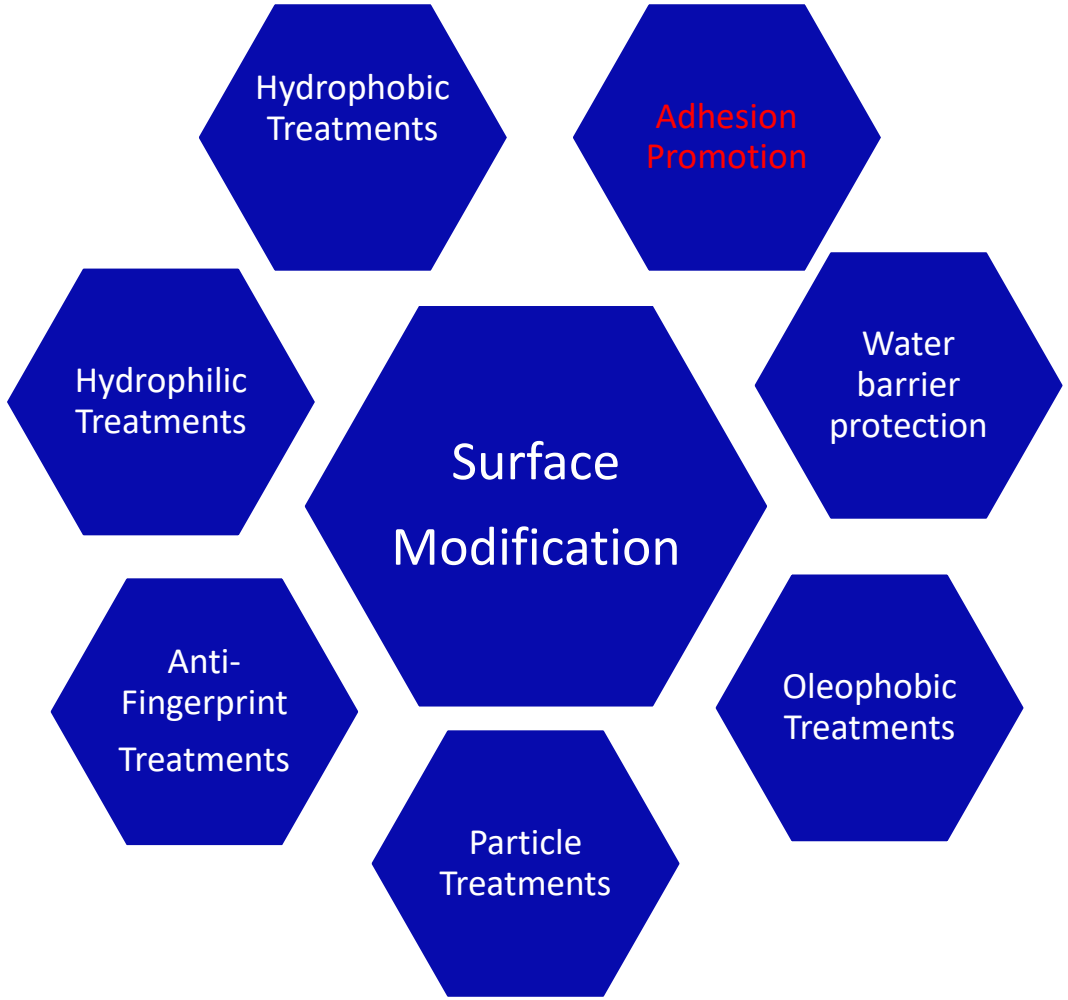
EXPERTISE AND PLATFORMS



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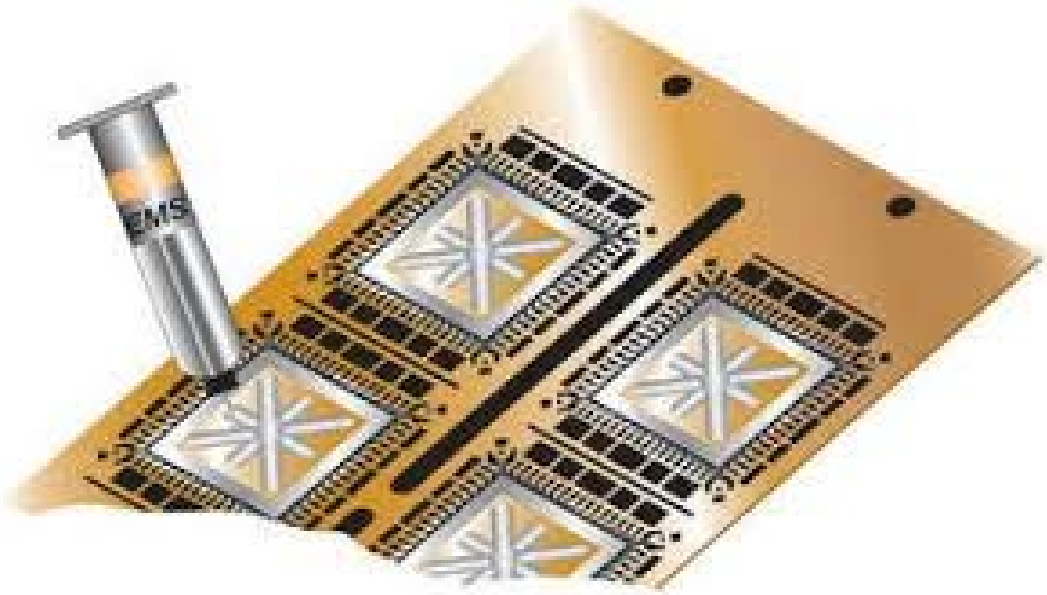
ADHESION PROMOTION

Improve adhesive and bonding characteristics of polymeric & oxide containing substrates:

- **Functionalize Surfaces Directly**
  - By directly functionalizing the substrate surface, delamination and adhesive failure are reduced
- **Reduce Thickness**
  - Traditional roughening for adhesion can be eliminated
- **Flexible**
  - Compatible with numerous polymer & oxide containing substrates & variety of functional adhesives



SUBSTRATE & CHEMISTRY MATCHING

The substrate in question needing adhesion promoting surface modification will drive the options available:

Metals & Oxide Containing Surfaces (Ceramics/Semiconductors/Glass)

- SAMPS
- Organometallics

Polymeric (non-oxide) Surfaces

- Organometallics

*Certain polymeric substrates when functionalized to behave as an oxide containing surface can be functionalized

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THE TECHNOLOGY

Treatments functionalize treated substrate with uniform coating 2-4 nm thick:

- **Reduces Delamination**
  - Improve adhesion where it is often most needed, at the interface
- **Strong Covalent Bonding**
  - Robust treatments are stable allowing for process time before applying adhesive/coatings
- **No appreciable thickness added**
  - Bondline thickness remains unchanged
  - Minimal qualification needed
  - Minimal possible negative interactions
- **Multiple Functional Options**
  - A range of functional group options allow for tailored solutions designed for your coating/adhesive chemistry

