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Xu

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(54) **HIGH BRIGHTNESS LIGHT SOURCE USING LIGHT EMITTING DEVICES OF DIFFERENT WAVELENGTHS AND WAVELENGTH CONVERSION**

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(58) **Field of Classification Search** 362/231, 362/84, 235, 293, 583, 551, 230, 800; 345/82, 345/83; 398/82, 85, 149; 313/498, 501
See application file for complete search history.

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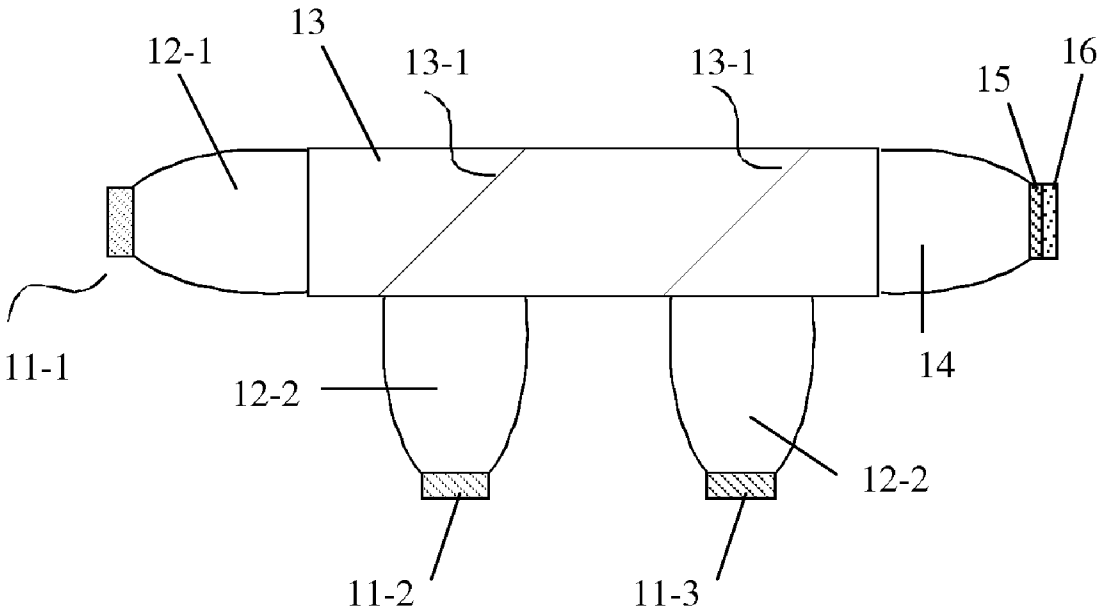
(57) **ABSTRACT**

A wavelength division multiplexer and etendue conserved optics are used to combine multiple wavelength LED lights into a combined light. The combined light, with higher intensity and higher power than the light from an individual LED, is used to excite a wavelength conversion material such as phosphors to generate a high brightness and high power light. Light generated by multiple LEDs of the same wavelength may be coupled into a optical fiber bundle before inputting it into the wavelength-division multiplexer, further increasing the brightness and power. The wavelength conversion material may generate light of three different color under excitation by different LED lights, or a white light with higher brightness and higher power. Such a light source can be used in image display devices such as a projector or in illumination systems.

