

MOMENTIVE™
inventing possibilities

Conformal / Selective Coating Materials for Enhanced Performance in Electronics Applications

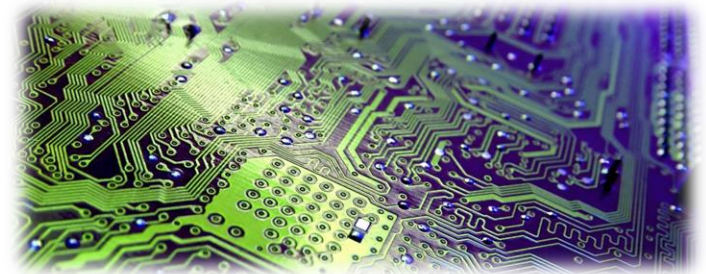


CONFORMAL COATING INTRODUCTION

Conformal Coating Introduction

Why Conformal Coatings / Key Functions

- Thin, non-conductive dielectric layer to provide environmental and mechanical protection of PCB assemblies
- Protection against
 - contamination
 - salt spray, moisture
 - fungus, dust
 - corrosion caused by harsh or extreme environments
- Reduce mechanical and thermal stresses
- Eliminate potential performance degradation and extend the lifetime of components and circuitry
- Enhance insulating properties
- Reduce size and weight
- Traditionally applied by dipping, spray coating or simple film coating



Conformal Coating Introduction

Future Trend

Increased capability of semiconductor assemblies to perform complex tasks in automotive, consumer, industrial and aerospace applications, has increased the demand for conformal coating

Devices are getting smaller, more efficient



Operating temperatures are increasing



improved heat stability

Emerging joining technologies such as Ag sintering

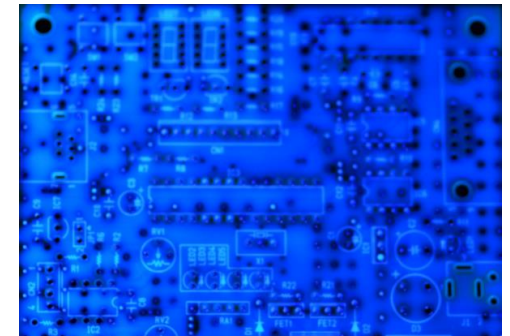


better environmental protection
against sulfuric gases

➔ **enhanced material solutions are inevitable**

KEY DRIVERS:

- Miniaturisation & System Integration & Higher Energy Density
- Higher Performance & more efficient & higher reliability
- Smaller & lighter weight - form factor



Momentive conformal coating under black light

CONFORMAL COATING MATERIAL CONSIDERATIONS

Coating Material Considerations

1) Polymer Gas Permeability

Several polymer options for Conformal Coating materials in addition to Silicones: Polyolefin, Acrylics, and Polyurethanes.

Polymer	Permeability (0.5mm) (g/m ² x 24h)	Permeability (1mm) (g/m ² x 24h)
Silicone (rubber)	215	117
Silicone (resin)	104	55
Polyolefin	6	3
Acrylic	36	30
Polyurethane	32	18



Common misperception: Silicones are less effective in protecting PCBs due to higher gas permeability

→ Gas Permeability is just one of several factors that must be considered!

When other factors e.g. thickness, adhesion, stress-relief, temperature resistance are considered, **Silicones stand out as an ideal conformal coating material for protecting PCBs.**

Coating Material Considerations

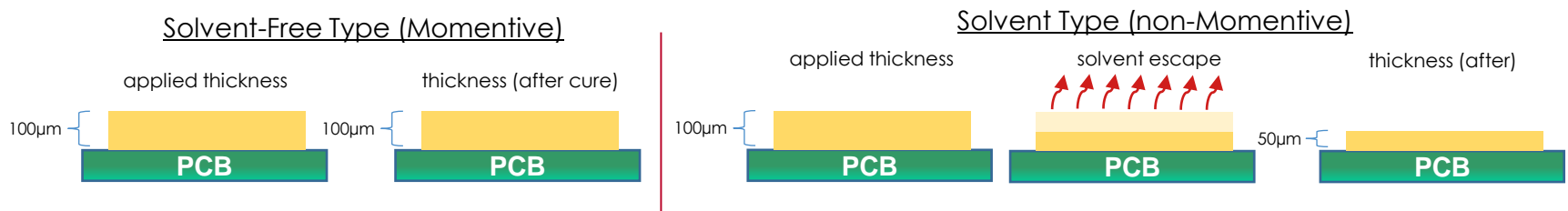
2) Thickness

Despite differences in gas permeability among varying types of polymers, we believe, **there is a minimum thickness level that must be maintained** to ensure performance, particularly with Salt Spray & Noxious Gas corrosion resistance.

For optimum performance Momentive Conformal Coating materials should be applied @ thicknesses of at least 100 μm (or higher).

- Most Conformal Coatings are highly diluted with solvents to reduce viscosity
 - ➔ Small percentage of the polymer (solid material) on the PCB surface after solvent escape
 - ➔ multiple spray passes are required to achieve the required thickness

Momentive Conformal Coatings are 100% solid content (solvent-free) and are able to achieve the required minimum thickness with one spray pass



Coating Material Considerations

3) Adhesion

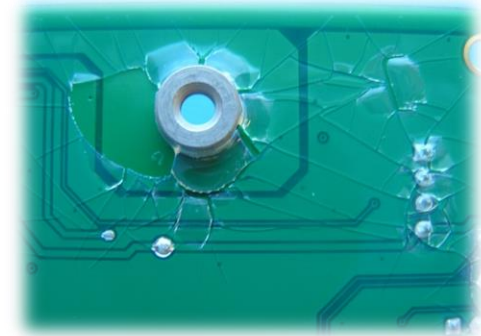
- Delamination/cracks can create a path for moisture and eventually cause corrosion.
- Good Adhesion to and wetting of the PCB is critical to achieve good reliability performance

4) Heat Resistance

- Typical operating conditions for Silicone Conformal Coatings: **-45 ~ 200°C** with limited change in properties
- Thermal performance at high temperature is superior to other polymer types

5) Stress-Relief

- Momentive Conformal Coatings are **elastomeric materials** with a **low modulus**
- They provide stress relief by **absorbing mechanical and thermal stress** that occurs during thermal cycling
- They allow to **maintain strong adhesion** to the substrate
- Rigid Conformal Coatings (polyurethane, acrylics, polyolefin and resin type silicones) can not only apply stress to components, but also cause delamination or cracking due to their inability to absorb thermal mechanical stress.



