

# Cd-free Quantum Dot Color Converters for MicroLED Applications

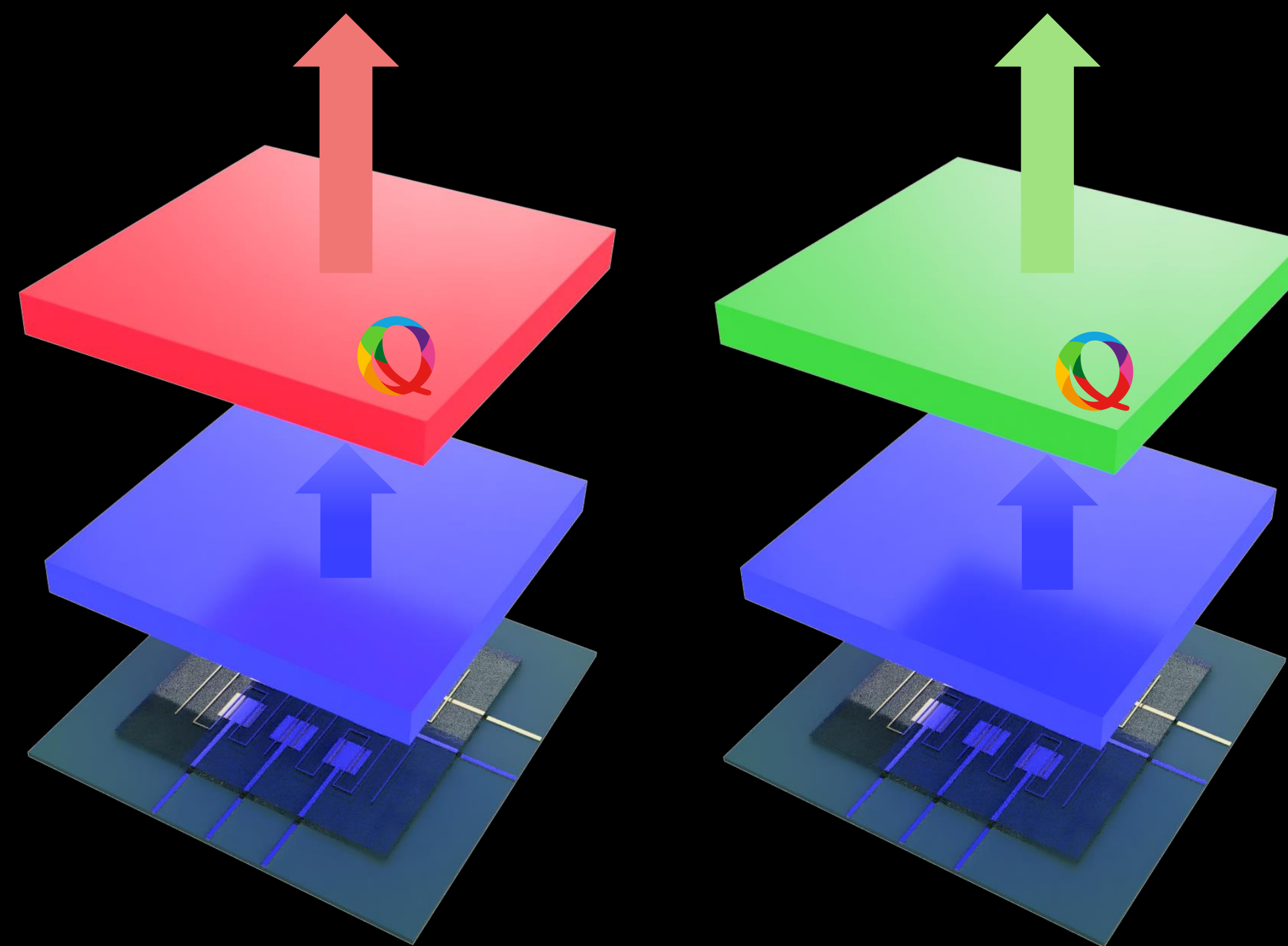
1





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

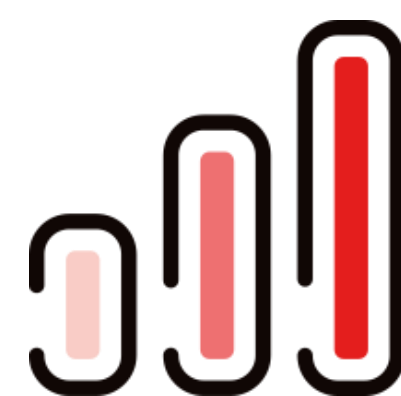
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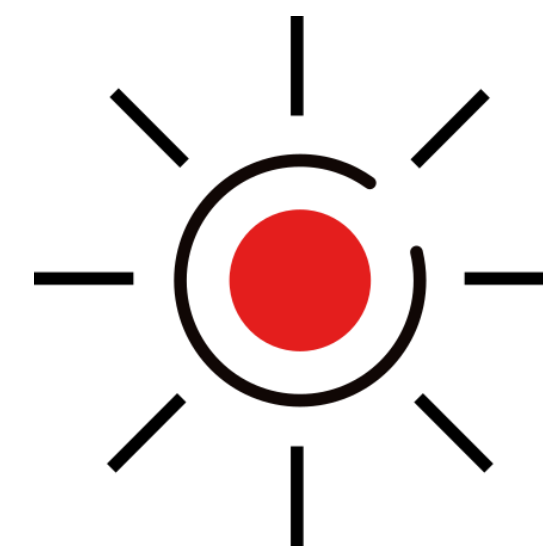


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microLED  
displays have a  
**strong and  
enticing USP**



Better energy  
efficiency than  
OLED or LCD



Incredible  
brightness



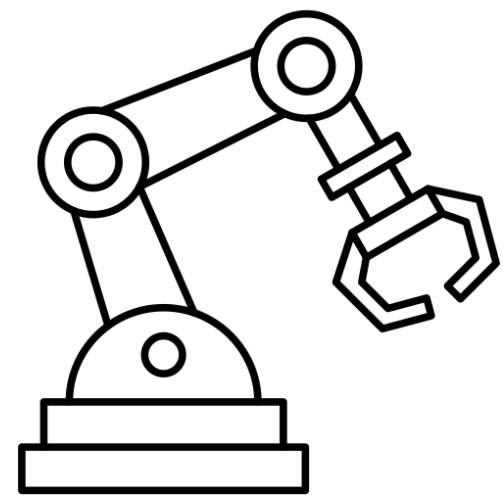


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microLED  
applications go  
**far beyond**  
current display  
technologies

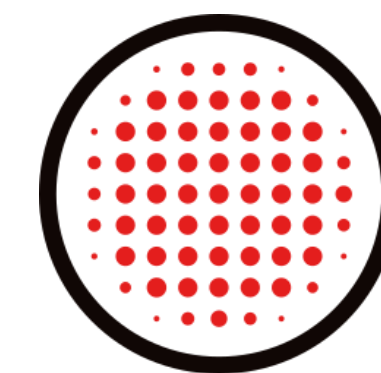






Production cost **20-40x too high** for commercial viability

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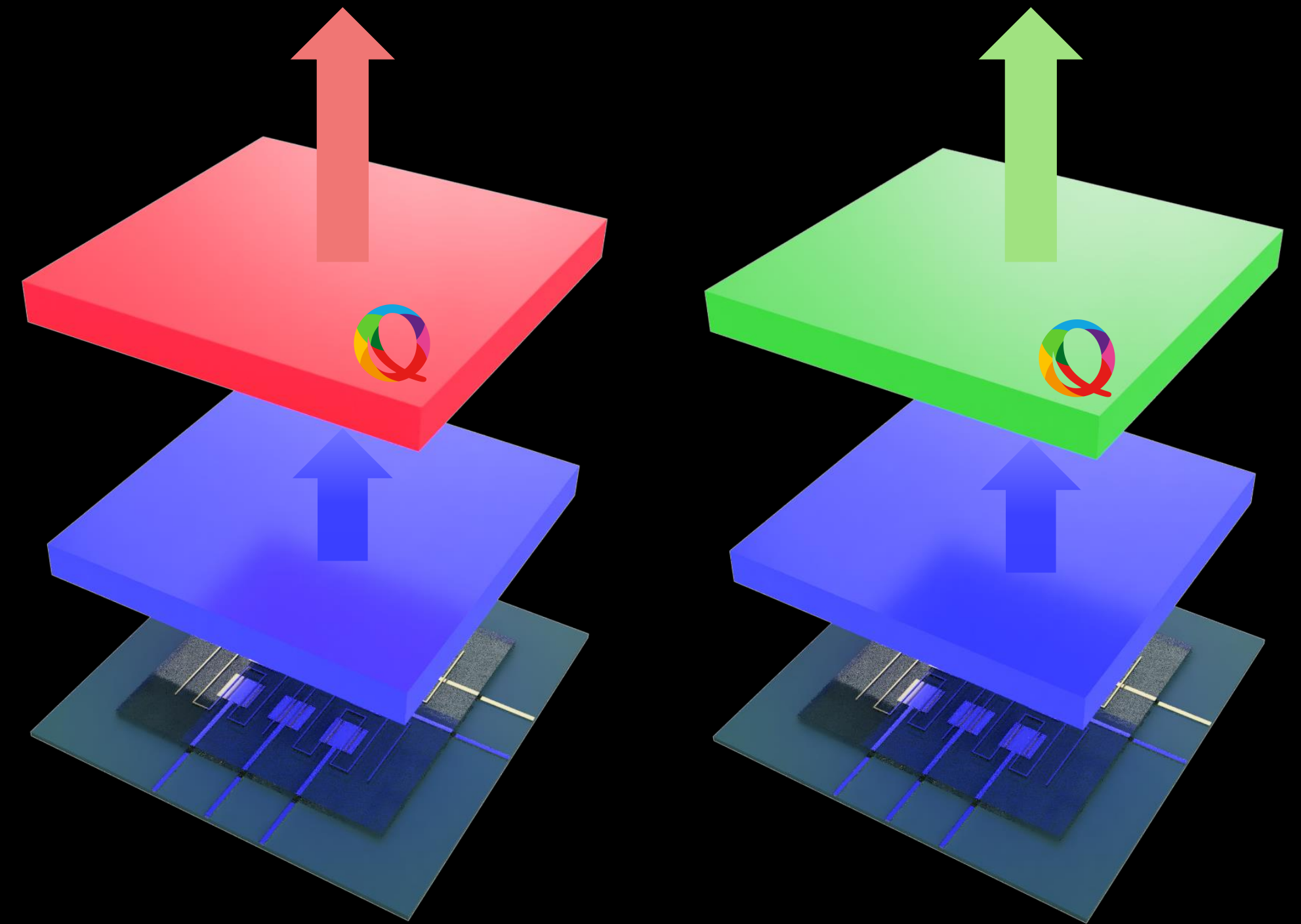


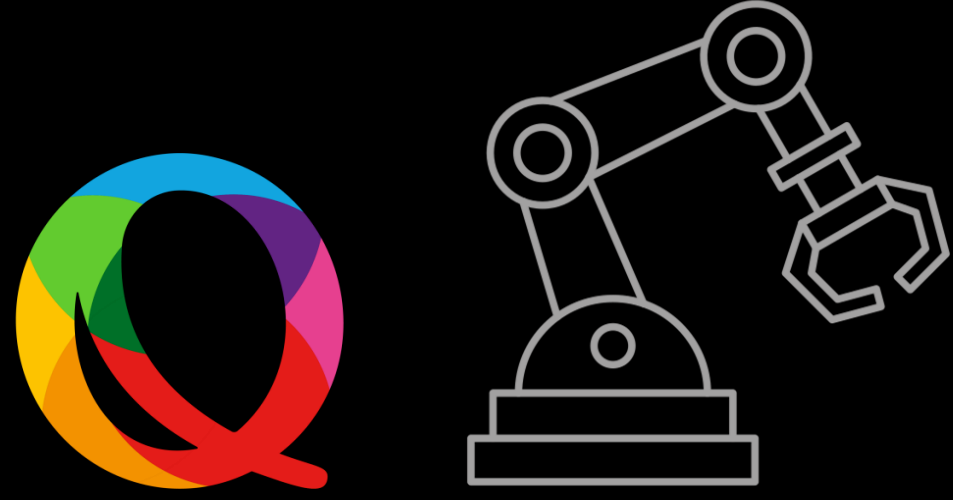
and **red** microLEDs are **inefficient** and expensive



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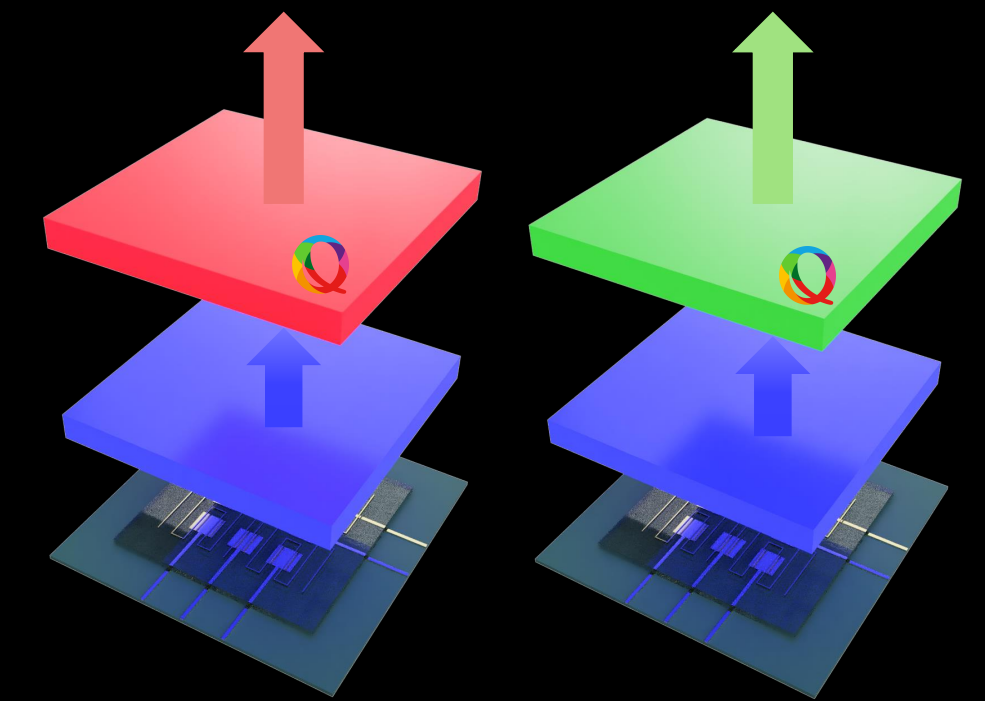
Red and green quantum dot  
**color conversion** enables a  
**commercially viable** microLED  
technology



