QustomDot

Bright, colorful and efficient: discover the future of QD-microLEDs with QustomDot

Introduction

QustomDot’s focus

Technology progress

Advancements towards microLED-CC

Business model and collaboration

How QustomDot can be of service

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QustomDot

Location

Belgium-based technology start-up

QustomDot

Location

Belgium-based technology start-up

Spin off

Ghent University

Research group of Prof. Zeger Hens

GHENT UNIVERSITY

PCN

Prof Dr. Ir. Zeger Hens

QustomDot

Location

Belgium-based technology start-up

Spin off

Ghent University

Research group of Prof. Zeger Hens

Financing

Venture backed

€3M venture capital seed round

Launch

Launched at the beginning of 2020

qbic fund

PMV
DOE- EN DURFBEDRIJF

VIGO
VENTURES

QustomDot

State-of-the-art lab facilities

QustomDot

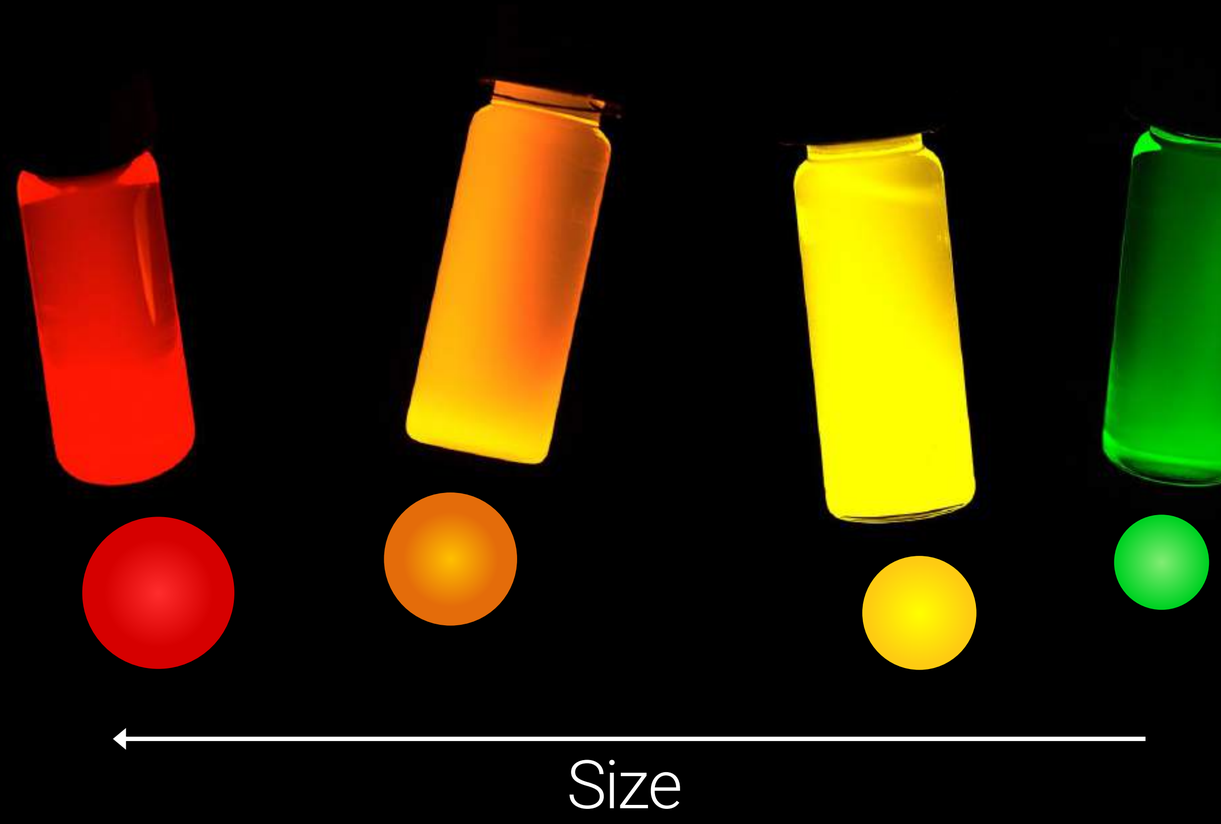
A motivated and talented team

Colorful, functional and efficient: discover the possibilities of quantum dots (QD) with QustomDot.

We develop on-chip grade, RoHS compliant QD technology for future applications in color conversion.

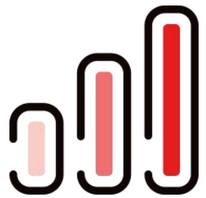
10

Quantum dots (QDs) are semi-conductor nanocrystals that can absorb blue or UV light and emit a pure color. The emitted color depends on QD size.



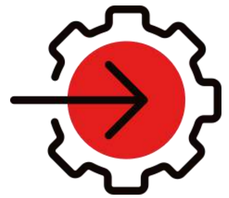
QustomDot’s focus

QustomDot focusses on MicroLEDs applications due to the enormous potential of the technology and its value:



Better brightness, lifetime and Efficiency

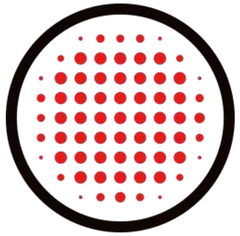
Whole new range of applications



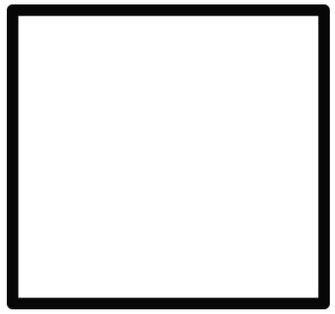
Integration of other functionalities in the display

