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Potting protection for outdoor LED video walls and signs

Application Note

Valid for:
DISPLIX®

Abstract

This application note provides basic information on the potting of flat SMT LEDs in video wall and signage applications. Thereby, details on material in use, examples of suitable equipment and the process are presented and described.

Additionally, the application note gives a short introduction into video walls with a typical setup, varying LED type system effects and general challenges. Finally, the results of selected environmental tests are presented to demonstrate their impact and the aptitude of potting protection method.

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Table of contents

A. Introduction

With the move into the digital age, outdoor signs and video walls are becoming more and more common. Nowadays these electronic signs can be seen in stadiums, as street bill boarding or advertising on buildings in cities, bus stops, gas stations, etc. (Figure 1). As many of these applications have contact with the outdoor environment, protection of the electrical components including the LED leads is a must.

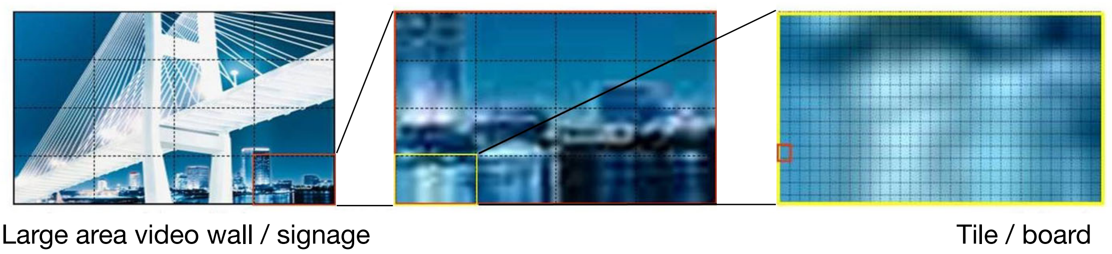
Figure 1: Typical example of video wall display

Owing to technological advancement and also by the transition from radial to Surface Mount Technology (SMT) LED technology, there are a few challenges in video wall and signage applications. One of the main topics, the protection materials and methods of SMT LEDs for outdoor video walls, is discussed here. Concretely, those methods are being addressed due to decreasing LED height, decreasing pixel pitch, coating material choice and the coating method. However these challenges can be handled as shown by some realistic potting trials combined with environmental tests made by OSRAM Opto Semiconductors.

B. Basic construction of LED video walls

Most commonly, larger outdoor video walls or signs are made up of multiple modules with LEDs on them which then define the finished product. As an analogy, one can think of the individual tiles on a bathroom wall as being video wall modules and the assembly of them next to one another as being the complete video wall (Figure 2).

Figure 2: Basic constuction of an LED video wall

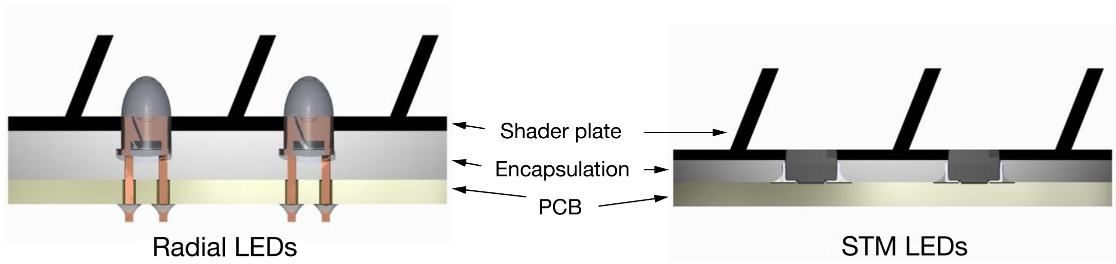


These basic modules, also called tiles, can vary in size but often they are about 20 to 30 cm in length and width. Following a basic construction they are composed of a frame, louvers, PCB(s) with LEDs and electronics. At the moment, louvers are a necessary part of the video wall tile as they act as sun blockers to increase the overall contrast, especially in outdoor application.

Advantage of SMT LEDs for video walls and signs

Until recently, the outdoor video wall and signage market has been dominated by an older lamp style, so called radial, LED technology. These types of LEDs are best described as having a bigger light emission dome and long metal leads. On the other hand, SMT LEDs tend to be smaller and do not have long leads. There are numerous advantages in using SMT LEDs as compared to radial.

Figure 3: Sketch of the two typical LED title setups

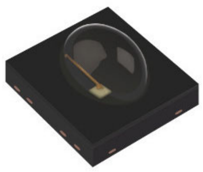


One of the first advantages is the technology. Most of the innovation and progress in the LED business is happening on the SMT level. SMT LEDs have the advantage of greater package shape versatility and are also available in multichip packages. The leads of radial LEDs can be as long as 30 mm. SMT LED packages could be less than 1 mm in height while the radial LED lamp can be as high as 10 mm and have a diameter of around 3 - 5 mm.

Consequently, the size of the LED limits the minimum pitch values for the video wall applications. A further factor is the weight of the LED itself which can make a big difference, especially in portable video wall applications such as concert and event setups.

A single SMT LED such as the DISPLIX Oval from OSRAM Opto Semiconductors weighs just 13 mg which is around 10 times less in weight than a typical lamp style LED (Figure 4). Due to the mentioned differences in the LED height, the amount of protection material needed is consequently different. Taking a simple estimation of a realistic video wall tile of the dimensions 24 by 24 cm and 16 by 16 pixels (pixel pitch 15 mm), the weights of different LED types and required protection material is compared.

