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Increased lumens per étendue by combining pulsed light-emitting diodes

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Abstract. LED-based projectors have numerous advantages compared to traditional projectors, such as compactness, larger color gamut, longer lifetime, and lower supply voltage. As LEDs can switch rapidly, there is the possibility to pulse. However, there is also an important disadvantage. The optical power per unit of étendue of an LED is significantly lower than, e.g., an ultra-high-performance (UHP) lamp. This problem can be remedied partly by pulsing the LEDs. If one drives an LED with a pulsed current source, the peak luminance can be higher, albeit the average luminance will not increase. By pulsing two LEDs alternately (50% duty cycle), their increased flux can be added up in time and will generate a higher average flux within the same étendue. We combine the LEDs with a polarizing beam splitter (PBS) and change the polarization of one LED with a switchable retarder. The achieved substantial net gain after all losses is 36%. [DOI: 10.1117/1.2186036]

Subject terms: light-emitting diode; pulsed; étendue; microdisplay; projector.

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1 Introduction

Today microdisplays are becoming more and more popular in all sorts of applications. These displays are so small that the image must be optically enlarged. The applications of these displays can be personal viewers, virtual and enhanced reality glasses, head-up displays, etc. These are near-to-the-eye applications. Another important domain of microdisplays is projection applications. Some examples are presentation beamers, rear projection television, home cinema projectors, etc.

2 State of the Art

Micro display technology is in the most cases based on liquid crystal or microelectromechanical systems (MEMS) technology. Typical projectors based on these technologies are the liquid crystal on silicon (LCOS), liquid crystal display (LCD), and digital light processing (DLP™) projectors. In all these projectors, the light source is practically always the same, namely, an ultra-high-performance (UHP) discharge arc lamp. This lamp has a very high power efficiency (in lumens per watt) and étendue efficiency (in lumens per unit étendue). Because of its small arc length, and thus small étendue, it is very attractive for small light valves in microdisplay projectors. Such projector architecture is shown schematically in Fig. 1. In this example, a classic three-panel LCOS projector is described. After some filtering, white light from the UHP lamp is divided in three basic colors (R, G, and B) by a set of dichroic mirrors. Afterward each color is independently modulated by another LCOS microdisplay (light valve). The X cube combines the three light paths and reflects the image to the projection lens.

This architecture, where an UHP lamp is used as the light source, has many disadvantages. White light should be divided into its basic components. For this three dichroic mirrors are required. This raises the price and enlarges the dimensions. The presence of UV and IR filters also raises the price. In addition, each component has some losses, so the total optical output is decreased. After splitting into R, G, and B components, each color still has a wide spectrum and this leads to a reduced color gamut.

Another important disadvantage of an UHP lamp is the

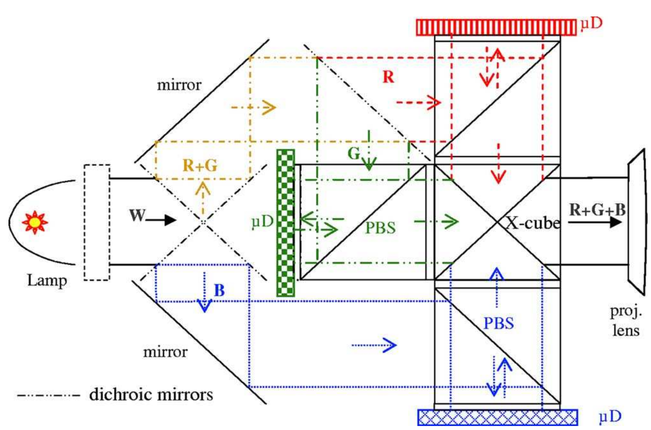

Fig. 1 Three-panel LCOS projector with white light source. PBS: polarizing beam splitter.

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