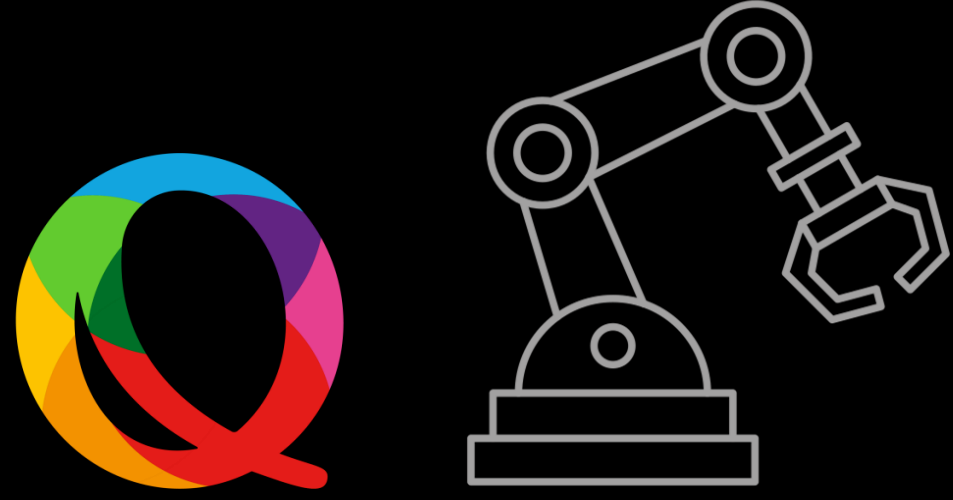


Color conversion **simplifies manufacturing**

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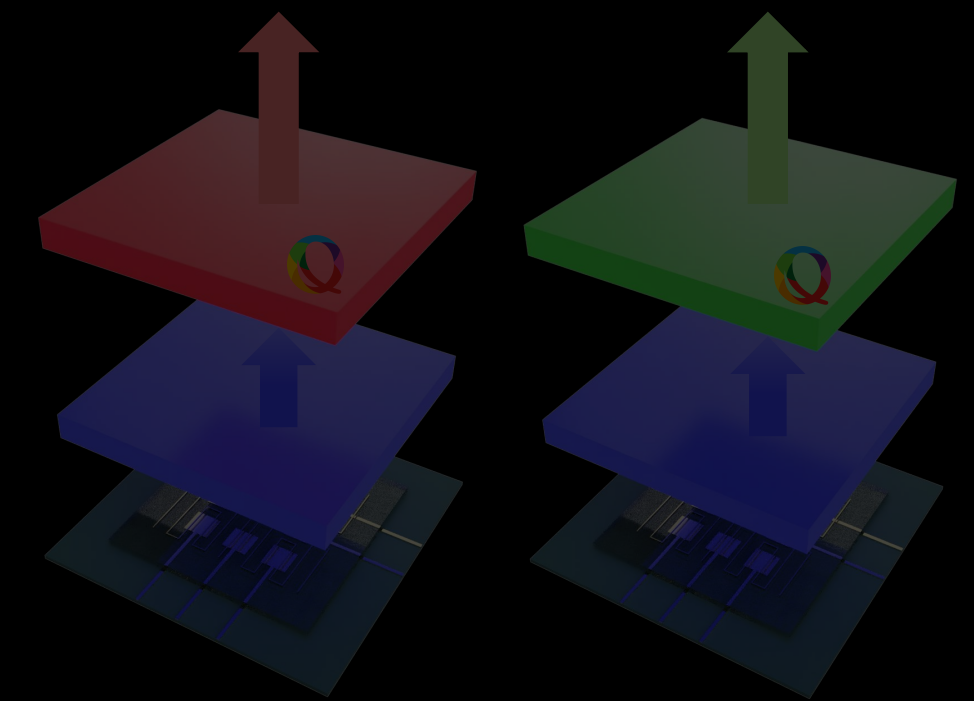


Color conversion delivers **high-performing red and green microLEDs**



Color conversion **simplifies manufacturing**

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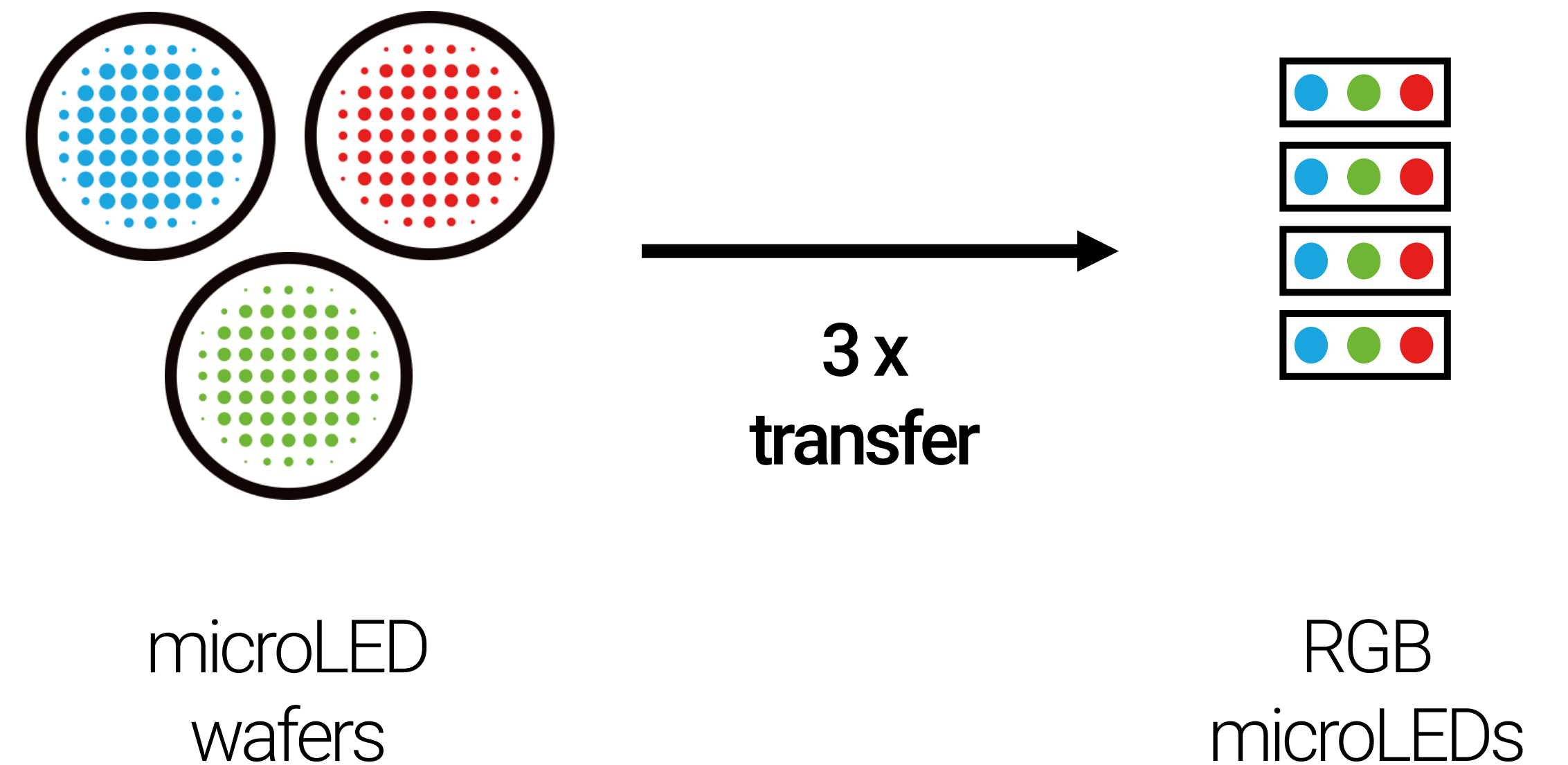


Color conversion delivers **high-performing red and green microLEDs**





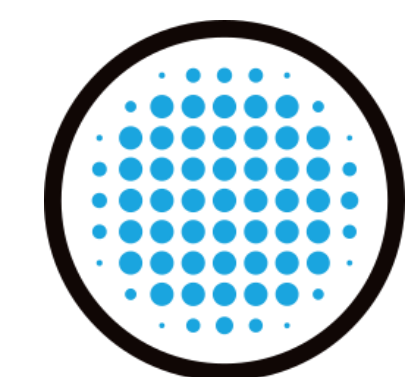
**Mass transfer** – conventional technology requires 3 mass transfer processes





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

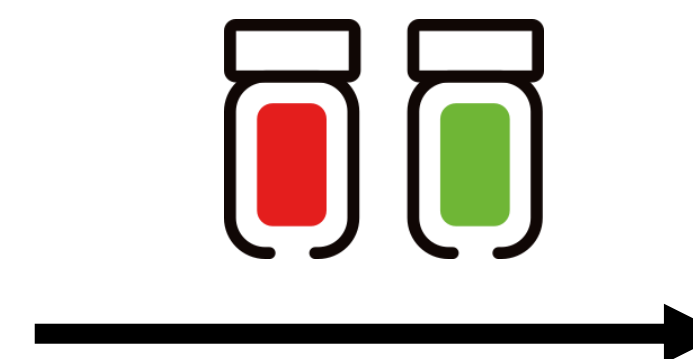
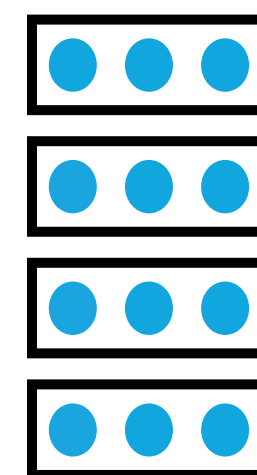
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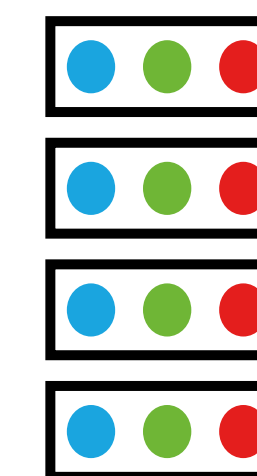
Blue  
microLED  
wafer



1 x  
**blue transfer**



**On-panel  
color  
conversion**

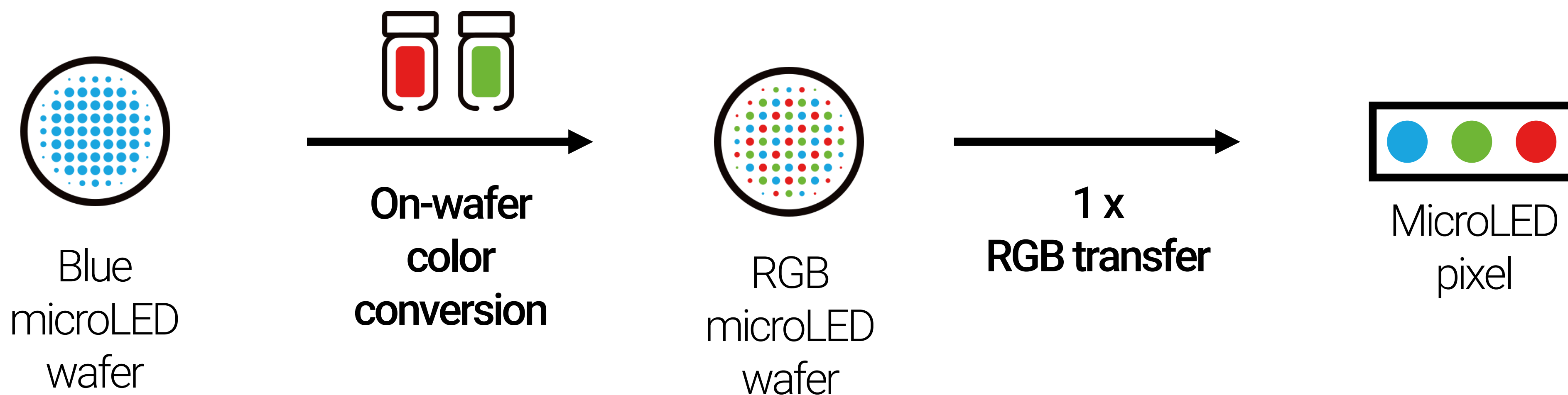


RGB  
microLED  
panel



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

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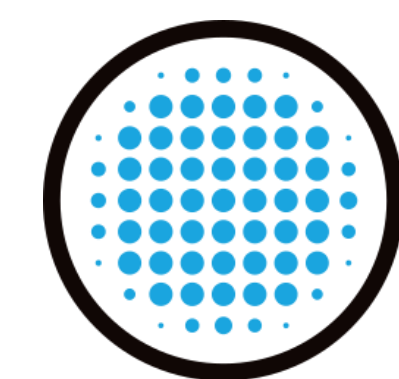




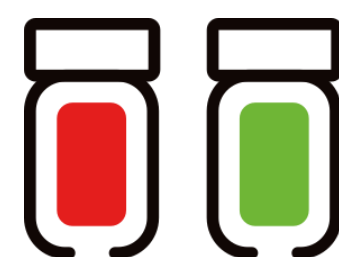


# Color conversion delivered **on wafer**, after mass transfer process

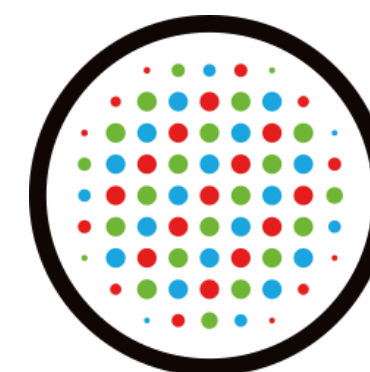
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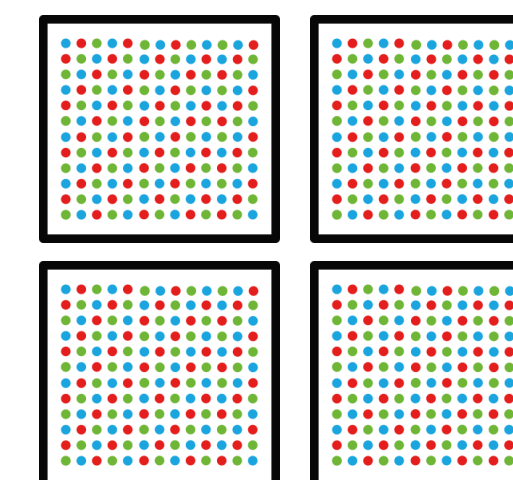
Blue  
microLED  
wafer