Figure 4: Images & data of DISPLIX® Oval & Blackprint and typical Radial LED



DISPLIX® Oval	DISPLIX® Blackprint	3.5 mm Radial (typ.)
Single-chip LED	Multi-chip LED	Single-chip LED
Weight 0.013 g	Weight 0.062 g	Weight 0.17 g
Package height 0.95 mm	Package height 2.1 mm	Package height 10 mm
Potting height 0.9 mm	Potting height 1.9 mm	Potting height 5 mm

For a better contrast, three LED types, 3.5 mm Radial, DISPLIX® Oval and DISPLIX® Blackprint were selected, with a setup of 3 LEDs per pixel for the radial type and DISPLIX® Oval and 1 LED per pixel for DISPLIX® Blackprint (multichip RGB LED). As for the potting material, SE-9187L from Dow Corning®, a one-component black silicone, was chosen. Based on the setup and LED dimensions a typical encapsulation height of 0.9 mm can be assumed for the DISPLIX® Oval, 1.9 mm for the DISPLIX® Blackprint and 5 mm for the radial LED. Concretely, this would mean that there is a possible weight reduction of the lighting component of up to 6 - 7 times to use the DISPLIX® Oval and about 3 - 4 times to use the DISPLIX® Blackprint than a typical radial style LED (based on the raw weight data sheet values). Transferring the estimation for one tile to a standard billboard size of 14 ft x 48 ft (4.3 m x 14.6 m) which has about 1084 of the above defined tiles shows a significant impact on the system weight (Table 1).

Table 1: Comparison of system weight influenced by LED type and portion of pottant based on an application example

	Radial (typ.)	DISPLIX® Oval	DISPLIX® Blackprint
Size of video wall	14 ft x 48 ft	14 ft x 48 ft	14 ft x 48 ft
Number of LEDs	832512	832512	277504
Weight of a single LED	0.17 g	0.013 g	0.058 g
Total LED weight	142 kg	11 kg	16 kg
Weight of silicone	263 kg	52 kg	112 kg
Total weight (LED + silicone)	405 kg	63 kg	128 kg

C. The challenge of LED outdoor use

Outdoor applications are among the most demanding areas for LEDs and LED light sources, because they are subject to or affected by many, sometimes conflicting conditions. For instance, they may be affected by temperature, radiation, moisture, rain, dust, chemicals, gases and other natural phenomena. To make a general outdoor qualification profile even more difficult, the geographical position and location have a tremendous influence on the type and magnitude of environmental occurrences, as well as the specific combination and interaction of varying ambient conditions.

For example, LED display installed in a Nordic rural town could be exposed to quite different conditions from a similar display at a busy city-center traffic intersection or a town in the tropics.

However, as it has been seen for the video wall manufacturer, one of the most critical impact on LED displays combined with outdoor use is the corrosion of the electrical components such as PCB circuits, LED lead/pins, solder pads, contacts, vias, etc. This corrosion could result in open contacts or shorts and affect the functionality even to the point of a total breakdown of the display. Therefore, the main quality focus in outdoor applications is the prevention of any kind of corrosion of the potentially exposed electrical metal parts.

D. Protection methods

There are several popular methods that are used for environmental protection of signs and video walls.

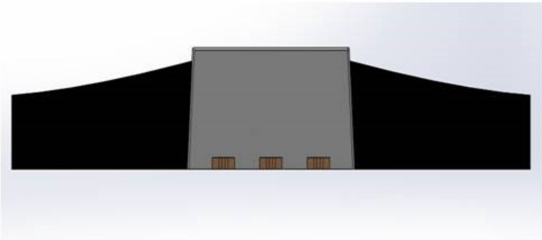
Vapor deposition process

Vapor deposition process in a chamber is usually how parylene is thinly coated (in the range of 20 - 30 µm) over the whole surface. Due to the fact that the parylene is applied in a gas state, all, even the smallest areas of the LED panel are uniformly coated including the LEDs and all electronics. It is a very common method in certain military and aviation applications for example. For such applications this could be a preferred method, but carries a potentially high cost and the parylene material provides only a limited UV stability. Another method is casting or LED encapsulation, meaning that the whole LED (including the light output area), is completely covered by dispensing a thick layer of a clear material (silicone, polyurethane, acrylic, etc.) up to cm-range. There are applications mostly in the general lighting field where this method is desirable due mechanical stability requirements, low process costs and broad range of very cheap protection materials. However, the influence on the radiation characteristic due to a thick layer over the light output area does not make it very desirable for video wall/signage applications. Similar to casting, conformal coating is a further method defined by some as the process of dispensing a thin layer of material of up to 300 µm over the whole LED panel (including the lens). With an advanced process called selective conformal coating, the material is dispensed selectively, especially avoiding the LED light output area or the top of the LED package. It is one of the common methods in the signage industry, but it could take extra equipment, longer processing time and could require lower machine tolerances.

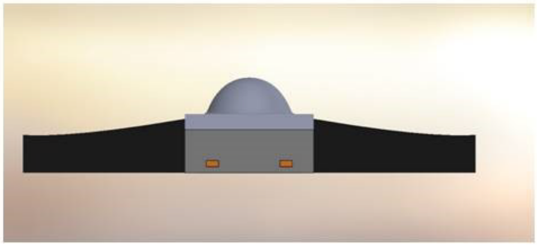
Finally, potting is a method commonly defined as the process of dispensing a thicker layer (typically greater than 300 µm) around the LED package, to cover the PCB surface and LED leads. This is one of the preferred methods of signage and video wall manufacturers, because the LED lens is not covered, the material potting height has more tolerance as long as it is below the package height and the processing method is quite straightforward.