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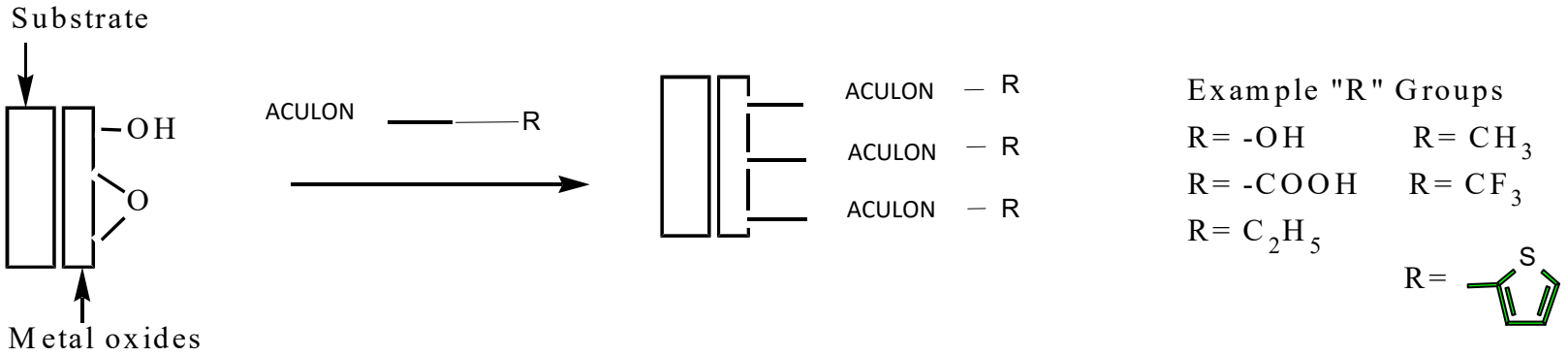
VERSATILE TECHNOLOGY



TAILOR THE "R" GROUP STRATEGY

"Hook"

- Strong Chemical Bonds – Resistant to Abrasion
- Chemically Resistant – Stable as the Underlying Substrate
- Thermally-Stable – up to 175-250˚C in ambient air.

"Tail"

- Surface Functionality – Lubricity, Cleanability, Surface Energy
- Interfacial Functionality – Reactivity, Adhesion of Polymers

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THE TECHNOLOGY – HOW IT WORKS

Increased Bonding Shifts Adhesive Failure to Cohesive Failure:

Interface strength can be measured by a simple shear test involving cementing together two disks of phosphonate film-coated titanium using a strong epoxy. For example, Titanium:

- Using epoxy cement (FM 1000), titanium coupons treated Aculon Adhesion Promoter were compared with untreated titanium lozenges:

- Compressional shear testing (ASTM 1044-99) showed that the treated interface withstands ≥ 70 MPa (limited by cohesion strength of epoxy). Untreated titanium shear strengths were measured to be ≤ 42MPa.

- After Aculon's pretreatment the strength of the interface is no longer limited by the epoxy–metal interface, but by the strength of the epoxy itself.

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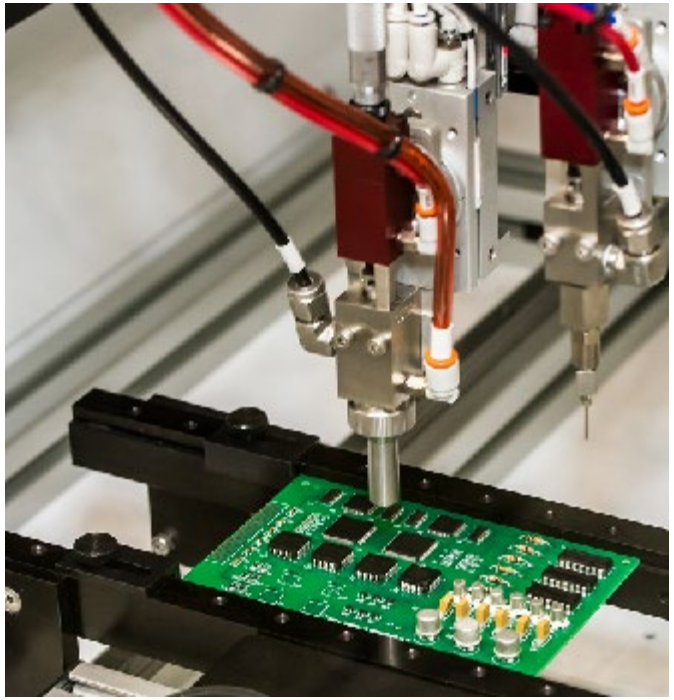
APPLICATION PROCESS

Adhesion promotion treatments are robust and scalable for high volume commercial applications. Treatments are all applied via wet chemical processes, meaning no deposition equipment, chambers, or batch processing, ever! application process depends on the application but can include:



