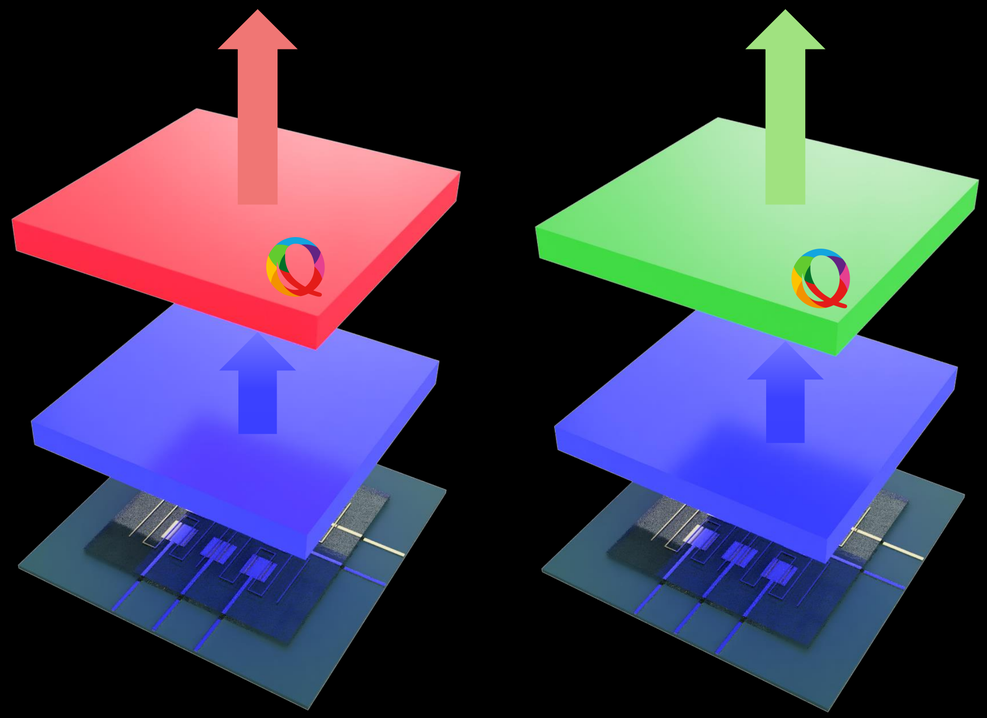
QustomDot

Cd-free Quantum Dot Color Converters for MicroLED Applications

FLANDERS INVESTMENT & TRADE

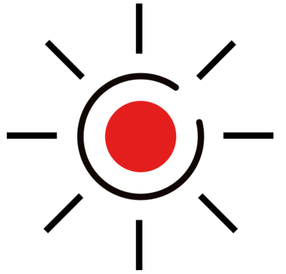
Flanders State of the Art

QustomDot delivers **Cd-free QD color conversion** for **microLED** applications



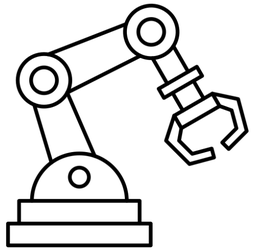
microLED displays have a **strong and enticing USP**

Better energy efficiency than OLED or LCD



Incredible brightness

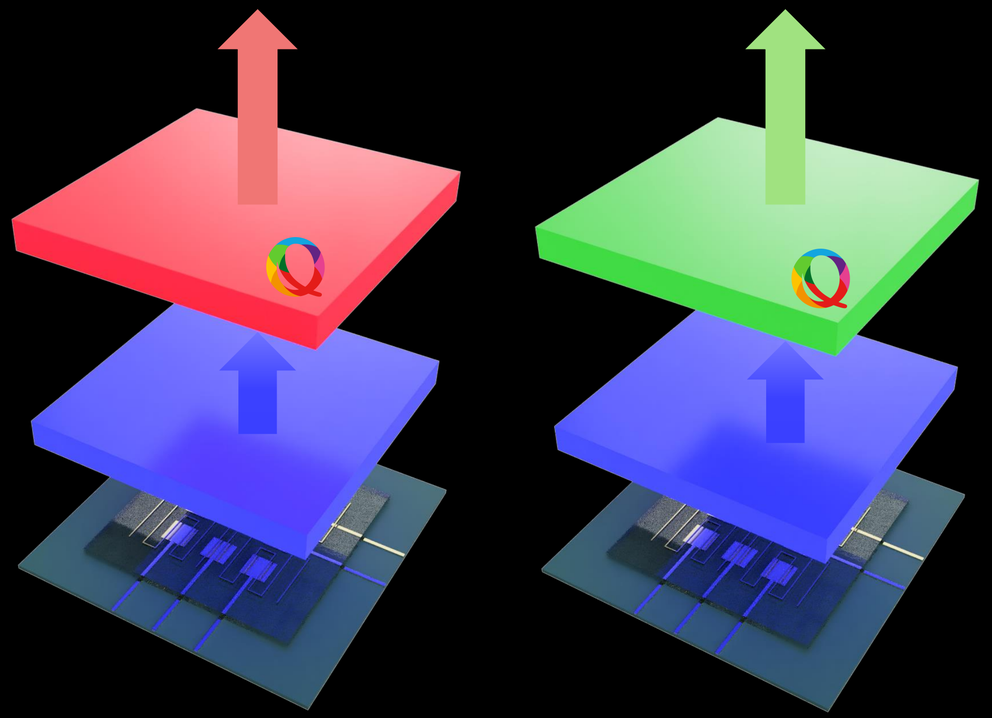
microLED applications go **far beyond** current display technologies



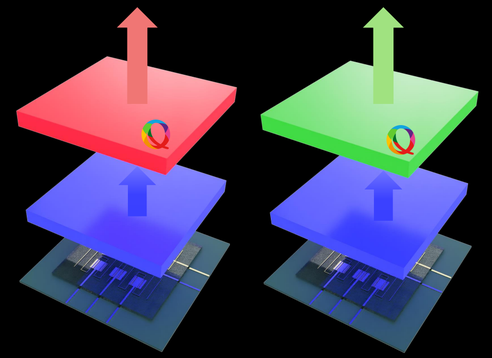
Production cost **20-40x too high** for commercial viability

and **red** microLEDs are **inefficient** and expensive

Red and green quantum dot **color conversion** enables a **commercially viable** microLED technology

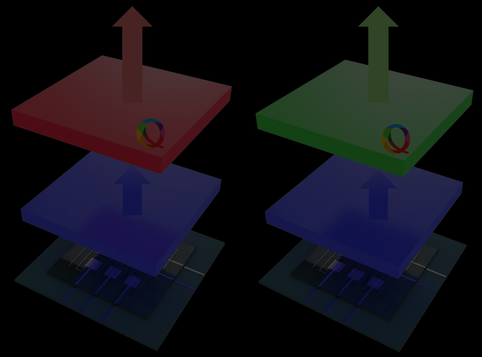


Color conversion **simplifies manufacturing**



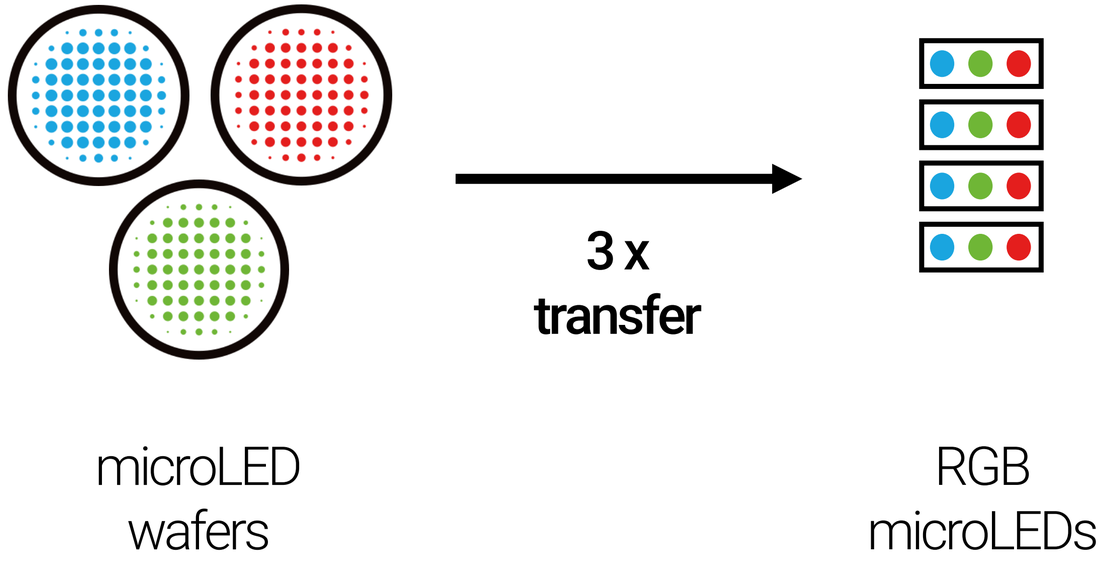
Color conversion delivers **high-performing red and green microLEDs**

