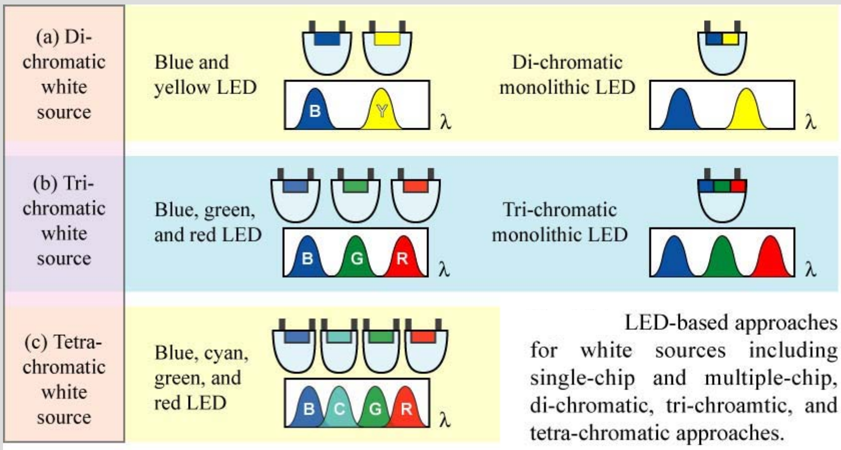
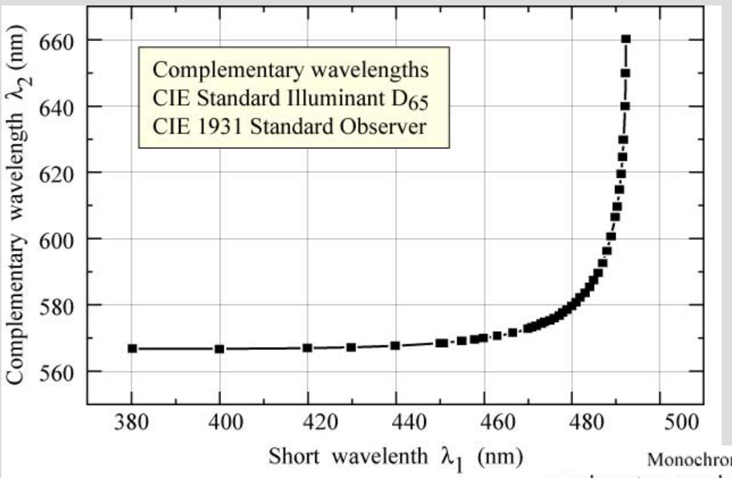
11 weiße LED



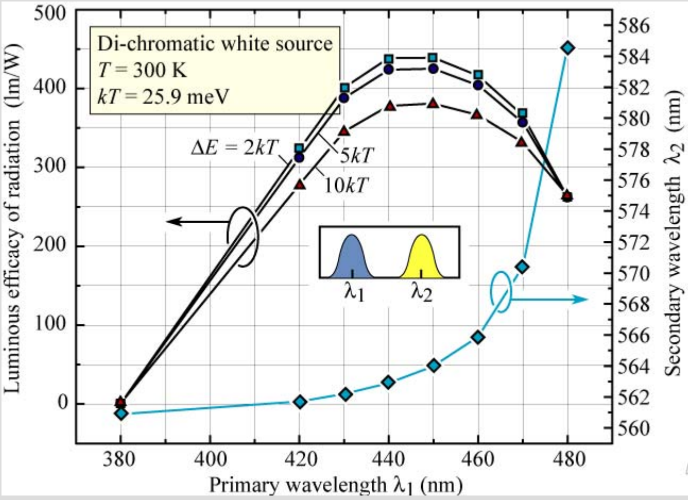
LED-based approaches for white sources including single-chip and multiple-chip, di-chromatic, tri-chroamtic, and tetra-chromatic approaches.

