Quantum Dots, The Future of LED Display Technology

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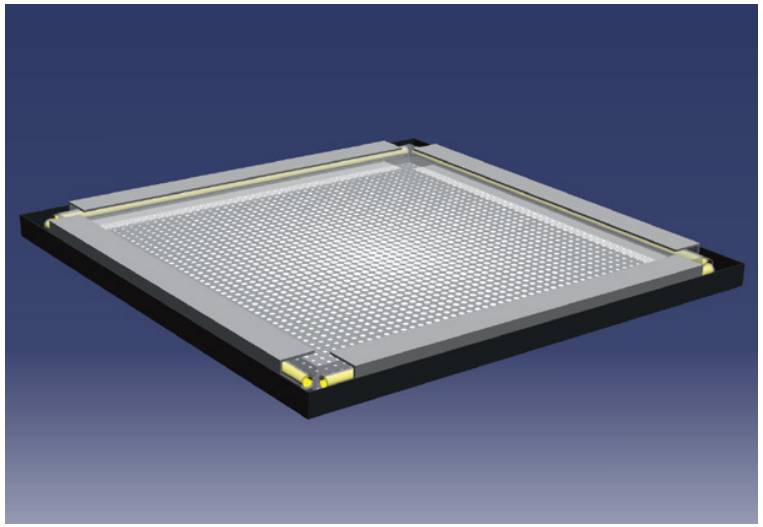
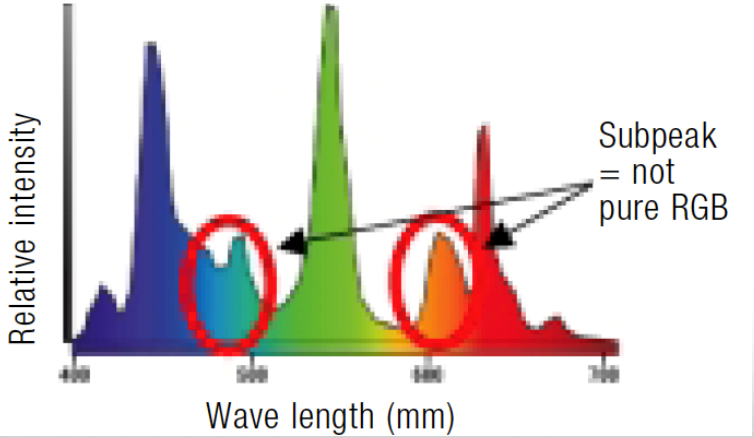
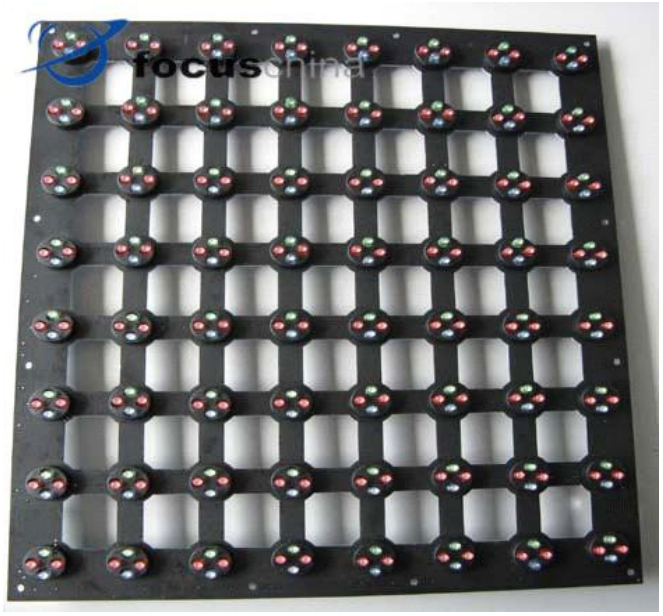
Back Lights for Flat Panel Displays
CCFL to LEDs

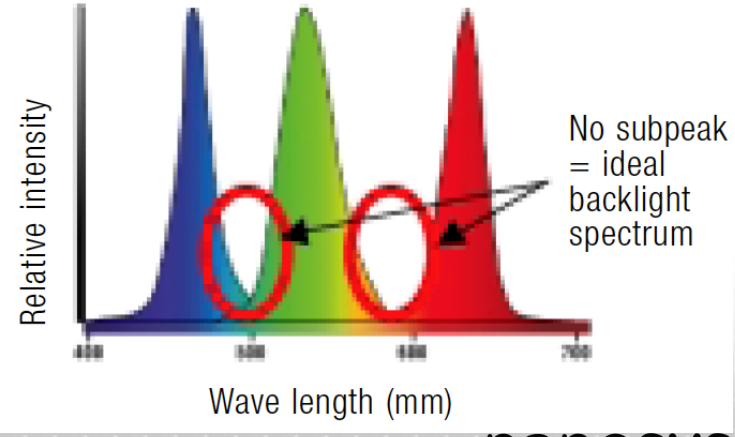
CCFL





LEDs





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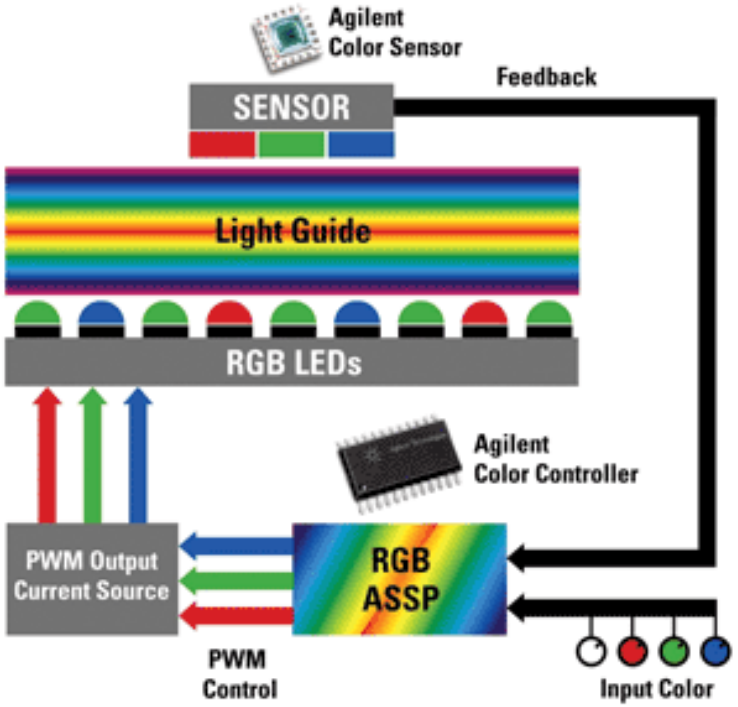
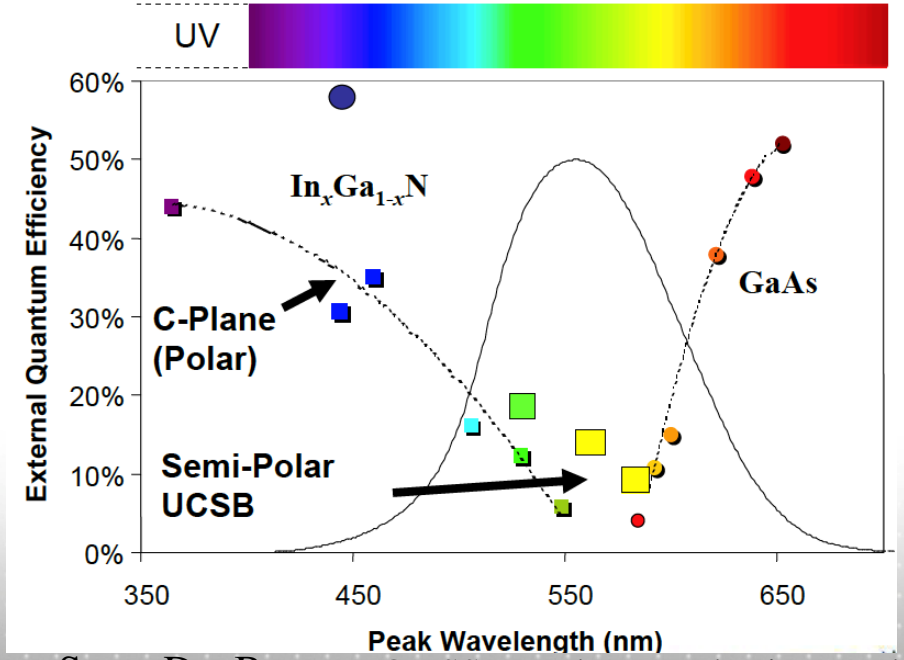
Backlights with RGB LEDs





- RGGB used due to lower efficiency of green LEDs
- Real-time feedback needed to keep the correct white point due to color drifts mostly in green and red LEDs

