

# Engineering Customized Light: Quantum Dots Beyond Information Display

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Talk, Munich 05.02.2026



# Our Mission Statement: We Make Materials Fit for the Future!



# OLED Applications in Automotive

## OLEDs are used in Automotive Displays and Backlights

- **Stability and sunlight readability now automotive ready**
  - LG & Samsung @ Mercedes-Benz & BMW
  - OLED Works @ Audi
- **OLED enabling:**
  - Unmatched designs and (almost) freeform shapes
  - Curved and bendable displays
  - Very high contrast
  - Ultra thin (< 1 mm) → lower system complexity
  - Brightness reaching 1000 nits (Display) or 2000 cd/m<sup>2</sup> (Backlight)
  - Low glare, low blue, UV-free
- **Perspectives:**
  - Ambient lighting and signage
- **Room for improvement:**
  - Brightness, Efficiency, Temperature budget, Production cost



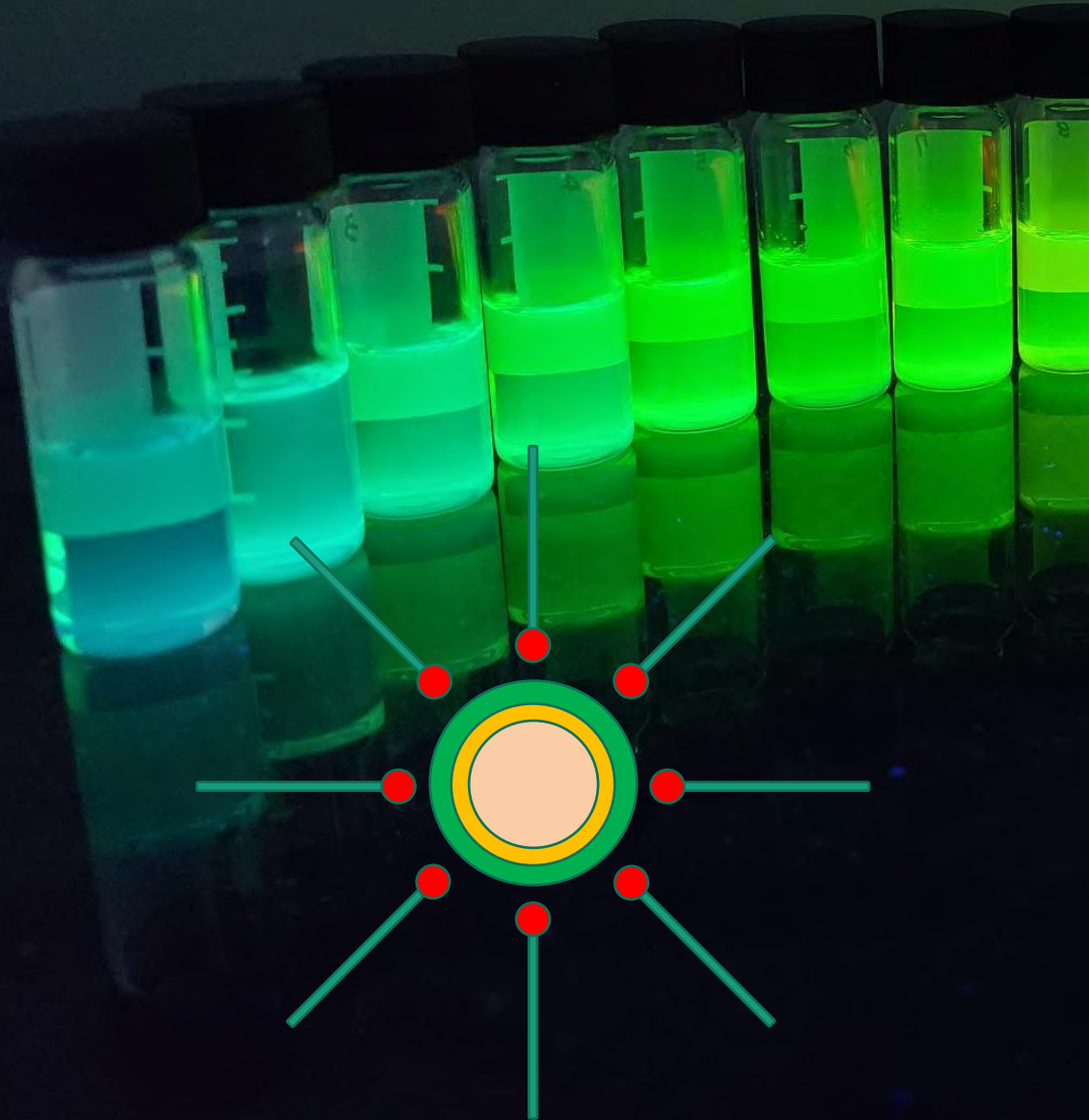
- Samsung Circular OLED Display
  - BOE Automatic Flexible OLED Vehicle Displays
- [SID Display Week 2024]



- OLED Works OLED Car Backlight [LOPEC 2022]

