IST Integrated Surface Technologies

Surface Engineering Techniques

Jeff Chinn, Ph.D.
Chief Technical Officer

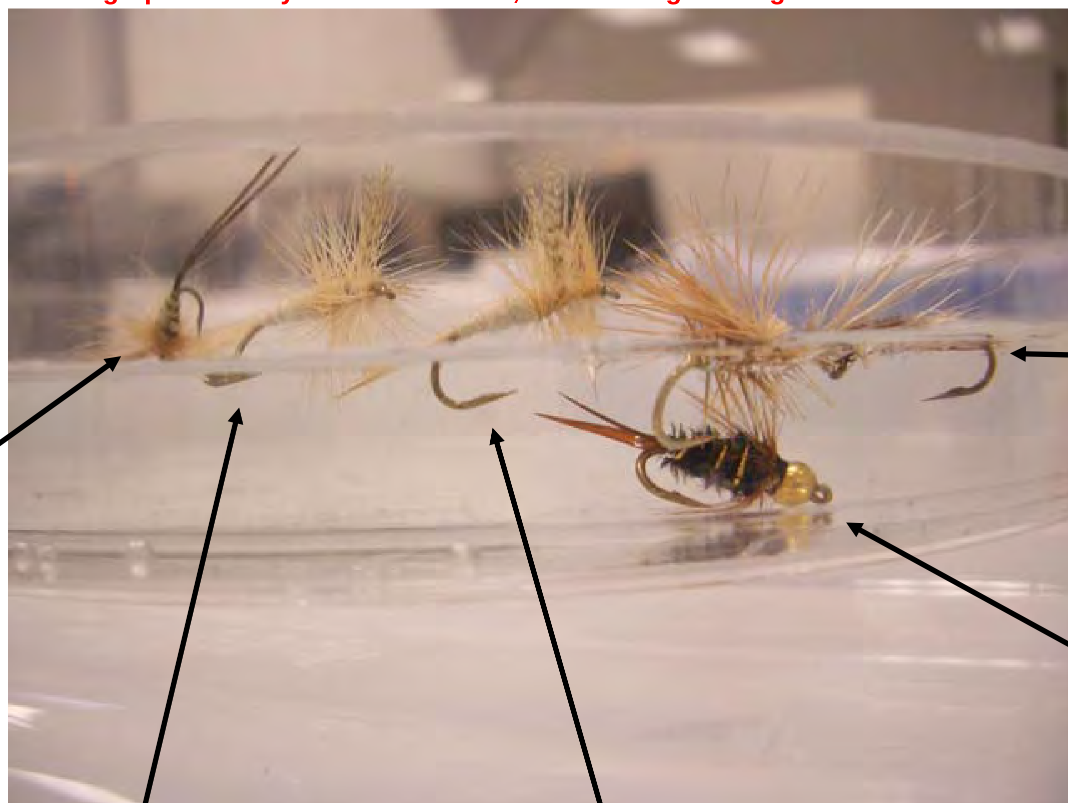
Outline

- Brief Definitions and Uses of Surface Engineering
- Who We Are
- Surface Modification Science
- Surface Reactions → Nano-Composites
- IST's as a Supplier
- Summary

Surface Engineering

- *Changing surface characteristics without altering “Bulk” material traits.*
- *Ability to create custom materials with a wide range of functionalities.*

Photograph courtesy of Tom Peterson, Caldera Engineering



Nature Fly

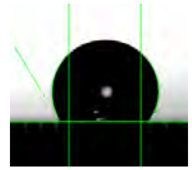
Super-Hydrophobic
CA>165^o
(Un-Sinkable)

Hydrophobic
CA=118^o
(Floats)

Hydrophobic
CA=108^o
(Partial Floatation)

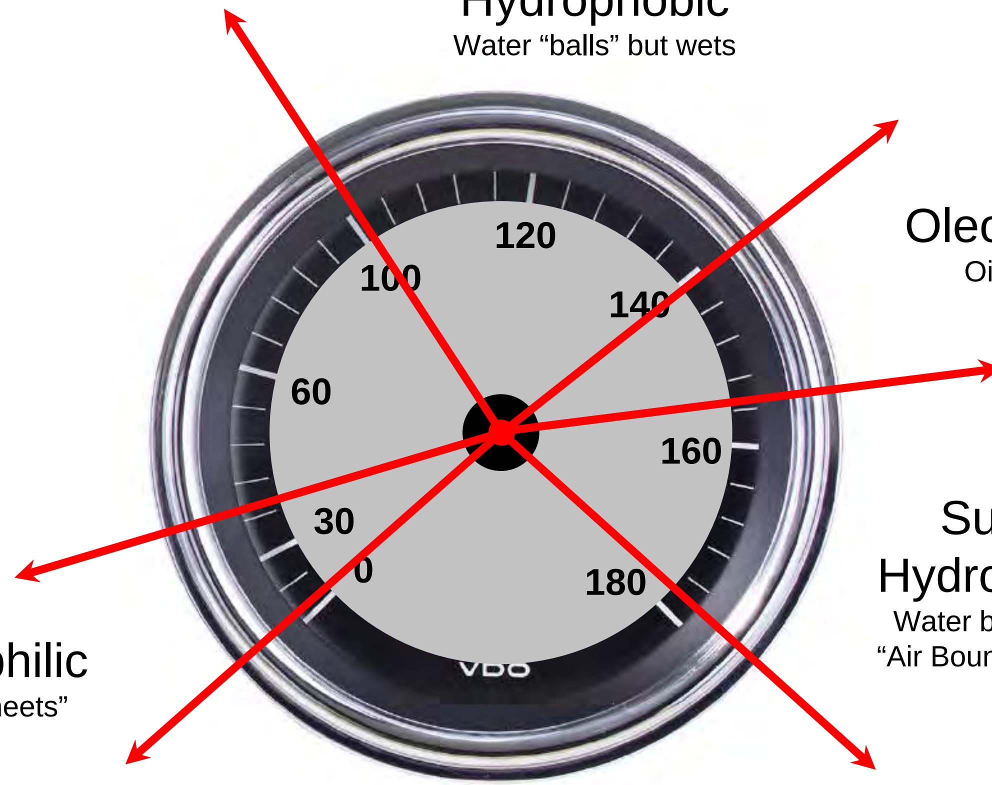
Hydrophilic
CA=30^o
(Sinks)

Goniometer (Water Contact Angle)



Hydrophobic
Water “balls” but wets

Oleophobic
Oil “balls”



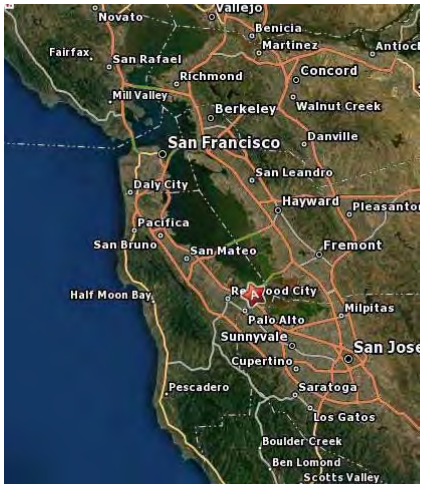
Super-Hydrophobic
Water bounces off
“Air Boundary Layer”

Hydrophilic
Water “Sheets”

Outline

- Brief Definitions and Uses of Surface Engineering
- Who We Are
- Surface Modification Science
- Surface Reactions → Nano-Composites
- IST's as a Supplier
- Summary

More on IST



Menlo Park, CA

Located in the heart of former "Silicon Valley"

Chemical Service

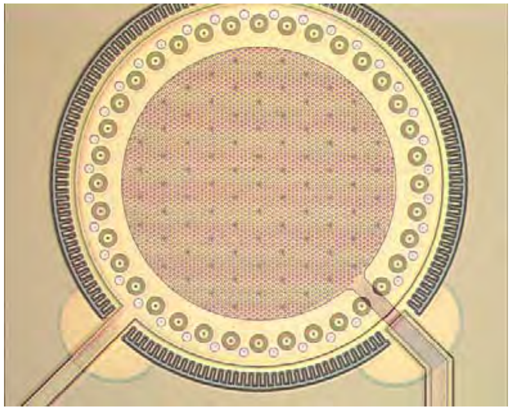
Demo Lab

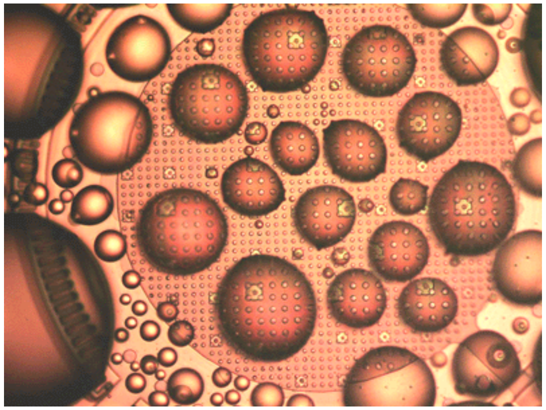
Metrology

Manufacturing

3 - Core Capabilities

– **Capability-1: State-of-the-art Advanced Surface Modification with the lowest Cost of Ownership in the industry.**

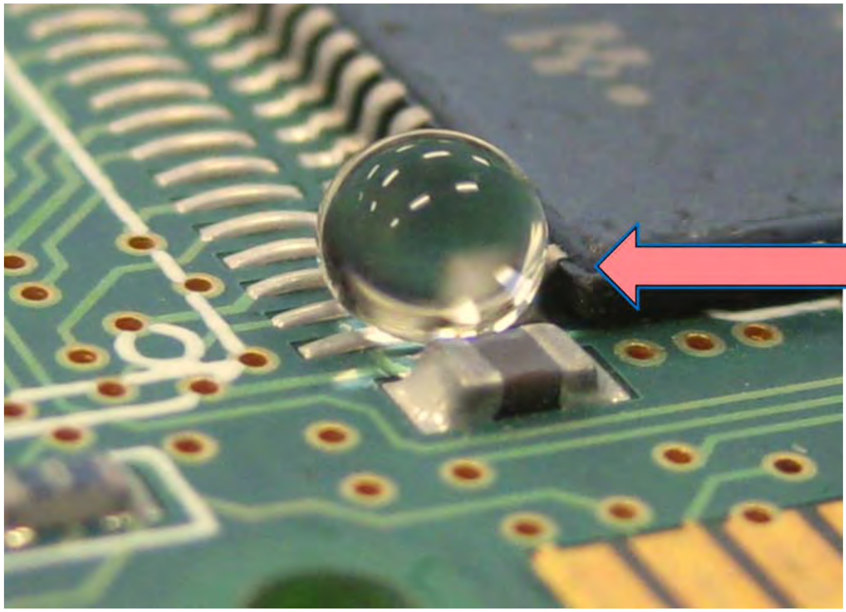




MEMS based Microphones Hydrophobic Coating

3 - Core Capabilities

- **Capability-1:** State-of-the-art Advanced **Surface Modification** with the lowest **Cost of Ownership** in the industry.
- **Capability-2: A nano-composite coating that repels water but is penetrated by the connectors for perfect electrical contact.**



Water cannot wet the treated surface !