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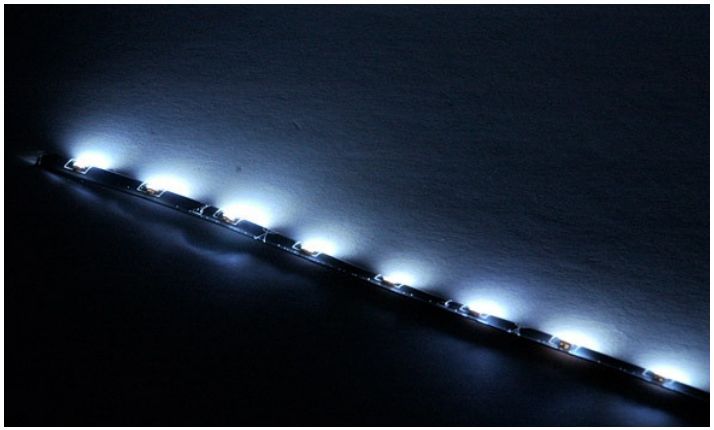
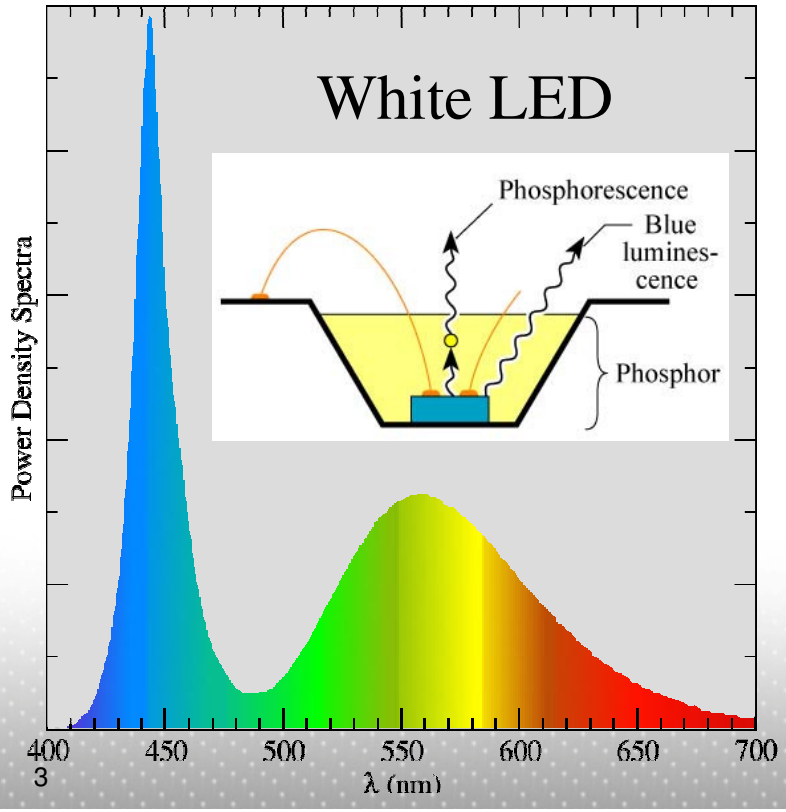
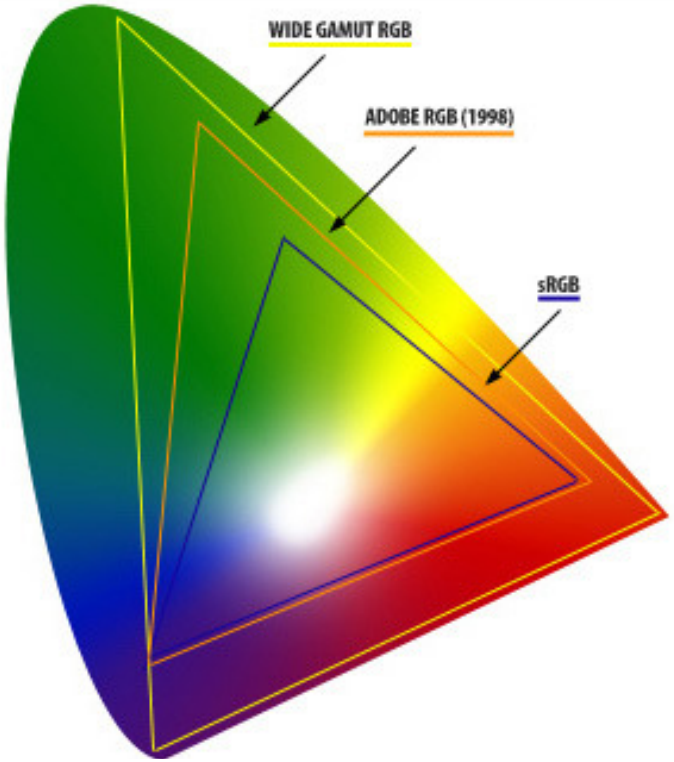
White LEDs – sRGB ~ 70% NTSC

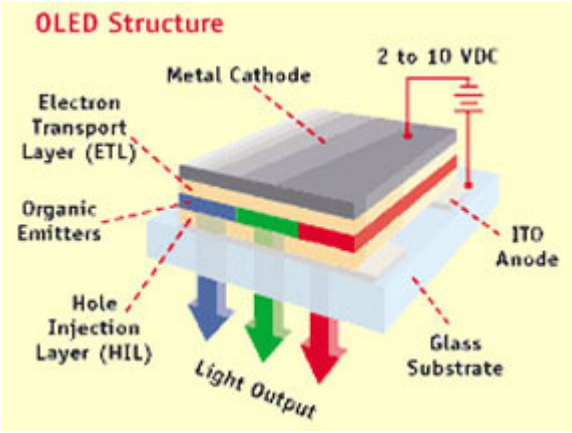


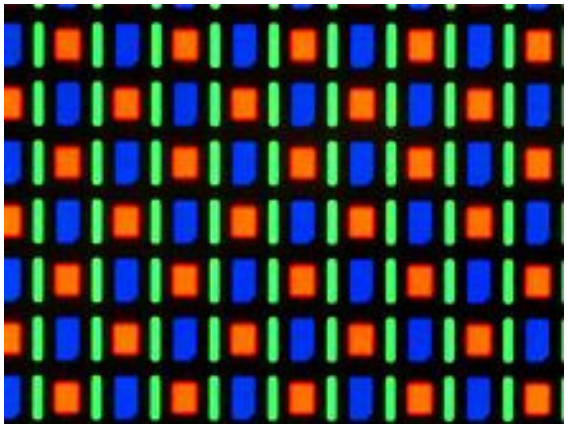


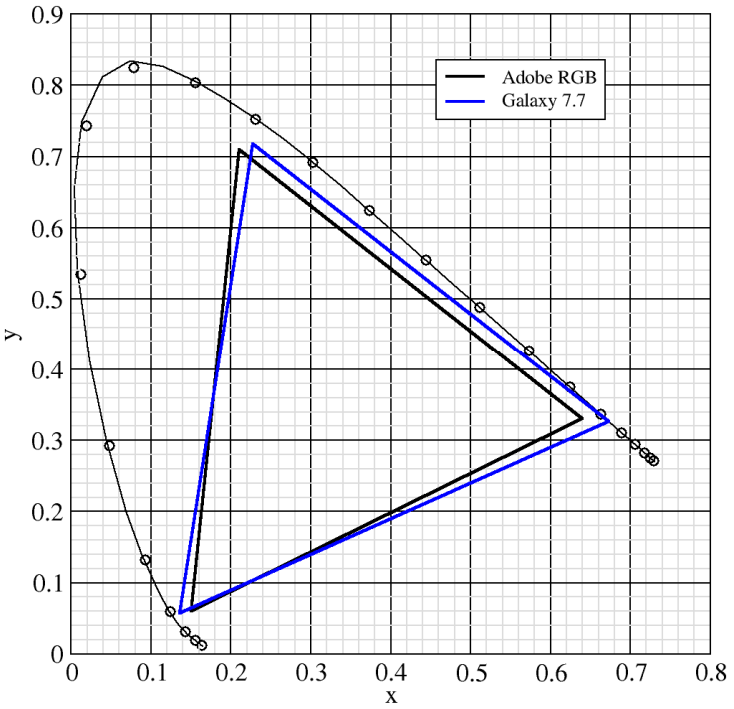


- White LEDs with high efficiency blue LED chips combined with yellow phosphor have become industry standard
- **Compromise on color: sRGB ~70% NTSC**