In the following chapters, a proof of concept is shown using a potting process on the low height DISPLIX® Oval providing easy adaptation to the future LED technology.

Figure 5: Sketch of ideal potted SMT LEDs



DISPLIX® Blackprint (Multichip LED)



DISPLIX® Oval

Figure 5 shows the way silicone is shaped due to the lower surface energy of the silicone as compared to surrounding materials it is in contact with. The material should not be placed on the top of the LED package or the lens as it could significantly change the LED radiation characteristic and/ or the luminance even if the material is clear.

E. Potting

Numerous potting materials could be dispensed to protect the LED metal contacts from the environment, such as polyurethane, acrylic, silicone, etc. As mentioned, the ever decreasing dimensions of LED packages allow smaller pitches and require different potting solutions. A lot of video wall manufacturers have chosen RTV (room temperature vulcanization) silicone (polydimethylsiloxane — PDMS) as a preferred material due to its advantages of this material. The silicones made for these applications possess the following characteristics:

- Suitable for use over a wide range of temperatures
- Provides stress relief and protection of delicate component leads
- Good moisture and humidity resistance
- Good adhesion to no-clean, low solids and lead-free flux technologies
- Processing versatility
- Easy reparability
- Low toxicity

Due to the high density of components on the PCB tile, a highly flowable and self-leveling silicone material is necessary.

Experimental potting setup

- Materials

For the experimental potting trials three different LED types, DISPLIX® Oval, DISPLIX® Blackprint and the DISPLIX® Black were used (Figure 6). The LEDs are especially designed for video wall and signage applications.

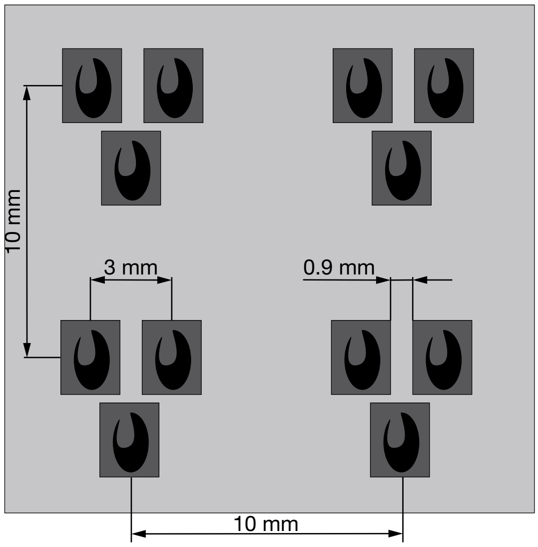
Figure 6: Images of tested LEDs of OSRAM Opto Semiconductors

The DISPLIX® Oval has a footprint of 2.7 x 2.1 mm and LED foot height of 0.9 mm with an oval lens on top whereas the multichip LEDs DISPLIX® Black & Blackprint have a 4.5 x 4.5 x 1.9 mm package dimension.

Of the many products available on the market the one component black RTV silicone SE-9187L from Dow Corning® has been selected, based on its low viscosity for enhanced flow and self-leveling to achieve a homogenous and flat coating. Furthermore, the very low surface energy of silicone will allow the material to efficiently wet out the substrate into the tiniest corners of the components creating a good protection.

Two types of PCBs were used, the first was a PCB with standard LED alignment which are commonly used by OSRAM Opto Semiconductors for LED testing and qualification (Figure 14). The second type provided the specific small LED pitch with the small DISPLIX® Oval LED and with a small pitch of 10 mm, and LED to LED intra pitch distance of ~ 3 mm (Figure 7).

Figure 7: Sketch of section of PCB with small LED pitch arrangement (DISPLIX® Oval)



- Equipment

The selection of the best possible equipment is based on the type of material (mainly one-component or two-component), the size of the products/title, the required accuracy and repeatability of the application and the required cycle time per product. Secondary the required investment should also not be forgotten — investment in the initial equipment, as well as daily maintenance costs. Robotic machines are available in many different versions and they all have their specific features that towards the particular requirements.

Here, the Nordson DIMA Dispense Master DD-500 in combination with the Nordson DIMA DD-5131 dispense valve were selected since small quantities but high varieties of different shapes had to be performed.

Figure 8: Nordson DIMA Dispense Master DD-500 with the DD-5131 dispense valve (Courtesy of Nordson DIMA)

The machine (Figure 8) was a good candidate for the test because it is flexible, the boards can be placed manually and it is an easy to operate desktop system. This desktop robot is a XYZ-system that is capable of handling boards up to 400 x 600 mm with a dispensing work area of 320 x 420 mm and a Z-stroke of 87 mm. The total size of the system is 700 x 700 x 550 mm (LxBxH). The maximum speed of the system is 80 mm/sec and the accuracy is at 150 microns. The Nordson DIMA DD-5131 dispense valve (suitable for 1K or 2K compounds) can be mounted to the gantry with a head that can move in the XYZ-direction. The camera is a standard feature in this machine that makes programming more user-friendly but it is not necessary for the process.

During the tests the camera helped to program the dispense positions. Other systems available on the market provide in-line capabilities, higher speed, better accuracy and a larger work envelope. The better machines for in-line capabilities, such as the Dispenser Elite line from Nordson DIMA provides higher speeds (10x faster dispensing as compared to the Dispense Master line), larger sample area and other technical features such as extremely good accuracy that provide fast in-line performance (Table 2).

