Parylene Technology for Advanced Packaging, Protection & Reliability of Electronics

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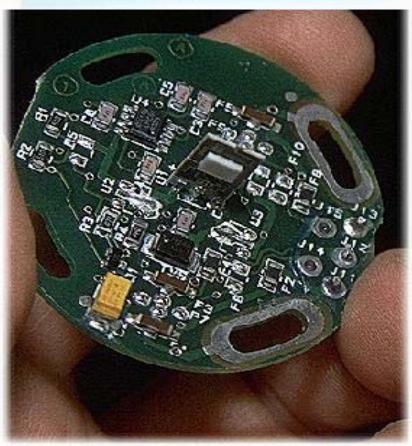
Outline

- Protection and reliability needs
- Brief description of Parylenes
- Characterization & Qualifications - enhanced reliability of electronics through Parylene HT
- Practical issues
- MEMS applications
- Conclusion

Introduction

Role of Polymers in Electronics Applications

- Due to protection & reliability demands
- Due to advances in other technology fields
- Growing challenge to assure safety and efficacy



Electronics

- Focus on miniaturization, denser packaging
- Device performance dependent upon protection of specialized components
- Manufacturers looking for protective coatings
  - –very thin, low mass
  - –acceptable application processing
  - –higher temperature integrity
  - –higher levels of electrical insulation per unit thickness

Packaging, Protection and Reliability Needs

Manufacturers issues

- Smaller and multi layer components
- Narrower lead spacing
- Fragile devices, Stiction issues
- Protection from moisture and other contamination
- Higher operating temperature
- Higher frequency operations
- Improved processing methods
- Product differentiation (via improved engineering)
- Reliability of the components in corrosive/harsh environments

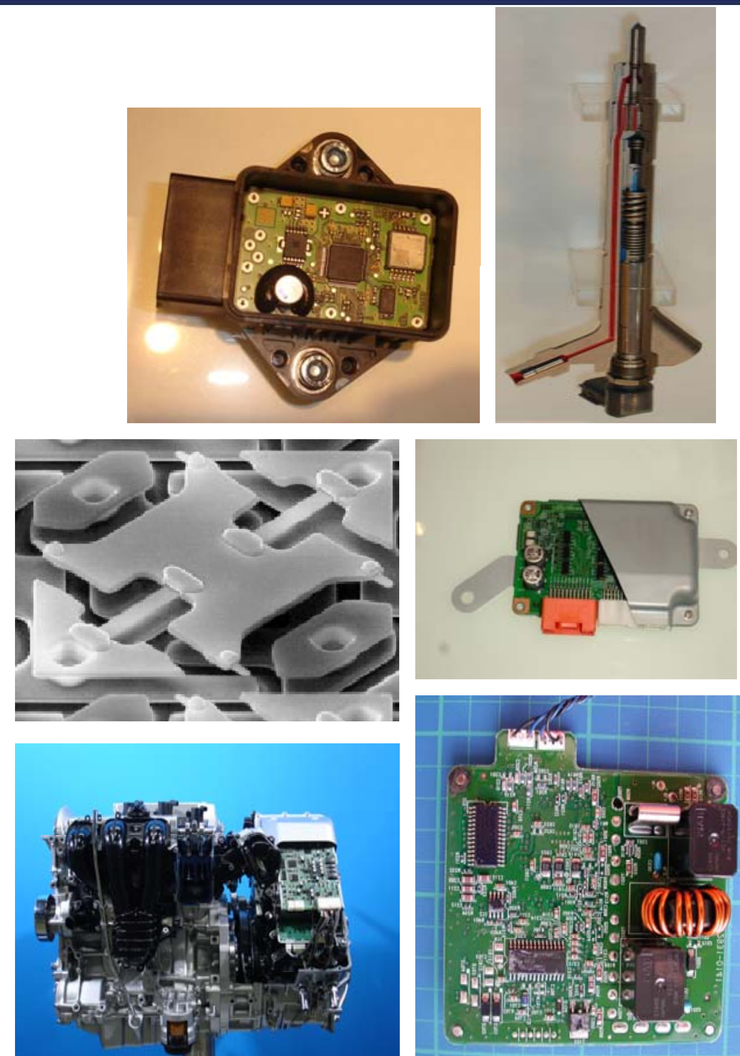
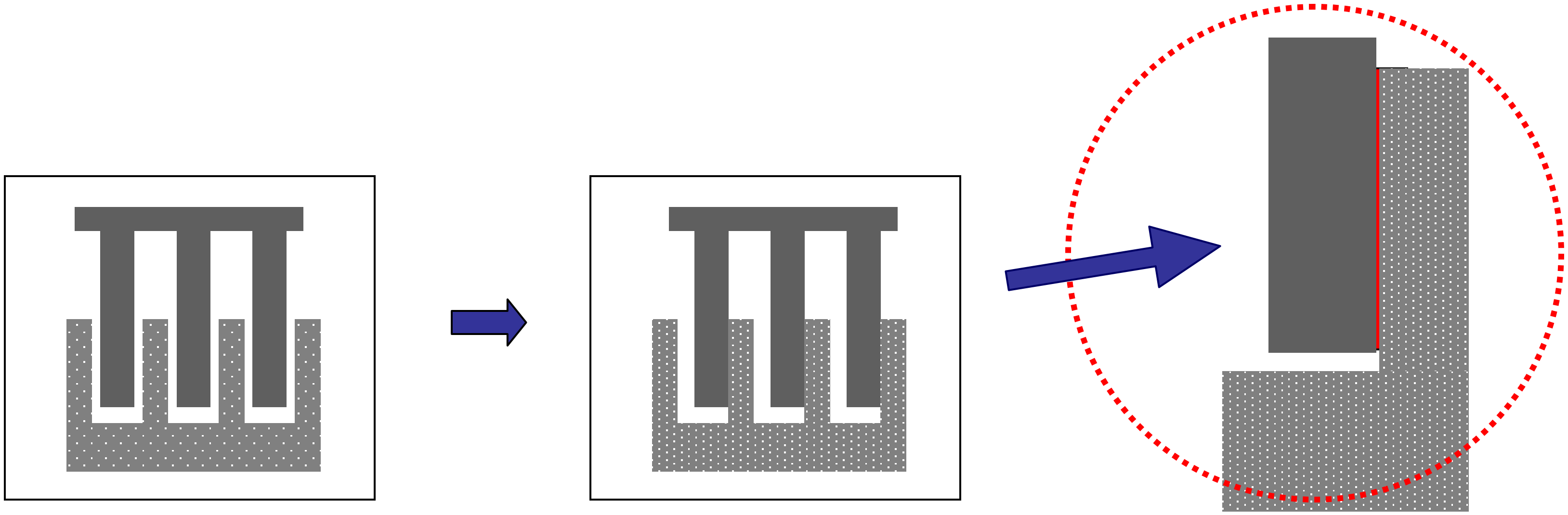


Photo courtesy by Prismark

MEMS Packaging and Reliability Issues

(airbag sensor example)



- **Packaging challenges**
  - Wafer and device level
  - Pre-package handling concerns
  - Post-handling issues; can be shock sensitive
  - cost-effective, high volume packaging
  - Stiction
    - Moisture (but too low can increase wear)
    - Hygroscopic surfaces; more H-bonding
    - Larger contact surfaces
    - Smooth surfaces; increases contact
    - High surface energy (more molecular attraction)

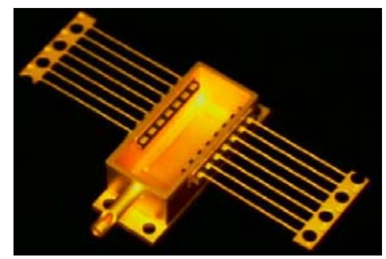
Requirements for Electronic Devices and Assemblies

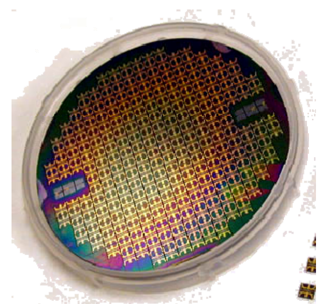
- Adhesion
- Low MVTR & water absorption
- Protection from corrosion
- No delamination, blistering, flaking or chemical decomposition on aging, thermal or humidity exposure or any other harsh environments
- High purity
- Non-nutrient (resistant to microorganisms)
- Low outgassing
- Low stress (Low CTE)
- Excellent electrical properties (insulation resistance, dielectric constant, dissipation factor, dielectric breakdown voltage) and their retention under thermal aging, humidity exposure and a wide frequency range.
- UV and ionizing radiation stability

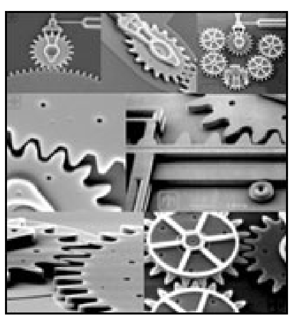
Examples of Electronic Components Needing Protection

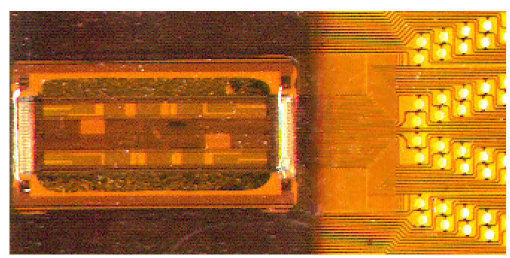
- Electronic circuit boards
- High frequency electronics
- MEMS & NEMS
- Mass air temperature and pressure sensors
- Diesel fuel heater
- Emission sensor
- Ceramic & ferrite cores
- “O” rings, seals and engine gaskets
- LED clusters

- Hybrid fuel system electronics
- Silicon carbide chips
- Fuel cell components
- Optoelectronic devices



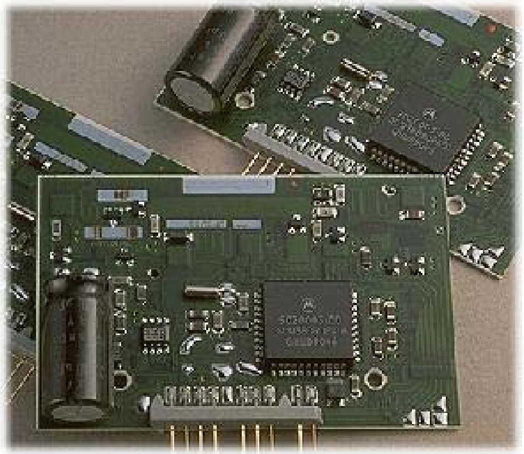


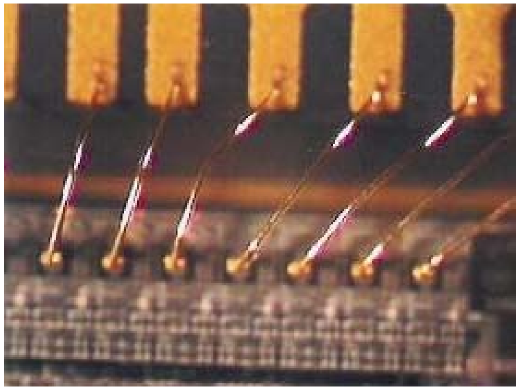




Why Parylene?

- Parylene is an excellent barrier against the liquid and corrosive chemicals used in the electronics and medical device industries
- Provides complete, pinhole-free encapsulation
- Conformal and uniform nature gives it high reliability & mechanical Strength
- Deposits as an inert, continuous film at room temperature
- Successful use coating electronics in the various industries
- Low static and dynamic coefficients of friction
- Excellent electrical resistance, high dielectric strength
- **Sterilization tolerant** (steam autoclave, H_2O_2 plasma, EtO, gamma and e-beam)





Why Parylene?

Significant roles

- Packaging and protection
- Enhancing reliability of medical devices & electronics
  - in the presence of tissue and fluids for implantable devices
  - in general, from adverse environments in non-implanted devices
- Numerous medical devices are being currently coated with Parylenes… e.g., stents, ocular and cochlear implants, implantable cardiac defibrillators, neurostimulators etc.

Encouraged researchers to explore new roles

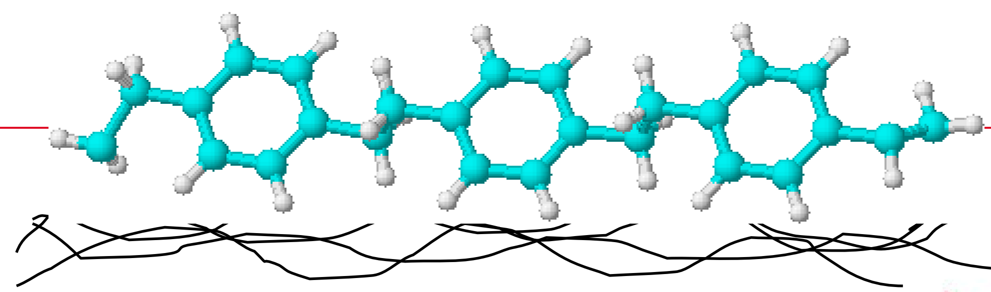
- Electro-wetting lenses
- Biosensors, biochips
- MEMS technology
- Structural components
  - microfluidic devices, mass flow controllers, electrospray micro-nozzle, electrostatic actuators etc.

What is Parylene?