OLED Displays with Wide Color Gamut







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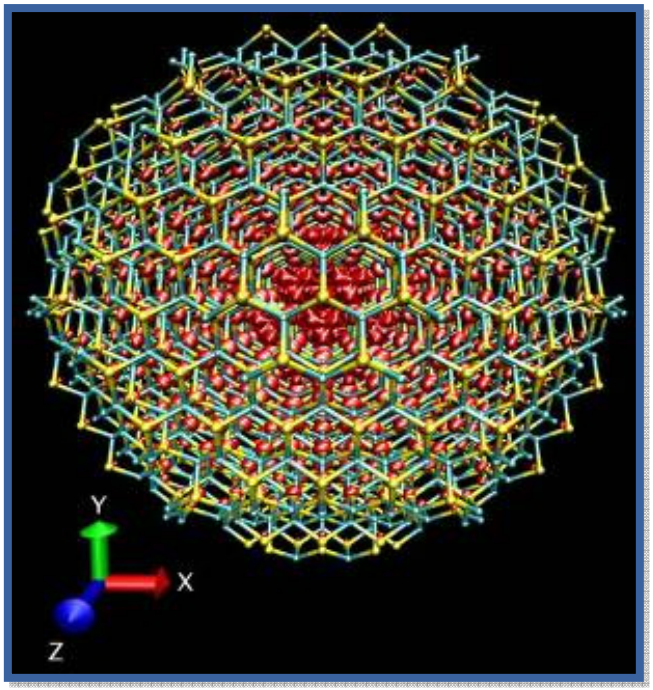
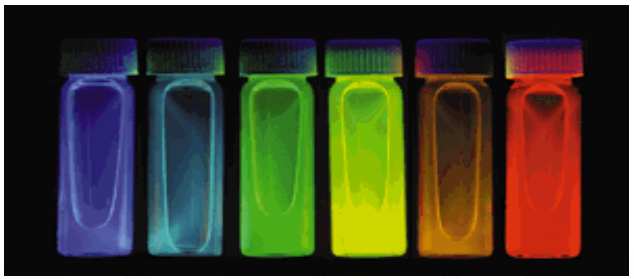
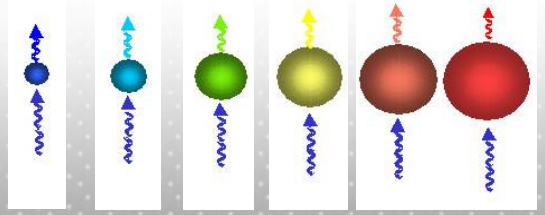
New Generation Phosphor: Quantum Dots







What is a Quantum Dot?

- An inorganic highly efficient phosphor crystal grown through standard wet chemical manufacturing processes.
- Governed by their size, QDs have the unique capability to precisely generate a specific wavelength of light.
- They produce pure saturated colors or can be blended to a precisely defined white point

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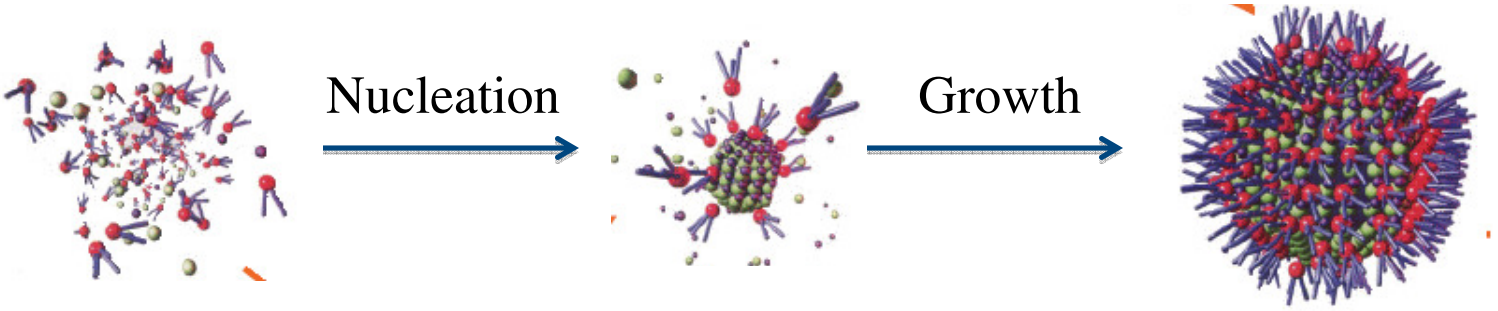
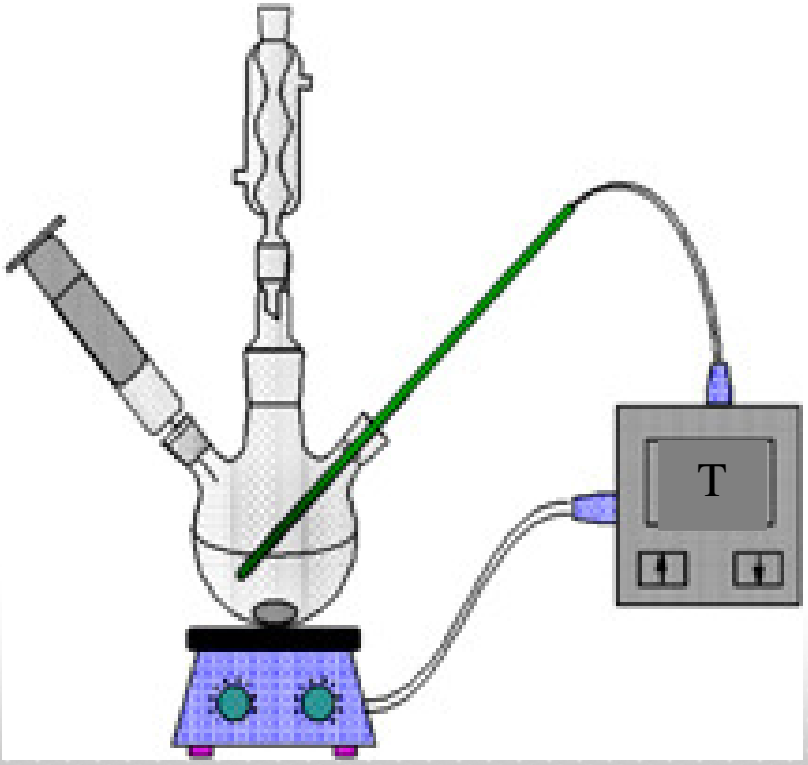
Synthesis of Quantum Dots





- QD synthesis done in solution chemistry typically using metal organic precursors in inert ambient
- Synthesis temp.: 100C-300C
- Time: few seconds to hours
- Size control
  - Precursor material, concentration
  - Temperature
  - Time
  - Ligand
  - …

