Phosphors for Next Generation Solid-State Lighting/Displays

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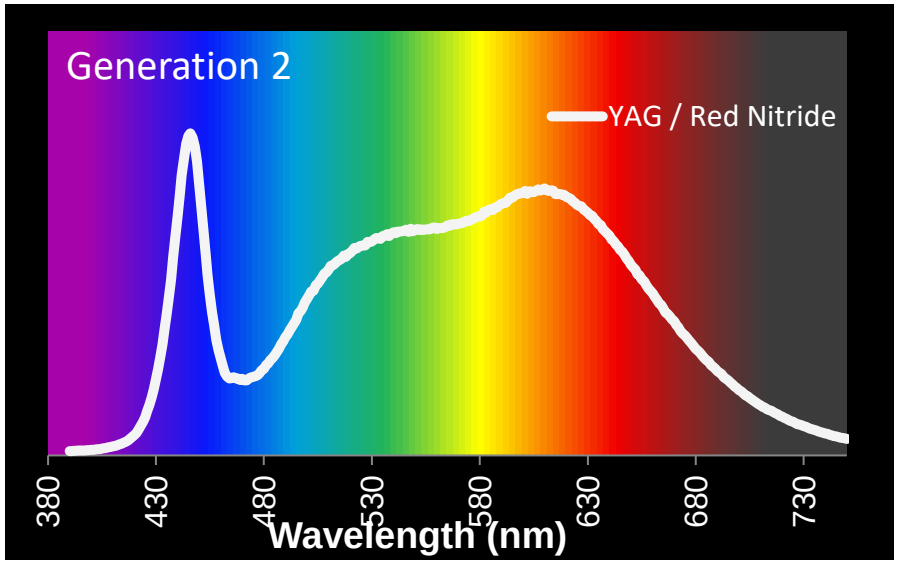
Phosphor Revolution in LCD Displays In Past 5 Years

Pre 2012 = broad band phosphors

Red = Nitride: Eu^{2+}

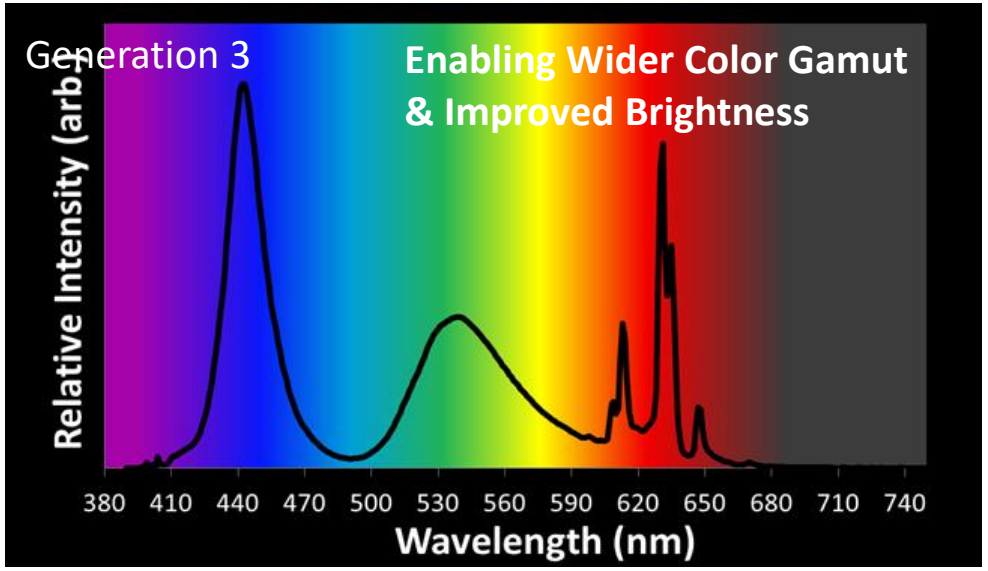
Green = Garnet: Ce^{3+}



Post 2014 = narrow band phosphors

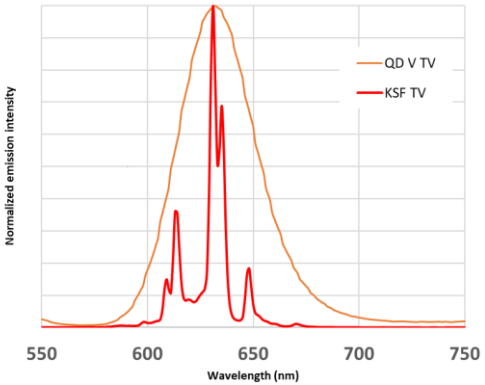
Red = K_2SiF_6: Mn^{4+} GE Technology known as PFS or KSF