- A common generic name for a unique polymer series of polymers based on p-Xylylene.

  - PARA-XYLYLENE

- Linear -
- Amorphous -
- Polycrystalline & Stable



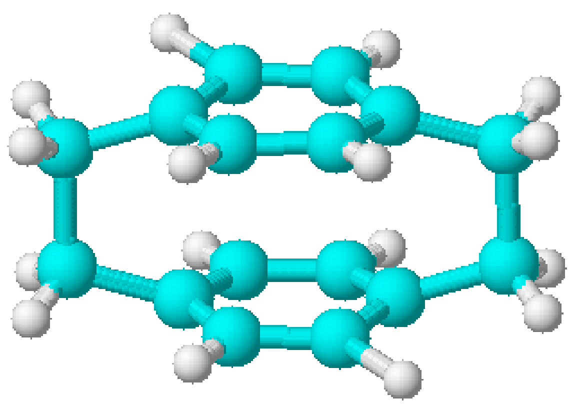
Parylene History

- An accidental discovery by Dr. Michael Szwarc, WW II refugee, at the University of Manchester, UK, in 1947
  - Dimer isolated as impurity in film
- Dr. W^M Gorham at Union Carbide Corporation in late 40's
  - proposed using powdered form of dimer … a laboratory curiosity
- Dr. Donald Cram at UCLA provided solution to synthesis of dimer in 1951
- Dr. Gorham announced the current vapor deposition polymerization
  - Coating process that bears his name patented in 1967
- Nova Tran Ltd. purchased license agreement from UCC in 1971
  - Made Parylene VDP a commercial success
- Union Carbide Corporation purchased Nova Tran Ltd. in 1984
- Renamed Specialty Coating Systems (SCS) in 1991
- Cookson Electronics acquired SCS in 1994
- Bunker Hill Capital acquires SCS on December 30, 2005

Parylene

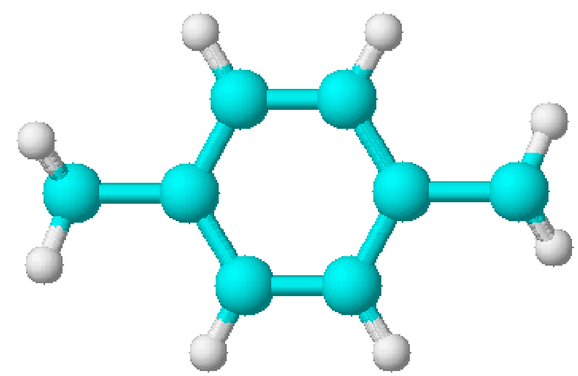
Dimer

- Process feedstock
- Granular powder
- Exceptionally stable at atmospheric pressure & room temperature
- Shelf Life “Indefinite” at given conditions
- Strained bond configuration

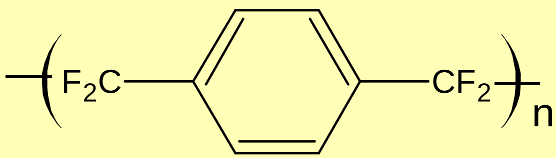


Monomer

- Monomer is chemical key to the process
- Extremely reactive, rarified low pressure gas (carbon-carbon bond)
- Cannot be stored
- Must be generated as needed
- Transport limitations
- Varying activity levels

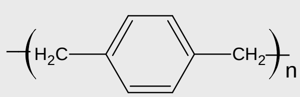


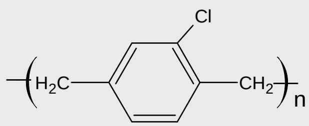
Parylenes

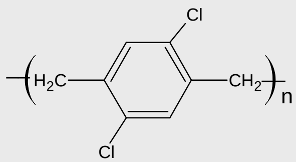


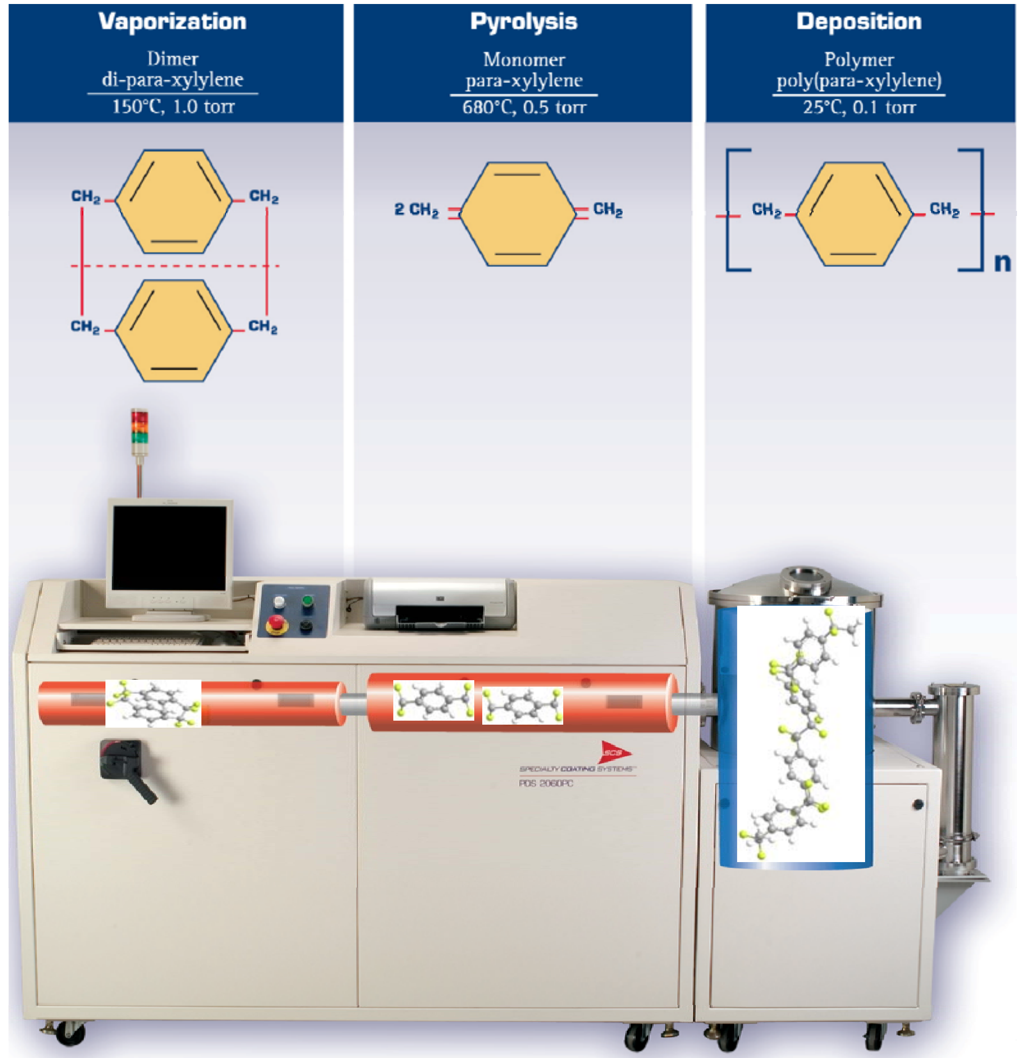
Parylene HT®

High Temperature
Fluorinated Parylene

Parylene N 

Parylene C 

Parylene D 



Parylene Deposition Systems

PDS 2060 PC

PDS 2035 CR

←PDS 2010

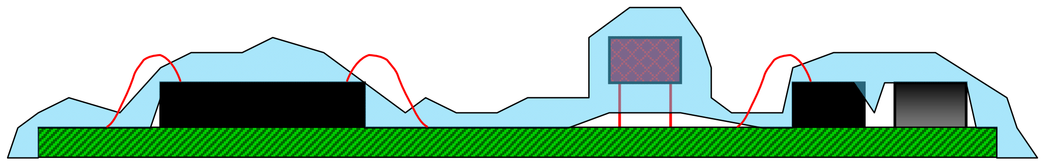
Unique Process Features

- Gas phase deposition (VDP)
- No liquid phase ever isolated
- Gas phase is highly reactive
- Controllable thickness
- No cure cycle
- No volatile component
- High purity polymer
- Clean, self-contained process
- Room temperature deposition
- Spontaneous formation
- No cure stresses
- Low mass thin films
- Molecular level deposition
- Non-line-of-sight coating