MicroLED challenges

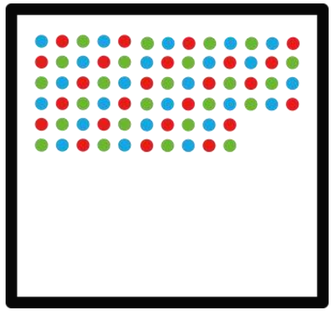
Need for wafer uniformity



Cost & performance of red µLEDs



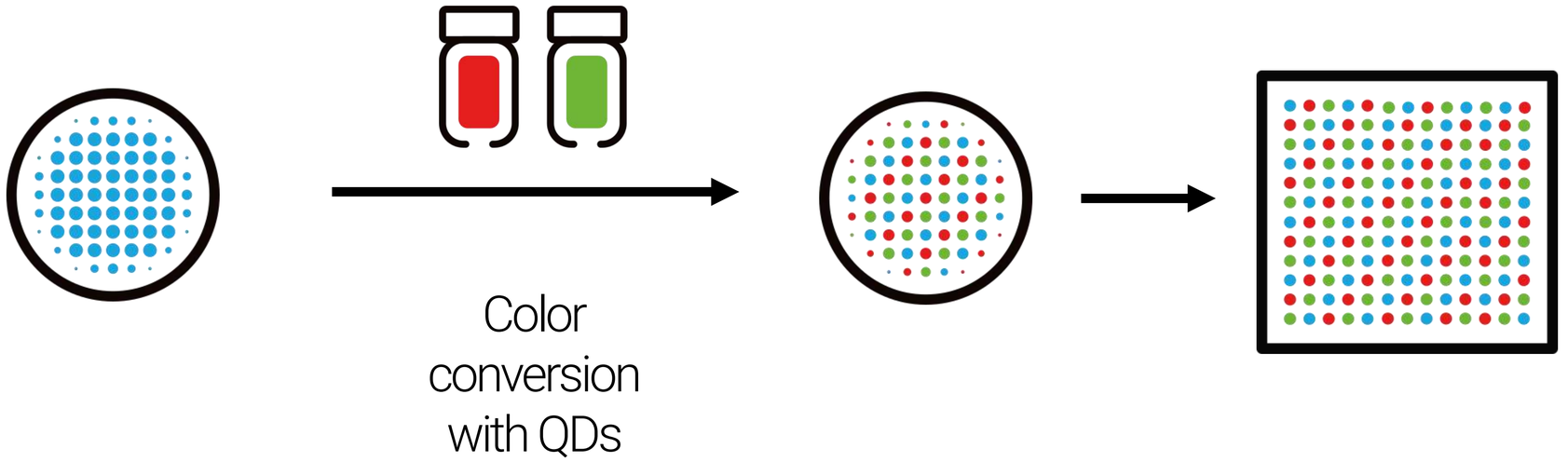
Complex driving electronics



Mass transfer is complex and expensive

Inspection and repair is expensive

Overcome challenges with QDs



For mass transfer, all-in-one transfer,
3D structures, monolithic integration, ...

MicroLED industry challenge:
Find the **best** possible QD technology

Great optical properties

On-chip grade

RoHS compliant

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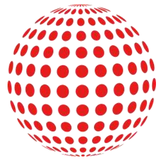
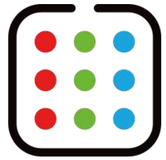
The 5 QustomDot Pillars

QD Synthesis



QD Surface

QD Resin/ink



QD Patterning

QD Device

The 5 QustomDot Pillars

QD Synthesis

QD Surface

QD Resin/ink

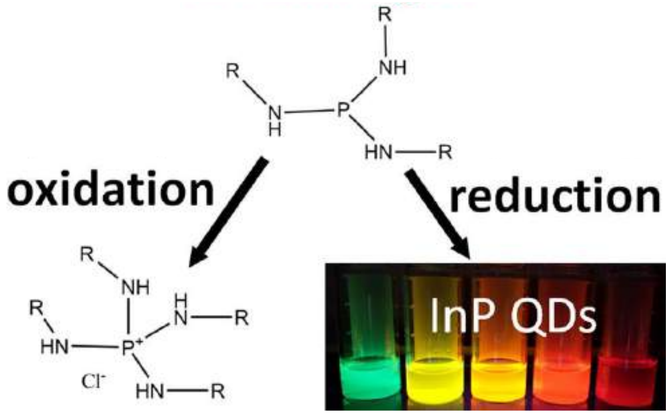
QD Patterning

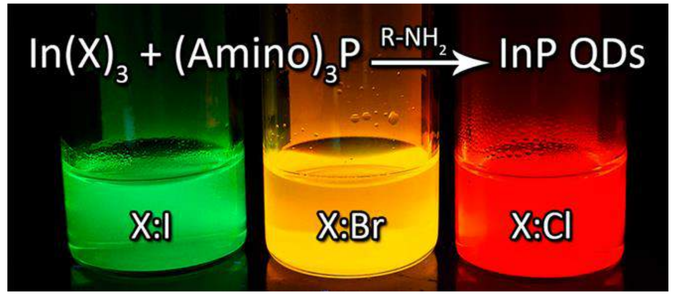
QD Device

Aminophosphine route for efficient InP QDs

Patented synthesis method using aminophosphine as phosphor source:

- Low-cost and safe to handle precursors
- Near unity chemical yield
- Size tuning through In-halide salts

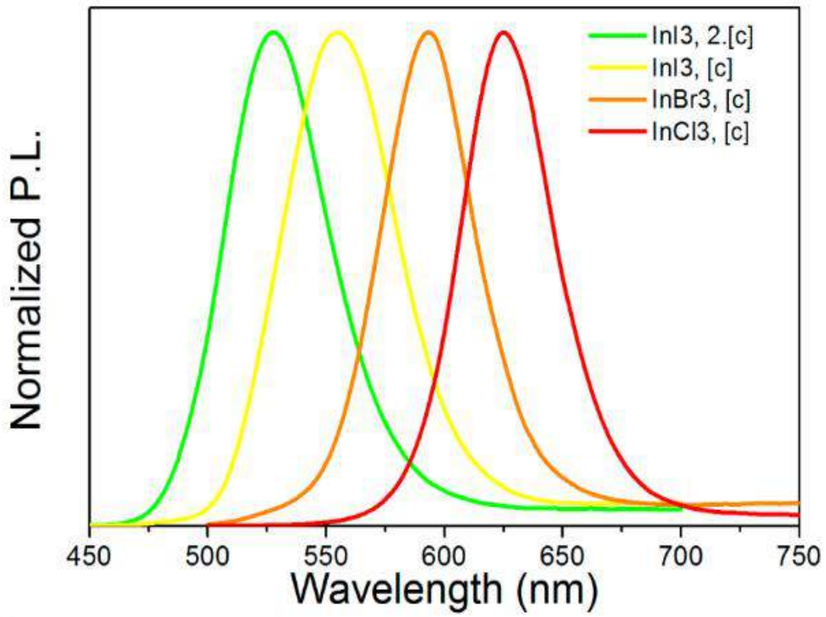




Aminophosphine route for efficient InP QDs

Decent optical properties, but not excellent:

