CLUSTER OF EXCELLENCE
Merge Technologies for
Multifunctional Lightweight
Structures

Integration of quantum dot lighting devices in plastic material

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1. Introduction

The electrical and optical properties of quantum dots (QDs) are strongly influenced by their particle size due to quantum effects [1]. This characteristic gave rise to the development of quantum dot light emitting diodes (QLED) over the last two decades [2]. In addition to the broad size-tunable spectral range QDs feature narrow emission bandwidth and excellent chemical stability. However, efficient and stable QLEDs are still subject of current research. In this work we want to introduce a route leading to an integrated quantum dot light source by enhancing its stability, which is e.g. suitable for display and lighting elements in interior and exterior of automobile applications.

2. Theory of QLEDs

QLED-Design

- Design dependent operating mode (DC/AC)
- QDs sandwiched by dielectrics (PVP, PS)
  → AC-mode
- No complicated injection of charge carriers required
- No additional layers needed for
  energy band gap alignment or
  improvement of electric contact

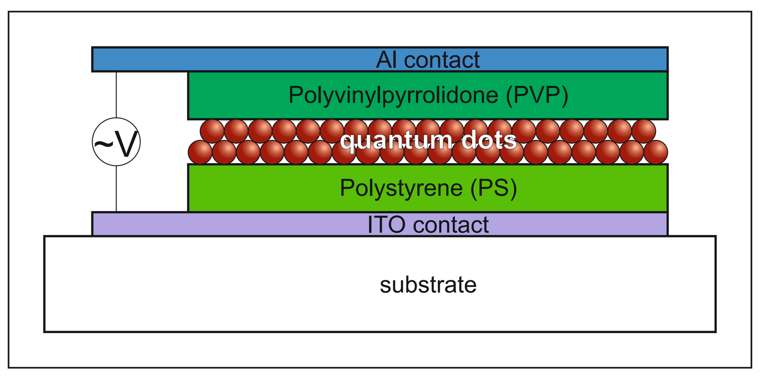

Fig. 1: Schematic of a QLED

Field-driven electroluminescence [3]

- Blue: Electron transfer from valence band to conduction band of neighboring QD due to strong electric field
- Green: Field assisted transport of charge carriers
- Red: Exciton forming and recombination (nonradiatively or radiatively)

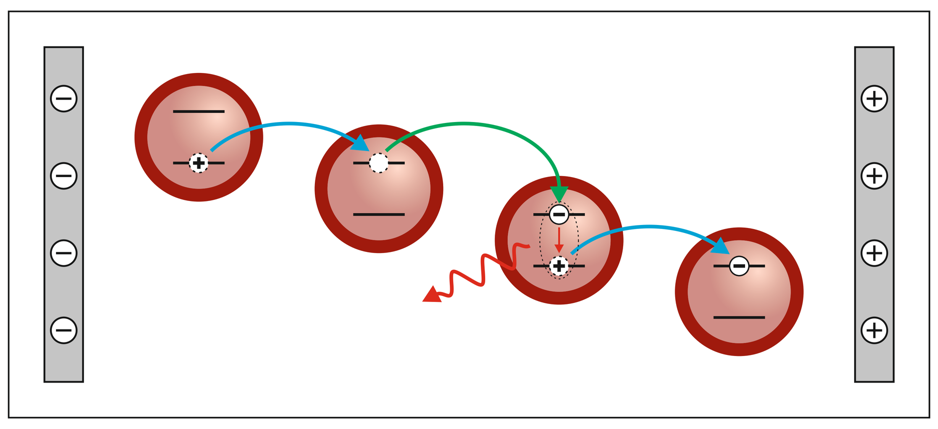

Fig. 2: Simplified illustration of the operating mode

3. Characterization of separate QLEDs

Samples

- Spin coating of PS, QDs & PVP from solutions on ITO-substrate (glass, PET foil)
- Al electrode deposited by PVD

Experimental setup

- Confocal microscope
- Sinusoidal AC voltage at 100 kHz
- Different amplitudes

QLED properties

- Turn-on voltage 70 Vpp
- Maximum brightness at 100 Vpp
- Start of degeneration at 100 Vpp
- Breakthrough at 150 Vpp or higher (not shown in the graphic)