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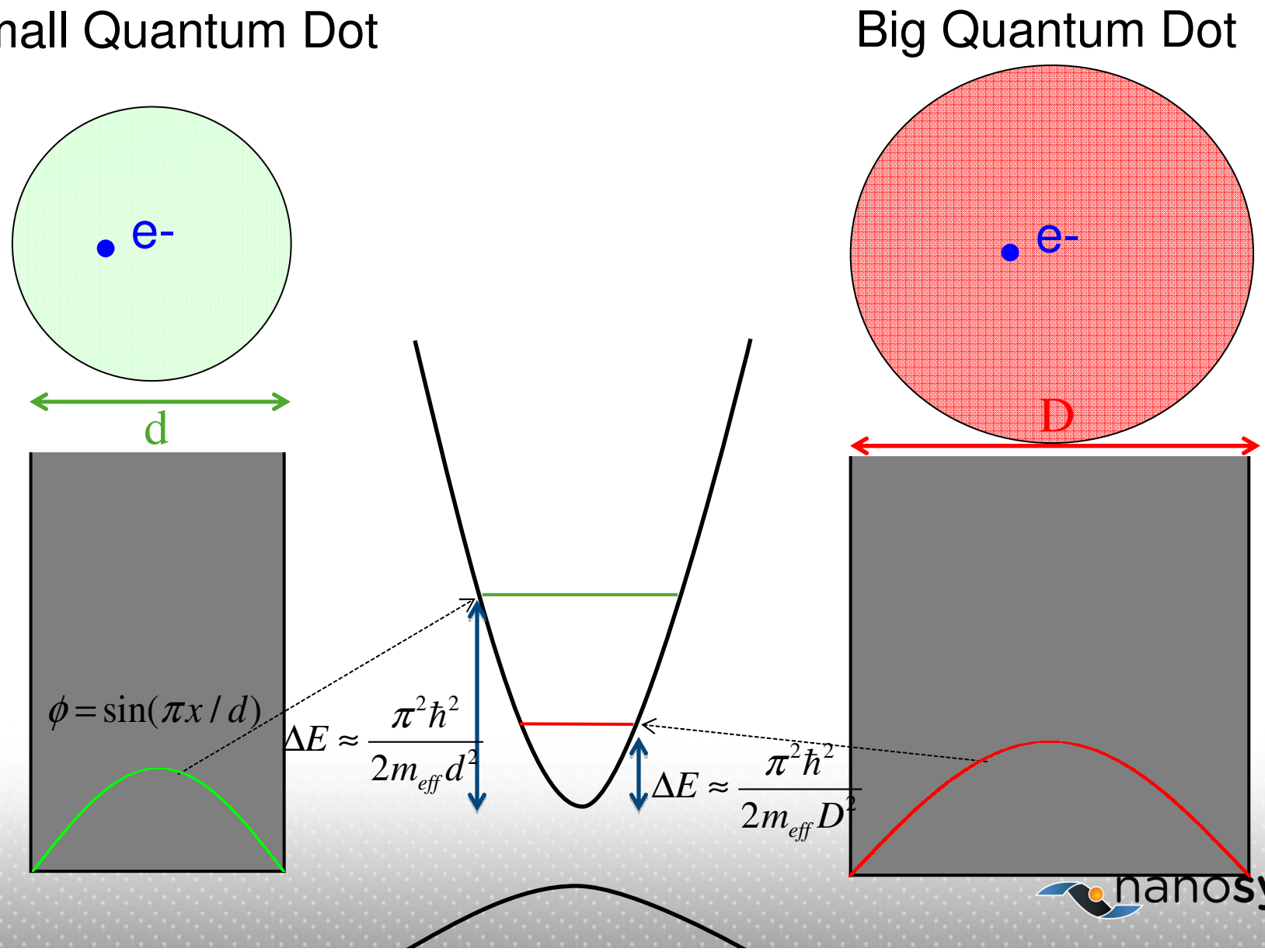
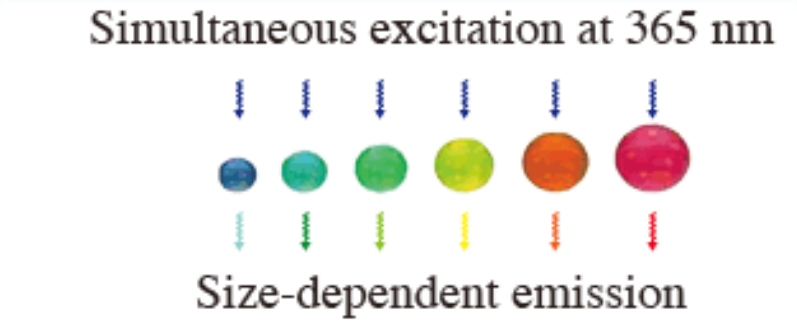
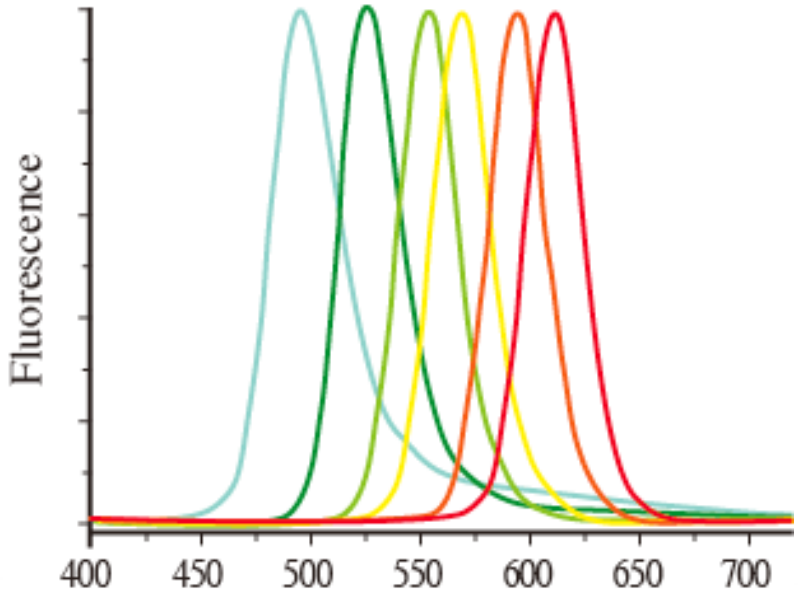
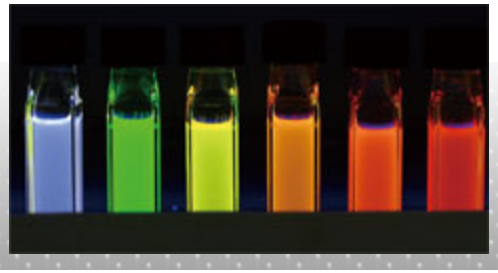
Quantum Confinement in Quantum Dots



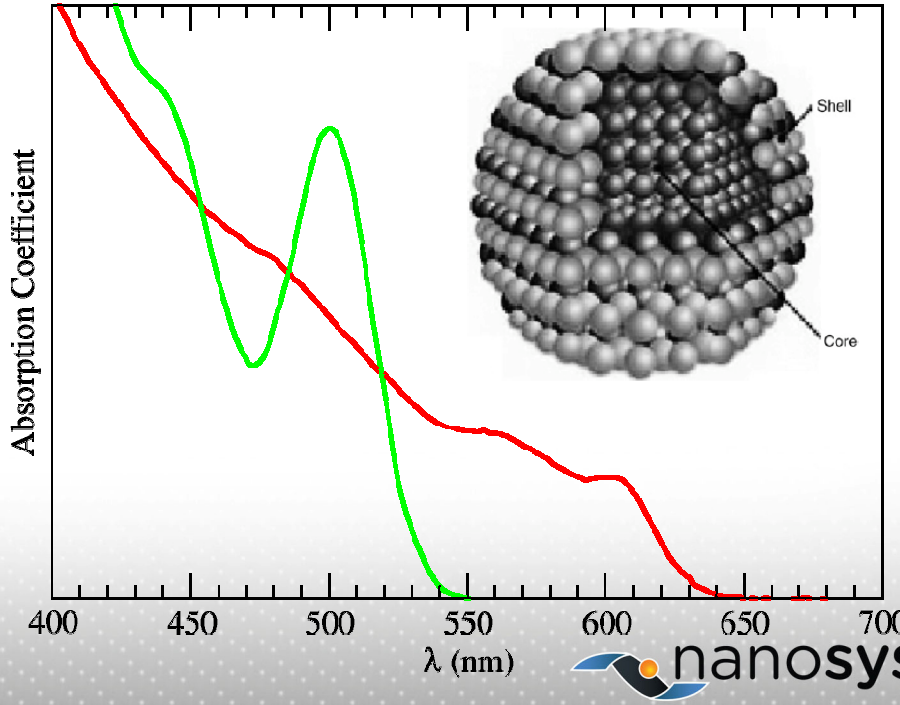
Spectral Characteristics of Quantum Dots







- Narrow FWHM: 30-40nm
- Core/shell quantum dots
  - High QY: ~90%
  - Long-term stability
- Continuous absorption spectra: common excitation wavelength for green & red QDs



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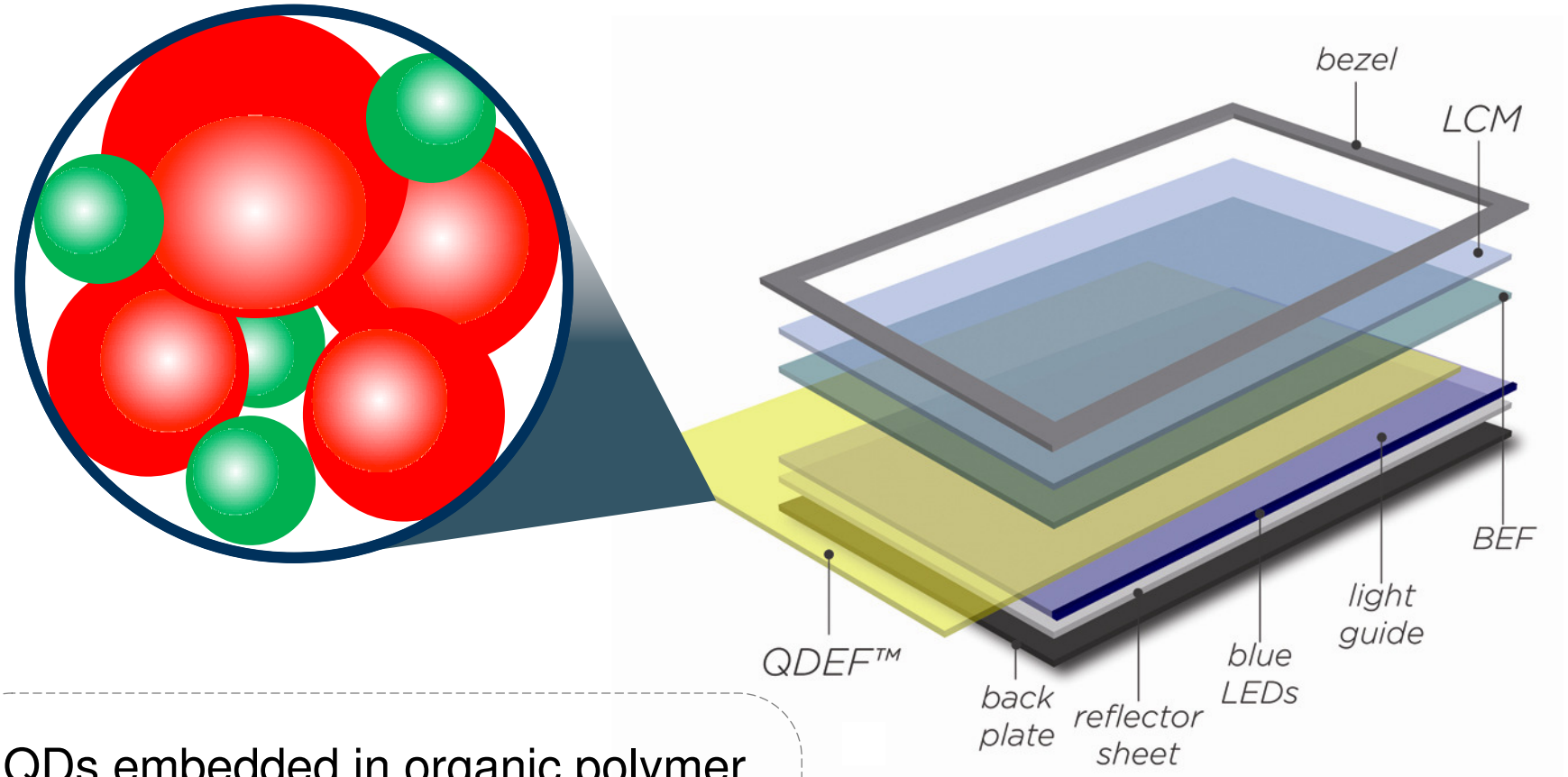
Quantum Dot Enhancement Film – QDEF