Table 2: Comparison of the technical data of the used desktop and two in-line systems from Nordson DIMA

	Dispense Master DD-500	**HybridC Dispenser HC-100**	**Dispenser Elite DR-060**
Machine type	Desktop	Batch/ In-line	Batch/ In-line
Machine size (LxBxH)	700x700x550 mm	1000x1200x1800 mm	1330x1430x1470 mm
Max. dispense area	320x420 mm	500x500 mm	525x410 mm
Max. speed	80 mm/sec	200 mm/sec	1000 mm/sec
Accuracy	150 micron	150 micron	50 micron
Integrated camera	Yes	Yes	Yes
Fiducial alignment	Optional	Optional	Standard
Off-line program-ming	Yes	Yes	Yes
Software	Windows based	Windows based	Windows based

- Dispensing procedure

Potting can be done by applying material in one position using the material flow to slowly fill up a complete area. However in case of LED boards, the accuracy needed to fill up the boards nicely to the edge of the LEDs needs a more precise movement of the dispense nozzle during the potting sequence.

The main challenge in process optimization is to not cover the top face of LEDs. In general five parameters determine mainly the dispensing process, and influence the dispensed line widths. These are:

- the pressure with which the material is being supplied from the original packaging (syringe, cartridge, pail) creating a certain material flow
- the speed of dispensing (motion of head)
- the diameter and style of the dispense needle
- the stroke of the dispense valve
- the distance of the dispense needle towards the LED board

For an optimized process and potting result the machine parameters have to be adapted to the material used and its properties. If cycle times are very critical, parallel processing is another way to speed up the process. This can be done by duplicating the amount of nozzles in the dispensing system and upgrading to faster in-line systems.

For process control/monitoring and to reach a board-to-board repeatability there are several more options available. The easiest one is to control all pressures within the machine that are being used to apply the material onto each board. Secondly one can make sure that the material reservoirs being used cannot run empty without providing a warning signal.

To make sure that every board will contain the same amount of material, flow monitoring can be used. Through flow monitoring the amount of material flow is monitored during the dispense cycle making sure that the exact, same amount of material is being applied on every single board.

The chosen RTV silicone can be repaired, though silicones generally do not adhere well to themselves. Therefore it is recommended to consider the optional use of a primer or gently roughening of the surface to improve adhesion. When touching up the solder joints of a rework site with new coating, it is imperative that the coating surfaces are clean.

- Curing Procedure

The silicone potting material Dow Corning® SE-9187L readily wets the substrate, providing an excellent interface for adhesion to develop. However the PDMS molecule itself will not bond chemically to a surface. To achieve a molecular bond between the silicone and a substrate, an adhesion promoter is added to the product formulation.

The cure of RTV silicones is initiated by moisture from the air that permeates into the silicone and reacts with the titanate catalyst. The resulting intermediate then reacts with the cross-linker and with the polymer. Finally, all of the remaining species complete the cross-linking reaction to form a uniform coating/potting layer. Because the first step depends on contact with moisture from the air, the outer layer of the coating will begin to solidify first. A “skin” of cured coating will form as the cure progresses from the outside inward.

At this point, the coating/potting layer can usually be handled and subsequent manufacturing steps can proceed. As the cure reactions proceed through the depth of the coating, the materials will completely solidify. Full cure occurs when the material is fully hardened and strong cohesive adhesion has been obtained to the PCB. Note that adhesion typically lags behind the cure and may take 72 hours to build up depending on the applied coating thickness. Low heat up to 60 °C can improve the cure speed, but should be applied with caution taking into consideration the tack-free time before heat-exposure (typically 10 minutes). If the “skin” is formed too quickly, solvents can be trapped under it causing the creation of bubbles.

While moisture from the air is mandatory for cure to progress, only a very small amount is actually needed. Even though a high humidity level accelerates the cure in a very deep coating thickness, excess moisture will slow down the cure in thin sections. This occurs when the catalyst near the coating surface becomes saturated with moisture and becomes deactivated. This can significantly slow both the skin-over time and the time to full cure. On the other hand, moisture levels below about 5 % relative humidity will slow down the cure significantly. Recommended relative humidity values range from 30 % to 80 %. Elevated temperatures greatly lessen the effects of humidity on the cure speed and no additional humidity is necessary in the oven (most of the ovens running at 60 °C will have a relative humidity close to 10 %).

Note that a good ventilation flow over the PCB is important to efficiently remove the solvents, but caution should be taken as too large air flows can cause wrinkles in the surface.

Potting results

The main purpose of the potting tests was to verify and test the suitability of the potting material concerning the use in LED video wall application, especially with low height SMT LEDs with a tight pitch.

For the potting with the one-component RTV silicone from Dow Corning® (SE-9187L) a 20-gauge plastic tapered needle (inner diameter of 0.6 mm) was used. The speed of dispensing was limited to 55 mm/sec and the pressure used on the material (supplied in 175 ml cartridges) was set at about 2 bar.

The distance between dispense needle and the LED board was set to 0.7 mm, creating a nice flow of material providing a 6 mm line.

The material was dispensed in a simple way vertical and horizontal lines, not especially adjusted to the LED alignment (Figure 9).