On-wafer  
color  
conversion



RGB  
microLED  
wafer



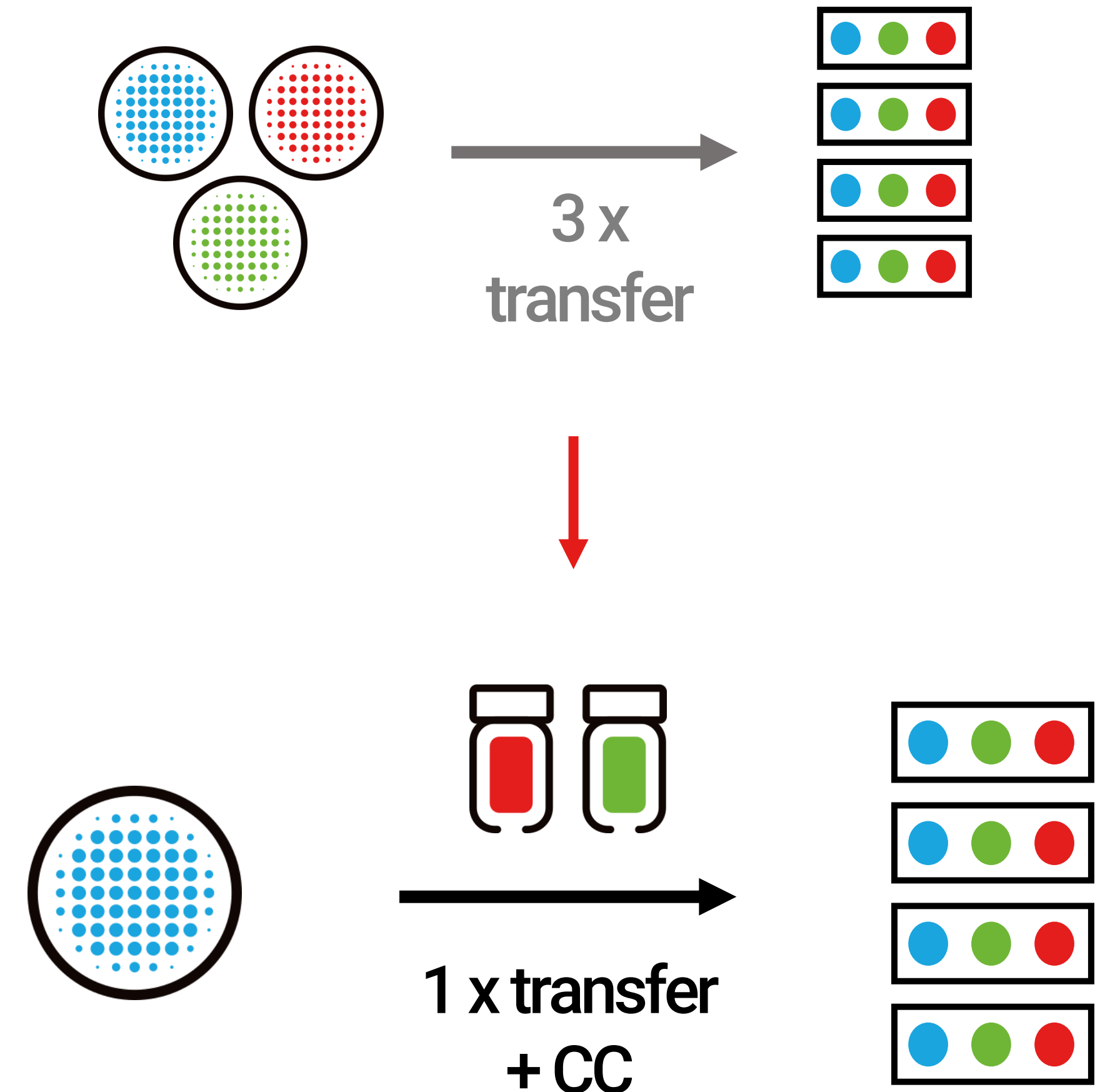
Microdisplay



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

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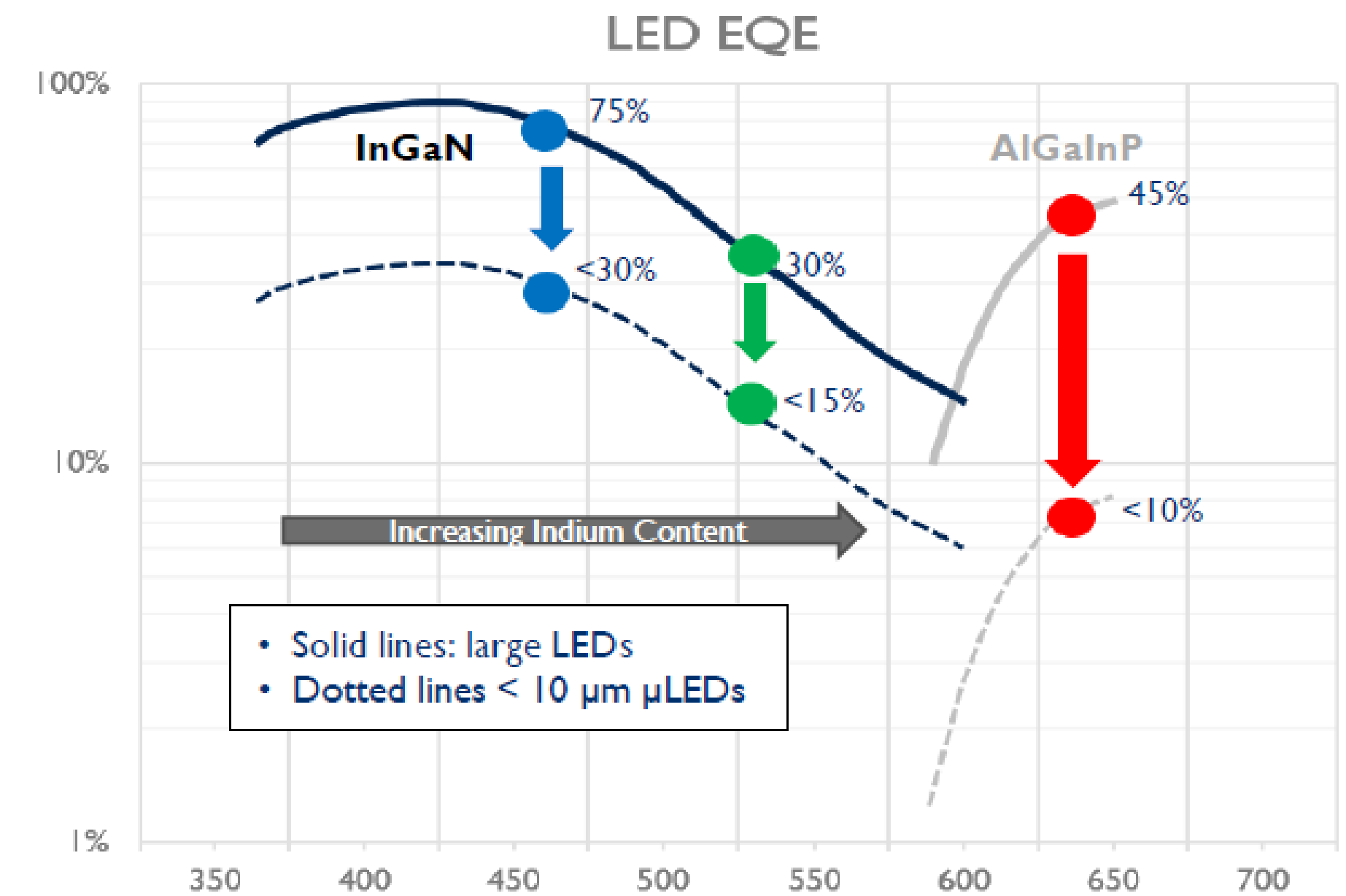
- Reduces number of transfer cycles 3x
- Overall transfer yield improvements
- Flexibility in color conversion integration





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

- Low efficiency of AlGaInP microLED
- Larger trade-off compared to InGaN



Source: yole

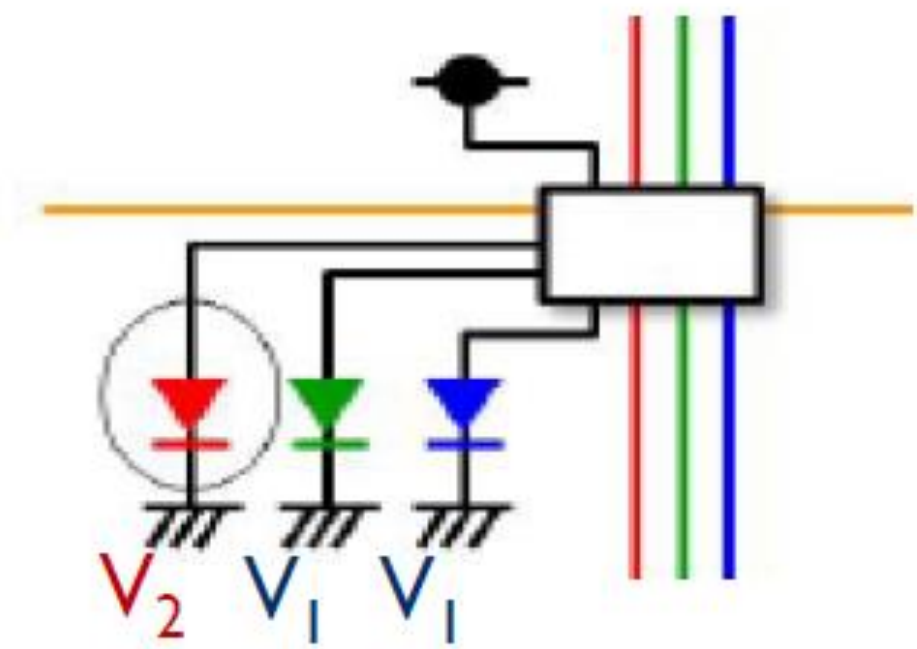
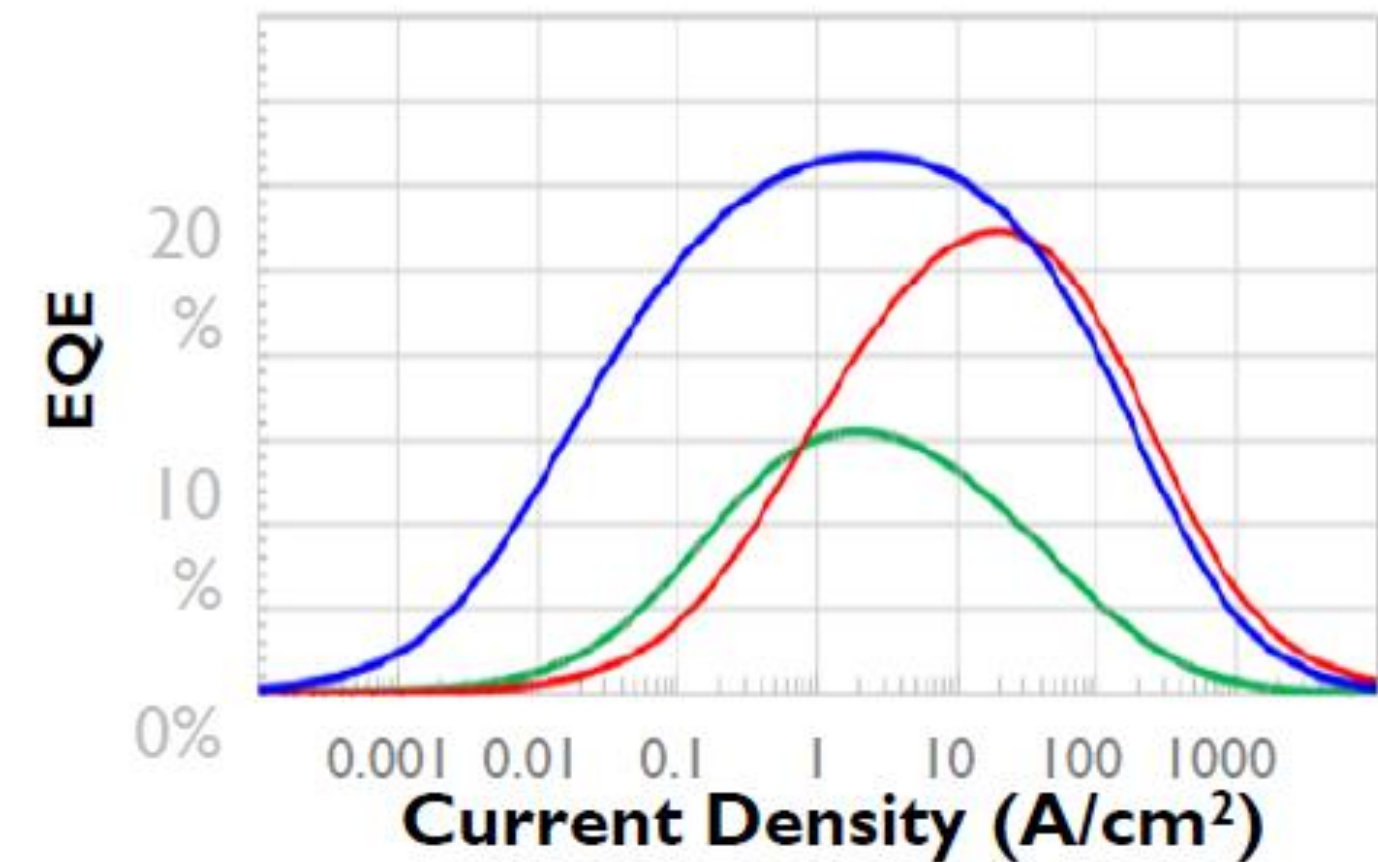




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## The **red gap** - conventional technology requires 2 different die materials

