Designed Surfaces
by
Plasma Nanoscale Coatings

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Nature Inspired Films

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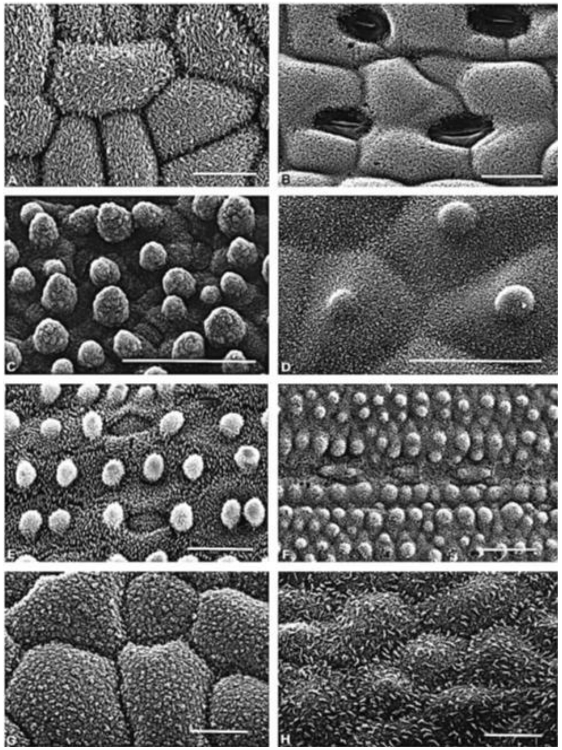
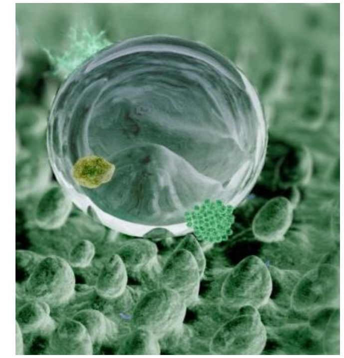


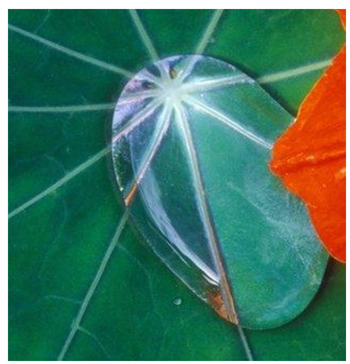
Micromorphological characteristics of water-repellent leaf surfaces:
(A) Hypericum aegypticum
(B) *Marsilea mutica*
(C) *Nelumbo nucifera*
(D) *Lupinus polyphyllos*.
(E) *Gladiolus watsonioides*
(F) Sinarundinaria nitida,
(G)*Tropaeolum majus*
(H) *Melaleuca hypericifolia*