- PLQY: 50-60%, outliers >75%
- Linewidth: 45-50 nm
- Wavelength range in dispersion: 525-640 nm



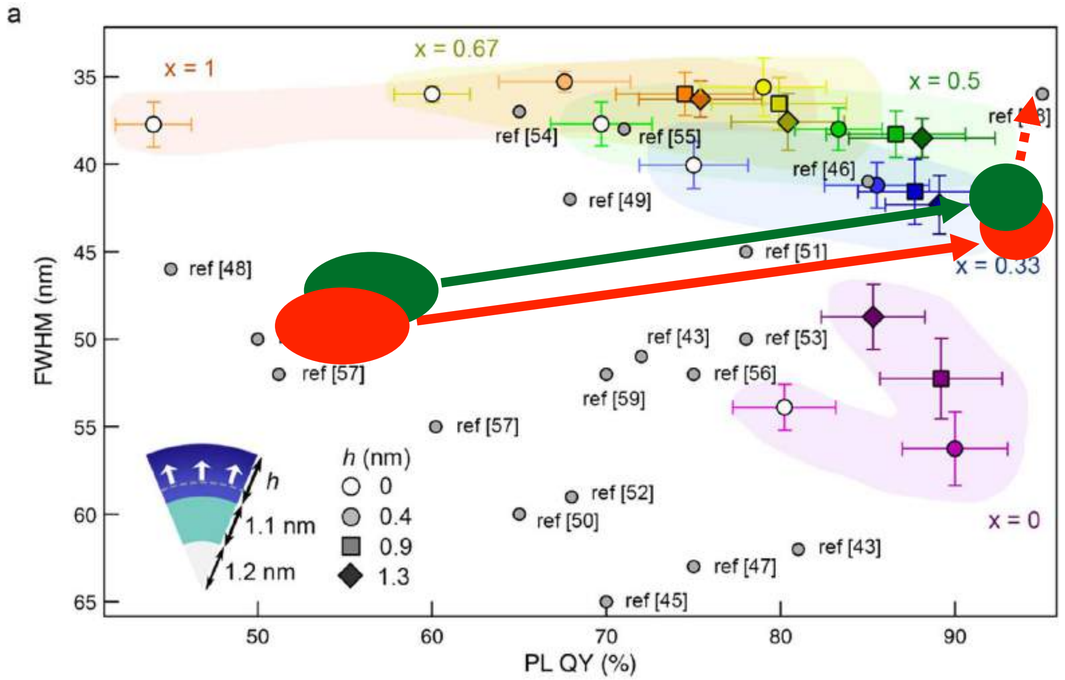
Aminophosphine route for efficient InP QDs

Red QDs (~ 605 nm)

- PLQY >95% in well purified dispersions
- Linewidth 43-45 nm

Green QDs (~ 525 nm)

- PLQY >95%
- Linewidth 40-43 nm

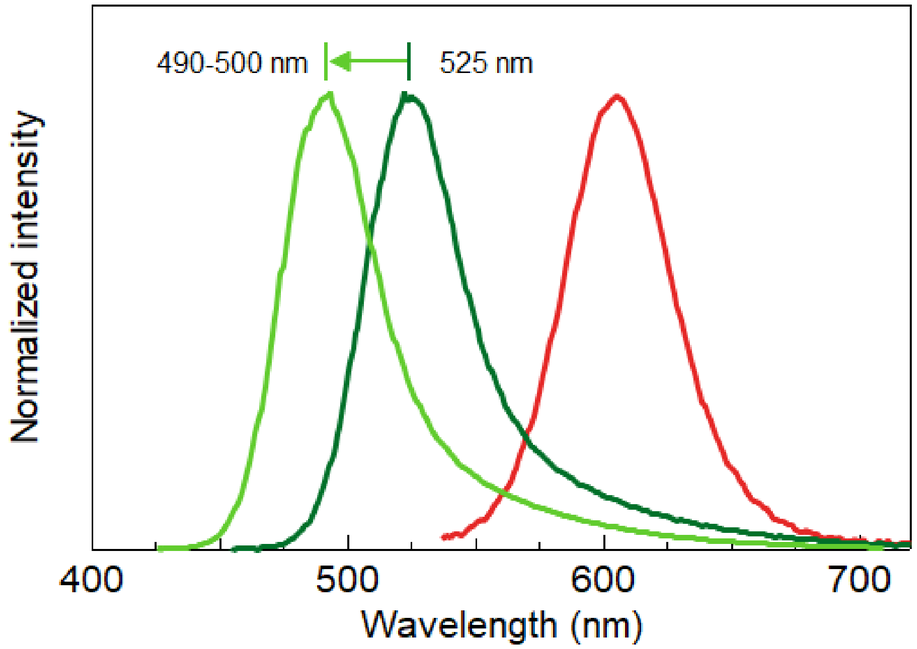


Chem. Mater. **2019**, 31, 9, 3476-3484

Aminophosphine route for efficient InP QDs

Shifting emission wavelength of green QDs towards cyan emission

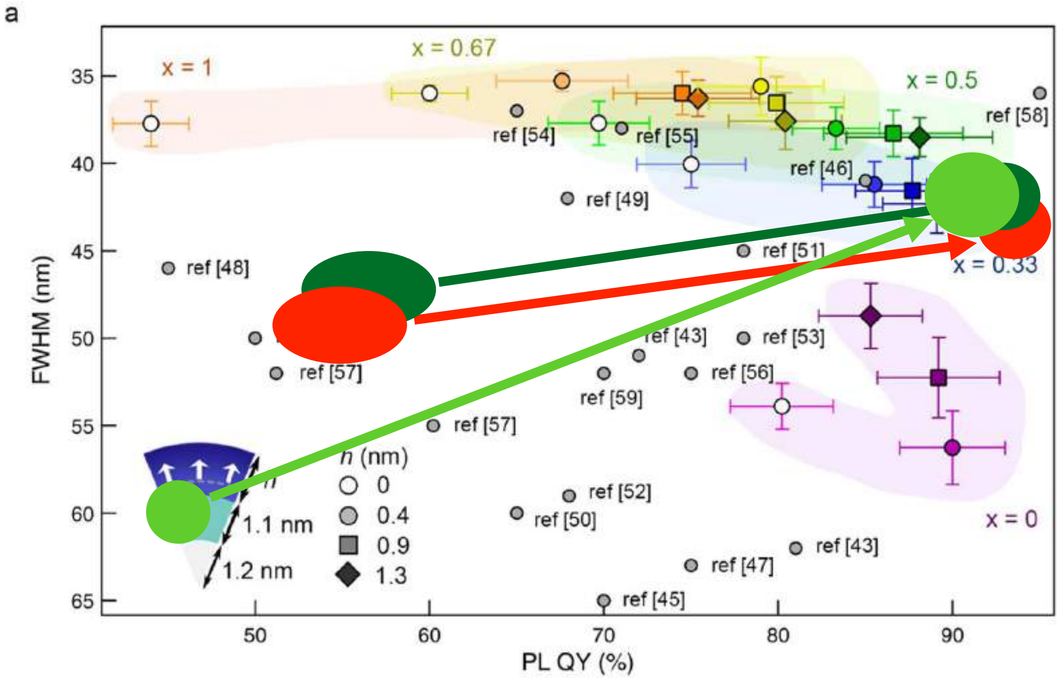
- Required to reach green emission in highly concentrated films
- Tuning of aminophosphine synthesis parameters yields high quality cyan QDs
- Chemical yield >95% (similar to red QDs)
- First focus on wavelength, then on PLQY