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



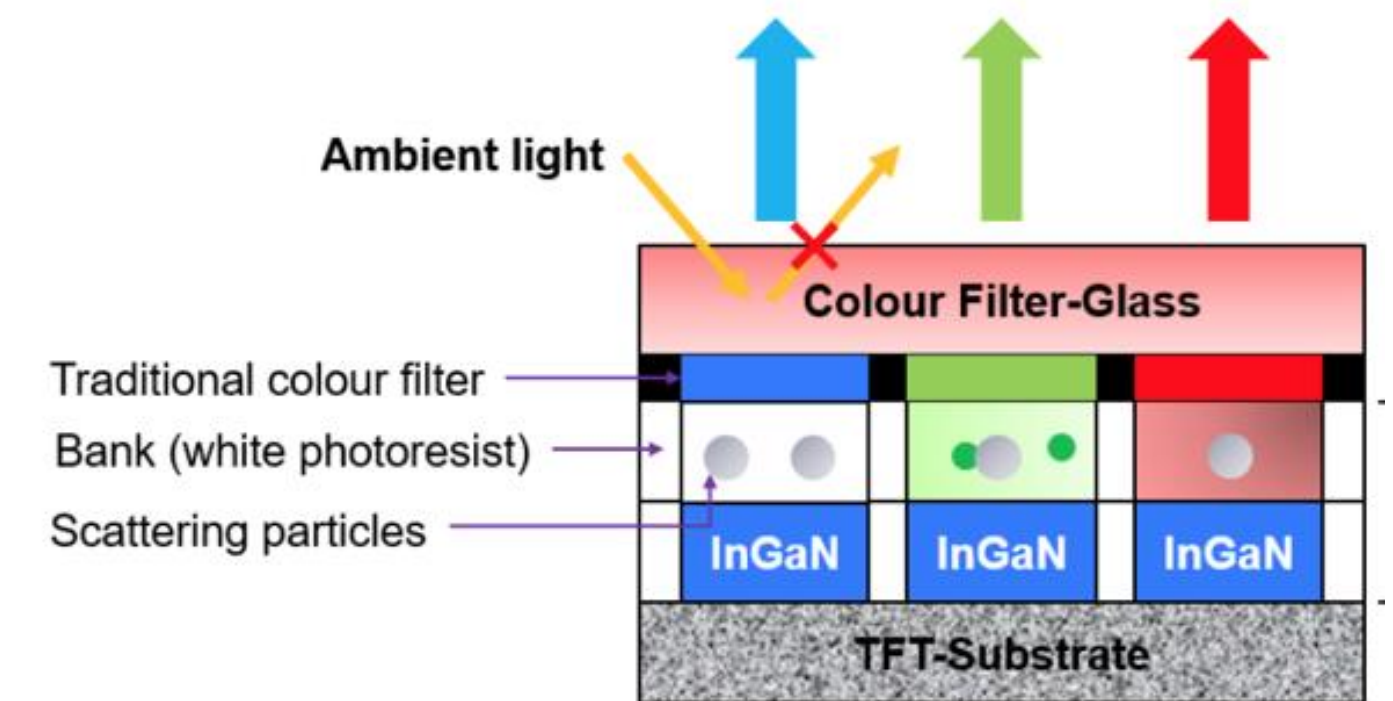
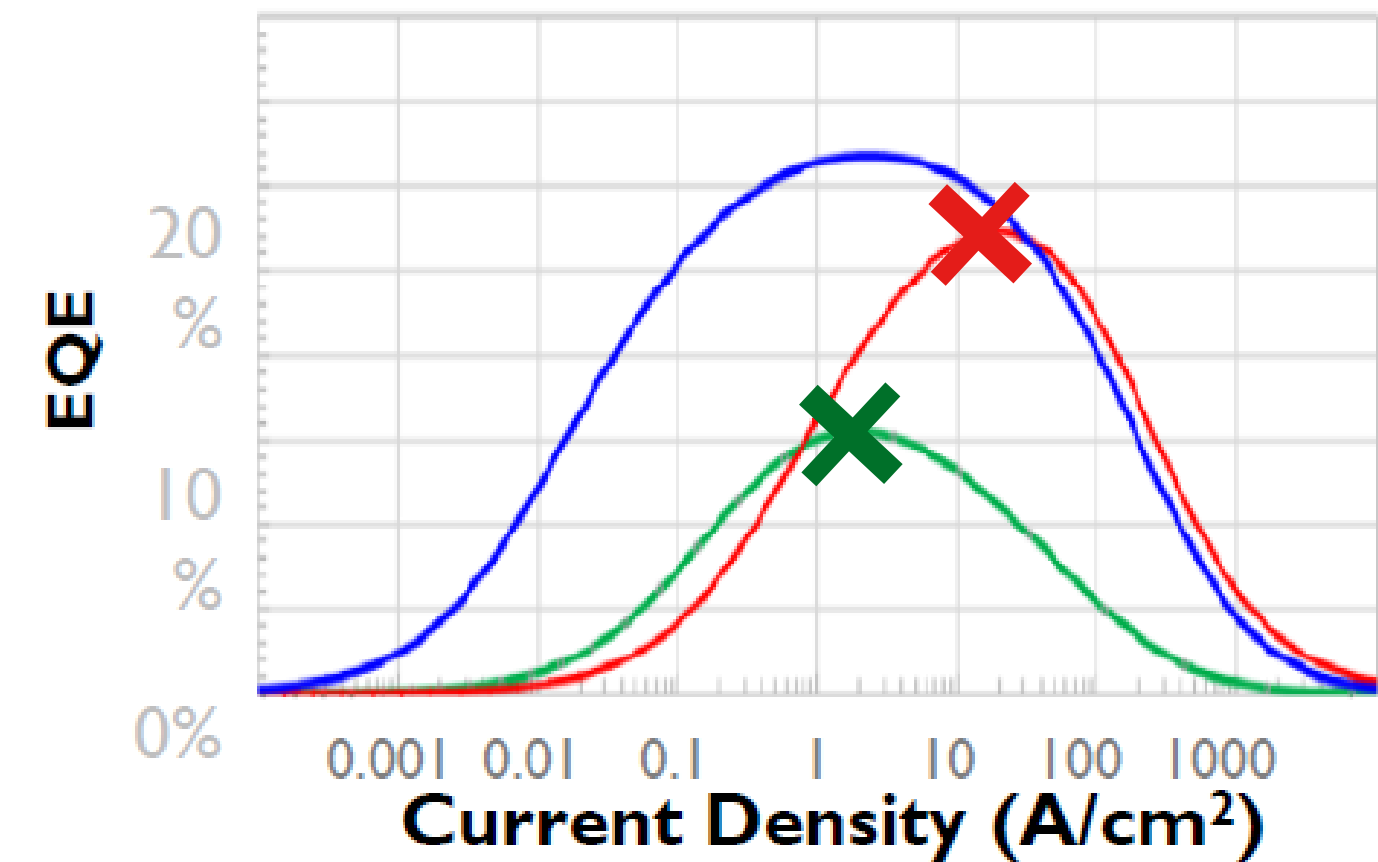
Source: yole



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

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

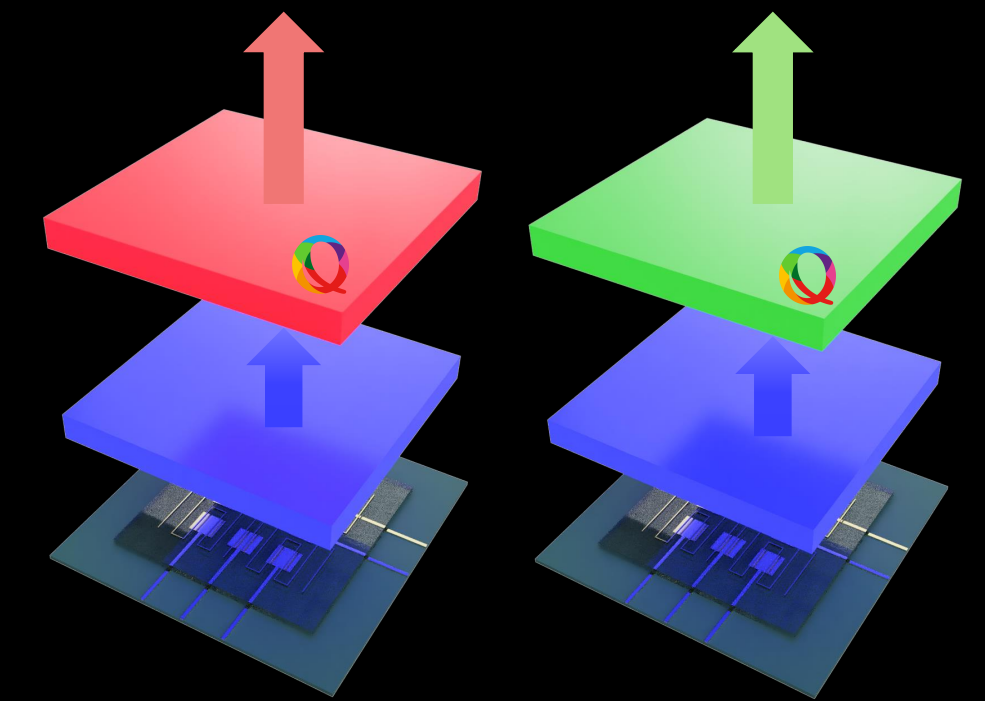


Source: Taiwan Nanocrystals Inc., SID 2018 in LA, USA



Color conversion **simplifies manufacturing**

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

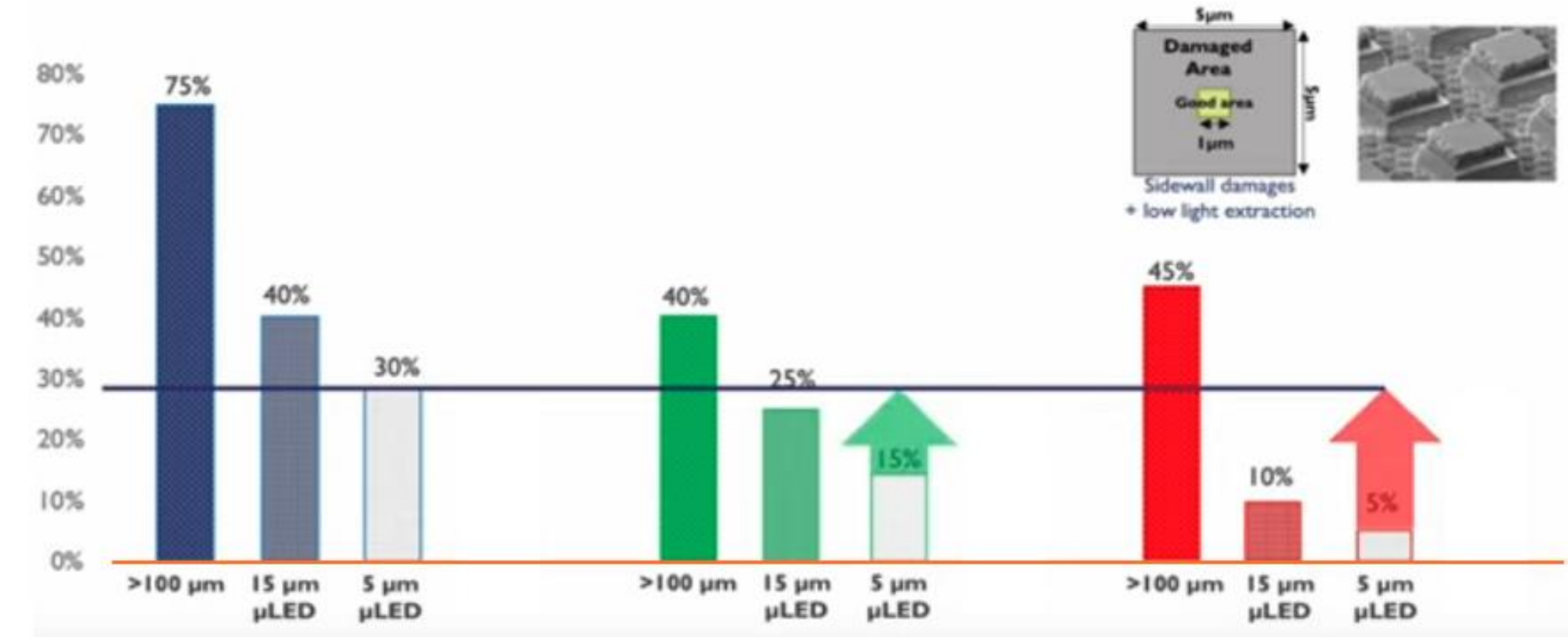




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# Color conversion delivers microLEDs with higher efficiency and lower power consumption

- 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		

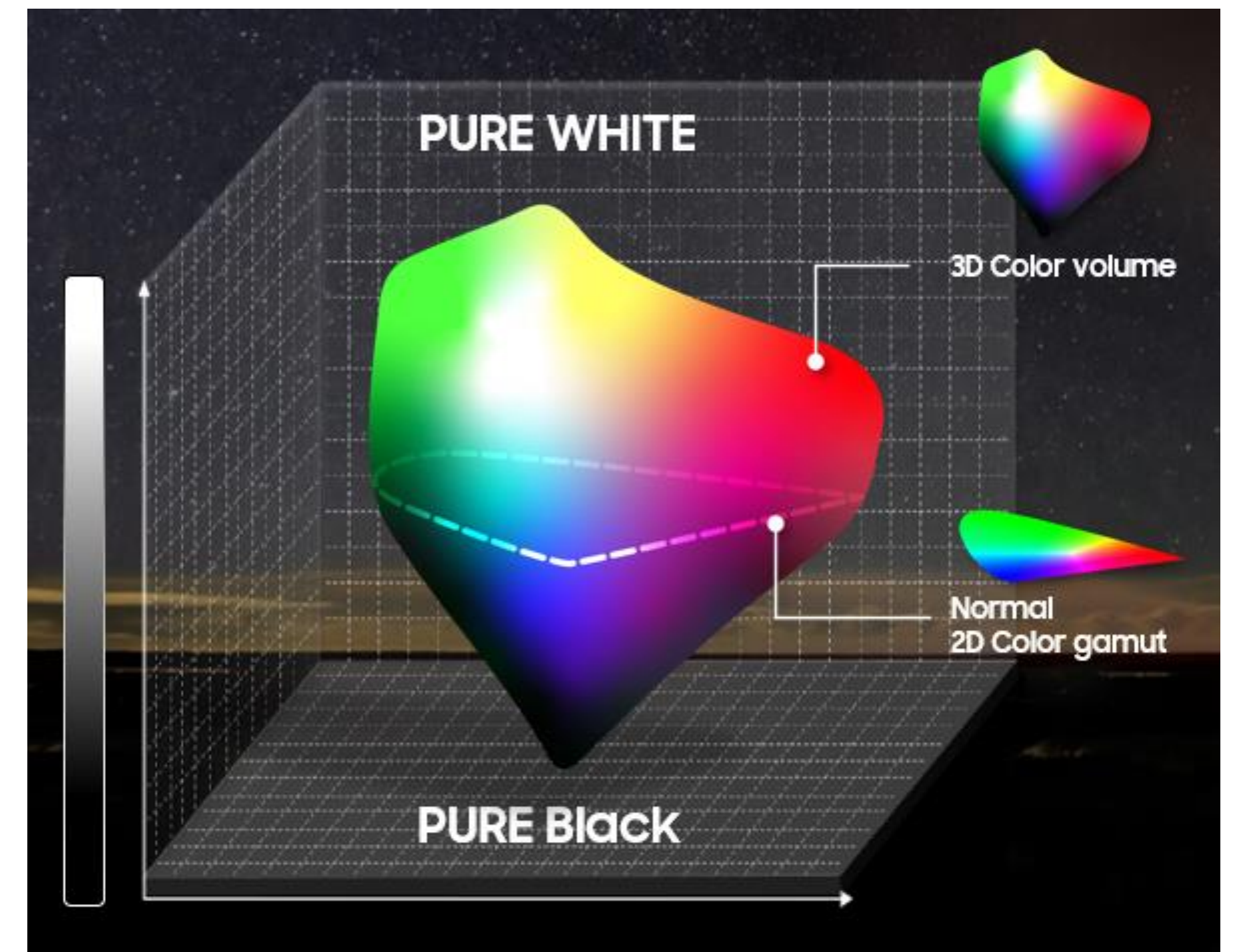
Source: yole



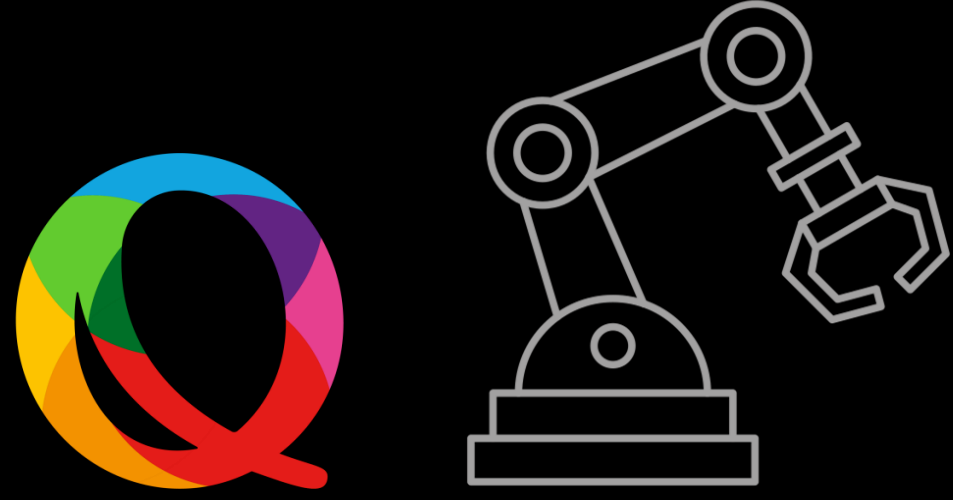
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# Color conversion **delivers** displays with **large color gamut** **volume**