Culled from Biology Inspired Nano-Materials: Superhydrohobic Surfaces, Jared

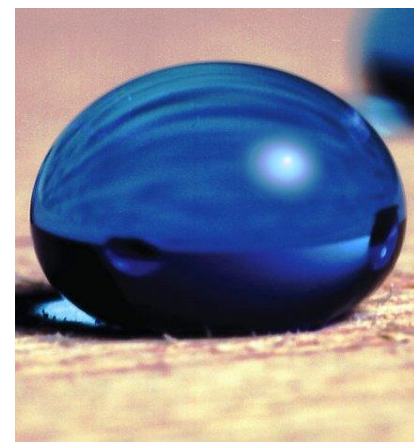
Hydrophobic Lotus Leaf



Mircrograph of Water Drop On Lotus Leaf



Superhydrophobic Nasturtin Leaf



Artificial Superhydrophobic Surface

Nature Inspired
Conformal Barrier Coatings

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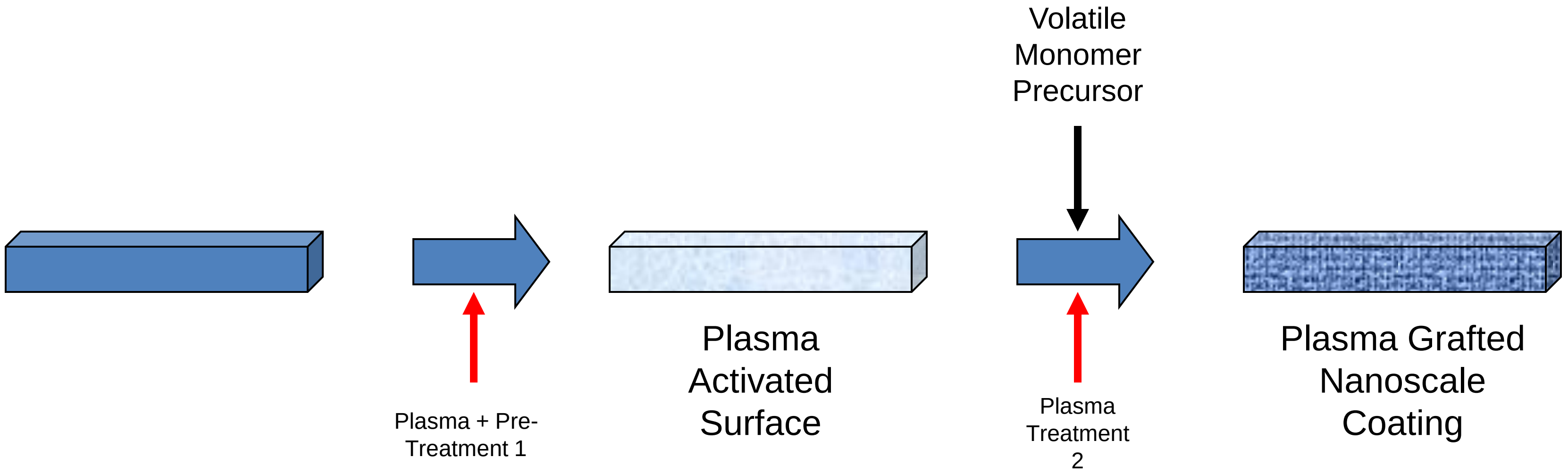
- Fuel and Hydrocarbon Barrier
  - Must protect from Hydrocarbons and Bio-Based Fuels
- Fuel Tanks for Small Engines
  - US annual volume: 19-20,000,000 units
  - Cost Sensitive
- **Thermoplastic Polymer Substrates Made by Blow Molding usually Polyethylene**
- Evolving Standards from California Air Resources Board and EPA [$1 g/m^2/day$]

- Moisture and Weather Barriers
  - Protect from Moisture, Environmental Polutants
  - May require UV Stability
  - Variations in Temperature Performance
  - May require reduced O_2 Permeability
- Applications
  - Packaging
  - Electronic Components
  - Displays, Signs and Signals
- Functional Barriers
  - Tie Coats and Subcoats
  - Designed Surface Chemistry

Nano-Texture + Layers:
Multi Stage Plasma Based Conformal Coatings

Plasma Based Conformal Coatings Platform



StormRider Technologies Process, Patent Pending

Examples of TEOS [SiO_x] Coatings on EVA Foam Substrate

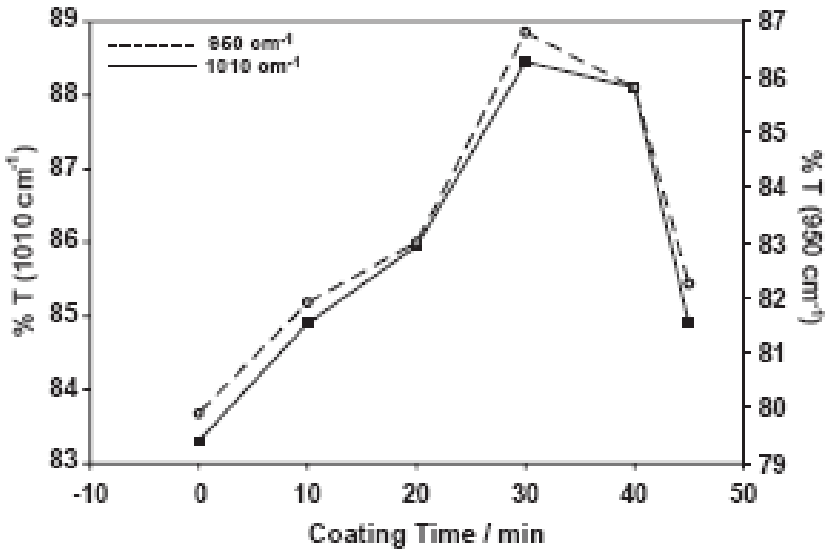


Fig. 2. Transmittance plot of surface ATR–FTIR signal through TEOS-coated PE-EVA foam substrate as a function of coating time.

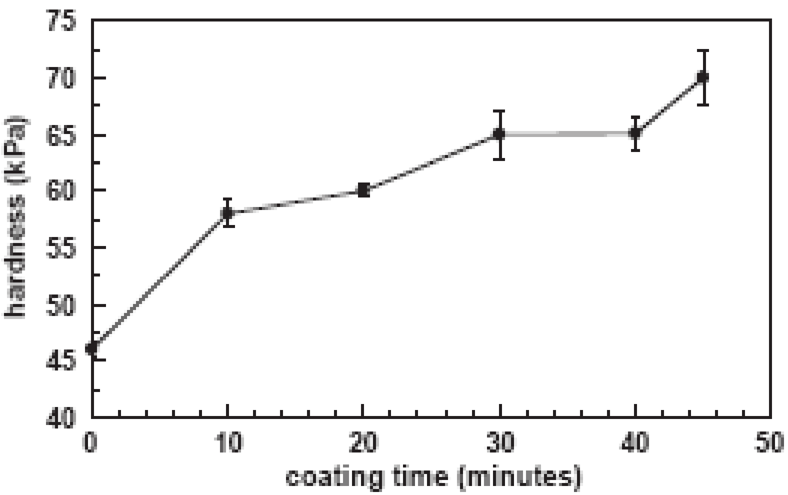


Fig. 5. Hardness as a function of PECVD-TEOS coating time.

