Final Exam, Spring Semester 2005

ECSE-6961, Light-emitting diodes and solid-state lighting

1. (a) Explain the effect of temperature change on the performance characteristics of (i) LED-based white sources, and (ii) phosphor-based white LED sources.
   (b) Discuss the significance of the temperature effect for any application of your choice.

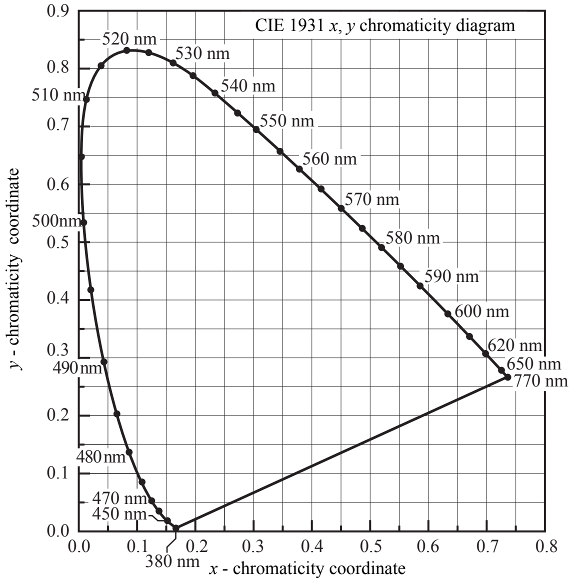
2. Give three methods each to
   (a) Increase light extraction.
   (b) Increase internal quantum efficiency.
   (c) Decrease the forward voltage of an LED.

3. (a) What is thermal runaway?
   (b) What is the advantage of a high cavity quality factor Q? How can one obtain a high Q?
   (c) State three differences between a laser and an LED.
   (d) What is the minimum flicker method?
   (e) What is the significance of the circadian rhythm?
   (f) What is the "green gap"?
   (g) Are semiconductors with a large Urbach tail preferable over semiconductors with a small Urbach tail?

4. (a) Can you obtain a color with (x, y) chromaticity coordinates (0.3, 0.4) if you have two LEDs with (x, y) chromaticity coordinates (0.1, 0.1) and (0.7, 0.3)?
   (b) Can you obtain a color with (x, y) chromaticity coordinates (0.2, 0.5) if you have three LEDs with (x, y) chromaticity coordinates (0.2, 0.1), (0.6, 0.3), and (0.3, 0.5)?
   (c) Can you obtain a color with (x, y) chromaticity coordinates (0.4, 0.6) if you have two LEDs with (x, y) chromaticity coordinates (0.1, 0.1) and (0.25, 0.35)?

5. Consider a two LED light source with the following parameters:
   Source 1: λ = 460 nm, $P_{\text{electrical}}$ = 50 mW, η_{external} = 50%, and V_{f} = 4.0 V
   Source 2: λ = 580 nm, $P_{\text{electrical}}$ = 50 mW, η_{external} = 30%, and V_{f} = 3.0 V
   Calculate the following quantities:
   (a) η_{power}.
   (b) Luminous efficiency.
   (c) Show the location of the resultant color on the (x, y) chromaticity coordinate system.

6. Consider a 1 km long multimode step-index fiber with a core index of 1.45 and a cladding index of 1.4. Assume that the fiber input comes from either an LED emitting at 800 nm or an LED emitting at 1300 nm. Assume that both the LEDs have a spectral linewidth of 25 nm.
   (a) Calculate the modal and material dispersion (pulse broadening) for each case.
   (b) What limits the maximum bit rate at each wavelength?
   (c) Explain the result obtained in (b).