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

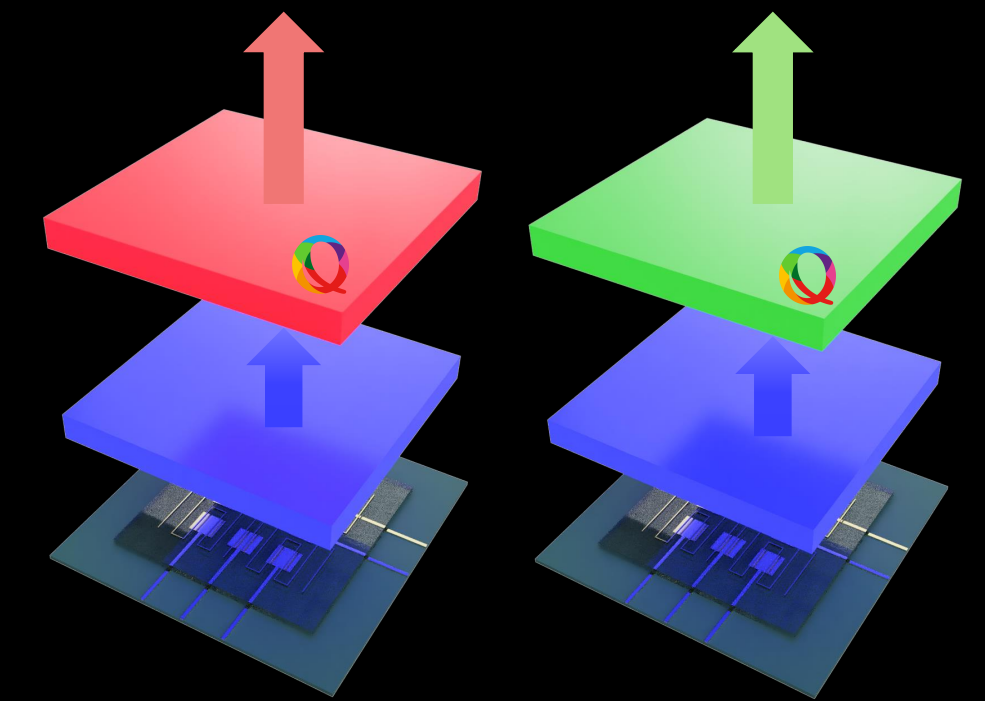


Source: Samsung Display Corporation



Color conversion **simplifies manufacturing**

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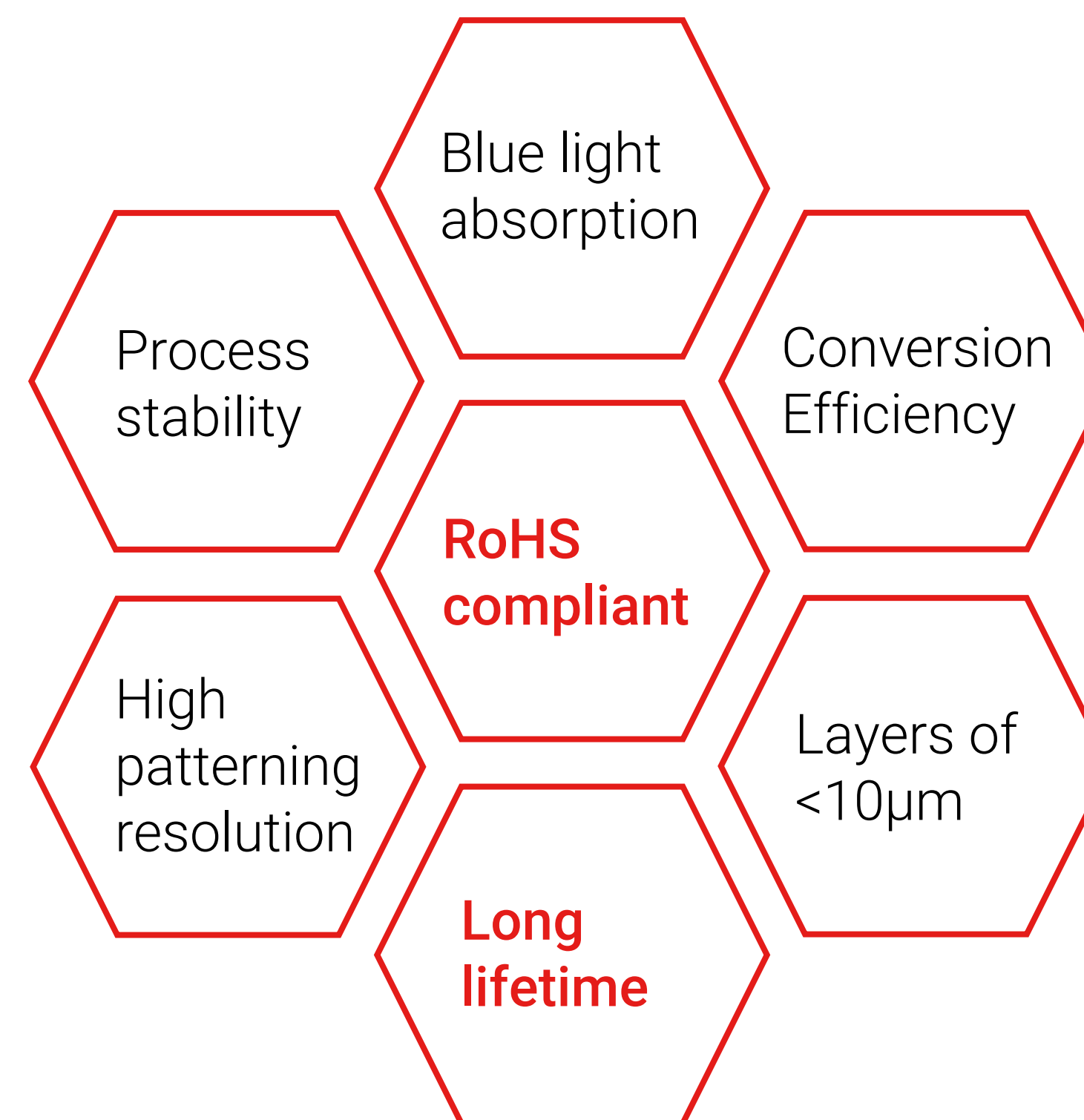
Color conversion delivers **high-performing red and green microLEDs**





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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  $\mu\text{m}$

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



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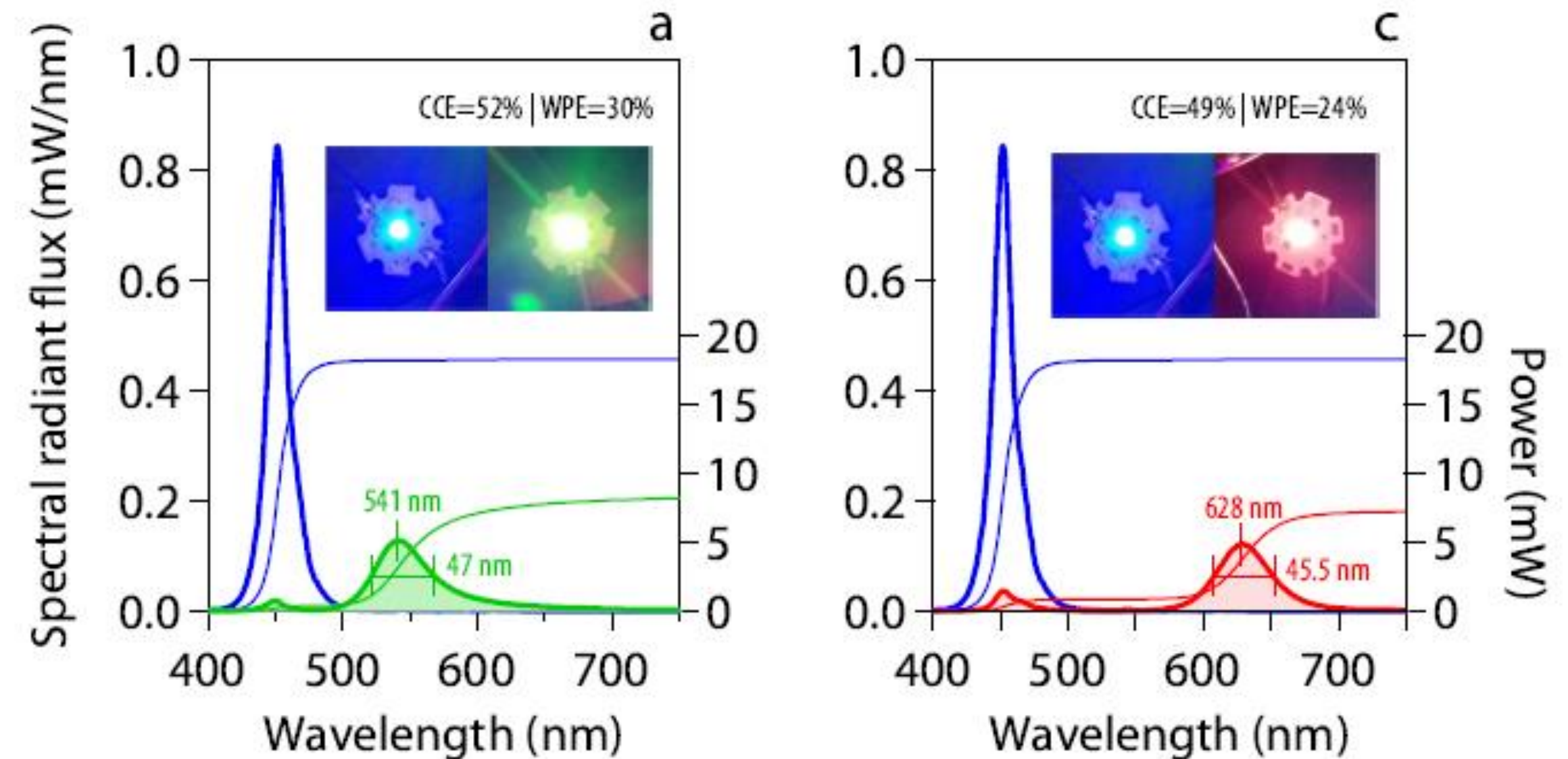
# Cd-free QDs deliver high color conversion efficiency in **large LEDs**

- 50% color conversion efficiency shown above 100  $\mu\text{m}$
- Manuscript in review

Color conversion efficiency

52 %

49 %

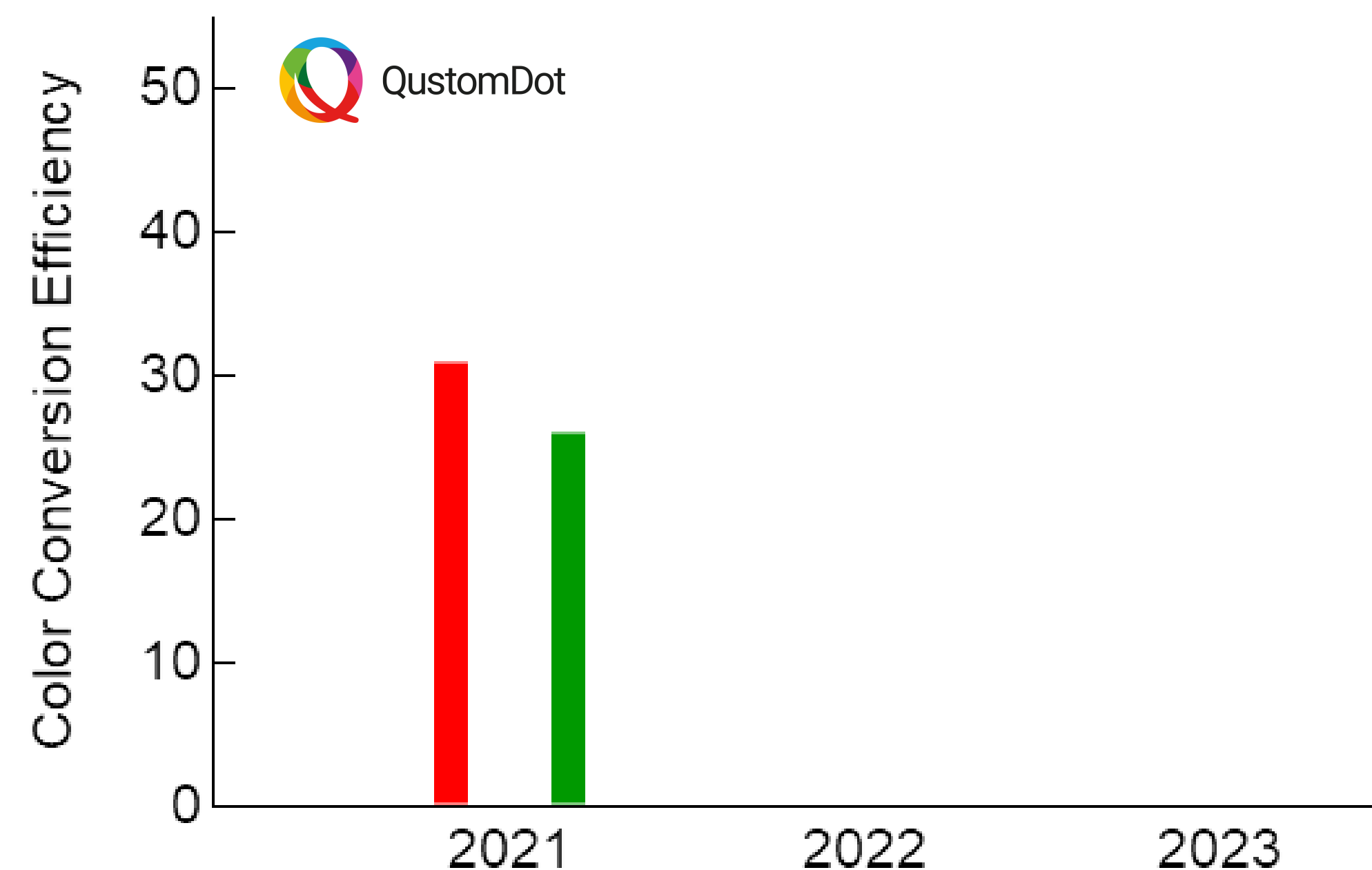




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## Cd-free QD challenge – high conversion efficiency in $< 10 \mu\text{m}$