Deshpande, Dakshinamurthy, Kuiry, Vaidyanathan, Obeng, and Seal, Thin Solid Films, ***483*** *(2005) 261– 269*.

TEOS on EVA Foam Continued

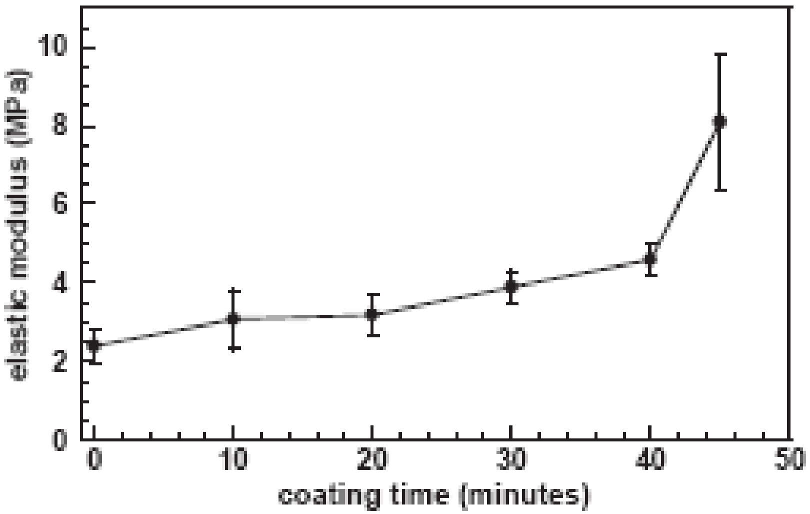
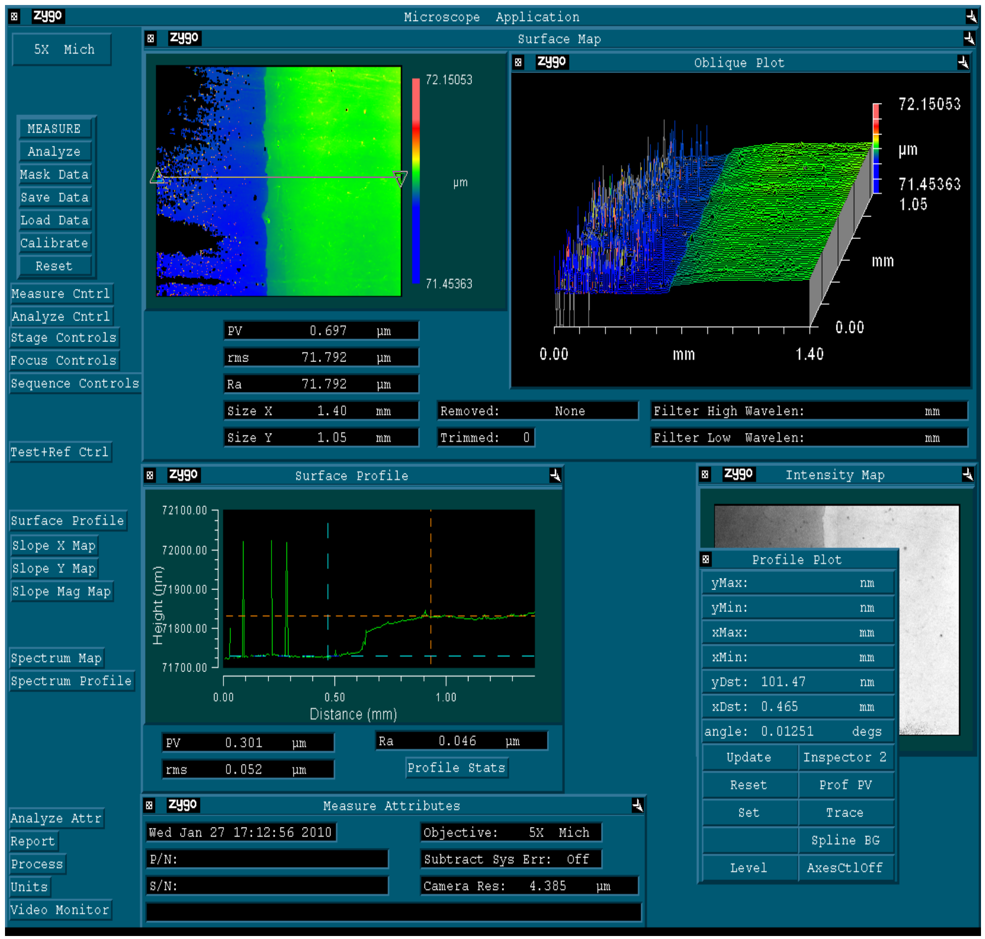


Fig. 6. Elastic modulus as a function of PECVD-TEOS coating time.