Komplimentärwellenlängen



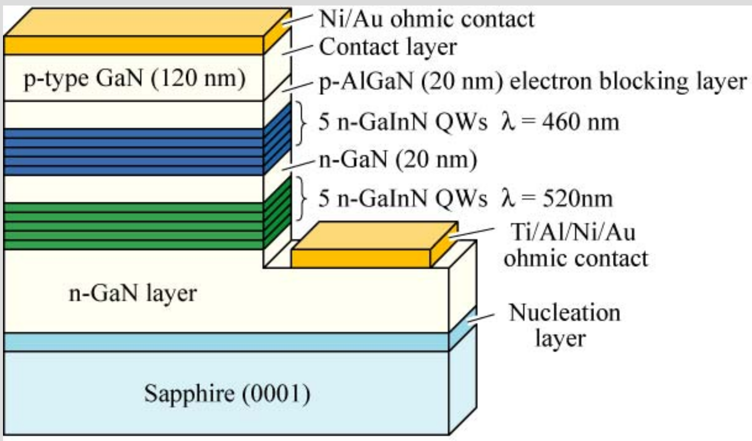
Monochromatic complementary wavelengths resulting in the perception of white light at a certain power ratio (after Wyszecki and Stiles, 1982).

Lumineszenzeffizienz dichromatischer weißer LEDs



Calculated luminous efficacy of dichromatic white light source (with chromaticity point at D_{65} standard illuminant) for different linewidths ΔE as a function of the primary wavelength. Also shown is the complementary secondary wavelength (after Li *et al.*, 2003).

Dichromatische Nitrid LED



Structure of a monolithic dichromatic LED with two active regions (after Li *et al.*, 2003).

PL und EL-spektra monolithischer dichromatischer LED 5

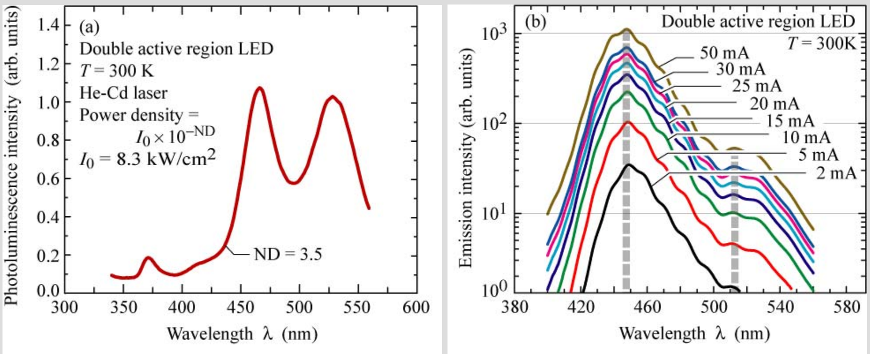


Fig. 20.5. Room temperature (a) photoluminescence and (b) electroluminescence spectra of monolithic dichromatic LED with two active regions (after Li *et al.*, 2003).

3-Farben weiße Multi-LED Quelle mit Farbtemperatur von 6500 K 6

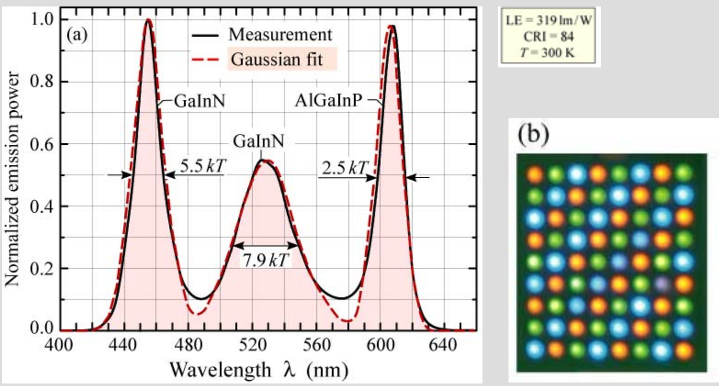
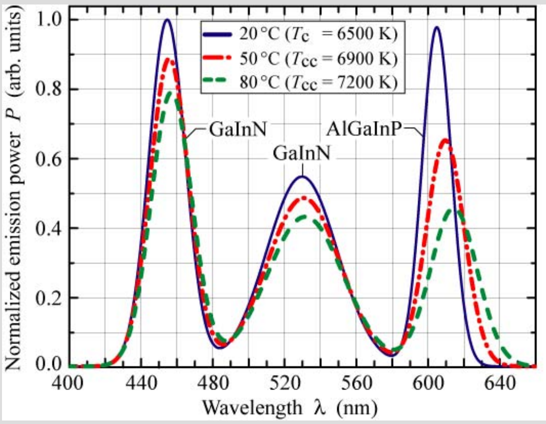