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



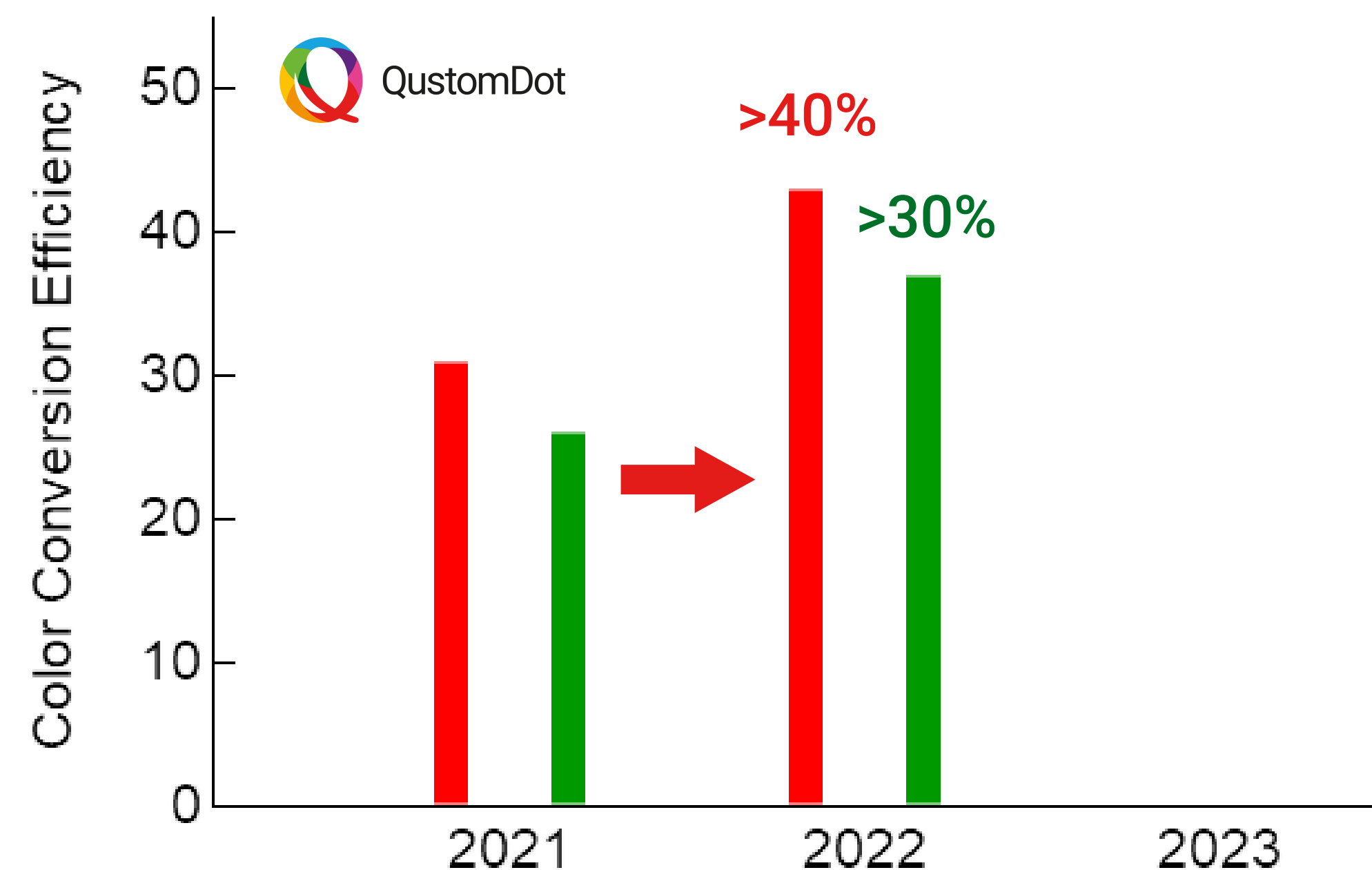




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## Cd-free QD challenge – high conversion efficiency in $< 10\ \mu\text{m}$

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

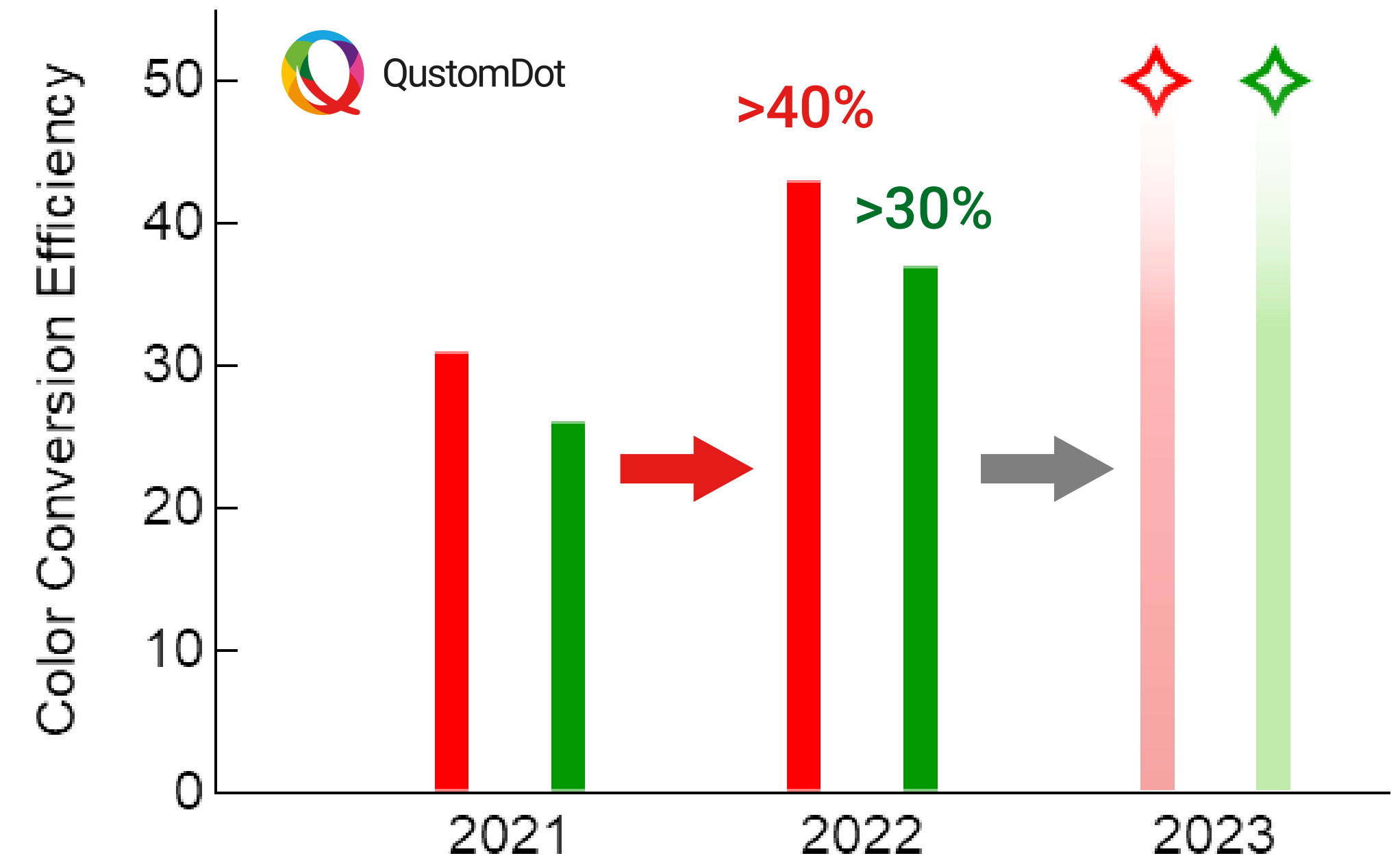




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Cd-free QD challenge –  
high conversion efficiency  
in  $< 10\ \mu\text{m}$

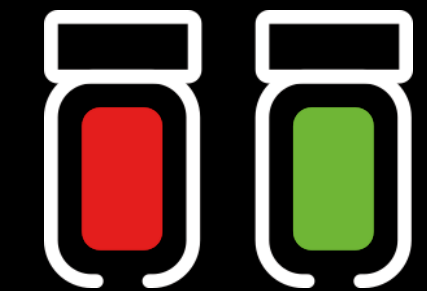
On track to breach 50% barrier in 2023





**Cd-free QD challenge 1:**  
high color conversion efficiency below 10  $\mu\text{m}$

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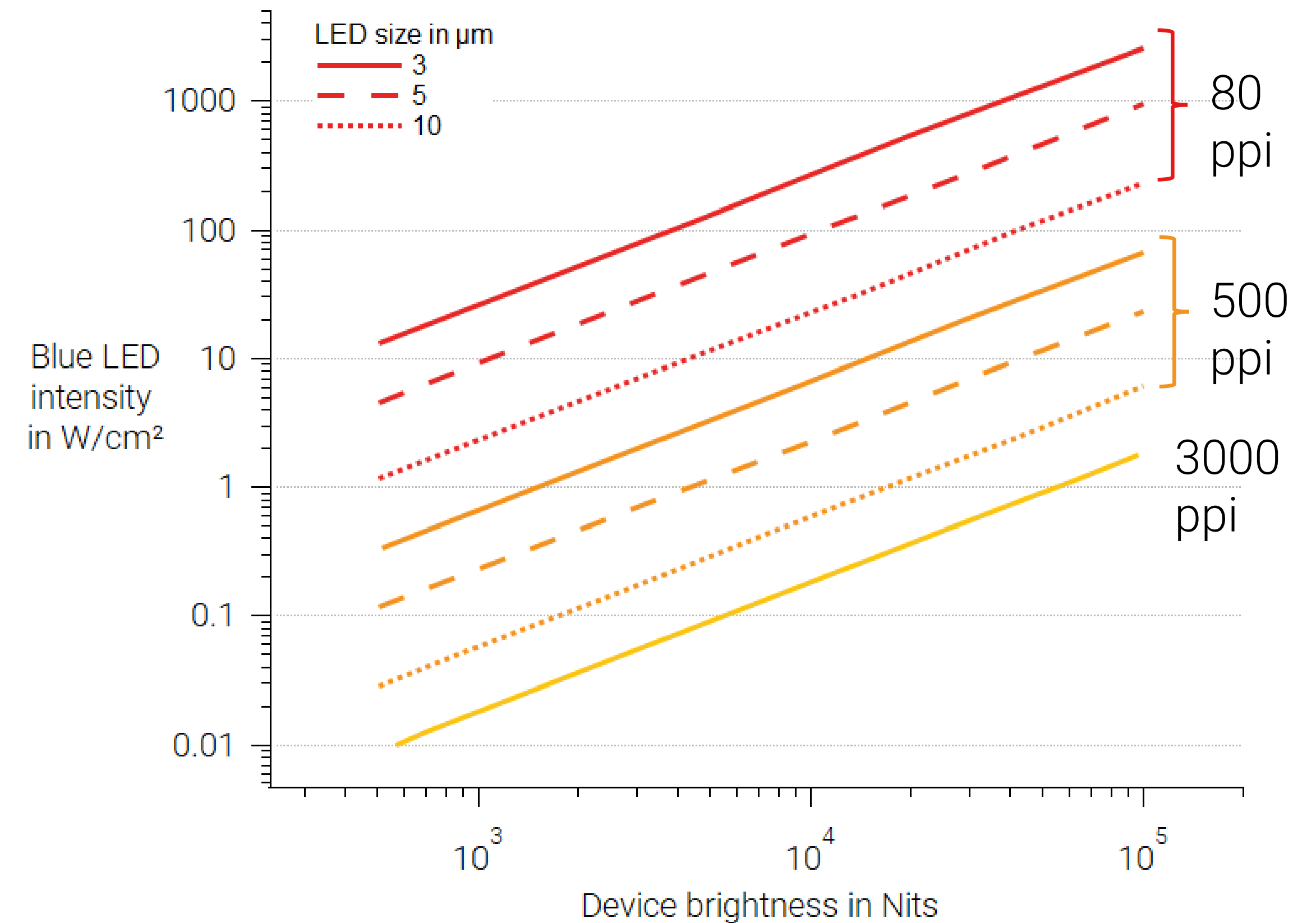
**Cd-free QD challenge 2:**  
photostability at high blue light flux



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## 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