3 - Core Capabilities

- **Capability-1:** State-of-the-art Advanced **Surface Modification** with the lowest **Cost of Ownership** in the industry.
- **Capability-2:** A nano-composite coating that repels water but is penetrated by the connectors for perfect electrical contact.
- **Capability-3: Supplier for coating equipment & chemicals, specializing in vapor processing.**

Plasma

Equipment ALD/CVD

Chemicals

Consumables

Outline

- Brief Definitions and Uses of Surface Engineering
- Who We Are
- Surface Modification Science
- Surface Reactions → Nano-Composites
- IST's as a Supplier
- Summary

Basics of BiFunctional Organic Precursors

- Coupling agents used to achieve control over the surface functionality and "coverage".

$$R - (CH_2)_n - Si - X_3$$

Organofunctional Group → R

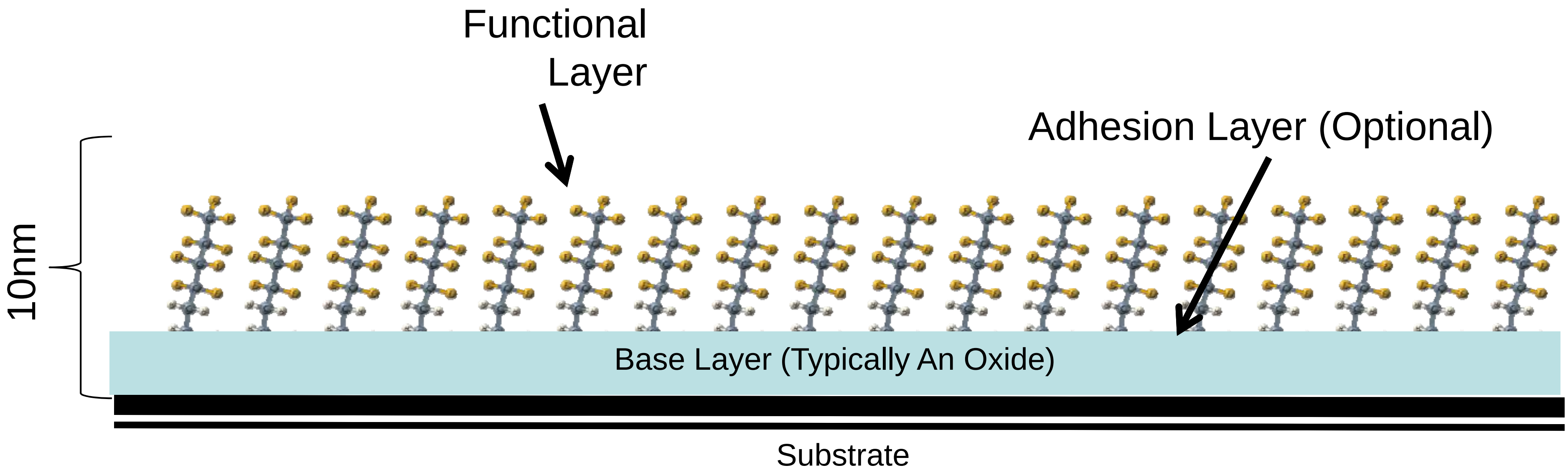
Linker → $(CH_2)_n$

Silicon Atom → Si

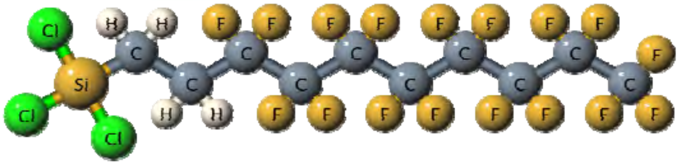
Hydrolyzable Groups → X_3

Advanced Surface Modification

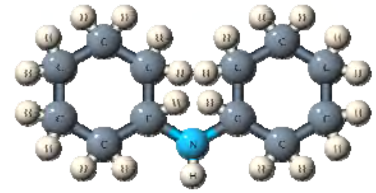
- **Vapor deposited Organic**
- **Global Coverage**
- **Choices of functional chemistry**
- **Inert: Hydrophobic (Perfluoronated (Teflon)**
- **Inert: Hydrophilic (Poly Ethylene Gycol)**
- **Reactive: Amine or Epoxy**



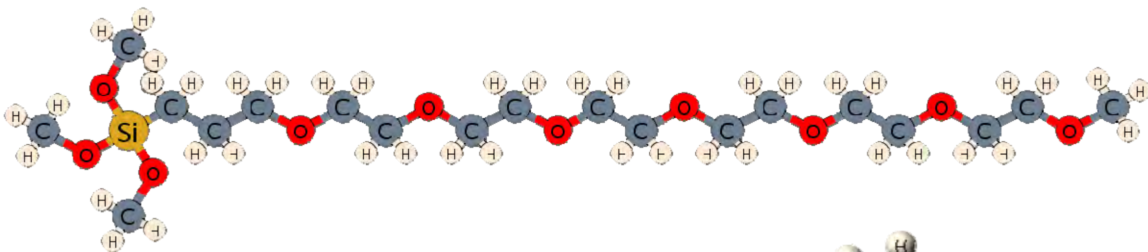
Most Common Silanes for Surface Modification



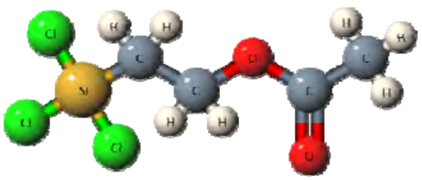
FDTS
Hydrophobic (110º)



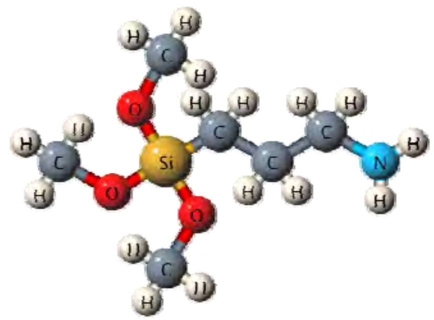
DCHA
Neutral-
Hydrophobic (80º)



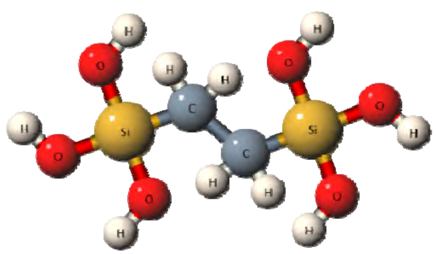
PEG
Hydrophilic (45º)



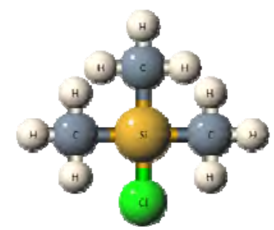
AETCS
Hydrophilic (65º)



APTMS
Reactive (50-60º)



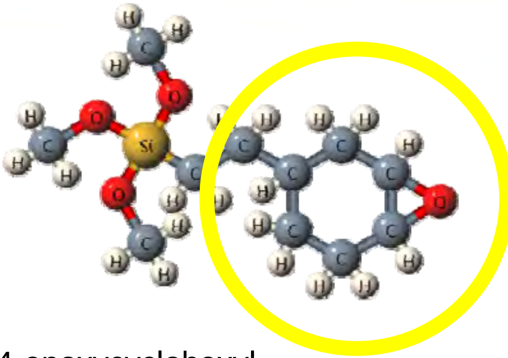
BTCSE
Hydrophilic (30º)



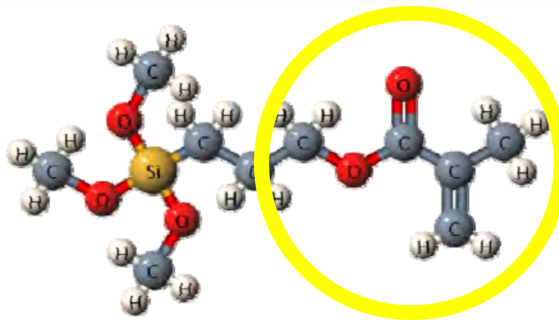
TMS
Hydrophobic (85º)

IST

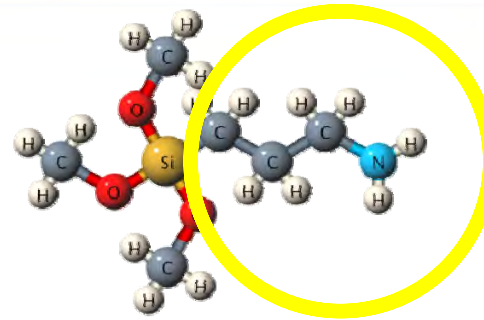
Most Common Linking Precursors



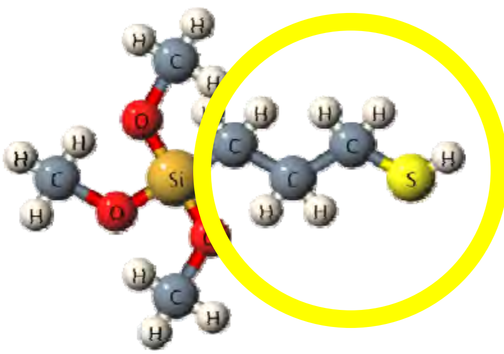
3-4-epoxycyclohexyl-
ethyltrimethoxysilane