The Effect of Solvents

Drawbacks of solvents:

- Difficult to achieve an appropriate thickness of a protective barrier
- Adverse impact on the operation environment of the coating process

Many competitor grades contain high concentrations of toluene to reduce viscosity

“Inhalation of toluene vapor can affect the central nervous system.

At approximately 50 ppm, slight drowsiness and headache have been reported. Irritation of the nose, throat and respiratory tract has occurred between 50 and 100 ppm. Concentrations of about 100 ppm have caused fatigue and dizziness; over 200 ppm has caused symptoms similar to drunkenness, numbness, and mild nausea; and over 500 ppm has caused mental confusion and incoordination.

Higher concentrations (estimated at higher than 10000 ppm) can result in unconsciousness and death. Most serious incidences of exposure have occurred when the vapor has accumulated in confined spaces.”

Canadian Centre for Occupational Health and Safety

Defoliation of tree located beneath ventilation fan of customer using competitor solvent-type Conformal Coating



Advantage of Momentive Conformal Coating Grades

Polymer	Gas Permeability	Achieves Thickness	Adhesion	Stress Relief	Heat Resistance	Solvent Free	Overall Assessment
Momentive (elastomeric)	-	●	●	●	●	●	●
Silicone (resin)	▲	-	-	▲	●	-	▲
Polyolefin	●	-	▲	-	▲	-	▲
Acrylic	●	-	●	-	-	-	▲
Polyurethane	●	-	-	-	-	-	-

● Good ▲ Mid - Poor

Momentive Conformal Coating Materials deliver outstanding performance vs. competitor materials; mainly with regards to **stress relief, heat resistance & adhesion**

Momentive Conformal Coating Material are solvent free; able to increase your productivity / efficiency, while being more eco-friendly (less risk to your production operators & the environment)

CONFORMAL COATING PRODUCTS

Silicone Conformal Coating Cure Type

1) Room Temperature Cure:

Pros:

- Easy to Handle & Apply
- Curing Equipment not required
- Cure can be accelerated with slight heating
- Cure can be accelerated with higher humidity
- Cure extends to “shadowed” areas.

Cons:

- Slower complete cure

2) Heat Cure:

Pros:

- Fast cure
- Cure extends to “shadowed” areas

Cons:

- Requires heating ovens
- Energy costs

3) UV Cure:

Pros:

- Very fast cure

Cons:

- Cure doesn't extend to “shadowed” areas (secondary cure may be required)
- UV system expenses
- Packaging & handling expenses

Overview Conformal Coating Products

Typical Properties	Legacy Grades			Improved Corrosion Resistance Grades	
	Heat Cure	Room Temperature Cure		Room Temperature Cure	
	ECC4865	ECC3010	ECC3050S	ECC3011 <i>NEW</i>	ECC3051S
Polymer Type	Silicone Rubber	Silicone Rubber	Silicone Rubber	Silicone Rubber	Silicone Rubber
Components	1 Part	1 Part	1 Part	1 Part	1 Part
Color	Clear	Clear	Clear	Clear	Clear
Viscosity (Pas)	0.25	0.11	0.55	0.11	0.55
Solid Content	100%	100%	100%	100%	100%
Solvents	None	None	None	None	None
Specific Gravity	0.98	0.99	0.98	0.99	0.98
Tack Free Time @23C (min)	-	3 (@100µm)	5 (@100µm)	3 (@100µm)	5 (@100µm)
Cure Time (min)	15 (@105C)	10 (@23C)	30 (@23C)	10 (@23C)	30 (@23C)
Hardness (Shore A)	35	35	22	35	22
Dielectric Strength (kV/mm)	20	20	20	20	20
Volume Resistivity (MΩ.m)	5.0 x 10 ⁶	1.0 x 10 ⁷	1.0 x 10 ⁷	1.0 x 10 ⁷	1.0 x 10 ⁷
UL Flammability	V-0	V-0	V-0	V-0	V-0
UL RTI Rating	105	105	130	130 (in process)	130 (in process)
Salt Spray Result*	-	-	-	Good	Good
Mixed Gas Test Result**	-	-	-	Good	Good
IPC –CC-830B Status	-	-	-	Good	Good

*IEC60068-2-52 Severity 5

**IEC60068-2-60 Method 4

APPLICATION METHODS

Application Methods

	Coating type	Line width [mm]	Precision	Speed	Viscosity [cps]	Remarks
Spray Coating	Area	10	No precise edges	fast	30-3500	Especially thin layer
Jetting	Selective	1-3	Precise	slow	< 2000	Pin coating / close to forbidden areas
Film coating	Selective/Area	10-12	Precise edges	fast	< 70	preferred

Videos:

Spray+Jet.mov

Conformal Coating - ECC 3010 @ Nordson (Film Coating).mp4

CONFORMAL COATING RELIABILITY DATA OF ECC3011 AND ECC3051S

IPC-CC-830B / MIL-I-46058C Testing

IPC-CC-830B – Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies

MIL-I-46058C – Specification for Insulating Compound, Electrical (For Coating Printed Circuit Assemblies)

Test Standard: IPC-CC-830B / MIL-I-46058C

Test Parameters:

- Appearance **Completed / PASS**
- Fluorescence **Completed / PASS**
- Thickness **Completed / PASS**
- Flexibility **Completed / PASS**
- Dielectric Withstanding Voltage **Completed / PASS**
- Moisture and Insulation Resistance **Completed / PASS**
- Thermal Shock **Completed / PASS**
- Temperature and Humidity Aging **Completed / PASS**