- Dip Applied
- Spray Applied
- Wipe Applied
- Dispense/Jet

Parameters:

- Concentrations
- Solvent
- Coverage
- Temperature

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ACULON FOCUSES

1. Electronics

2. Oil & Gas

3. Specialty

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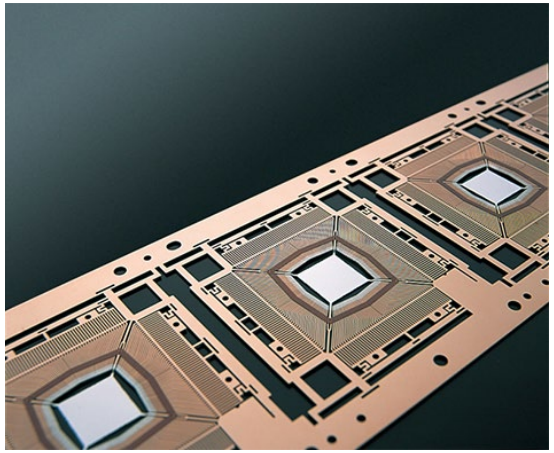
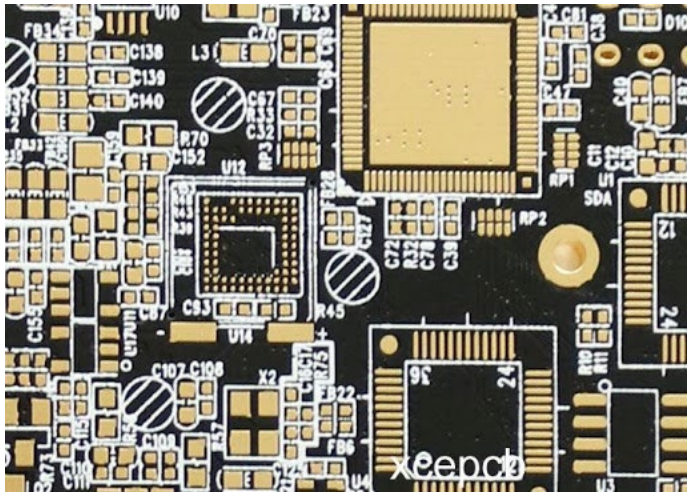
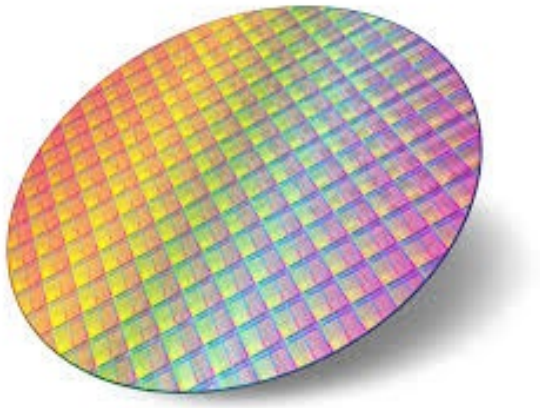
ELECTRONICS

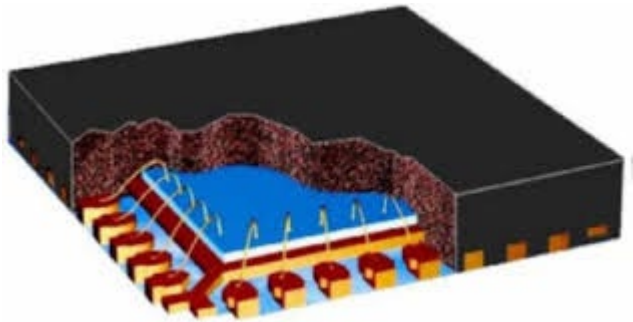
Applications include:

- Leadframe adhesion to epoxy mold compound
- Functionalize gold for adhesion to soldermask
- Functionalize silicon for improved adhesion









