3M Science. Applied to Life.™

Corrosion protection for challenging conditions

Salt Spray (Fog) Protection using 3M™ Novec™ Electronic Grade Coatings

Introduction

Today's consumers expect their mobile devices to work flawlessly in the most challenging environments. Increasingly compact and sophisticated electronics, however, are highly susceptible to environmental contaminants, such as moisture, salt, sulfur, pollution and grime. Without proper protection, sensitive electronic components can quickly corrode – often leading to electrical shorts, poor performance and device failure.

3M™ Novec™ Electronic Grade Coatings were evaluated for mitigating corrosion of exposed metal on printed circuit boards under salt spray (fog) conditions. Salt deposits from moisture in the air can cause corrosion of the metals on a printed circuit board or its components, shortening the device life.

Novec coatings are low viscosity, low surface tension solutions of fluorinated polymers carried in segregated-hydrofluoroether fluid. They are designed for the protection of printed circuit boards, components and a variety of surfaces from moisture and corrosion. Novec coatings dry to thin, transparent films with excellent hydrophobic and oleophobic properties.

Background

Salt fog testing is one of the most common corrosion evaluation tests for protective coatings for electronics. It is used to compare different coated substrates to each other or to uncoated substrates. Salt fog testing exposes substrates to a humid, salt depositing, corrosive atmosphere and monitors any resulting deterioration of the surface.

One common test method is ASTM B117[1]; additional alternative standards include ISO 9227[2] and JIS Z 2371[3]. For all of these test methods, the appearance of corrosion on the surface is the criterion used to determine the level of protection.

Though these tests are widely used in the electronics industry, they have a weak correlation with coating protection duration results in natural environments. Results should be viewed as comparative, and not as stand-alone, data to correlate or extrapolate coating performance to long-term atmospheric exposures. The controlled conditions of a salt fog test are not representative of the complex environmental conditions that exist in everyday life.[1]

Experiment

The objective of this experiment was to determine whether 3M™ Novec™ Electronic Grade Coatings would provide corrosion protection under salt fog conditions. Tested in accordance with the ASTM B117 test method, Novec coated printed circuit boards were placed in a chamber, exposed to a salt fog environment with the temperature and salt fog concentration controlled, and then monitored for corrosion on the coated metal surfaces.

Test Boards

IPC-B-25A circuit boards[4], shown in Figure 1, were used in this test. These test boards are from the IPC and are specified for testing solder masks (IPC-SM-804C) and conformal coatings (IPC-CC-830A). These circuit boards were cut to isolate the D-patterns on the boards. All of the cut boards were then cleaned with 3M™ Novec™ 72DA Engineered Fluid in a vapor degreaser. These immersion silver (ImAg) metal finish IPC-B-25A boards were either left uncoated to be used as control samples, or coated with different thicknesses of 3M™ Novec™ Electronic Grade Coatings. Both sets were aged and tested under the same conditions.

Coating

For the coated boards, a variety of test samples were produced using different 3M™ Novec™ Electronic Grade Coatings and application methods (Table 1).

Table 1. List of coatings and application methods used to coat the D-patterns of the IPC-B-25A boards with ImAg finish that were tested in the salt fog test.

Sample	3M™ Novec™ Coating	Application Method	Estimated* Thickness (µm)
A	Novec 1700	Dip	~ 0.1
B	Novec 2704	Dip	~ 0.5
C	Novec 2708	Dip	~ 1
D	Novec 2704	1X atomized spray	~ 5
E	Novec 2704	2X atomized spray	~ 10
F	Novec 2704	3X atomized spray	~ 15
G	Novec 1904	1X atomized spray	~ 5
H	Novec 1904	2X atomized spray	~ 10
I	Novec 1904	3X atomized spray	~ 15

*Estimated from a variety of coating thickness measurement methods (e.g. ellipsometry, SEM or mass change).

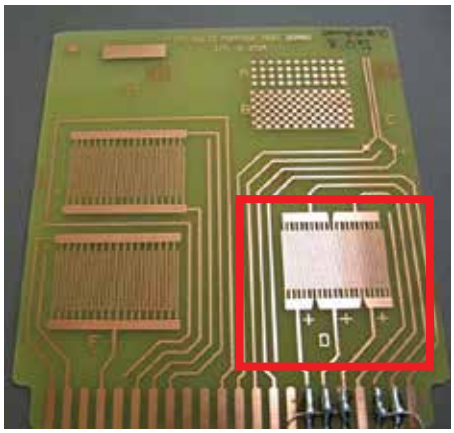


Figure 1. IPC-B-25A test vehicle used in this experiment.

Dip or spray coating (in a controlled environment) are the recommended application methods for Novec coatings. For this study, different application methods and coating thicknesses were used to demonstrate the various options and any resulting performance differences.