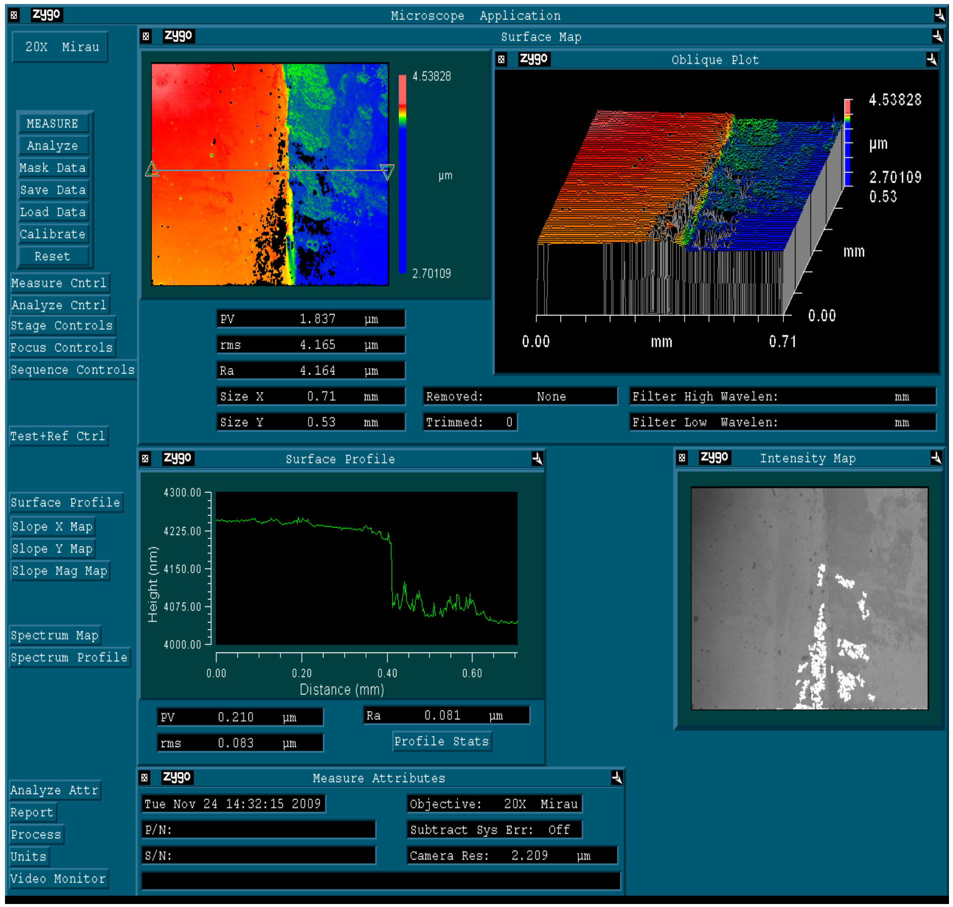
Deshpande, Dakshinamurthy, Kuiry, Vaidyanathan, Obeng, and Seal, Thin Solid Films, ***483*** *(2005) 261– 269*.