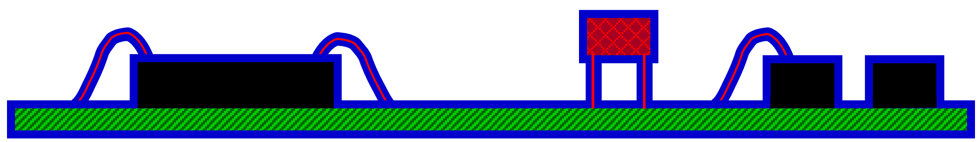
Liquid vs. Parylene Coating

Circuit Board Comparison

Liquid Coating

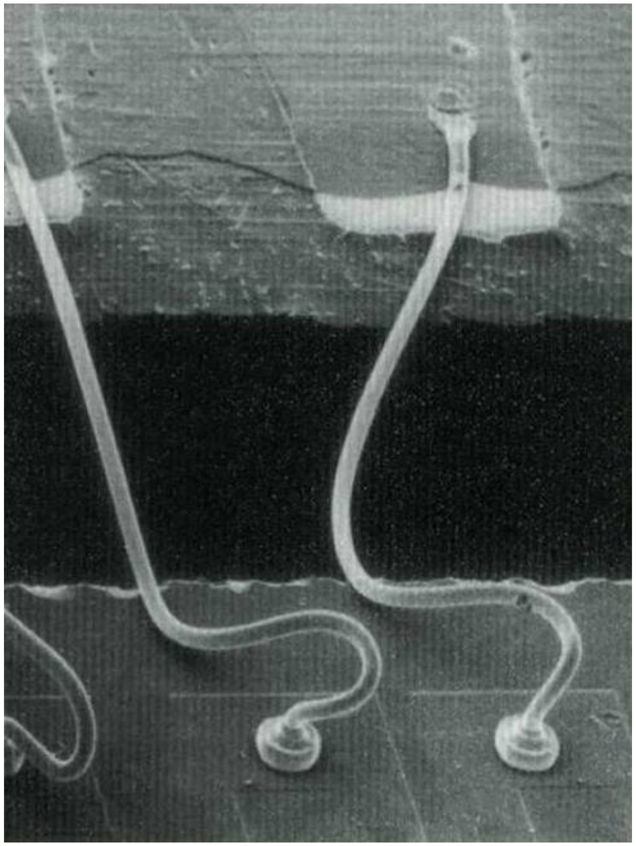


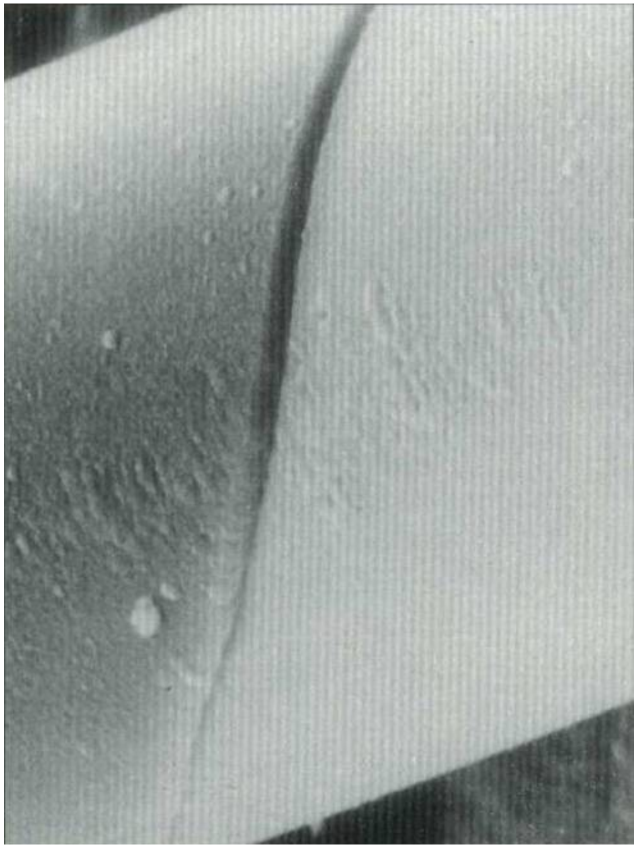
Parylene Coating



Parylene Characteristics

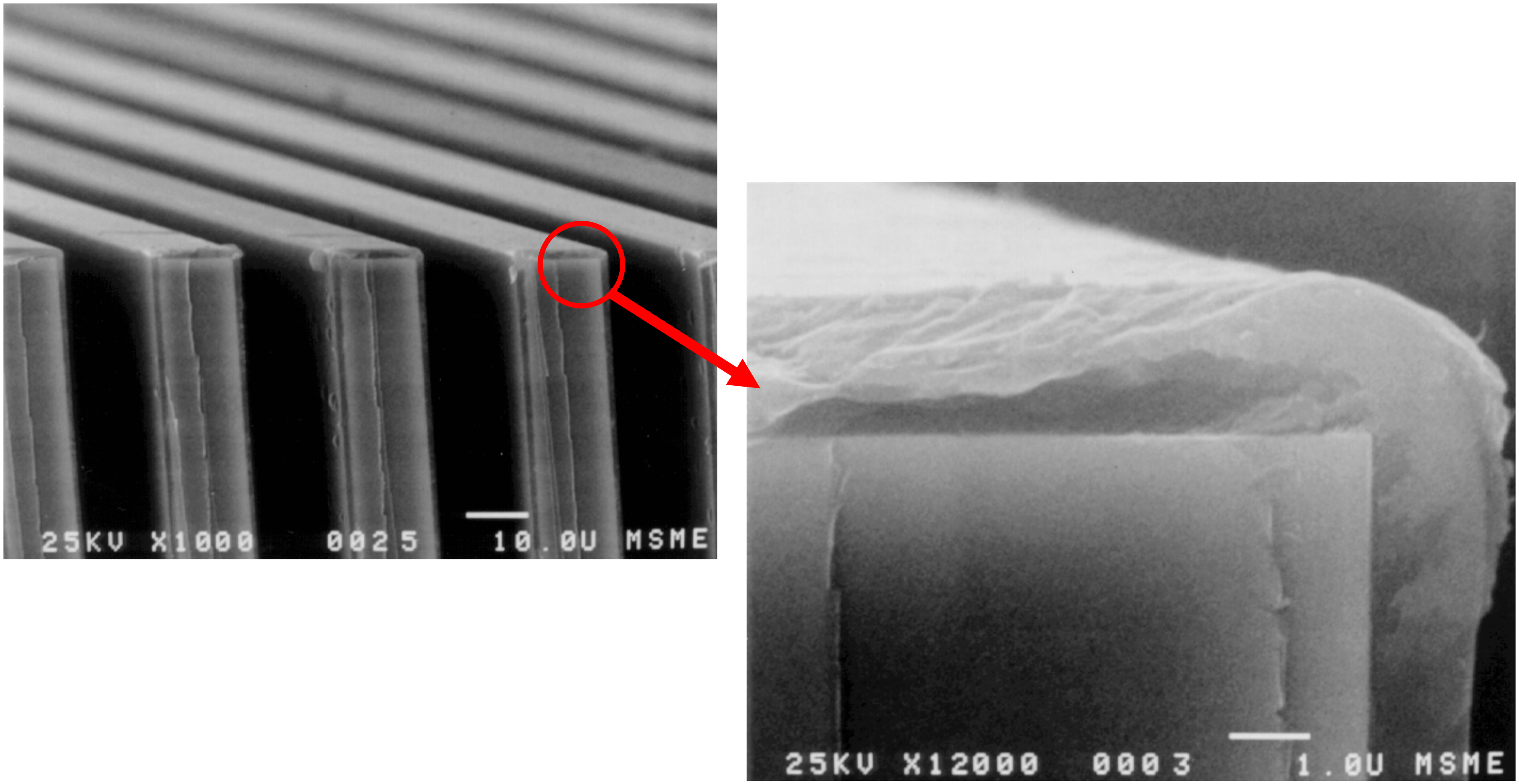
Truly Conformal





0.001" (1 mil) gold wire with a 1.5μm Parylene C coating

Parylene Characteristics



Parylene C; As deposited

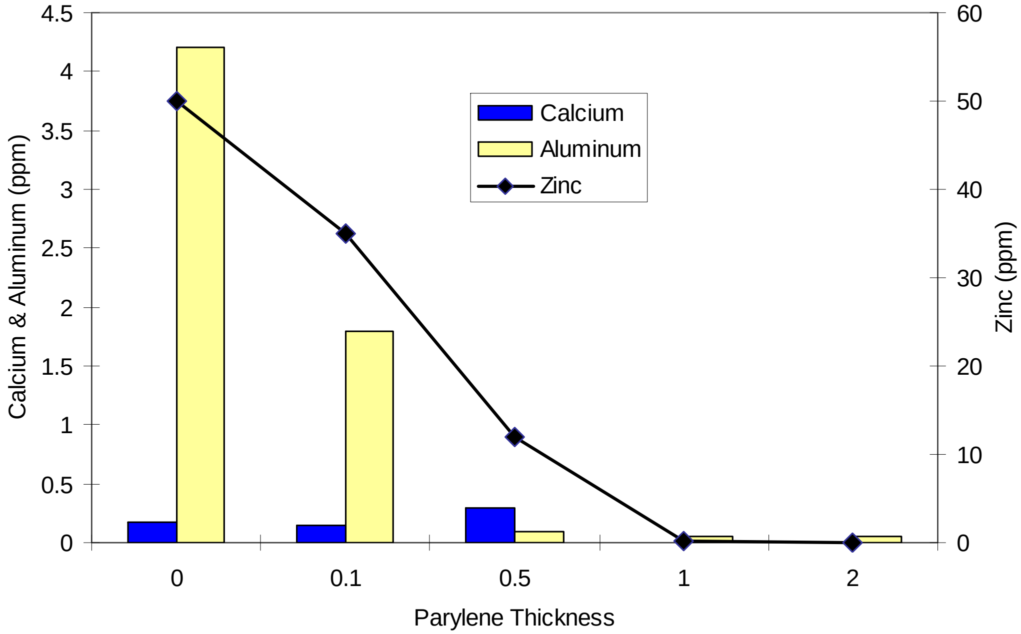
E.E. Hui, UC Berkeley

Parylenes' Characteristics Important for Electronics Applications

- Barrier Properties and Chemical Inertness
- Corrosion Control
- Electrical Resistance
- Thermal Humidity Aging Resistance
- Fungus Resistance
- Dry Lubricity
- Biostability and Bioacceptability
- Sterilization
- Resistance to Oxidation
- Radiation Resistance
- Outgassing
- Crevice Penetration Ability
- Whisker Growth Prevention
- RoHS compliance

Parylene Barrier Properties

The effect of Parylene C coating thickness on extractable metals in rubber specimens



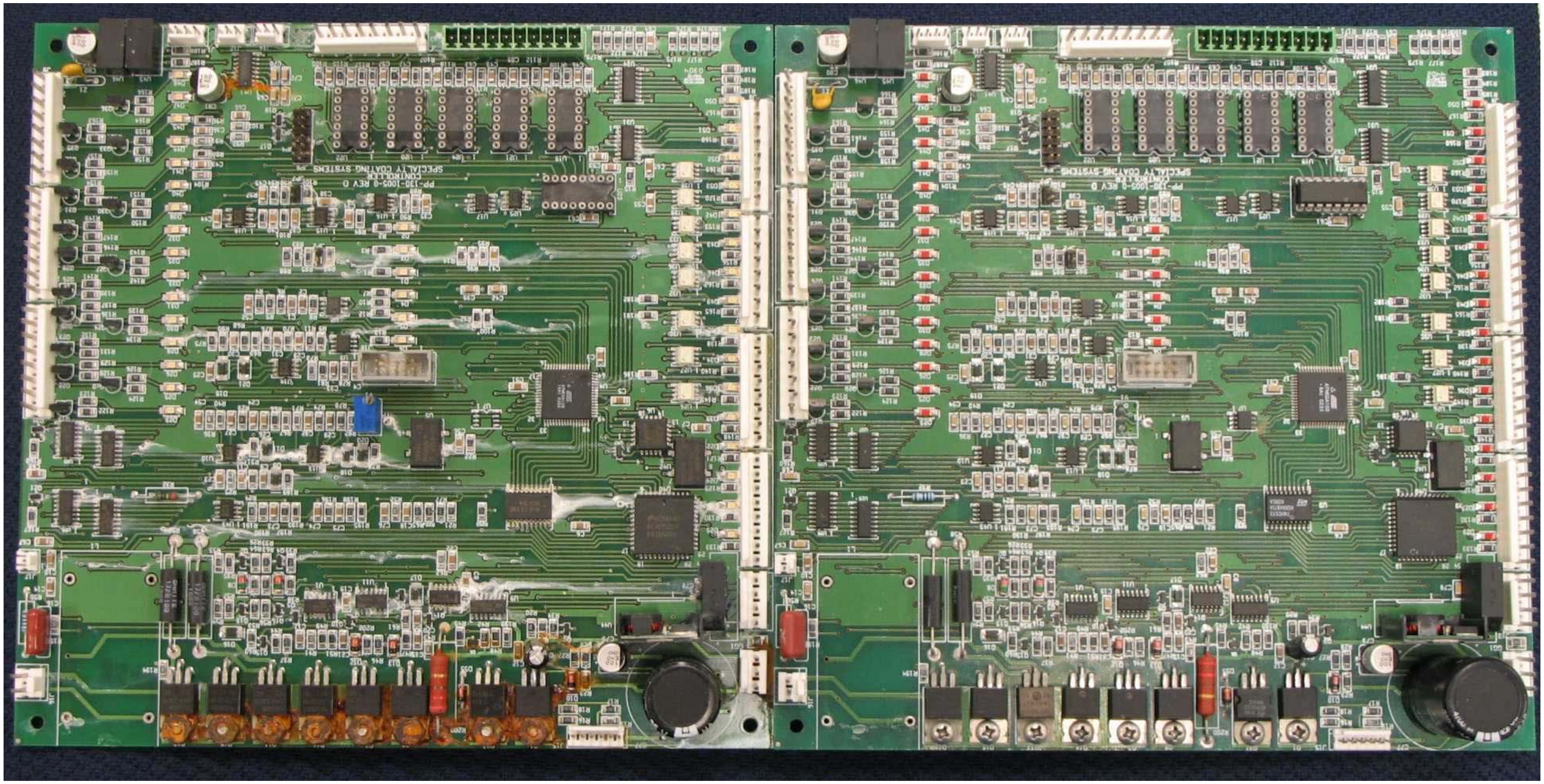
Example: Cardiac pacemaker electronic modules tested in ~1% saline solution at 37C

Test parameters: pulsewidth, current drain, pulse interval

Results: Parylene C performed well over 30 days compared to the second best which lasted 58 hrs only. All other coatings failed within 8 hours.

Ref: Devanathan, D, and Carr, R. "Polymeric Conformal Coatings for Implantable Electronic Devices", IEEE Transactions on Biomedical Engineering, 1980, Vol. BME-27, No. 11, pp.671-674.

Corrosion Control



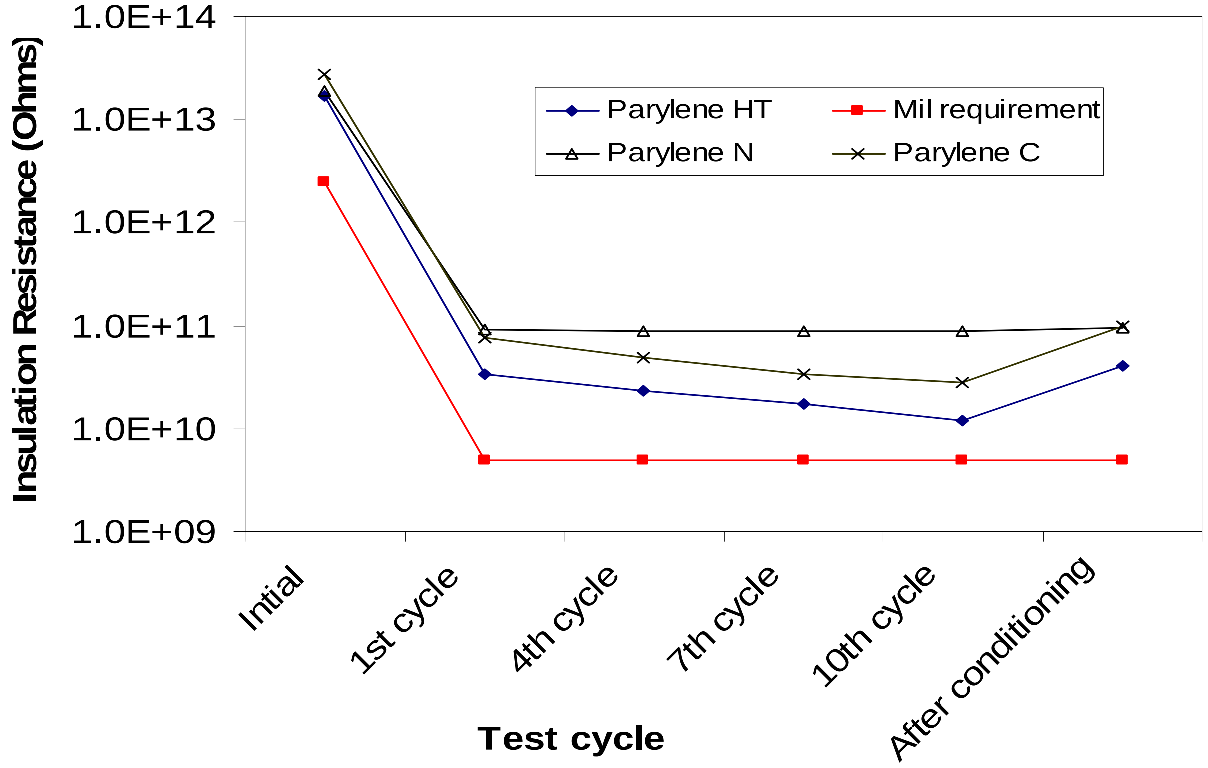
Uncoated (left side) and Parylene HT coated (right side) PCB boards after 144 hours salt fog test in accordance with ASTM B117-(03)