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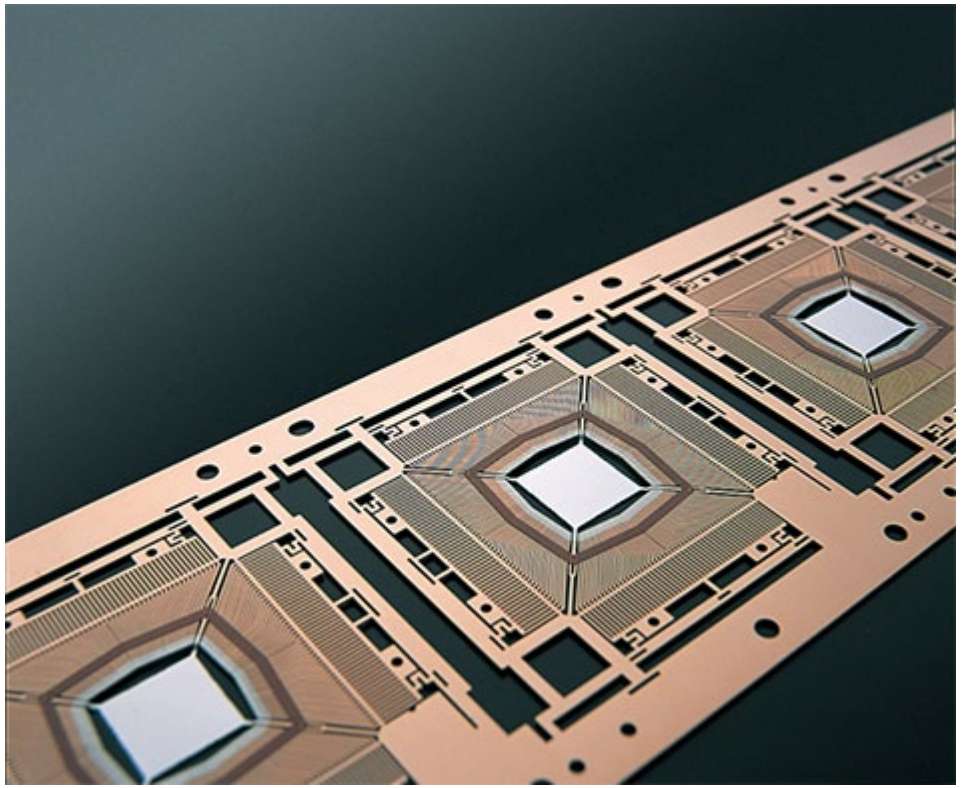
LEADFRAME ADHESION

Functionalize metal leadframes to have improved adhesive characteristics to epoxy mold compounds and other functional adhesives/coatings

- **Improve adhesion strength to die attach adhesives & mold compounds**
- **Improve durability and MSL rating**
  - Decrease package sizes as roughening is a space inefficient process
- **Adhesion Improved and Delamination Eliminated**
  - Peel strength of treated substrate increased up to 5X
- **Compatible with a wide range of functional adhesives & coatings**



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COPPER FOIL ADHESION

Functionalize copper foil to have improved adhesive characteristics and reduced delamination

- **Eliminate Surface Roughening**
  - Eliminate labor intensive
  - Decrease package sizes as roughening is a space inefficient process
- **Adhesion Improved and Delamination Eliminated**
  - Peel strength of treated substrate increased up to 5X
- **Compatible with a wide range of functional adhesives & coatings**