Color conversion **simplifies manufacturing**

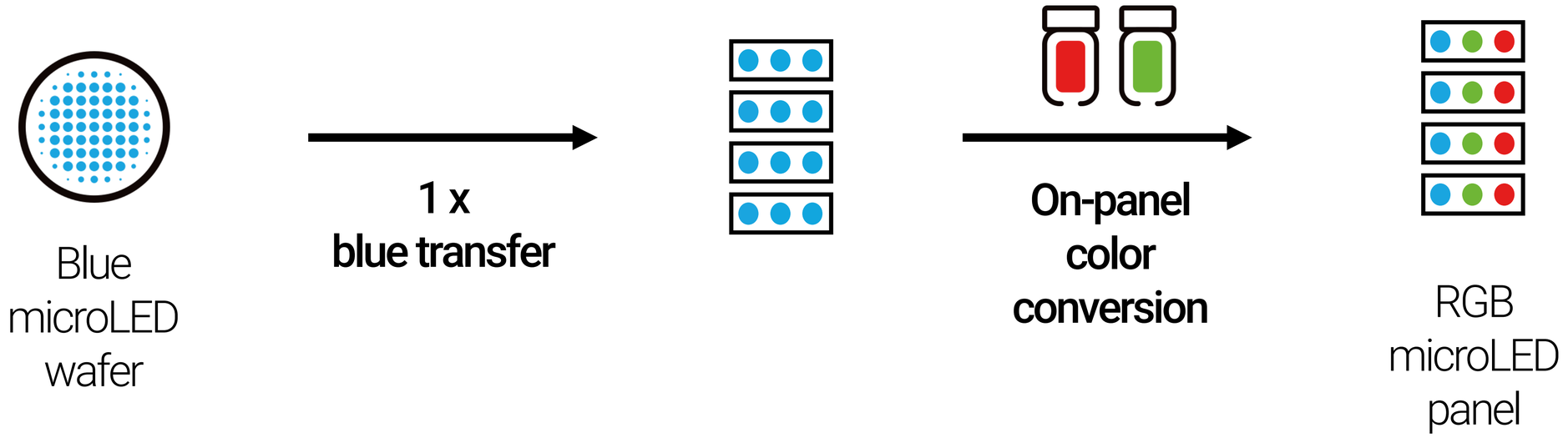


Color conversion delivers **high-performing red and green microLEDs**

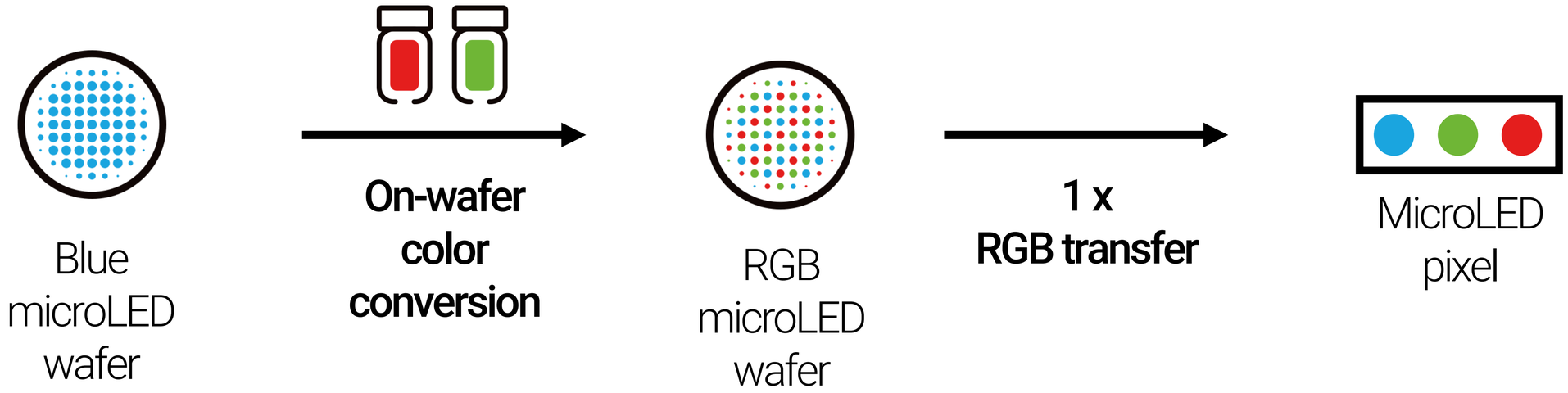
Mass transfer – conventional technology requires 3 mass transfer processes



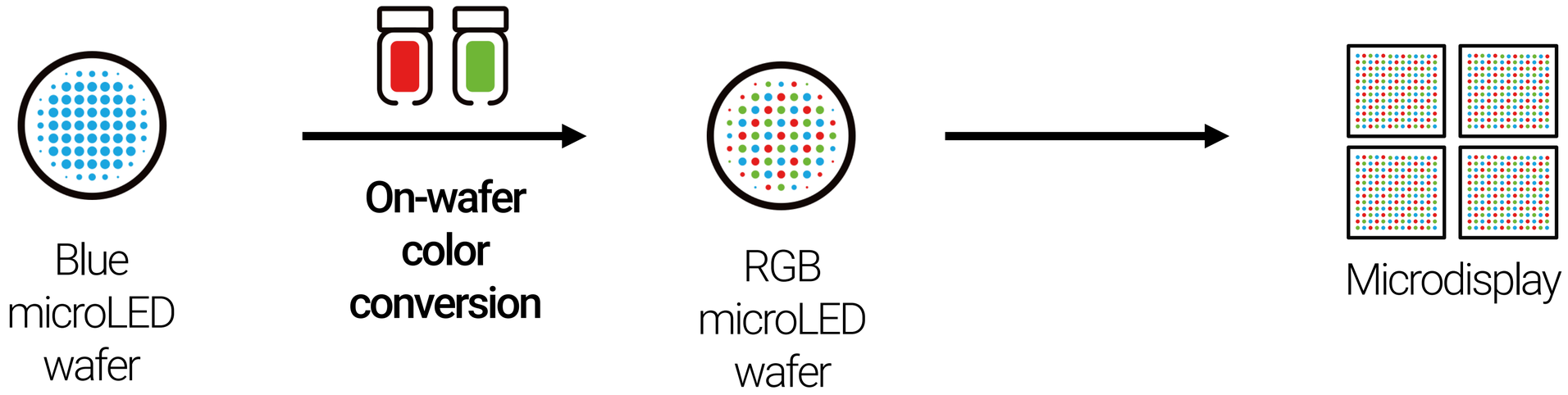
Color conversion delivered **on panel**, after mass transfer process



