LED Chemical Compatibility using 3M™ Novec™ Electronic Grade Coatings

Introduction

Corrosion and contaminates from harsh environments can decrease electronic components' performance and lifetimes. Internal components such as printed circuit boards and light emitting diodes (LEDs) often use coatings to protect them from these elements.

During LED operation, discoloration of gas permeable lenses and encapsulants may occur if volatile organic compounds (VOCs) are produced by these coatings. This discoloration can degrade the brightness and color of the LED. Chemical compatibility testing is essential to verify that materials do not generate VOCs that adversely affect LED performance.[1]

3M™ Novec™ Electronic Grade Coatings are liquid applied, low viscosity fluorinated polymer solutions that dry to ultrathin protective coating films. They help provide longer life for electronics and components by protecting them against moisture, chemicals and environmental contaminants. To determine if these coatings are chemically compatible with LEDs, a study was conducted using 3M™ Novec™ 1908 and 2702 Electronic Grade Coatings.

Summary

Novec 1908 and 2702 coatings were shown to be chemically compatible with LEDs as tested according to the Cree® XLamp® LEDs Chemical Compatibility test procedure (CLD-AP63 rev. 4 August, 2013).[1] Coatings were applied over or near (around the base of) MX-6, XP-E, and XR-E LEDs and aged 1000 hours. Brightness and color changes were measured after aging. Novec 1908 and 2702 fluorinated polymer coatings did not visually discolor the LEDs. They did not decrease brightness and there was no visible color shift.

Test Procedure

Testing was performed according to the Cree® XLamp® LEDs Chemical Compatibility test procedure (CLD-AP63 rev. 4 August, 2013).[1] Cree offers a test kit with the MX-6, XP-E, and XR-E XLamp® LED products. (Figure 1)

Product Examples

Figure 1. Cree LEDs tested.[1]

The kit consists of a metal-core circuit board populated with six LEDs, glass caps and an adhesive. The LED test boards were coated as follows:

LED-1: Uncoated control

LED-2 and 3: Novec coating was brush applied around the base of the LED, but not on the LED lens, to a thickness of approximately 1 µm

LED-4, 5 and 6: Novec coating was dip applied over the LED lens to a thickness of approximately 1 µm

After coating, the glass cap was used to encapsulate the LEDs and the adhesive was used to seal the enclosure. If volatile materials are created during aging, they will be contained in the cap. The VOCs could degrade the LEDs during aging and any changes are measured at the end of the test. (Figure 2)

Uncoated | Coating Near LED | Coating Over LED

LED 1 | LED 2 | LED 3 | LED 4 | LED 5 | LED 6

Figure 2. Cree LED test board after Novec coating and glass cap applied.

The coated LED test boards were powered to the drive current specified in the Cree methodology (350 mA for MX-6, 700 mA for XP-E and XR-E) and aged under ambient conditions (23°C) for 1000 hours (approximately six weeks). Light output was measured for each LED using an OL IS-3900 1-meter integration sphere with an OL-770 spectroradiometer at the start of the test before coating and after 1000 hours on coated LEDs.

Test Results

The data gathered included visual inspection of the LED, the relative change in luminous flux (i.e. brightness) and chromaticity (i.e. color), reported as the difference in u' and v' measurements (du'v'). Note that each LED test board is comprised of LEDs with similar outputs to ensure a proper test comparison. Since light output and characteristics may vary slightly from one LED to another, comparisons were made within the same test board, rather than across multiple test boards.

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Visual Inspection Results

After 1000 hours, the LEDs on the test boards were inspected for variations in color and brightness versus the uncoated control LED-1. This was done at full drive current and at lower current close to 1 mA to allow for direct viewing of the LED with the naked eye. A closer inspection was also done using a digital stereoscope at 20× magnification on unpowered boards.

The result showed no variation in color and light intensity for any of the coated Cree® XLamp® LEDs . **The LEDs' silicone lens, phosphor and chip were unchanged when compared to the uncoated LED-1 at 1000 hours and to images taken of each LED-1 through LED-6 at the start of the test.** (Figure 3)

Typical Examples of Cree LEDs after 1000 Hours

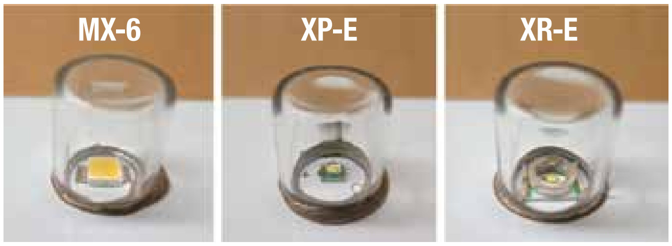

Figure 3. LEDs coated with 3M™ Novec™ Electronic Grade Coating show no discoloration after 1000 hours.