Figure 9: Potting image of DISPLIX® Oval with the RTV silicone Dow Corning® SE-9187L

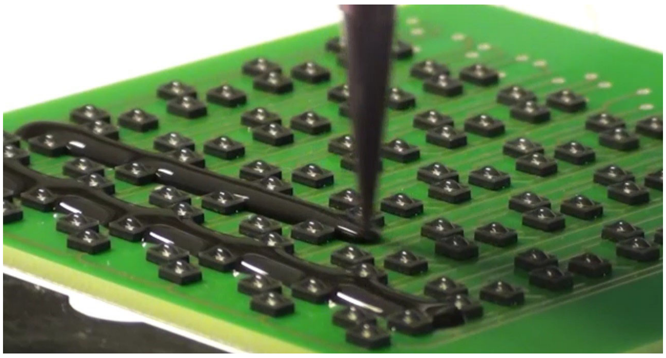
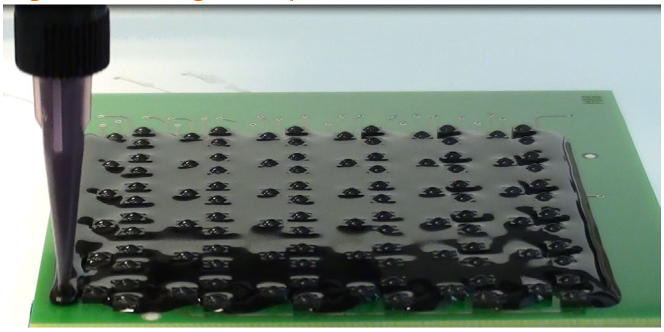


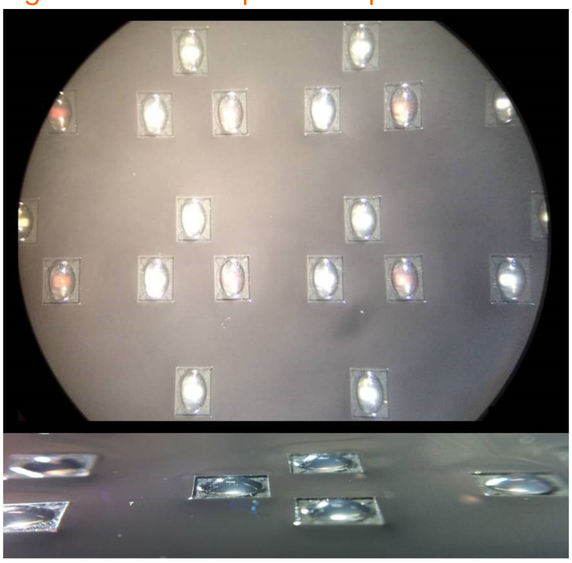
Figure 10: Image of a potted PCB with DISPLIX® Oval LEDs



One of the most critical areas seemed to be small sections that needed to be covered between LEDs within a pixel, in this case small lines of 0.9 mm width.

But as the tests have showed, the selected silicone flowed well between the LEDs, due to the capillary effect, even with a small intra pixel LED-to-LED distance. Even though when looking at the board from further away, it almost seemed that the LED package and the lens were covered by the silicone material (Figure 10), however after close inspection with a microscope it was confirmed that the package and the lens were not covered (Figure 11).

Figure 11: Close-up view of potted LEDs



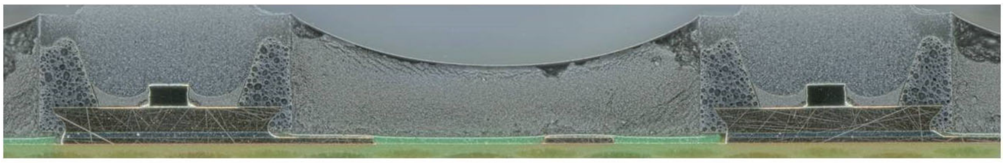
Near the PCB edges the material forms a decreasing coating layer and stops at the rim of the board without overflow depending on the deposited quantity, but a frame for potting was not needed.

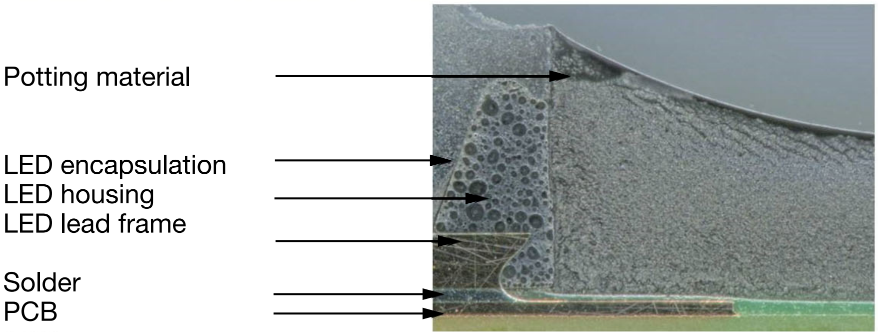
In one trial, an elevated temperature cure was done according to the material data sheet and it was discovered that the strong air flow caused wrinkles in the "skin" formation of the silicone during the cure. This should be avoided by using a suitable oven as mentioned in curing procedure section above.

The potted test boards were cured at room temperature for 24 hours and then were transported. According to the data sheet, greater than 90 percent of full physical properties should be attained within 24 to 72 hours. Therefore possibly allowing careful handling which in return could save time in the manufacturing process. Furthermore, the potting process was done on different days with varying humidity levels in the room (it is an advantage of this material is that it doesn't need high humidity levels to complete the curing process).

Handling was easy and the material showed good repeatability in multiple trials. The tested silicone has an adhesion promoter inside and from the first look showed good adhesion to the PCB after the full cure. In a standard lap-shear test the adhesion strength to a typical FR4 board was measured to be 0.2 MPa, with 100 % cohesive failure (Dow Corning®).