# Quantum Dots

Nobel Prize 2023



Illustrations: Niklas Elmehed

## THE NOBEL PRIZE IN CHEMISTRY 2023



Moungi G.  
Bawendi

Louis E.  
Brus

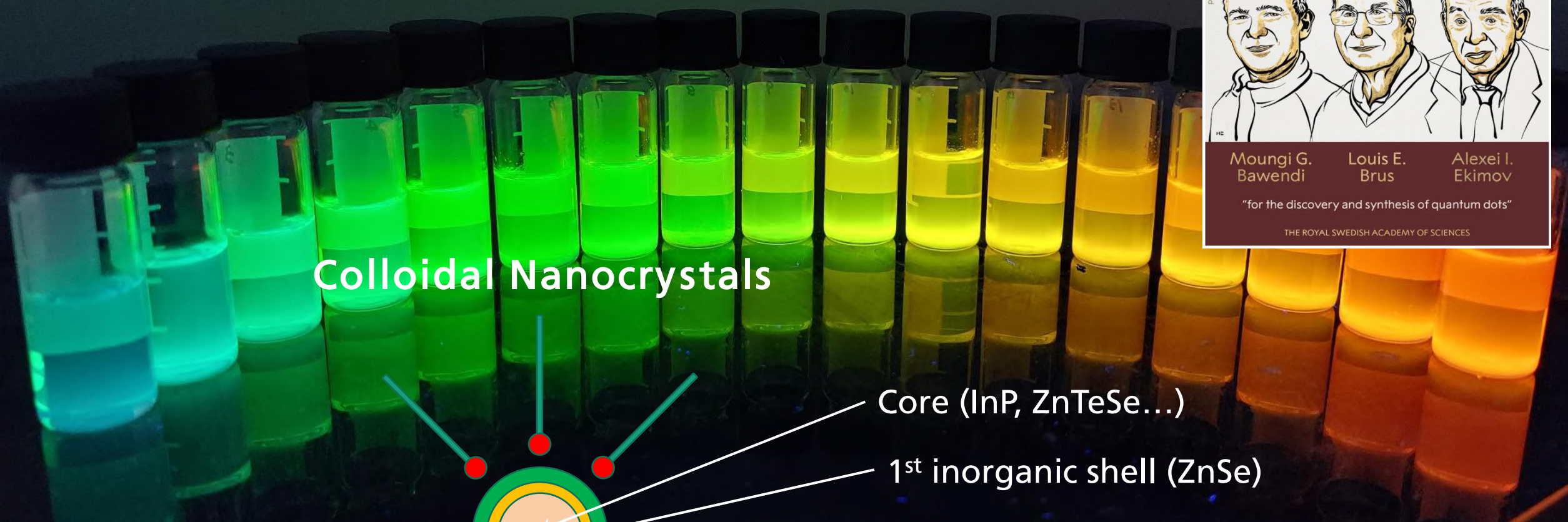
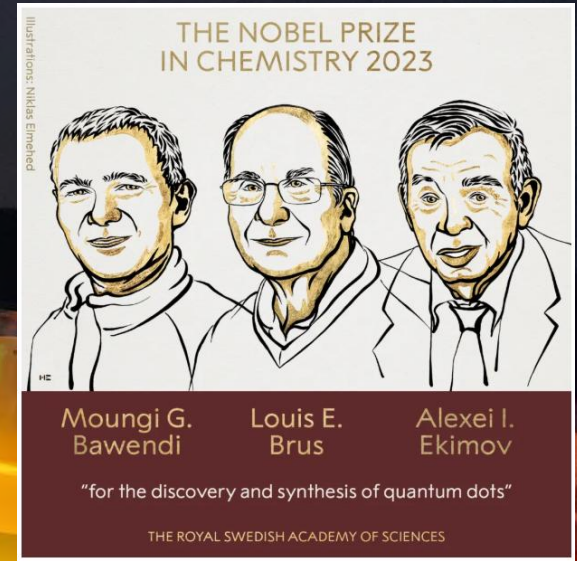
Alexei I.  
Ekimov

"for the discovery and synthesis of quantum dots"

