

Optical Coating Technology Enables Improvements In Solid State Lighting

Recent years have seen advances in Solid State Lighting (SSL).

More advances are possible with new optical thin film-coating technologies.

By Robert Crase and David Gray

Solid state lighting (SSL) is one of the fastest growing areas in the lighting market. As the efficiency of these systems improves, light emitting diodes (LEDs) will gain a larger share of the lighting market. Gains in efficiency have been made at an ever increasing rate over the past several years. As impressive as these gains have been, they have been made largely through improvements at the chip level. These gains were developed with a semiconductor approach to the problem. As a thin film optical coating company, DSI approaches improvements in efficiency gains from a different perspective and direction. This

the front of the LED. This metal coating, typically aluminum, is not a very effective reflector of visible light but it is an extremely efficient reflector of heat. If this aluminum coating could be replaced by dielectric coatings, which would have higher reflection in the visible and would also transmit in the infrared, it would allow the LED to run much cooler. Figure 1 shows a cold mirror with the wide-angle acceptance necessary to meet this application.

Heat dissipation can be an issue with solid state lighting systems. The current state-of-the-art is to



Figure 1

paper will discuss several proposed optical coating-based solutions to develop and extend improvements in solid state lighting.

Chip-Level Improvements

LEDs can emit light from every direction, even from the bottom of the chip. Presently, a common practice is to deposit a metal coating on the bottom of the chip to reflect and redirect some of this light to

use conduction and a large radiating surface to remove the heat from the LED. The conduction at the first interface can be improved with the deposition of an index-matching stack at the chip interface. Using dielectric-coated mirrors (as proposed earlier), the last layer can be made of a material which has good thermal conductive properties. This LED package with the cold mirror is bonded to the heat sink, improving the conduction of heat away from the light-emitting diode.

Packaging-Level Improvements

Many current white light LEDs use a short wavelength-emitting LED to excite a phosphor on a cover lens. The short wavelength LED serves to excite the phosphor and add blue to the LED output. A dichroic coating deposited onto the outside surface of the phosphor coated lens will reflect some of the excitation wavelengths of the LED (those that escape the system) back onto the phosphor for a second pass. Figure 2 shows the reflectivity of this dichroic coating.

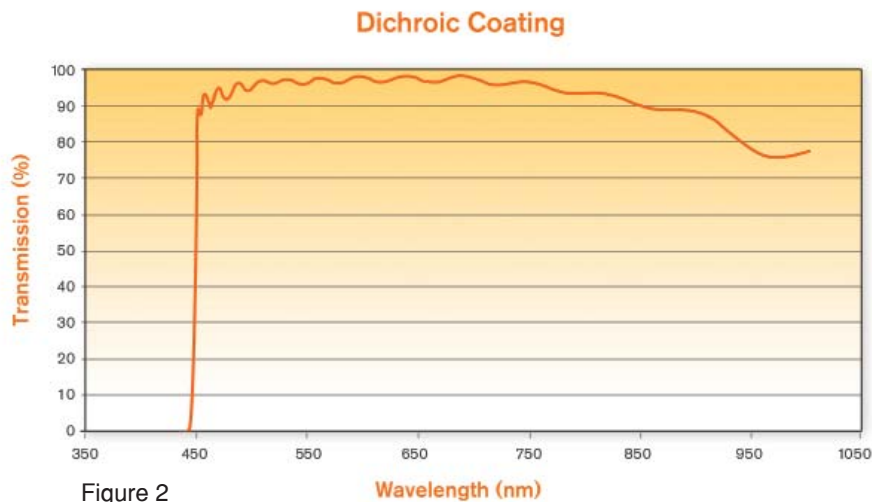


Figure 2

On the second pass the phosphor will absorb more of the excitation wavelength, improving the output of the system. As the coating is dichroic, it is able to transmit white light without trapping it in the system

the output of the LED. This step will make the LED safe for museum lighting, medical illumination, and other UV-sensitive lighting applications.

Reflectors for individual LEDs and solid state lighting applications can be significantly improved with advanced optical coating technology. The present state of the application is to use vacuum-deposited aluminum on these reflectors. The typical reflectivity of the aluminum is nominally 85 percent across the visible spectrum. Aluminum has been used because it is easily protected from environmental damage and can last in the system for many years.

DSI has developed a durable, silver coating for the concentrating photovoltaic (CPV) market. The reflectivity of this durable silver is 94 percent across the visible spectrum and is relatively angle-insensitive.