Conformal Coating Comparison

Benchmark Testing

Typical Properties	Competitor Polyurethane	Competitor Polyolefin	Competitor Acrylic	Competitor Silicone	Momentive ECC3011	Momentive ECC3051S
Components	1 part	1 part	1 part	1 part	1 part	1 part
Polymer	Polyurethane	Polyolefin	Acrylic	Silicone	Silicone	Silicone
Cure Type	Room Temp.	Room Temp.	Room Temp.	Room Temp.	Room Temp.	Room Temp.
Color	Clear	Clear	Clear	Clear	Clear	Clear
Viscosity (Pas)	0.18	0.185	0.025	0.075	0.11	0.55
Solid Content	44%	22%	15%	72%	100%	100%
Solvents	Toluene, Butanone	Cyclohexane	Butyl Acetate	Toluene	Solvent Free	Solvent Free
Solvent Content	56%	78%	85%	28%	0%	0%
Tack Free Time @ 23°C (min)	15 (@75μ)	10 (@75μ)	30 (@75μ)	7 (@100μ)	3 (@100μ)	6 (@100μ)
Tack Free Time @ 60°C, 15% r.h.				2 (@100μ)	1 (@100μ)	2 (@100μ)
Cure Time (@ 23°C)	720h (30days)	24h	24h	-	10min	30min
Hardness (Type A)	-	-	-	80	35	22
Dielectric Strength (KV/mm)	-	-	-	16	20	20
Volume Resistivity (Mohm.m)	2.0 x 10 ⁶	2.0 x 10 ⁶	5.5 x 10 ⁶	5.0 x 10 ⁶	1.0 x 10 ⁷	1.0 x 10 ⁷
UL Flammability Class	V-0	None	V-0	V-0	V-0	V-0
UL RTI Rating	105	None	105	130	105	130

Salt Spray Test

Test Standard: IEC60068-2-52 Severity 5

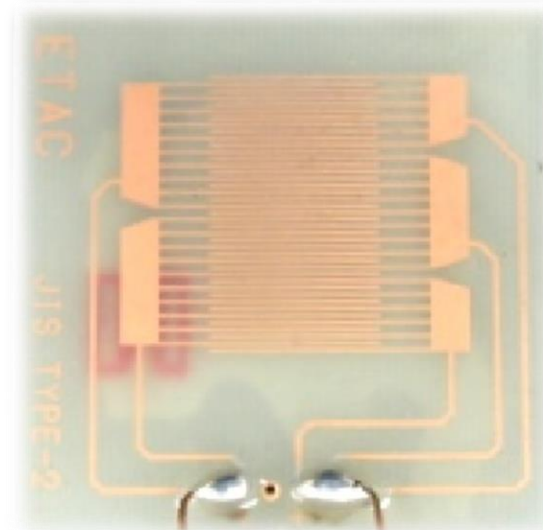
Test Parameters

- Salt Spray Cycle: [(Salt Spray at 35°C x 2 h) + (40°C, 95%r.h. x 22 h)] x 4 cycles (96 hours total)
- Conditioning Cycle: After each Salt Spray Cycle, dwell at 23 °C, 50%r.h. x 72 h (168 hours total)
- Cycle Repetition: Repeat above process 4 times (672 hours, 28 days)

Test Samples: Comb Pattern Boards

Evaluation Criteria

- Visual inspection for corrosion
- Measure Surface Insulation Resistance (SIR) stability initial & after 28 days (DC100V Impressed Voltage)