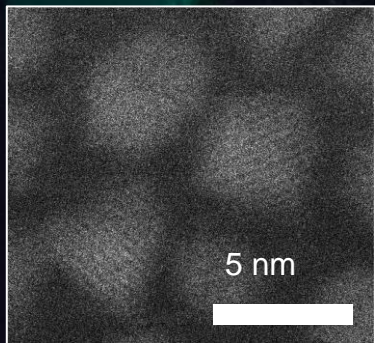
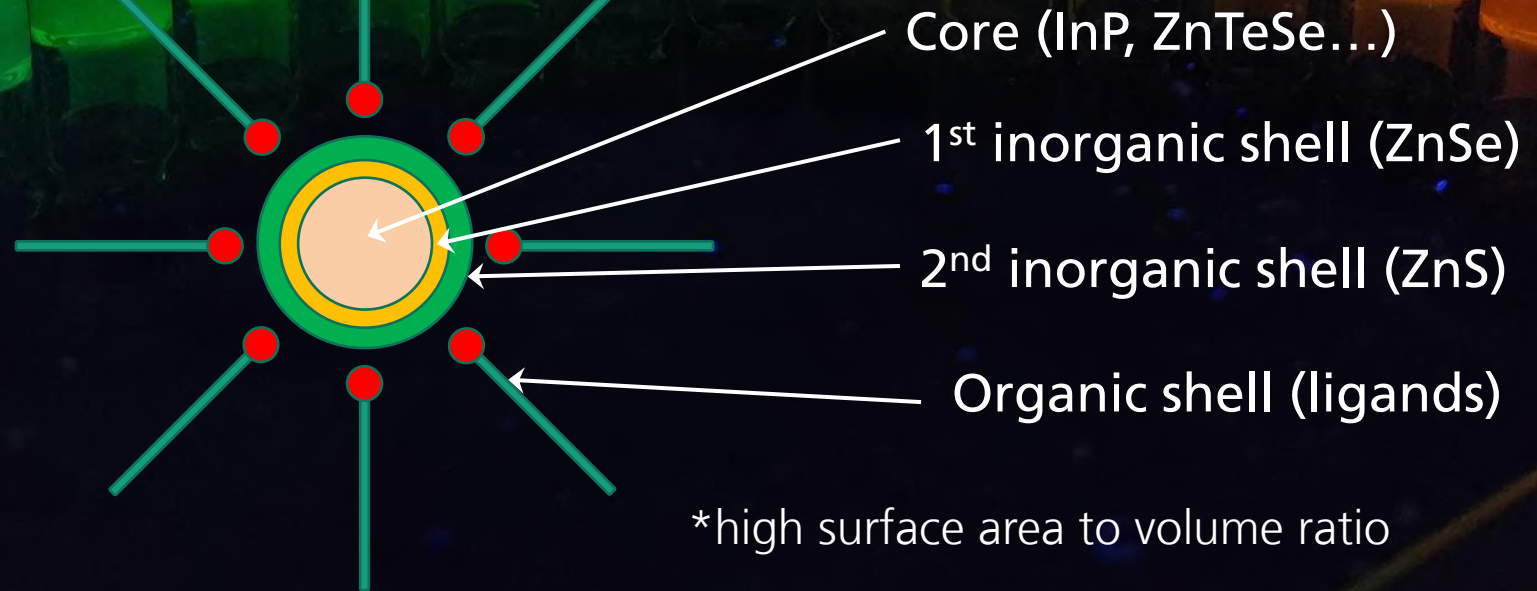
THE ROYAL SWEDISH ACADEMY OF SCIENCES