SiOx on Polycarbonate Edge Mask



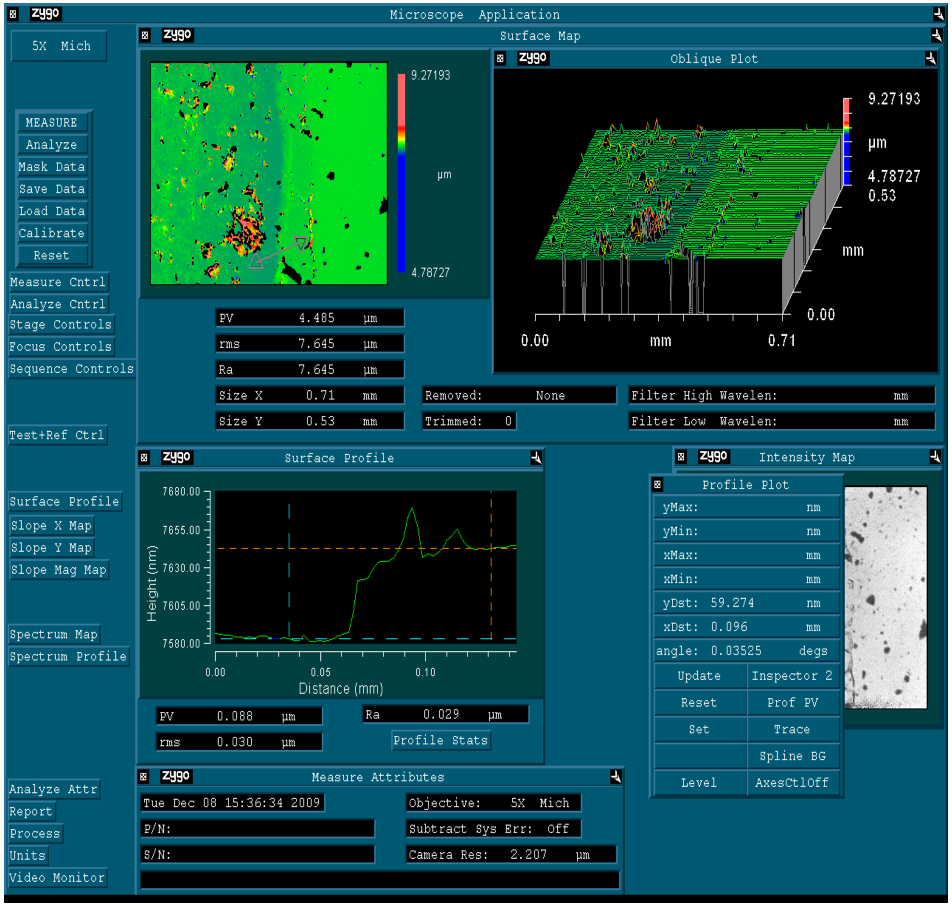
101 nm SiOx on PolyCarbonate

SiOx on Glass Substrate 150nm



SiOx Coating on Glass Slide Surface Witness Sample
Zygo NuVue White Light Interferrometer
Prof. Kathleen Richardson
Clemson AMRL

60 nm Polyolefin on Glass



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Broad Technology Platform

- Wide Range of Substrates
  - Polyolefins
  - Polyolefin Foams
  - Polycarbonates
  - Carbon Fiber Composites
  - Rubber
  - Latex Films
  - Filled and Complex Formulations
- Dry-in, Dry-out
- Formed and Irregular Shapes
- Straightforward Scale-Up

- Organic Monomers:
  - Allyl Alcohol
  - Allyl Amine
  - Vinyl Acetate
  - Acrylic Acid
  - 2-Hydroxyethylmethacrylate
  - N-Vinylpyrrolidinone
  - Olefins
  - Fluorocarbons
- Inorganic/Ceramic Monomers
  - SiOx Precursors
  - TiOx Precursors

Surface-R -> Surface-R*
Surface-R* + Monomer -> Surface-R-Graft

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Key Issues in Emerging Sectors

- Non Corrosive and Green Processes
- Conformal Coating Throughput [Mass Market Applications >300K Pieces/yr]
  - Chamber sizes are mass flow limited
  - Number of coating cycles/day/chamber
    - Parylene: 1-2 /day
    - Plasma: 10-20 /day
- Conformal Coating Cost
  - Cost per piece
  - Capital costs per coating applicator
  - Complex cyclophane monomer cost
- Coating Chemical/Physical Properties Flexibility
  - Temperature performance
  - Moisture resistance
  - Solvent resistance
  - Adhesion
  - Abrasion resistance

Applications Specificity: Defined by the End Use Market

- Wet Lubricious
- Dry Lubricious
- Reactive Functional Group
- **Barrier Coatings**
  - **Moisture Barrier**
  - **Hydrocarbon Barrier**

Some Potential Killer Applications Space

- **Biomaterials**
  - Tissue engineering
  - Regenerative medicine
  - Drug delivery
  - Proteins and peptides at interfaces
  - Lipid and biomimetic membranes
- **Responsive colloids and materials**
  - Biosensors
  - Surfaces and colloids in imaging and diagnostics
  - Radiation Detection
- **Reactive Surfaces**
  - Adsorption
  - Catalysis
  - Electrochemistry
- **Materials for Advanced Electronics**
  - Storage
  - Memory
  - Optical communications
  - Materials to enable novel device architectures
- **Novel phenomena and techniques**
  - Interfacial processes,
  - capillarity and wetting in biological systems

Barrier Coatings

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Solvent and Moisture Barrier Films

Solvent Barrier

- Applications
  - Fuel Tanks
  - Circuit Boards
  - LED Lighting
  - Chip Level Packages
- Coatings
  - SiOx Ceramic
  - Fluorocarbon

Moisture Barrier

- Applications
  - Circuit Boards
  - LED Lighting
- Coatings
  - SiOx Ceramic
  - Fluorocarbon
  - Polyolefin
  - TiOx Ceramic [Photoactive-Self Cleaning]
  - Fluorosilicate

Ceramic Nano Coatings over Thermoplastics

- Glasses have low water and hydrocarbon permeability
- TiO_x coatings have potential to be photo reactive and self cleaning.
- SiO_x and TiO_x coatings can be applied to thermplastic parts at the nano scale via StormRider patented Plasma method.
- Commercial low cost monomers. Scalable process.
- Process is rapid: less than 1 hr/cycle
- Large scale plasma deposition machines available 42”x42”x54”.
- Dry-in dry-out process.
- Applications in Automotive, Consumer Electronics, Lighting, Medical Devices, Aerospace and Packaging.