Green = β-sialon: Eu^{2+}



Gen	Phosphor(s)	Brightness	Gamut
1	Garnet: Ce^{3+}	high	Low
2	green + nitride:Eu^{2+}	lower	Higher
3	BSiAlON:Eu^{2+} + KSF	highest	highest

- Majority of displays today use phosphor on chip.
- KSF/PFS phosphor has more narrow emission than InP QD.



Narrow-band emitting phosphors enable more efficient, brighter, wider color gamut displays

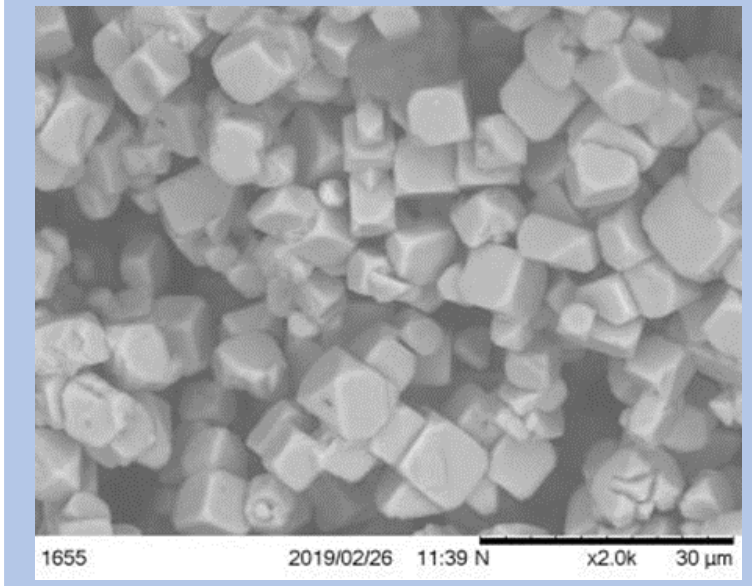
Color Conversion in Minileds: “The future of displays is size diversity”

Display Size Diversity requires LED size diversity which requires phosphor size diversity

We need to consider power consumption as direct view displays may have >10x LED usage with local dimming vs. edge lit displays

Most Affordable WCG Solution

Small Size KSF + green phosphor on chip



Air stability and great blue flux & thermal reliability

KSF + green in a remote part

- Enables high nit/best in class HDR
- high contrast ratio
- Green can be conventional phosphors or QDs
- KSF remote parts now commercialized.

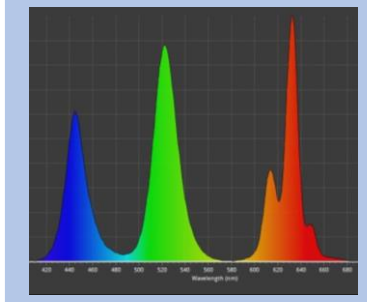
Widest Color Gamut Solution

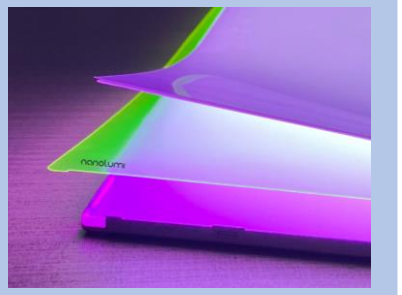
Hybrid GE KSF “Magenta” LED + QD film

Green CdSe QDs = 25nm FWHM

Green Perovskite QDs < 25nm FWHM

KSF + green QD = Rec. 2020 > 91%





The color gamut of KSF on blue LEDs + perovskite QD backlight reached 95% BT.2020

Products expected in 2021

- https://www.displaydaily.com/article/display-daily/ge-updates-on-its-phosphor-technologies
- Honglei Ji et al., SID Digest 2019, p. 1064
- https://nanolumi.com/2020/news/green-perovskite-for-professional-monitors/

