Degradation of LED Encapsulants

Most white phosphor-converted LEDs are produced by the combination of optical radiation from a gallium nitride (GaN) semiconductor LED and a yttrium garnet (YAG:Ce) phosphor. The phosphor is embedded in an encapsulant surrounding the LED die and produces a broad spectrum light by down-converting a portion of the LED's emitted radiation. The encapsulant is subjected to short-wavelength radiation and thermal energy from the LED chip and the phosphor, due to the losses in the down-conversion process, which cause degradation of the encapsulant material. This degradation results in a reduction in light output and an overall shortening of the LED package's life.

Previous studies have shown that thermal stress and short-wavelength optical radiation are key factors that degrade the LED encapsulant, but how each factor affects the encapsulant is not very well understood. This study evaluated the effects of short-wavelength radiation and thermal stress on the degradation of an epoxy LED encapsulant, with and without phosphor in the medium.

Experiment

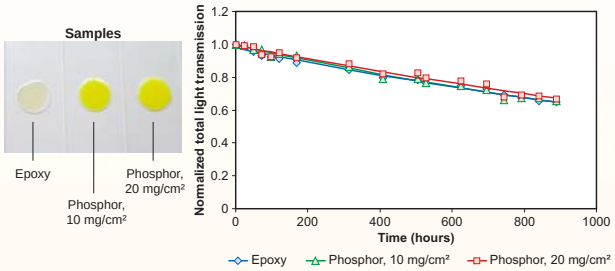
The study utilized two experimental setups, one to subject the epoxy encapsulant sample to applied thermal stress by heating the ambient around the sample to ~90°C, and another to irradiate the samples with short-wavelength optical radiation from blue LEDs (~450 nm, 0.28 W/cm²). A separate measurement setup was used to test the effect of the experimental conditions by measuring the light transmission in encapsulant samples. Three different YAG:Ce phosphor concentrations (0 mg/cm², 10 mg/cm², 20 mg/cm²) were used in the study.

Reference

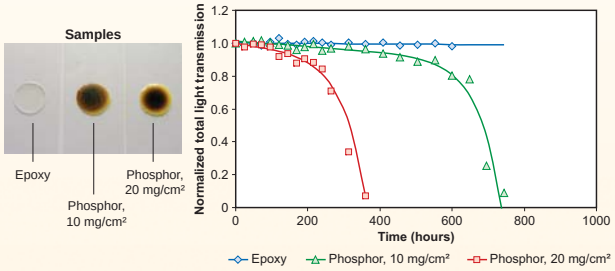
Appaiah P. 2013. Effect of heat and short-wavelength visible radiation on phosphor-embedded LED encapsulant. *Master's thesis.* Rensselaer Polytechnic Institute, Troy, NY.

Results

Encapsulant samples with an increase in phosphor concentration indicated constant degradation rates with time when subjected to externally applied thermal stress. The encapsulant samples showed higher degradation rates as phosphor concentration was increased



Normalized total light transmission with time for encapsulant samples subjected to externally applied thermal stress



Normalized total light transmission with time for encapsulant samples subjected to short-wavelength optical radiation

under short-wavelength irradiance. However, the degradation rates under short-wavelength irradiance increased with time. Analysis of the data revealed that the main cause of the light output deterioration was the degradation of the epoxy. Curve-fitting indicates there are at least two rate reactions that govern the degradation of the encapsulant when exposed to short-wavelength radiation, which is different from the degradation rate when subjected to externally applied thermal stress at a similar encapsulant temperature.

Rensselaer

Lighting Research Center

Lighting Research Center, Rensselaer Polytechnic Institute • 21 Union Street • Troy, NY 12180 • (518) 687-7100 • www.lrc.rpi.edu