POLYMER SOLUTIONS GROUP

TECHNICAL PAPER
ECOFLUOR®

Corrosion Protection of Electronic Boards By Dip Coated Ecofluor® Fluorinated Thin Films

SUMMARY

Ecofluor® is a cost-effective one part fluorinated system which provides current protection to electronic devices under harsh environments for extended periods of time. Key benefits of Ecofluor® include:

- Thin films can be generated via dip coat in minutes, avoiding the cost and time associated with vapor deposition techniques and spray coating.
- Ecofluor® is low in toxicity, non-ozone depleting, and VOC exempt. It forms chemically resistant and thermally stable transparent thin film.
- Standard electronic IPC test boards with 20 μm coating exhibit no corrosion and virtually no current flow under salt water conditions for one hour.

INTRODUCTION

Remarkable technological advancements have led to the ubiquity of portable devices into all areas of our life. As mobile device performance and functionality has improved, protection against harsh environments (particularly salt water immersion) has become a critical requirement for the lifetime performance of the device.

One proven approach to achieve environmental protection is to coat critical internal components of the device with a protective conformal layer that prevents water and ion contamination from damaging these key components. The current state of the art includes parylene conformal coating due to high thermal stability and barrier properties, providing protection from aqueous environments. However, the raw material cost of parylene approaches $5,000 per pound. Also, parylene is applied as a vapor in a high vacuum (<1 torr), requiring specialized vacuum chambers with limited capacity. The process time required to achieved vacuum and coat the substrate limit the use of this process on a manufacturing scale.

Alternatively, fluorinated organic coatings are hydrophobic, durable, and applied without expensive vacuum chamber processing associated with parylene. One common method to apply the fluoro-polymer is to use controlled spray coating. Due to the "line of sight" application approach, this process utilizes expensive automated control to fully coat the substrate. Furthermore, extensive masking of connectors is necessary, since the connected components may block the line of sight of the spray. These issues can significantly increase cost and decrease throughput.

An alternative approach is to use a simple "dip coat process" to coat critical device components with a protective polymer layer while avoiding the cost and expense of vapor deposition or spray coating. This process utilizes a simple mechanical dipping step where the sample is submerged, and the solution wets the substrate surface. Upon withdrawal the solvent evaporates resulting in a substrate coated in the polymer material. Because the entire device is submerged and all exposed surfaces are coated, the entire connected board can be coated without the need to selectively mask connector components.

Here, we utilize Ecofluor®, a thermally stable fluorinated material, to provide a thin transparent film that provides excellent chemical and electrical protection (nA scale) even under harsh salt water conditions. This coating can be applied in minutes via simple dip coating without the need for expensive masking or thermal curing. This material exhibits low surface tension and low viscosity for excellent wetting properties on a variety of substrates and irregular surfaces.

EXPERIMENTAL OVERVIEW

To demonstrate this technology, we utilize standard IPC test boards (IPC-25B-A), shown in **Figure 1**[1]. These boards represent a commercial electronic board without its enclosure or packaging. These boards were cleaned and prepared using standard IPX protocol (IPC-TM-650-2.6.3). To coat the substrates, samples were dip coated once, with 6.7 mm/s submersion speed and withdrawal speed, and 5 minute submersion time. The entire process takes several minutes. Copper wire leads were then attached to the IPC board (comb structure D).

Following dip coating, the samples were tested via a modification of the IPX7 testing standard, established by the International Electrochemical Commission (IEC)[2,3]. Here, the unpackaged coated board was submerged in salt water under power (4V) for 60 min. The current leakage across the test comb structure was measured using a CH Instruments 440C model potentiostat. After 60 minutes, the board was removed and rinsed with water and evaluated using optical microscopy. Uncoated boards were also tested as a control.

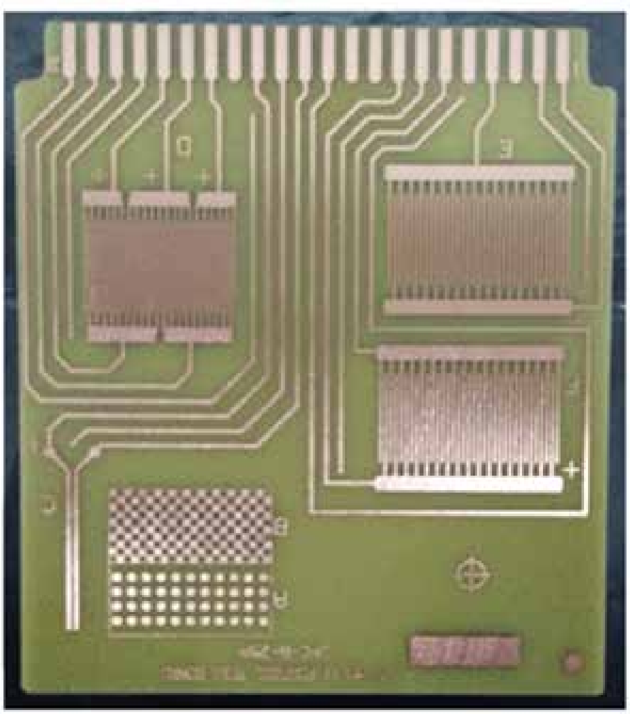

Figure 1. IPC-25B-A Test Board. Test comb structure D used in this study exhibits copper lines 20 μm in height, 300 μm in width and 300 μm spacing.

