XLamp® XN-P Color LED Design Guide: Power and PCB Choice for Optimal Performance

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INTRODUCTION

The XLamp® XN-P RGBW 4-in-1 LED package offers the best-in-class output, efficacy, and the broadest range of phosphor-converted channels (including various CCTs, CRIs, PC amber and PC lime) optimized for high-performance lighting applications in entertainment, architectural, and machine vision. The XN-P LED was designed and constructed specifically for a maximum power rating of 3-A per channel and 2.5-A all-on, for a total 32.5 W for the package. However, extracting the full performance of this package requires careful thermal management in the end-use case. This design guide compares the performance of the XN-P LED (specifically, XNPAPL-H0-0000-00000CPAAALA) on standard Al metal-core printed-circuit boards (Al-MCPCB) versus copper direct thermal path (Cu-DTP) starboards. General guidance is provided on when to use each type of PCB technology.

A cross-section comparison of these two PCB constructions is provided in Figure 1.

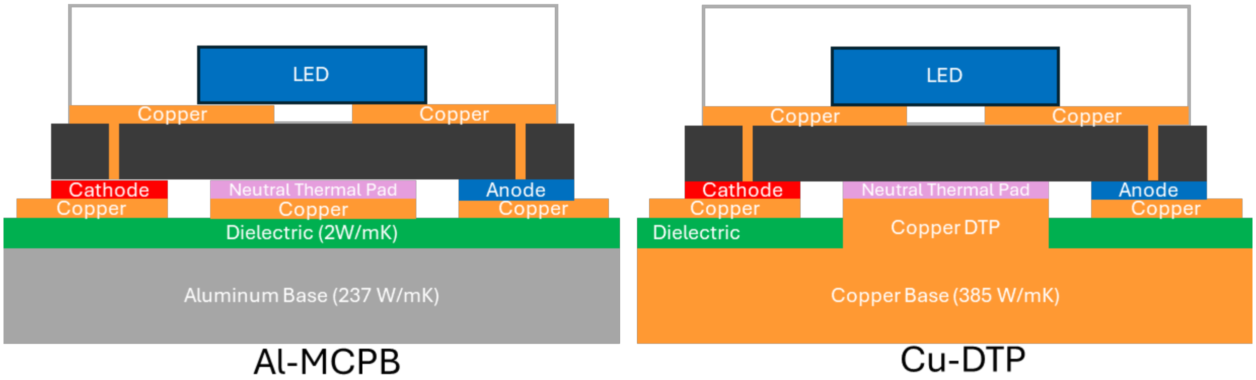

Figure 1: Cross section diagrams of the aluminum (left) and direct thermal path copper (right) printed-circuit board types. Pertinent structures are labeled for clarity.

CHARACTERIZATION SET-UP

XN-P LED components were built on Al-MCPCB and Cu-DTP starboards and wired in an all-on series configuration. A thermocouple was attached to each starboard to monitor T_{case} temperature, then the assembly was mounted on a thermo-electric cooler (TEC) set to 25 °C or 55 °C. This set-up was then placed inside a 2M integrating sphere with an IR camera above the XN-P LED to monitor the light emitting surface (LES) temperature. The XN-P LED was allowed to reach steady state and the corresponding T_{case}, T_{LES}, electrical and photometric performance was recorded. For each type of PCB and TEC setting, 3 samples were measured and the average of the data is presented.

RESULTS

Quadratic fits of the triplicate steady-state measurements for Al-MCPCB versus Cu-DTP at TEC = 25 °C and TEC = 55 °C are shown in Figure 2. Both T_{LES} (as measured by IR thermal imaging) and T_{case} (thermocouple to starboard) show the significant thermal advantage of a Cu-DTP PCB versus an Al-MCPCB. As the input power increases, the gap between Cu-DTP and Al-MCPCB widens due to the increased thermal conductivity across the heat path. Figure 2 summarizes the collected data in graph form, where radiant flux (RF) is plotted rather than luminous flux (LF) to exclude the wavelength-vs-weighting function of LF as dominant wavelength shifts over a given temperature range for royal, green, and red emitters. The RF output between the two PCB constructions start to deviate around 10 W of input power, and for the Al-MCPCB, the RF actually rolls over around 18 W due to thermal droop. However, for the Cu-DTP construction, the XN-P LED shows an increasing steady state output beyond its maximum current all-on rating of 2.5 A (32 W).