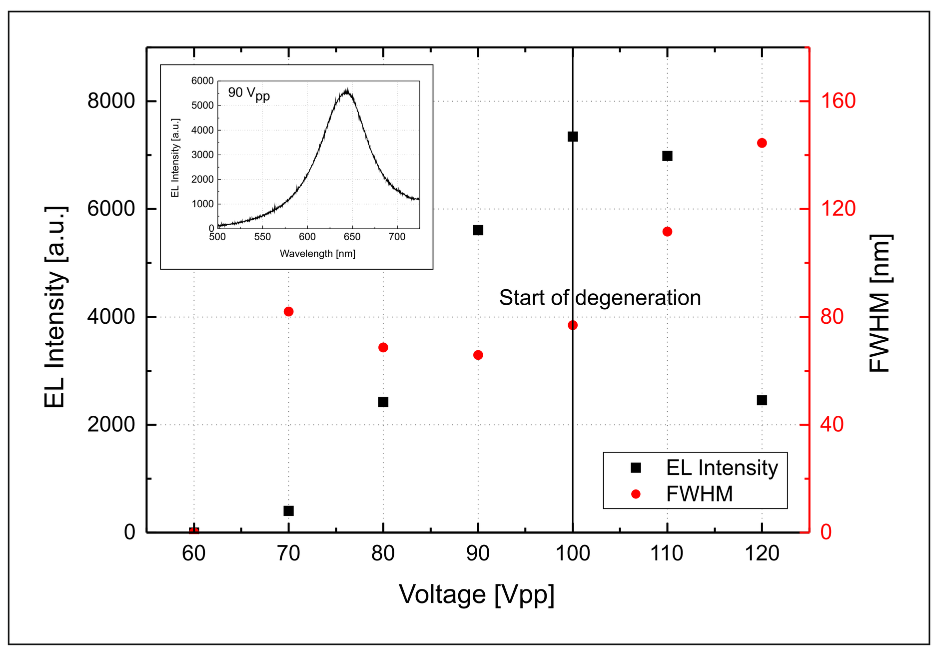

Fig. 3: Electroluminscence (EL) intensity and FWHM of a QLED at different applied voltages

4. Injection molding

Investigation of behavior during production process and adhesive strength afterwards

Materials

- Unreinforced and glass-reinforced polymers PP, PMMA, PC & PA
- ITO and Al coated PET foils with and without surface treatment (plasma or acid) for activation

Process parameters:

- Foil dimensions
- Positioning
- Fixing inside of molding tool
- Melt and mold temperatures

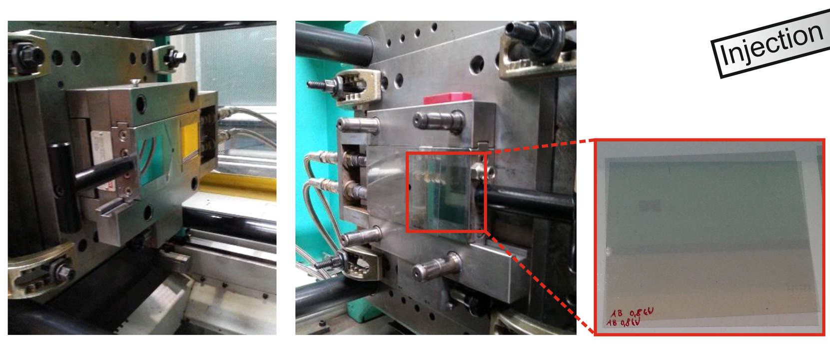

Fig. 4: Experimental setup

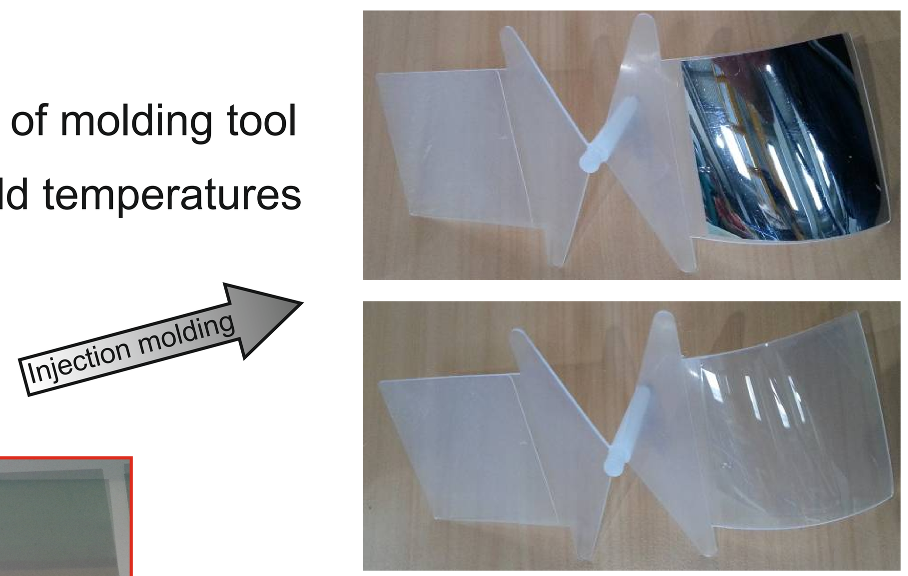

Fig. 5: PP samples show strong deflection

Fig. 6: PA specimen with coated foils

Results

- Unreinforced Polymers: Strong deflection due to high shrinkage compared to PET foil
- PA: Lower shrinkage and deflection, increase in stiffness because of reinforced polymer

5. Conclusion

- First investigations on integrateable QD-based light sources
- Promising results regarding light emission intensity and required AC voltage
- Next steps: Processing and characterization of undermolded and reinforced QLED-foils

6. References

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