# Quantum Dots

Nobel Prize 2023

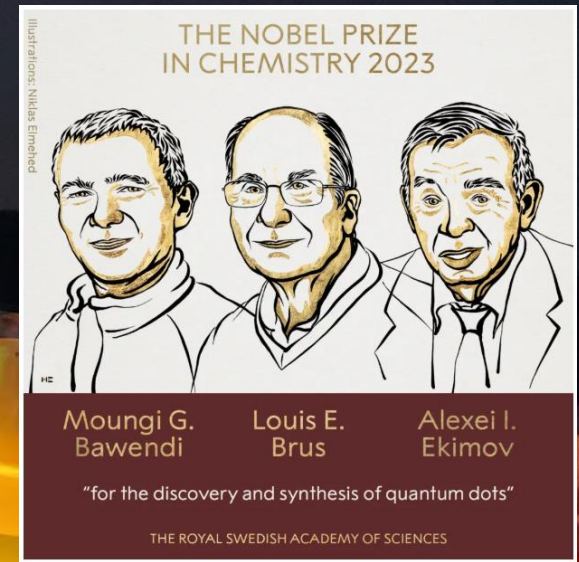


## Colloidal Nanocrystals

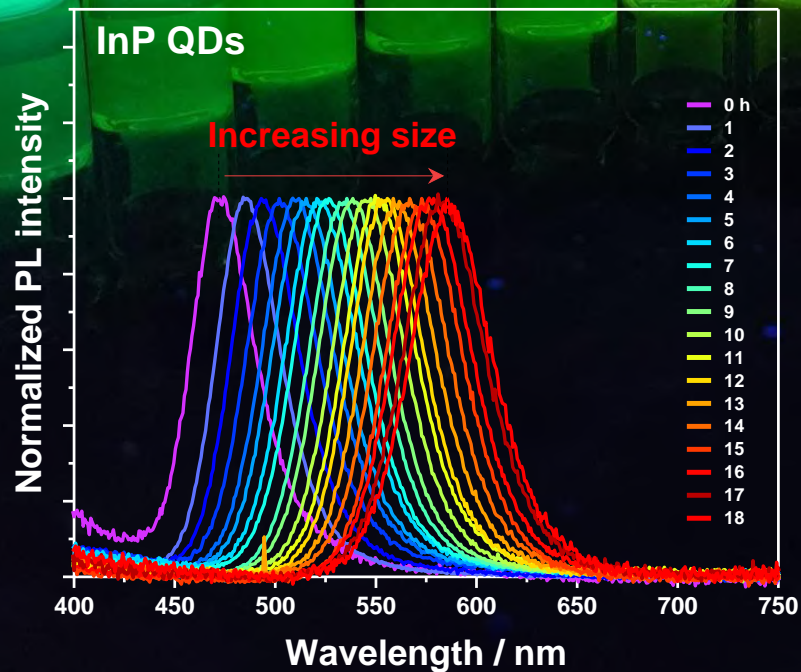


# Quantum Dots

Nobel Prize 2023



Tunable color with size



Scalable Synthesis



# Quantum Dots for Color Conversion

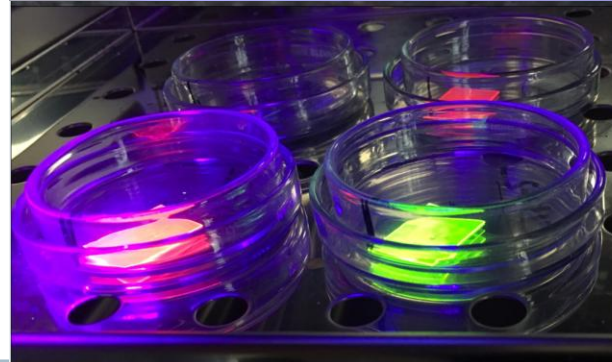
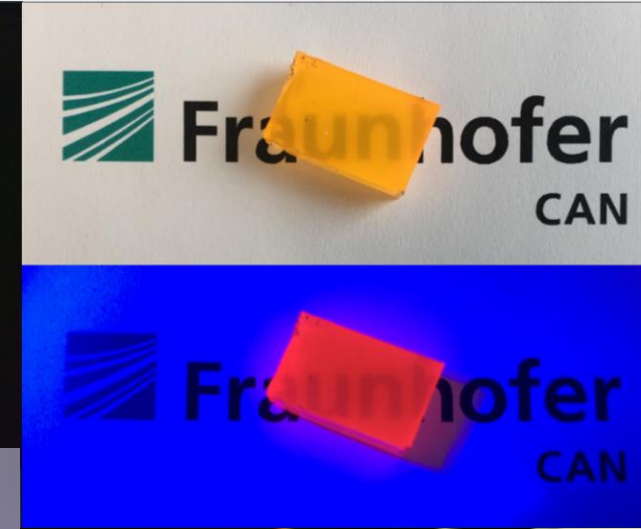
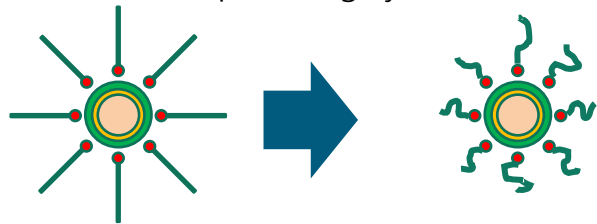
## QDs Enabling Colorful Fluorescence

### ▪ **Methods of application:**

- Polymer-embedded
- Back-/Side lit by blue LEDs
- QDs in printable ink formulations (UV curable)
- Added as phosphor to LEDs

### ▪ **Advantages over inorganic/organic phosphors:**

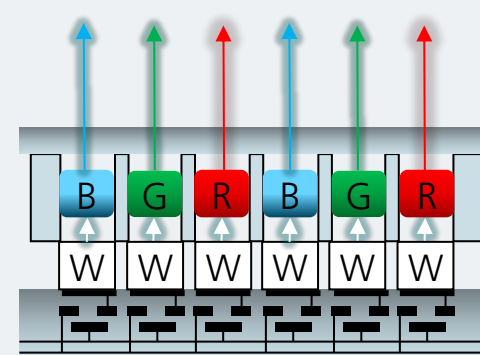
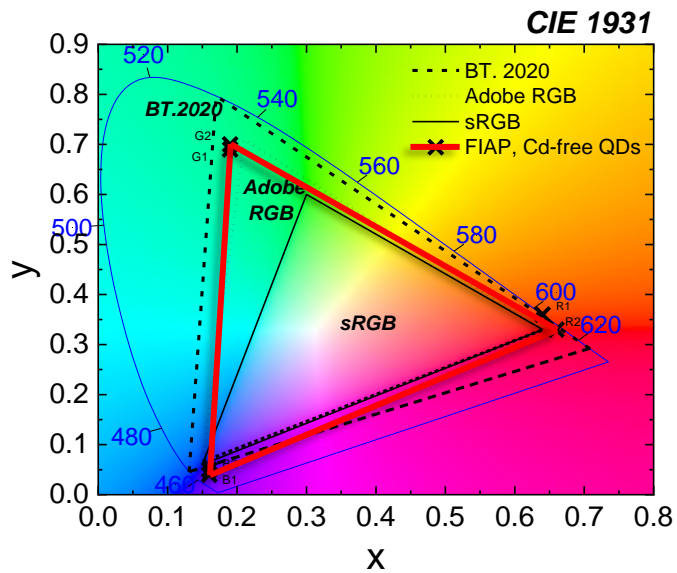
- Processibility very flexible due to ligand exchange
- Almost free tunability of colors → Match of light color or branding
- Very narrow FWHM → Pure colors and high efficiency
- High stability due to inorganic nature
- Cost efficient when up-scaling synthesis