20 Claims, 3 Drawing Sheets



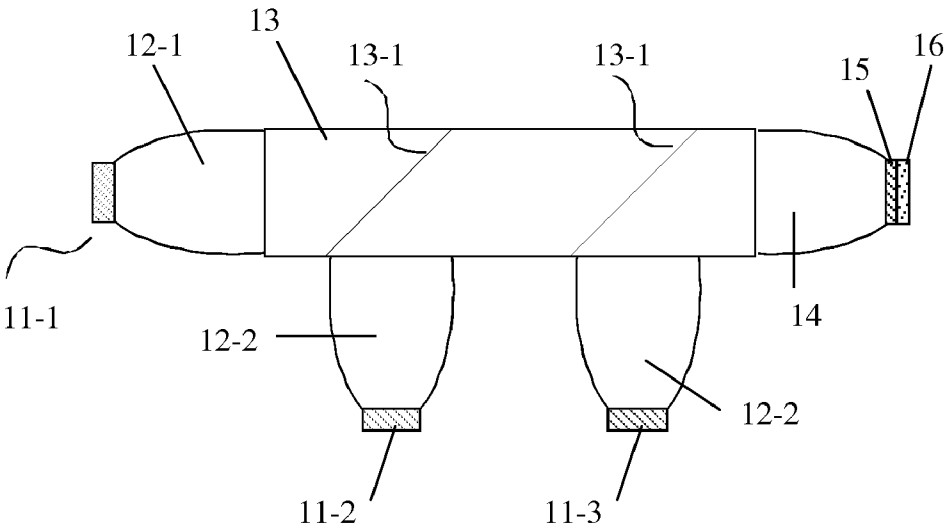


Fig. 1

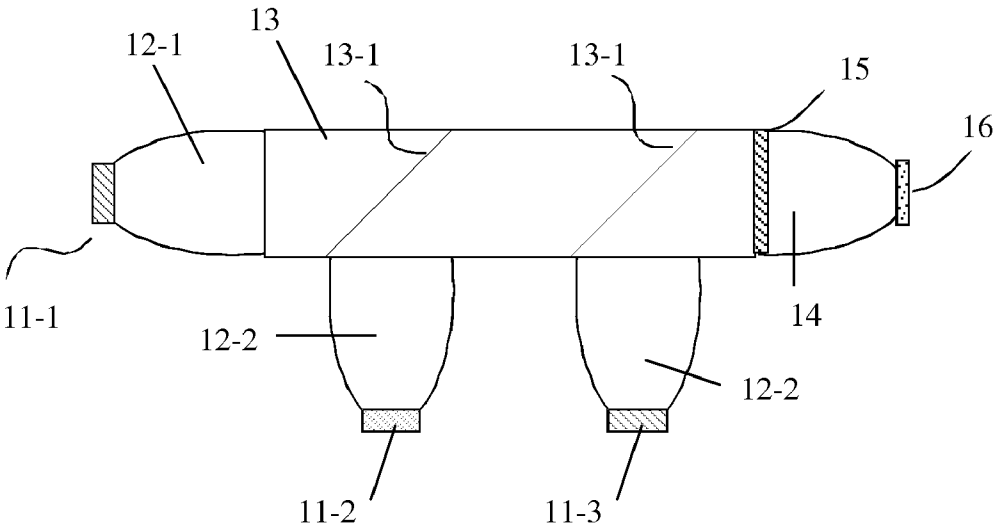


Fig. 2

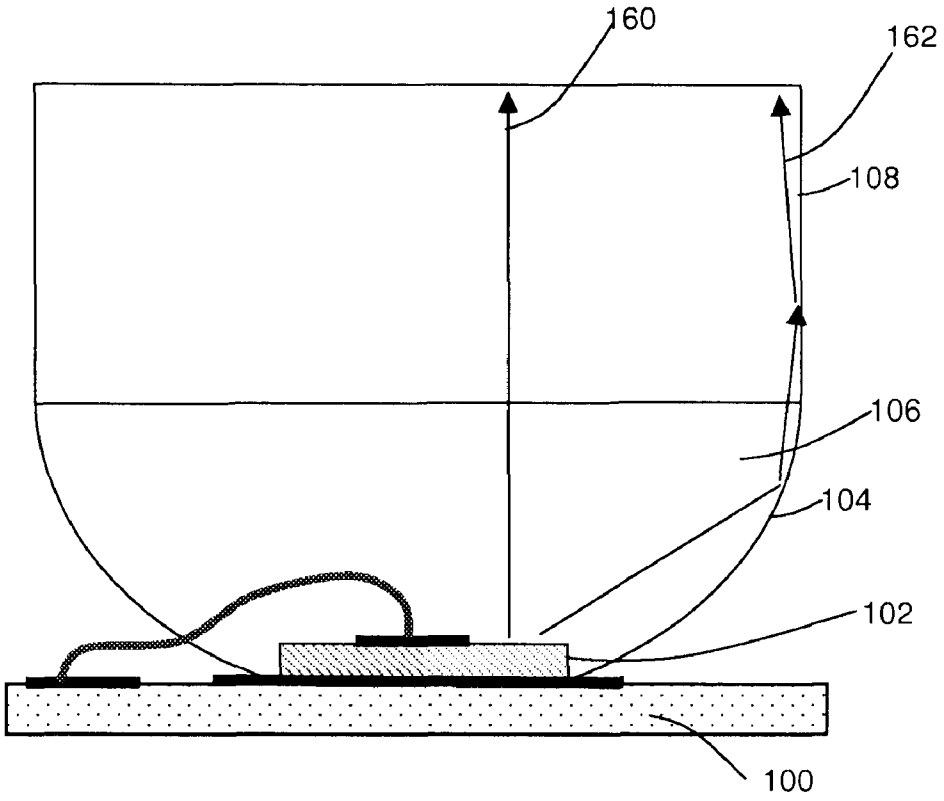


Fig. 3

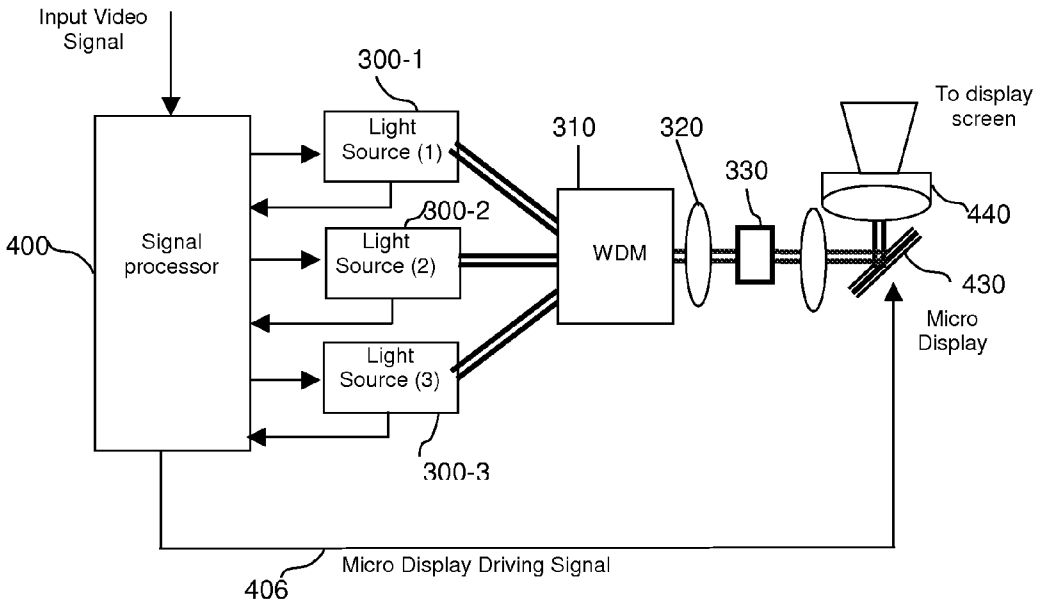


Fig. 4A

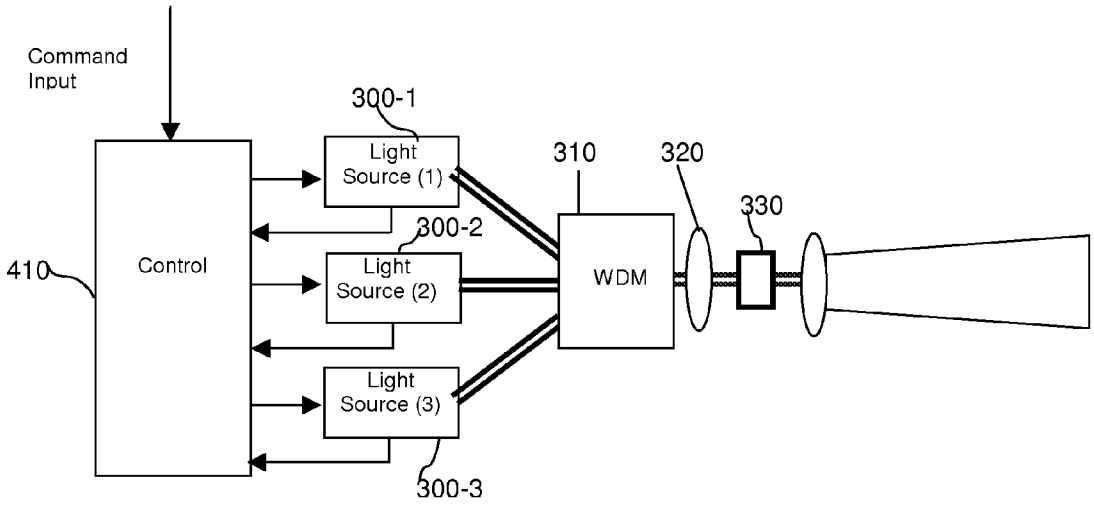


Fig. 4B

HIGH BRIGHTNESS LIGHT SOURCE USING LIGHT EMITTING DEVICES OF DIFFERENT WAVELENGTHS AND WAVELENGTH CONVERSION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to lighting devices and systems, and in particular, it relates to high brightness light sources.

2. Description of the Related Art

Light sources are used in a wide variety of application, including image projection such as rear projection TV (RPTV) or front projector, headlights or illumination lights for transportation vehicles such as automobiles, motorcycles, boats and airplanes, etc. One import requirement for a light source is to provide high brightness and high power output at the same time. Currently, light sources for these and other applications are still dominated by traditional light sources such as high-pressure mercury lamps, Xenon lamps or metal halide lamps. However, the arc lamps have technical limitations in many applications: relatively short lifetime, difficulty to control and maintain its color, un-stability especially when operating in a pulsed mode. For many applications, especially in an environment where heat generation is undesirable or when electricity is unavailable, light from the light source needs to be coupled into optical fibers or waveguide and directed to where illumination is required. However, the coupling from the arc lamp into fiber can be costly, bulky, inefficient and unstable due to, e.g., the change of discharge arc itself from time to time. In many cases, the arc lamp also potentially interferes with other components in a system.