Color conversion delivered **on wafer**, before mass transfer process

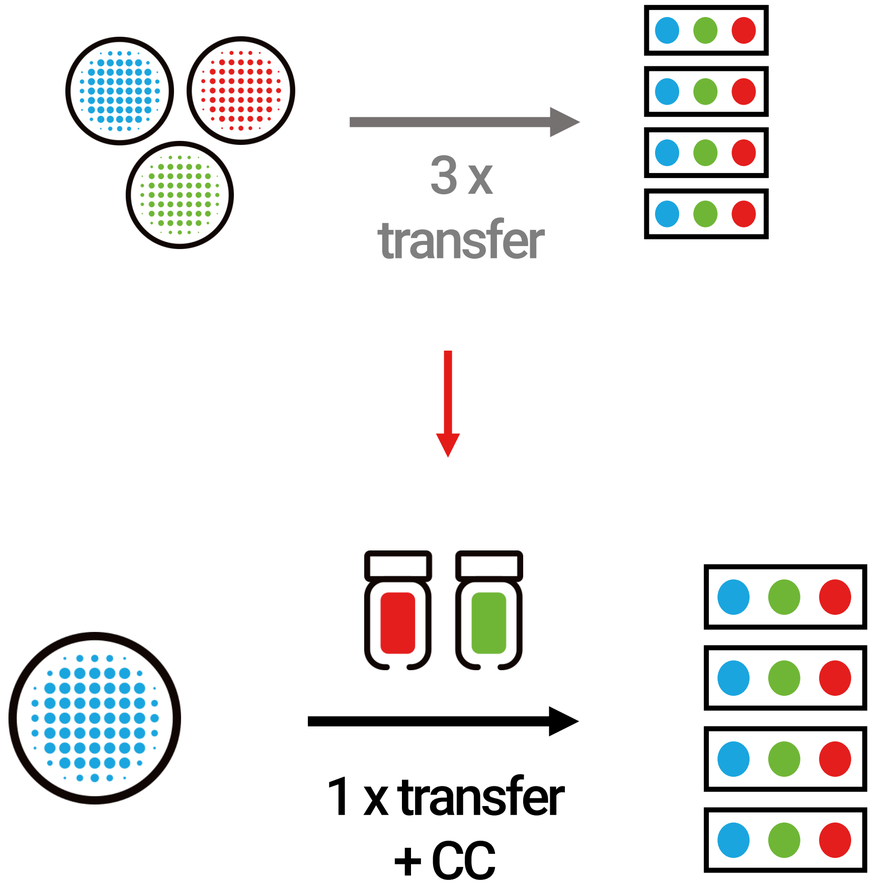


Color conversion delivered **on wafer**, after mass transfer process



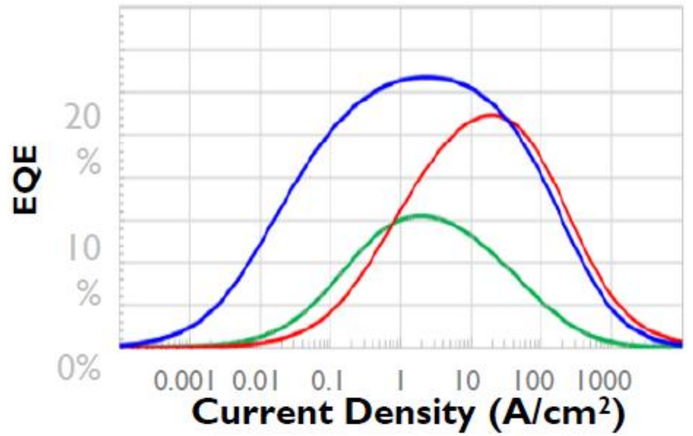
Color conversion **simplifies** the microLED **mass transfer** process

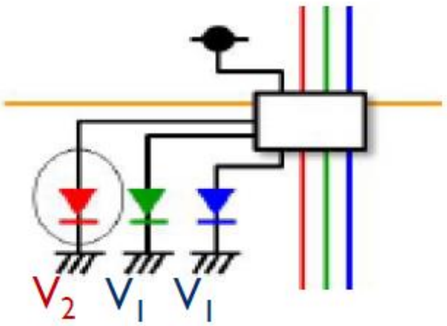
- Reduces number of transfer cycles 3x
- Overall transfer yield improvements
- Flexibility in color conversion integration



The **red gap** - conventional technology requires 2 different die materials

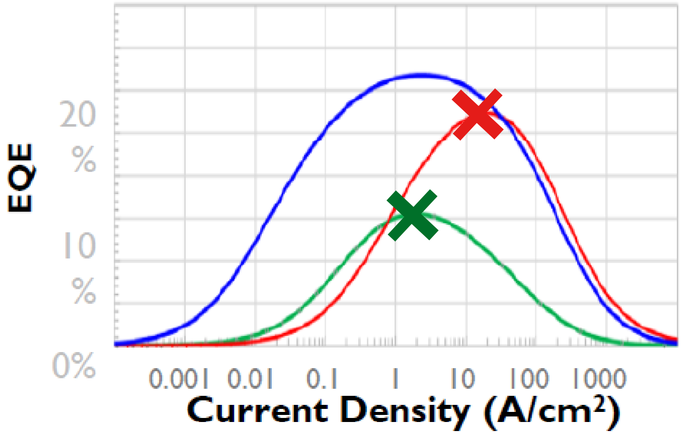
- Red AlGaInP driven at current densities far from optimal efficiency
- Different driving voltage required
- Accommodating for AlGaInP adds complexity to the electronic circuits



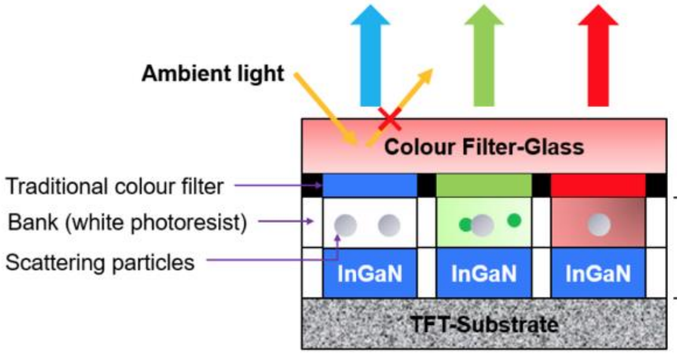


Source: yole

Color conversion **simplifies** the microLED **driving electronics**

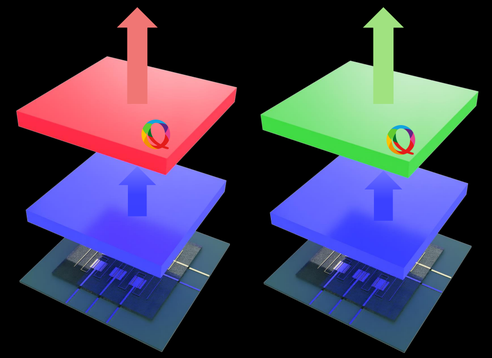


- 1 single blue InGaN material
- Single set of turn-on voltages, I(V) and temperature characteristics
- QD-CC leverages maximal efficiency of blue InGaN



Source: Taiwan Nanocrystals Inc., SID 2018 in LA, USA

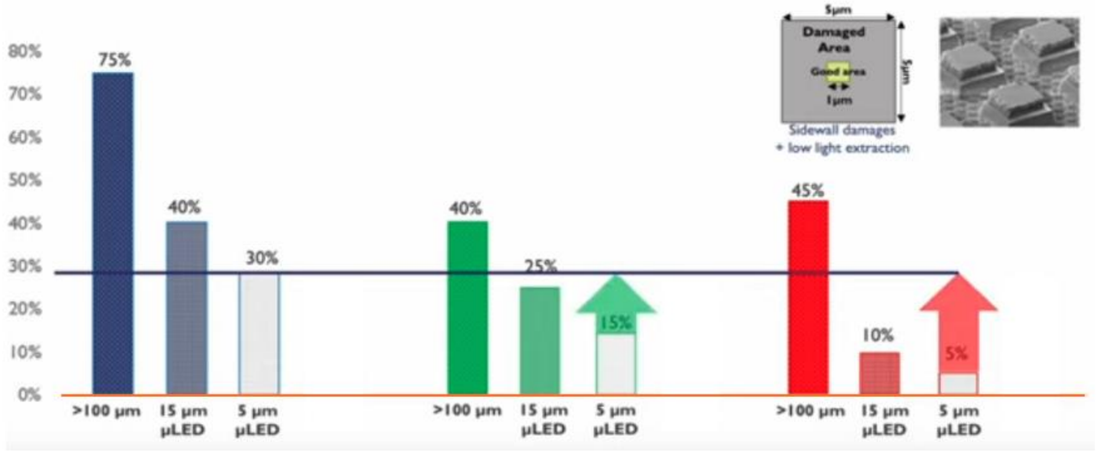
Color conversion **simplifies manufacturing**



