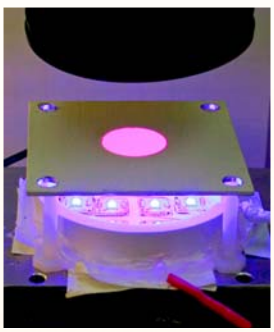
Managing Heat in the LED System's Remote Phosphor Layer

Traditional white LEDs consist of a blue LED with a phosphor coating to convert the blue light to white. Some systems employ a remote phosphor design in which the phosphor layer is placed at a distance from the chip to improve light output and life. However, requirements for higher lumen output and smaller packages have increased the amount of heat generated in the phosphor layer, thereby increasing the operating temperature, which reduces conversion efficiencies and affects performance including light output, color, and life. In this study, LRC researchers investigated methods to reduce the operating temperature of the remote phosphor layer and the resulting effects on LED performance.



A remote phosphor light engine viewed by an infrared imager.

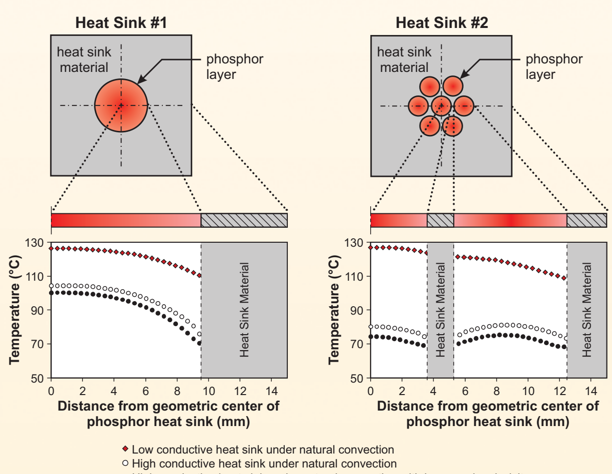
In a laboratory experiment, the phosphor layer was embedded in perforated heat sinks, and the parameters that influence the effectiveness of heat extraction were studied, including the heat sink-to-phosphor layer interface area, the thermal conductivity of the heat sink material, active and passive convective cooling methods, as well as the contribution of radiative cooling by coating the heat sink with white paint. The phosphor layer's light emitting surface temperatures were measured from the geometric center radially moving out along the phosphor layer.

	Heat Sink #1	Heat Sink #2
Geometric center temperature (°C)	104	80
Relative visible radiant power	100%	89%

Maximum phosphor layer temperature and relative visible radiant power for each high thermally conductive heat sink configuration tested under natural convection. More holes increased the heat conduction area, reducing the temperature.

The results showed that heat sinks can effectively extract heat from the phosphor layer, depending on the heat sink's geometry and thermal conduction properties; however, visible radiant power also decreased along with the temperature decrease. The temperature distribution of heat sink #2 revealed a reduction in the maximum temperature while maintaining a more uniform temperature across the phosphor layer surface.

The results also showed that under natural convection, a temperature reduction of ~5°C was possible in the phosphor layer by increasing the surface emissivity of the heat sink by coating it with white paint.



Phosphor-embedded heat sink configurations with different numbers of perforated holes for heat conduction but equal emitting surface area. The temperature distribution on the light-emitting surface of the phosphor layer is also represented with distance from the geometric center of the phosphor layer.

For details

Perera, I. U., and N. Narendran. 2014. Understanding heat dissipation of a remote phosphor layer in an LED system. *ITHERM 2014: The 14th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems,* Lake Buena Vista, FL, May 27-30, 2014, 186–192.

Perera, I. U., and N. Narendran. 2013. Thermal management of the remote phosphor layer in LED systems. *Proceedings of SPIE* 8835: 883504.

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