Efficient and stable laser-driven white lighting

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Introduction

- Solid-state white lighting has gained interest since the development of candela-class, high brightness InGaN light emitting diodes by Nakamura and coworkers in 1995.
- 1 This development, in combination with appropriate phosphor compositions and improvements in devicepackaging, have led to devices that use less energy and are a viable option to replace conventional incandescent or fluorescent light sources.
- 2 Traditional solid-state white lighting devices comprise a blue or near-UV LED as the excitation source and one or more phosphor compositions which down-convert all or part of the LED emission to longer wavelengths.

- 3.The LEDs used in these devices currently suffer a loss in external quantum efficiency as operating current increases,known as droop. As LED efficiency decreases with higher operating currents, the result is an increasein the temperature of the device, since this efficiency is lost as heat.
- 4. The increased temperature will in turn cause more efficiency loss from the LED and may lead to a shift in the peak emission wavelength and broadening of the emission spectrum. The increased temperature of the device will also affect the phosphor, causing a decrease in efficiency and a possible shift in the peak emission wavelength of the phosphor.

- 5.These changes in the spectrum of the LED and phosphor will change the ratio of light emitted by each component, resulting in a shift in the color point of the white light, and a decrease in overall device efficiency, making high-power devices difficult to achieve using single LEDs as the excitation source.
- 6. In contrast to LEDs, laser diodes do not exhibit this efficiency loss. The output power and EQE of laser diodes increase linearly with current, and maintains color stability of the laser emission, making laser diodes an attractive excitation source for new high-power white lighting applications.

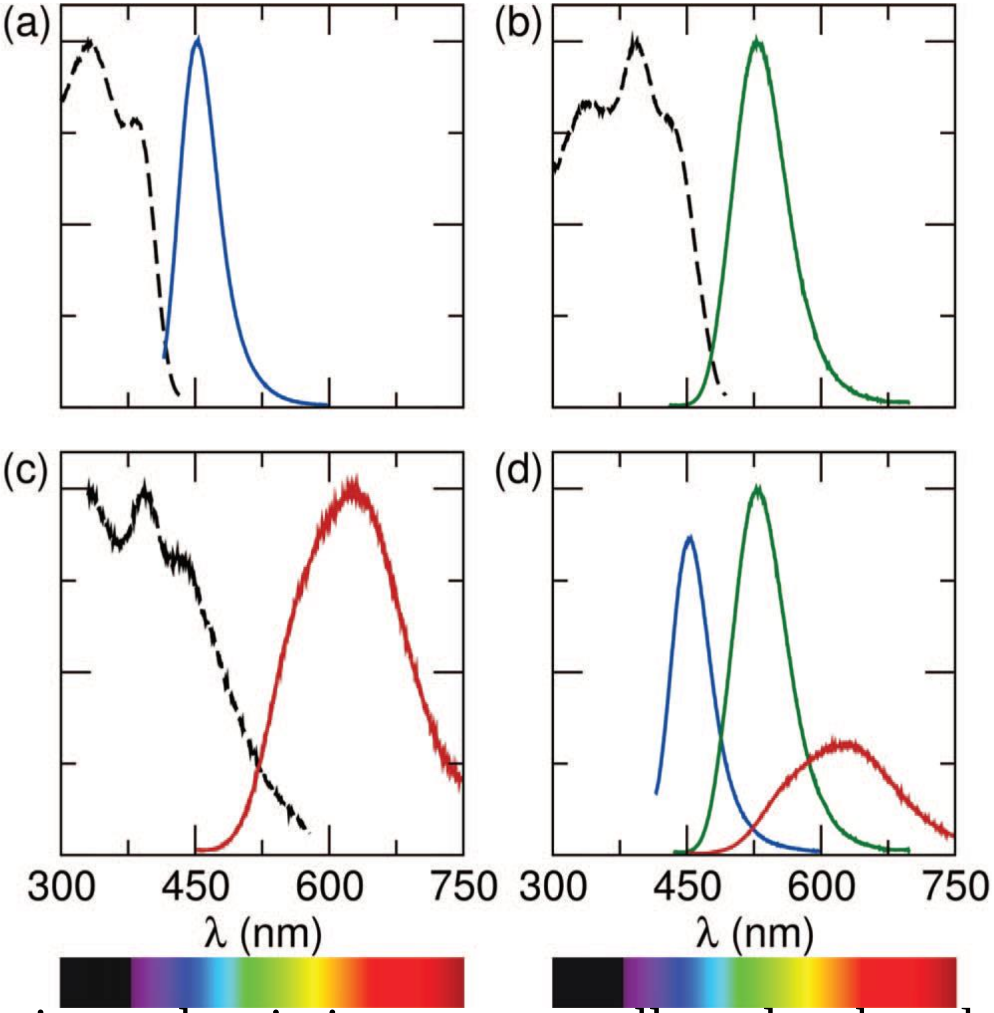

FIG. 1.Excitation and emission spectra, collected at the relative maxima
(a) the blue-emitting phosphor (λex = 335 nm;λem = 452 nm),
(b) the green-emitting phosphor (λex = 395 nm; λem = 530 nm),
(c) the red-emitting phosphor (λex= 395 nm; λem = 630 nm).
(d) shows the relative emission intensities collected at 402 nm excitation.