Figure 12: Cross section of the potted PCB



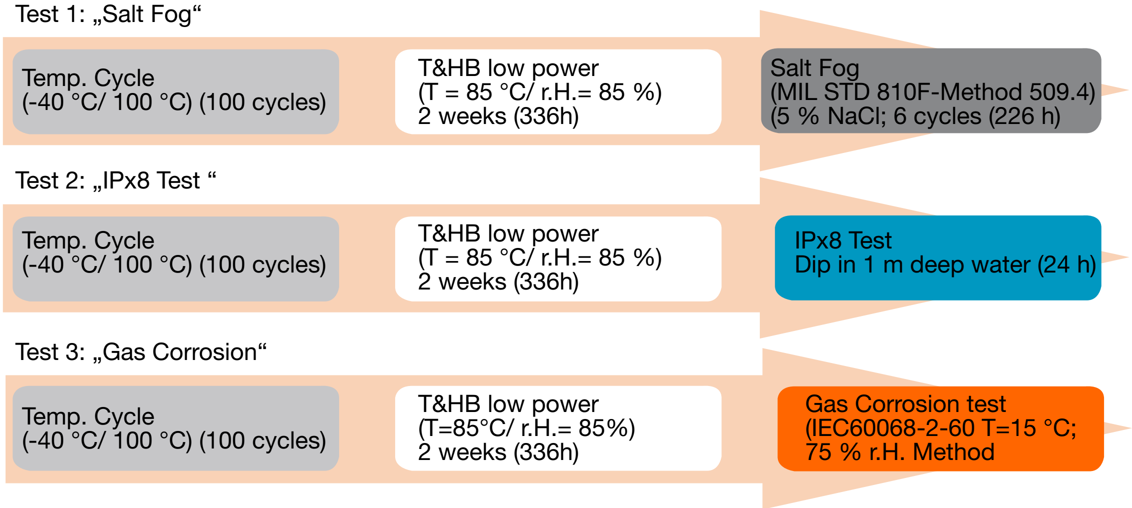


The potting process for the DISPLIX® Blackprint was similar as with the DISPLIX® Oval except that the LED to LED wall space was larger (5.5 mm with a 10 mm pitch) due to the 3 in 1 chip package, having even less accuracy requirements in the processing.

F. Environmental tests

Since there are no specific standards regarding environmental tests for outdoor video wall applications, selected tests were completed in order to determine the harshest condition. The tests include "Salt-fog stress", "IPx8" and "Mixed flowing gas corrosion". All three tests are preceded by the same pre-conditioning steps in order to put even more stress on the LED — moisture preconditioning according the moisture sensitive level (MSL), reflow soldering at maximum temperature (260 °C peak), Temperature Cycle (TC) and Temperature & Humidity Bias (T&HB). Temperature Cycle is regularly used to demonstrate that package, chip and wire / chip bond integrity are stable against mechanical stress caused by extreme temperature variations. This is done in two air-filled tempered chambers (e.g. - 40 °C and 100 °C) based on JEDEC JESD22-A104.

Figure 13: Overview of the realized environmental tests with parameter



The intention of using TC-stress as preconditioning before the corrosion testing is to find possible weak links in the interfaces which could lead to delamination and in the end to increased stress levels as well as enhanced corrosion attack. Temperature and Humidity Bias (T&HB) is used to evaluate the reliability of devices in humid conditions by accelerating the penetration of moisture through any protective material. With this material degradation or corrosion and migration mechanisms caused for example by material incompatibility, misprocessing or mishandling which may lead to reduced reliability can be revealed (JEDEC JESD22-A101). In the preconditioning sequence of the tests, the T&HB was performed at 85 °C / 85 % R.H. using on/off mode in order to increase the effect of the moisture and the mechanical stress on the LED.

IPx8 test is defined according to CEI/IEC 529 covering immersion into water up to 1 m for at least 30 minutes (at OSRAM Opto Semiconductors 24 hours was performed). Flowed Mixed Gas Corrosion Test is used to determine the corrosive influence of operating and storage indoor environments on electrochemical products. Methods emulate different corrosive conditions: method 1 is for mild corrosive environments (rather clean environments), method 2 and 4 are moderately corrosive and method 3 is more corrosive (industrial instrument rooms). Here, contacts are prone to pore corrosion and creep of corrosion products while with method 1, 2, and 4 the main corrosion mechanism is pore corrosion (IEC 60068-2-60). The Salt Fog test is used to determine the resistance of devices against salt corrosion.

This “Salt Atmosphere” test or a variation thereof is commonly used by the video wall/ signage manufacturers (related to MIL-STD-810 Method 509.4) for qualification.

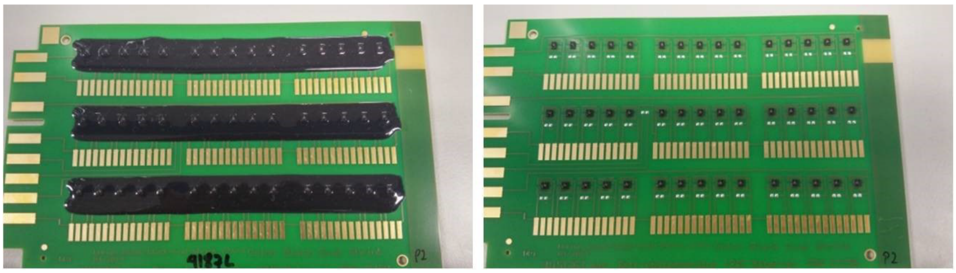
Environmental test results

There were two main purposes behind the realized environmental tests.

