Use of LEDs in a Hermetically-Sealed Environment

In outdoor light fixtures such as headlamps, street lights, and floodlights, there are cases where the fixture is hermetically-sealed in order to protect it from moisture/dust. If an LED is used in an environment where the light fixture is hermetically-sealed, volatile components may be outgassed from materials around the LED due to heat/light. Examples of the components being outgassed include volatile organic compounds (VOCs), sulfur gas, and halogen gas, all of which can be a contributing factor that affects LED's characteristics. Thus, thorough consideration is required when selecting materials used around LEDs.

Nichia uses materials suitable for intended applications/purposes in our LEDs. For the LEDs' encapsulating resin, epoxy resin and silicone resin etc. are used.
In the case of LEDs intended for outdoor applications in which LEDs can be exposed to the outside air, epoxy resin is often used to prioritize gas barrier performance and mechanical strength; whereas for LEDs used in light fixtures/electronic devices where LEDs will not be exposed to the outside air, silicone resin is often used to prioritize LED's characteristics under high temperature and longer lifetime.

Silicone resin, in particular, has good resistance to heat, photochemical reactions, and moisture; however, due to its gas permeability, it is more likely to allow outgassed components to enter the LED. Hence, considerations/precautions need to be taken against the components that may be outgassed from materials (e.g. VOCs and sulfur/halogen gases). The following sections discuss examples of the effects of the components outgassed from materials.

Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) are organic chemicals that easily volatilize and turn into gas in the air. VOCs are generally found in adhesives, paint, and organic solvents (e.g. cleaning agents) etc. They can also be contained in additives in molded resins such as housings/gaskets, thus, can also be outgassed from solid materials.
Organic compounds that have volatilized and turned into gas enter an LED by passing through the silicone encapsulating resin and stay inside the LED. Some organic compounds discolor due to chemical reaction when they are exposed to heat/light energy.
If the organic compounds inside the LED discolor, it may affect the optical characteristics of the LED.

Sulfur Gas

The typical examples of sulfur gas are hydrogen sulfide and sulfur dioxide, and they can be outgassed from rubber materials/cardboard boxes containing sulfur. The electrodes of Nichia LEDs are gold-plated or silver-plated. In the case of gold plating, there is no concern for the effects of sulfuration, while in silver plating, since silver reacts with sulfur easily, it may lead to adverse effects on the optical characteristics or lighting failure if an LED with silver plating is exposed to sulfur gas.

Halogen Gas

Halogen gas can occur when bromine etc. contained in additives such as flame retardants volatilizes. Halogen gas can cause cracking/delamination of silicone resin and/or property changes in the electrodes, which may lead to adverse effects on the optical characteristics or lighting failure of the LED.

As discussed above, in the case of LEDs using silicone resin, there is a possibility that the outgassed volatile organic compounds (VOCs) and sulfur/halogen gases affect the characteristics of the LED.
While it is preferable to use the LED in an environment where the concentration of the

outgassed components can be lowered by ventilation or air circulation etc., it is also important to select materials that are less likely to outgas such components if the LED is used in a hermetically-sealed environment or alike. Additionally, even if the materials are unlikely to outgas in a room temperature, outgassing may occur once the LED is operated and the temperature inside the light fixture becomes high. Thus, sufficient verification should be performed when selecting materials used around LEDs.

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While it is preferable to use the LED in an environment where the concentration of the outgassed components can be lowered by ventilation or air circulation etc., it is also important to select materials that are less likely to outgas such components if the LED is used in a hermetically-sealed environment or in an environment where air circulation is limited. Additionally, even if the materials are unlikely to outgas in a room temperature, outgassing may occur once the LED is operated and the temperature inside the light fixture becomes high. Thus, sufficient verification should be performed when selecting materials used around LEDs.

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