To dip coat samples A through C, boards were submerged in a chamber filled with 3M™ Novec™ Electronic Grade Coating and then removed at a controlled rate (Table 2). The board removal rate controls the thickness of the coating and, in general, the faster the board is removed, the thicker the coating. After the coating dried, the samples were placed in the salt fog test chamber (Figure 2).

Table 2: Dip coating settings.

Parameter	Setting
Time submerged	30 seconds
Pull out rate	30 centimeters per minute

To spray coat samples D through I, an automated spray coating machine and atomized spray valve were used (Table 3). The spray coating application cycle was repeated one, two or three times on different samples in order to achieve different thickness levels. After the coating on the boards dried, the samples were placed in the salt fog chamber (Figure 2).

Table 3: Atomized spray coating settings.

Parameter	Setting
Valve	PVA FCS300-ES
Estimated flow rate	~5.5 mL/min
Canister pressure	5 psi
Stroke Setting (nozzle opening)	0.075 mm
Atomization Pressure	2 psi
Gantry speed (nozzle speed)	100 mm/s
Area Spacing (distance nozzle moves between passes)	2 mm
Nozzle Height (distance from nozzle to substrate)	65 cm

Figure 2. Specimens in this experiment were exposed in the Harshaw salt spray (fog) unit shown above.

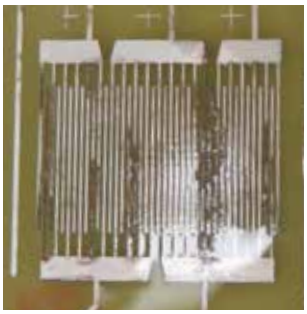
Salt Spray (Fog) Test

The ASTM B117 test method relies on a controlled, corrosive environment to produce relative corrosion resistance information for metal and coated metal specimens. The uncoated and coated printed circuit boards specimens were placed on a rack and held so that the side of the boards with the metal trace pattern were less than a 30° angle from vertical. The salt solution, per the test method, was 5 ± 1 parts by mass of sodium chloride in 95 parts water. This combination resulted in a salt solution with a pH range of 6.5 to 7.2 when atomized at 35°C (95°F).

For testing, samples A through I were exposed for 245 hours, removed from the salt fog chamber, cleaned with deionized water, patted with a tissue, dried at room temperature, and evaluated.

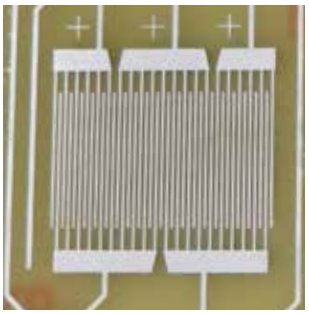
Results – Samples A through C – Dip application method

After 245 hours, significant corrosion was shown on the uncoated sample. Samples coated with 3M™ Novec™ Electronic Grade Coatings did not have any significant signs of corrosion after 245 hours.

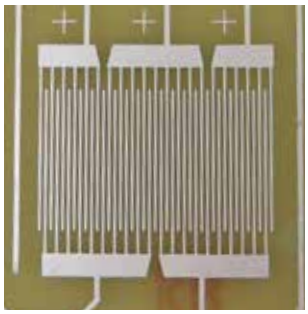


After 245 hours, severe corrosion was present on the control (uncoated).

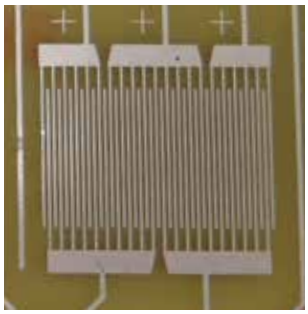
Samples coated with 3M™ Novec™ Electronic Grade Coatings – After 245 hours of salt fog exposure.



Sample A
~ 0.1 µm thick



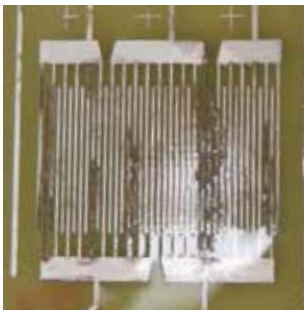
Sample B
~ 0.5 µm thick



Sample C
~ 1.0 µm thick

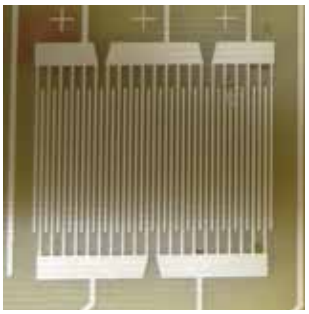
Results – Samples D through I – Atomized spray application method

After 245 hours, significant corrosion was shown on the uncoated sample. Samples coated with 3M™ Novec™ Electronic Grade Coatings did not have any significant signs of corrosion after 245 hours.