# Quantum Dots for Color Conversion

## QDs Enabling Brilliant Displays

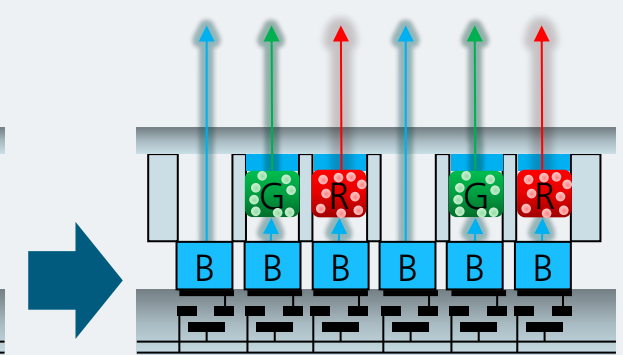
- Improving the Backlight of LCD displays
  - 1<sup>st</sup>: Sony's 2013 Triluminos
- Improving the color purity of OLED displays
  - 1<sup>st</sup>: Samsungs 2023 QD-OLED



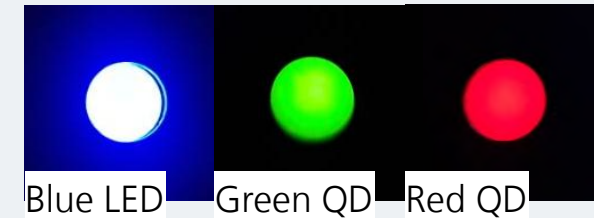
Scheme of OLED Display



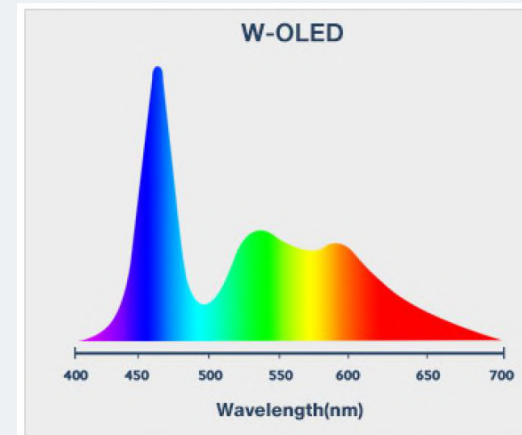
Green, Red and Blue OLEDs



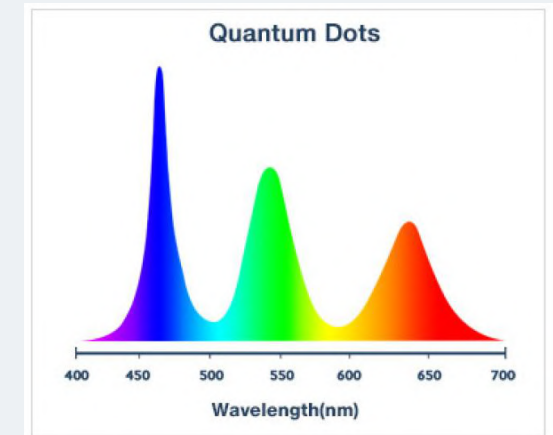
Scheme of QD-OLED Display



Blue LED Green QD Red QD



Source: Nanosys

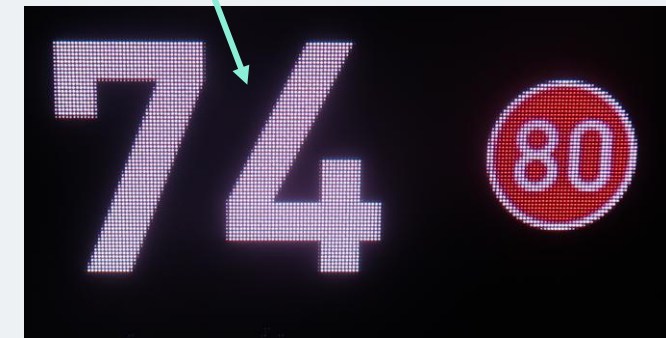
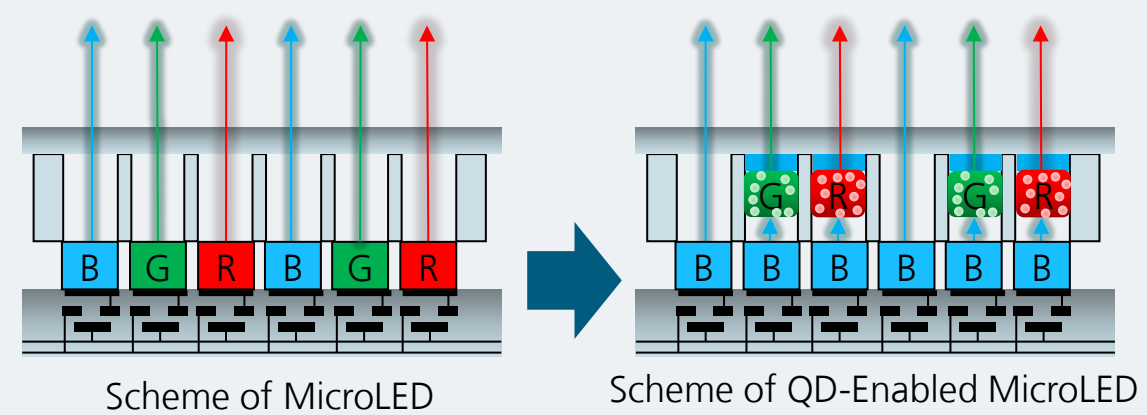