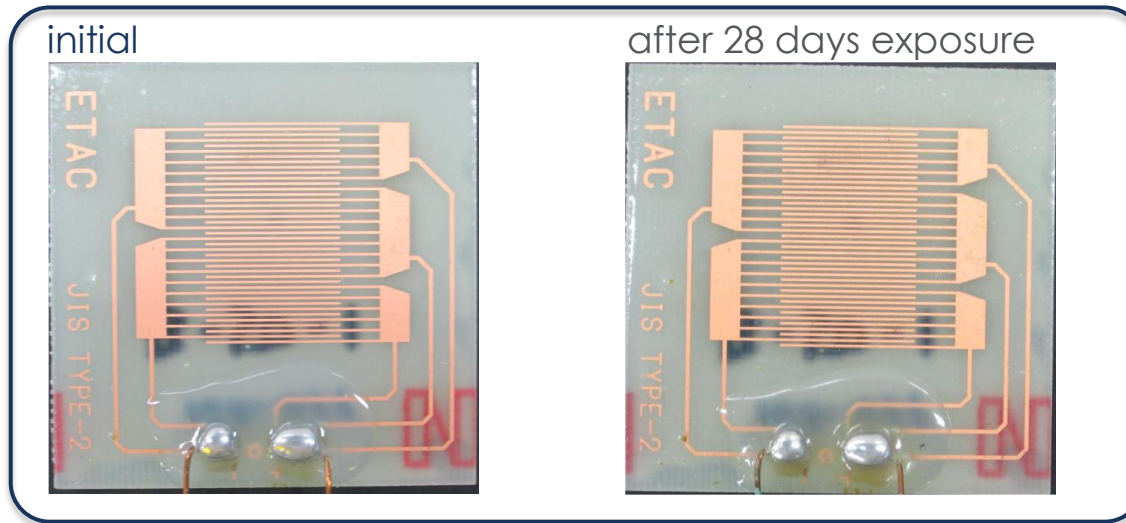


Salt Spray Test

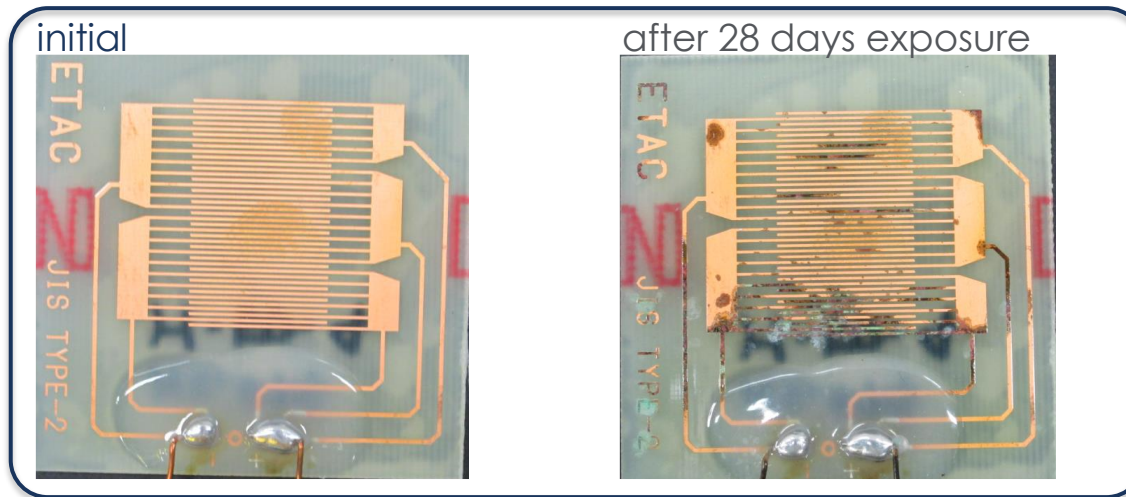
**Momentive
ECC3011**

vs.