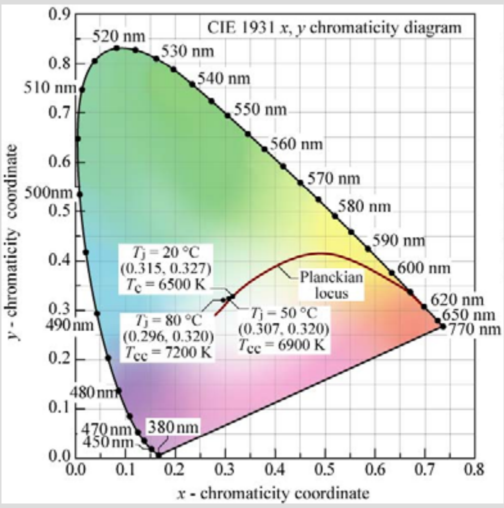
Fig. 20.6. (a) Emission spectrum of tri-chromatic white multi-LED source with color temperature of 6500 K (solid line) and gaussian fit (dashed line). The source has a luminous efficacy of radiation of 319 lm/W and a color rendering index of 84. (b) Photograph of source assembled of 5 mm LEDs (after Chhajed *et al.*, 2004).

Einfluss der Umgebungstemperatur auf die Frabtemperatur

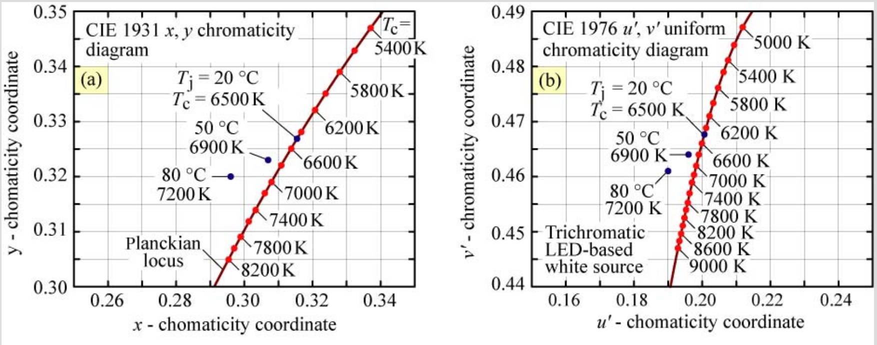


Emission spectrum of trichromatic white LED source for different ambient temperatures (junction heating neglected). Optical power, linewidth, and peak wavelength change with temperature. As a result of these changes, the color temperature of the source increases (after Chhajed *et al.*, 2004).