Solid state light sources, especially light emitting diodes (LEDs), exhibit longer lifetimes, lower power consumption, manageable wavelengths and other benefits in comparison with the above and other traditional light sources. Therefore, these solid-state light sources increasingly become the alternative or even preferred choice of light sources for a variety of applications. However, there are many performance issues that need to be improved for LEDs so that their applications can be broadened. Currently, two potential solutions can be explored to achieve high brightness and high power LED light sources. The first one is to further improve individual LED chip performance by increase chip dimension and improve its quality. However, this approach is limited by the total output of one individual chip, currently in tens of lumen level in the visible wavelength range. Going to larger area chips and higher driving currents can increase the total output but will compromise the device lifetime and brightness. The chip uniformity and thermal dissipation of large LED chip are serious limitation for this approach. The second approach is to package many LED chips together in an array structure to obtain high total output, up to hundreds even thousands lumens currently. The brightness of light directly from an LED array is significantly lower than that of single LED since the array brightness is limited by the relatively low package density of LEDs in the array. The major challenge of high-density LED packaging is the thermal management of the high power operation of LEDs since the LED interferes each other thermally if they are too close to each other. Due to the

tional light source such as high pressure mercury lamp or metal halide lamp are still the choice of applications.

SUMMARY OF THE INVENTION

The present invention is directed to a light source that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a high brightness and high power light source.

Additional features and advantages of the invention will be set forth in the descriptions that follow and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims thereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the present invention provides a light source, which includes: two or more light emitting devices for generating light having respective spectra different from each other; a wavelength-division multiplexer receiving the light from the two or more light emitting devices and combining them into a combined light which exits an output end of the wavelength-division multiplexer; and a wavelength conversion material disposed near the output end of the wavelength-division multiplexer, the wavelength conversion material absorbing the combined light and emitting an output light having a spectrum different from the spectra of the light generated by the emitting devices.

The light source preferably also includes two or more light-coupling devices each for coupling the light generated by a light emitting devices to the wavelength-division multiplexer, a dichroic filter disposed between the output end of the wavelength-division multiplexer and the wavelength conversion material for transmitting the combined light from the wavelength-division multiplexer and reflecting light generated by the wavelength conversion material, an output light-coupling device disposed between the output end of the wavelength-division multiplexer and the wavelength conversion material for coupling the combined light to the wavelength conversion material.

Practical applications of such a light source include illumination systems and image display devices such as projectors.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a light source device and system according to an embodiment of the present invention.

FIG. **2** illustrates a light source device and system according to another embodiment of the present invention.

FIG. **3** illustrates a structure for coupling the light from a light emitting diode into an optical fiber.

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