



Nanograde AG

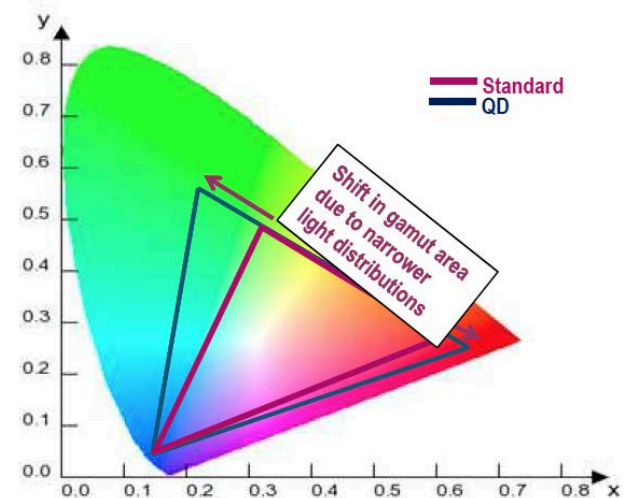
High-Performance Cadmium-Free QD Formulations for
LCD Backlight Films

Dr. Samuel Halim (CEO)

sch@nanograde.com

Concept of QD backlight films

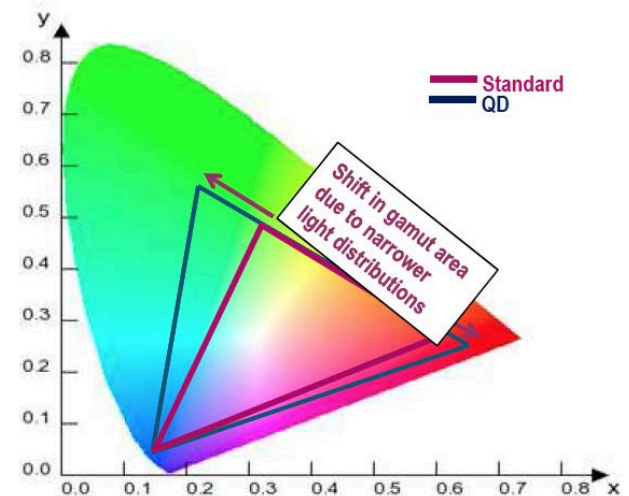
- Goal
 - Increase performance of LCD displays
 - Wide color gamut by narrow red and green emission (FWHM)
 - Less power consumption by high quantum yield (QY) of red and green QD's
- Concept
 - Red and green QDs convert blue backlight
 - 3 design modes:
 - Film
 - Edge
 - On-chip

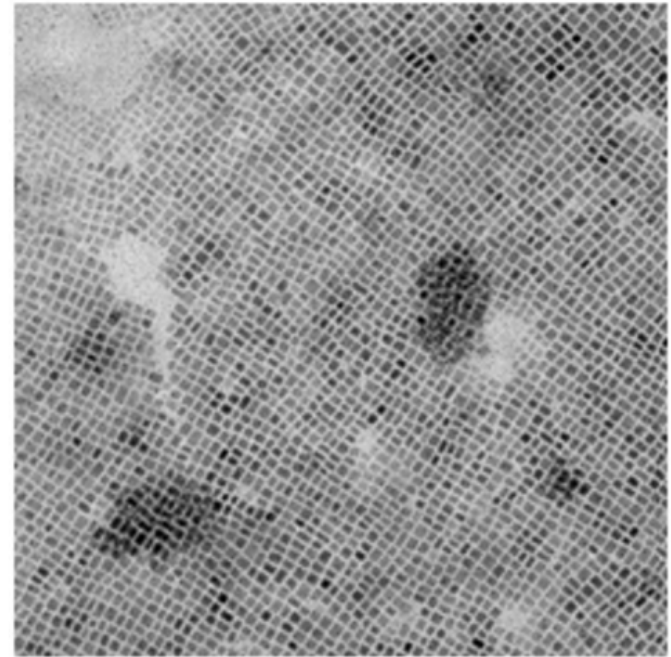


State-of-the-art QD backlight films

- Material issues
 - Non-RoHS compliant (CdSe)
 - Limited color gamut (InP)
- Cost issue
 - Cost for QD backlight film ($> 40\$/\text{m}^2$)
 - BOM for low-cost 55-inch LCD display: $< 300 \$$

- Need for
- Cd-free / RoHS compliant
 - narrow emissions
 - Attractive cost structure