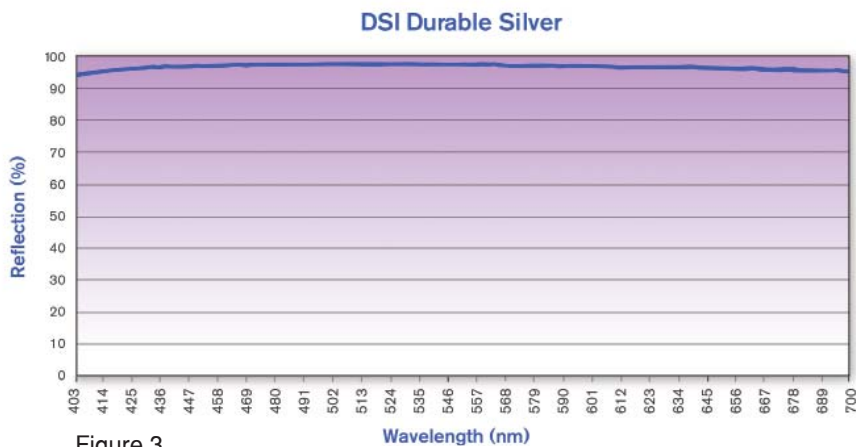


Figure 3

thereby increasing the white light output of the LED package. The coating could be constructed to also reflect the ultraviolet (UV) waveband. This would serve to effectively eliminate UV wavelengths from

This silver can be deposited onto the reflector of an LED or solid state lighting system, increasing the output of the SSL system by 10 percent. Figure 3 shows the reflectivity of the DSI durable silver coating.

One of the most common issues mentioned with an LED solid state lighting system is the lack of a continuous color spectrum. To produce white light, the LED systems use a very high color temperature, very blue, white LED or alternatively a short wavelength

It is possible to create the proper white color, and most colors, by using red, green, and blue LEDs, mixing and modulating these colors. However this solution requires electronics, software, and a sophisticated feedback system. While functional, this is not

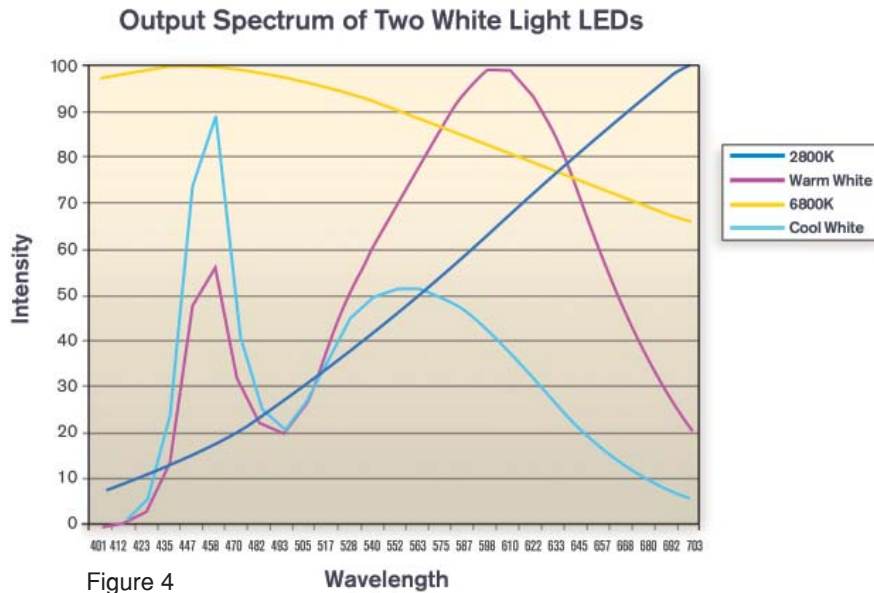


Figure 4

LED is used to excite a phosphor which produces the longer wavelengths' more yellow light. Figure 4 shows the output spectrum of these two white lights when compared to the black body curves for the same color temperatures. While there have been improvements in the quality of these two white light sources, they are each missing some color components. These missing colors make these LED systems difficult to use in applications which require good color rendition.

a practical or cost-effective approach for a general lighting system. Attempts have been made to create a white system that is closer to the black body curve by combining different color LEDs and a white phosphor.