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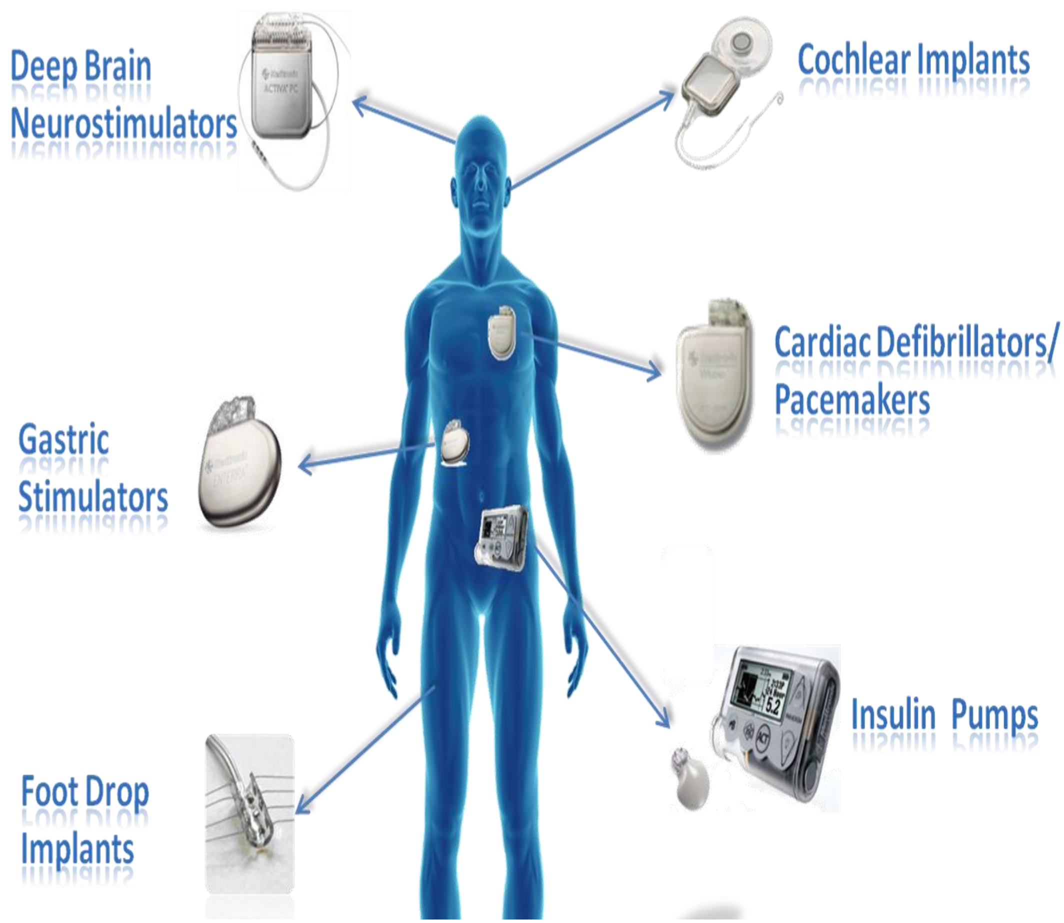
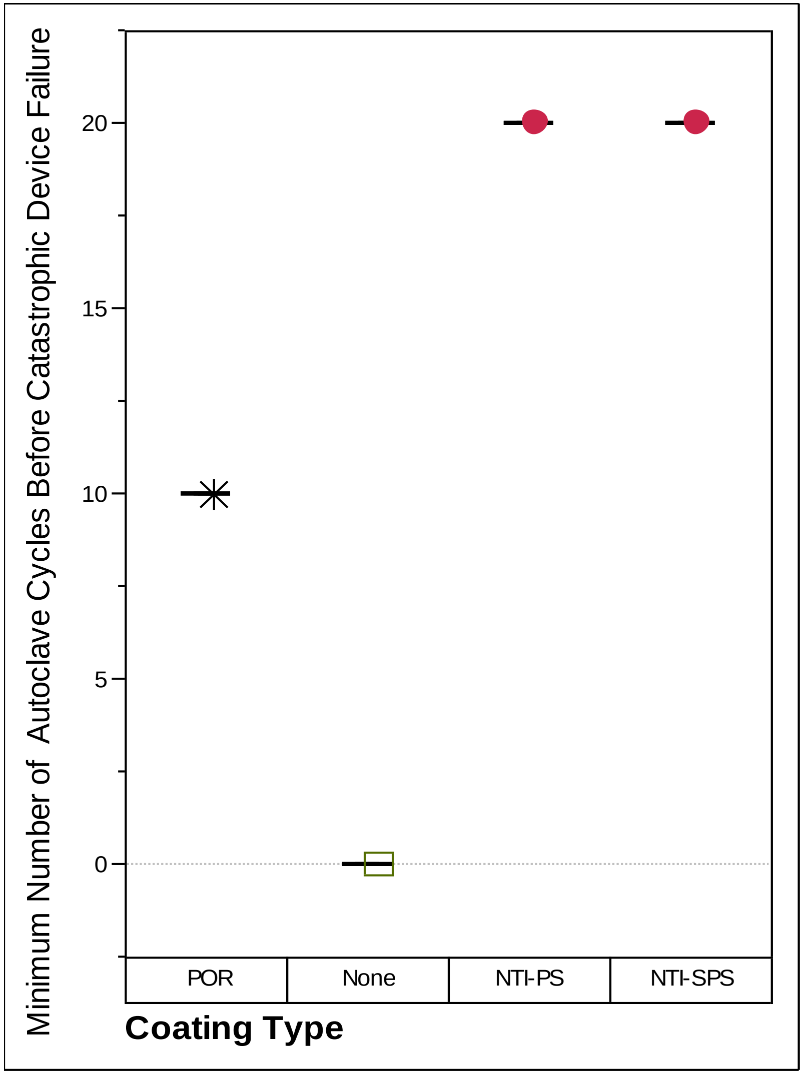
Industrial Applications