Experiments

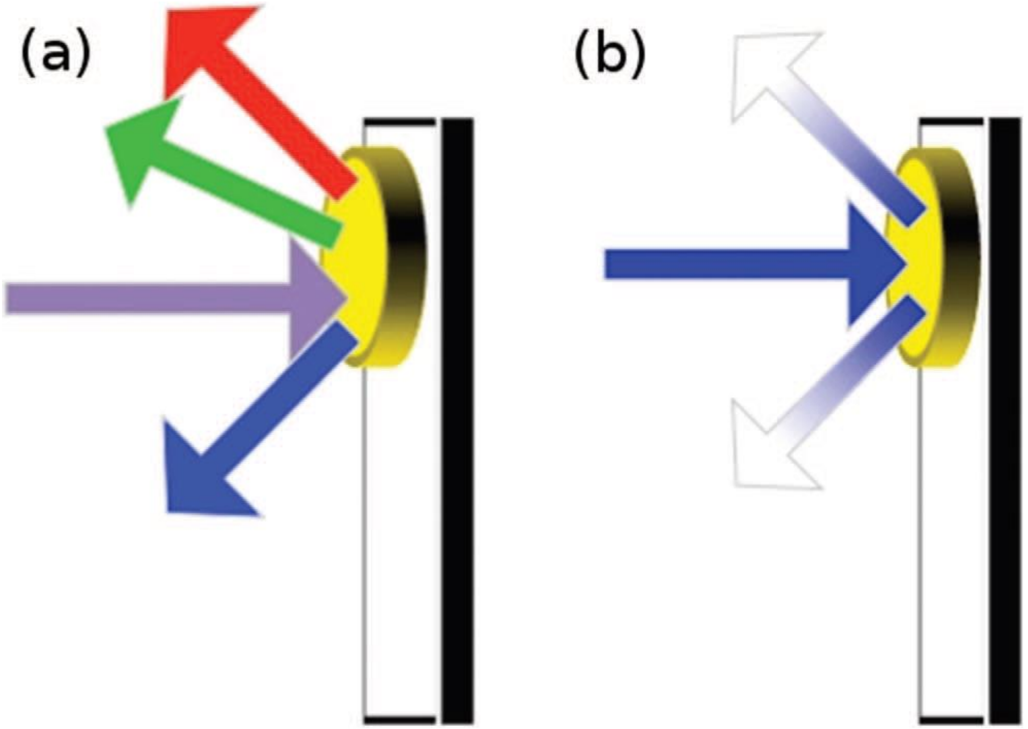

FIG. 2. Schematic illustrations of the experimental setup used to measure laser excited phosphor samples in an integrating sphere. The phosphor encapsulated silicone disk, mounted on a transparent quartz substrate, is positioned with the surface at a slight angle to the incoming laser beam. The resulting device operates in reflection mode due to the dense phosphor pellet,illustrated for

(a) the near-UV excited RGB phosphors
(b) the blue excited YAG:Ce.

Sample	**CCT(K)**	Ra	ϕv (lm)	ηv (lm/W)
RGB1	3600	91	47	16
RGB2	2700	95	53	19
YAG	4400	57	252	76

- TABLE1.Measured properties including the correlated color temperature, color rendering, luminous flux ,and luminous efficacy of the resulting white light using the near-UV(λmax = 402 nm) laser diode in combination with phosphor samples RGB1 and RGB2 and using the blue (λmax = 442 nm) laser diode in combination with YAG.