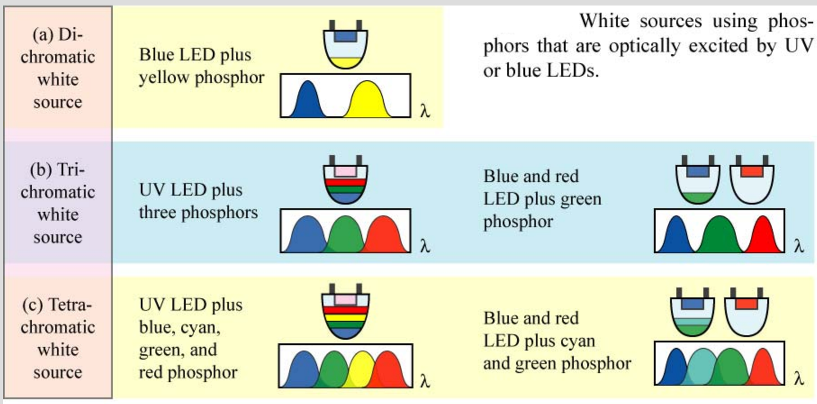
Farbänderung weißer LEDs



Change in chromaticity of trichromatic white LED-based source. The source color temperature is 6500 K when devices are at room temperature. Due to the dependence of emission power, peak wavelength, and linewidth on temperature, the chromaticity point migrates off the planckian locus as the device temperature increases (after Chhajed *et al.*, 2004).

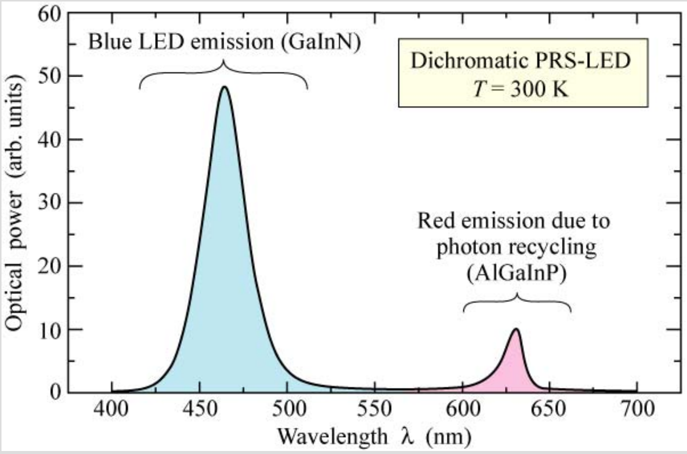


Change in (a) x, y and (b) u', v' chromaticity of trichromatic white LED source. $T_c = 6500$ K when p-n junctions are at room temperature (after Chhajed *et al*., 2004).



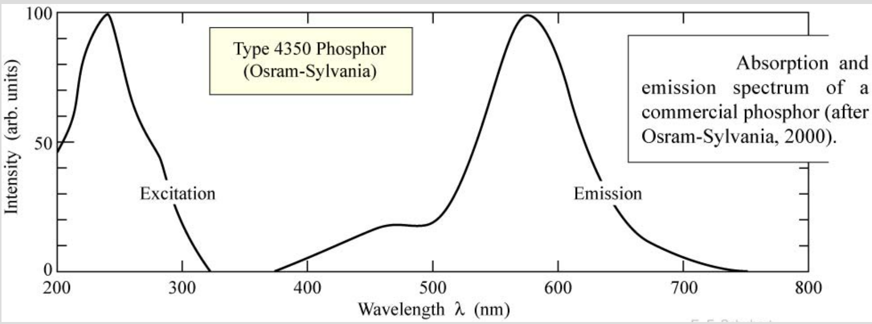
White sources using phosphors that are optically excited by UV or blue LEDs.

PRS-LED



Emission spectrum of dichromatic PRS-LED with current-injected GaInN blue LED primary source and AlGaInP photon recycling wafer (secondary source) emitting in the red (after Guo *et al.*, 2000).

Absorption und Emissionspektrum



Absorption and emission spectrum of a commercial phosphor (after Osram-Sylvania, 2000).