RESULTS & DISCUSSION

The thickness of the coated boards was evaluated using stylus profilometry and reflectometry. The average thickness of the polymer coat on the IPC boards was about 20 μm. While thicker films (>100 μm) associated with non-fluorinated polymer materials cause practical manufacturing and functional concerns, these thinner 20 μm films mitigate packaging and thermal management issues.

While IPX7 test standard utilizes water exposure, the current analysis shown here utilizes salt water (3.6 wt%) conditions which mimic the practical exposure associated with sweat or the beach. **Figure 2** represents the optical images of coated and non-coated samples exposed to these harsh conditions. Notice the corrosion associated with the uncoated board after salt water exposure. The entire anode comb structure has been removed due to oxidation. On the other hand, the coated board shows

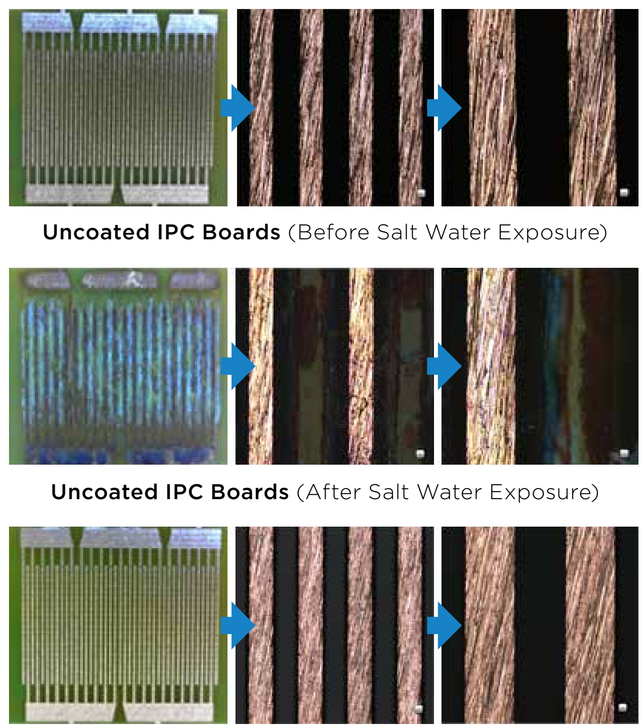

Figure 2. Optical images of the uncoated board before and after exposure, and the board coated with Ecofluor® (20 μm thick) after exposure. Notice the copper anode on the uncoated board is completed oxidized and removed, while no corrosion or degradation is observed on the coated board.

no sign of corrosion or copper degradation across the sample. **Figure 3** represents the current profile for the coated and uncoated boards. Notice that 700 mA current is observed for the uncoated board which steadily drops as the copper lines are degraded and destroyed. The coated board exhibits virtually no current flow (<5 nA peak current), **Figure 4.**

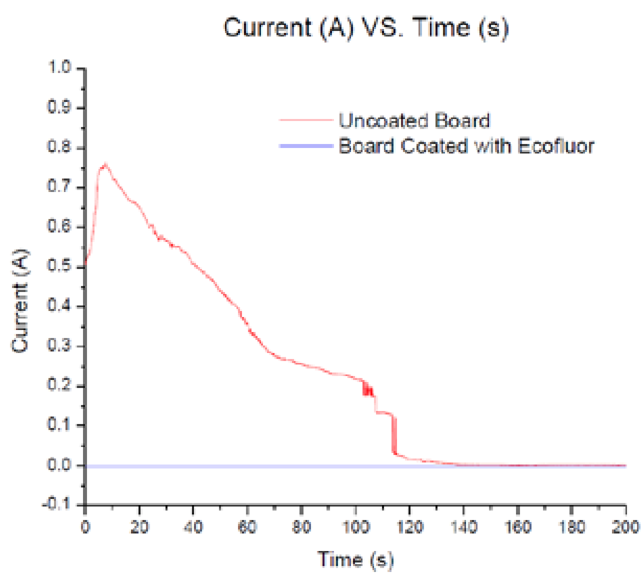

Figure 3. Current trace of coated and uncoated IPC Comb D test board at 4 V, submerged in 3.6 wt% salt water solution for one hour. The copper anode on the uncoated board is oxidized and completely removed until the device completely breaks down after 2 minutes. The coated board exhibits virtually no current flow (nanoscale current).