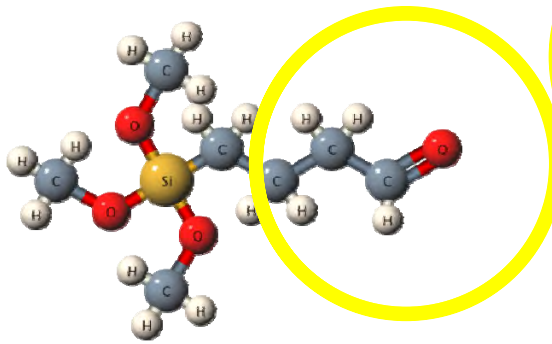
3-methacryloxy
propyltrimethoxysilane



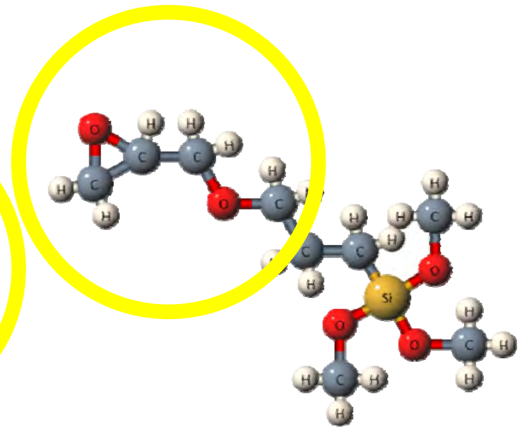
aminopropyltrimethoxysilane



mercaptopropyltrimethoxysilane

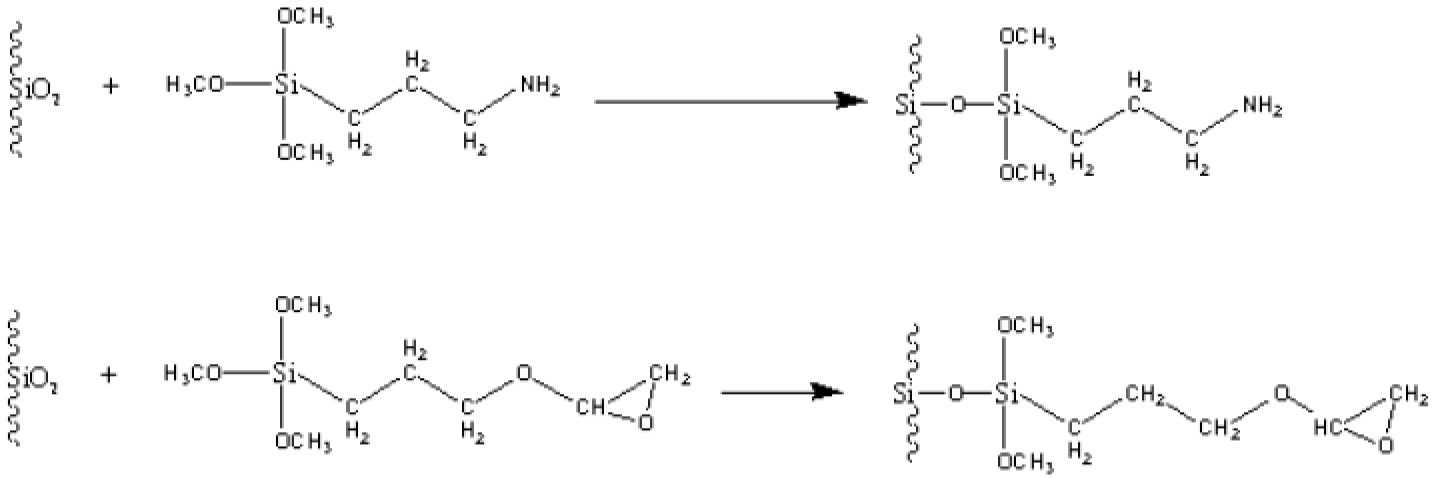


Butyl-Aldehyde-
Trimethoxysilane



Glycydoxy-
Trimethoxysilane

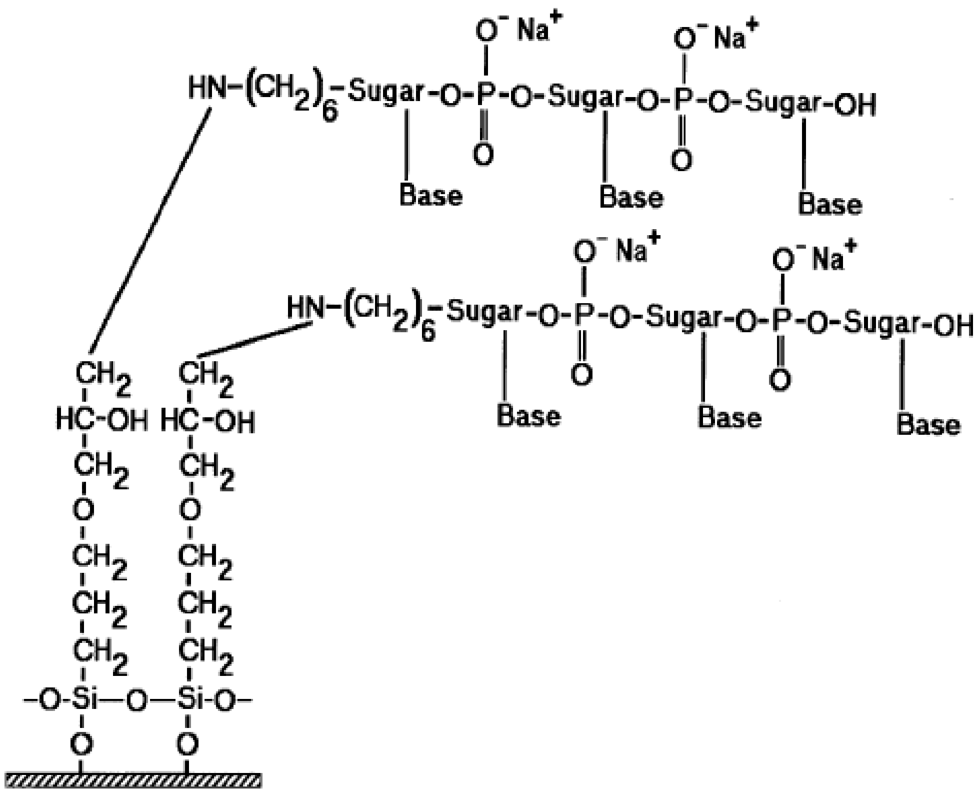
Biological Binding

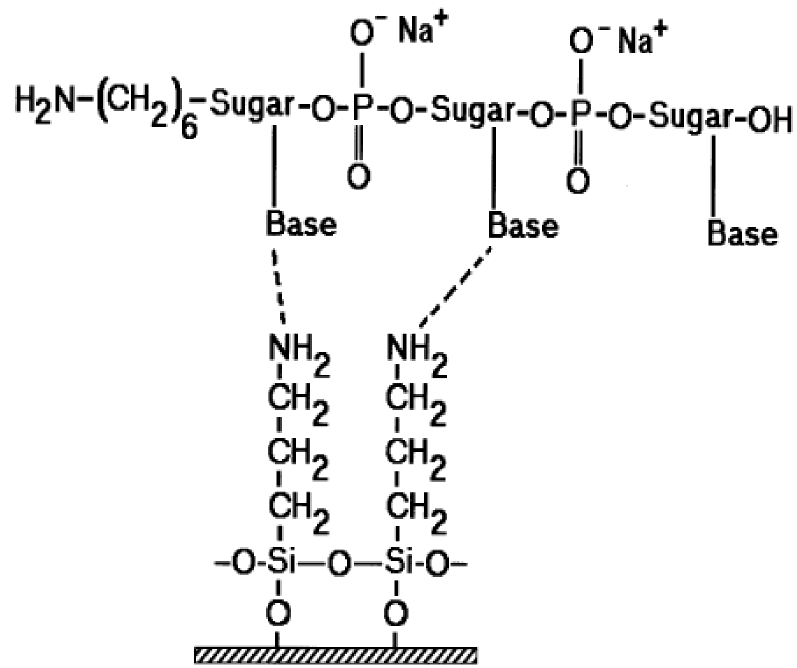


Covalent Coupling Reactions

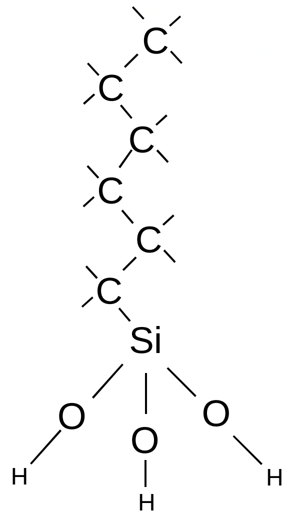
-COOH	Carboxylic Acid
$-RNH_2$	Primary Aliphatic Amine
$-ArNH_2$	Aromatic Amine
$-CONH_2$	Amide
$-CONHNH_2$	Hydrazide
-CHO	Aldehyde
-OH	Hydroxyl
-SH	Thiol
-COC-	Epoxy