Result and Discussion

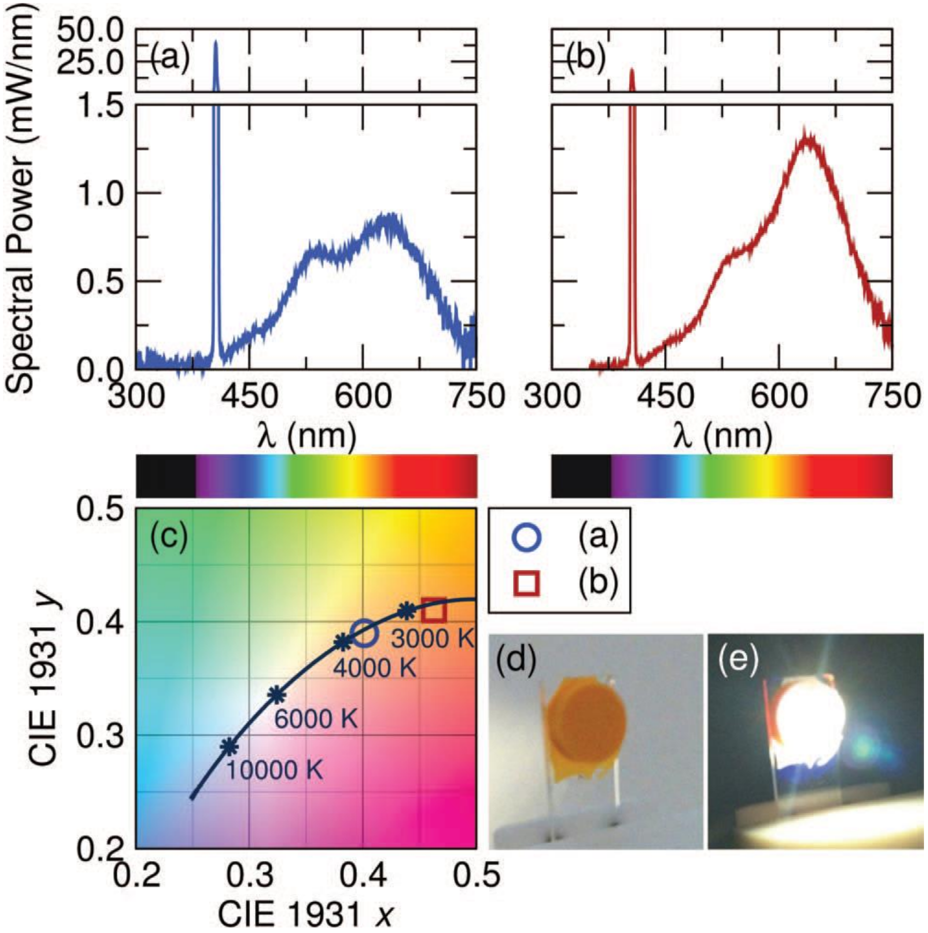

FIG. 3. SPD for phosphor samples

(a) RGB1

(b) RGB2 excited using a near-UV (*λmax* = 402 nm) laser diode

(c) The corresponding CIE chromaticity coordinates show white light with a variety of color temperatures is attainable. Photographs of the RGB2 phosphor sample (d) without and (e) with laser excitation.

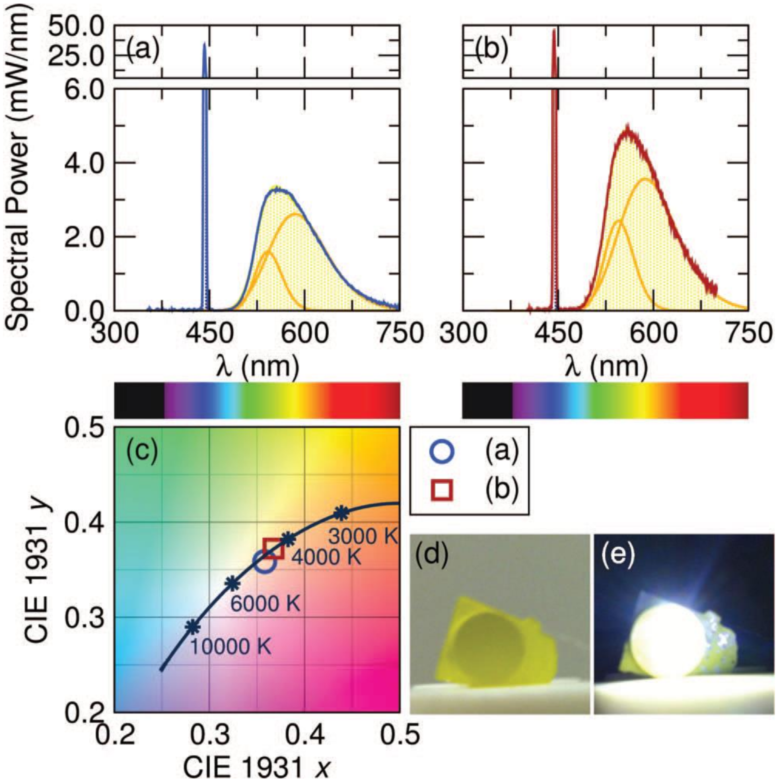

FIG. 4. (a) Calculated SPD for target white light composed of YAG:Ce and a blue laser diode, (b) experimentally measured
SPD with a similar ratio of laser to phosphor emission as that of the calculated SPD, (c) the corresponding CIE chromaticity
coordinates, and a photograph of the YAG:Ce phosphor sample (d) without and (e) with laser excitation. The SPDs show the
fits to three Gaussian curves, representing the fraction of emitted white light from laser emission and phosphor emission.

Conclusion

We have also shown that the luminous fficacy of such a device can be improved by stimating the maximum efficacy and altering the ratio of laser emission to phosphor emission in order to reach this maximum efficacy.

Further improvements in these devices can be envisioned through advancements in laser diode technologies and optimization of device packaging and phosphor properties.

References

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Thanks for your attention !