Color conversion delivers **high-performing red and green microLEDs**

Color conversion **delivers** microLEDs with **higher efficiency** and **lower power consumption**

- Largest efficiency gain in red color
- Total power consumption decreases by more than 40%
- Further gains are a function of blue microLED development

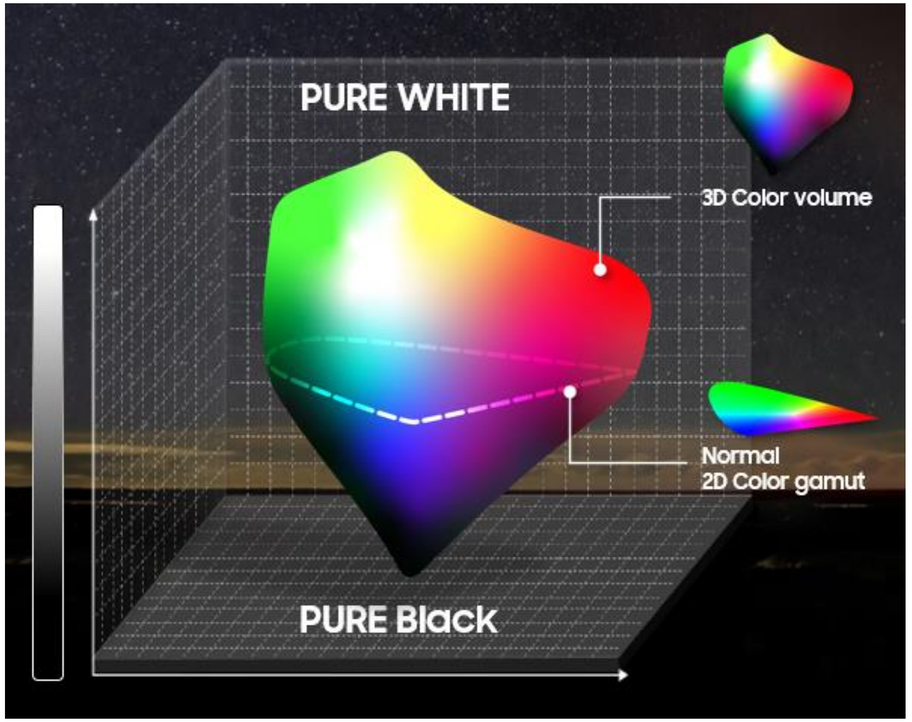


	Native RGB			Color Conversion		
	Required Optical Power: 100			Required Optical Power: 100		
Power distribution	Red: 35%	Green: 50%	Blue: 15%	Red: 35%	Green: 50%	Blue: 15%
µLED efficiency	5%	15%	25%	25%	25%	25%
QD efficiency				60%	75%	
Color filler				90%	90%	90%
Total efficiency	5%	15%	25%	14%	17%	23%
Power consumption	700	333	60	259	296	67
Total Power	1093			622		

Source: yole

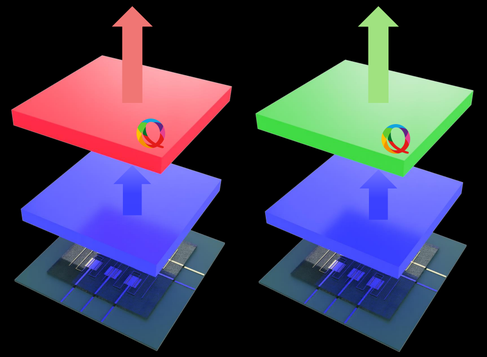
Color conversion **delivers** displays with **large color gamut volume**

- Emission wavelength can be tuned towards application need
- Narrow emitters
- Color saturation maintained at high luminance: large color gamut volume



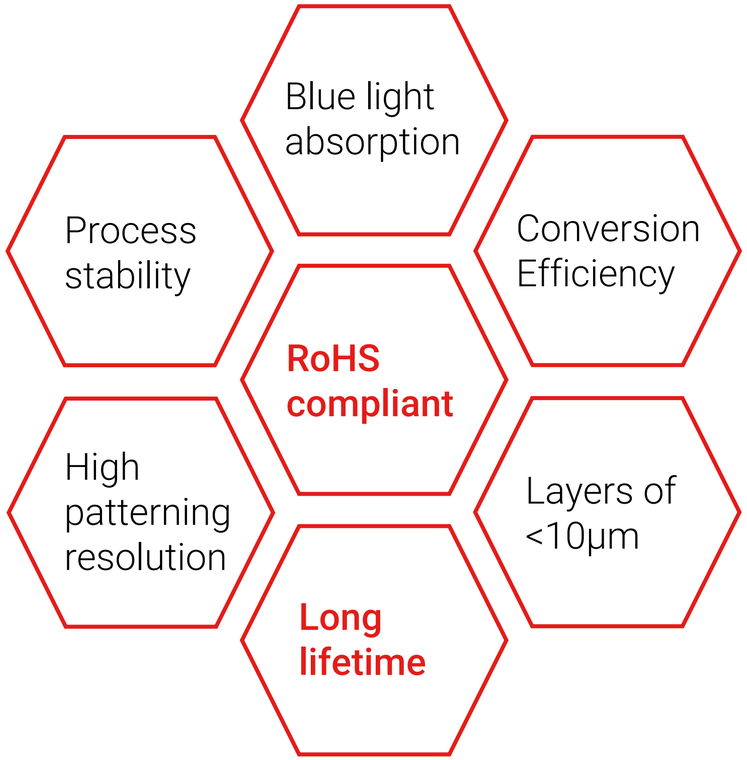
Source: Samsung Display Corporation

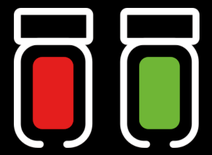
Color conversion **simplifies manufacturing**



Color conversion delivers **high-performing red and green microLEDs**

The **challenge** for QD colour conversion: bring a complete & easy-to-use solution to microLED manufacturers