Aminophosphine route for efficient InP QDs

Cyan QDs (~ 495 nm)

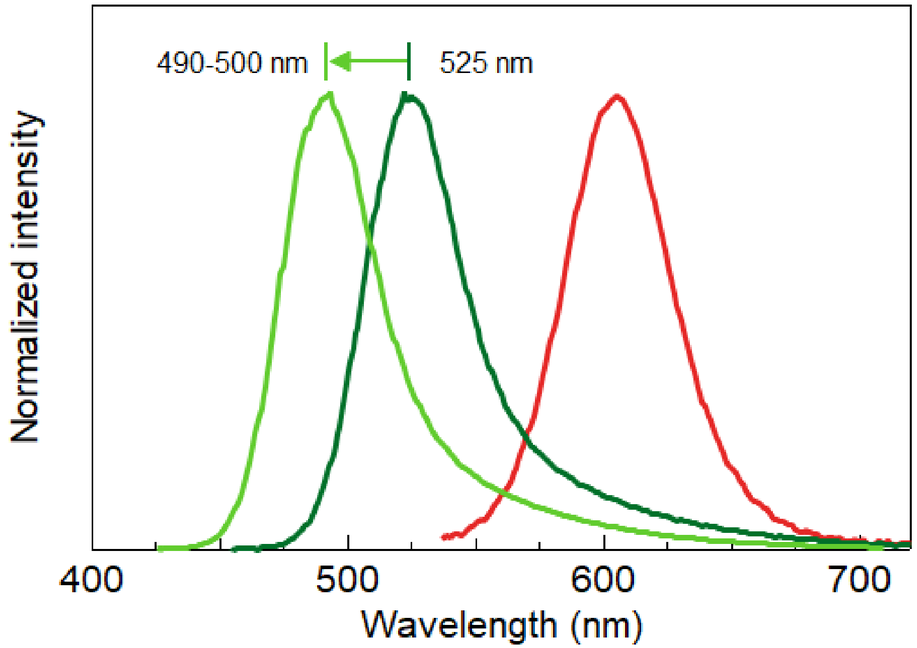
- Wavelength shift to 490-500 nm
- PLQY >90%
- Linewidth <44 nm



Chem. Mater. **2019**, 31, 9, 3476-3484

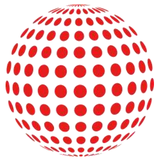
QD synthesis – conclusions

- Cyan and red QDs synthesized at 95-100% chemical yield
- €/emitted photon favors amoniphosphine route
- Red, green and cyan QDs at near unity PLQY



The 5 QustomDot Pillars

QD Synthesis



QD Surface

QD Resin/ink

QD Patterning

QD Device

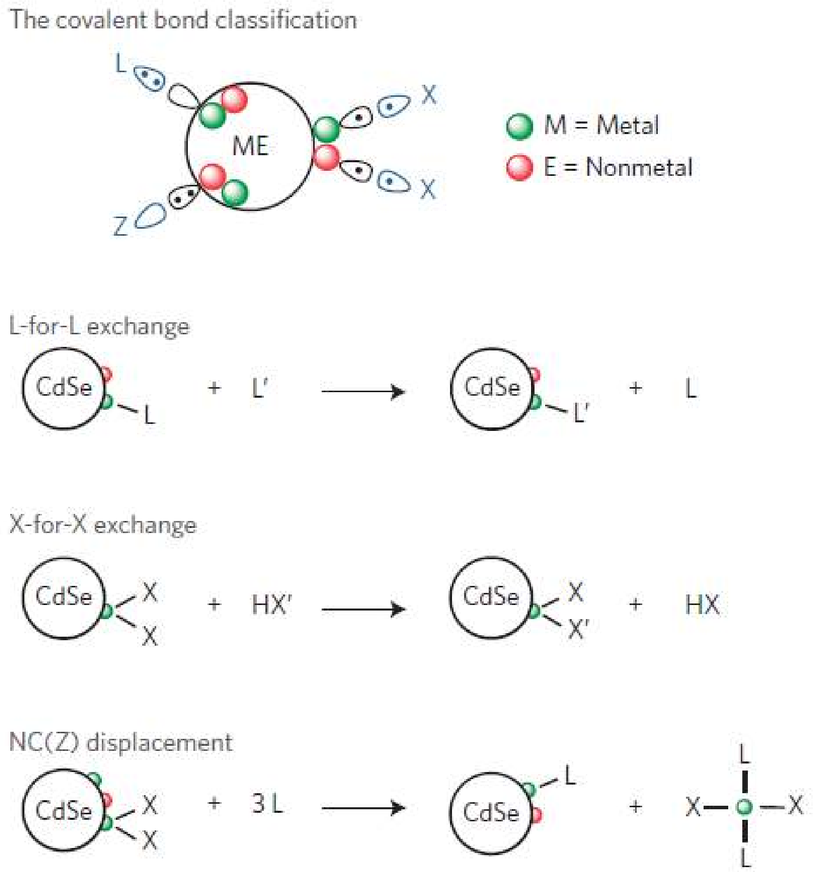
QD ligand exchange

The composition of the ligand shell influences:

- Optical properties
- Dispersibility in solvents and matrices
- Photoluminescent quantum yield
- Chemical stability
- Photostability
- …

Many possibilities in the exchange methods and final ligand shell composition

Target: Establish ligand exchange procedure that preserves PLQY and yields resins with >10 V% QDs



Nature Materials, **15**, pages 517–521 (2016)

QD ligand exchange – increasing solid loading

QDs in apolar medium

Ligand exchange

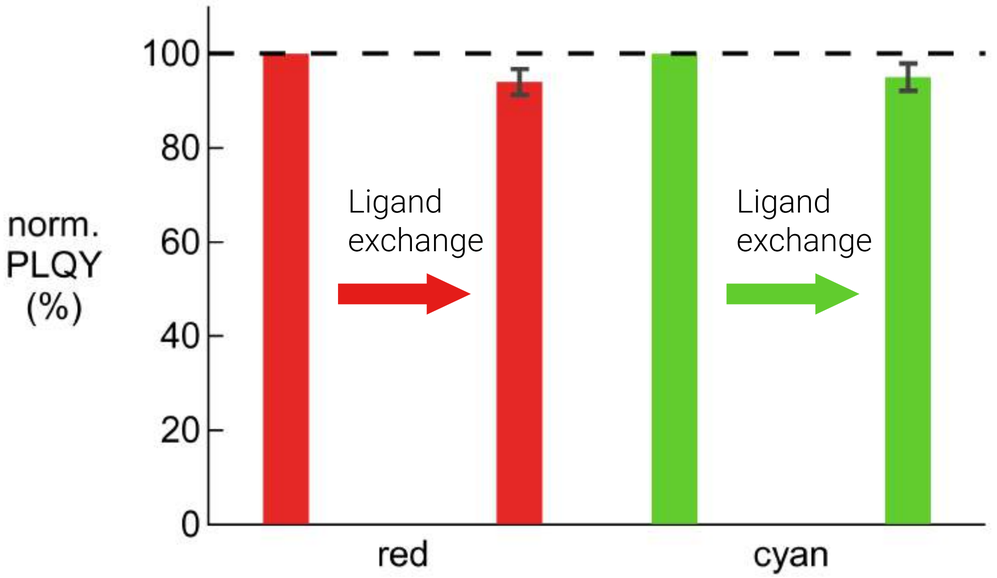
UV-curable, high solid loading resin

1-20 V% QDs

QD ligand exchange – preserving PLQY

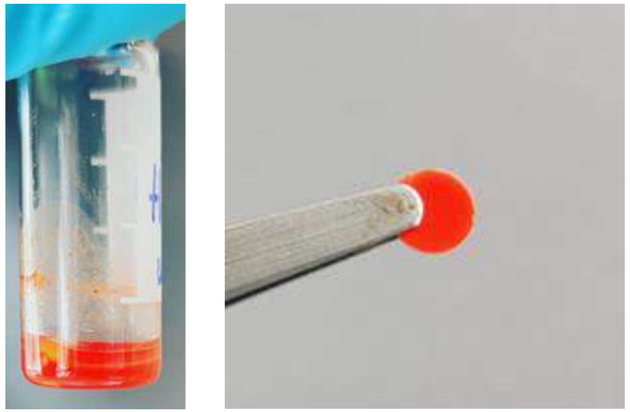
Optimization of ligand exchange reactions

- Gradual improvement of results
- 90-100% of initial PLQY preserved, both for red and cyan QDs



QD ligand exchange – conclusions

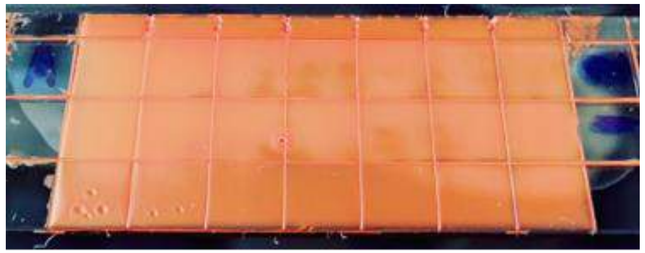
- Ligand exchange methods developed for high solid loading resins (10-20 V%)
- 90-100% of initial PLQY retained after ligand exchange

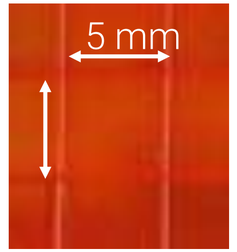


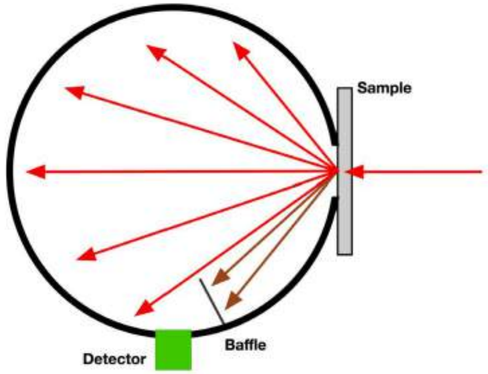
Absorption in thin film

Absorption measurements

- Uniform test samples made with bar coater
- Substrate: 5x5 mm² pre-grooved borofloat glass
- Thickness range: 4-40 µm
- Absorption determined through integrating sphere measurements