- Abrasion Resistance
  - Instrument Panels
  - Displays
  - Solder Masks
- Circuit Board Level Barrier Coatings
  - Automotive
  - Consumer Electronics

Nature Inspired Passivation Films Afford Enhanced Protecting for Implantable Electronic Circuitry





Adapted from http://groups.csail.mit.edu/netmit/IMDShield/

Automotive Circuit Board Example. Hydrocarbon and Moisture Barrier

Automotive Control System Circuit Board

- Chasis-Underhood Environment
- SiOx Plasma Based Conformal Coating
  - 500K Units/yr
  - Temperature Tolerant to 140°C Board Components
- Cycle Time: 25-50 min.
- Dry-in, Dry-out
- Economics [est.]:
  - Capital Hardware: $350K installed, 36”x36”x48” chamber
  - Throughput: 250/hr
  - Monomer Cost: $20K/yr
  - Low Emissions

Nature Inspired Passivation Films Afford Enhanced SORE Compliance with Permeation Regulations

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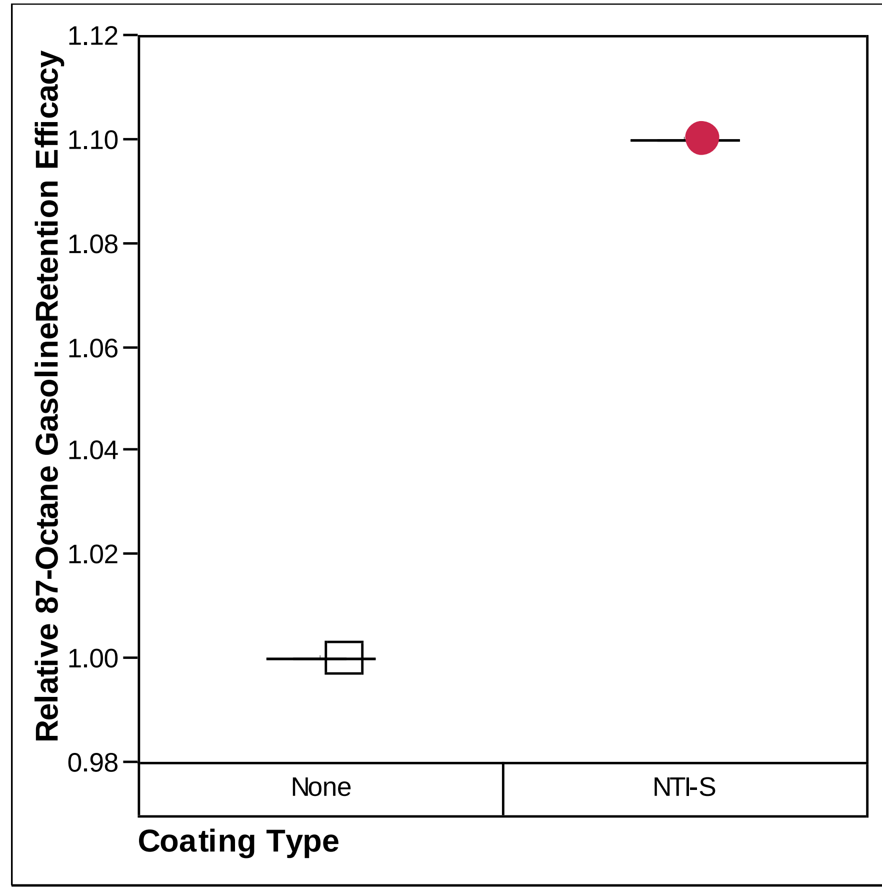