Cd-free QD challenge 1:
high color conversion efficiency below 10 µm

Cd-free QD challenge 2:
photostability at high blue light flux

Cd-free QDs deliver high color conversion efficiency in **large LEDs**

- 50% color conversion efficiency shown above 100 µm
- Manuscript in review

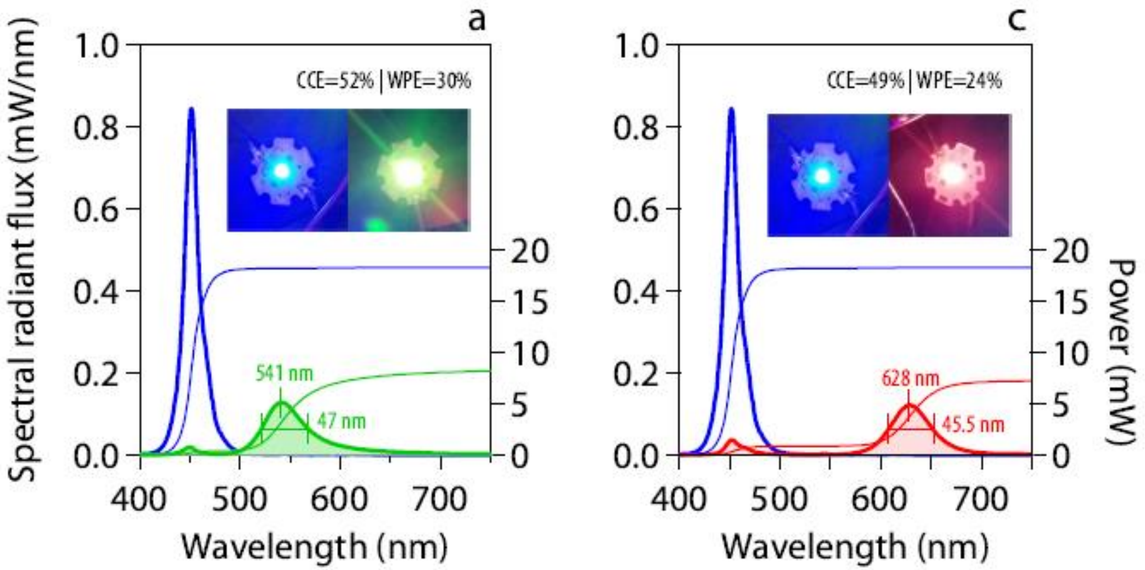
GHENT UNIVERSITY

KU LEUVEN

QustomDot

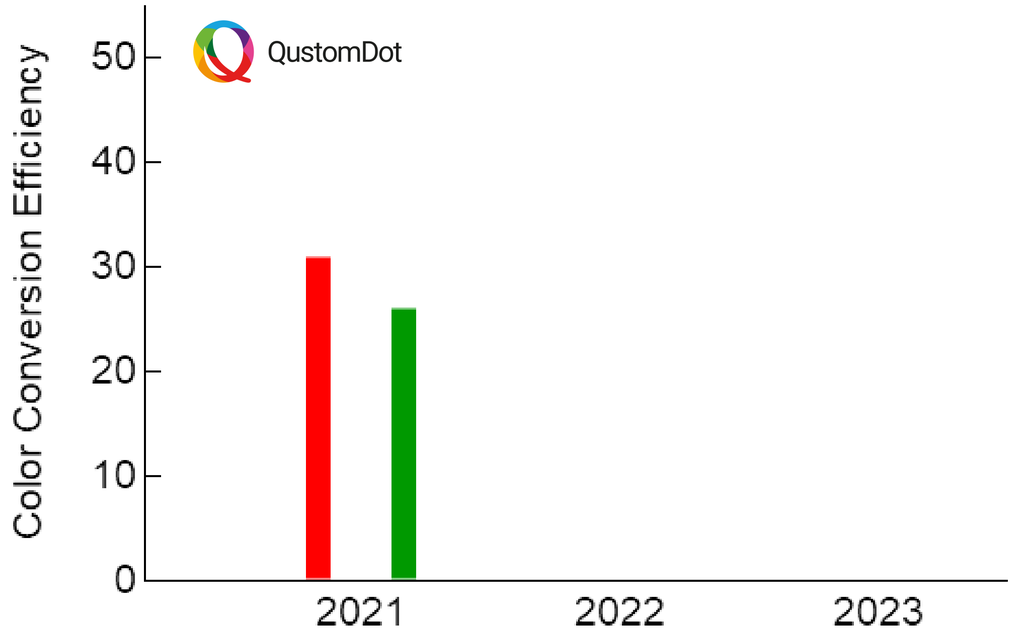
Color conversion efficiency

52 % **49 %**



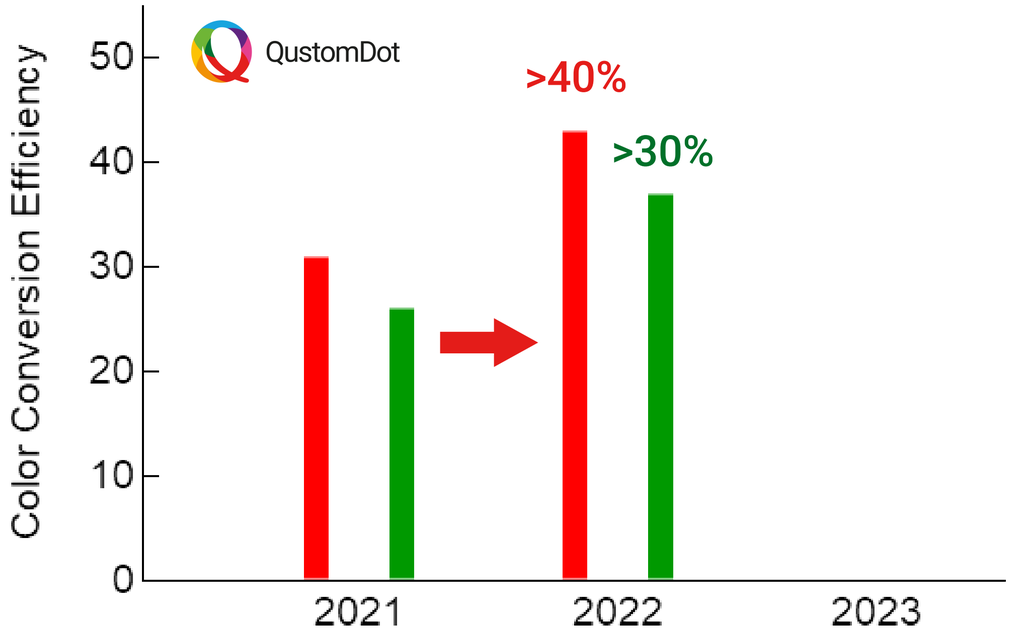
Cd-free QD challenge – high conversion efficiency in < 10 µm

- 10-40 x increase in QD solid required compared to large LEDs
- Expertise in QD surface chemistry is essential



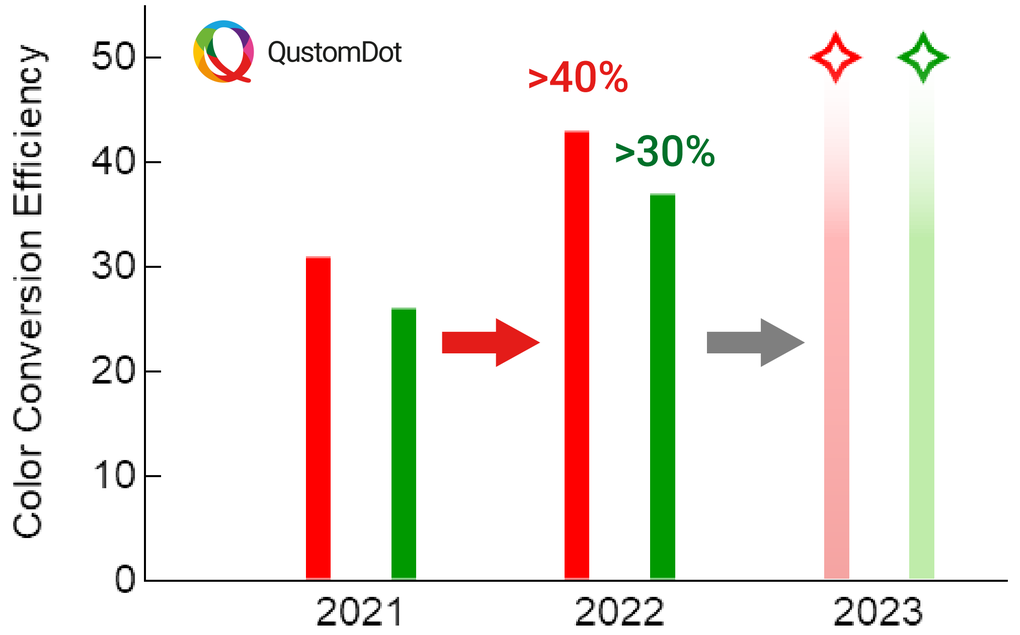
Cd-free QD challenge – high conversion efficiency in < 10 µm

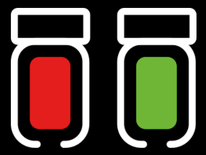
- 40% color conversion efficiency breached for red QD films
- 30% color conversion efficiency breached for green QD films