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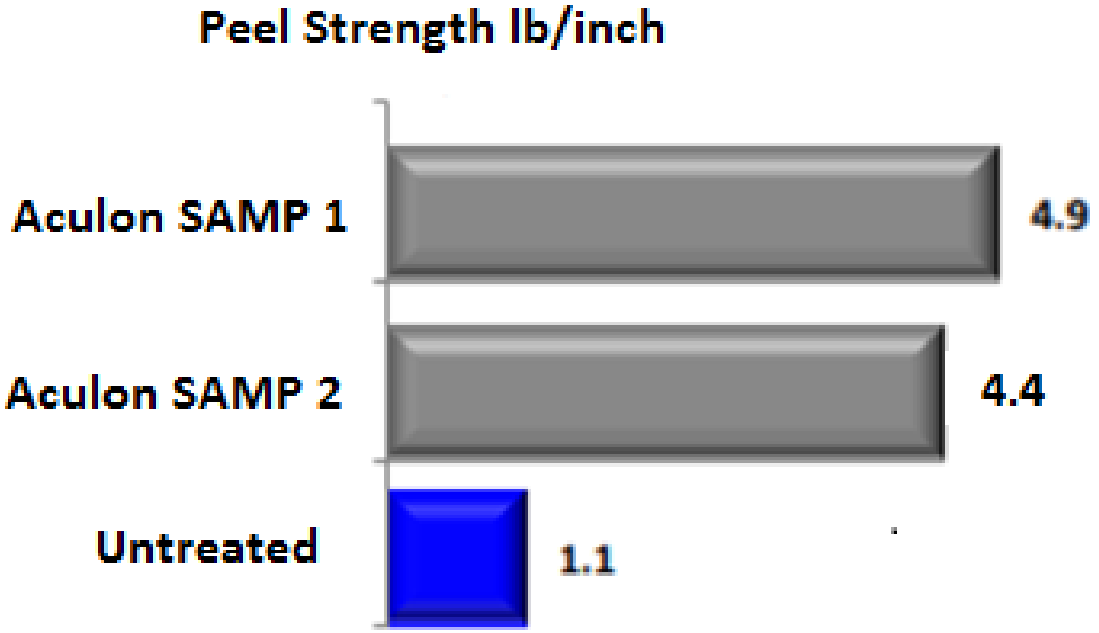
COPPER FOIL ADHESION – TESTING

Treated foils shows increased peel strength and exhibit desired cohesive failure after peel testing:

Untreated – delamination

SAMP 1 – Cohesive Failure

SAMP 2 – Cohesive Failure



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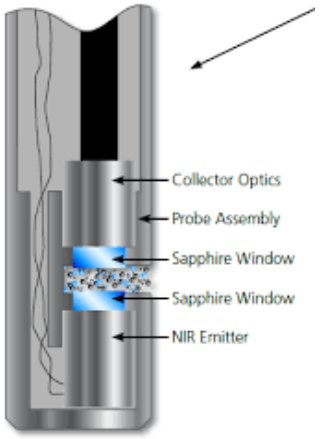
OIL & GAS

APPLICATIONS

Adhesion :

- Numerous potential applications where epoxies and other functional adhesives/coatings are required to have good adhesion in extreme environments
- Treat metal surfaces prior to epoxy coat application.
- Treat sapphire and other critical parts requiring robust bonding during manufacturing



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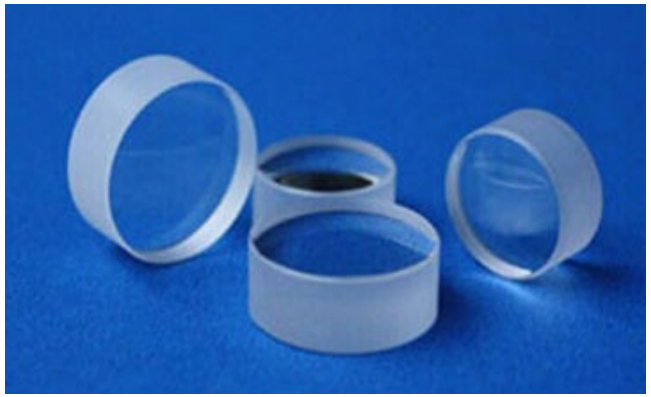
SPECIALTY

Applications include

- Wheel Weight Adhesion
- Medical Devices
- Beverage Cans
- Glass & Sapphire
- Paint/Coating Adhesion to Metal
- Particle Functionalization



WHEEL WEIGHT ADHESION

Functionalize aluminum wheels coated with polysiloxane & other polymer coatings to prevent delamination and failure of adhesive wheel balancing weights:

- **Easy Application**
  - Apply via easy to use wipe application or via bulk chemistry
- **Performance**
  - No visual impact (nanoscale treatment)
  - Deposited organometallic compound results in 60-70 dyne of surface energy change
- **Significant Increase in Adhesion**
  - Shear & pull testing shows 4-5X increase in strength

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WHEEL WEIGHT - TESTING

- Samples tested using toughest conditions to simulate road conditions. (heat / humidity) Results were impressive!
- Samples with no primer failed at interface of the wheel i.e. both the weight and tape came off from the wheel!
- When the Aculon primer used adhesion to the wheel surface was increased by up to 81% causing the bond between the weight and the tape to be the weaker part of the system while the tape remained bonded to the wheel surface.

Table I. Sample Matrix for Shear Testing Performed

	Description	Aculon Primer Used	No Primer Used
Thermal Shock	20 cycles between -30°C and 80°C	3 samples	3 samples
Humidity	7 days at 85% RH	2 samples	2 samples
Room Temperature	7 days at 23°C, 50% RH	3 samples	2 samples

Fifteen wheel weights were provided with tape pre-applied. Some sample sets only had two samples because of limited supply.

WHEEL WEIGHT - RESULTS

Aculon Adhesion Promoter (Primer) significantly increases adhesion of wheel weights during accelerated aging testing

Table II. Shear adhesion results of weights removed from wheels

Condition	Preparation	Average Peak Load (kgf)	Standard Deviation (kgf)
Thermal Shock	No Primer	23	4
	Aculon Primer	30	9
Humidity	No Primer	16	5
	Aculon Primer	29	0
Room Temperature	No Primer	15	4
	Aculon Primer	18	8

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ALUMINUM BEVERAGE CANS

Adhesion Promoters for Aluminum Used in Packaging

Aculon Adhesion Promotion Technology can be used as a chrome replacement coating.

- Increased adhesion of aluminum sheet to organic coatings
- Increased the corrosion resistance/durability of the food/beverage package made from the coated metal sheet.

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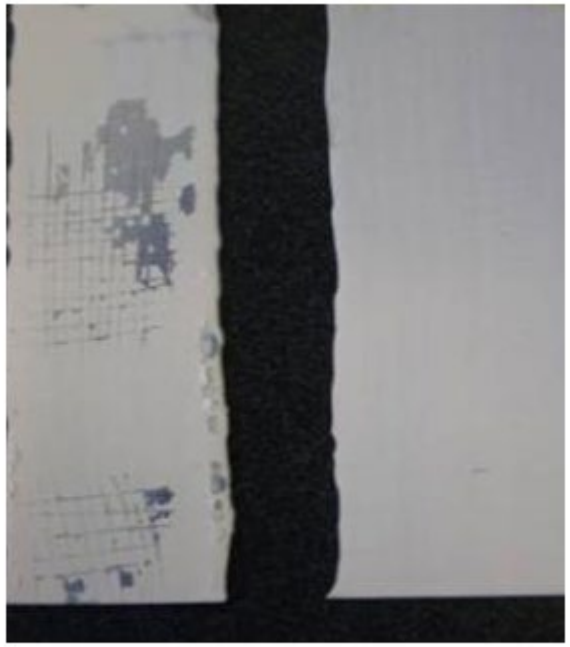
TIN PLATED STEEL

Functionalize tin plated steel to have improved adhesive characteristics and reduced delamination

- **Adhesion Improved and Delamination Eliminated**
  - Performance was tested using a cross-hatch / tape peel test after boiling strips in water for 10 minutes
- **Compatible with a wide range of functional adhesives & coatings**