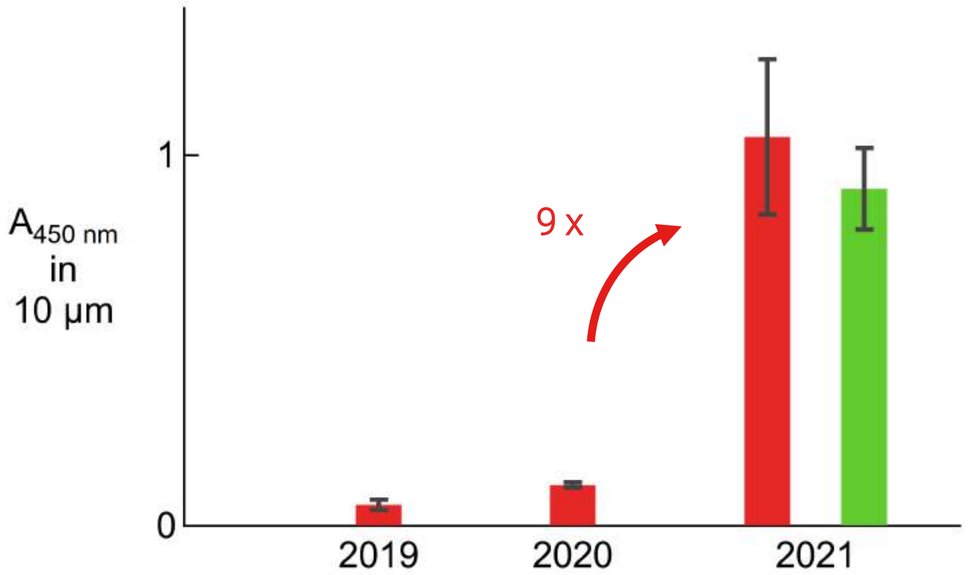




Absorption in thin film

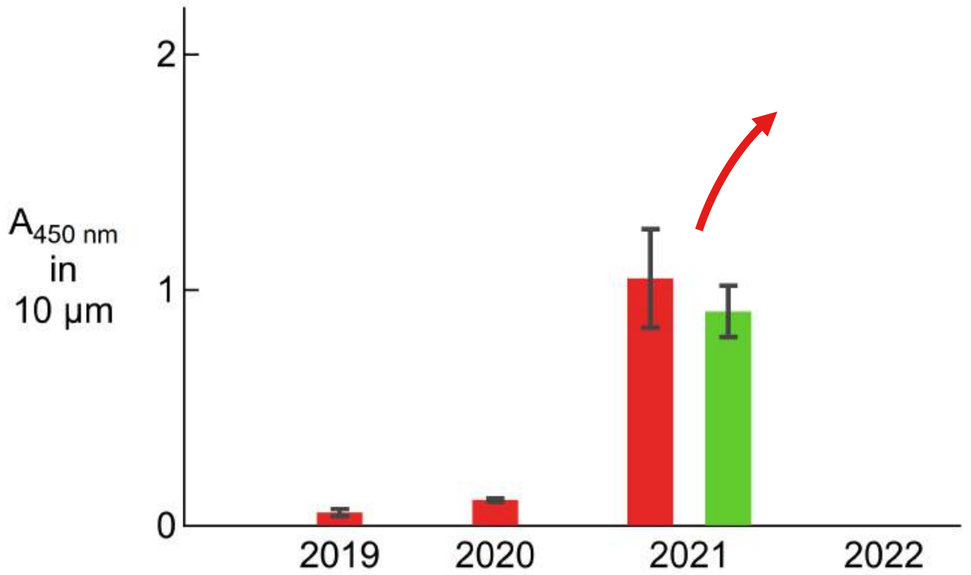
2021 progress

- 9-fold increase of absorption in 10 µm films
- ~ 90% of 450 nm light absorbed
- Both for red and cyan QDs
- Absorption/thickness range for microLED within reach



Absorption in thin film

- Further increase to 95-99% absorption planned for 2022
- Red and cyan InP-based QDs promising for microLED down-conversion



The 5 QustomDot Pillars

QD Synthesis

QD Surface

QD Resin/ink

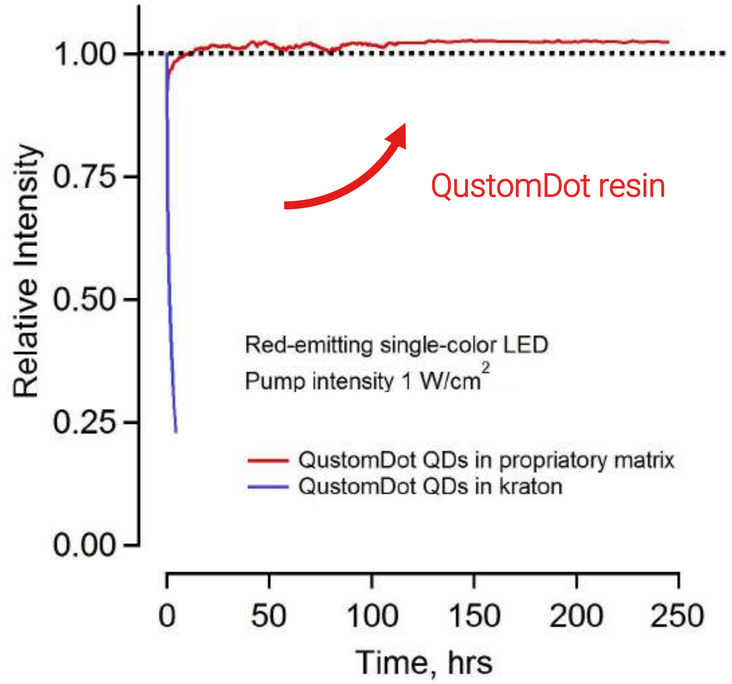
QD Patterning

QD Device

Formulation of QD resins

QD surface expertise is a crucial part of a successful ink or photoresist formulation, but not the only part

QustomDot’s approach makes a good link between the QD surface and the matrix – important for successful implementation



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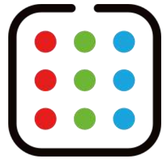
QD Resin/ink



QD Patterning

QD Device

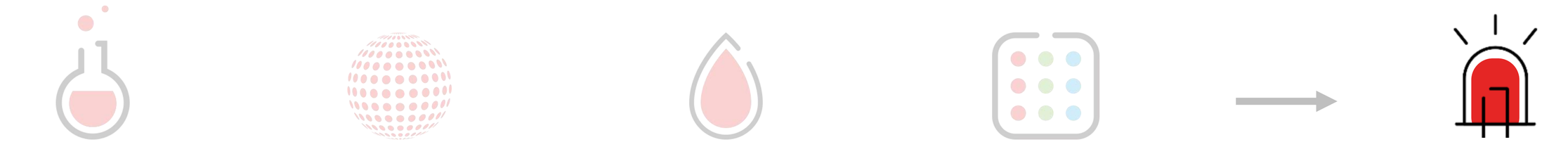
Patterning of QD resins

Target: pattern 20x20 µm² features (short term)

move to < 10x10 µm² in 2022-2023

QustomDot is actively looking for collaborations/partnerships to make demonstrators