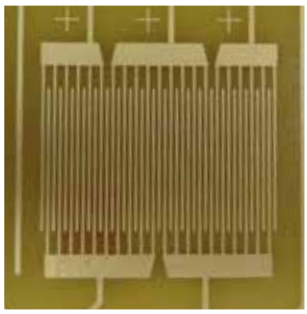


After 245 hours, severe corrosion was present on the control (uncoated).

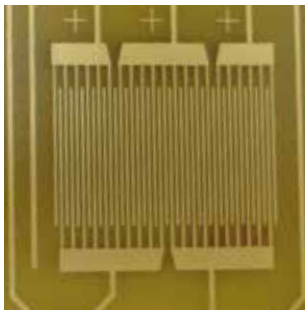
Samples coated with 3M™ Novec™ 2704 Electronic Grade Coating – After 245 hours of salt fog exposure.



Sample D
~ 5.0 µm thick



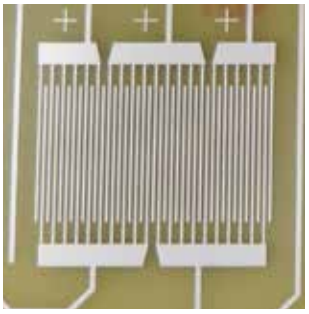
Sample E
~ 10 µm thick



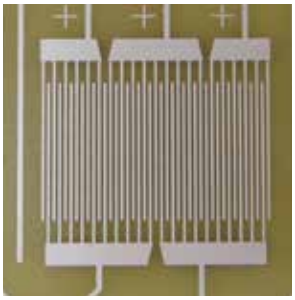
Sample F
~ 15 µm thick

After 245 hours, severe corrosion was present on the control (uncoated).

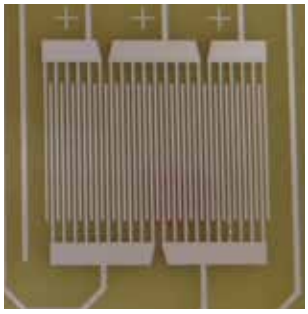
Samples coated with 3M™ Novec™ 1904 Electronic Grade Coating – After 245 hours of salt fog exposure.



Sample G
~ 5.0 µm thick



Sample H
~ 10 µm thick



Sample I
~ 15 µm thick

Summary and conclusions

Salt spray (fog) testing helps compare different coatings' protective properties relative to each other when tested under the same conditions.

The salt fog test results show that a thin coating of 3M™ Novec™ Electronic Grade Coatings can protect common metal finishes such as immersion silver from corrosion created by harsh, salt fog environments. Thicker coating layers can help provide additional protection and help ensure coverage of high profile components or difficult board configurations.

Safety, handling & storage

To make sure your coating solutions perform as designed, it is important that they are handled and stored appropriately. Please follow the "Safety, Handling and Storage" information on the 3M Technical Data Sheets and Safety Data Sheets for these products.

To avoid thermal decomposition, the liquid coating solution should not be heated above 150°C (302°F) and the dried fluorochemical polymer film should not be heated above 250°C (482°F). Please note that we do not recommend open, manual spraying of the material. Use of automated equipment that is enclosed and vented is highly suggested.

Before using 3M products, please read the current product Safety Data Sheet (SDS), which is available through your 3M sales or technical service representative or at 3M.com/electronics, and the precautionary statement on the product package. Follow all applicable precautions and directions. Always practice smart and safe industrial hygiene practices.

For additional information

To request additional product or process information, please contact 3M Customer Service at one of the numbers below or visit 3M.com/Novec. For other 3M global offices or information on other 3M products for electronics, please visit our website at 3M.com/electronics.

References

1 ASTM B117, "Standard Method of Salt Spray (Fog) Testing," ASTM International, West Conshohocken, PA: http://www.astm.org/Standards/B117

2 ISO 9227:2012, "Corrosion tests in artificial atmospheres, Salt spray tests," International Organization for Standardization, Geneva, Switzerland: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=60000

3 JIS Z 2371, "Methods of Neutral Salt Spray Testing," Japanese Industrial Standards Committee: http://www.jisc.go.jp/eng/index.html

4 IPC-Association Connecting Electronics Industries is an organization that sets standards used by the electronics manufacturing industry: https://www.ipc.org/default.aspx

The 3M™ Novec™ Brand Family

The Novec brand is the hallmark for a variety of proprietary 3M products. Although each has its own unique formula and performance properties, all Novec products are designed in common to address the need for safe, effective, sustainable solutions in industry-specific applications. These include precision and electronics cleaning, heat transfer, fire protection, protective coatings, immersion cooling, advanced insulation media replacement solutions and several specialty chemical applications.

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