Phosphor Inks/Ink Jet Printing for microled color conversion

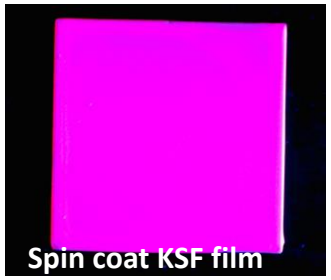
Removal of LCD BLU architecture = great potential for energy savings

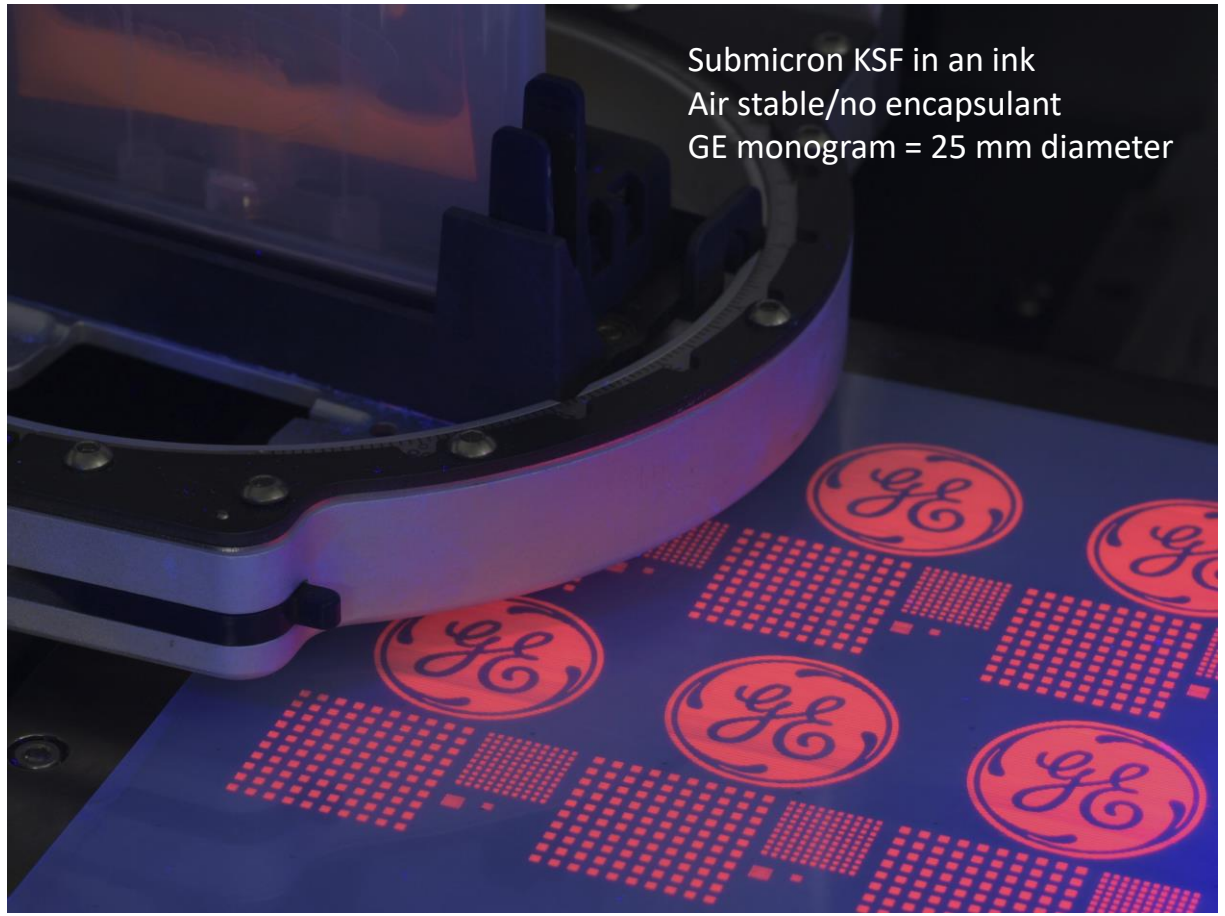
Pros of phosphor inks:

- Reliability
- color gamut
- brightness

Challenges in developing phosphor inks:

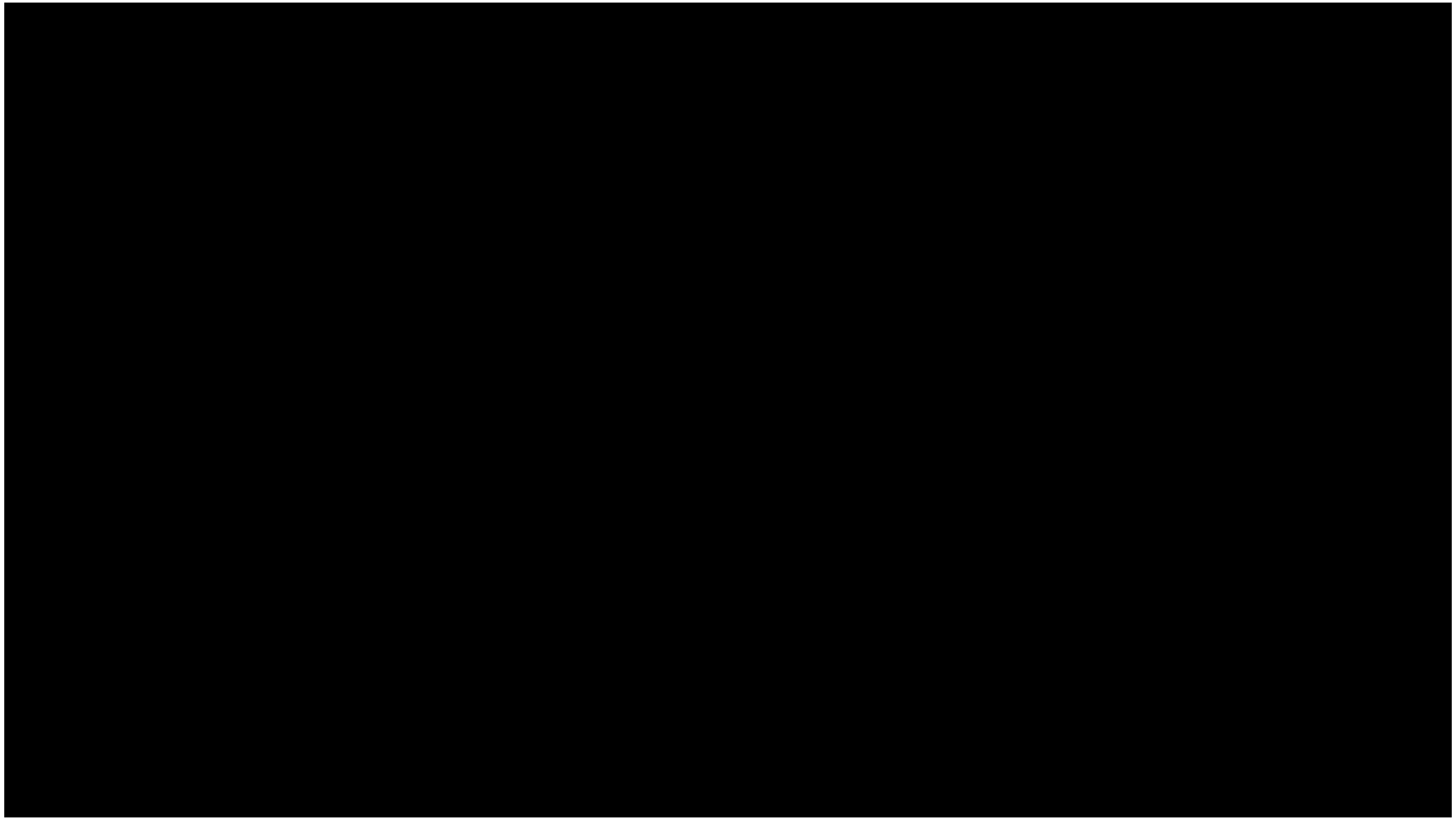
- Can submicron phosphor absorb all blue light in a thin film?
- Maximizing dispersion, minimizing agglomeration.
- Need a more narrow submicron green phosphor





- GE Patented technology enables small size, high absorption KSF
- Decreased particle size by more than 10x while maintaining QE = 90%
- Customer sampling in Q2 2021.
- Contact us to learn more: murphyj@ge.com