CIE 1931 x, y chromaticity diagram
520 nm
530 nm
540 nm
550 nm
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770 nm
510 nm
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y - chromaticity coordinate
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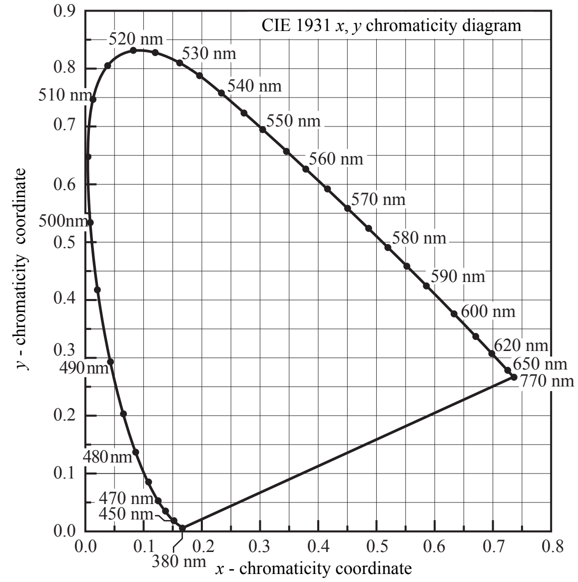
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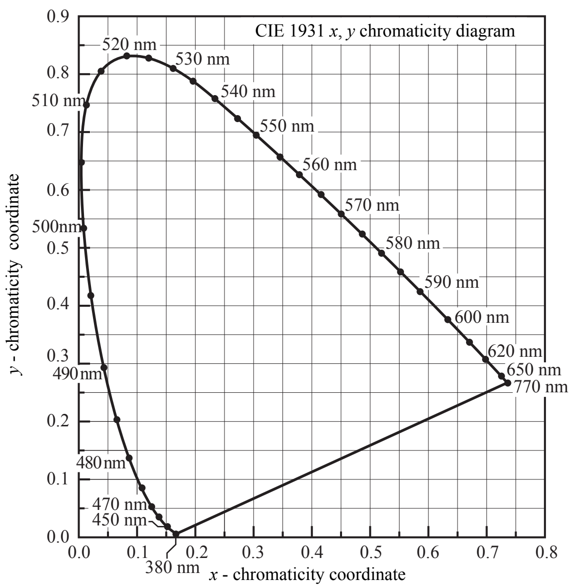
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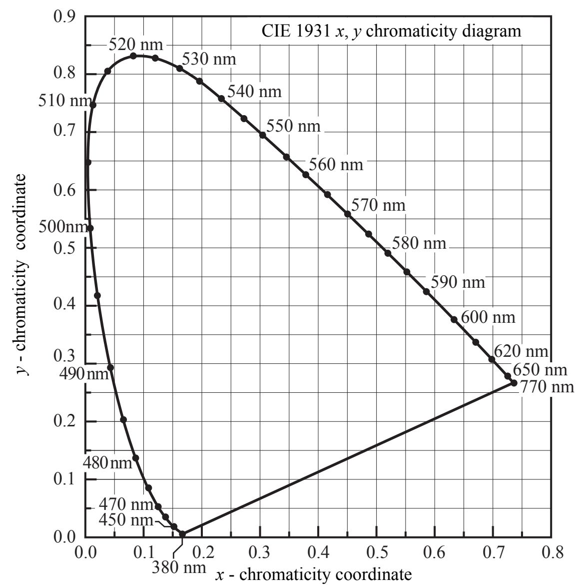
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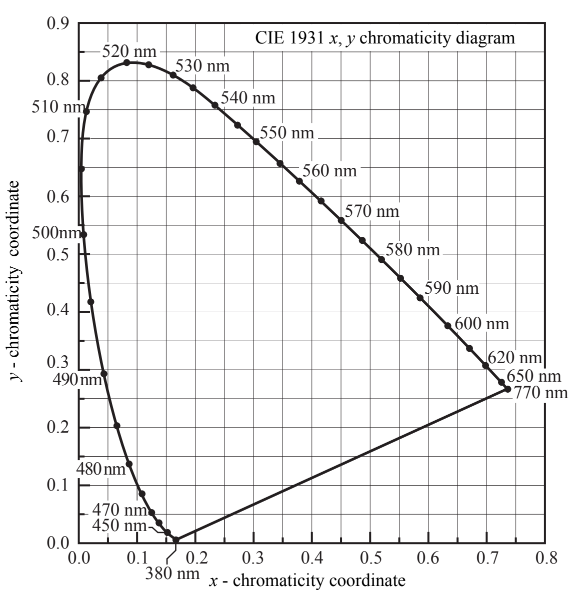
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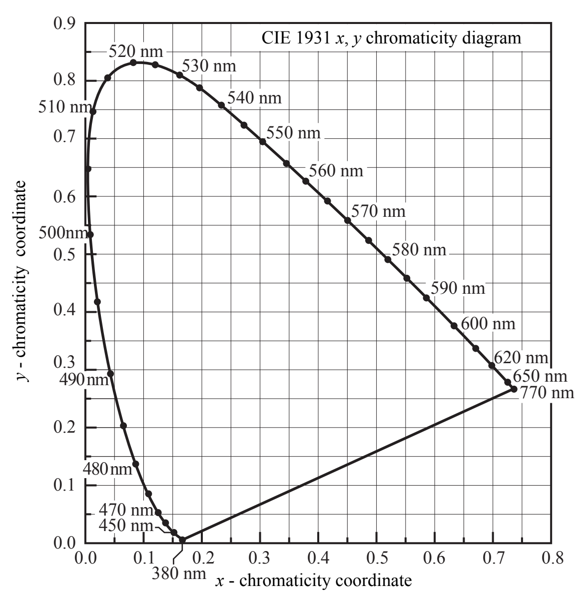
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