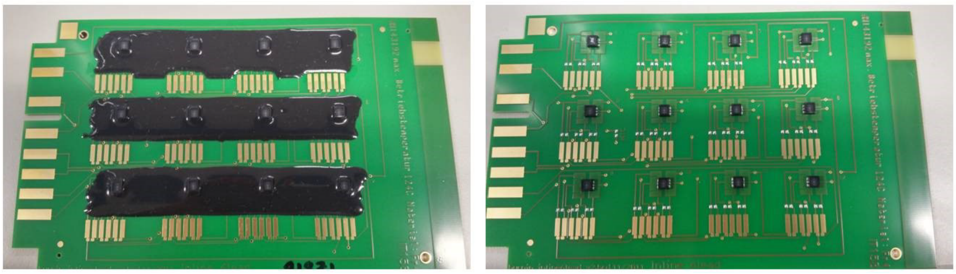
First, the chosen tests with their specific conditions should be surveyed to check corrosion, electrical and physical effects on the device and also the practicability for the application. The second was to test the effectiveness of protective coatings and finishes on materials.

For each test standard test boards with DISPLIX® Oval, DISPLIX® Black or DISPLIX® Blackprint were used — a potted sample and a non potted sample for reference (Figure 13). The environmental tests were performed 2 weeks after potting per recommendation of Dow Corning®.

Figure 14: Example of PCB with and without potting for environmental test (DISPLIX® Oval, DISPLIX® Black)



DISPLIX® Oval



DISPLIX® Black

A visual inspection of the boards was done before and after the procedure (Figure 15). To check and verify the optical and electrical parameters of the LEDs, the boards were referenced and electro-optically re-measured after each single test step.

The failure criteria were defined as change in forward voltage U_f of more than ± 10 % variation and/ or change of brightness (I_V/ I_e) of more than ± 30 % of the original value.

As it can be seen in the diagrams, IPx8 and Gas Corrosion tests can be considered as not aggressive enough because even on the unpotted, bare LEDs no deterioration was observed (Figure 16).

Figure 15: Extract of the visual inspection of the DISPLIX® Oval board before and after the Salt Fog Test

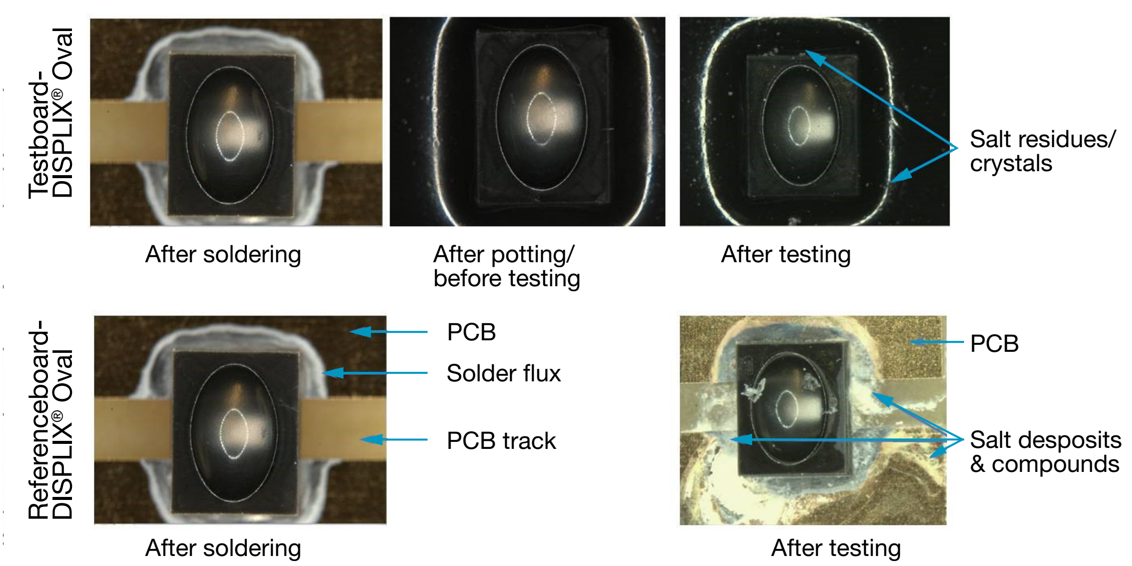
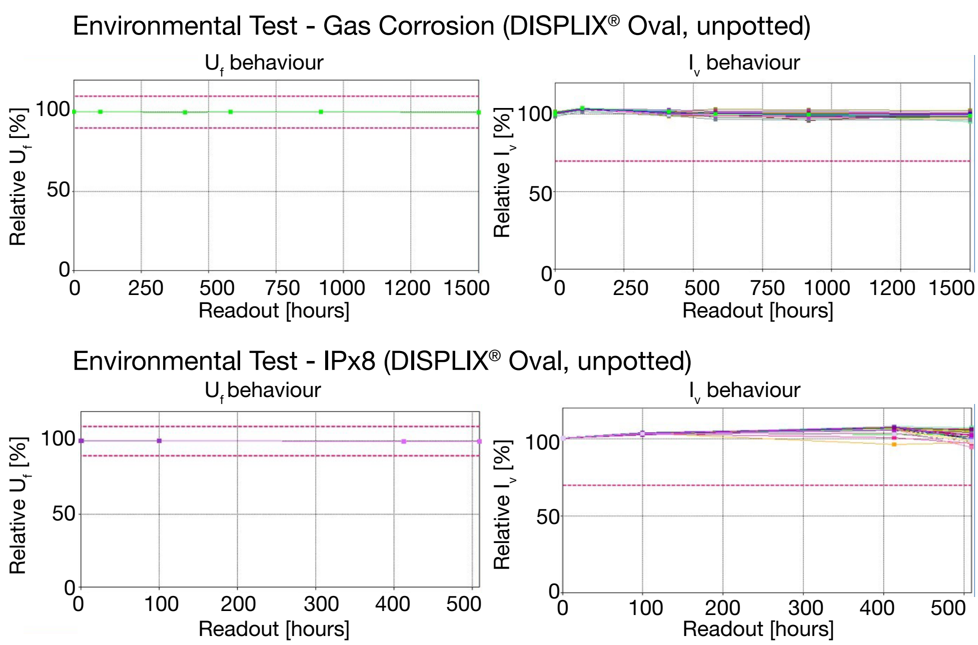
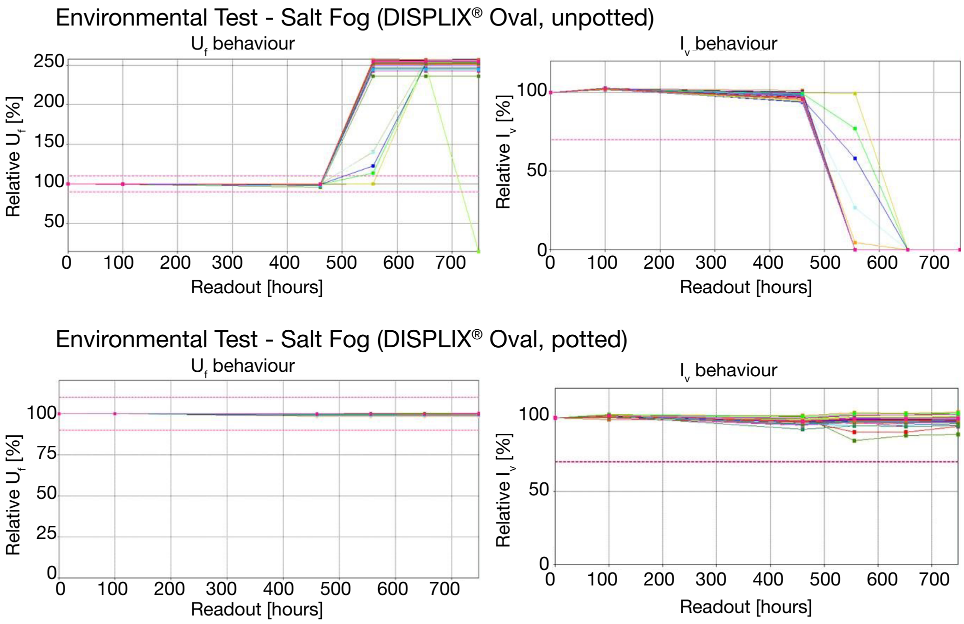