Absorption und Emissionsspektrum von Dye „Coumarin 6“

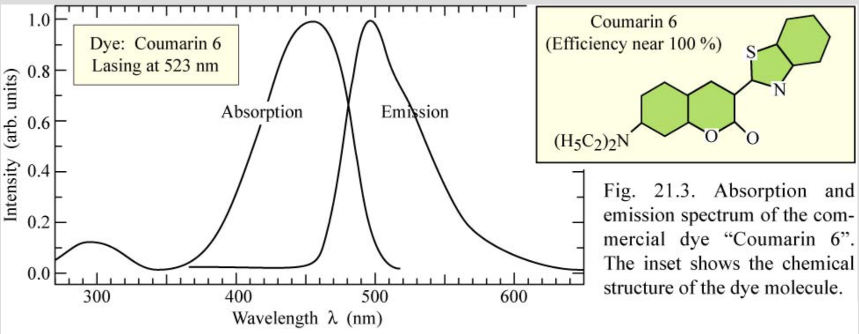
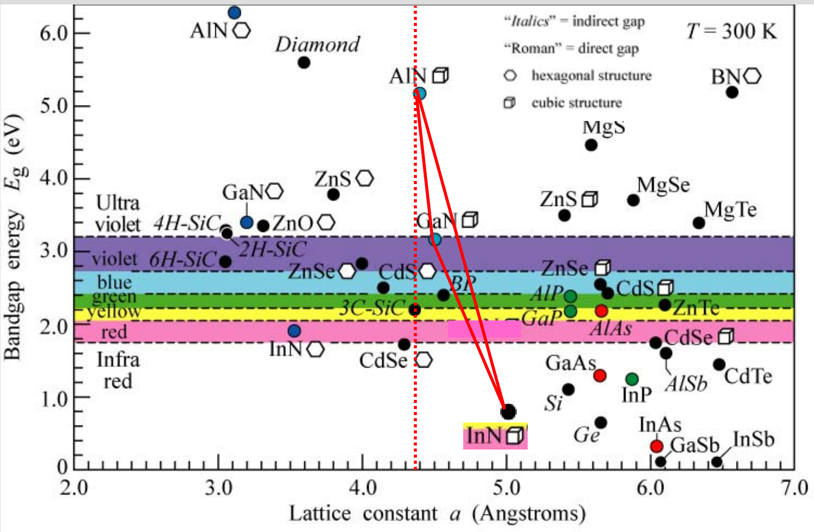


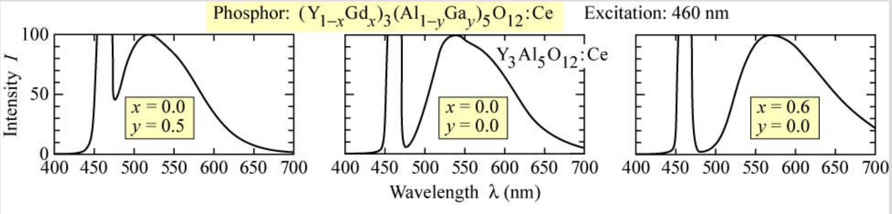
Fig. 21.3. Absorption and emission spectrum of the commercial dye “Coumarin 6”. The inset shows the chemical structure of the dye molecule.

RT Bandlücke vs. Gitterkonstante



Emissionspektra von Ce-dotierten YAG:Ce Phosphor

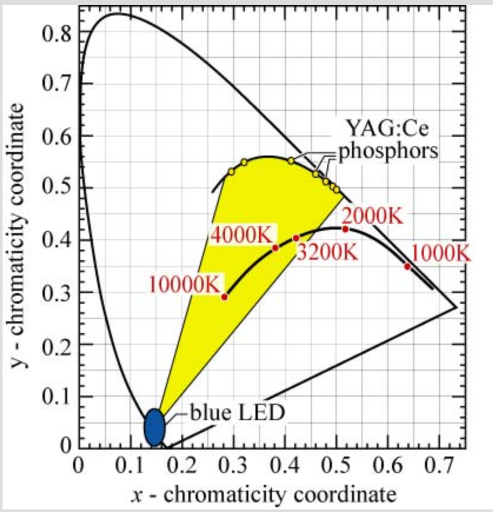
15



Emssion spectrum of Ce-doped yttrium aluminum garnet (YAG:Ce) phosphor for different chemical compositions. The excitation wavelength is 460 nm (after Nakamura and Fasol, 1997).