Barrier Properties

Polymer	Gas Permeability at 25°C, (cc•mm)/(m²•day•atm)[a] N_2	O_2	CO_2	H_2	Water Vapor Transmission Rate (g•mm)/(m²•day)
Parylene N	3.0	15.4	84.3	212.6	0.59[b]
Parylene C	0.4	2.8	3.0	43.3	0.08[c]
Parylene D	1.8	12.6	5.1	94.5	0.09[b]
Parylene HT	4.8	23.5	95.4	–	0.22[d]
Acrylic (AR)	–	–	–	–	13.9[e]
Epoxy (ER)	1.6	2.0 – 3.9	3.1	43.3	0.94[e]
Polyurethane (UR)	31.5	78.7	1,181	–	0.93 – 3.4[e]
Silicone (SR)	–	19,685	118,110	17,717	1.7 – 47.5[e]

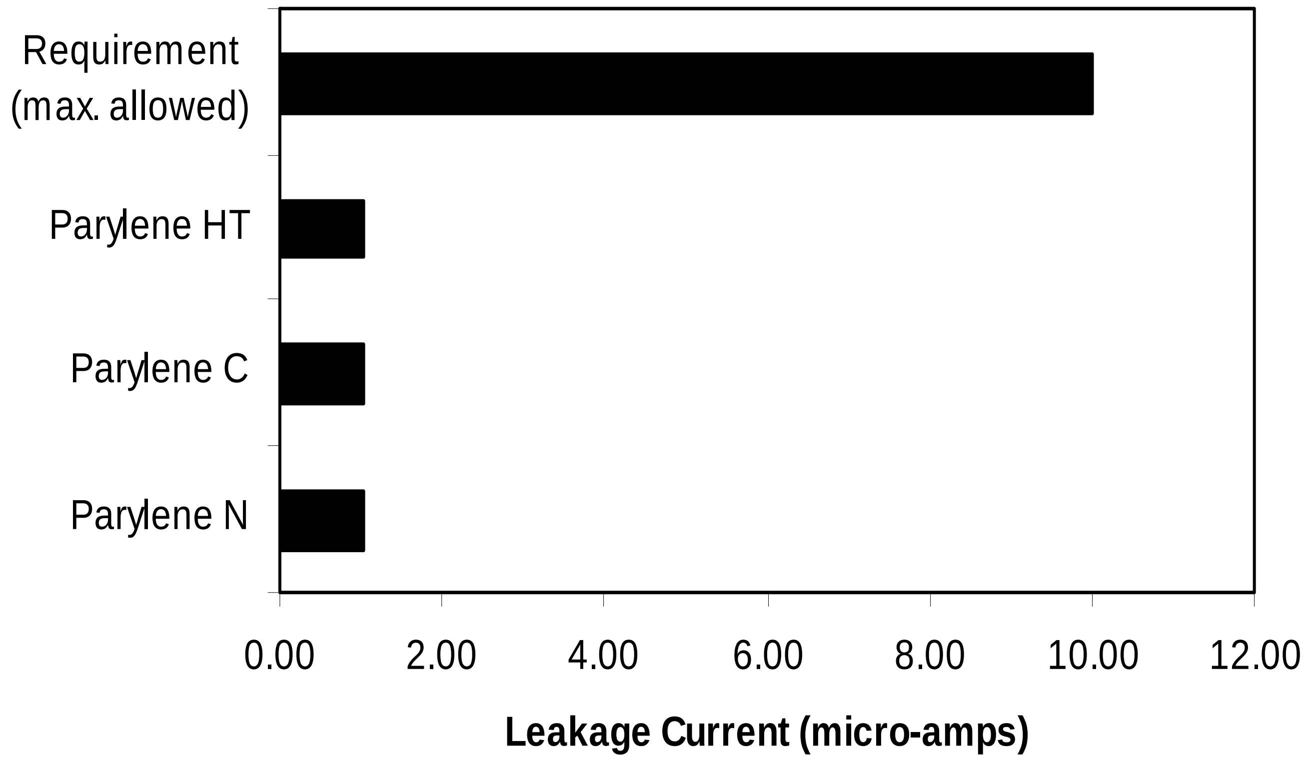
[a]ASTM D 1434
[b]ASTM E 96 (at 90% RH, 37°C)
[c]ASTM F 1249 (at 90% RH, 37°C)
[d]ASTM F 1249 (at 100% RH, 38°C)
[e]*Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

Moisture Resistance -Insulation Resistance



Tested in accordance with Mil-STD 202, Method 302, test condition B (Temp: 65^{0}C, RH: 90-96%)

Electrical Resistance

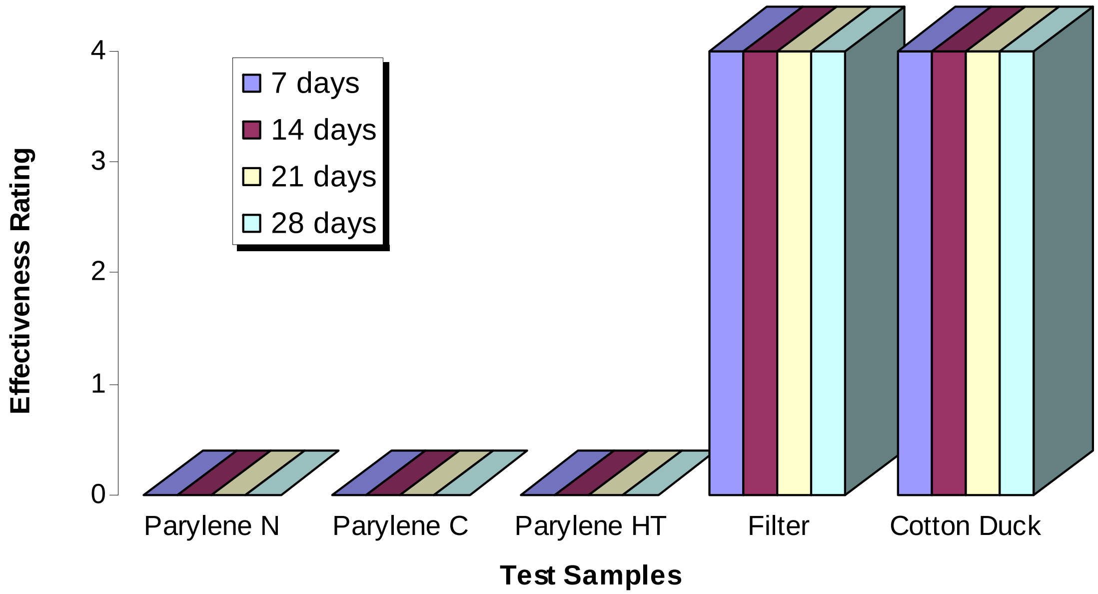


For moisture resistance-dielectric withstanding voltage test, several samples (Y-test patterns) coated with Parylene N, C and Parylene HT were tested (upon completion of moisture resistance testing) in accordance with Mil-Std-202, method 301, using 1500 Vrms at 60 hertz. Duration of voltage application was 60 seconds.

Thermal-Humidity Aging

- **Test conditions**
  - Temp: 85^0C
  - RH: 95%
  - Control sample kept at Temp: 25^0C, RH: 50%)
- **Samples were examined at following intervals**
  - After 28th day (after 2 hr stabilization @ 25^0C/RH: 50%
  - After 56th day (after 2 hr stabilization @ 25^0C/RH: 50%
  - After 84th day (after 2 hr stabilization @ 25^0C/RH: 50%
  - After 120th day (after 7 days stabilization @ 25^0C/RH: 50%
- **Results** (visual examination compared to control sample)
  - No evidence of softening, chalking, blistering, cracking, loss of adhesion or liquifications. All markings and color underneath the coating were legible and distinguishable

Microorganism Resistance



Rating:

0 = none
1= Traces of growth (less than 10%0
2= Light growth (10-30%)
3= Medium growth (30-60%)
4= Heavy growth (60% to complete coverage)

Test Method: ASTM G-21

Electrical Properties

Properties	Method	Parylene N	Parylene C	Parylene D	Parylene HT	Acrylic (AR)[a,b]	Epoxy (ER)[a,b]	Polyurethane (UR)[a,b]	Silicone (SR)[a,b]
Dielectric Strength V/mil	1	7,000	5,600	5,500	5,400	3,500	2,200	3,500	2,000
Volume Resistivity, ohm-cm, 23°C, 50% RH	2	1.4×10^{17}	8.8×10^{16}	1.2×10^{17}	2.0×10^{17}	1.0×10^{15}	1.0×10^{16}	1.0×10^{13}	1.0×10^{15}
Surface Resistivity, ohms, 23°C, 50% RH	2	1.0×10^{13}	1.0×10^{14}	1.0×10^{16}	5.0×10^{15}	1.0×10^{14}	1.0×10^{13}	1.0×10^{14}	1.0×10^{13}
Dielectric Constant									
60 Hz	3	2.65	3.15	2.84	2.21	–	3.3 – 4.6	4.1	3.1 – 4.2
1 KHz		2.65	3.10	2.82	2.20	–	–	–	–
1 MHz		2.65	2.95	2.80	2.17	2.7 – 3.2	3.1 – 4.2	3.8 – 4.4	3.1 – 4.0
Dissipation Factor									
60 Hz	3	0.0002	0.020	0.004	<0.0002	0.04 – 0.06	0.008 – 0.011	0.038 – 0.039	0.011– 0.02
1 KHz		0.0002	0.019	0.003	0.0020	–	–	–	–
1 MHz		0.0006	0.013	0.002	0.0010	0.02 – 0.03	0.004 – 0.006	0.068 – 0.074	0.003 – 0.006

[a] *Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

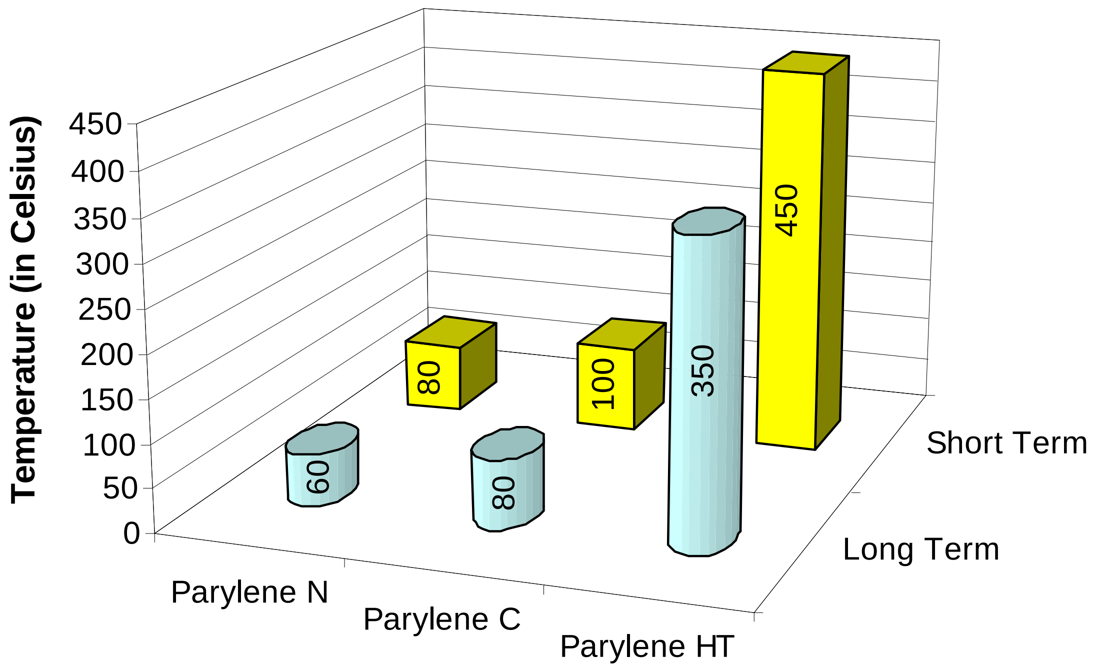
[b] *Conformal Coating Handbook*, Humiseal Division, Chase Corporation, Pennsylvania, 2004.