The 5 QustomDot Pillars



QD Synthesis

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QD Patterning

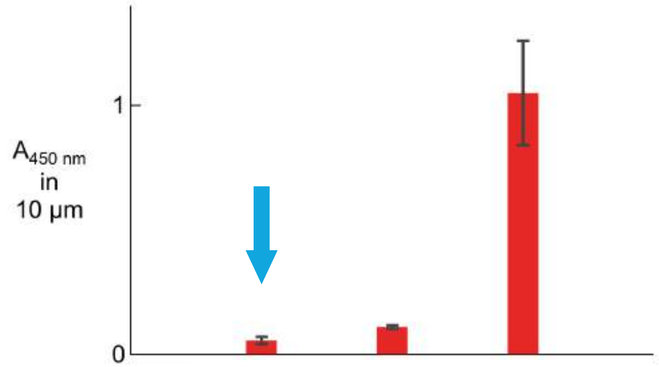
QD Device

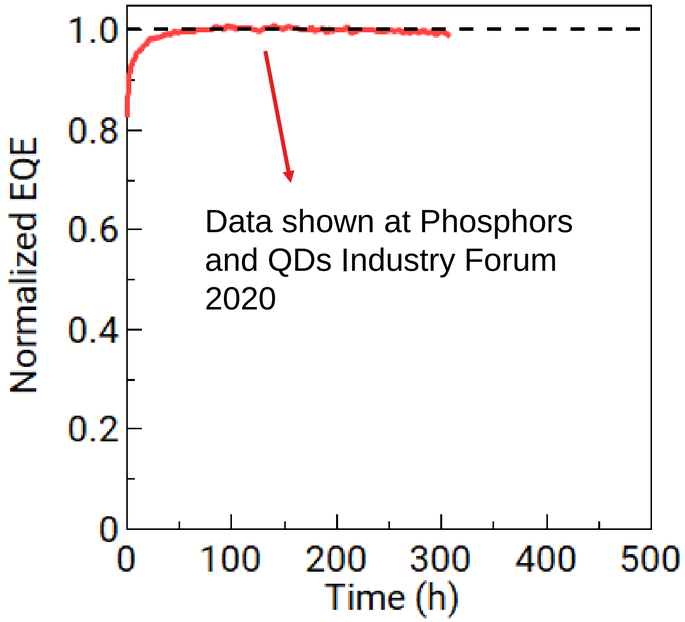
Photostability – thick QD films

300-500 µm

1 W/cm²

1-2 V%





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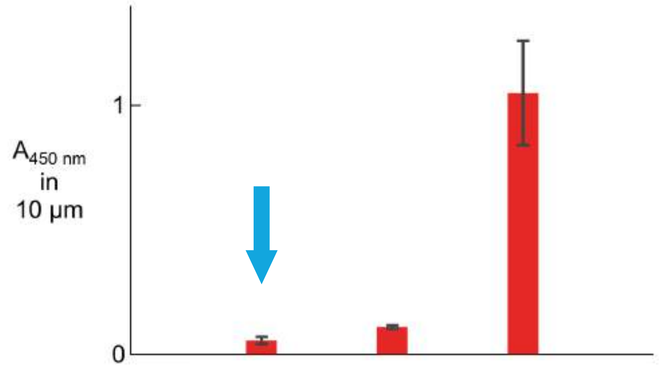
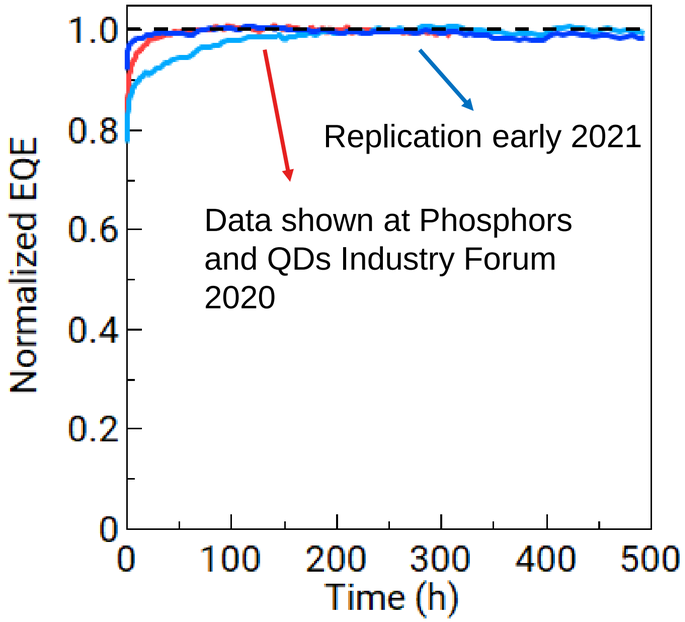