Polyurethane



Result:
No change visible
after aging
*** **CLEAN** ***

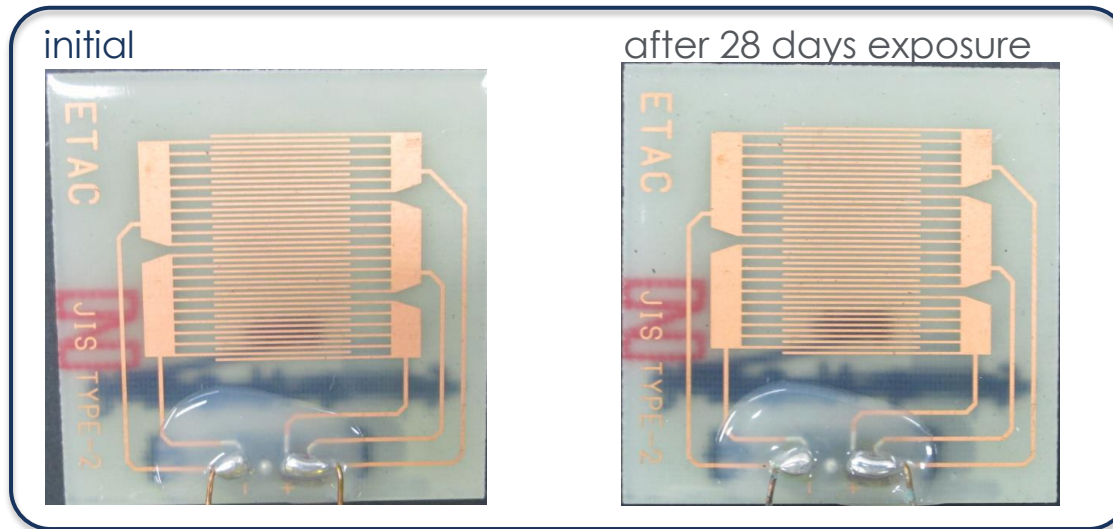


Result:
Significant corrosion
in many areas



Salt Spray Test

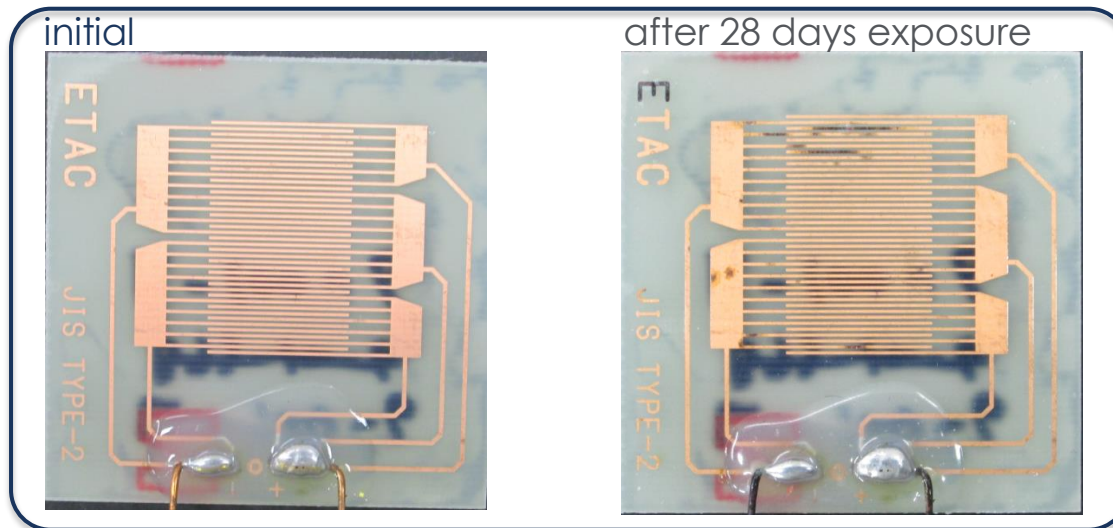
**Momentive
ECC3051S**



Result:
No change visible
after aging
*** **CLEAN** ***



Acrylic

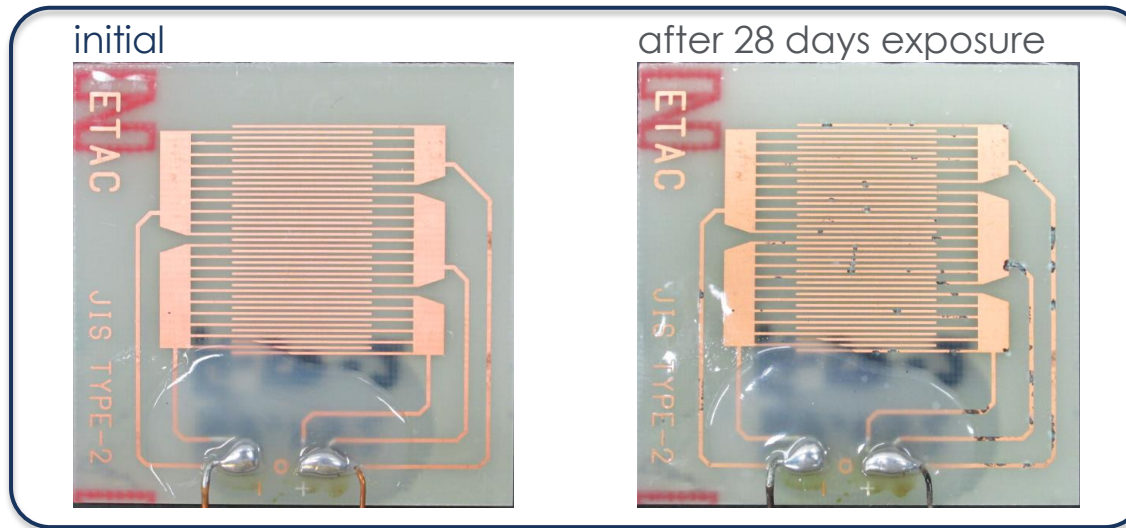


Result:
Localized corrosion
visible in some areas



Salt Spray Test

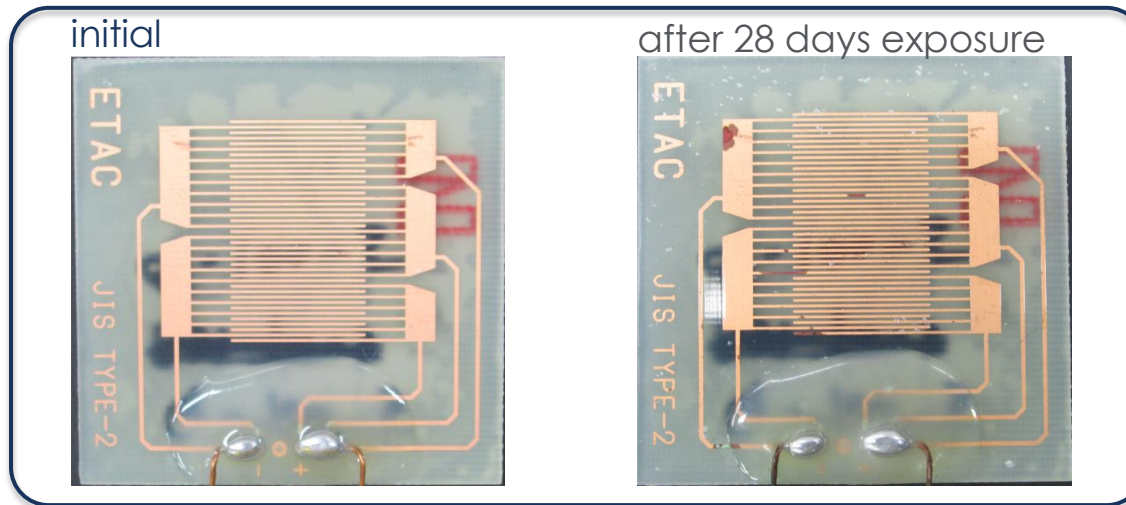
**Competitor
silicone
resin type**



Result:
Significant corrosion
visible in many areas



Polyolefin



Result:
Early stages of
localized corrosion in
some areas visible



SUMMARY Salt Spray Test

RESULTS

- ECC3011: PASS
- ECC3051S: PASS
- Silicone: FAIL
- Polyurethane: FAIL
- Polyolefin: EARLY STAGES OF FAILURE
- Acrylic: FAIL

OBSERVATIONS

- Our anti-corrosion additives delivered superior performance in this testing
- The ideal thickness for Momentive's new Conformal Coating Materials, appears to be at around 100 μm
- All competitor grades (silicone & non-silicone) showed at least early stages of corrosion

Mixed Noxious Gas Corrosion Test

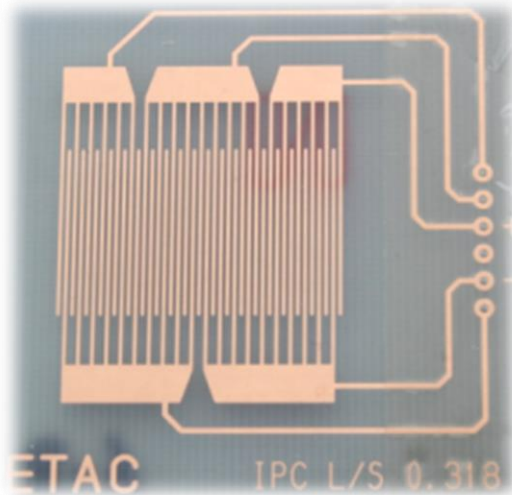
Test Standard: IEC60068-2-60 Method 4

Test Parameters

- Place Coated Comb Pattern Boards in Gas Chamber According to Test Conditions
- For 21 days
- Visual Inspection initial & after aging
- Measure Surface Resistance (initial & 21 days)