- QDs embedded in organic polymer
- Continuous roll-printed sheet
- Replaces bottom diffuser
- Exceptional color gamut
- High uniformity

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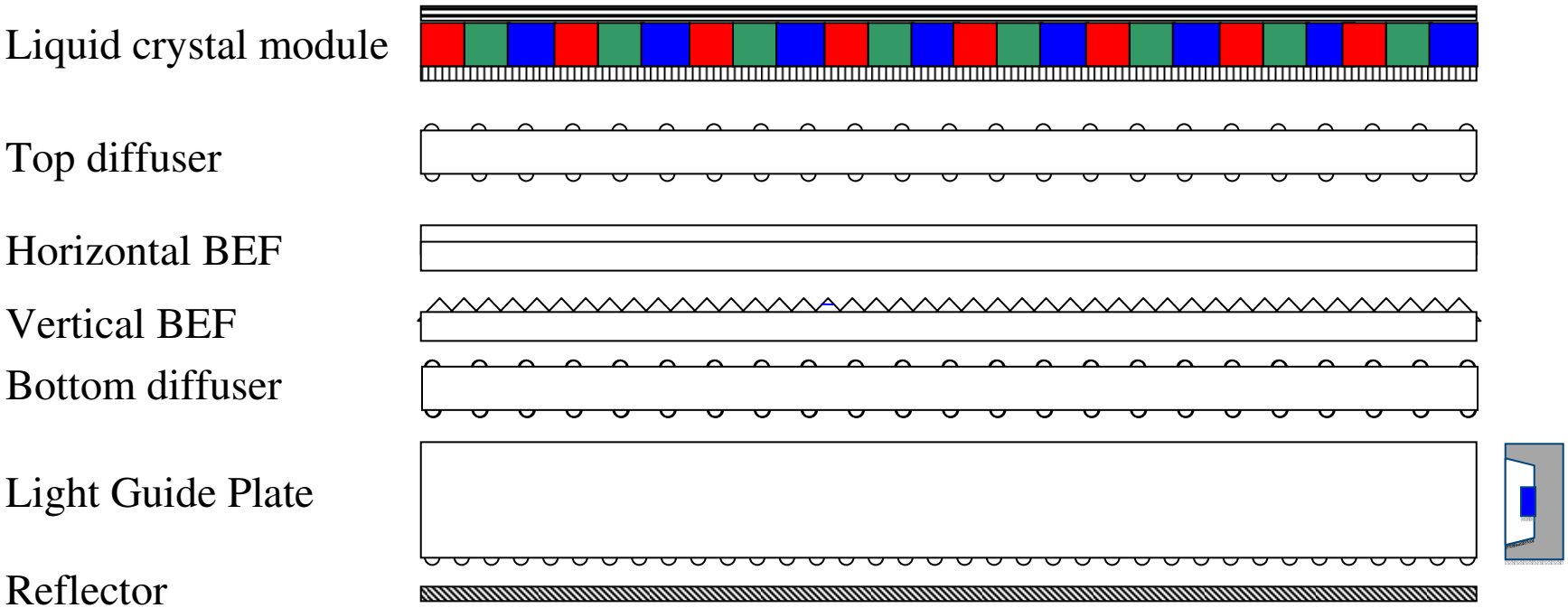
Backlight Unit with White LEDs



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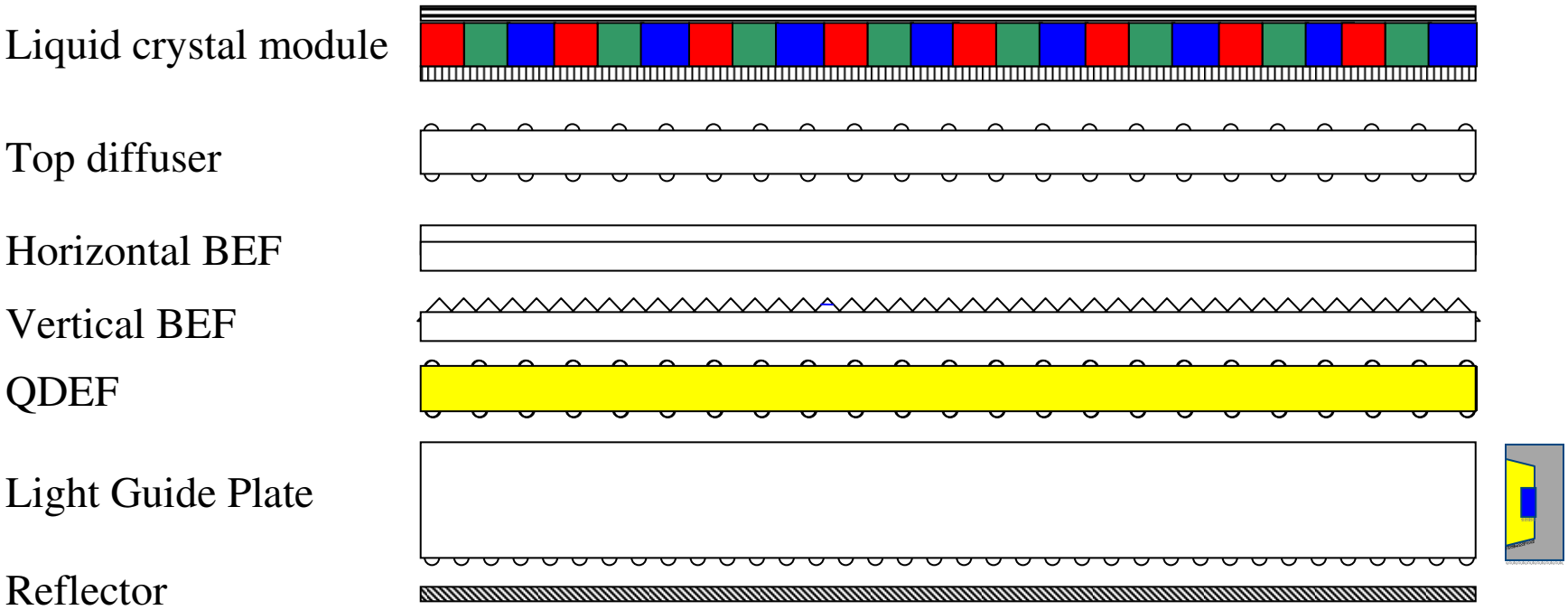
Backlight Unit with QDEF