Test Methods:

1. ASTM D 149
2. ASTM D 257
3. ASTM D 150

Oxidation Resistance

Thermal-oxidative stability of Parylenes



Physical & Mechanical Properties

Properties	Method	Parylene N	Parylene C	Parylene D	Parylene HT	Acrylic (AR)[a,b]	Epoxy (ER)[a,b]	Polyurethane (UR)[a,b]	Silicone (SR)[a,b]
Secant (Young's) Modulus (psi)	1, 2	350,000	400,000	380,000	370,000	2,000 – 10,000	350,000	1,000 – 100,000	900
Tensile Strength (psi)	3	7,000	10,000	11,000	7,500	7,000 – 11,000	4,000 – 13,000	175 – 10,000	350 – 1,000
Yield Strength (psi)	3	6,100	8,000	9,000	5,000	–	–	–	–
Elongation to Break (%)	3	Up to 250	Up to 200	Up to 200	Up to 200	2 – 5.5	3 – 6	>14	100 – 210
Yield Elongation (%)	3	2.5	2.9	3.0	2.0	–	–	–	–
Density (g/cm^3)	4	1.10 – 1.12	1.289	1.418	1.32	1.19	1.11 – 1.40	1.10 – 2.50	1.05 – 1.23
Index of Refraction (n_D^{23})	5, 6	1.661	1.639	1.669	1.559	1.48	1.55 – 1.61	1.50 – 1.60	1.43
Water Absorption (% after 24 hrs)	7	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.01	0.3	0.05 – 0.10	0.6 – 0.8	0.1
Rockwell Hardness	8	R85	R80	R80	R122	M68 – M105	M80 – M110	68A – 80D (Shore)	40A – 45A (Shore)
Coefficient of Friction									
Static	9	0.25	0.29	0.33	0.15	–	–	–	–
Dynamic		0.25	0.29	0.31	0.13	–	–	–	–

[a]*Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

[c]*Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

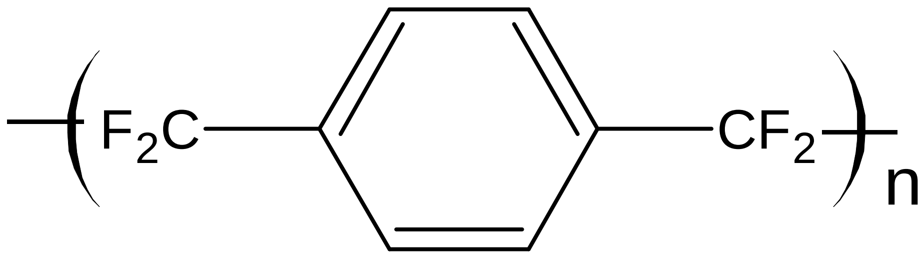
Test Methods:

1. ASTM D 882 (except Parylene HT)
2. ASTM D 5026 (Parylene HT only)
3. ASTM D 882
4. ASTM D 1505
5. Abbe Refractometer (except Parylene HT)
6. ASTM D 542 (Parylene HT only)
7. ASTM D 570
8. ASTM D 785
9. ASTM D 1894

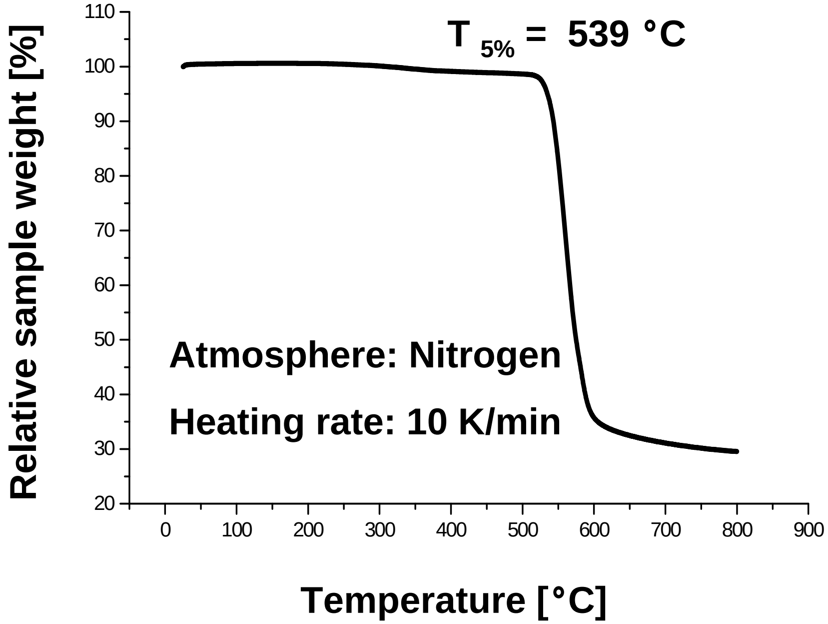
SCS

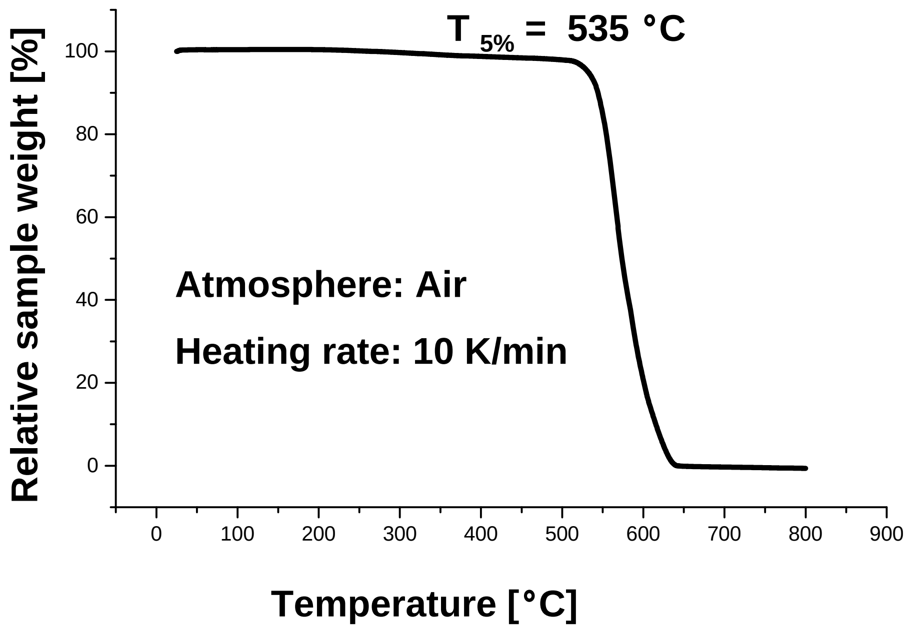
Exceptional Characteristics of Parylene HT

- **Thermal** - Higher temperature integrity
- **Electrical** - Low dielectric constant and low dissipation factor
- **UV Stability**
- **Protection from corrosion**
- **Crevice Penetration**
- **Low Coefficient of Friction**
- **Low CTE**



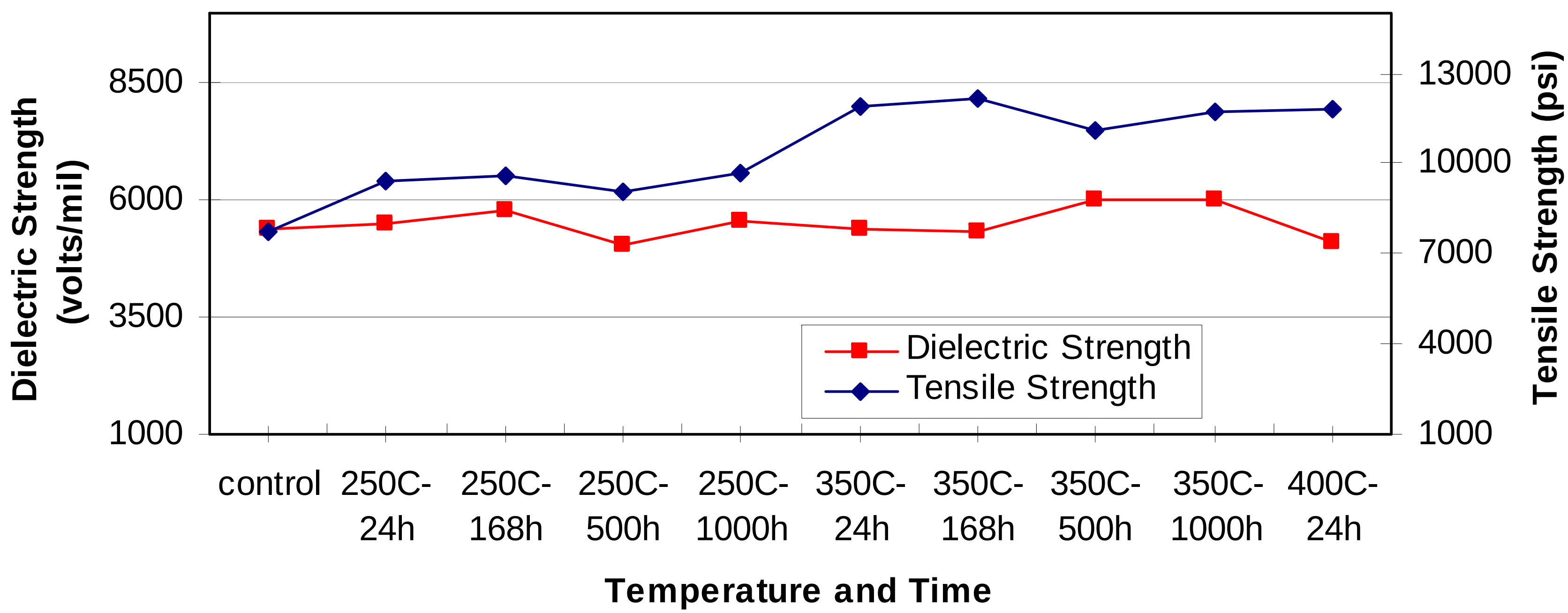
Parylene HT – Thermal Characteristics
TGA