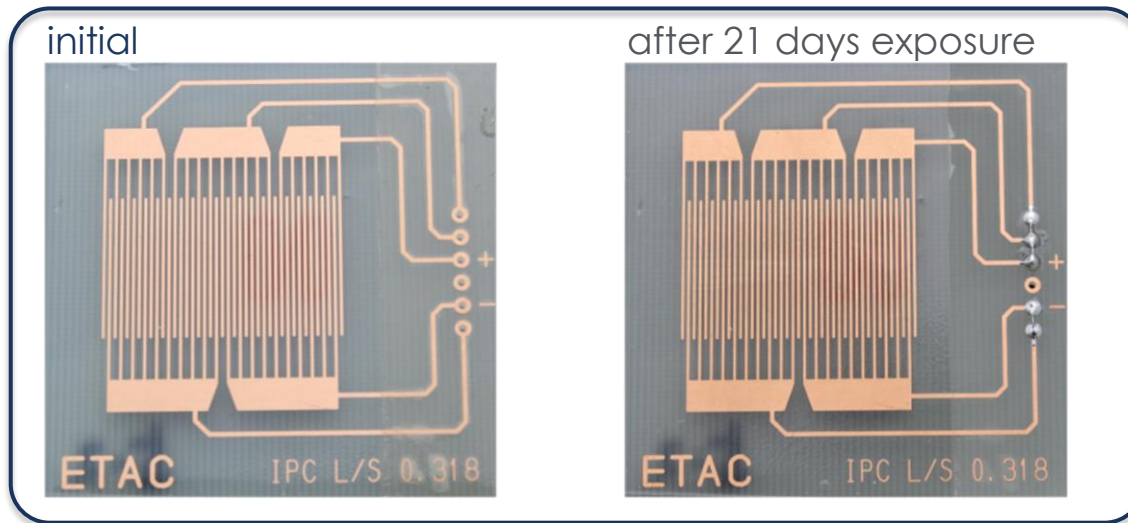
Test Samples: Comb Pattern Boards

IEC60068-2-60 Method 4		Concentration (ppm)
H ₂ S	Hydrogen Sulfide	10 ±5
NO ₂	Nitrogen Dioxide	200 ±20
Cl ₂	Chlorine	10 ±20
SO ₂	Sulfur Dioxide	200 ±20
Temperature [°C]		25 ±1
Relative humidity r.h. [%]		75 ±3



Mixed Noxious Gas Corrosion Test

**Momentive
ECC3011**

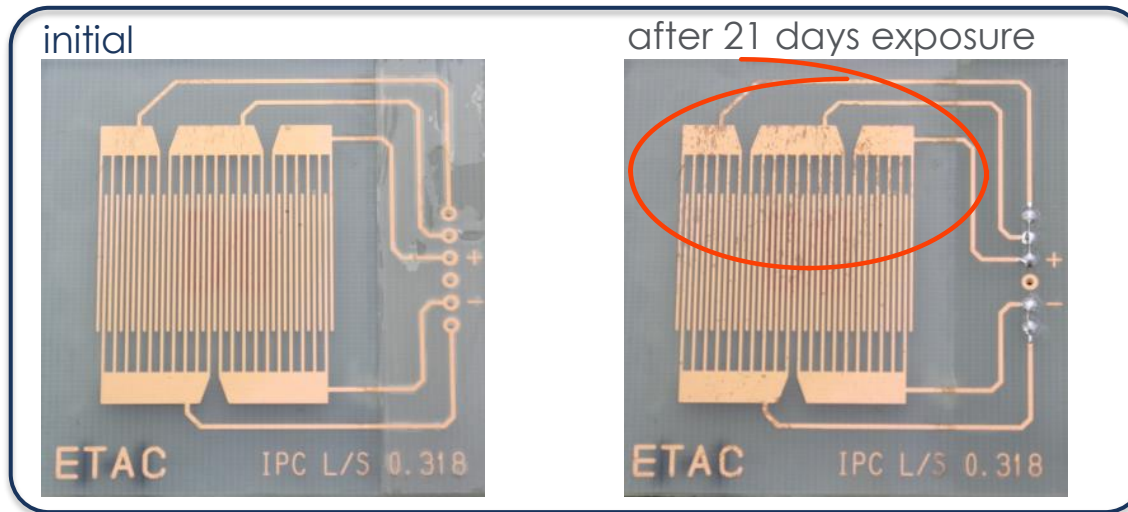


Result:
No change visible
after aging
***** CLEAN *****



vs.