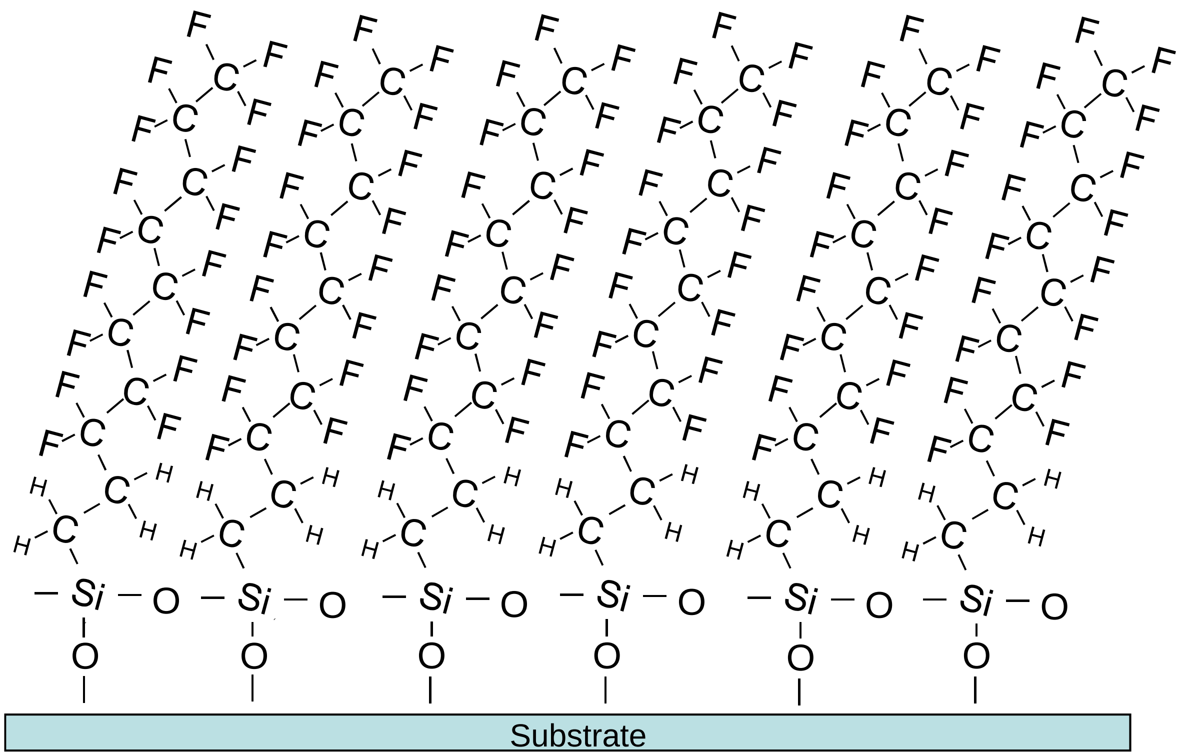
DNA Surface Immobilization





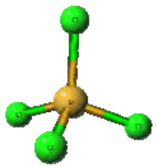
Organic Surface Modification



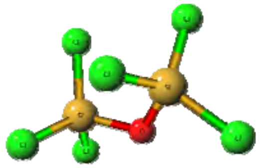


Hydroxyl surface linkages are formed.
Molecule attaches to the substrate via covalent bonding.

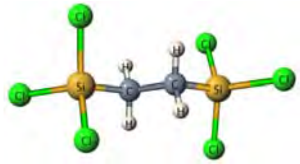
Surface Chemistry Effects



~5^{o}



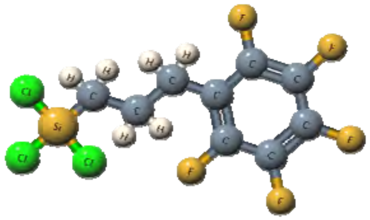
~20^{o}



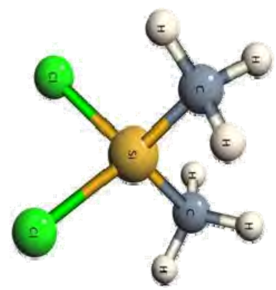
~30^{o}

~50^{o}

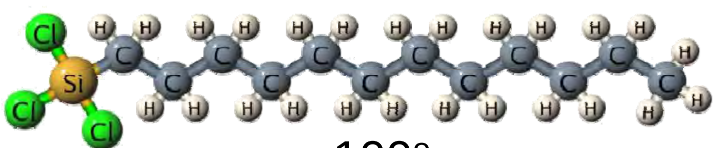
~70^{o}



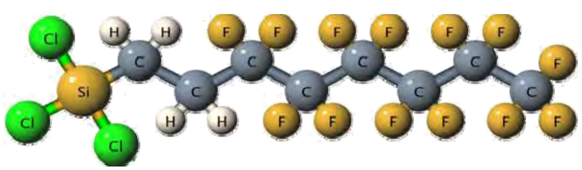
~90^{o}



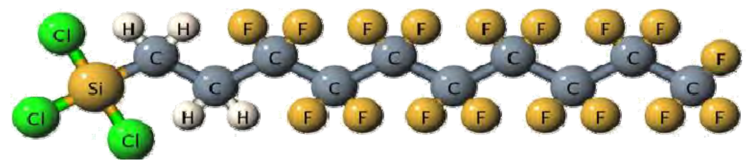
~103^{o}



~100^{o}



~108^{o}

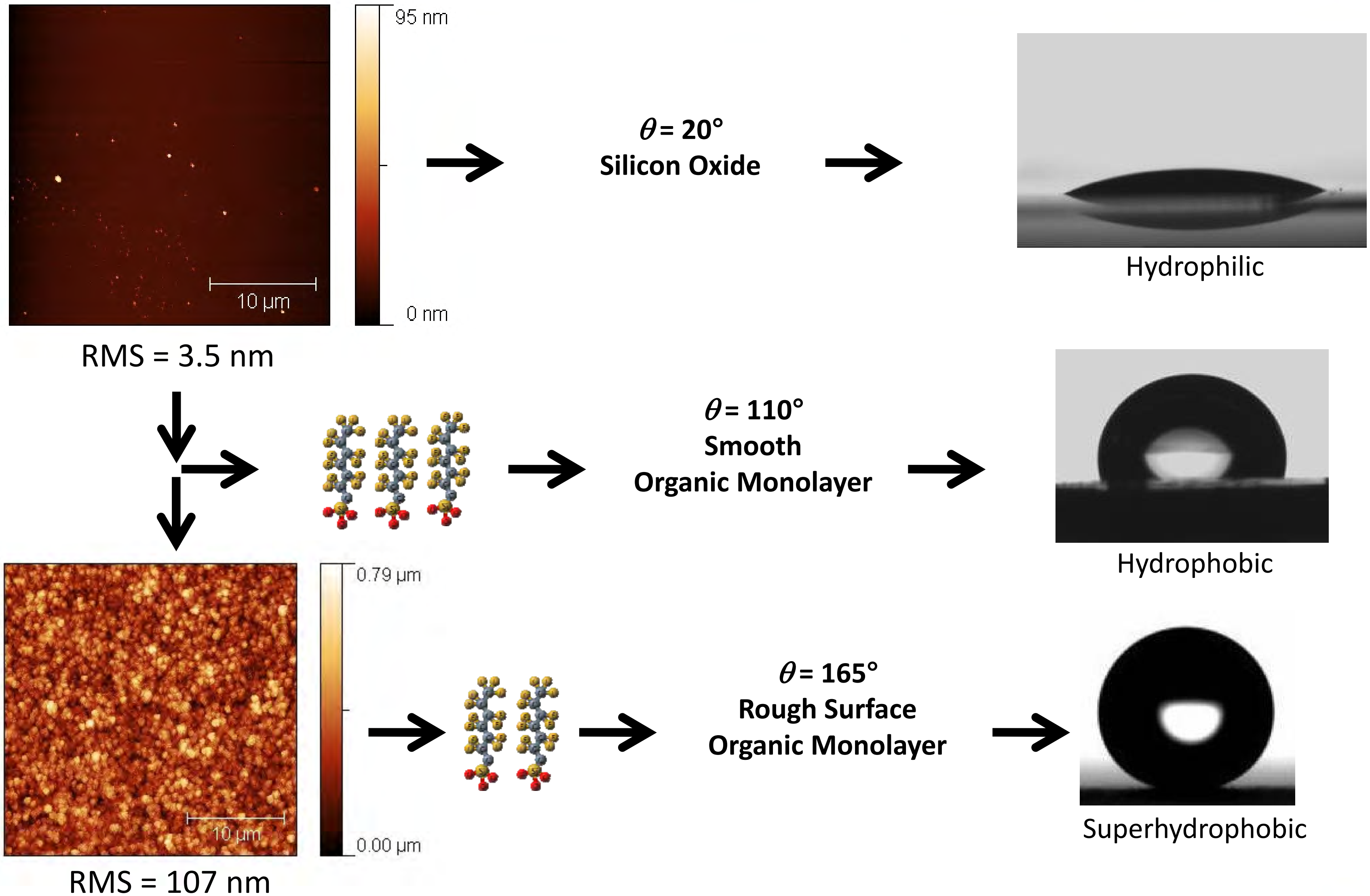


~110^{o}

Hydrophobicity Function of Surface Fluorine

Precursor Name	Water Contact Angle (degs)
Henicosyl-1,1,2,2-tetrahydrododecyldimethyltris(dimethylaminosilane)	118.0
Heptadecafluoro-1,1,2,2-tetrahydrodecyltrichlorosilane - (FDTS)	110.0
Nonafluoro-1,1,2,2-tetrahydrohexyltris(dimethylamino)silane	110.0
3,3,3,4,4,5,5,6,6-Nonafluorohexyltrichlorosilane	108.0
Tridecafluoro-1,1,2,2-tetrahydrooctyltrichlorosilane - (FOTS)	108.0
BIS(Tridecafluoro-1,1,2,2-tetrahydrooctyl)dimethylsiloxymethylchlorosilane	107.0
Dodecyltrichlorosilane – (DDTS)	105.0
Dimethyldichlorosilane - (DDMS)	103.0
10-Undecenyltrichlorosilane - (V11)	100.0
Pentafluorophenylpropyltrichlorosilane	90.0

Surface “Smoothness” Effects



Outline

- Brief Definitions and Uses of Surface Engineering
- Who We Are
- Surface Modification Science
- Surface Reactions → Nano-Composites
- IST's as a Supplier
- Summary

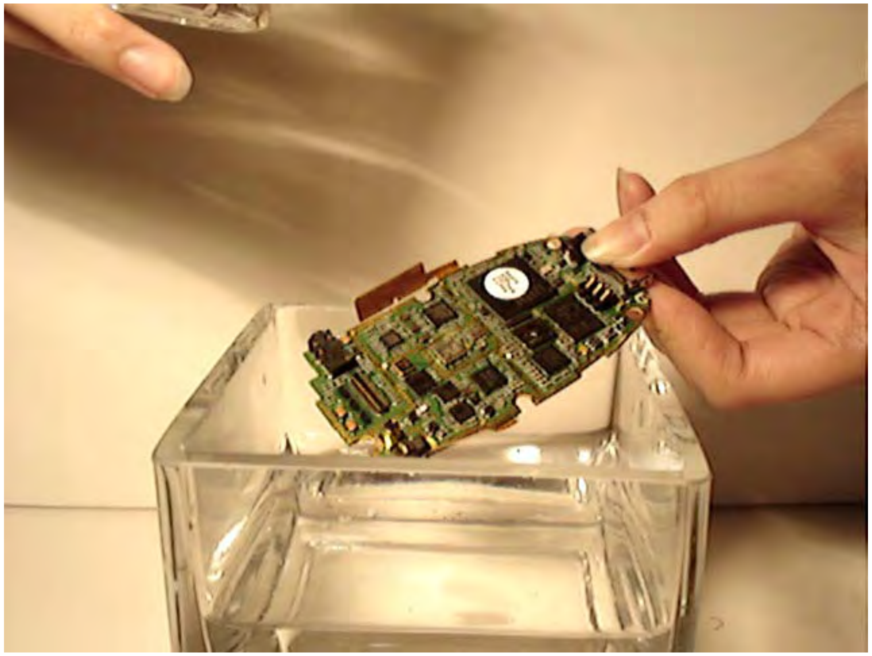
An Advanced Coating Technology

- A room-temperature, vapor deposited, textured ceramic coating with superior anti-wetting and anti-corrosion protection for Printed Circuit Boards.

