Enhancing the Performance and Lifetime of LED Designs

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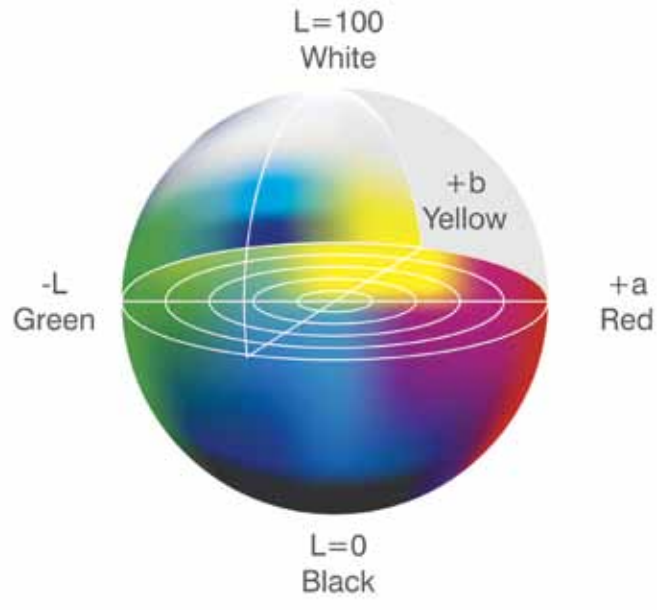
The LED market is one of the fastest growing sectors within the electronics industry. With an increasing number of potential uses, LEDs are now present in all types of lighting, signage and domestic appliance products, to name just a few. In offering alternatives to halogen, incandescent and fluorescent lighting systems for both interior and exterior applications, the growth of the LED lighting market alone is impressive. Such growth is attributed to the advantages LEDs offer over traditional lighting forms in terms of adaptability, lifetime and efficiency; they allow more design freedom, offer an exceptionally long lifetime and they are also considerably more efficient, converting the majority of energy to light and thus minimising the heat given off.

Specially designed and formulated chemical products are widely used in the electronics industry for a vast array of applications. Whether it is during PCB manufacture or for the protection of components or complete devices, such products have become an essential factor in ensuring the performance and quality of electronic devices. Specifically in LED applications such products can be used to assist Design Engineers in protecting LED systems in a variety of conditions, including the installation of lighting designs in corrosive environments, for example. Due to the design freedom that LEDs offer, applications are becoming more diverse and challenging and as such, aesthetic results must be achieved in conjunction with the consideration of reliability and lifetime of the product. In addition, specialist chemical products can also be used as part of the design for cosmetic reasons as well as helping to provide key functional improvements such as increased efficiency and reduced energy consumption.

Enhancing Performance in Challenging Environments

The environment that the LEDs and associated electronic components are used in will have an effect on the type of product required to protect the system and ensure reliability. Environmental challenges can be in the form of corrosive environments; when high humidity, salt mist or corrosive gases are present, for example. Due to the potential variety of LED applications it is also possible that UV exposure, water immersion or chemical exposure may also make up part of the operating environment. It is therefore imperative that the end-use application is fully understood to ensure the correct protection media is applied.

Where protection directly over the LED is required there are a number of points that must be considered. The clarity of the material applied is crucial to ensuring the maximum utilisation of light output from the LED. In addition, any potential changes to the colour temperature, clarity of the material or light output of the LED during operation must also be considered. Protection can be offered in the form of conformal coatings or encapsulation resins, with the choice between the two being determined by the severity of the operating environment and the desired aesthetic effect. For example, for protection against high



humidity or salt mist a thin layer acrylic conformal coating would offer a high level of protection with minimal impact on the light output and colour temperature of the LED. Encapsulation resins are used for harsh environments such as immersion in water, or where light dissipation and environmental protection are required in one process; Electrolube UR5635 is a good example of such a resin.

As briefly mentioned, the colour temperature of the LED will be affected by the protection media applied and therefore the potential colour temperature shift should be tested in accordance with the LED used. Typically, a conformal coating, such as Electrolube AFA, will have only a small effect on these properties due to the formulation of the material and the very thin layer of 25–75μm applied. An encapsulation resin, however, may have a greater effect due to the thicker layer used, which in turn offers an increased level of protection. In such cases, it is important to understand the effect of the encapsulation resin on the LED properties and to also establish the consistency of any changes that may occur. For example, if a colour temperature shift occurs from 3500K to 4500K consistently, it is possible that an LED of lower colour temperature could be specified to account for this change; there are obviously other factors that must also be considered but this is just one example of how a colour temperature shift can be managed.