Source: Nanosys

# Quantum Dots for Color Conversion

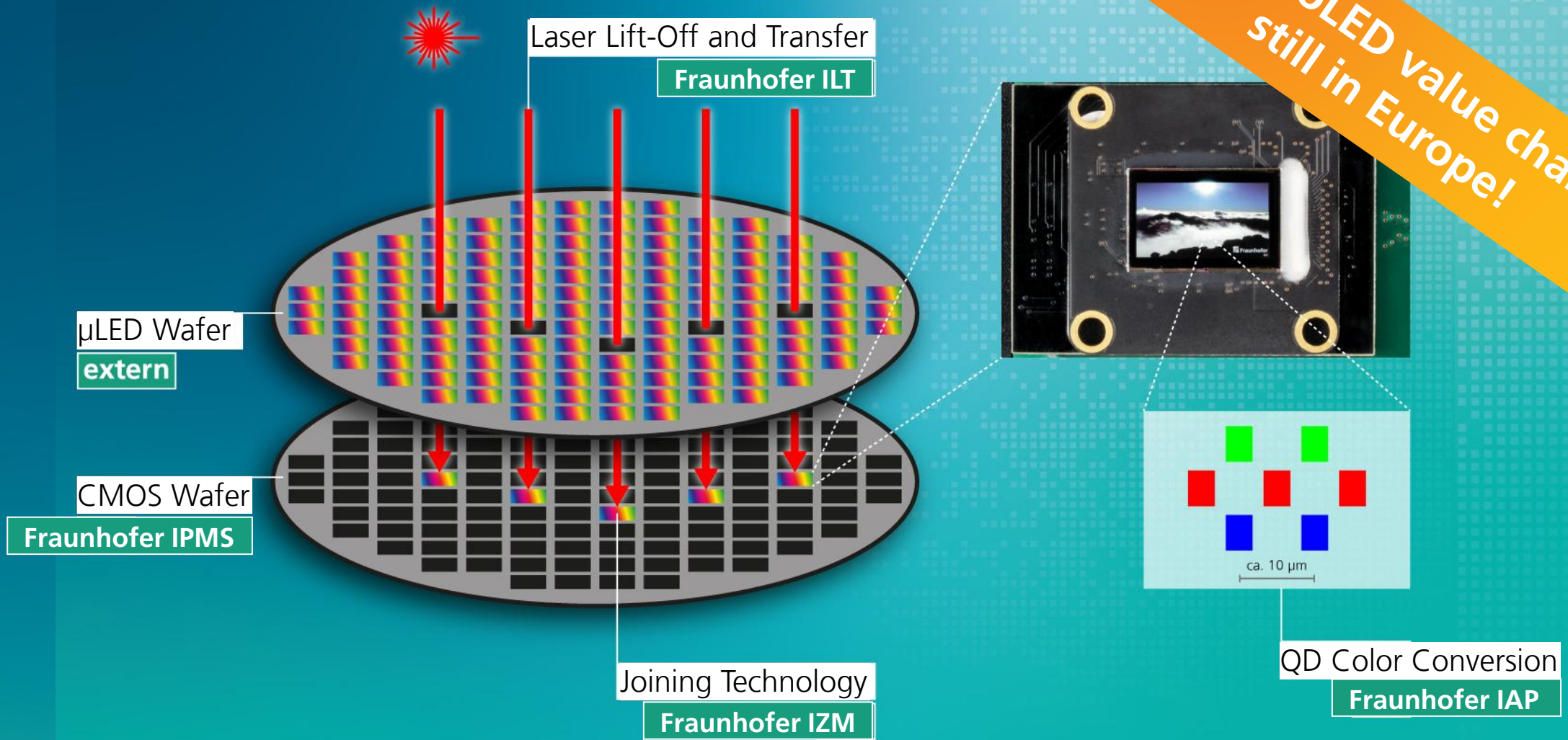
## QDs Enabling MicroLEDs (LEDs of $<20\ \mu\text{m}$ )

- **Promising new high-performance technology**
  - Enabling high-resolution displays with LED performance
  - High efficiency
  - Outstanding lifetime without encapsulation
  - Outstanding brightness ( $>10.000\ \text{cd}/\text{m}^2$ )
- **Challenges:**
  - Mass transfer process
  - Poor efficiency of green and small red LEDs ( $<10\ \mu\text{m}$ )
- **Solution → Quantum Dot Color Conversion**



BOE Automotive Transformer Display Prototype [SID Display Week 2025]

# Fraunhofer $\mu$ LED Assembly Project



MicroLED value chain still in Europe!