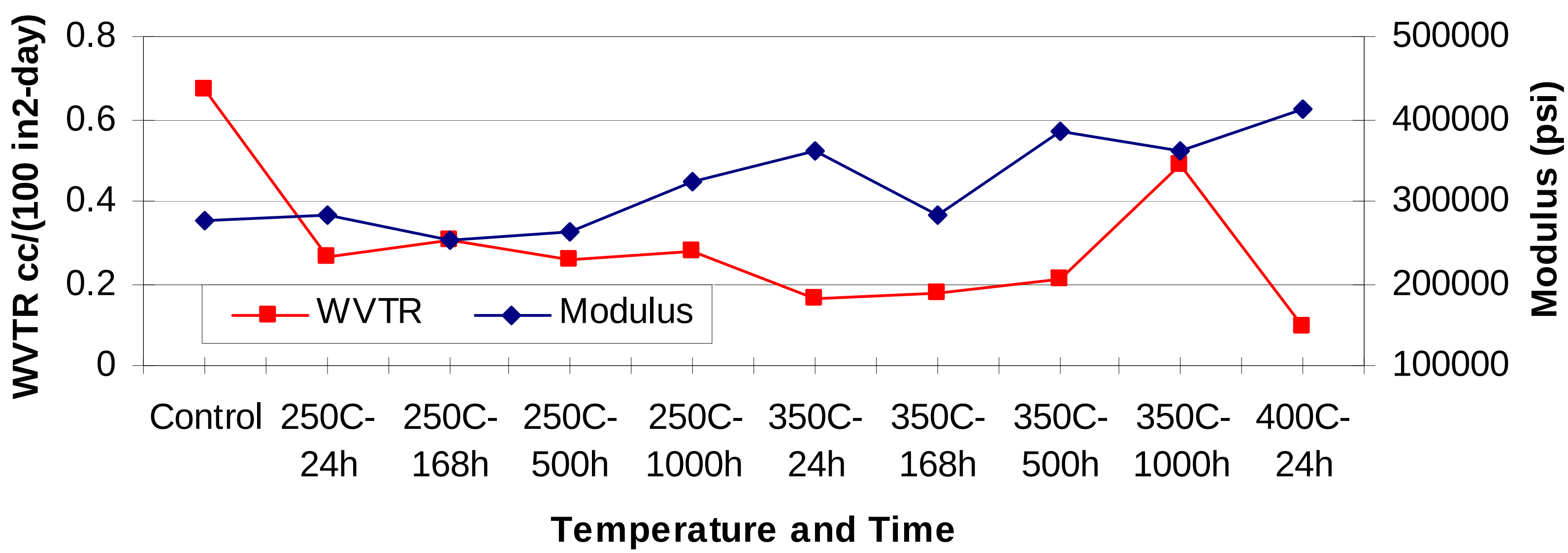
Parylene HT - Long - term thermal aging

Dielectric and Tensile Strength



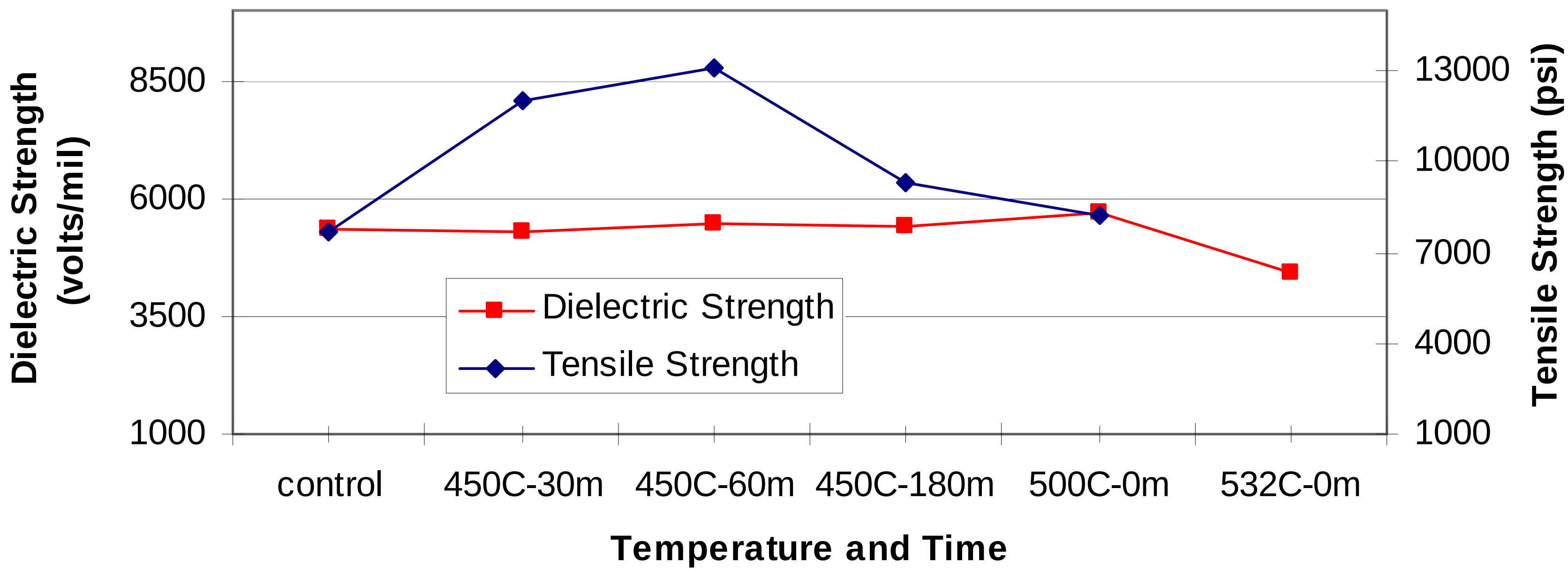
Parylene HT - Long - term thermal aging

Water Vapor Transmission Rate (WVTR) and Modulus



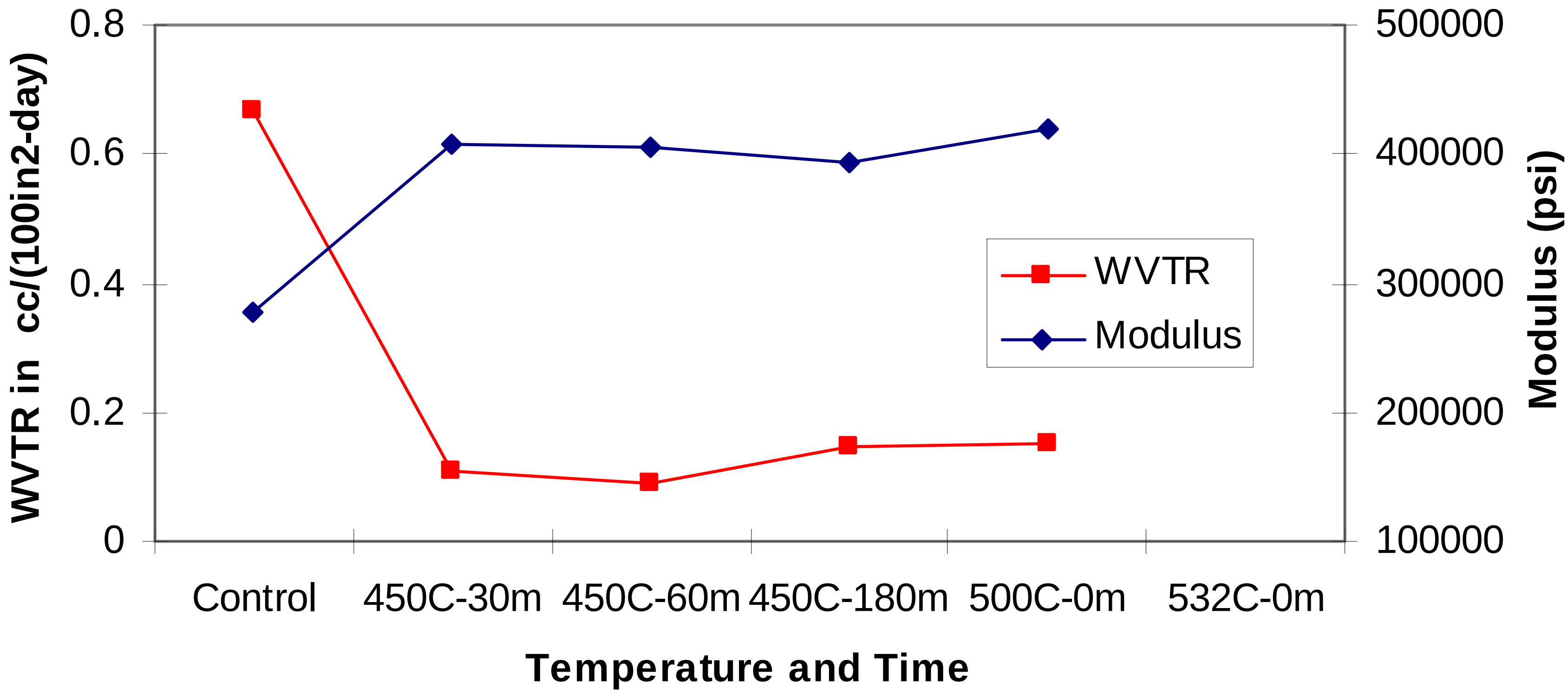
Parylene HT - Short - term thermal aging

Dielectric and Tensile Strength



Parylene HT - Short - term thermal aging

Water Vapor Transmission Rate (WVTR) and Modulus



Thermal Properties

Properties	Method	Parylene N	Parylene C	Parylene D	Parylene HT	Acrylic (AR)	Epoxy (ER)	Polyurethane (UR)	Silicone (SR)
Melting Point (°C)[a]	1	420	290	380	>500	85 – 105[b]	NA	~170[b]	NA
T5 Point (°C) (modulus = 690 MPa)	2, 3	160	125	125	377	–	110	~30	~125
T4 Point (°C) (modulus = 70 MPa)	2, 3	>300	240	240	>450	–	120	–	~80
Continuous Service Temperature (°C)	–	60	80	100	350	82[b]	177[b]	121[b]	260[b]
Short-Term Service Temperature (°C)	–	80	100	120	450	–	–	–	–
Linear Coefficient of Thermal Expansion at 25°C (ppm)	4	69	35	38	36	55 – 205[b, c]	45 – 65[b, c]	100 – 200[b, c]	250 – 300[b, c]
Thermal Conductivity at 25°C (W/(m•K))	5, 6	0.126	0.084	–	0.096	0.167 – 0.21[c, d]	0.125 – 0.25[c, d]	0.11[c, d]	0.15 – 0.31[c, d]
Specific Heat at 20°C (J/(g•K))	–	0.837	0.712	–	1.04	1.04[b]	1.05[b]	1.76[b]	1.46[b]

[a]The temperature at which heat flow properties show signs of change.

[b]*Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

[c]*Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

[c]*Lange's Handbook of Chemistry*, 5th Edition, McGraw Hill, Inc., New York, 1999.

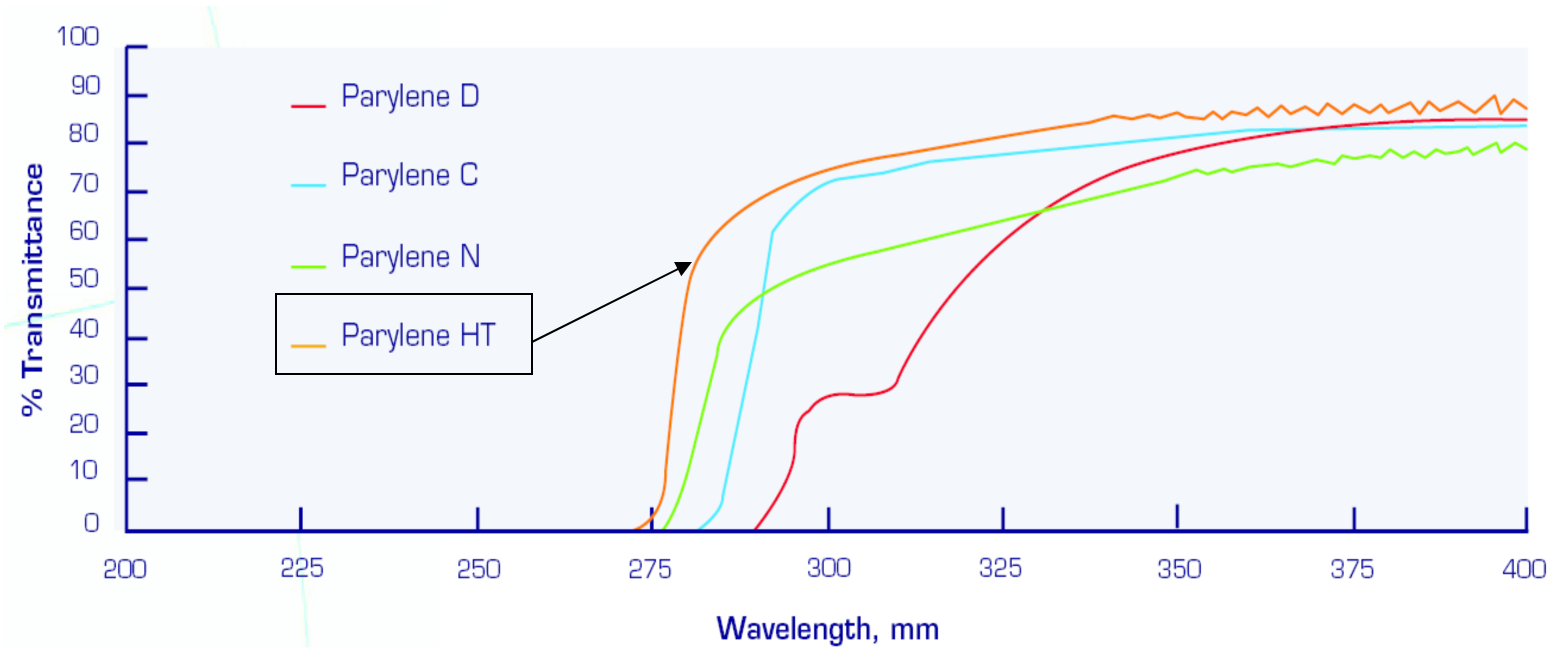
Test Methods:

1. DSC
2. Taken from Secant modulus-temperature curve (except Parylene HT)
3. ASTM 5026 (Parylene HT only)
4. TMA
5. ASTM C 177 (except Parylene HT)
6. ASTM 1461 (Parylene HT only)

UV Stability

Parylene films were exposed to radiation from a bank of fluorescent lamps with following details..

- **Device used : QUV**
- **Test method: ASTM 154**
- **Type of test: Accelerated Weathering**
- **Source: UVA 340 lamp**
- **Irradiance: 0.77 Watts per square meter**



UV Stability of Parylenes

Visual color, Chalking, Cracking, Blistering and Flaking were characterized on the films after 100, 300, 500, 1000, 1250, 1500 and 2000 hrs of UV exposure. Numerical scales (0 -10) are used to depict the degree of effect of the exposure. The observation results are summarized below:

- **Parylene HT**: Stability is more than 2000 hrs.
  - After 2000 hrs of exposure, there was no discoloration, chalking, cracking or blistering.
- **Parylene C**: Stability is less than 100 hrs.
  - After 100 hrs of exposure, film turned yellow (3Y), but there was no chalking, cracking or blistering.
- **Parylene N**: Stability is less than 100 hrs.
  - After 100 hrs of exposure, film turned yellow (4Y), but there was no chalking, cracking or blistering.

Scale: 10 - Excellent (no effect), 0 - Very poor (very severe)

Chemical Resistance of Parylene HT

Corrosive chemicals

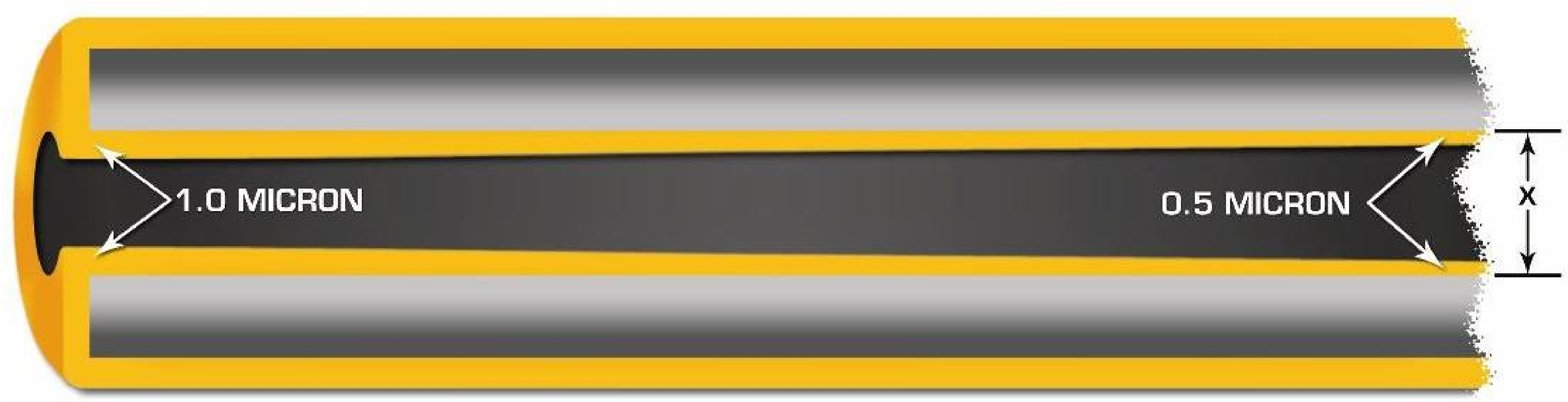
	Parylene HT Swelling %	Parylene HT annealed Swelling %
10% Nitric Acid, RT	0.0	1.2
10% Nitric Acid, 75°C	0.0	1.2
70% Nitric Acid, RT	0.0	0.0
70% Nitric Acid, 75°C	0.0	0.6
10% Sulfuric Acid, RT	0.0	0.0
10% Sulfuric Acid, 75°C	0.0	0.0
95-98% Sulfuric Acid, RT	0.6	1.2
95-98% Sulfuric Acid, 75°C	0.0	0.0