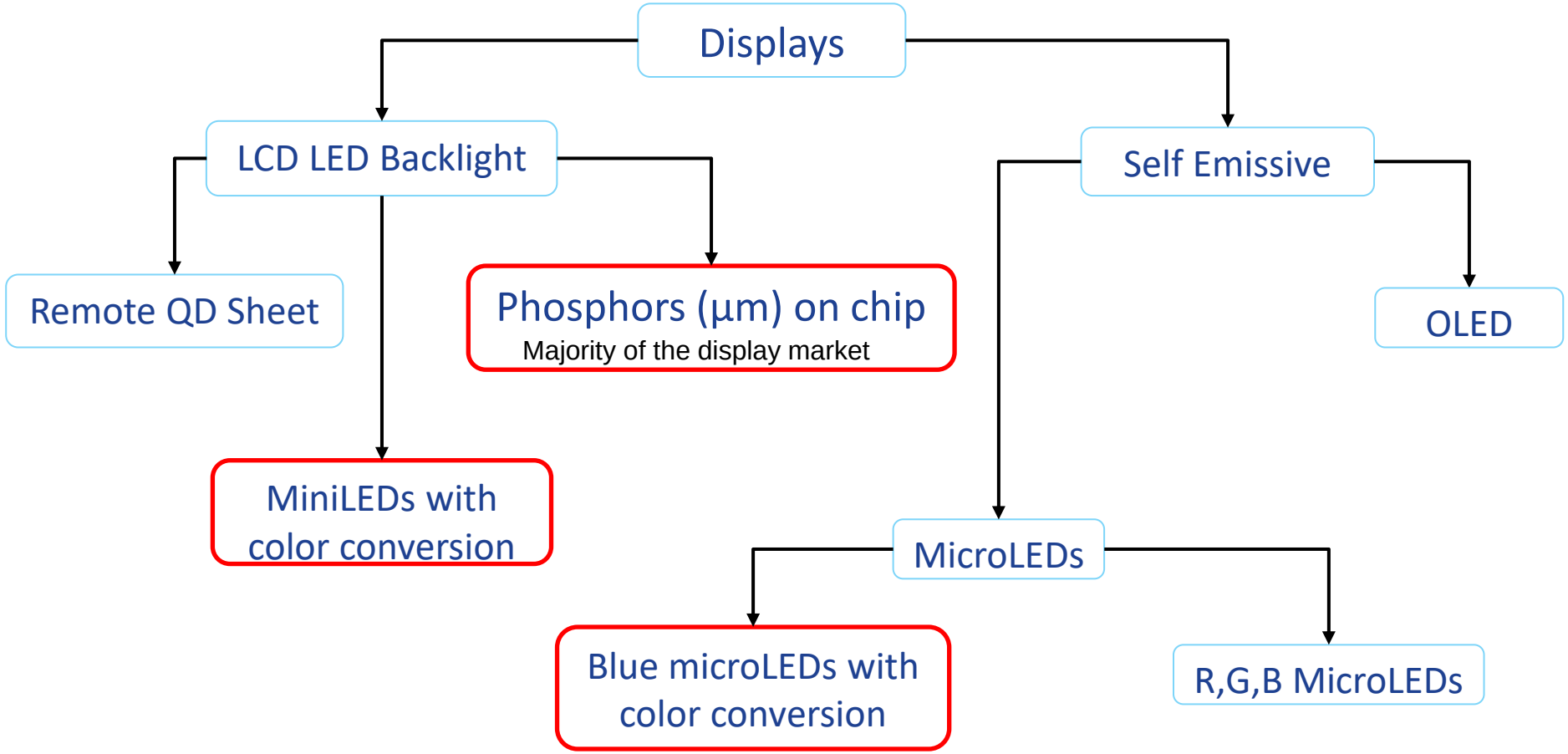
GE ink jet printing submicron KSF for microled displays



https://www.linkedin.com/posts/james-e-murphy-69a34310_microled-displaytechnology-displays-ugcPost-6695339276797833216-g62t

https://www.ge.com/research/newsroom/ge-unveils-inkjet-printed-red-phosphor-pfs-ksf-eyes-next-generation-micro-led-mini-led

Color in Displays of “Tomorrow”



Lighting and Display Cross Cutting R&D

1. Narrow Band Phosphors: Can a more narrow band emitting green phosphor be developed? Can QDs improve reliability to be on chip?
2. LED Size Diversity = Will blue microLEDs + color conversion or R, G B microLEDs prevail as the primary microLED architecture?
3. Physiological response (Circadian response, alertness, macular degeneration concerns, etc.)
   Shifting spectral power distribution to alter human response may require new phosphors (AI/ML opportunities).

https://eyesafe.com/display/