IST's Repellix^{TM} coating creates a barrier film that protects the circuit board from water damage.

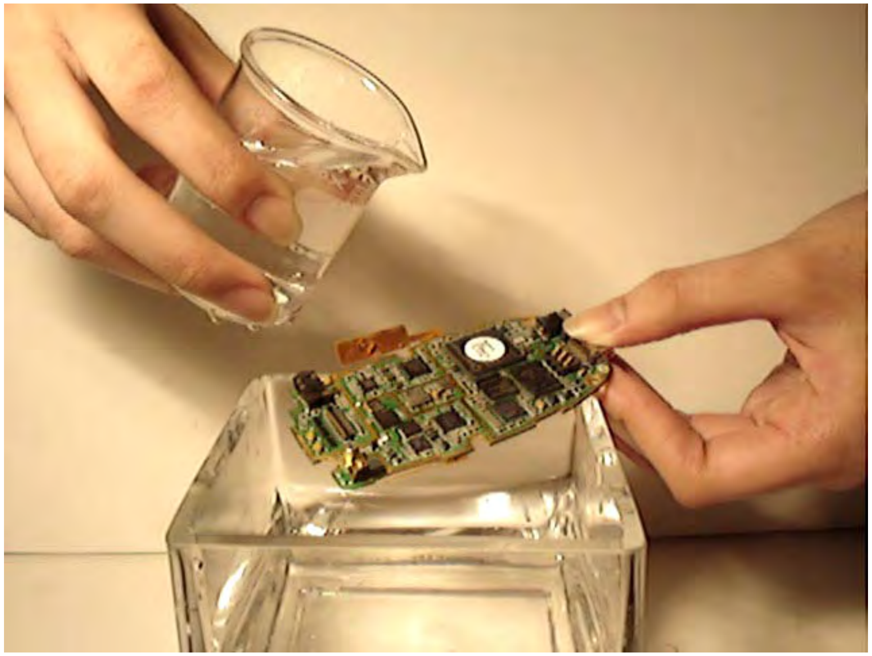
Repellix Wetting Demo

Water on an **Uncoated** Cell Phone Board



The uncoated board spreads the water across the board

Water on a **Repellix Coated** Cell Phone Board



The Repellix coated board sheds the water, and creates a narrow stream

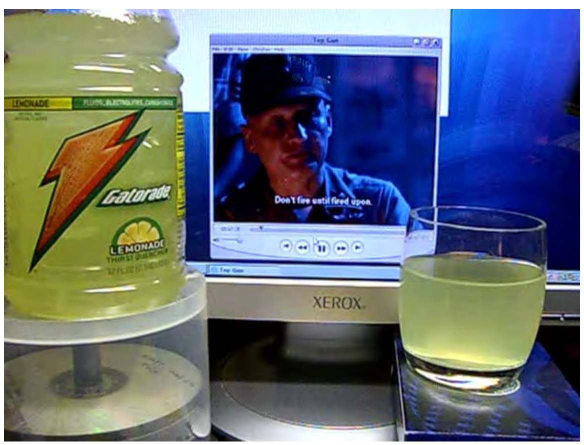
Active Electronics

Gatorade = Potassium Phosphate + Citric Acid (Electrolyte (Salt) Solution)