Polyurethane

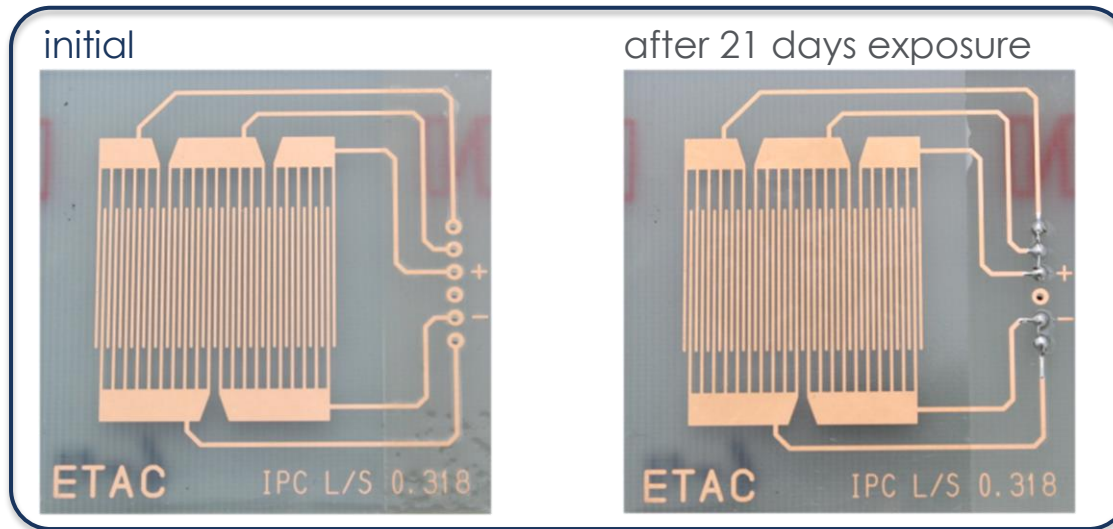


Result:
Early stages of
localized corrosion in
some areas visible



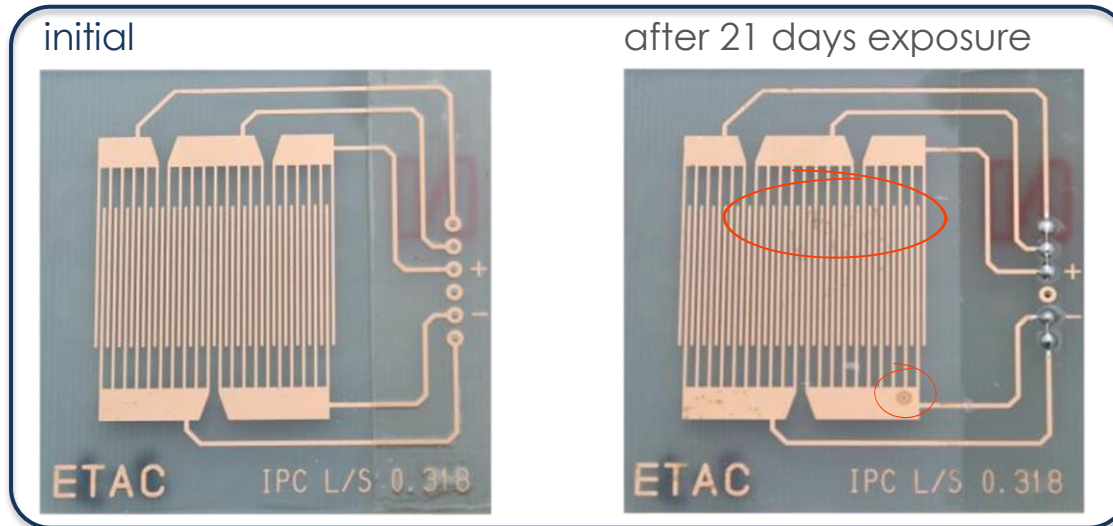
Mixed Noxious Gas Corrosion Test

**Momentive
ECC3051S**



Result:
No change visible
after aging
***** CLEAN *****

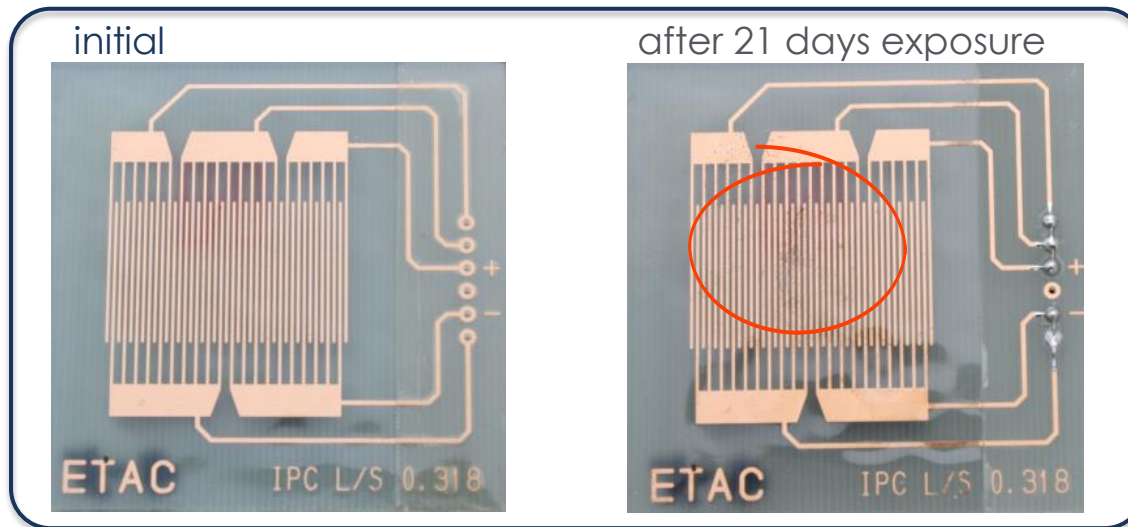
Acrylic



Result:
Early stages of
localized corrosion in
some areas visible

Mixed Noxious Gas Corrosion Test

**Competitor
silicone
resin type**

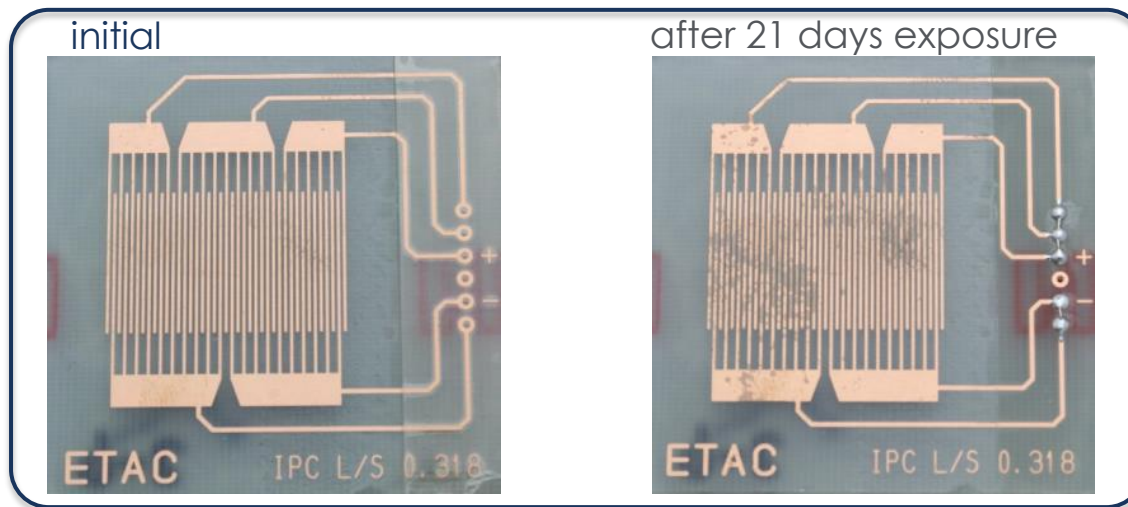


Result:

Early stages of localized corrosion in some areas visible



Polyolefin



Result:

Early stages of localized corrosion in some areas visible



SUMMARY Mixed Noxious Gas Corrosion Test



















RESULTS

- ECC3011: PASS
- ECC3051S: PASS
- Silicone: EARLY STAGES OF FAILURE
- Polyurethane : EARLY STAGES OF FAILURE
- Polyolefin: EARLY STAGES OF FAILURE
- Acrylic: EARLY STAGES OF FAILURE