- Blue LED replaces white LED
- QDEF replaces bottom diffuser

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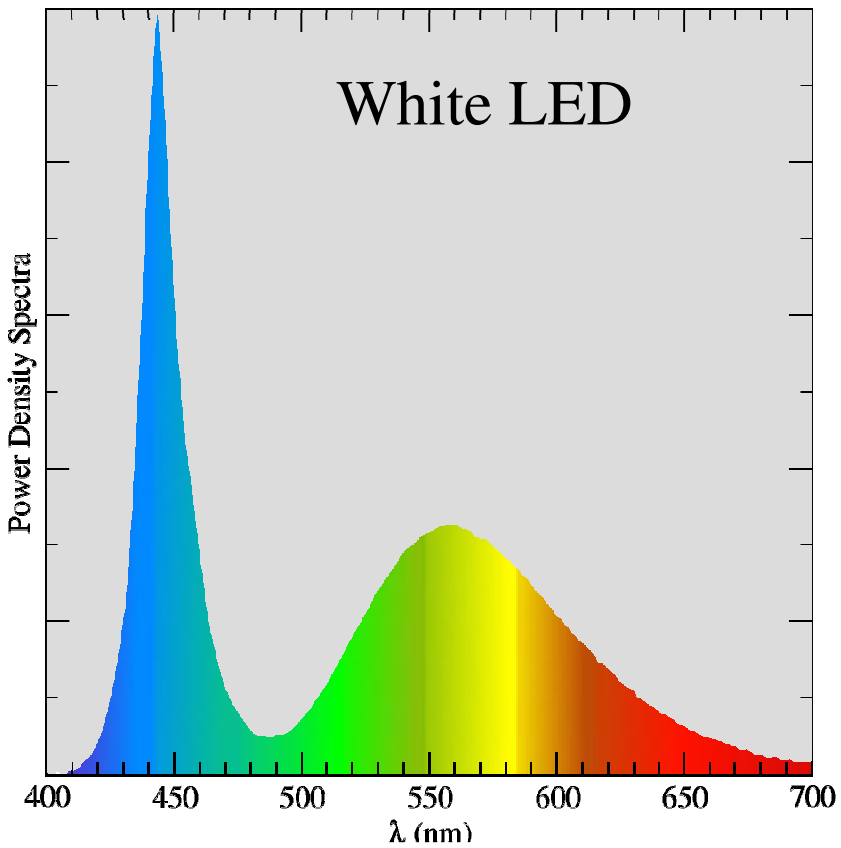
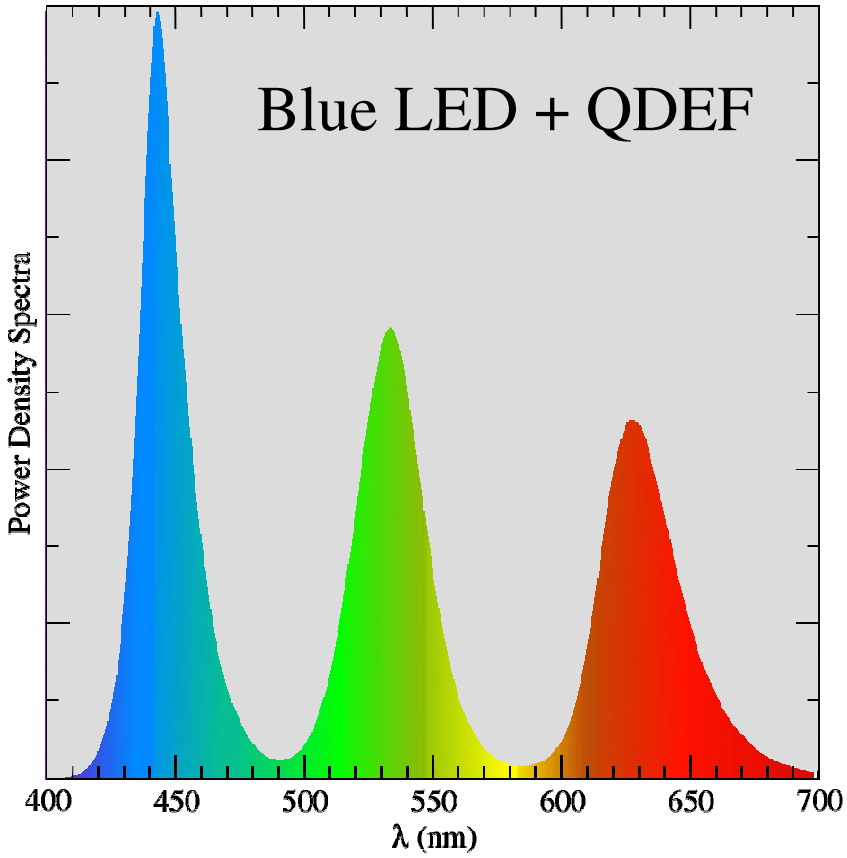
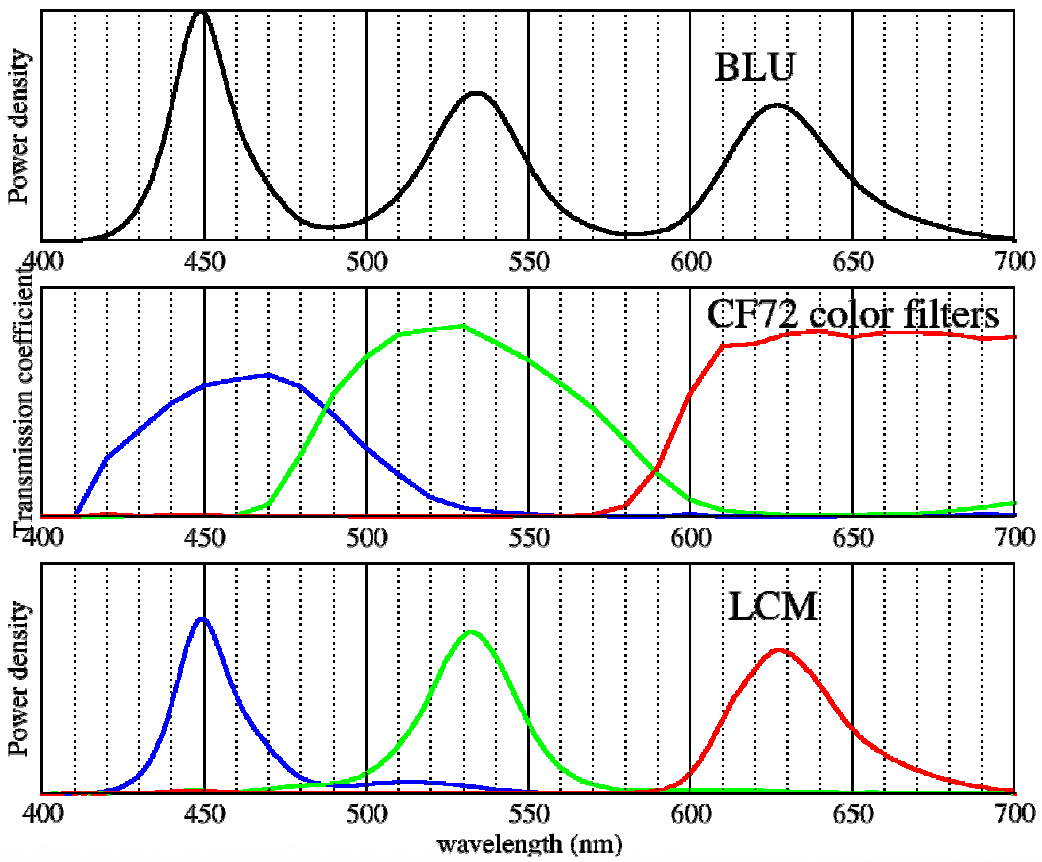
Backlight with QDEF

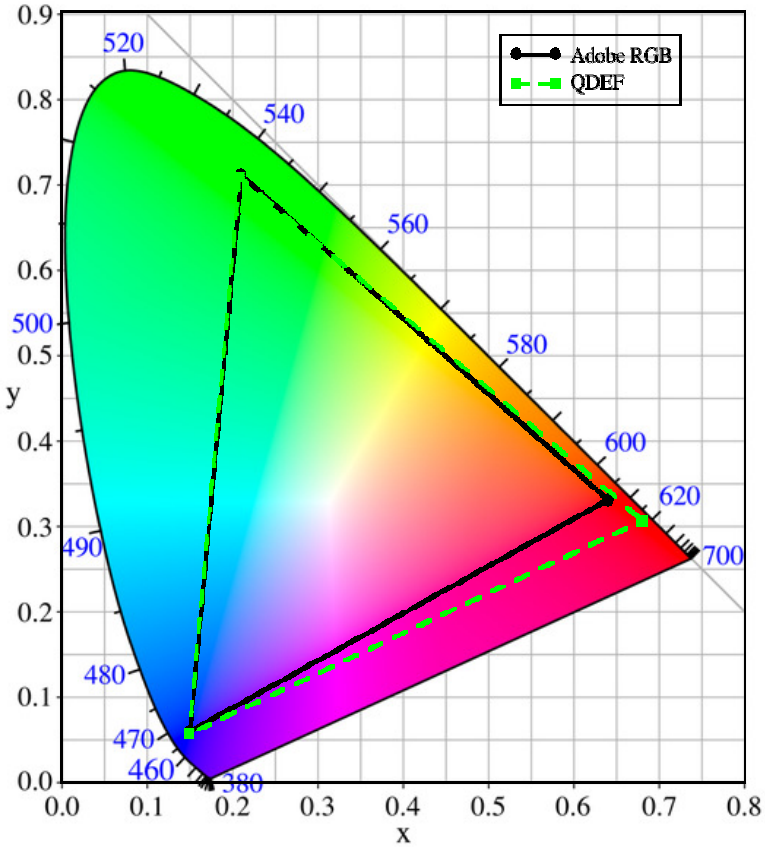




- QDEF wavelengths can be precisely controlled: ±2nm from Nanosys manufacturing process