Nanograde QDs

- High performance
- RoHS compliant
- Cost efficient

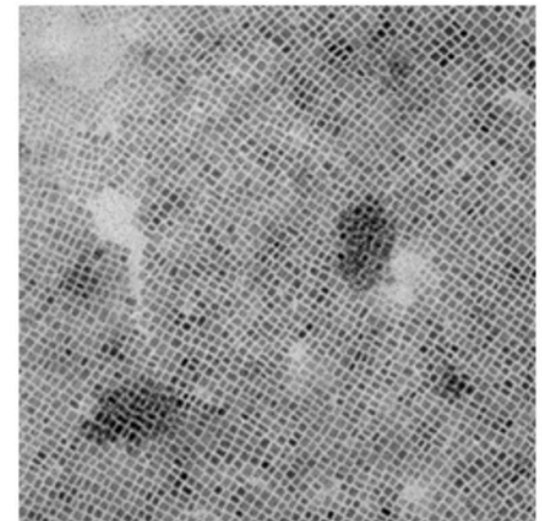
25 – 35 nm FWHM

Cd-free

10\$/m²

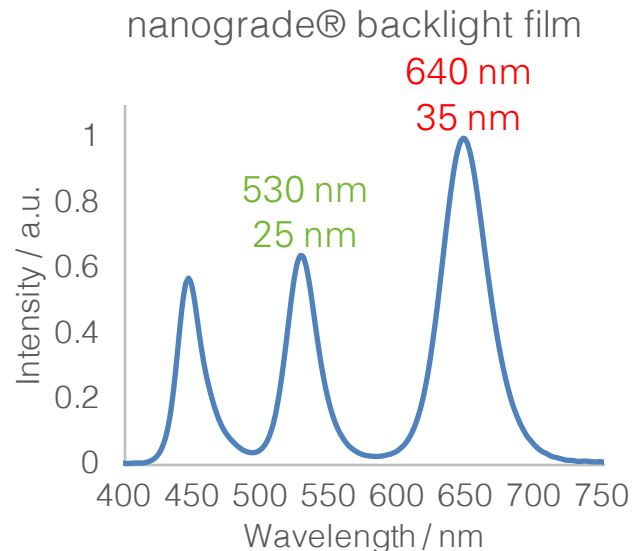
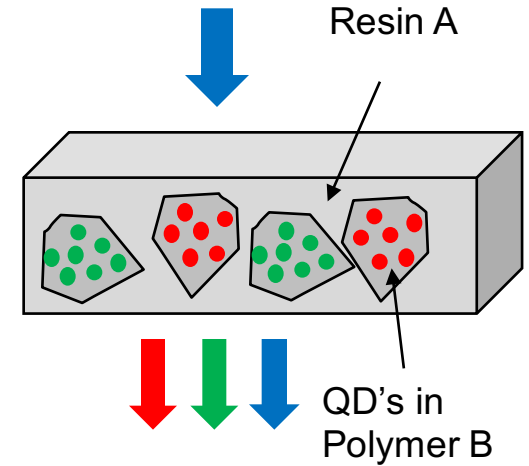
Nanograde QD suspension

- Composition
 - CsPbX₃ nanocrystals (X = Cl, Br, I)
 - Color tuning by chemical composition
- Synthesis
 - Nanograde proprietary synthesis process
 - 1-step synthesis of 5 wt% QD directly in solvent at room temperature
 - Capacity: 1kg pure QDs per day (Q3 2016)
- Liquid suspension properties
 - QY: > 85%
 - FWHM:
 - 25 nm @ 530 nm (green)
 - 35 nm @ 640 nm (red)



Nanograde QD layer

- Adaptive formulation system
 - Solvent based
 - Solvent free
- ROHS compliant QD layer
- Nanograde proprietary architecture
 - 50-um layer of Resin A
 - Polymer B insoluble in Resin A
 - Red and green QDs separated avoiding ion exchange
- Optical performance nanograde backlight film



In-device comparison

Goal:

Compare QD backlight films of different suppliers in Kindle Fire HDX device

	Kindle Fire HDX	Samsung SUHD	Nanograde QD film
QD composition	CdSe	InP	CsPbX ₃ (X = Cl, Br, I)
Color gamut (area) – backlight films in Kindle Fire HDX (replacement of original 3M backlight film) ^{1,2}	85% NTSC	89% NTSC	108% NTSC

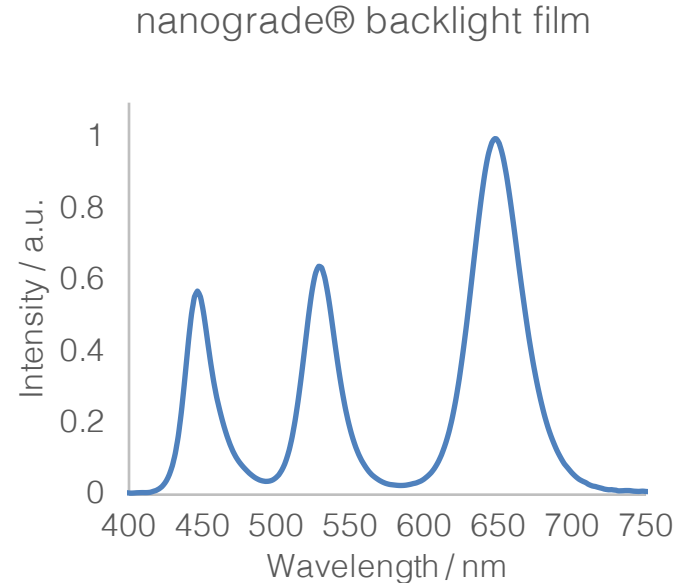
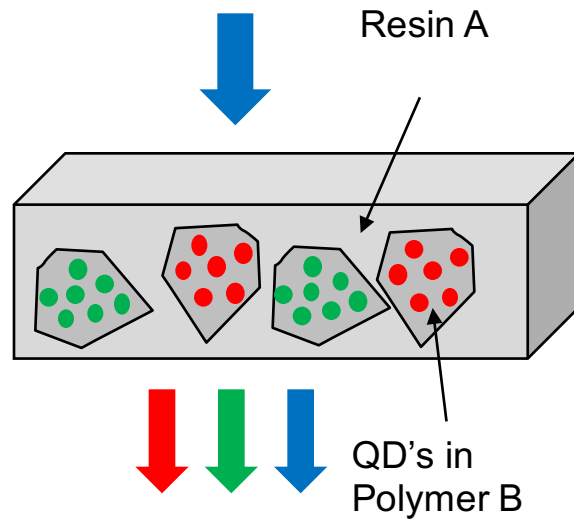
¹ measured by Spectroradiometer (Uprtek)

² based on CIE-1976;

Very wide color gamut possible with Nanograde QDs

Summary

- Cd-free and RoHS compliant
- High-performance QD's
- Cost efficiency due to proprietary synthesis process
- High QD production capacity ready by Q3 2016



Thank you for your attention



nanograde[®]