Cd-free QD challenge – high conversion efficiency in < 10 µm

On track to breach 50% barrier in 2023



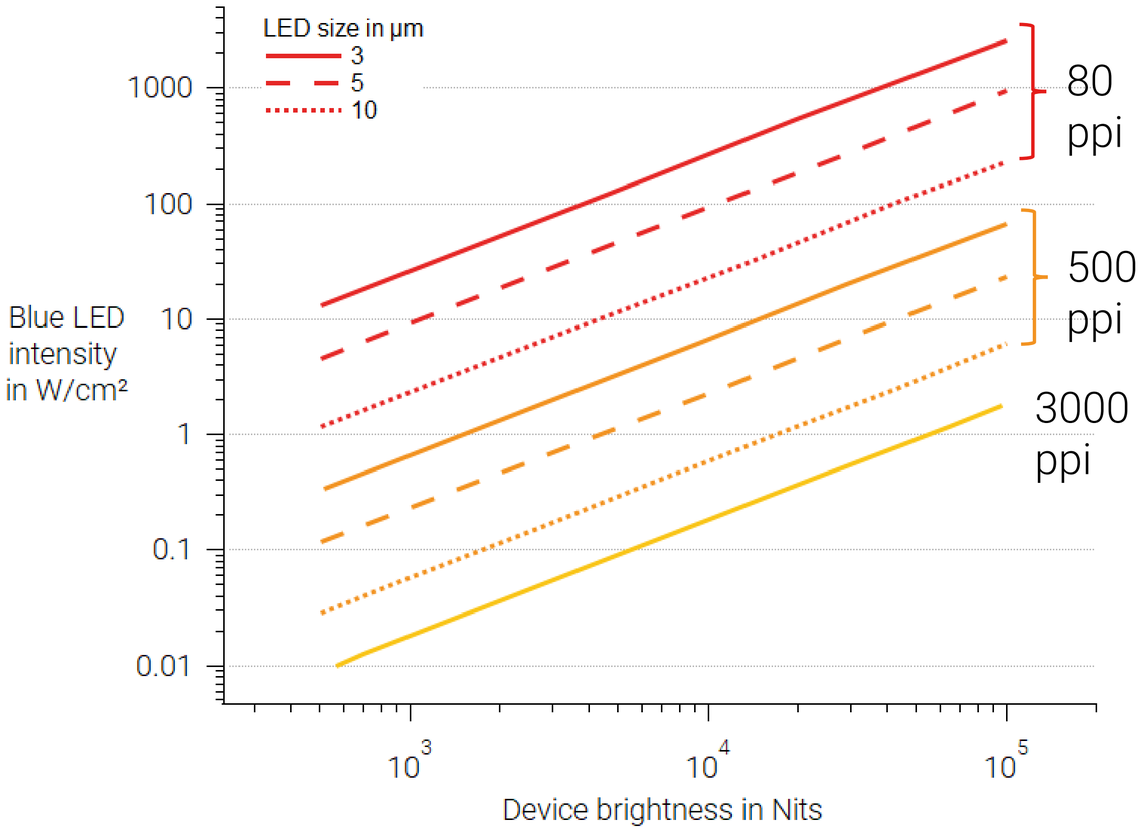


Cd-free QD challenge 1:
high color conversion efficiency below 10 µm

Cd-free QD challenge 2:
photostability at high blue light flux

Required pump flux depends on **display brightness and panel design**

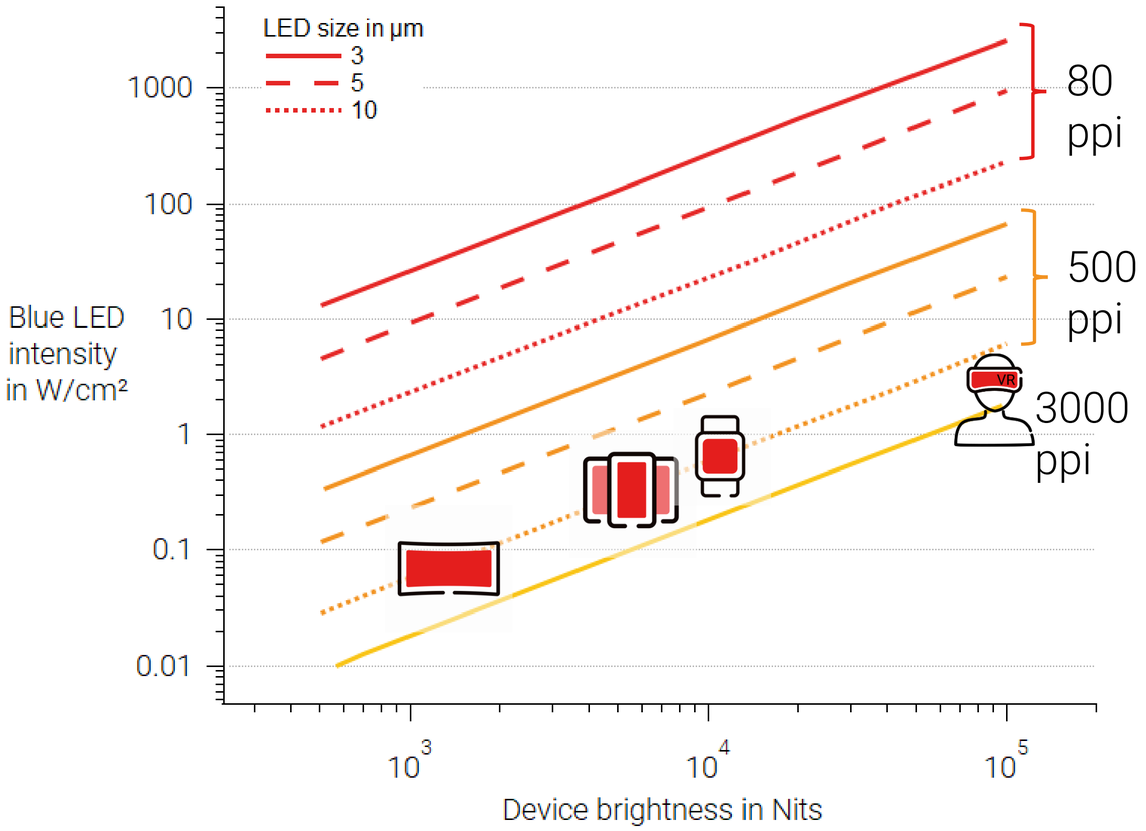
The screen brightness, pixel density and LED size determine the blue pump intensity



Source: yole

Application segmentation as guiding principle

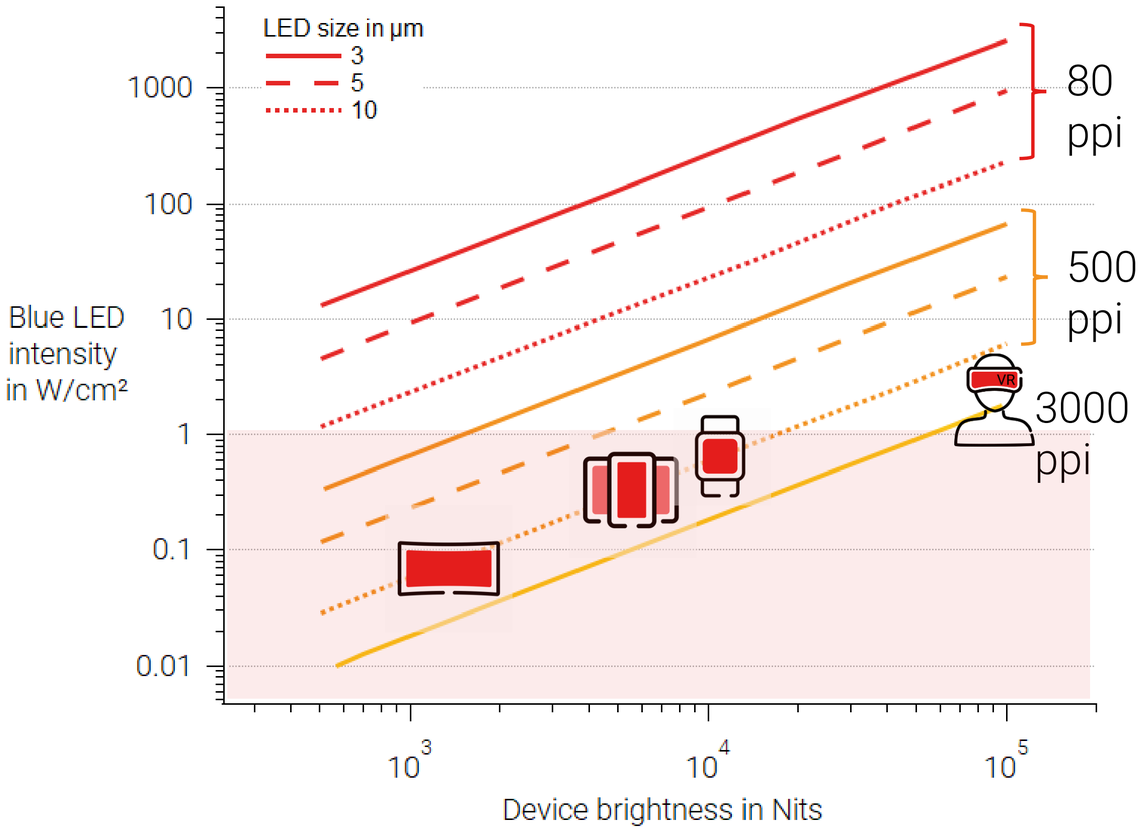
- Different microLED applications can be positioned in different regions of the graph
- Still highly variable on pixel/panel design