Contact Angle: <50°

Contact Angle: >160°

Standard Memory Board



Memory Failed ~2 sec

Coated Board

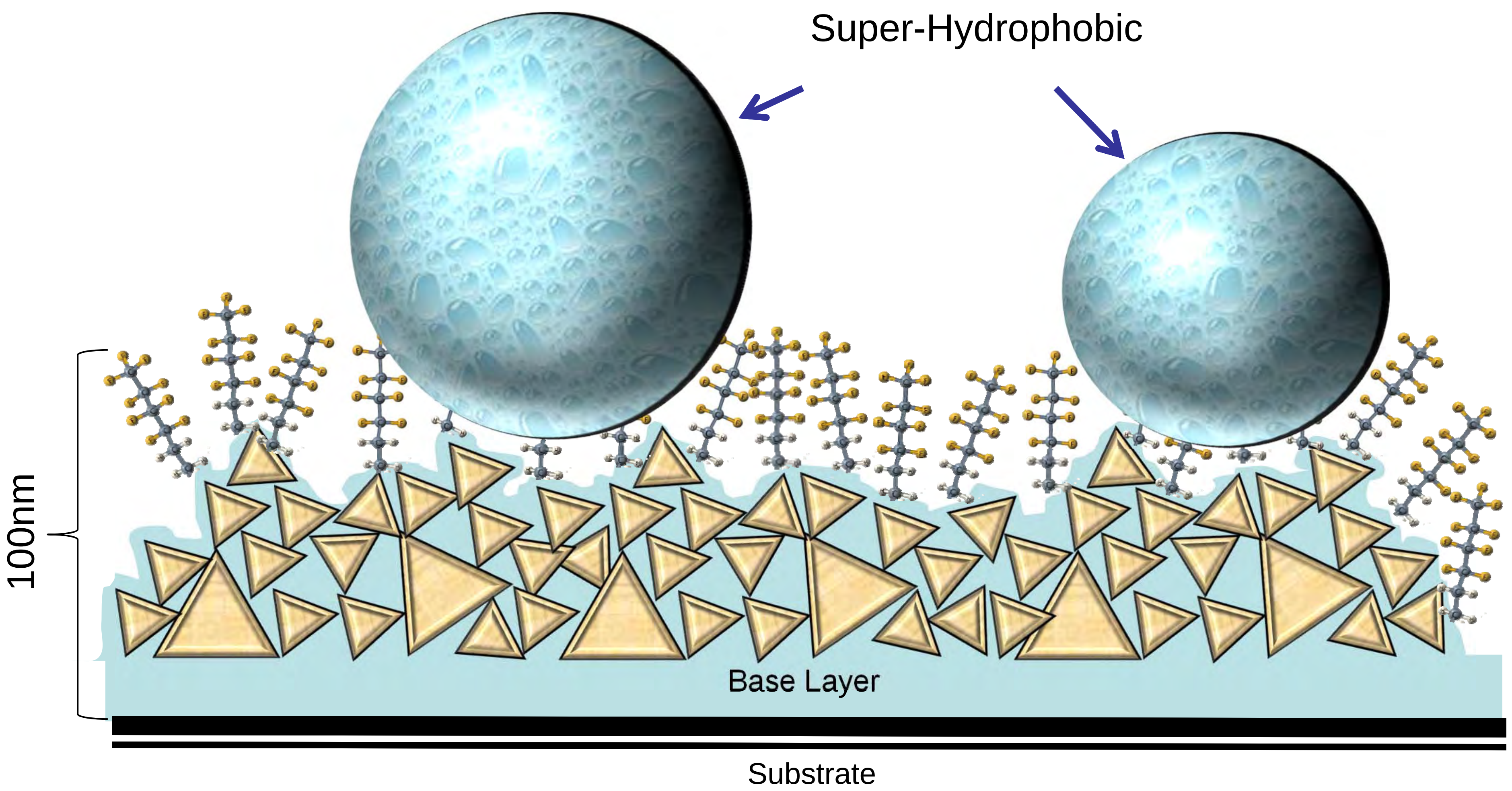
Game Changing Technologies

No Coating

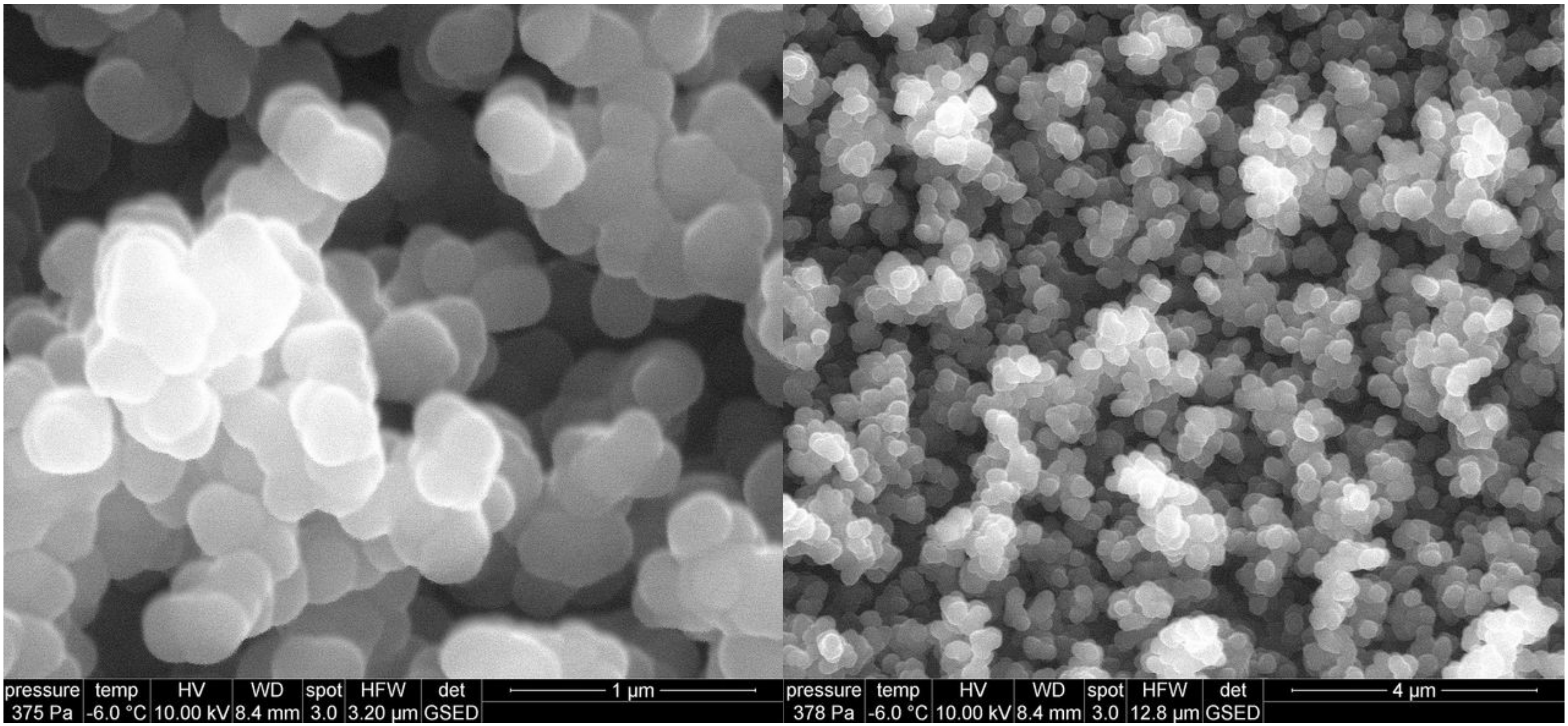
RPX Coated

After Neutral Salt Fog Exposure – 40 hours

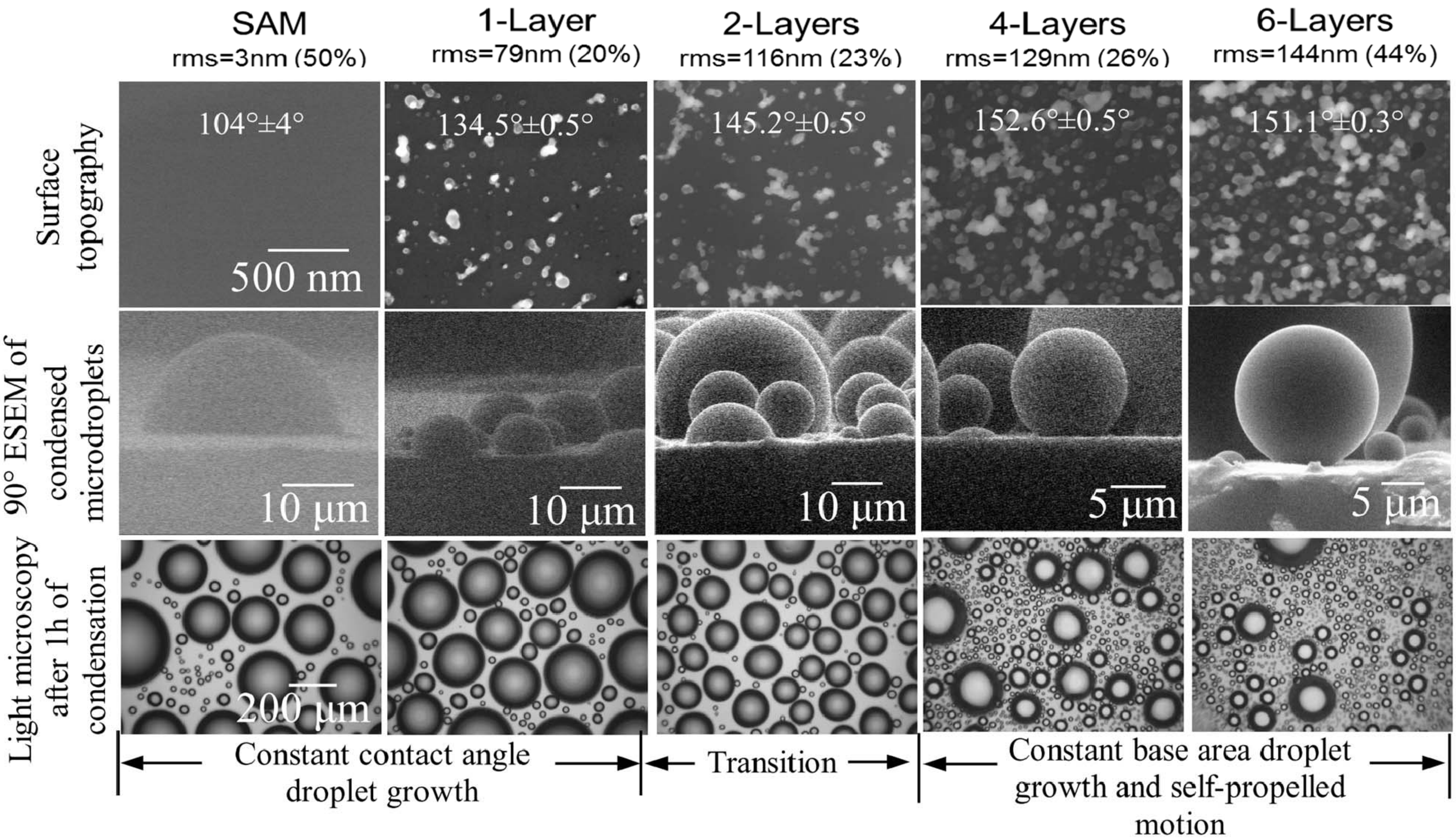
The Film Properties



Repellix with 100nm Linkerrix - Unscratched



Process Layering



Outline

- Brief Definitions and Uses of Surface Engineering
- Who We Are
- Surface Modification Science
- Surface Reactions → Nano-Composites
- IST's as a Supplier
- Summary

IST Standard Hardware Platforms

-210

- Surface Modification

RPX-540

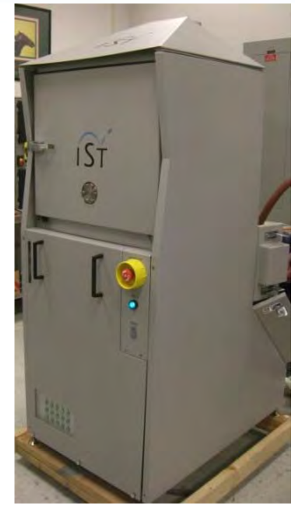
Additional Options:

- Ozone
- Plasma

-560

Enhanced Features:

- Dual Injection
- Plasma

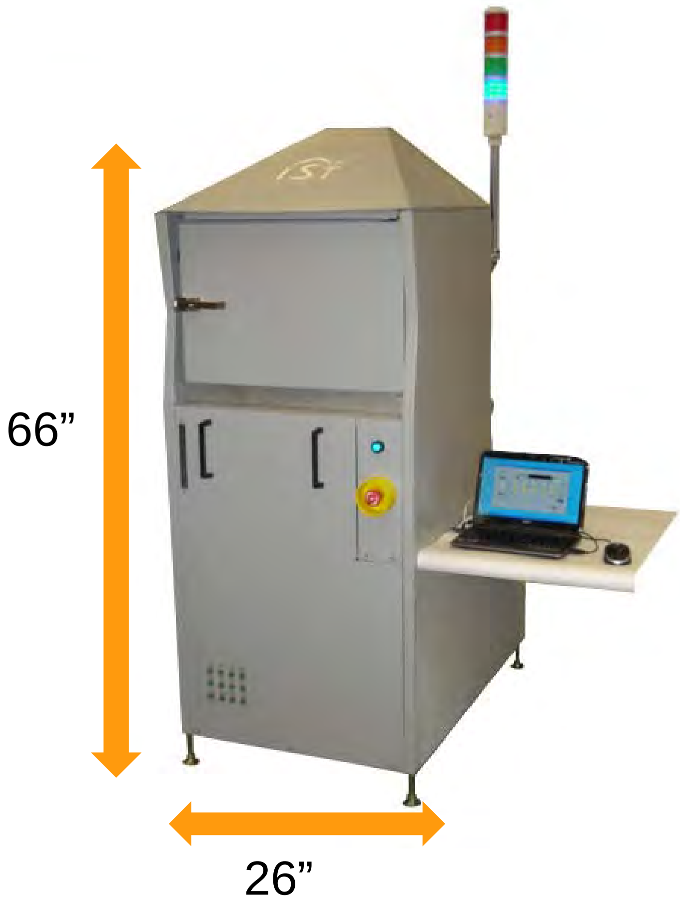


BL1

- Plasma Polymer

	BL1 (Plasma)	RGM-210	RPX-540	RGM-560
Width	12”	12.5”	20”	20”
Height	8”	10”	12”	17”
Depth	10”	9.6”	16”	16”
Vol. (liter)	12	20	60	90
Gases	1	2 ½	5	5

RPX-540 Hardware Designs

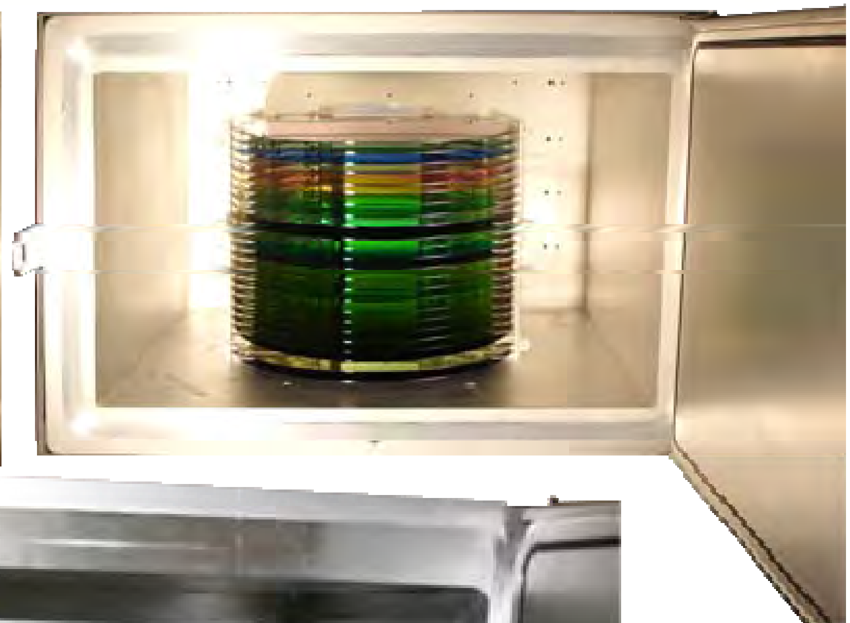


Ozone

Compact design with pull out electronics modules.