Brightness Results: Lumen Shift

Percent Luminous Flux (%LF) is the ratio of measured lumens after aging (1000 hours in this test) to the original lumens, indicating changes in brightness. A %LF greater than 100 would indicate the LED is brighter than the original brightness.

LED brightness will vary over time so, to normalize the data and light output cycle, the percent luminous flux of LED-2 through LED-6 was compared to that of the uncoated control LED-1. All LED results were similar to each other and comparable to LED-1. (Figures 4 and 5)

Whether the coating was applied over or near the LED, there was little to no degradation in brightness using these 3M™ Novec™ Electronic Grade Coatings after 1000 hours of aging.

Test Board Color Key

LED-1 (Uncoated Control) | LED-2 | LED-3 | LED-4 | LED-5 | LED-6

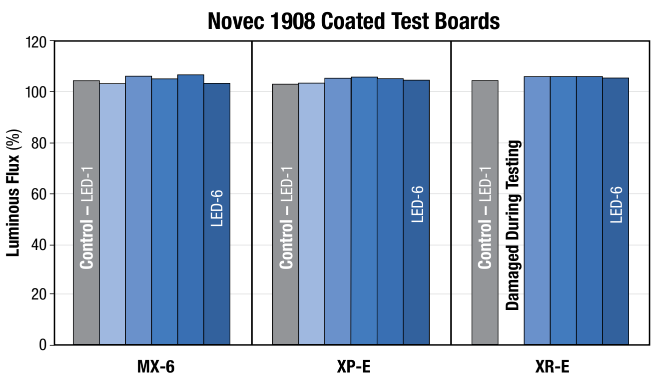

Figure 4. Little or no brightness degradation after 1000 hours.

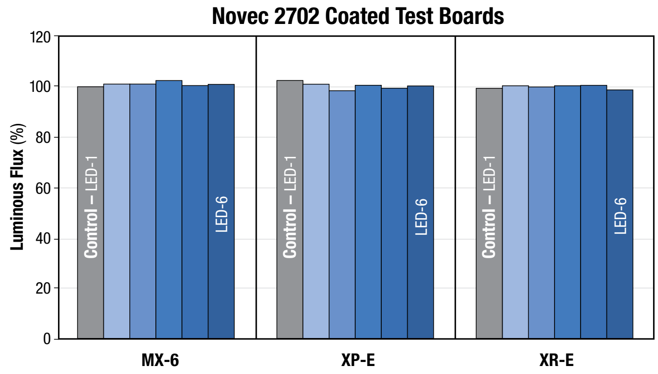

Figure 5. Little or no brightness degradation after 1000 hours.

In addition, the change in luminous flux was also measured on MX-6 LEDs after applying 3M™ Novec™ 1908 Electronic Grade Coating at three approximate thicknesses: 1 µm, 6 µm and 18 µm. The 1 µm coating thickness was achieved by dip coating the LED with Novec 1908 coating. The 6 µm and 18 µm thicknesses were achieved by spraying the LED with Novec 1908 coating.[2]

Comparing the coated LEDs to the uncoated control shows the %LF was not affected by coating thickness. (Figure 6)

Novec 1908 Coated MX-6 LEDs

1 Meter Sphere	Uncoated Control	1 µm Thick (Dip Coat)	6 µm Thick (Spray Coat)	18 µm Thick (Spray Coat)
% LF	100.9%	99.1 %	101.5%	101.3%

Figure 6. Thickness shows little or no impact on luminous flux at time zero.

Color Results: CIE 1976 u', v' Chromaticity Difference

The most accurate metric to describe the color shift of a light source is du'v'. Color shift (du'v') is the change in u', v' coordinates on the International Commission on Illumination (CIE) 1976 (u'v') chromaticity diagram, which is the most visually uniform diagram of a light source's color. In this test, du'v' represents the change in u' and v' initial values as compared to values at the end of 1000 hours of aging. A du'v' value of less than 0.002 is undetectable to the eye and considered excellent.