Source: yole

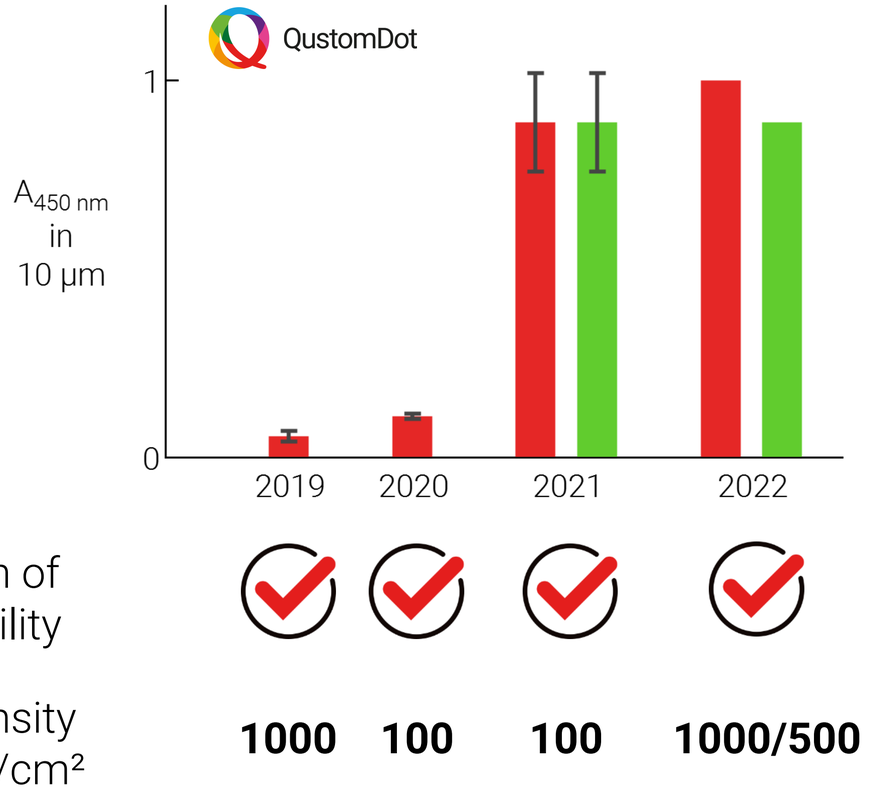
Cd-free QD challenge– high blue light flux

- Majority of microLED applications can be targeted below 1 W/cm² blue LED intensity
- High-end AR applications (>1M nits) operate around 5 W/cm²

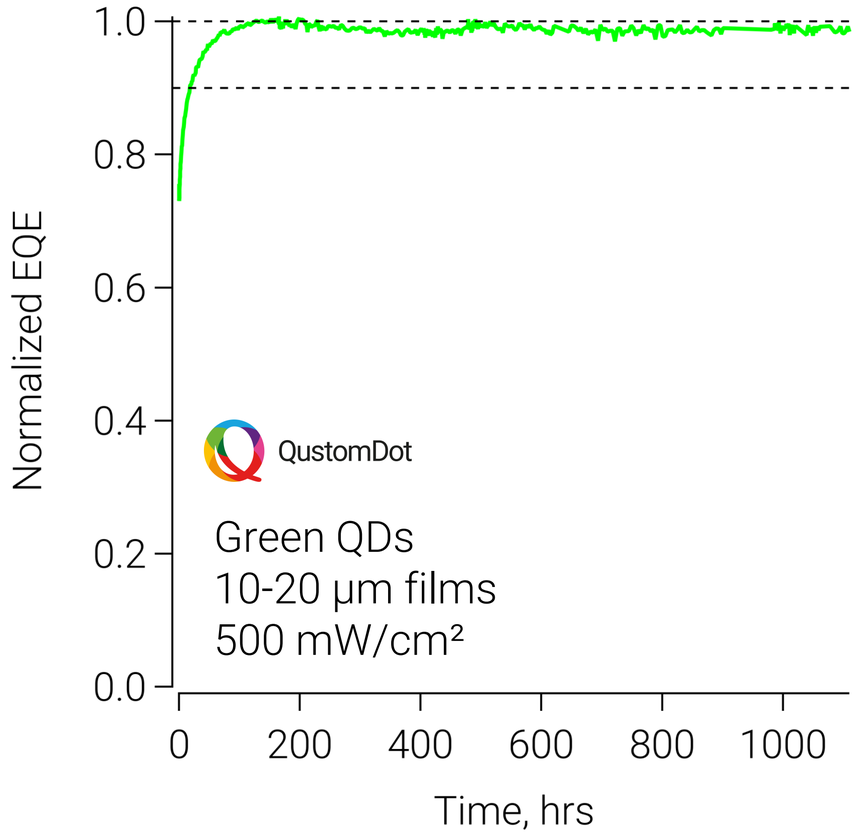


Source: yole

QustomDot’s Cd-free QD photostability facilitates QD-microLED applications

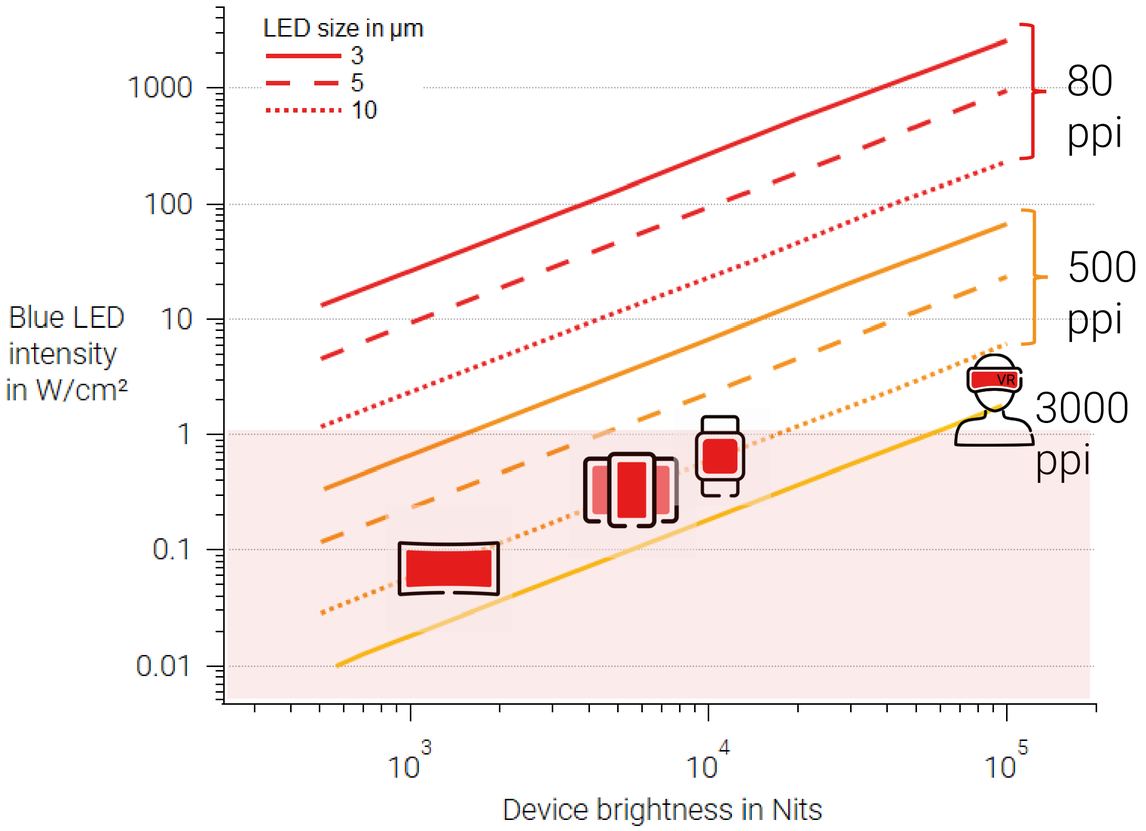


Excellent optical properties maintained over 1000 hours



Cd-free QD challenge– high blue light flux

- QustomDot on track to enable entry-level microLED displays with color conversion
- Further development towards high-end microLED applications