Chemical Resistance of Parylene HT

Automotive fluids

	Parylene HT Swelling %	Parylene HT annealed Swelling %
Antifreeze, RT	2.5	0.4
Antifreeze, 90°C	1.0	0.9
Brake Fluid, RT	0.0	1.0
Engine Oil, RT	1.2	1.1
Engine Oil, 90°C	4.2	2.3
Power Steering Fluid, RT	2.6	1.4
Transmission Fluid, RT	1.3	2.0
Transmission Fluid, 90°C	3.6	0.8
Windshield Washer Fluid, RT	1.3	0.2
Unleaded Gasoline, RT	1.1	0.5
Diesel Fuel, RT	2.8	1.4

Parylene HT - Crevice Penetration



Parylene HT : 50 times the diameter

Parylene N : 40 times the diameter

Parylene C : 5 times the diameter

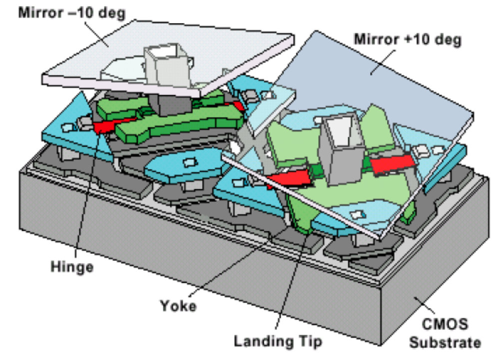
Acrylics – Spray or Brush

Silicones – Spray or Brush

Urethanes – Spray or Brush

Parylene HT : Low Coefficient of Friction

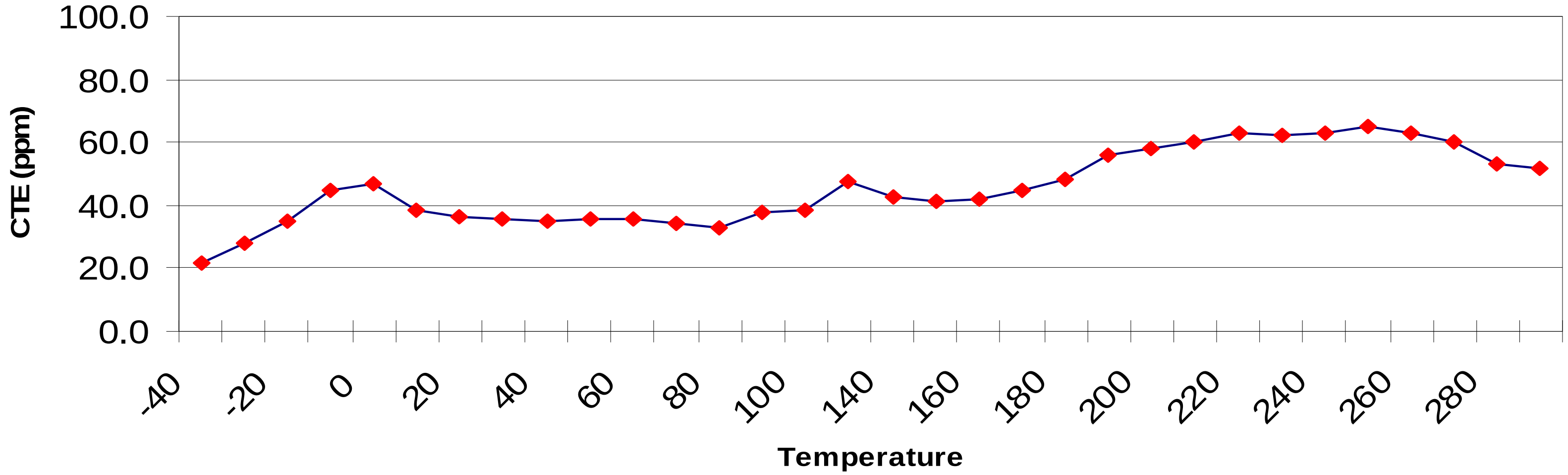
	Parylene HT	Parylene N	Parylene C	Parylene D
Static	0.15	0.25	0.29	0.33
Dynamic	0.13	0.25	0.29	0.31



Parylene HT as a Friction, Stiction Solution

Attribute	MEMS	MOEMS
Stress-free coatings	Yes	Yes
Thin contiguous film without pinholes	Yes	Yes
Inert	Yes	Yes
Even coating of sides and edges	Yes	Yes
Hydrophobic	Yes	Yes
Low surface energy	Yes	Yes
High temp. capability up to 350˚ C	Yes	Yes
Low k down to 2.21	Yes	
Optically clear, UV resistant		Yes

Parylene HT- CTE



36 ppm at Room Temperature

Parylene as a Suppressant for Tin Whiskers Growth

- **Parylene C and Parylene HT are suitable for suppressing the growth of tin whiskers growth.**
  - **Parylenes are truly conformal**
  - **Low stress coating**
  - **Chemically inert**
  - **High modulus and tensile strength**
- **Annealing of Parylenes can help enhance the performance**
- **Parylene HT is well suited under harsh conditions, high temp applications**

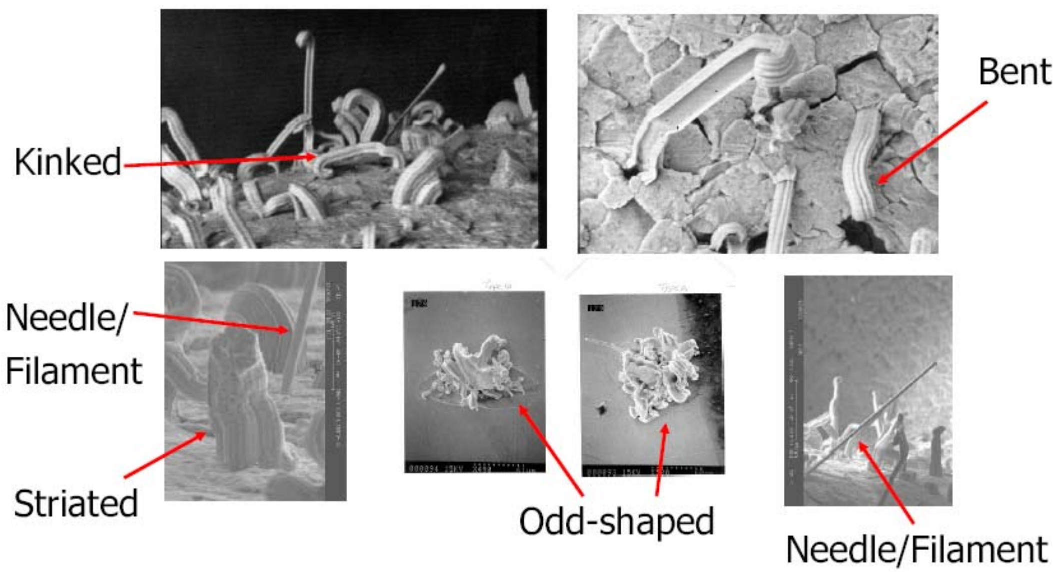
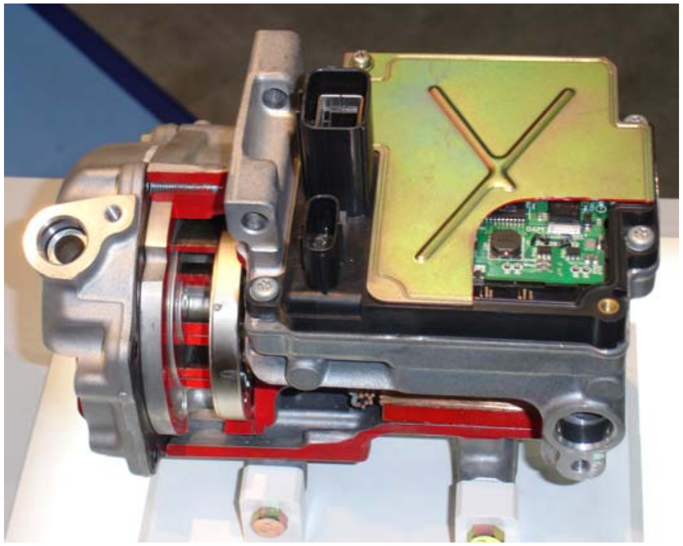


Photo courtesy: http//nepp.nasa.gov/whisker

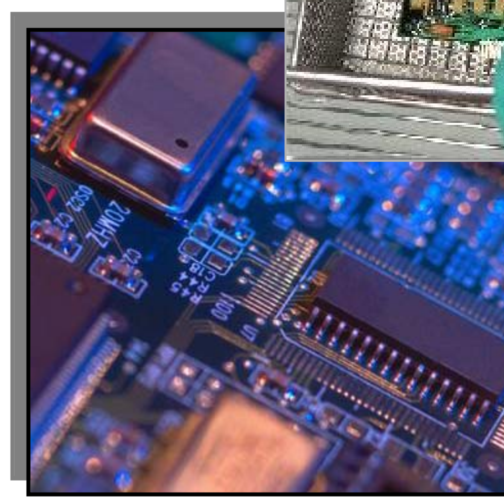
Standards and Qualifications

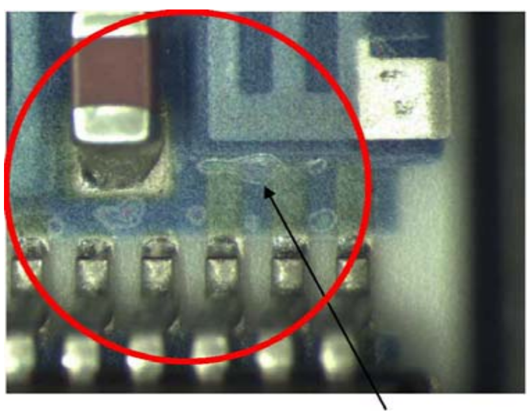
- SCS Parylenes N, C and Parylene HT are ISO 10993 and USP Class VI certified.
- SCS Parylenes meet the requirements of IPC-CC-830.
- SCS Parylenes are listed on the QPL for MIL-I-46058C.
- SCS Parylene C is UL (QMJU2) recognized.
- SCS Parylene coating services, raw materials and equipment comply with the European Union's RoHS Directive 2002/95/EC.



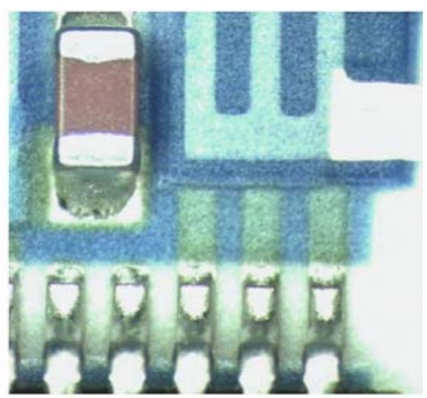
Parylene Coating
Practical Issues

- Quality and type of substrate
- Substrate preparation
- Masking and adhesion promotion
- Fixturing
- Handling