CARB (California Air Resource Board) and the EPA's (U.S. Environmental Protection Agency)

Blow Molded Fuel Tank Process Example. Hydrocarbon Barrier

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Blow Molded PE Small Engine Fuel Tank

SiOx Plasma Based Conformal Coating

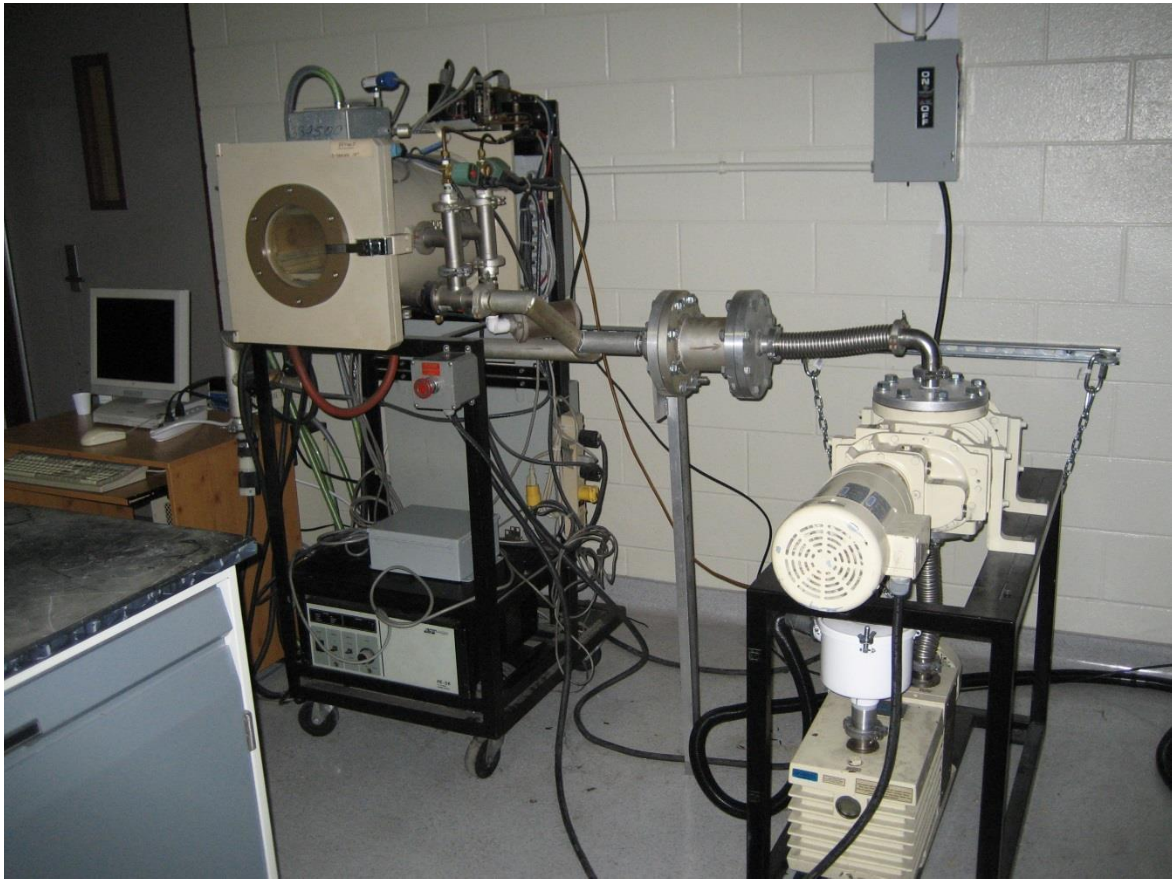
Cycle Time: 25-50 min.

Dry-in, Dry-out

Economics [est.]:

- Capital Hardware: $350K installed, 36"x36"x48" chamber
- Throughput: 120/hr
- Monomer Cost: $20K/yr
- Low Emissions

Pilot Plasma Coating Unit



Production Plasma Coating Units

Production Plasma Coating Unit

36"X36"X48" Chamber

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Contact Us!

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