Farbpunkte des YAG:Ce Phosphors

16



Chromaticity points of YAG:Ce phosphor, and the general area (shaded) accessible to white emitters consisting of a blue LED and YAG:Ce phosphor (adopted from Nakamura and Fasol, 1997). Also shown in the planckian locus with color temperatures.

Weiße LED und Emissionsspektrum

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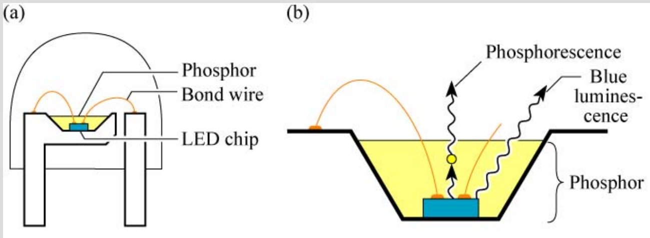
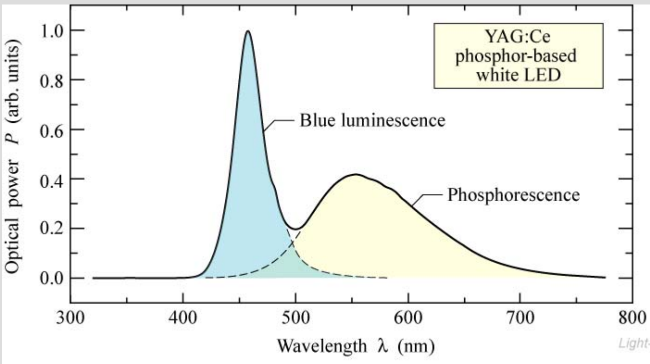


(a) Structure of white LED consisting of a GaInN blue LED chip and a phosphor encapsulating the die. (b) Wavelength-converting phosphorescence and blue luminescence (after Nakamura and Fasol, 1997).



Emission spectrum of a phophor-based white LED manufactured by Nichia Corporation (Anan, Tokushima, Japan).

Farbkoordinaten und EL konventioneller weißer LEDs

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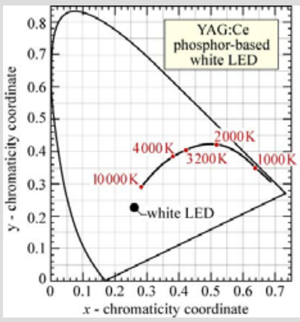
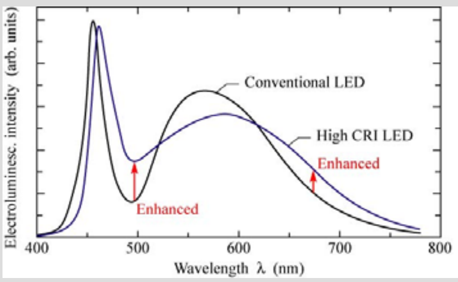
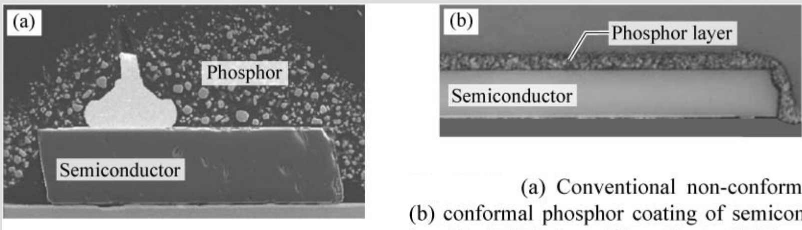


Chromaticity coordinates of a commercial phophor-based white LED manufactured in 2001 by Nichia Corporation (Anan, Tokushima, Japan). Also shown is the planckian locus and associated color temperatures.