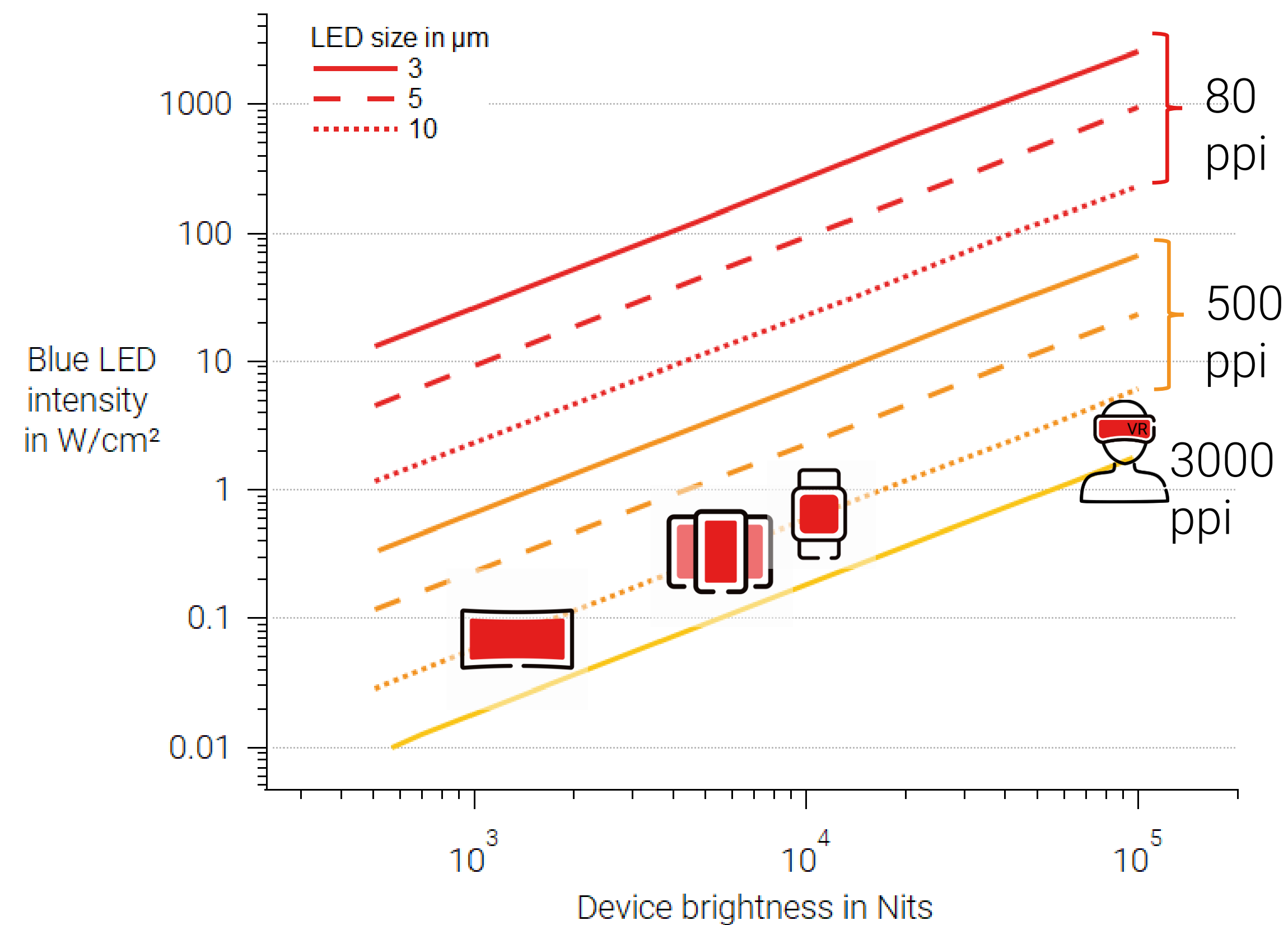




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## Application segmentation as guiding principle

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



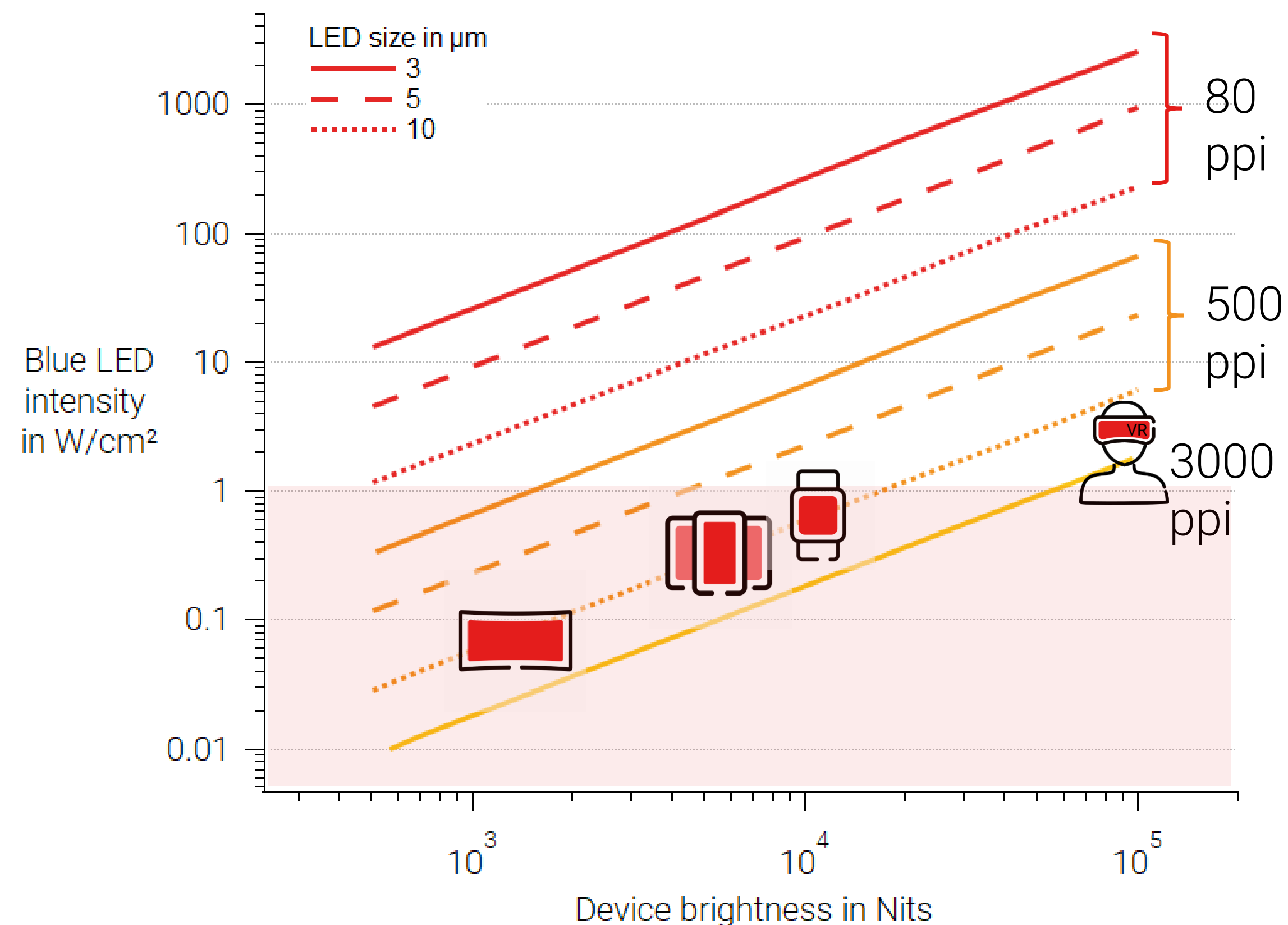
Source: yole



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## Cd-free QD challenge— high blue light flux

- Majority of microLED applications can be targeted below 1 W/cm<sup>2</sup> blue LED intensity
- High-end AR applications (>1M nits) operate around 5 W/cm<sup>2</sup>

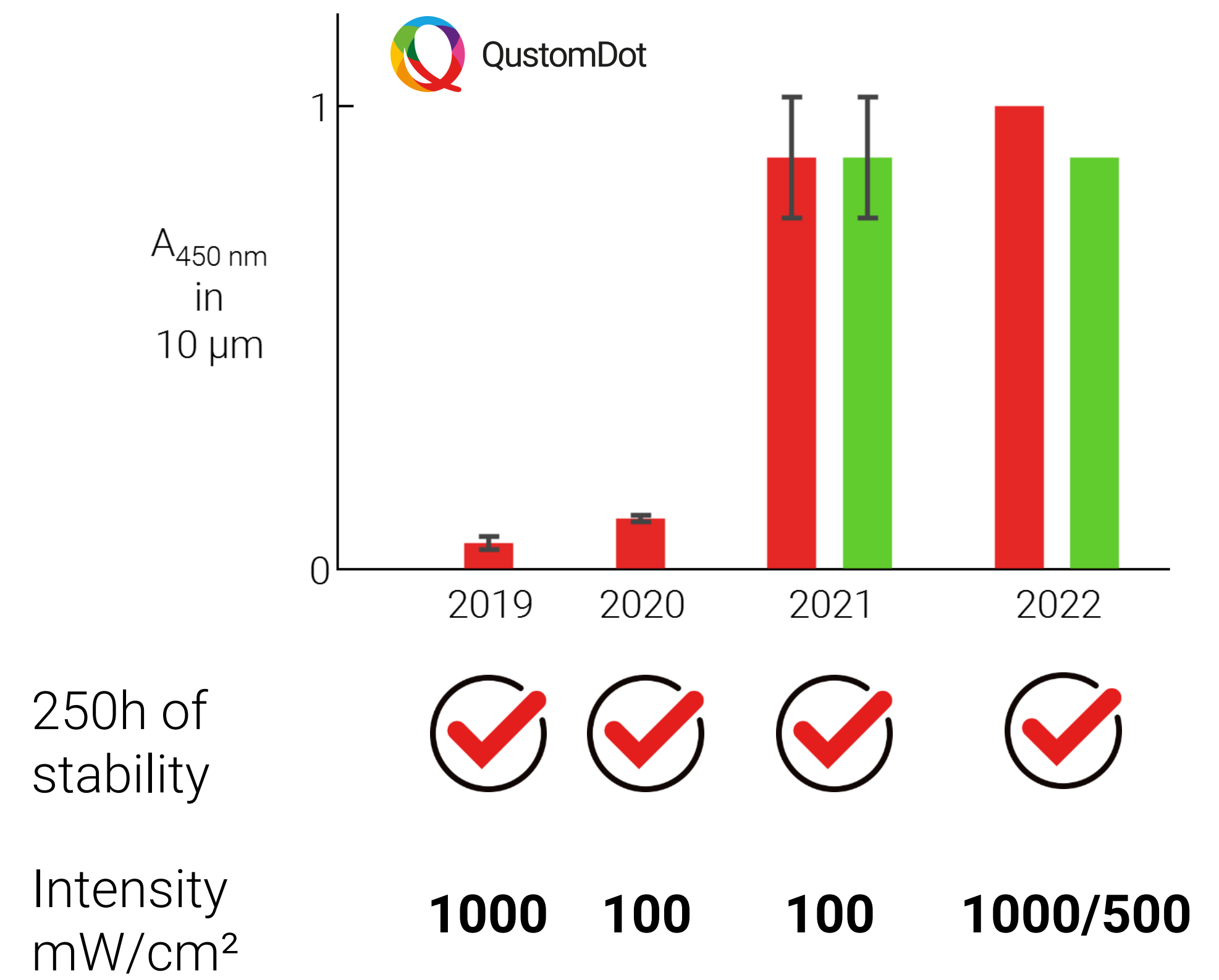


Source: yole



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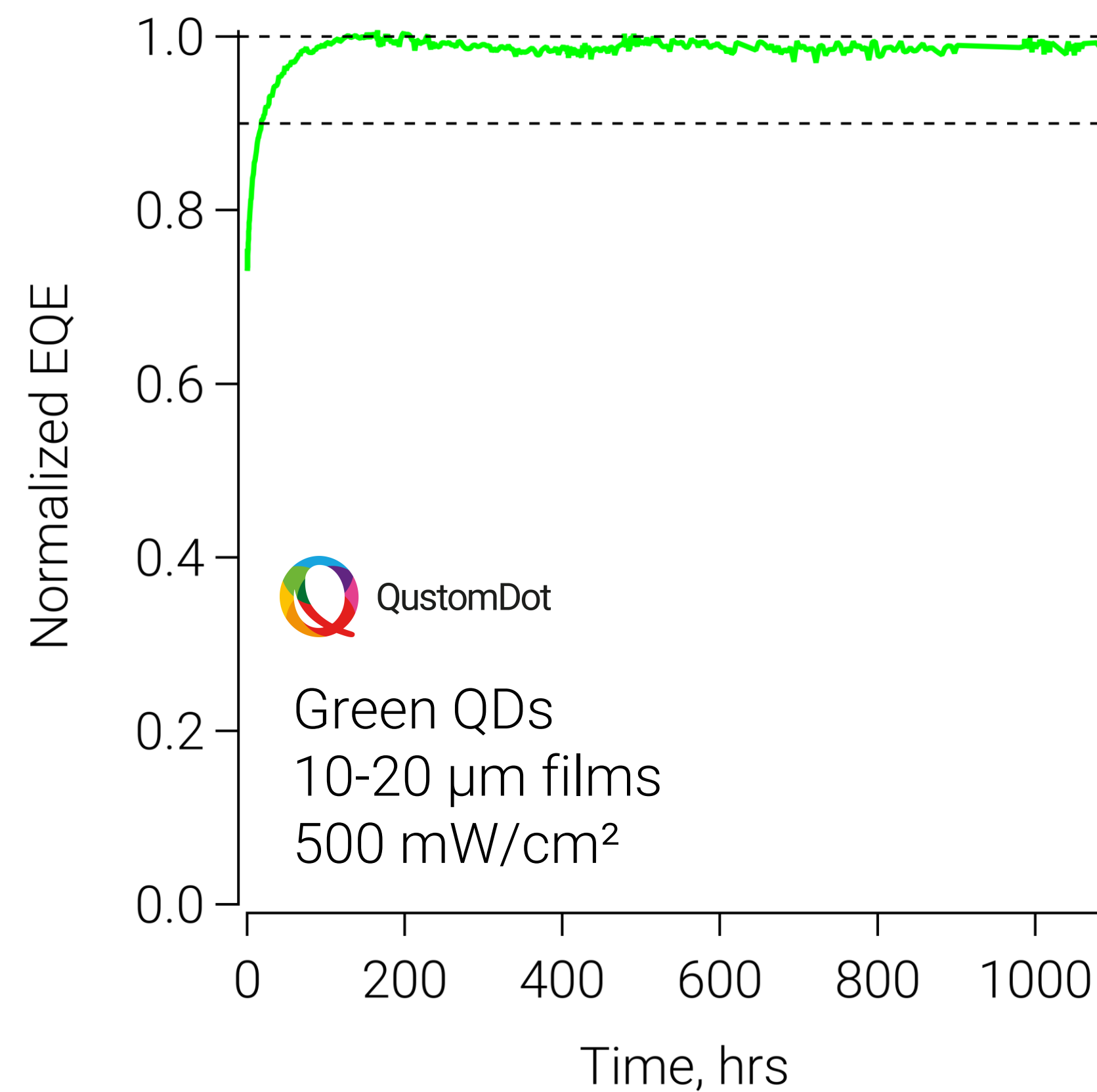
# QustomDot's Cd-free QD photostability facilitates QD-microLED applications





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Excellent optical  
properties maintained  
over 1000 hours