OBSERVATIONS

- Our anti-corrosion additives delivered superior performance in this testing
- A Conformal Coating thickness of 100µm is sufficient to pass the reliability requirement
- All competitor grades (silicone & non-silicone) showed early stages of corrosion

FINAL Assessment

Grade	Salt Spray	Mixed Gas	Overall
ECC3011 (MPM silicone)			
ECC3051S (MPM silicone)			
Competitor Silicone Resin			
Polyurethane			
Polyolefin			
Acrylic			



Good. No corrosion



Early stages of corrosion



Fail. Excessive corrosion

- **Both of our new Conformal Coating Materials showed outstanding performance in all tests conducted and outperformed the other materials.**
- **Gas permeability of the polymer appears to be less of an issue than thickness & adhesion**

CONFORMAL COATING RELIABILITY TESTS - OUTLOOK POPULATED BOARDS

Summary and Key Take-Away

- **Unique material technology** delivers significant performance benefits
- **Enhanced reliability, better heat stability and corrosion resistance** were demonstrated (a thin layer of ~100 µm can be sufficient to protect assembly)
- **Flexibility** provides dampening and impact protection
- **Good Adhesion** - Low surface energy for better wetting
- Existing equipment can be utilized

RECAP - **KEY DRIVERS:**

- **Miniaturisation & System Integration & Higher Energy Density**
 - Insulating properties allow a reduction in PCB conductor spacing
 - Stable over wide temperature range -40° to 200°C
- **Higher Performance & more efficient & higher reliability**
 - Eliminate potential performance degradation due to environmental hazards
 - Minimize environmental & mechanical stress on a PCB assembly
- **Smaller and lighter weight - form factor**
 - Can help eliminate the need for complex, sophisticated enclosures

Optimal material design combined with optimum coating thickness presents an effective solution for more reliable PCB protection

THANK YOU for your attention!

For more information & specific product recommendation please contact:

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BACKUP

“Also, the permeability of the coatings to water does not appear to affect their ability to protect circuitry from corrosion as none of the conformally coated, but uncontaminated, boards showed any signs of corrosion.”

A MENSAH and C HUNT, The Role of Permeability and Ion Transport in Conformal Coating Protection, NPL Report, 2005

IPC-CC-830B / MIL-I-46058C Testing

Dielectric Withstanding Voltage

Test Parameters:

- Test voltage 0 → 1,500 VAC at 100 VAC/s
Apply 1,500 VAC at 50-60 Hz for 1 minute
& record any leakage rate
- No evidence of disruptive discharge by
flashover, spark-over, or breakdown
- The leakage rate shall not exceed 10 μ A

Test Samples: PCB per MIL-I-46058C

Results

Grade Name	Leakage Rate (μ A)
ECC3011	4.6
ECC3051S	4.4

Flexibility

Test Parameters:

- Place a 0.3cm mandrel in the
center of the coated panel. Bend
one side 180° over the mandrel.
- Inspect for cracking

ECC3011



ECC3051S



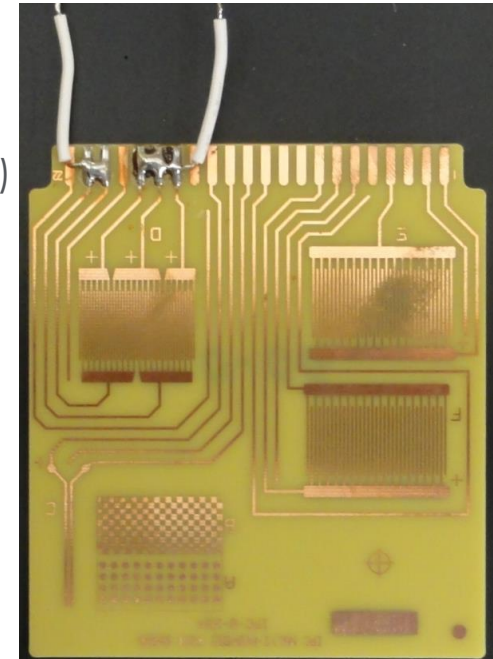
IPC-CC-830B / MIL-I-46058C Testing

Moisture and Insulation Resistance

Test Parameters

- Apply 50 VDC polarizing bias to test patterns
- Expose test specimens to 20 cycles of temperature/humidity (> 85%)
- Cycle:
 - 25°C → 65°C within 1.75 h
 - 65°C for 3 h
 - 65°C → 25°C within 1.75 h
- 100 VDC are applied on the specimen's contacts at cycles 1, 4, 7 and 10 without opening the chamber
- At cycle 20, maintain 25°C/50% r.h. for 24 h and measure insulation resistance
- Pass Condition: Insulation resistance shall be $\geq 5000 \text{ M}\Omega$ during humidity and after 24 h at reference conditions

Test Samples: IPC-B-25A coupon



Results

Grade Name	Unit	Initial	1 cycle	4 cycles	7 cycles	10 cycles	20 cycles (& 24h dwell)
ECC3011	MΩ	2,500,000	117,525	151,299	86,558	121,307	2,125,000
ECC3051S	MΩ	2,500,000	55,537	39,319	30,921	42,411	2,500,000

IPC-CC-830B / MIL-I-46058C Testing

Thermal Shock

Test Parameters

- Thermal Shock cycle: -65°C/125 °C, dwell time 15 minutes
- After 100 cycles, maintain at 25°C/50% r.h. for 24 h
- No evidence of disruptive discharge by flashover, spark-over, or breakdown
- The leakage rate shall not exceed 10 μ A

Test Samples: PCB per MIL-I-46058C

Results

Grade Name	Leakage Rate (μ A)
ECC3011	4
ECC3051S	4

Temperature and Humidity Aging

Test Parameters

- 85 °C / 95 % r.h. climate chamber
- 120 days
- Visual/tactile inspection after 28, 56, 84 & 120 days
- Pass condition:

No evidence of reversion as indicated by softening, chalking, blistering, cracking, tackiness, loss of adhesion or liquefaction.

Evaluate also legibility of the markings on the board and/or the resistors

Test Samples: IPC “Y” Test Coupon