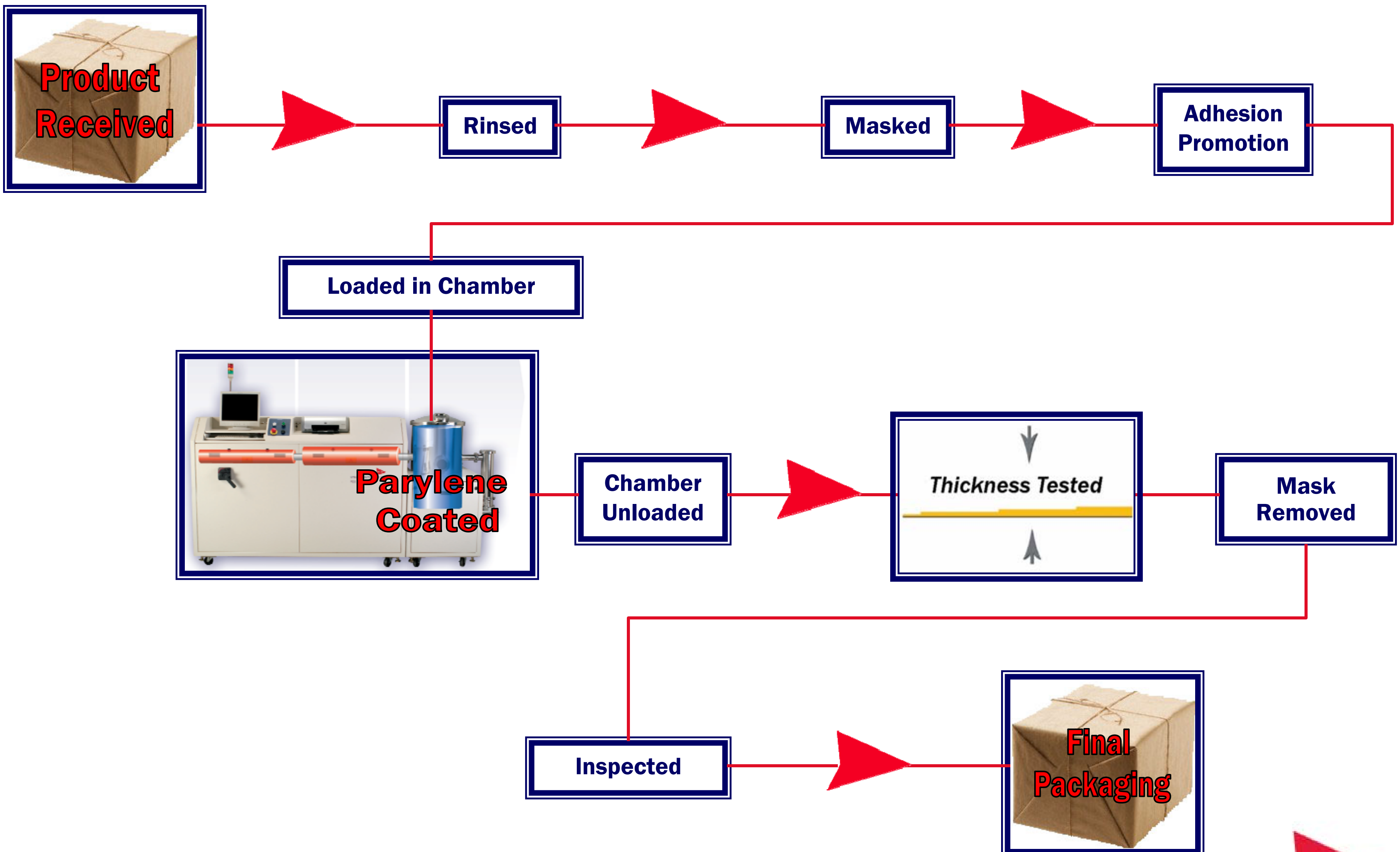


Failed Assembly with spots of poor adhesion

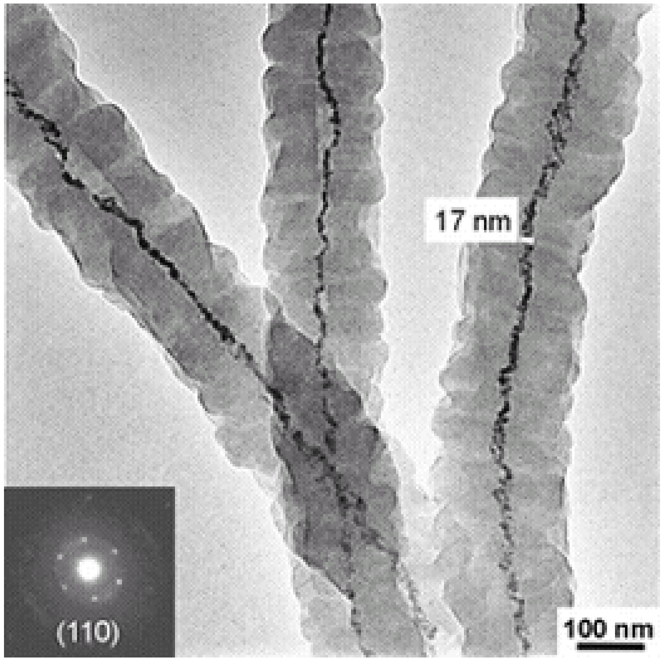


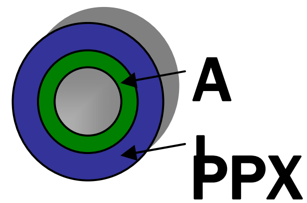
Good Assembly with only good adhesion (no spots)

SCS Coating Process

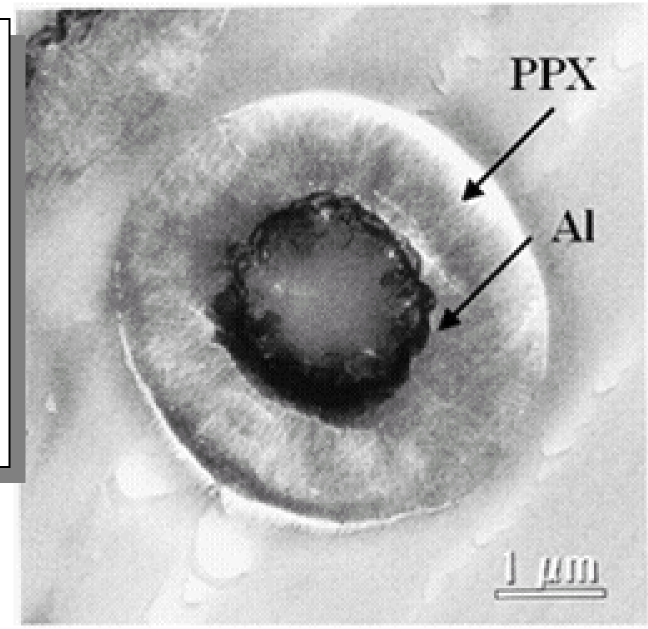


Parylene Nanotubes

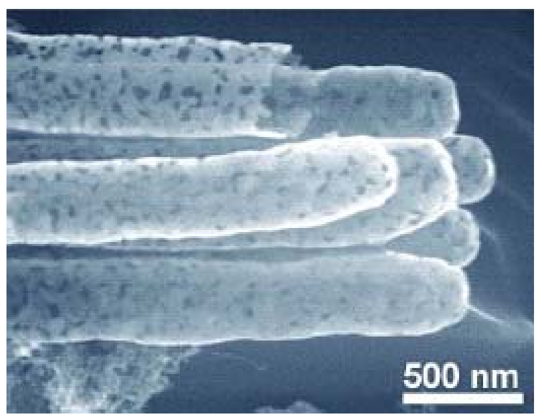


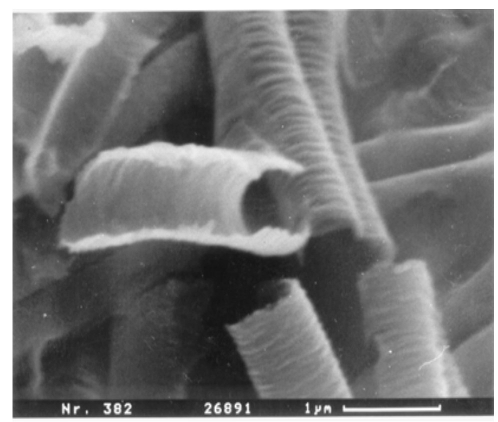


1. PLA template
2. PVD of Al
3. CVD of PPX
4. Degradation of PLA

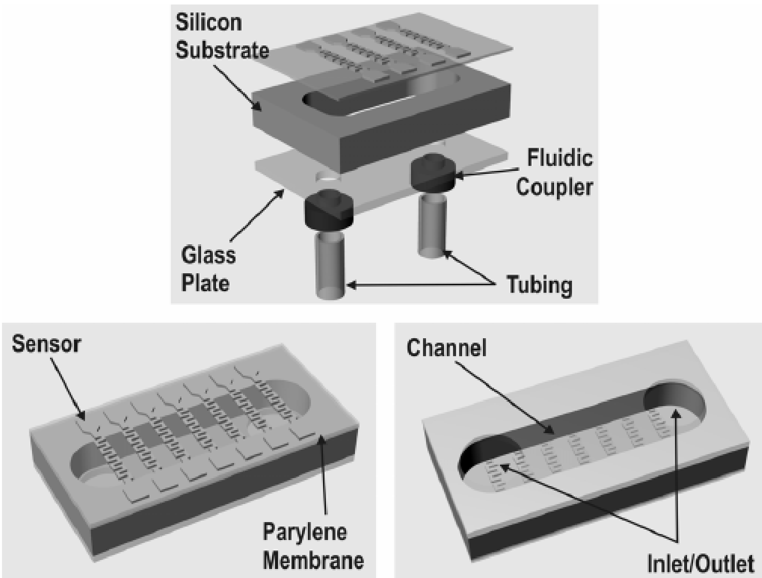


Palladium-Nanowire

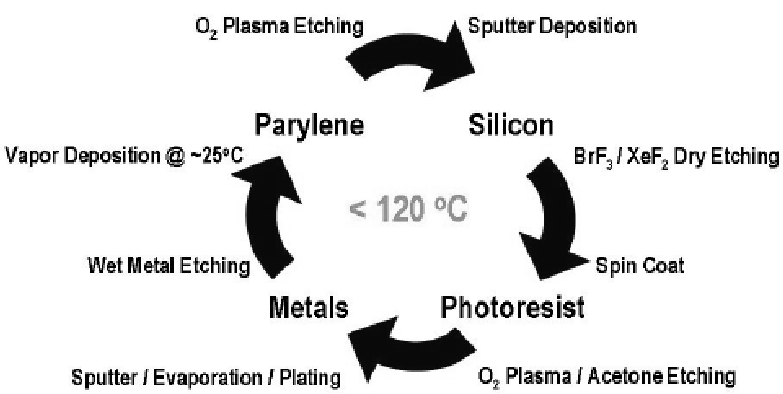




Parylene Etching



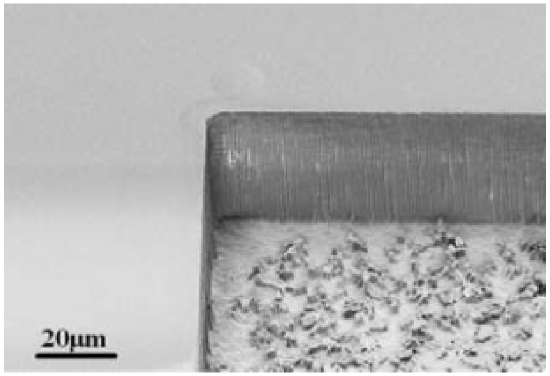
Parylene thermal sensor array- showing sensor construction



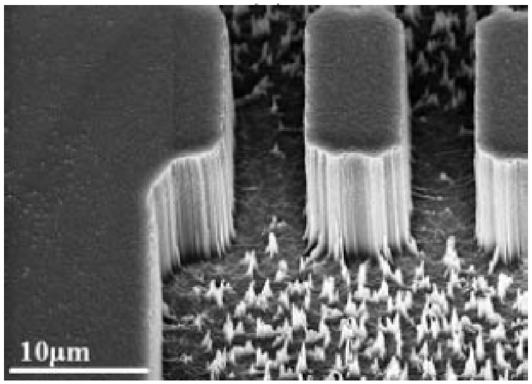
Etching method	Parylene
Plasma (200 mT, 400 W)	.19 µm/min
RIE (100 sccm, 200 mT, 400 W)	.56 µm/min
DRIE (60 sccm, 23 mT, 800 W)	.77 µm/min

Ref. & Photo courtesy by :E. Meng and Dr. Y. Tai, Caltech

Parylene Etching



Anisotropic profile of 55 microns thick Parylene



Anisotropic profile of 10 microns thick Parylene

Etch #	Etch Rate (μm/min)	RF Bias power (W)	Source Power (W)	O_2 (sccm)	Ar (sccm)
a	1.7	250	400	20	0
b	1.0	100	400	10	10
c	0.5	100	150	10	10

ICP etch recipes for low temperature (5°C) Parylene etching

Reference: A HIGH ASPECT RATIO, FLEXIBLE, TRANSPARENT AND LOW-COST PARYLENE-C SHADOW MASK TECHNOLOGY FOR MICROPATTERNING APPLICATIONS

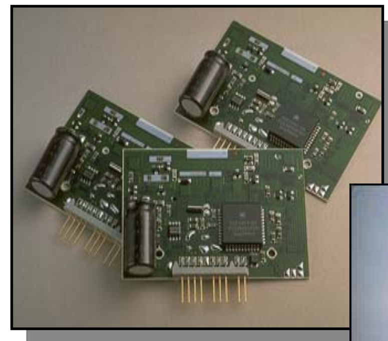
By S. Selvarasah1, S. H. Chao, C.-L. Chen, D. Mao, J. Hopwood, S. Ryley, S. Sridhar, A. Khademhosseini, A. Busnaina, and M. R. Dokmeci, Shadow Mask Transducers 2007

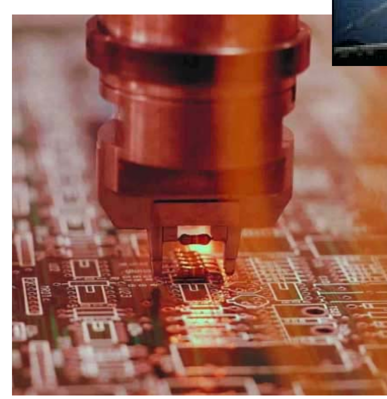
Conclusion

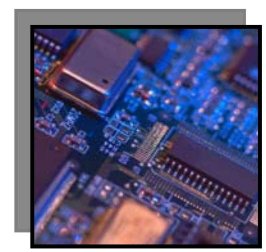
Parylene N, C and Parylene HT are suitable and capable of meeting the growing requirements of packaging, protection and reliability of electronics and advanced MEMS & NEMS devices.

Parylene HT has additional advantages because of:

- Exceptional thermal stability in air and inert atmosphere
- Improved electrical properties
- Excellent crevice penetration
- Low coefficient of friction
- UV stability
- Resistance to solvents, corrosive solvents and gases
- Resistance to various chemical and physical factors such as humidity, thermal cycles, shock and vibration







Courtesy by: www.corrosionsource.com

Thank You

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