Figure 16: Diagrams (U_f & I_V) of the environmental tests Gas Corrosion and IPx8 (e.g. DISPLIX® Oval, unpotted)



Only Salt Fog effectuates in the non-protective LEDs a gradual deterioration of the electrical (U_f) and thus also the optical property (I_V). Figure 17 shows the influences using the example of DISPLIX® Oval LED type. The same results were shown for the DISPLIX® Black/Blackprint. In contrast the potted LED boards with the silicone Dow Corning® SE-9187L show no adverse effects. Due to that it can be stated, that the used silicone is able to prevent an impact of the electro optical properties of LEDs at the salt atmosphere ambient conditions.

Figure 17: Diagrams (U_f & I_V) of the environmental tests Salt Fog (e.g. DISPLIX® Oval, unpotted/ potted)



G. Summary

The use of SMT LEDs for video wall applications implicates several advantages compared to radial LED packages. On the one hand the broad benefits of the SMT processing technology, on the other hand the SMT LEDs enlarge the system properties like higher display resolutions due to the smaller or higher integrated packages (e.g. Multichip) or reduced system (module) weight, because of the lightweight package of the LED itself and the reduced necessary amount of potting material.

In general it can be stated that Potting as a possible precaution is also suitable for SMT LEDs with low heights (min. test height 0.9 mm at DISPLIX® Oval). However due to possible smaller gaps between the LEDs, the selection of proper silicone specifically developed for potting in electronics and lighting applications is necessary. The black silicone from Dow Corning® complies with the requirements in terms of simple processing and protective effect. Close gaps as they occur at higher pixel densities are automatically filled by capillary action to the top edge of the component.

As it has been proven during the potting tests, a process adaptation to low heights is easily possible because it can be set with a few parameters. With corresponding equipment, some process experience and slightly optimization good results are possible.

From the selected environmental tests it can be seen that the Salt- Fog effectuates in the non-protected LEDs a gradual deterioration of the electrical property (U_f) and thus also the brightness (I_V) whereas the silicone is able to prevent an impact of the electro optical properties of LEDs at the Salt Atmosphere conditions.

Since there is currently no clearly specified definition of “outdoors” and no standards governing the use of LEDs in outdoor applications, there is plenty of scope for different interpretations as to what is an appropriate and suitable characterization.

For further information concerning LED application support, please contact your sales representative or OSRAM Opto Semiconductors. OSRAM Opto Semiconductors offers its customers support during their development and design processes in order to find the best solution for a specific application.

For information and questions regarding the dispensing machine and related valves, please contact Nordson DIMA. (www.nordsondima.com)

For information and questions in terms of silicone protection materials please contact Dow Corning®. (www.dowcorning.com)

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ABOUT OSRAM OPTO SEMICONDUCTORS

OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. OSRAM Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. OSRAM Opto Semiconductors also has sales offices throughout the world. For more information go to www.osram-os.com.

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