# Quantum Dot LEDs

## The Best of Quantum Dots

### QDs as direct Emitter (Similar to LED):

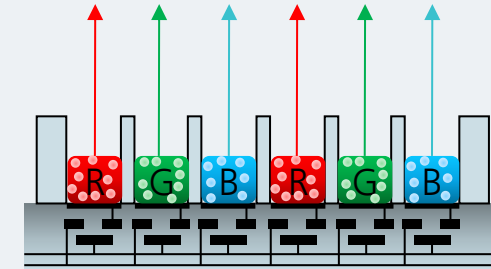
- Outstanding color gamut of QD-OLED / QD-MicroLED
- Much simpler device layout
- High brightness
- High efficiency

### Challenges:

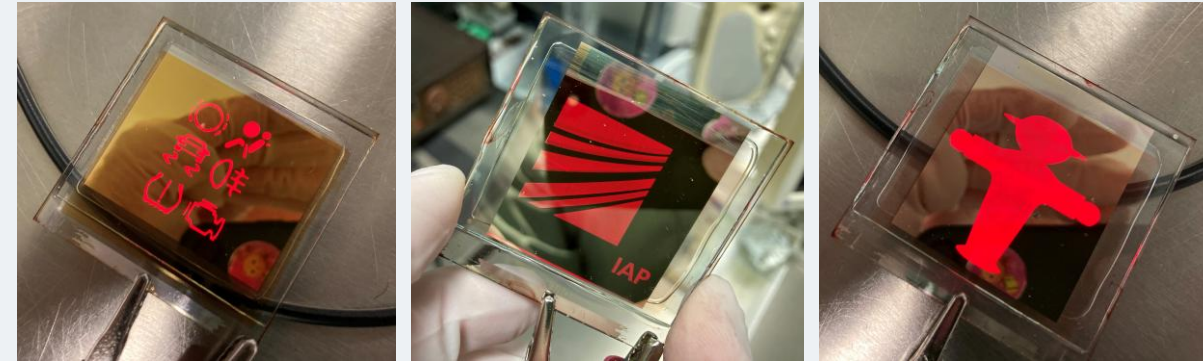
- Lifetime (blue)
- Ink formulation
- Printing Processes



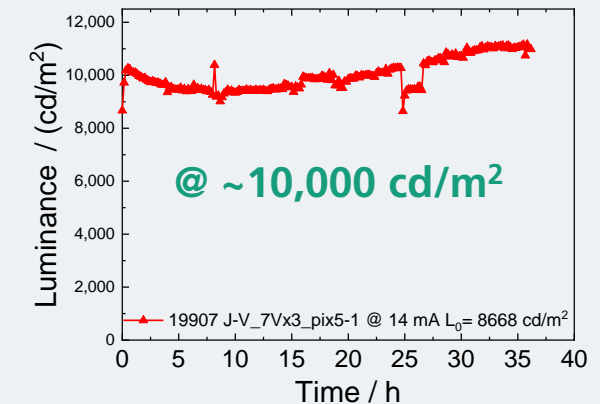
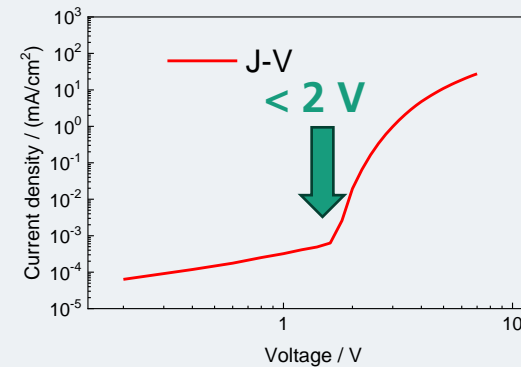
Samsung QD-LED Display Prototype  
[SID Display Week 2024]



Scheme of QD-LED



QD-LED Demos using Fraunhofer IAP GS-Quantum Dots



# Pilot line at Fraunhofer IAP / Application Center - 300 mm<sup>2</sup>

From lab scale to pilot scale

Semi-automation by robots  
Size of Substrates (150 mm x 150 mm)



## Module A:

- Inkjet (LP50)
- Slot-die
- Vacuum oven, O<sub>3</sub>

## Module B:

- Evaporation
- Thermal & e-beam
- Metal and organic

## Module C:

- Atomic layer deposition (ALD)
- Glass encapsulation

# General Development Process

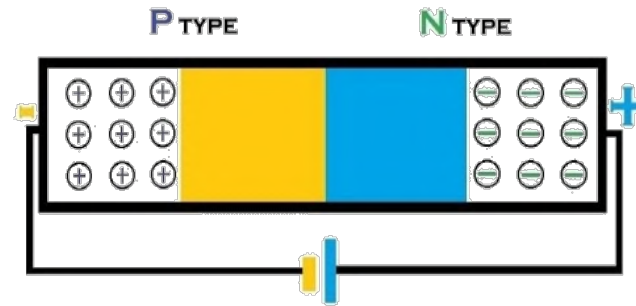
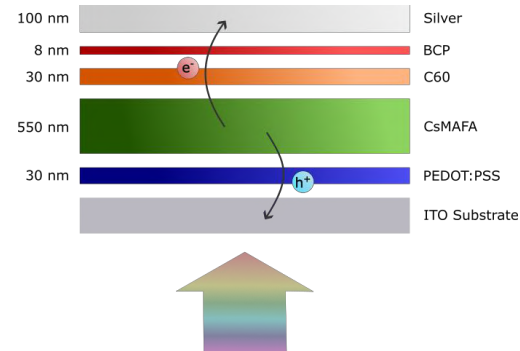