Untreated **Epoxy Adhesion promotion**

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TIN PLATED STEEL - DATA

Tin Plated Steel Results		
Coating	**Customer Proprietary**	**Customer Proprietary**
Substrate	**Tin Plated Steel**	**Tin Plated Steel**
Surface	**Control**	**Aculon CR-V**
Rating Scale 0-100: 0 = 0% Passing, 100 = 100% Passing		
Dry Crosshatch Adhesion	100	100
Retort Adhesion	100	100
Retort Blushing	85	95
Brine Adhesion	10	100
Brine Corrosion	90	100
Sulfide Adhesion	70	100
Sulfide Corrosion	70	90
Sulfide Blushing	90	80
Sulfide Staining	70	80
Lactic Acid Adhesion	10	100
Lactic Acid Corrosion	60	80
Lactic Acid Blush	50	80
Acetic Acid Adhesion	100	90
Acetic Acid Corrosion	90	100
Acetic Acid Blush	70	90
Drawn Cup Fabrication	0	90
Drawn Can Fabrication	0	90
Drawn Can Retort Adhesion	0	100

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ALUMINUM

Functionalize Aluminum to have improved adhesive characteristics and reduced delamination

- **Adhesion Improved and Delamination Eliminated**
  - Performance was tested using a cross-hatch / tape peel test after boiling strips in water for 10 minutes
- **Compatible with a wide range of functional adhesives & coatings**

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Aluminum- DATA

Cleaned Only Aluminum Results		
Coating	**Customer Proprietary**	**Customer Proprietary**
Substrate	**Cleaned Only Alum**	**Cleaned Only Alum**
Surface	**Control**	**Aculon CR-V**
Feathering Measured in Inches (Degree of coating fray) Rating Scale 0-100: 0 = 0% Passing, 100 = 100% Passing		
Feathering (Fraying)	0.288"	.0270"
Gatorade Stain	100	100
Gatorade Blush	40	40
Gatorade Adhesion	0	90
Dowfax Blush	70	70
Dowfax Adhesion	0	100
Coffee Stain	70	70
Coffee Blush	0	0
Coffee Adhesion	100	100
Water Retort Blush	75	75
Water Retort Adhesion	100	100

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PARTICLE TREATMENTS

Ability to change functionality of broad variety of particles & powders for specific behavior via adhesion promotion functionalization:

- **Surface Energy**
  - Options available for altering surface energies of particles for desired performance
- **Easy Application**
  - Liquid based treatment options make bulk treatment of particles easy & scalable
- **Applications**
  - Functionalized particles and powders add value in performance in wide variety of applications

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LAB SERVICES

Understand Customer Requirements → Aculon Lab Services → Analyze & Characterize → Customer Testing & Feedback → Optimize → Selection & Recommendation → Customer Plant Trial

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INTELLECTUAL PROPERTY & EXPERTISE

Strong combination of hard and soft IP:

- Granted over 35 Patents
- Developed many trade secrets
- Treated and tested thousands of applications
- UCSD Partnership gives access to millions of dollars of equipment
- Spent hundreds of thousands of hours solving surface problems
- Invested millions of dollars in building capabilities & expertise

SUSTAINABILITY

Aculon is committed to offering a range of environmentally friendly products and follow good sustainable business practices. We help our customers support their sustainability goals and help protect the environment.

VOC-Exempt Options

PFOA-Free Products

Eco-Packaging & Waste Reduction

- Nearly all Aculon packaging (shippers, pails, bottles) is reusable or recyclable
- Green alternatives are utilized wherever possible
- From paper to pens, reusable or recyclable office supplies are used throughout our business operations

Reduced Transportation-Related Emissions

- Reduced material used → reduced transportation of material & wastes
- Localization with suppliers & distributors in Europe & Asia
- Utilize carbon-neutral shipping options when using UPS

Sustainable Energy & Increased Efficiency

- Retrofitted LED Lighting Throughout our HQ (>800 LEDs) & Utilize Extensive Natural Light
- Switched to Energy Efficient Equipment

CONCLUSION

- Platform technology company that make customers products better!
- Surface solution experts
- Strong history of working with customers to solve problems
- Broad portfolio of products, including more sustainable options
- Strong IP, testing capabilities and in-house expertise

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PERFORMANCE. SURFACE. SOLUTIONS

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THANK YOU

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