Luxeon™ Star LEDs Compared to Nichia LEDs

By Henry Schneiker, updated January 2003
Originally published in the CREG Journal (ISSN 1361-4800)

LEDs are taking another significant step forward with the introduction of the Luxeon Power Light LED product line from LumiLeds (www.lumileds.com). In this article we will be talking specifically about the white Luxeon 1 and 5W emitters.

The Luxeon emitter is available in many configurations: with and without a culminating optic, using a batwing lens, a lambertian lens or a side-emitting lens, with or without a heat sink. Note that not all combinations make sense or are available. As with all LEDS, the Luxeon LEDS are ranked by total light output, color temperature and Vf - reels are marked with bin information but you are not allowed to order by bin so receiving product it a bit like Russian Roulet. The 5W unit contains four 1W dies on the same emitter, wired as two series strings in parallel for a nominal operating voltage of just over 7V and a maximum current of 700mA.

A single Luxeon 1W LED of common rank (with batwing lens and newer culminating optic) can replace an array of 19 to 24 Nichia LEDs and produce similar lighting results. Further, the single Luxeon configuration costs less than $20 compared to $95 for a manufactured array including 19 Nichia LEDs, a circuit board and the labor to assemble it. The better ranks of Luxeon LEDs can be twice as efficient as the S rank Nichia LEDs - producing over 45 lumens per watt. These are, of course, in very short supply.

The Luxeon LED uses a much larger LED chip (die) than the Nichia LED. The larger chip size allows the chip to run at much higher power settings without increasing current densities (i.e., current per unit square of material). The result is that a single chip can generate much more light without significant additional stress on the chip.

The Luxeon LED die is bonded directly to a substrate that can be in turn bonded directly to a large heat sink. The substrate provides a short thermal path and allows the chip to dissipate heat quite rapidly. The maximum die temperature is the same for both Luxeon and Nichia - 120°C. However, the short thermal path on the Luxeon LED allows the die to run cooler for a given current density than is possible using a standard 5mm LED package - allowing higher efficiency, higher power or a combination of both. The shorter thermal path notwithstanding, stuffing the Luxeon LED into a small plastic housing and adding lots of power will cook the Luxeon LED just as fast as doing the same thing with a comparable Nichia array.

The beam produced by the Luxeon culminating optic assembly produces a narrower beam than Nichia 5mm LEDs. This makes the center spot brighter when compared to the Nichia LED array - one that is much closer to the standard incandescent spot produced using a parabolic reflector. This is both a plus and a minus. The plus is that the center of the spot is much brighter so you can see further. The minus is that the spot and beam contain blemishes and cannot produce the smooth beam transition users of a comparable Nichia LED array have come to expect. The exact shape and character of the beam depends on which optical path the LED was assembled with.

The color of the light is now a more minor difference. Whereas the older Luxeon LEDs produced much lower CRE (Color Rendering Index) of around 55, the newer Luxeon LEDs are closing in on the Nichia LED's CRE of 65. The Nichia LED arrays are known for producing vivid accurate colors when compared to other light sources - something the Luxeon LEDs are only recently coming close to. Note that there is still a large notch in the blue-green part of the spectrum. As Nichia and Lumileds have agreed to a cross-license, addition improvements should be coming to both product lines.

The space needed to mount the Luxeon LED is significantly smaller than for an array of Nichia LEDs when using one of the common Luxeon configurations. Although the substrate is 1"

(26mm) across in a hexagonal shape, the lens is only 0.84" (22mm) in diameter. An array of 19 Nichia LEDs is 1.2" (29mm) in diameter using a dense hexagonal packing and 6mm centers - admittedly, a closer packing could be used to achieved a closer match. The depth of both is similar - the Luxeon being a couple of millimeters deeper.

For those building their own light, be aware that the early Luxeon LEDs came with a static protection diode in parallel with the LED. This means that if you connect a battery backwards, it will only see one forward diode drop (<1.0V) and can pull enough current to destroy the protection diode before you realize you screwed up. This will render your Luxeon LED worthless. Later units are protected with back-to-back 7V zener diodes.

Like all LEDs, the Luxeon LEDs should be driven using a current mode power supply. The Luxeons have a much steeper voltage/current curve than the Nichia LEDs, making them more sensitive to slight changes in voltage - either from the power supply or thermal characteristics. They also tend to have a much lower Vf at full power. The old tabulated voltage data was removed because there are now just too many variables to make it meaningful.

Luxeon 5W emitters ran into a snag late last year - before any of the low volume orders were filled. Lumileds discovered that the 5W Luxeon units could not pass the longevity tests. In fact, it was so bad that they came up with a new Luxeon Portable V emitter - aka marketing spin - to handle the flaw and pulled all references to the original 5W emitters. The new Portable V units are only rated at 500 hours and have a lumen retention of less than 50% at the end of that time, highly dependent on the operational temperature, of course This is a serious heat issue. It is hard to heat sink a small flashlight burning through 5 watts of power. Unlike an incandescent bulb that can loose significant heat through radiation, a typical Luxeon emitter looses most of its heat though conduction to the flashlight body. I know of cases where very small 1W flashlights became too hot to pick up if set down on a table while turned on - imagine what 4 times the power would do.

The future looks quite bright. As Lumileds gets into full volume production and gets the kinks worked out, manufacturers should finally be able to specify and purchase the ranks needed to create a consistent product. Lumileds should be able to ship what the manufacturers want. Flashlights as we once knew them will be changed forever. The middle and high ground will be taken over by the LED lights in a few years. Only the throwaway lights at the lower end will still be incandescent.

Luxeon is a trademark of LumiLeds.

The Cave Radio and Electronics Group (CREG), publishers of the CREG Journal can be found at http://www.bcra.org.uk/creg/