Characterizing Light Transmission Properties of LED Encapsulants When Exposed to Heat and Short Wavelength Radiation.

by

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ABSTRACT

Light emitting diodes (LEDs), with their potential for energy savings and long life are gaining popularity in the lighting industry. Ongoing research is targeting LED efficacy to reach 150 lm/W by the year 2012. One of the methods of producing white LEDs is by down converting narrow band short wavelength radiation into broad band white light using a phosphor with gallium nitride emitters. In most phosphor converted (PC) white LEDs, the phosphor is dispersed in an encapsulant that surrounds the LED die. Epoxy and silicone are two of the most commonly used encapsulants in this application. During operation LED die can reach temperatures higher than 125 degrees Celsius and can affect the encapsulant and the phosphor surrounding it and thus shortening the useful life of the white LED. Additional degradation can take place because the encapsulant is constantly exposed to the short wavelength radiation from the LED die. Past studies have speculated that the degrading encapsulant is one of the main causes for the light output degradation in white LEDs. The objective of this thesis study is to understand light transmission properties of epoxy and silicone materials used in white LEDs when exposed to heat and short wavelength radiation, with and without cerium-doped yttrium aluminum garnet (YAG: Ce) phosphor mixed-in.

This study consisted of several pilot studies that helped to design the final experiment to verify the hypotheses. Epoxy and silicone are the two encapsulants used in this study. The epoxy and phosphor mixed-in epoxy samples were subjected to a heat treatment in the temperature range from 90°C to 150°C while silicone and phosphor mixed-in silicone samples were heat treated in the temperature range from 150°C to 200°C to study their degradation profiles. Additionally, the samples were irradiated by short wavelength radiation at 470 nm while being heat treated to investigate the potential excess degradation due to short wavelength radiation. For epoxy samples, the short wavelength light transmission degradation rate increased with increase in temperature. However, for silicone samples, the degradation rate was very much lower, but showed a similar trend, degradation rate increasing with increase in temperature. Contrary to the proposed hypotheses, the results showed that with increase in phosphor density the light output degradation rate decreased for both epoxy and silicone when heat treated. The

results also showed that when an epoxy encapsulant mixed-in with a certain density of YAG:Ce phosphor was heat treated along with short wavelength radiation, the light transmission degradation rate in the shorter wavelength region was greater than when the YAG:Ce mixed-in epoxy was heat treated at elevated temperature without short wavelength radiation.

The results were able to explain some studies observed in past white LED life studies, including why in 5 mm LEDs the white LED degraded faster than blue LEDs, whereas in high power white LED the blue LED degraded faster than white LEDs. Additionally, the results provided insight to why in past LED life studies the chromaticity shift for some LEDs was towards the yellow while in others the shift was towards blue.