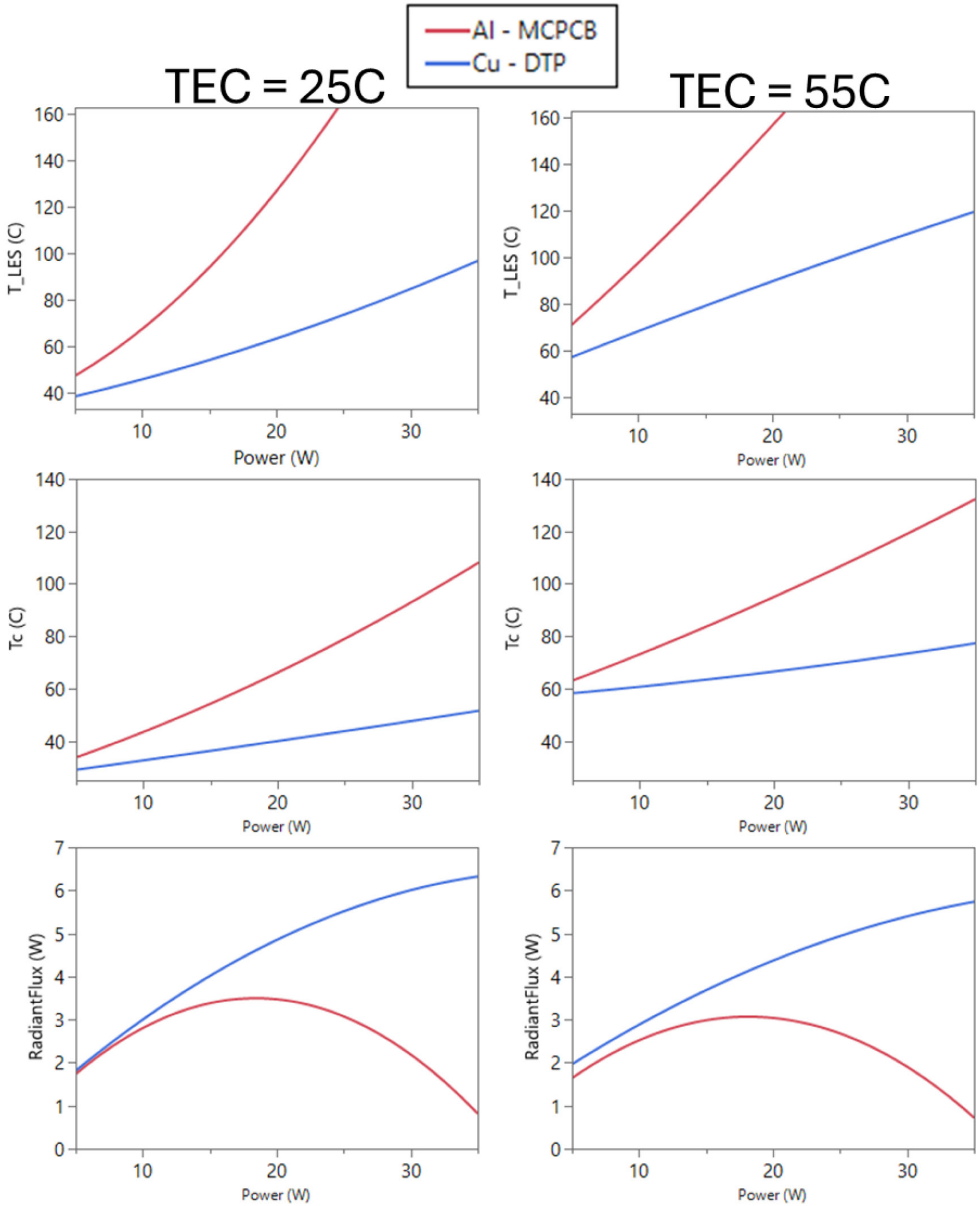

Figure 2: Steady-state measurements of XN-P for T_LES, T_{case} (Tc), and Radiant Flux versus input power in all-on in series configuration. Stabilized TEC temperatures are noted at the top of each column.

CONCLUSION

This design guide is intended to provide guidance on the optimal PCB construction for different ranges of input powers when using XN-P LEDs in high-performance applications. Each application requires a specific tradeoff between system-level costs and performance. However, the overall principles from this study can be employed based on the power requirements of the application. A general consideration is that Al-MCPCB construction lacks the thermal conductivity to keep the RF output from rolling over above 18 W and the performance inflection point between the Al-MCPCB and Cu-DTP architectures appears around 10 W in this setup.

An important caveat of these results is that, for any application, the full thermal performance depends not just on PCB construction, but also thermal interface materials, heat sinks, and the presence of active cooling. Please contact your Cree LED sales representative for any further questions or to request guidance on a particular application or design.