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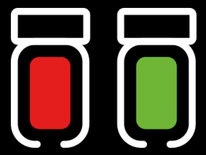
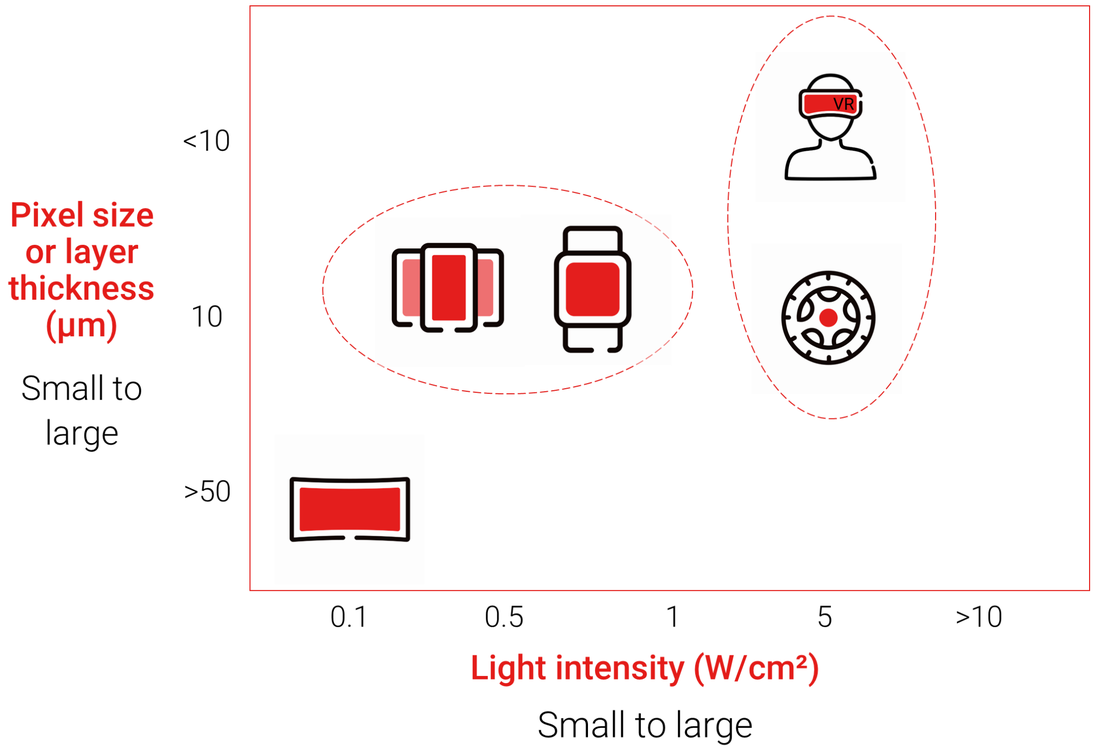


Cd-free QD challenge 1:
high color conversion efficiency below 10 µm

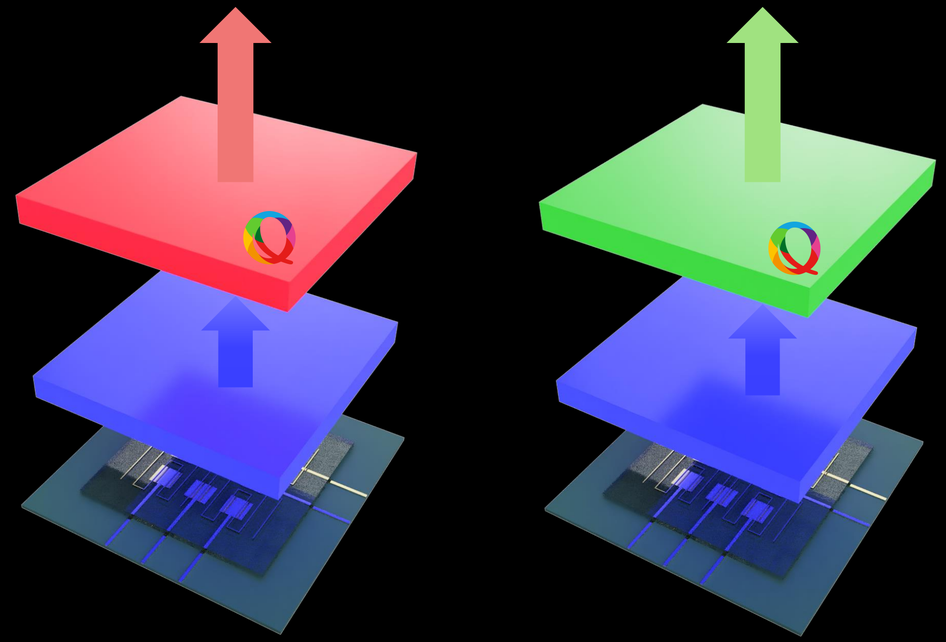
Cd-free QD challenge 2:
photostability at high blue light flux

2023 outlook

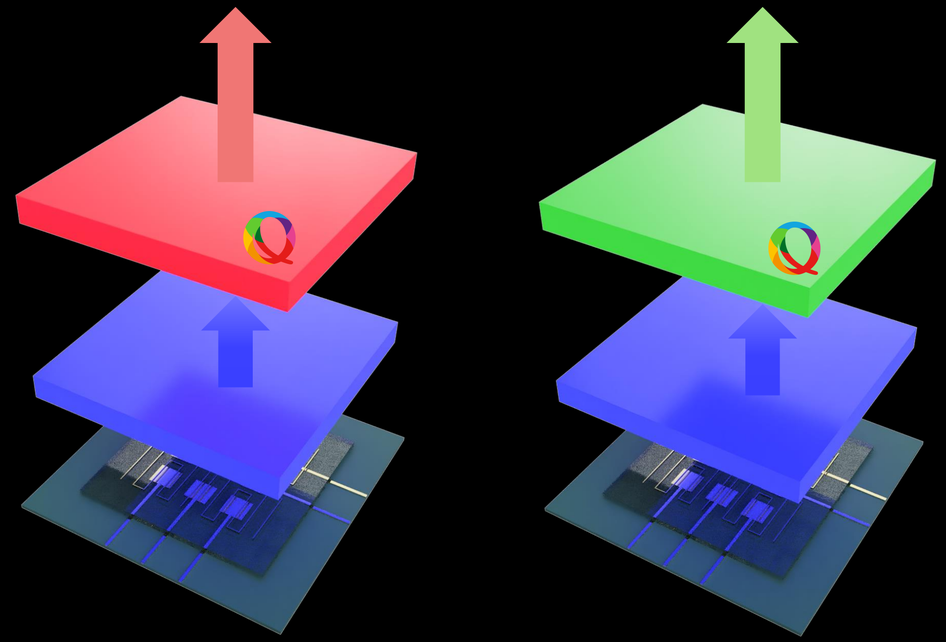
- **Product development** towards entry-level microLED applications
- Technology development for high-end microLED applications
- Fundraising to support our mission



Raising series A to bring a **Cd-free QD ink** for **microLED** applications to the market



Check out our podcast QustomDot Radio!



Don’t hesitate to reach out!

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