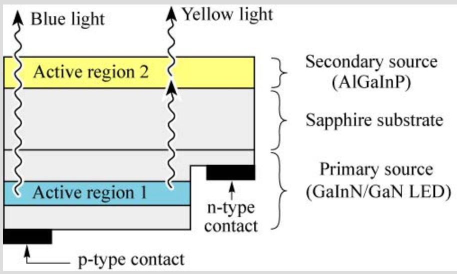
Electroluminescence spectrum of conventional white LED and of high-color-rendering white LED. The high CRI results from the broader emission spectrum and the reduction of the notch in the spectrum (after Narukawa, 2004).

REM Bilder

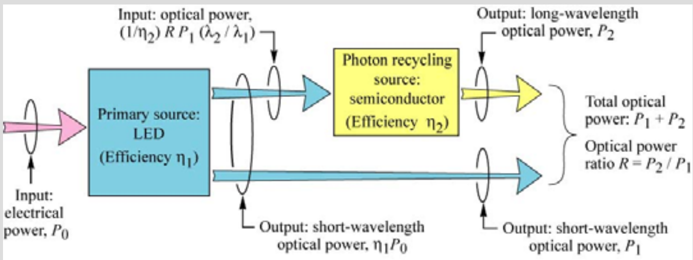


(a) Conventional non-conformal and (b) conformal phosphor coating of semiconductor in white LED (adopted from Goetz, 2003).

Photonen-recycle Halbleiter LED

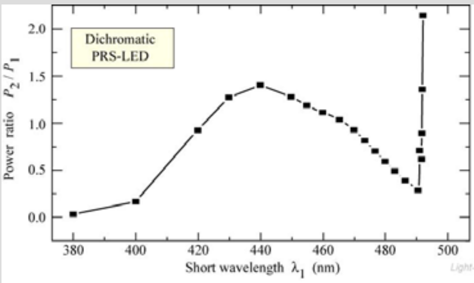


Schematic structure of a photon-recycling semiconductor LED with one current-injected active region (Active region 1) and one optically excited active region (Active region 2) (after Guo *et al.*, 1999).

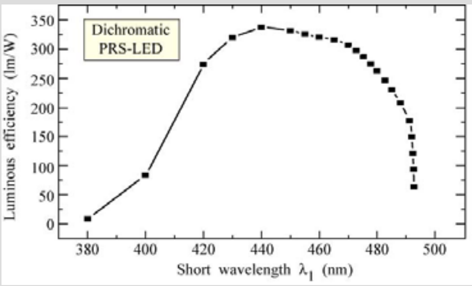


Photon-recycling semiconductor LED power budget with electrical input power P_0 and optical output power P_1 and P_2.

Leistungsverhältnis und Lichteffizienz

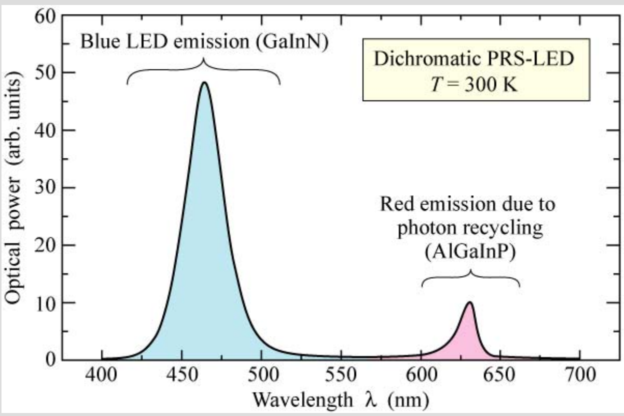


Calculated power ratio between the two optical output powers P_1 and P_2 required to obtain white light emission (after Guo *et al.*, 1999).



Calculated luminous efficiency of a dichromatic PRS-LED versus its primary emission wavelength (after Guo *et al.*, 1999).

Dichromatische PRS-LED aus GaInN und AlGaInP LEDs



Emission spectrum of dichromatic PRS-LED with current-injected GaInN blue LED primary source and AlGaInP photon recycling wafer (secondary source) emitting in the red (after Guo *et al.*, 2000).