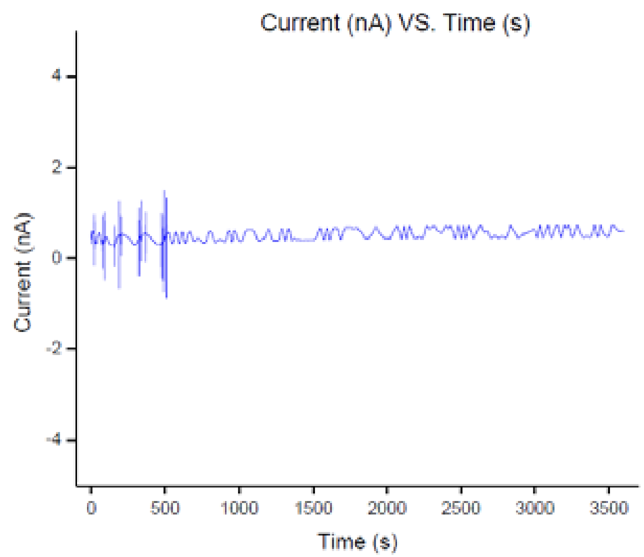

Figure 4. Zoomed in view of current trace of coated IPC Comb D test board at 4 V, submerged in 3.6 wt% salt water solution for one hour. Notice peak current is less than 5 nA.

SUMMARY & CONCLUSIONS

Ecofluor® provides a chemically resistant and thermally stable transparent thin film. This film can be generated via dip coat in minutes, avoiding the cost and time associated with spray coating and vapor deposition techniques. Standard electronic IPC test boards with 20 μm coating exhibit no corrosion and virtually no current flow even under harsh salt water conditions for one hour. This work demonstrates a simple economical approach to protecting devices from the harsh conditions of everyday life.

PRODUCT SUMMARY

COATING SOLUTION DETAILS	
Solids:	>20 wt%
Solvent:	Fluorinated Organic Solvent
Appearance:	Clear, Colorless
Specific Gravity:	1.5 g/ml
Boiling Point of Solvent:	>70°C
Flash Point:	None
Environmental:	Low in Toxicity, Non-ozone Depleting, Non-flammable, VOC Exempt, (U.S. EPA), RoHS Compliant, Contains No Chlorine or Bromine
System:	One Part
Viscosity at 25°C (cP):	>100

DRY FLUOROPOLYMER COATING	
Appearance:	Transparent, Colorless
Coating Thickness:	20 Microns
Solvent and Chemical Resistance:	Yes
Tg (Glass Transition Temperature):	>40°C
Tdecomp (Decomposition Temperature):	>250°C
Contact Angle (Static, Dip Coated/Dried on Glass):	113° (Water), 96° (Diiodomethane)
Solder Through Repairability:	Yes

ABOUT POLYMER SOLUTIONS GROUP

Polymer Solutions Group (PSG) is an innovative manufacturer of proprietary and custom polymer additives, dispersions, and performance chemicals for the rubber, plastic, wood, consumer, construction, and medical industries. PSG was formed by Arsenal Capital Partners in 2015 with the acquisition of Peach State Labs. A key component to our Functional Materials Division, Peach State Labs is an advanced organic chemistry manufacturer that specializes in surface and stain protection for the carpet, hard surface, and electronics industries with over 30 years of specialty chemical experience.

At PSG, we offer a variety of customer-centric solutions that improve polymer processing, increase surface protection, and enhance your product performance. Trusted by the world's leading companies in over 41 countries our unparalleled products and global reach is not matched by any other supplier. If you are interested in this product, please feel free to contact us directly. We look forward to starting a discussion.

CONTACT INFORMATION

Peach State Labs, A PSG Company
Functional Materials Division
180 Burlington Road, PO Box 1087
Rome, Georgia 30162-1087, USA
Phone: +1.706.291.8743, Toll-Free: +1.800.634.1653
info@peachstatelabs.com
www.polymersolutionsgroup.com/PSL

REFERENCES

1. IPC-Association Connecting Electronics Industries is an organization that sets standards used by the electronics manufacturing industry: https://www.ipc.org/default.aspx
2. IP code defined: http://www.ce-mag.com/archive/06/ARG/bisenius.htm
3. IP Code Defined: http://www.osram.com/media/resource/hires/342330/technical-applicationguide---ip-codes-in-accordance-with-iec-60529-gb.pdf