100% Adobe-RGB Solution with QDEF





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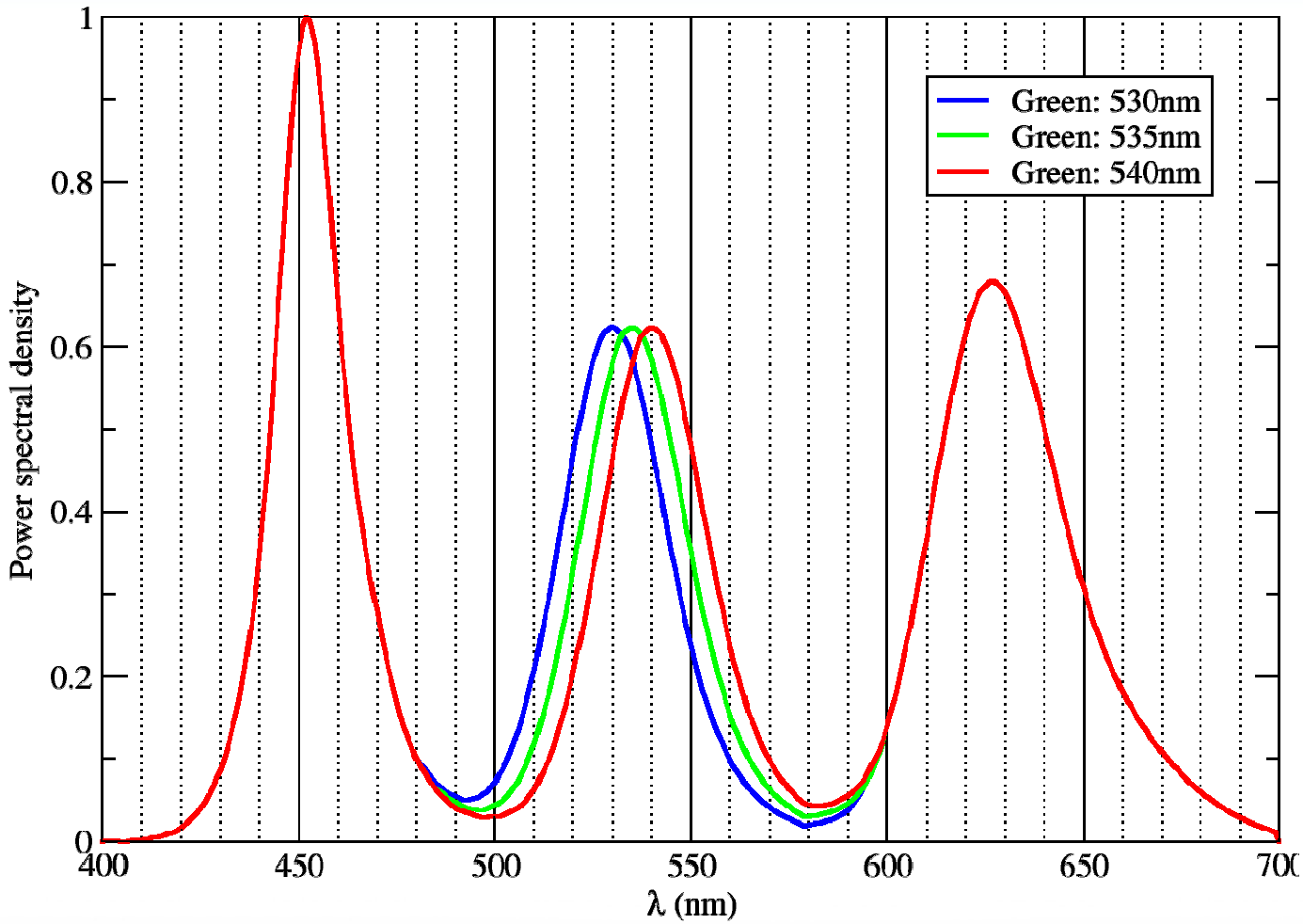
Custom Wavelengths for Target Applications



- QDEF wavelengths can be tuned continuously to target different primary color coordinates and match color filters for optimal performance

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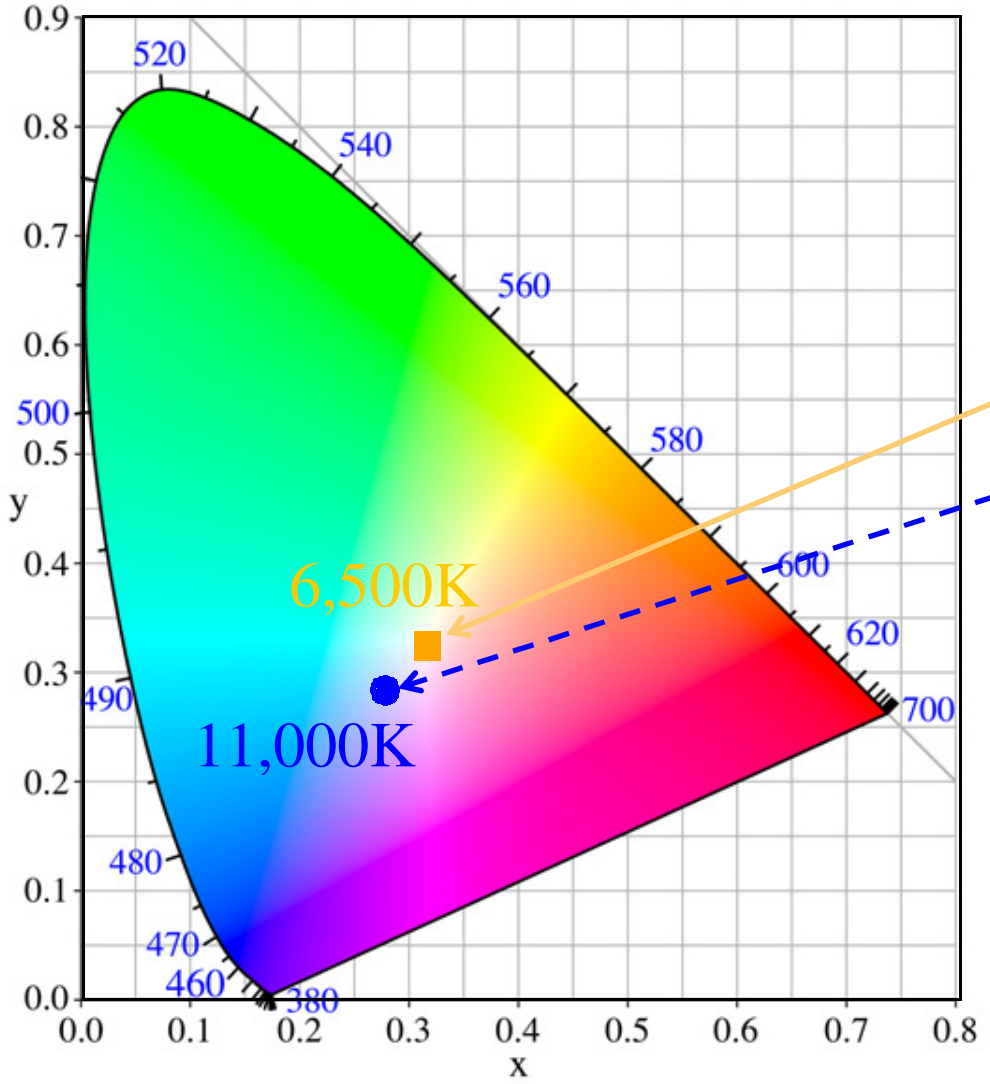
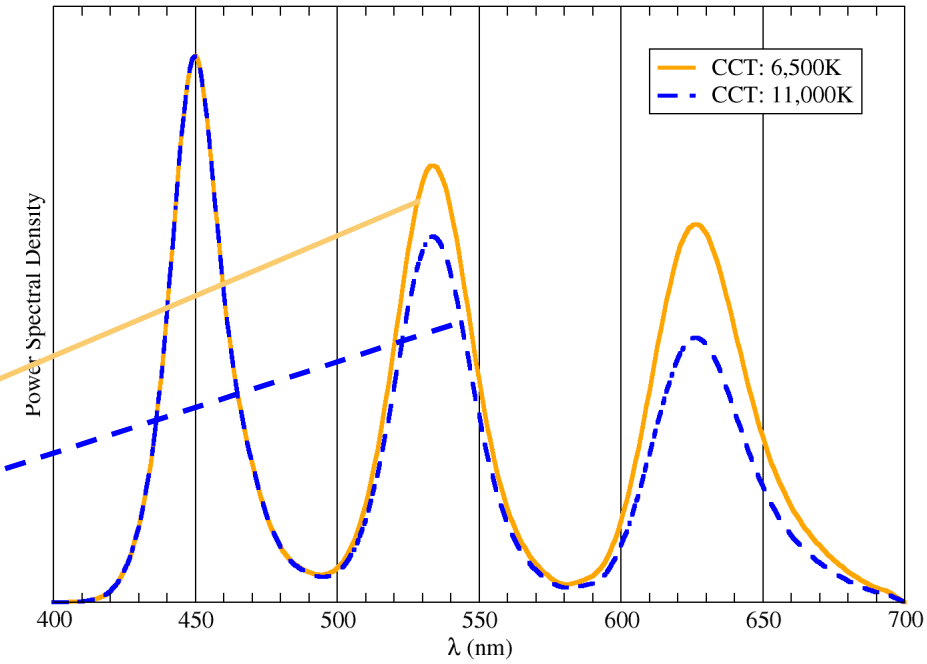
Custom White Points for Target Applications





