Increased LED Brightness for Projection Displays – Compact to High Output Systems

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Abstract

LED has gained its importance in the projection display market from very compact, micro-projectors to potentially high output, desktop systems. In both of these systems, the output levels are less than desirable. This paper describes practical recycling and multiplexing systems that provide brightness increases, and allow projectors to achieve outputs beyond its current levels.

1. Introduction

Microdisplay based television and projectors have the potential of being low cost with large screen size. Traditional projection displays are usually illuminated by arc lamps. Although this light source is the brightest at the lowest cost, the need to split the white light into 3 colors and the short lifetime make is less desirable. As LED technology advances, RPTVs and projectors had be demonstrated using LED as the light source, capturing the long life feature of LEDs and other benefits include instant ON. At present time, LEDs are not bright enough for low cost application using small imaging panels or with large screens. This paper describes several schemes to increase brightness of LED illumination systems using compact multiplexing, recycling, and their combinations for high power projectors and low power microp-projectors.

2. Compact RGB Multiplexer

The current state of the art RGB multiplexer usually consist of red, green, and blue LED chips or set of chips. The output of each color is collimated into parallel beams and combined into a single beam using dichroic filters. The combined beam is then focused into a light pipe and homogenization and eventually relayed to the imager panel. Although this system is etendue efficient, the physical size is usually large making it marginally acceptable for RPTVs and bulky for front projectors.

Figure 1 shows a compact multiplexer able to combined the output of red, green and blue LEDs into a single output with the same etendue of a single LED. On top of each LED is a beam combiner, which consists of two right-angled prisms and a dichroic coating in between. These beam combiners act as waveguides directing the light output from the LED chips to the output. They are not simply reflecting light as in mirrors as the triangular faces of the prisms are also polished promoting TIR for waveguiding operation. The beam combiner above the blue LED can simply be a reflector of all wavelengths. The beam combiner above the green LED reflects green, and transmit blue such that both blue and green light pass to the left towards the beam combiner above the red LED. The coating of this beam combiner transmits red and reflects blue and green light such that the output at the top consists of all 3 colors. The 3 LED chips and the 3 beam combiners are all assembled into a single package as shown.

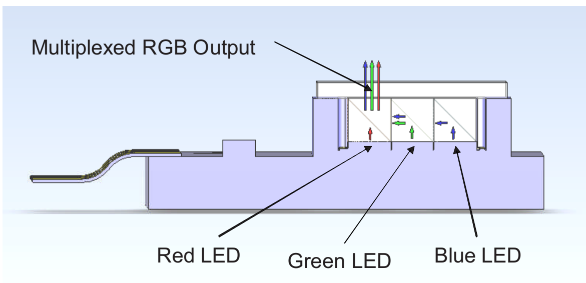


Figure 1 – Schematic diagram of a RGB multiplexer

Figure 2 shows the experimental output of a bench-top system using PT-39 LED chips made by Luminus showing the outputs with each LED turned on individually and all of them turned on at the same time. At this time, the overall efficiency of 60% has been achieved, with future expectation of 80%

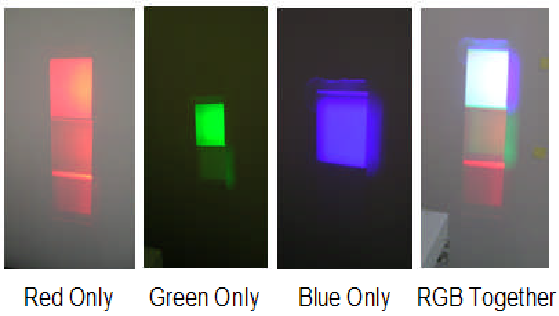


Figure 2 – Output of the bench-top multiplexer demonstration

Figure 3 shows the implementation of the multiplexer with spacers added in between the LED chips and combiners such that the heat cross talk can be reduced.

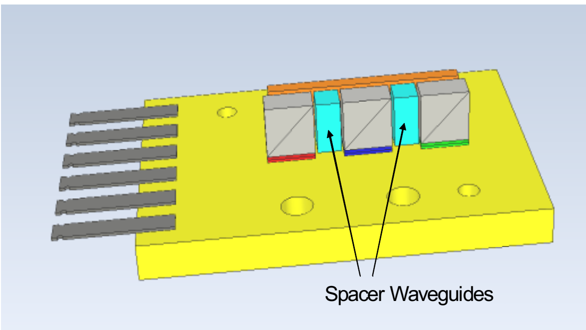


Figure 3 – RGB multiplexer with spacer

3. Recycling Light Pipe

From the brightness principle, the brightness of LED cannot be increased by combining and can only be increased by recycling in which part of the output light is feedback to the LED source itself. Figure 4 shows a basic structure of the LED recycler. It consists of a light pipe coupling the output from the LED chip to the output. Part of the output is reflected back into the LED chip and recycled. The amount of brightness increase depends critically on the amount of recycling, which in turn, depends critically on the reflectivity. For a typical reflectivity of 40% to 60%, a brightness increase of 30% to 50% can be achieved.

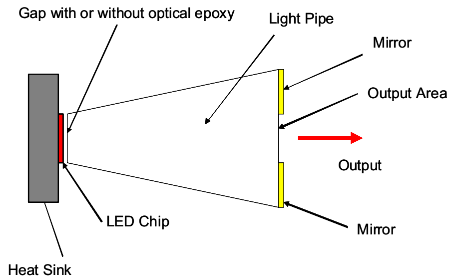
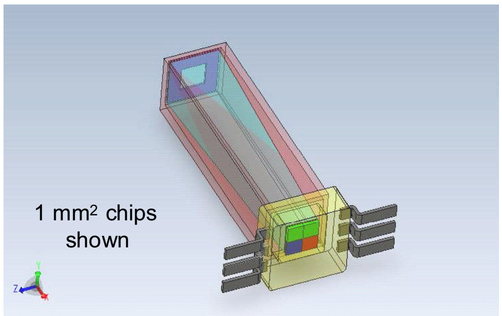


Figure 4 – Light Pipe Recycler

4. Multiplexer/Recycling Light Pipe

In micro-projection applications, besides brightness, size is of utmost importance. Figure 5 shows a multiplexer/recycler suitable for micro-projection



applications.

Figure 5 – LED Multiplexer/Recycler

A set of RGGB LED chip is assembled into a small pill-package. The input and output ends of the multiplexer/recycling light pipe are coated to promote recycling. The input end is coated such that the coatings above each color transmit that particular color and reflects the other two colors. The output end is coated with reflective coating with an opening that matches with the imager chip. With this configuration, a brightness improvement of 2X has been estimated. A reflective polarizer can be added to recycle polarized light and product polarized output.

5. Summary

A compact, efficient high power multiplexer suitable for front projectors has been described and demonstrated. A very small multiplexer has been described, which provide increased brightness for micro-projector applications.