300mm Wafers or 15” Laptop

300mm



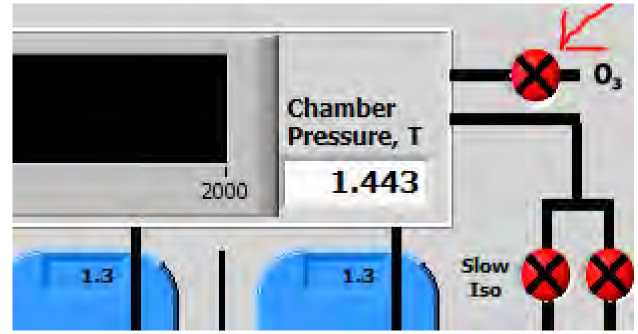
3rd Gen : Chemical Delivery

Vaporizers

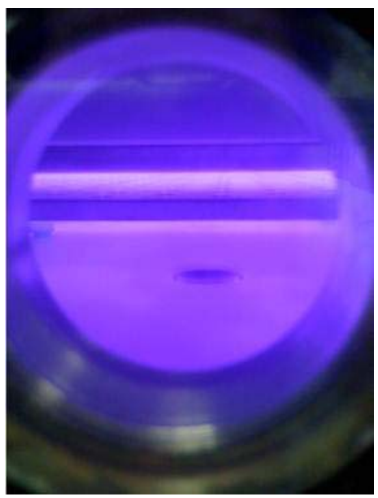
Interchangeable Cartridges

Fully Integrated Plasma Option

- Safety interlocked
- Use of plasma assisted reactions and surface mixing within individual process steps.
- RF Power (0-1000W) controlled within the process recipe.

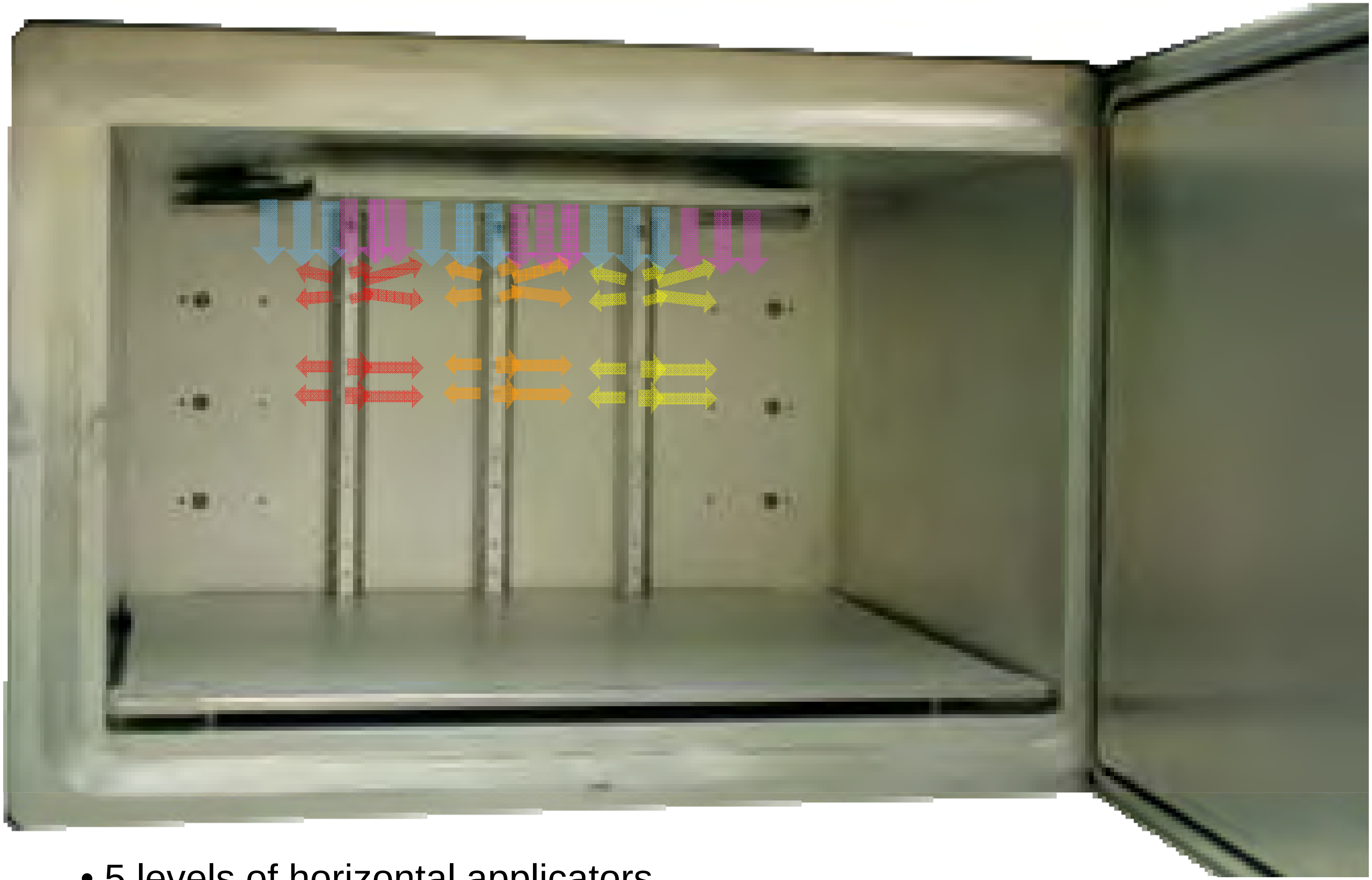


Pressure TimeLim	RF On	RF Power
	1	200
	1	150
35		
	1	50
60		
	1	35



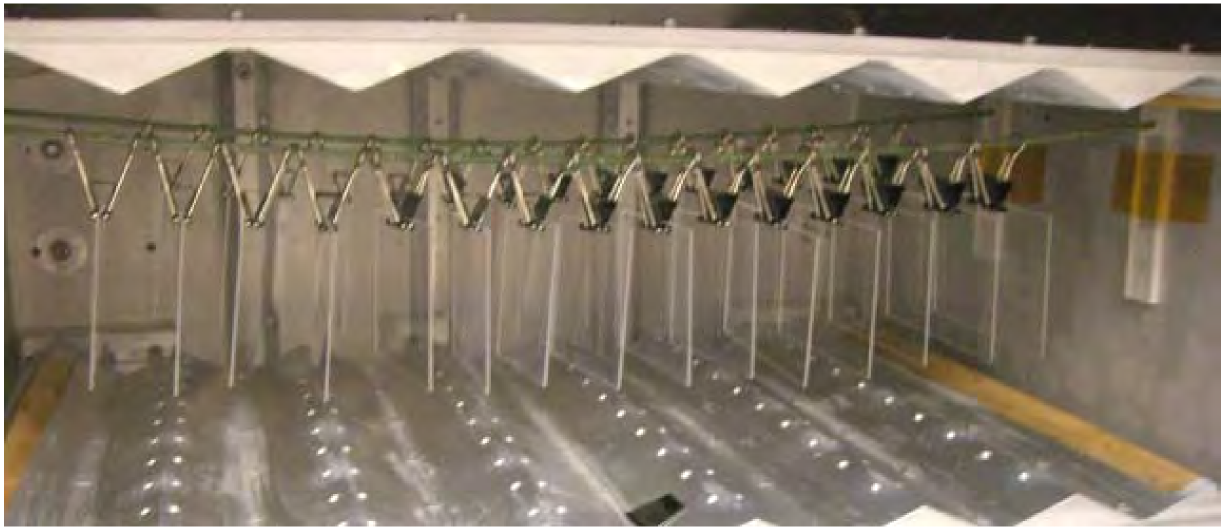
IST

Multi-Gas Injection Chamber Design



- 5 levels of horizontal applicators
- 3 vertical dispersion towers

Slides & Cartridges



The Cartridge – Safe, Reliable, Easy

Gas Cartridge is designed for a simplistic "plug and play" operation for easy maintenance

Cartridge Features:
- Precursor Charge
- Manual Shut-off Valve
- Heater
- Insulation
- Temperature Sensor
- Identification Interlock
- Electrical Over-temperature Safety Switch
- Lockout Safety to software