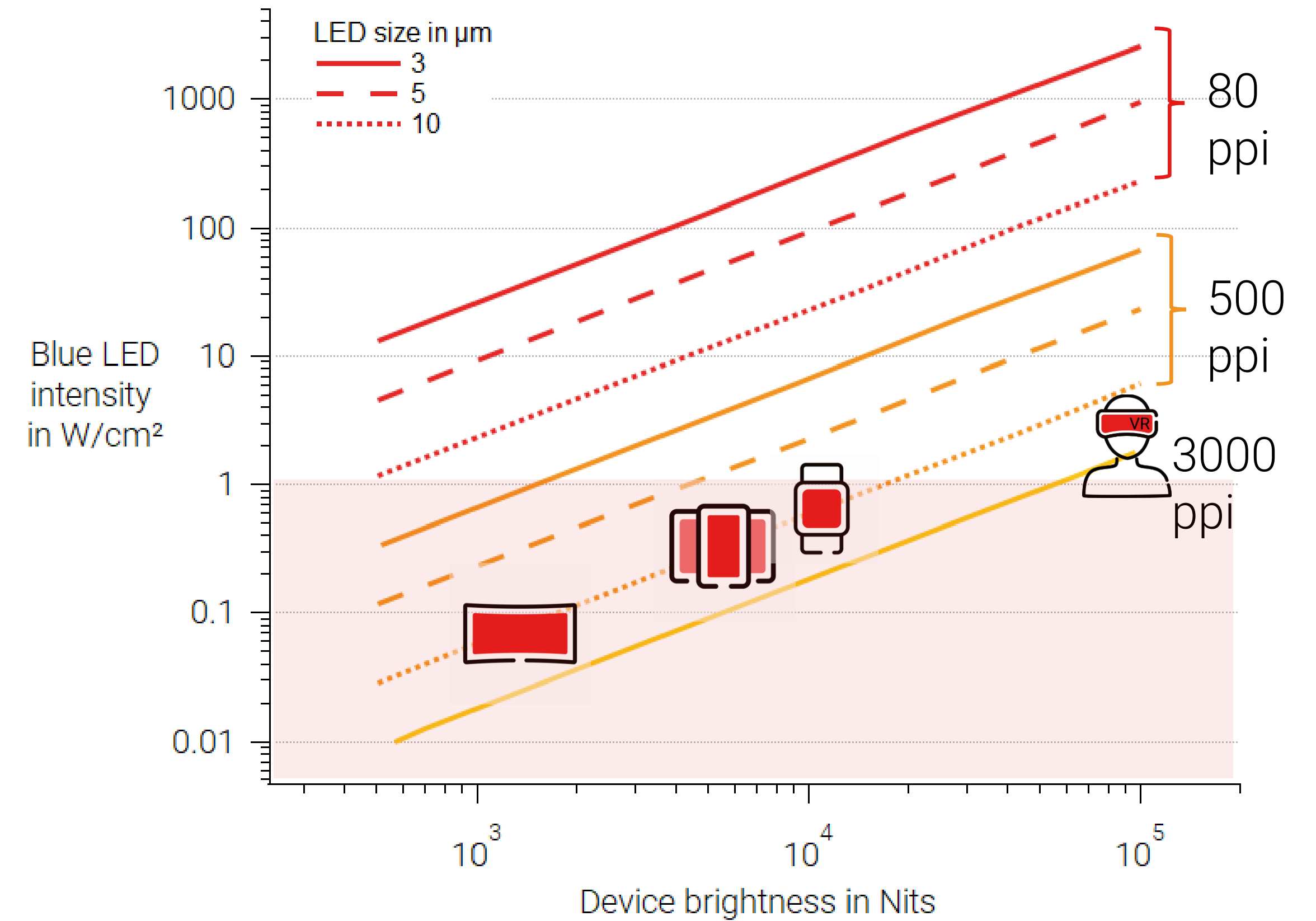




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# Cd-free QD challenge— high blue light flux

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

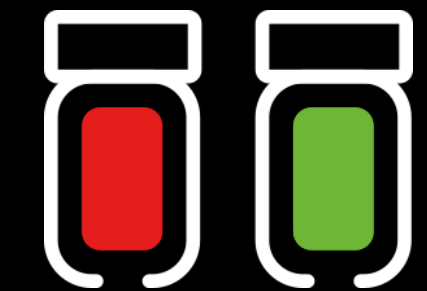


Source: yole



**Cd-free QD challenge 1:**  
high color conversion efficiency below 10  $\mu\text{m}$

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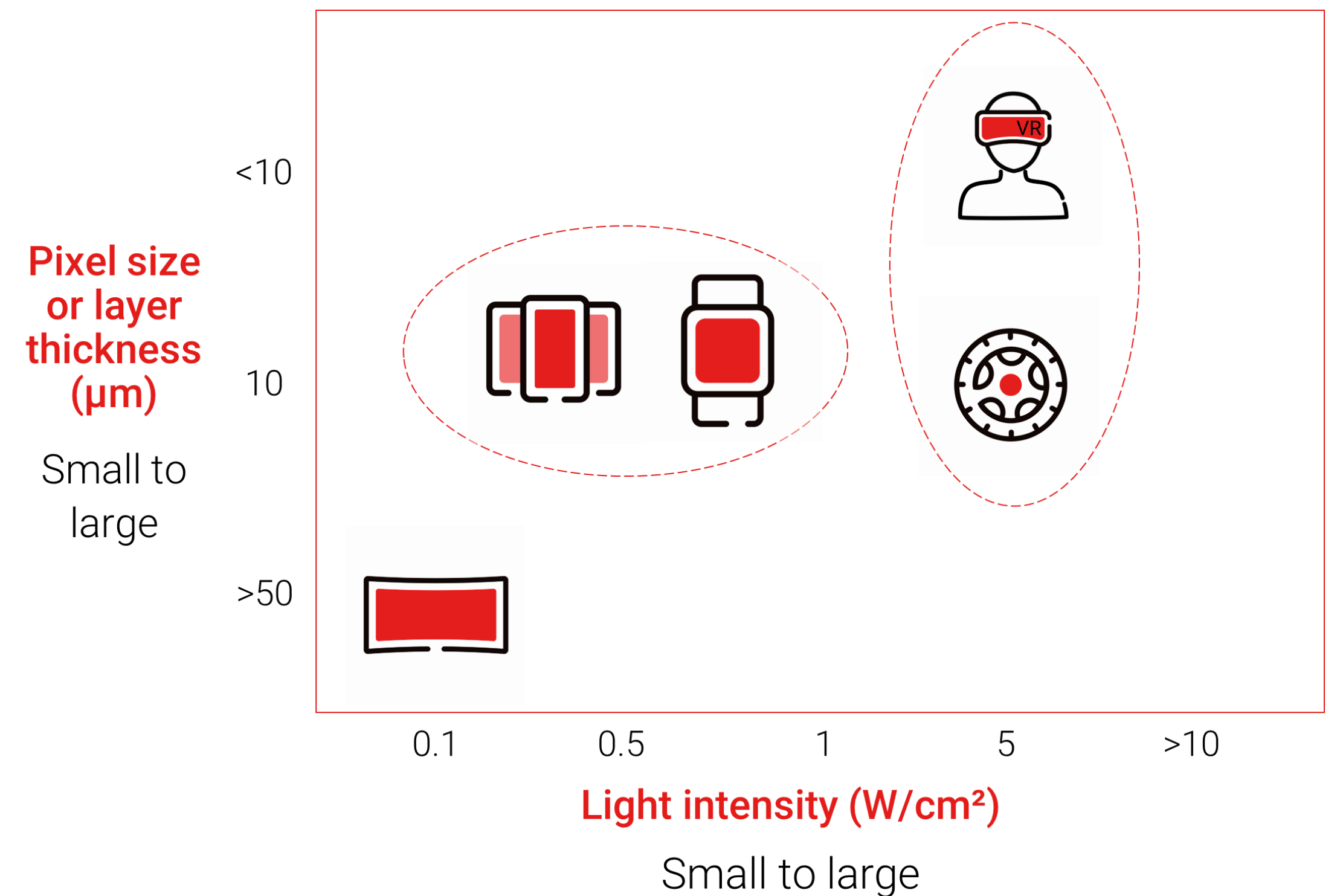
**Cd-free QD challenge 2:**  
photostability at high blue light flux



## 2023 outlook

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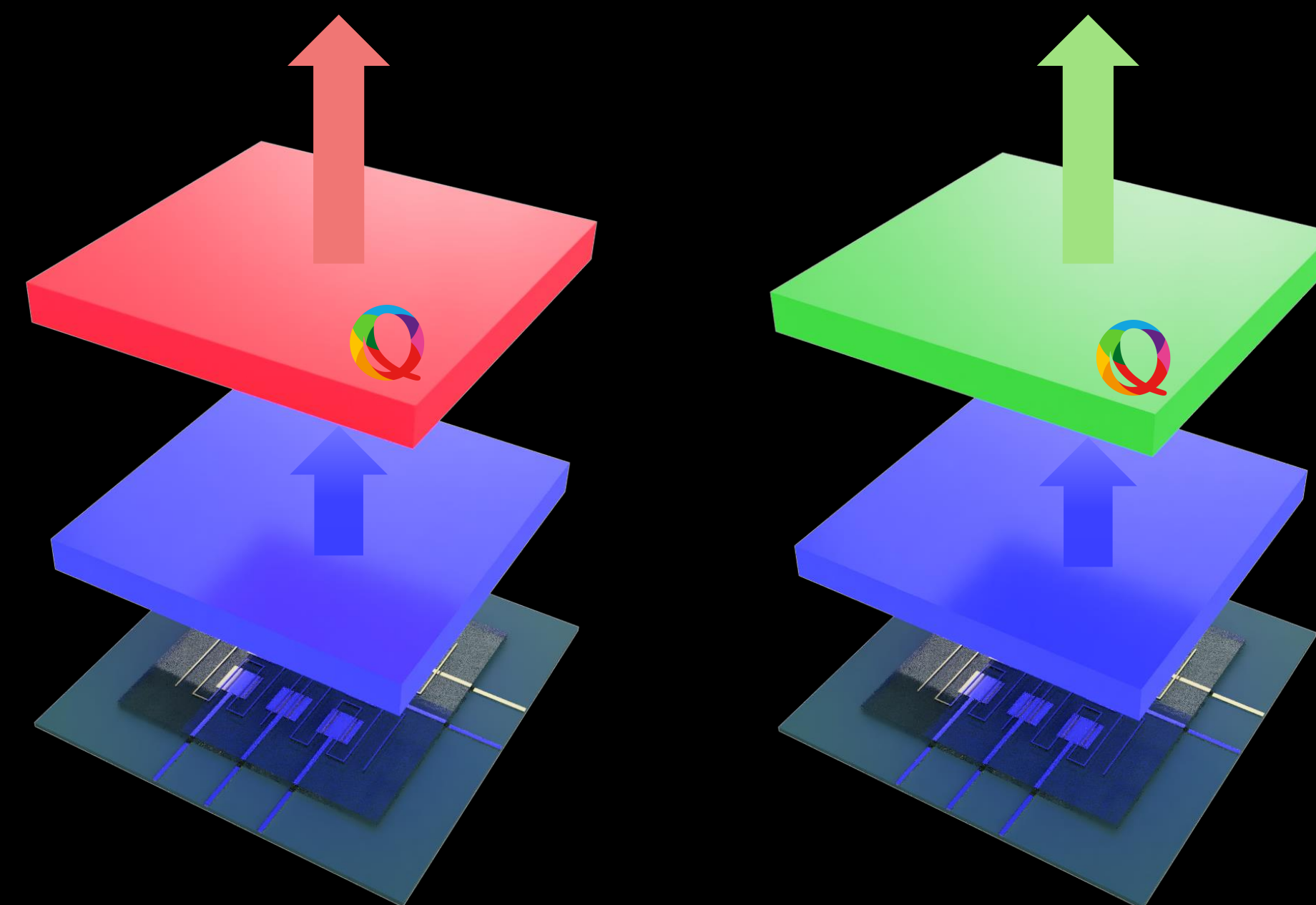
- **Product development** towards entry-level microLED applications
- Technology development for high-end microLED applications
- Fundraising to support our mission





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

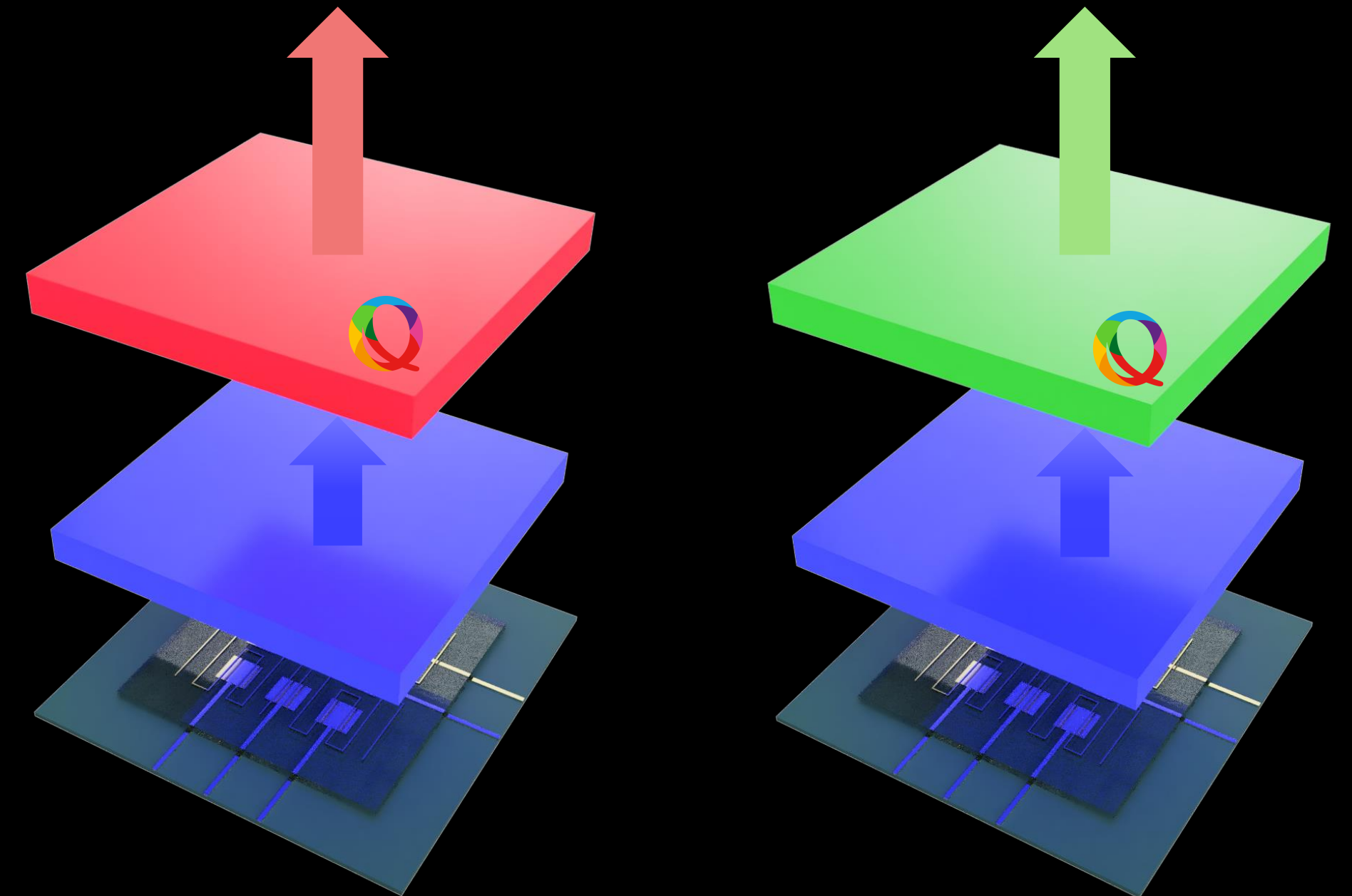






Check out our podcast  
QustomDot Radio!

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# Don't hesitate to reach out!



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