- White point can be easily tuned using different loading of green and red QDs

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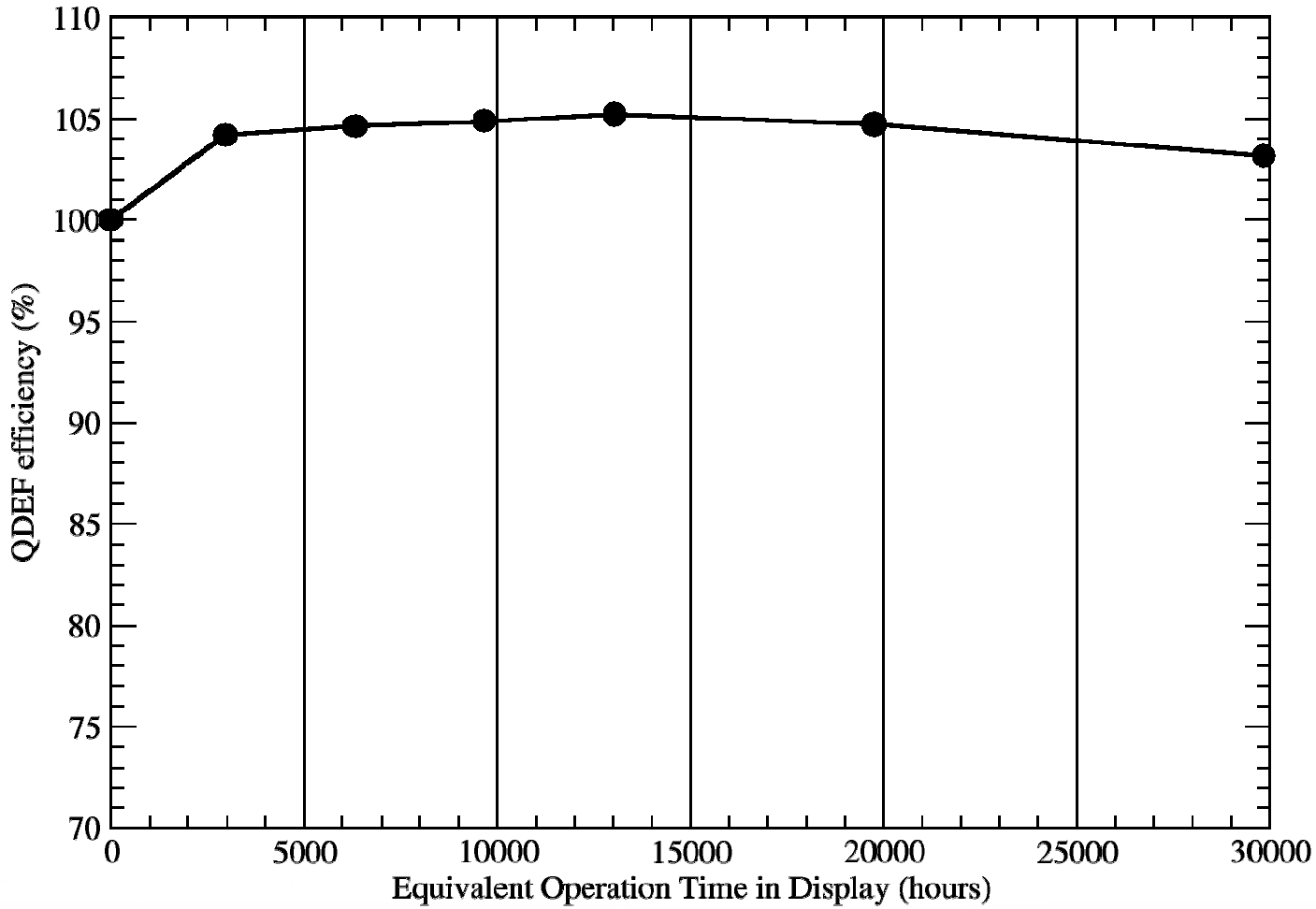
Long-Term Stability of QDEF



- QDEF proven stable under highly accelerated testing
- Equivalent operation lifetime in displays > 30,000hrs

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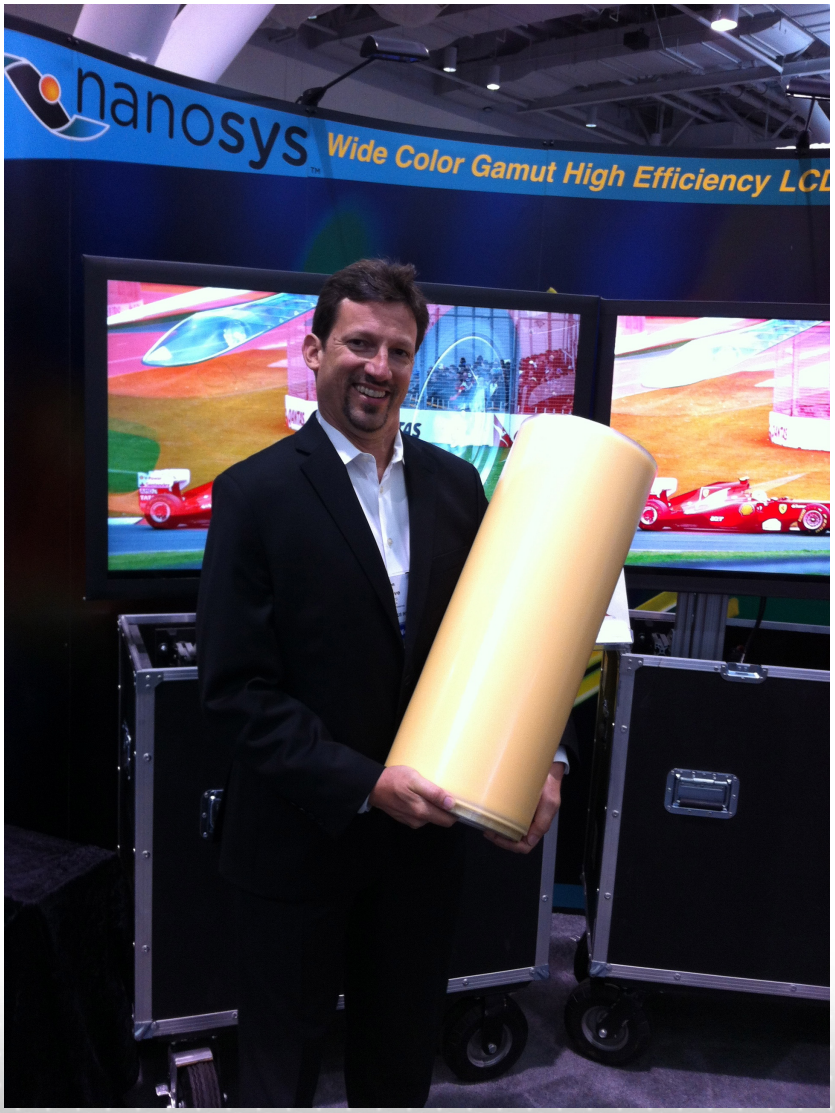
Roll-to-Roll Process for QDEF



- Roll-to-roll process for QDEF developed
- Good uniformity achieved for white-point and brightness uniformity requirements

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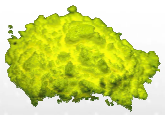
QDEF – Bring Amazing Color to LCD Displays

White LED Backlight

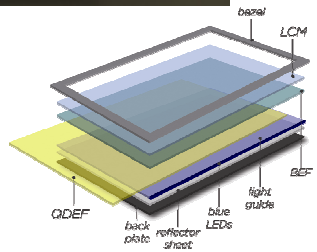
Blue LED enhanced with YAG

Rare earth element based phosphor (YAG)

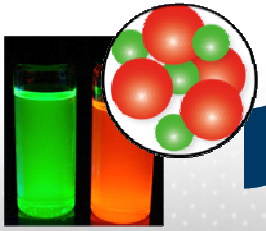


QDEF Backlight

Optical film enhanced with core shell quantum dots



Core shell quantum dot phosphors



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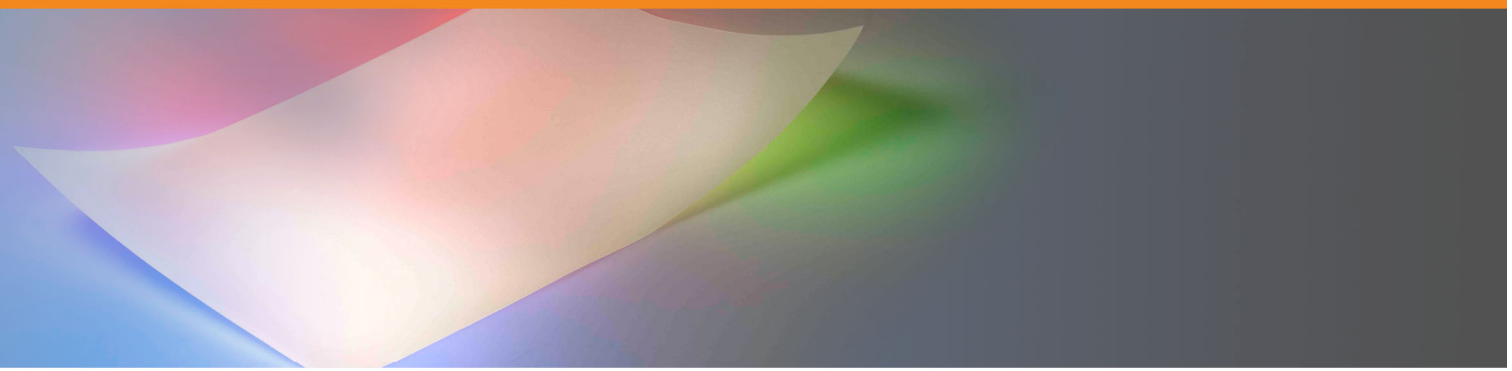
Thank You!



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