Image: Johanna von Scheven

**Materials**

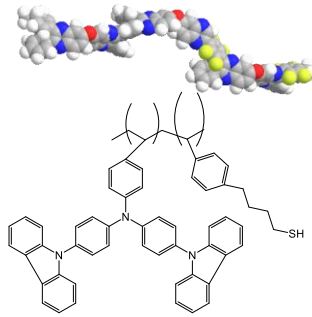
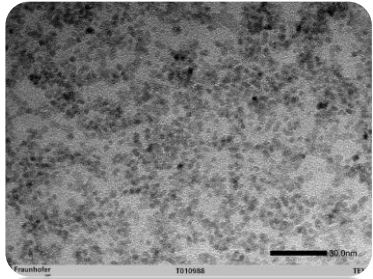
**Devices**

**Printing**

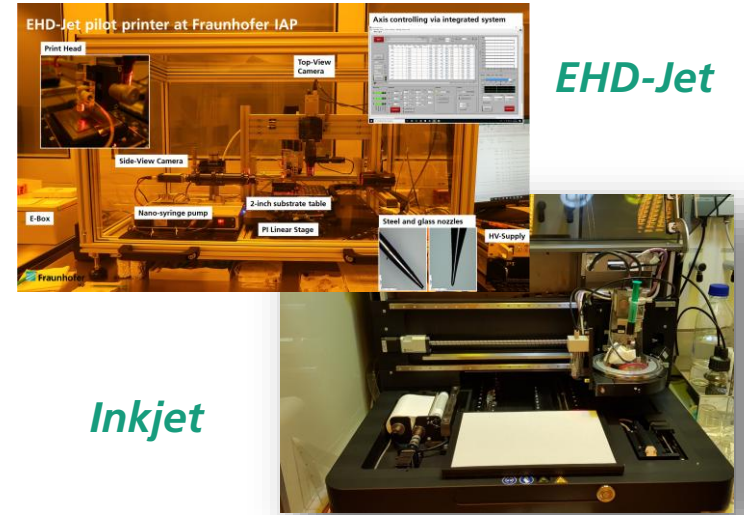
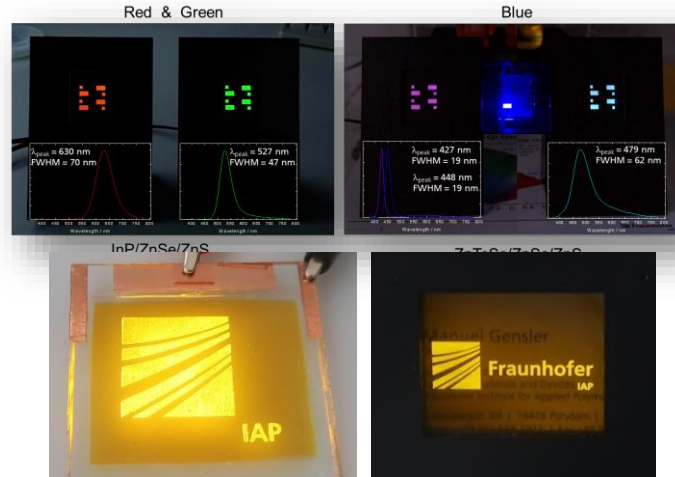


# General Development Process

Nanoparticles (ZnO, ZnMgO)  
Organic Semiconductor



Displays (OLED, QD-LED)

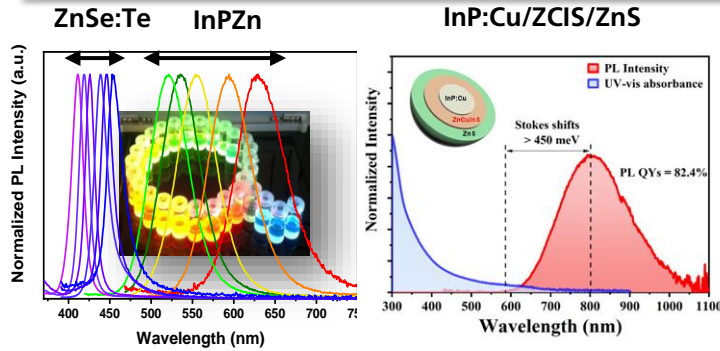


Inkjet

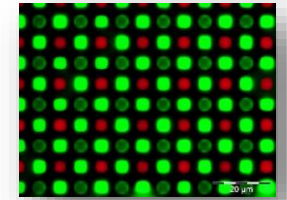
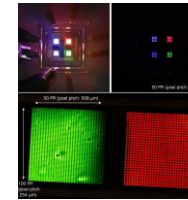
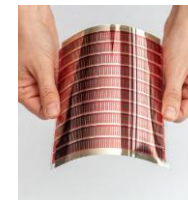
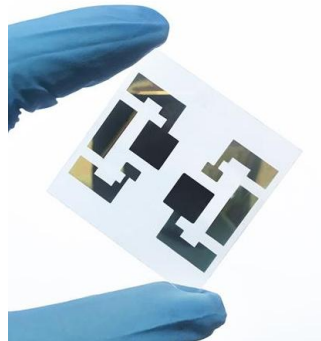
Materials

Devices

Printing



Quantum Dots (Visible, NIR)



Pilot-line / Printed Devices

Energy Harvesting (OPV, Perovskite, LSC)

# Questions and Ideas?

Please get in touch with us!

Head of Department:

Functional Materials and Devices  
Printing Technologies, OLED, OPV

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