Figure 5 shows one of these systems overlaid with the same black body curve. The curve is closer to the black body but there are colors that are missing from the curve. It is possible to increase the output of the individual LEDs to try to add these missing

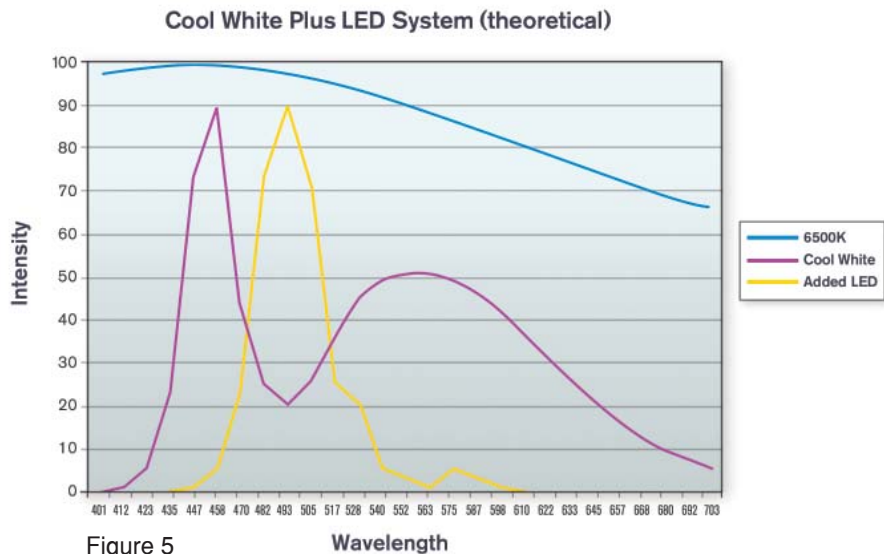


Figure 5

Cool White LED System Filtered (theoretical)

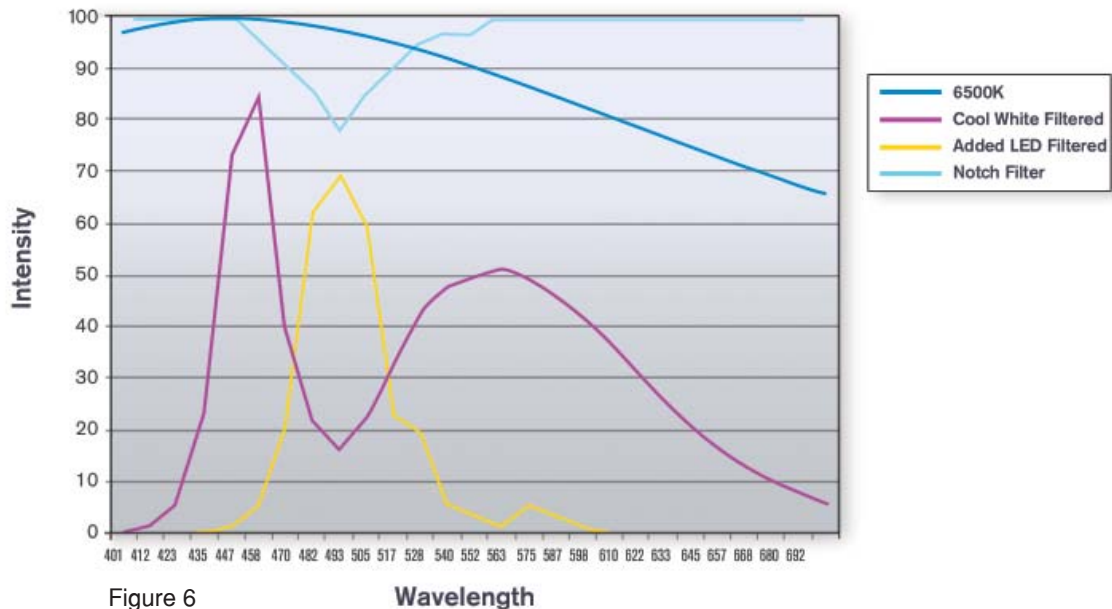


Figure 6

colors but the peak output of the LED will dominate the output spectrum. An optical coating can be used effectively to trim the output of this system. A notch filter will reduce the peak of the LED and bring the output of the system closer to the blackbody curve. Figure 6 shows the output of the system with the addition of this notch filter. By using this example as a building block it is possible to create an LED system that mimics the color of a 2800K or a Xenon light source.

It is clear that solid state light sources have made great advances in the past several years. The addition of the latest optical thin film coating technologies will allow even greater advances in the future.



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