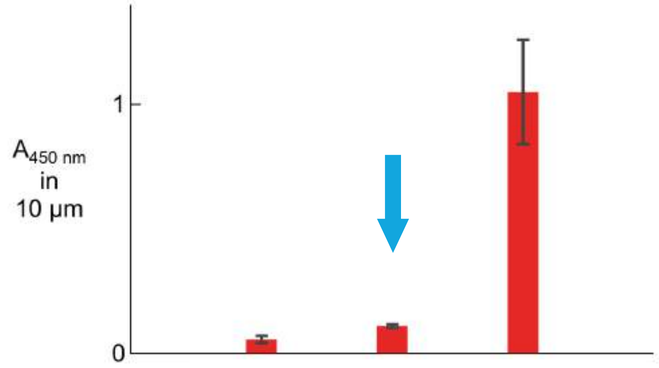


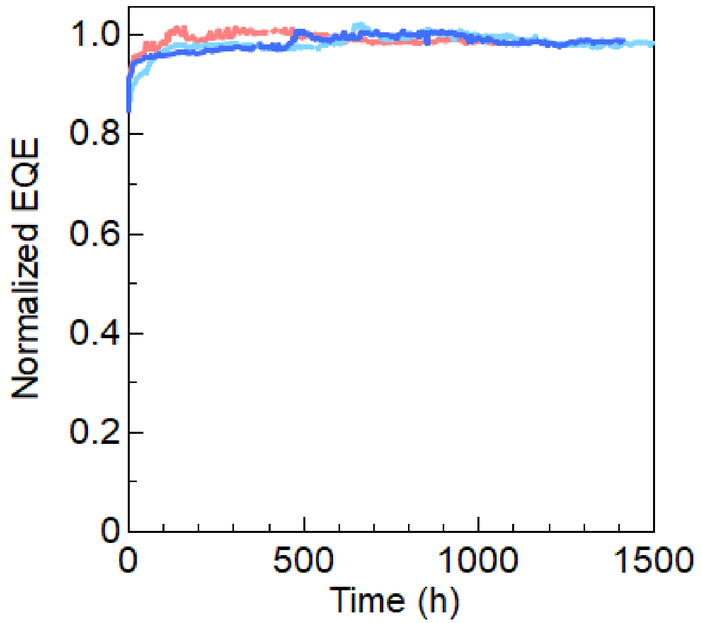
Photostability – towards thinner films

100-150 µm

0.1 W/cm²

1-2 V%



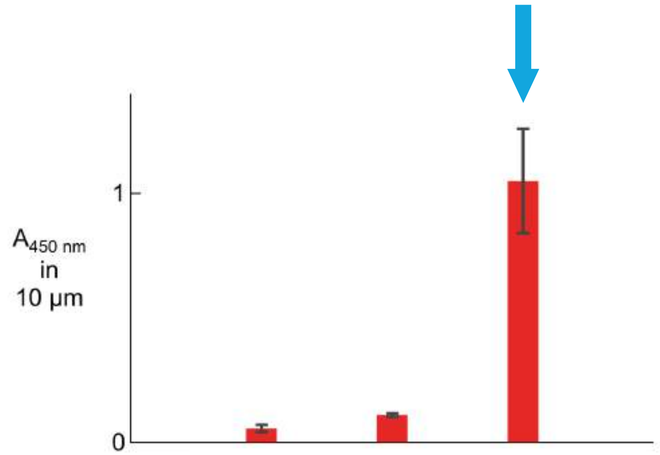


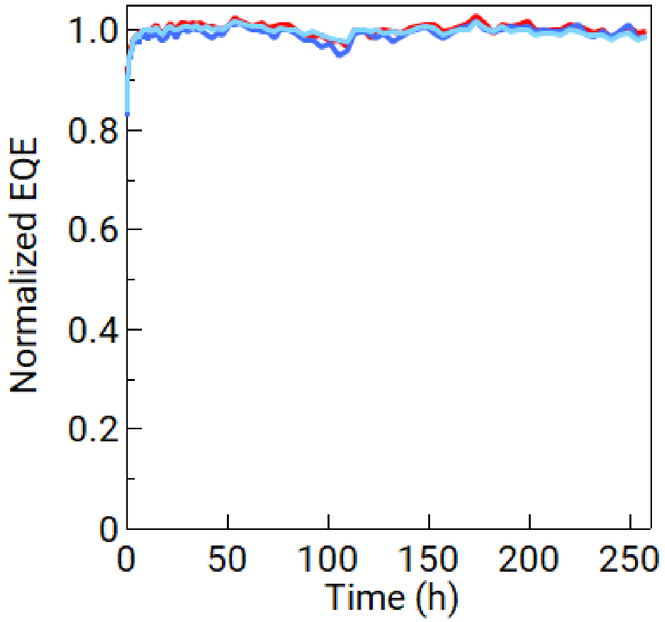
Photostability – towards microLED

15-20 µm

0.1 W/cm²

~10 V%





Photostability – towards microLED

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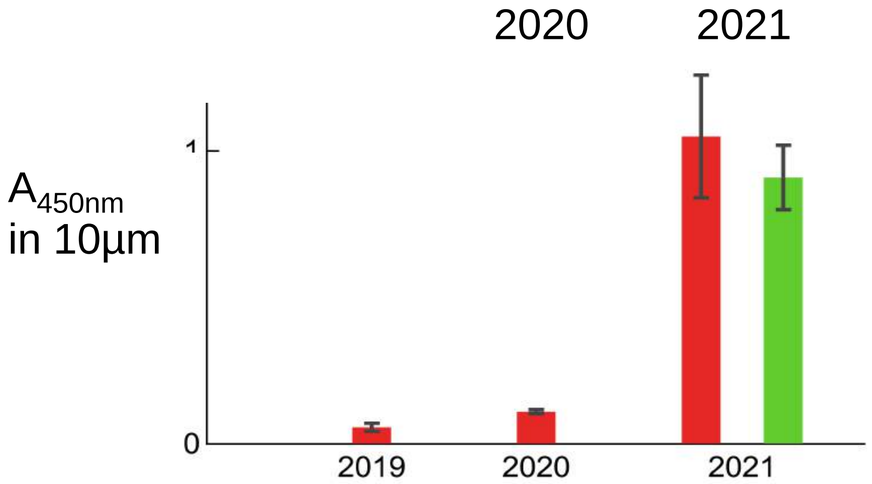
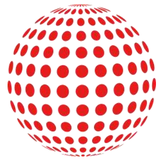


	2019	2020	2021
250h of stability	✓	✓	✓
Intensity W/cm²	1	0.1	0.1

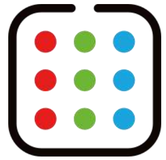
The 5 QustomDot Pillars

QD Synthesis



QD Surface

QD Resin/ink



QD Patterning

QD Device

Introduction

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Business model and collaboration

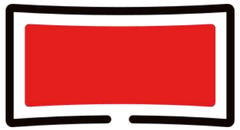
How QustomDot can be of service

The market potential is huge

There are various applications where on-chip grade QDs could make the difference.

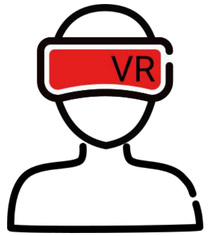
Automotive head-up displays

$80B



MicroLED TVs & laptops

$45B & $11B

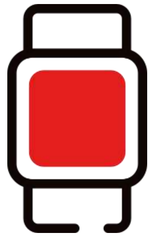


AR/VR googles

$6B

Smartphones

$51B



Smart watches

$2B

Our business model

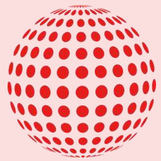
QustomDot develops on-chip grade QD technology for MicroLED manufacturers.

We produce an QD ink/photoresist through an industrialization partner (to be determined).

QustomDot → QD ink/photoresist industrialization partner → MicroLED manufacturers → Display partners → End customers

The 5 QustomDot Pillars

QD Synthesis



QD Surface

QD Resin/ink

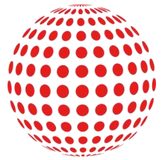
Own expertise

QD Patterning

QD Device

The 5 QustomDot Pillars

QD Synthesis



QD Surface

QD Resin/ink

QD Patterning

QD Device

Partnerships

Thank you for your attention

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