Comparing the color shift difference (du'v') of LED-1 to LED-2 through LED-6 shows the shift was less than 0.002, which is considered excellent. (Figures 7 and 8)

Whether the Novec coating was applied over or near the LED, the color shift after 1000 hours was undetectable to the human eye.

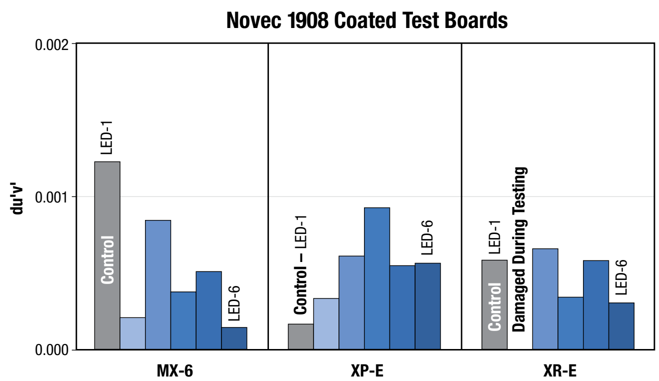

Figure 7. Changes in CIE 1976 color coordinates, du'v' < 0.002.

Test Board Color Key

LED-1 (Uncoated Control) | LED-2 | LED-3 | LED-4 | LED-5 | LED-6

Novec 2702 Coated Test Boards

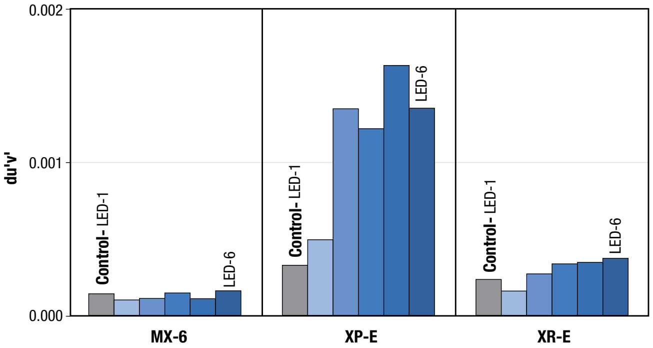

Figure 8. Changes in CIE 1976 color coordinates, du'v' < 0.002.

In addition, the color shift was also measured on MX-6 LEDs after applying 3M™ Novec™ 1908 Electronic Grade Coating at three approximate thicknesses: 1 µm, 6 µm and 18 µm. The 1 µm thickness was achieved by dip coating the LED with Novec 1908 coating. The 6 µm and 18 µm coating thicknesses were achieved by spraying the LED with Novec 1908 coating.

Comparing the coated LEDs to the uncoated control shows the color shift was not affected by coating thickness and was less than 0.002, which is considered excellent. (Figure 9)

Novec 1908 Coated MX-6 LEDs

1 Meter Sphere	Uncoated Control	1 µm Thick (Dip Coat)	6 µm Thick (Spray Coat)	18 µm Thick (Spray Coat)
du'v'	0.00026	0.00063	0.00033	0.00050

Figure 9. Thickness shows little or no impact on color at time zero.

Summary and Conclusions

Protection of LEDs with coatings may be needed to reduce the harmful effects of some environments and help maintain LED performance. If VOCs are emitted from these coatings, they can discolor LED components and cause loss of brightness or a change in color. Chemical compatibility testing can help determine the effects of these coatings on the long-term performance of LEDs.[1]

Using the Cree Corporation's Chemical Compatibility test method,[1] 3M™ Novec™ 1908 and 2702 Electronic Grade Coatings were applied over or near (around the base of) MX-6, XP-E, and XR-E LEDs, aged for 1000 hours and tested. These coatings did not affect light transmission. There was no decrease in brightness and no visible color shift.

Novec 1908 and 2702 coatings are designed to provide moisture and corrosion protection and neither significantly changed the LEDs' performance after 1000 hours. Novec coatings are available in other concentrations to fit application needs.

For Additional Information

To request additional product information or sales assistance, contact 3M Customer Service at one of the numbers below or visit 3M.com/Novec.

References

[1] Cree XLamp LEDs Chemical Compatibility Support Document http://www.cree.com/search-results?&lcid=9&q=chemical%20compatibility&

[2] All Novec coatings can be applied using spray, dip or syringe methods. For spray application, 3M recommends using engineered controls or personal protection equipment (PPE) to minimize worker exposure. Thickness can be achieved in a variety of ways. Please contact 3M Technical Service for details.

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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