In addition to these initial changes when a protection compound is applied, it is also imperative that the performance of the LED system is tested in accordance with the end-use conditions. The clarity of the protection media may be affected by the surrounding environment; exposure to UV light is a good example. A clear resin such as SC3001 can be tested to understand more about its colour spectrum and results can be used to compare the clarity of a resin before and after UV exposure.

Performing when the heat is on

Although LEDs are considerably more efficient than traditional lighting forms, they do still produce some heat. This heat can have an adverse effect on the LED and therefore must be managed to ensure the true benefits of this technology are realised. Thermal management is therefore another area where specially formulated chemical products are utilised to enhance the performance and lifetime of LED systems. Colour temperature is not only affected by the protection media or surrounding environment, it can also be affected by the temperature at which the LED

operates. For example, with white light an increase in operating temperature of the LED could lead to a 'warmer' colour of light being emitted. In addition, if a variance in die temperatures is present across LEDs in the same array, a range of colour temperatures may be emitted, thus affecting the quality and cosmetic appearance of the device.

Maintaining the correct die temperature of the LED can not only extend the life but also lead to more light being produced and therefore, fewer LEDs may be required to achieve the desired effect. In addition, operating temperature is directly related to the lifetime of the LED; the higher the temperature, the shorter the LED life. To overcome this issue, thermal interface materials are used between the PCB and the heat sink in order to dissipate heat away from the LED, in turn reducing the junction temperature and prolonging the life of the LED. Thermal interface materials can be in the form of thermal bonding products, such as Electrolube TBS or non-curing options, thus providing options should rework be required.

The choice of thermal interface material will also depend on the operating environment and power of the luminaire. Silicone and non-silicone options are available as well as mid-range and high thermal conductivity options. The facts and figures provided on thermal interface materials are not sufficient on their own, however. The application of the thermal interface material is also crucial — designed to improve the effective surface area and remove any air gaps, thermal interface materials should not form an additional thick layer within the system as this would significantly increase thermal resistance. Electrolube's non-curing thermal management pastes can be applied easily in very thin films, thus dramatically reducing the thermal resistance at the interface and maximising the efficiency of heat transfer.

Another option for managing the transfer of heat away from electronic devices is to utilise a thermally conductive encapsulation resin such as ER2220 or UR5097. In this case, these products are designed to offer protection of the unit from environmental attack whilst also allowing heat generated within the device to be dissipated to its surroundings. The encapsulation resin essentially becomes the heat sink and conducts thermal energy away from the device. Such products can be used to encapsulate the technology behind and attached to the LED device and can also assist with the reflection of light back from within the unit, depending on the colour chosen. Encapsulation resins also incorporate the use of thermally conductive fillers; however, the base resin, hardener and other additives used can be altered to provide a wide range of options, including epoxy, polyurethane and silicone chemistries. The choice between chemistries will depend on the environment, for example, if the assembly will be exposed to frequent and rapid changes in temperature, a flexible polyurethane or silicone material will offer better performance than a tough, rigid epoxy.

Whether choosing a protective material for the individual LEDs or the entire unit design it is clear that the operating environment must be considered. With applications becoming more and more diverse, the number of challenges is increasing. By the correct selection and application of protection compounds, it is also possible to use LED arrays in a vast array of products and when combined with efficient thermal management it is possible to achieve consistent quality and appearance whilst improving the lifetime of LED arrays. It is therefore clear that by the continued use of specially formulated electro-chemical compounds, the opportunities for further applications are increasing within this ever evolving industry.

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Electrolube Ltd is a global manufacturer of specialist chemicals for the electronics market and has a growing presence in over 55 countries around the world. Electrolube provides innovative and effective solutions in a range of key product groups including Thermal Management, Conformal Coatings, Contact Lubricants, Encapsulation Resins and Potting Compounds, Cleaning and Maintenance and Service Aids.