Each Cartridge is a self contained module delivered

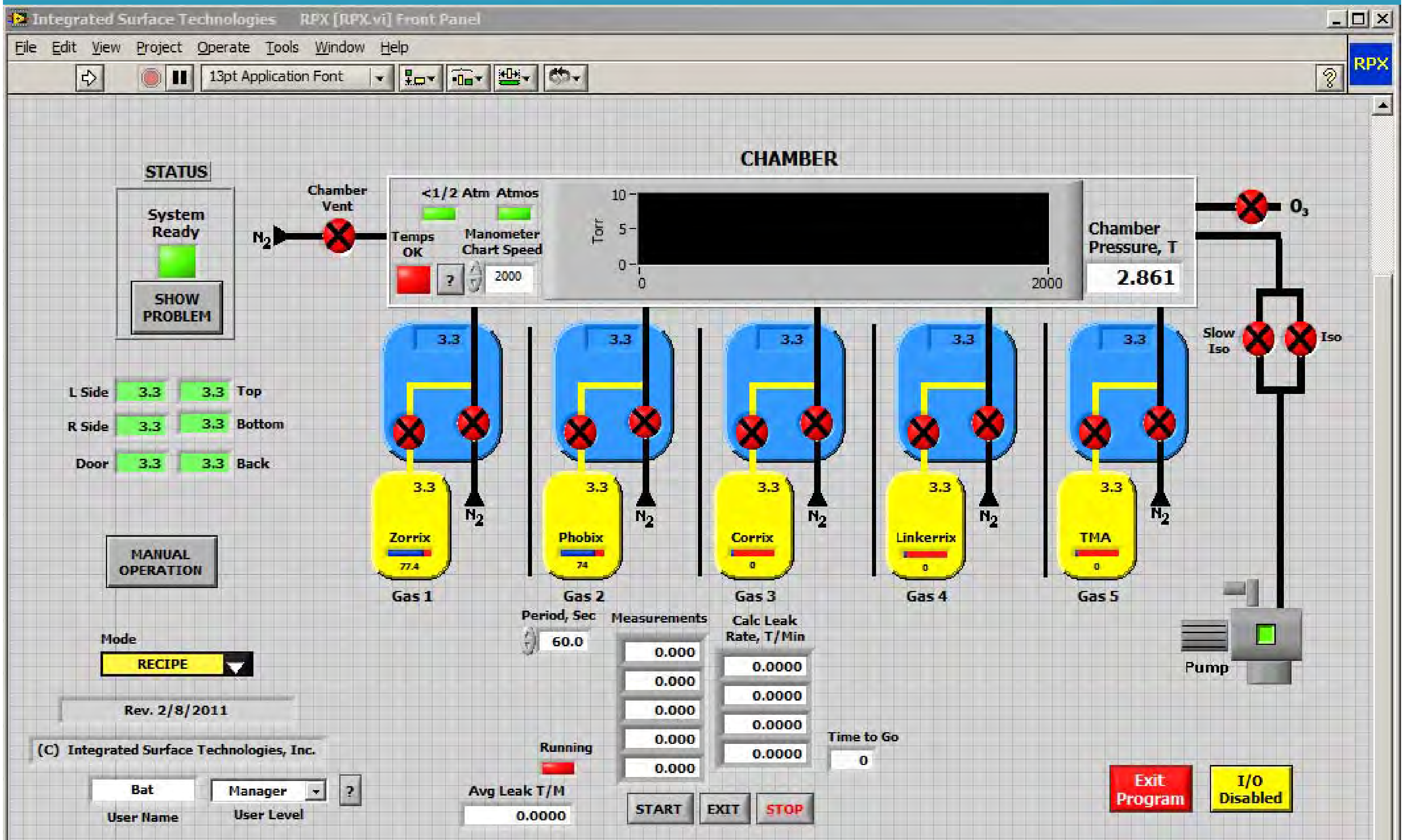
Cartridges in Volume

- **Lower COO for our customers**
- **Convenient Recycle Programs**
- **Economic Refilling**

Chemical Matrix

	Application Type								
Chemical	Hydrophobic	Repellix^{TM}	Bio	Adhesion	Bio Oxide	ALD Oxide	ALD TiO_x	ALD Alumina	Anti-Corrosion
BCHTCS			•	•					
BCH-E-TCS			•	•					
C8-silane	•								
C12-silane	•								
F(C5)TS	•								
F(C6)TS	•								
F(C8)TS	•								•
F(C10)TS	•		•						•
APTMS			•	•					
BCTSE			•	•	•				
Epoxy			•	•					
Glycidoxy			•	•					
Linkerrix		•		•		•			
Phobix		•							
Pyridine						•			
TMA		•		•				•	
TIP							•		
PEG			•						
Corrix (Cu)									•
Corrix (Metal)									•
Zorrix	•	•	•	•	•	•	•	•	•
Contact Angles	90^o-115^o	>160^o	30^o-70^o	30^o-70^o	< 30^o	< 30^o	< 30^o	< 20^o	50^o-70^o

Labview Interface v2



Example: Installation at Customer Site

Thru-the-wall Installation

IST

IST's Issued Patents

(12) **United States Patent**
Chinn et al.

(10) **Patent No.: US 7,968,187 B2**
(45) **Date of Patent: *Jun. 28, 2011**

(54) **SURFACE COATING**

(75) Inventors: **Jeff Chinn**, Menlo Park, CA (US); **W. Robert Ashurst**, Auburn, AL (US); **Adam Anderson**, Auburn, AL (US)

(73) Assignee: **Integrated Surface Technologies**, Menlo Park, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 78 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/209,629**

(22) Filed: **Sep. 12, 2008**

(65) **Prior Publication Data**

US 2009/0107713 A1 Apr. 30, 2009

Related U.S. Application Data

(60) Provisional application No. 60/983,504, filed on Oct. 29, 2007, provisional application No. 61/029,801, filed on Feb. 19, 2008.

(51) **Int. Cl.**
B32B 7/12 (2006.01)
H01L 23/29 (2006.01)

(52) U.S. Cl. **428/339**; 428/142; 428/143; 428/145; 428/148; 428/352; 257/789; 257/791; 257/635; 257/642

(58) **Field of Classification Search** 174/255, 174/258; 428/142, 143, 145, 148, 339, 352; 257/635, 642, 789, 791
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,656,830	A *	8/1997	Zechman	257/784
6,138,349	A *	10/2000	Vinciarelli et al.	29/841
6,902,947	B2 *	6/2005	Chinn et al.	438/48
7,329,439	B2 *	2/2008	Sachdev et al.	427/517
7,638,167	B2 *	12/2009	Kobrin et al.	427/248.1

* cited by examiner

Primary Examiner — Cathy Lam
(74) *Attorney, Agent, or Firm* — Daniel L. Flamm

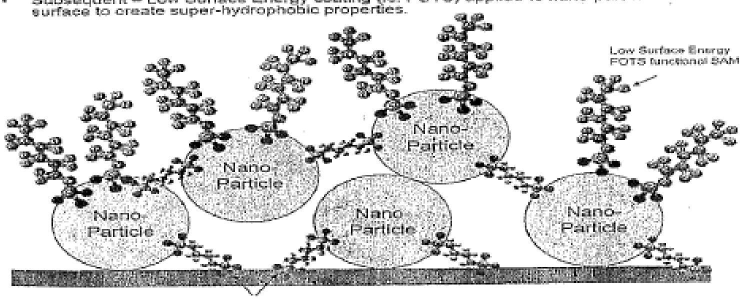
(57) **ABSTRACT**

A composite is provided, comprising a substrate and a film on the substrate. The film has an RMS surface roughness of 25 nm to 500 nm, a film coverage of 25% to 60%, a surface energy of less then 70 dyne/cm; and a durability of 10 to 5000 microNewtons. Depending on the particular environment in which the film is to be used, a durability of 10 to 500 microNewtons may be preferred. A film thickness 3 to 100 times the RMS surface roughness of the film is preferred.

22 Claims, 17 Drawing Sheets

Durability Improvement

- Nano-particles adhesion improved with silane linker make a more durable film.
- Subsequent – Low Surface Energy coating (ie. FOTS) applied to nano-particle surface to create super-hydrophobic properties.



(12) **United States Patent**
Chinn et al.

(10) **Patent No.: US 8,071,160 B2**
(45) **Date of Patent: *Dec. 6, 2011**

(54) **SURFACE COATING PROCESS**

(75) Inventors: **Jeffrey D. Chinn**, Foster City, CA (US); **Robert W. Ashurst**, Auburn, AL (US); **Adam N. Anderson**, Moseley, VA (US)

(73) Assignee: **Integrated Surface Technologies**, Menlo Park, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 749 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/115,874**

(22) Filed: **May 6, 2008**

(65) **Prior Publication Data**

US 2009/0110819 A1 Apr. 30, 2009

Related U.S. Application Data

(60) Provisional application No. 61/029,801, filed on Feb. 19, 2008, provisional application No. 60/983,504, filed on Oct. 29, 2007.

(51) **Int. Cl.**
B05D 5/12 (2006.01)
H05K 3/00 (2006.01)
C23C 16/00 (2006.01)

(52) U.S. Cl. **427/96.6**; 427/96.2; 427/97.5; 427/96.8; 427/126.4; 427/126.3; 427/204; 427/205; 427/220; 427/255.29; 427/255.31; 427/255.37; 427/419.2; 439/43

(58) **Field of Classification Search** 427/96.6, 427/407.1, 189, 96.2, 96.5, 126.1, 126.2, 427/126.4; 349/149; 977/720, 722, 779, 977/782
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,913,827	B2 *	7/2005	George et al.	428/402
7,258,895	B2 *	8/2007	Sandhu	427/255.28
2002/0025446	A1 *	2/2002	Chen et al.	428/543
2007/0141114	A1 *	6/2007	Muisener et al.	424/427
2007/0275411	A1 *	11/2007	McGall et al.	435/7.1
2008/0304008	A1 *	12/2008	Muisener et al.	351/159

OTHER PUBLICATIONS

Bourlinos et al., "Clay-Organosiloxane Hybrides: A Route to Cross-Linked Clay Particles and Clay Monoliths", Chem. Mater. 2004, vol. 16, pp. 2404-2410.*
Ashurt et al., "Vapor Phase Anti-Stiction Coatings for MEMS", EEE Transactions on Device and Materials Reliability, vol. 3, No. 4, Dec. 2003, pp. 173-179.*

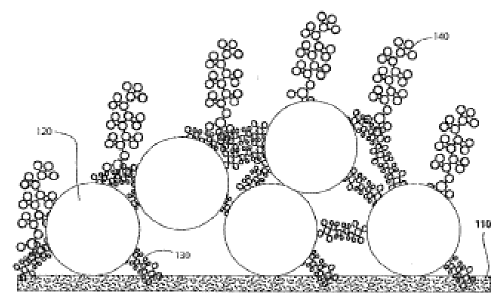
* cited by examiner

Primary Examiner — Duh-Wei Yuan
Assistant Examiner — Jose Hernandez-Diaz
(74) *Attorney, Agent, or Firm* — Microtechnology Law & Analysis; Daniel L. Flamm

(57) **ABSTRACT**

A method of forming a film is provided. Nanoparticles are deposited on a surface of a substrate using a liquid deposition process. The nanoparticles are linked to each other and to the surface using linker molecules. A coating having a surface energy of less than 70 dyne/cm is deposited over the film to form a coated film. The coated film has an RMS surface roughness of 25 nm to 500 nm, a film coverage of 25% to 60%, a surface energy of less than 70 dyne/cm; and a durability of 10 to 5000 microNewtons. Depending on the particular environment in which the film is to be used, a durability of 10 to 500 microNewtons may be preferred. A film thickness 3 to 100 times the RMS surface roughness of the film is preferred.

5 Claims, 17 Drawing Sheets



#3 US Patent: 8,221,828

Working with IST

- As a Supplier:
  - IST is provider of custom processing equipment for variety of surface engineering films (Super-Hydrophobic, Adhesion Promoters, Wetting solutions, Plasma.)
- As a Service Provider
  - Contract Coating Services
    - IST provides rapid turn coatings as a contract service for “You” R&D. and product lines.
- As a Partner
  - Technical Consult
    - IST has extensive expertise in materials and thin film technologies and can advise “You” on case-by-case scenarios.

Contact Us

- Fred Helmrich (fred@insurftech.com)

- Jeff Chinn, Ph.D., CTO
Integrated Surface Technologies
1455 Adams Drive, Suite 1125
Menlo Park, CA 94024
jeff@insurftech.com
+1-650-324-1824