White Light Emission from InGaN/GaN LEDs and Nanorods Using a Novel Organic Compound for Colour Conversion

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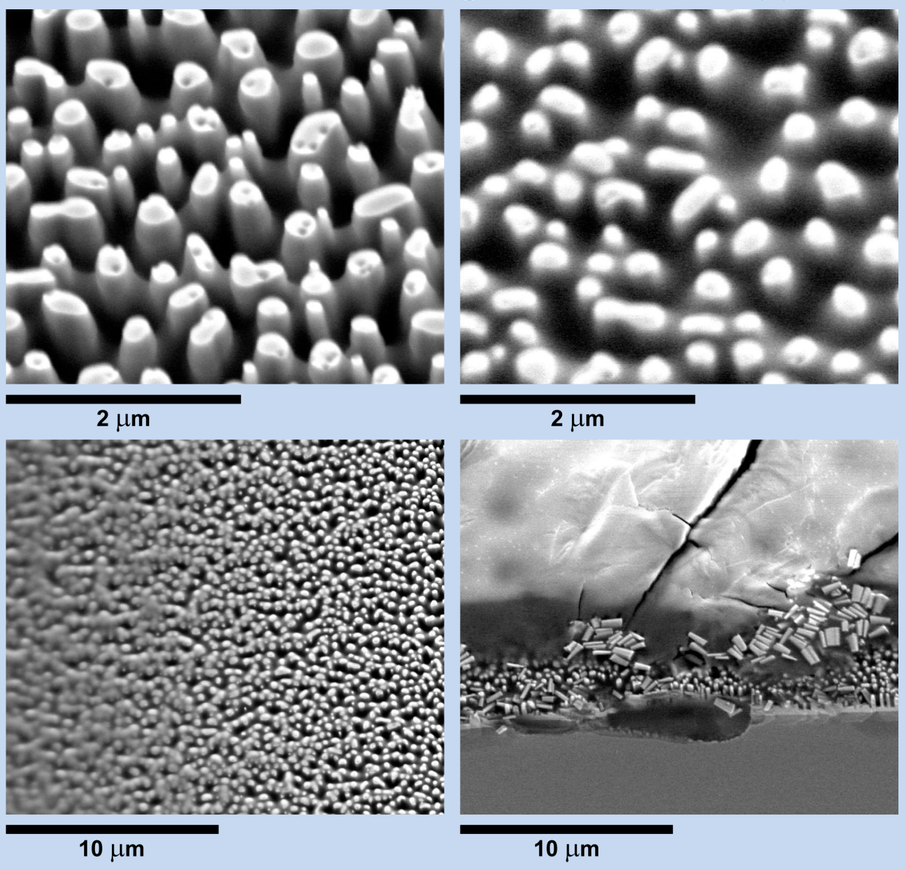
Motivation

- Light-emitting diodes (LEDs) used for solid-state lighting are already being successfully commercialised
- Commonly, a white LED consists of an *inorganic* blue LED pumping a yellow-emitting phosphor
- However, there is still scope for improved wavelength converters for optimising the quality of the white light
- In this work, white LEDs are fabricated by combining novel *organic* wavelength converters based on the BODIPY unit with either a standard blue planar LED or with a blue-emitting nanorod sample
- In case of the nanorods the organic material will fill in the spaces between the nanorods to be in direct contact with the active region for enhanced energy transfer

Blue-emitting nanorods

Environmental scanning electron microscopy



- An InGaN/GaN multiple quantum well (MQW) structure, emitting around 445 nm, is embedded at the top of the nanorods

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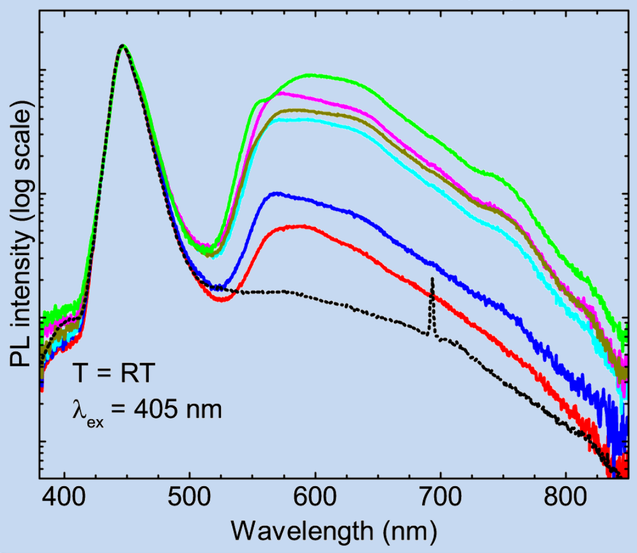
- Drop-casting produced a film of variable thickness; from a continuous film to filling in the spaces between the nanorods
- Selective excitation of the MQW emission using a laser diode showed that the organic compound is optically pumped by the MQW emission, which increases with film thickness

Photoluminescence (PL)

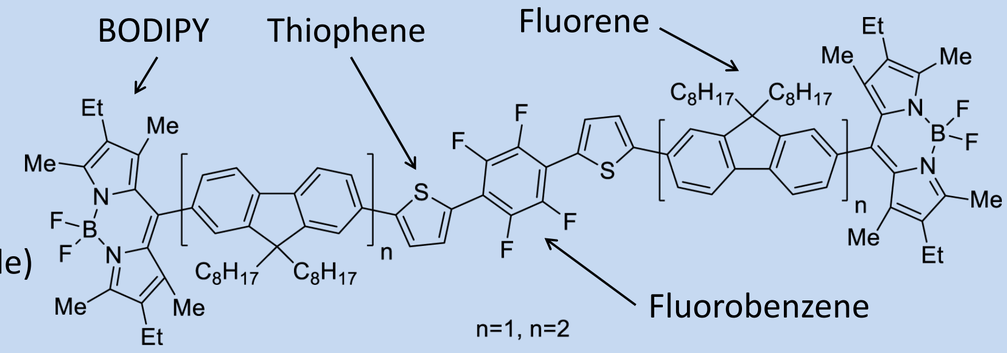


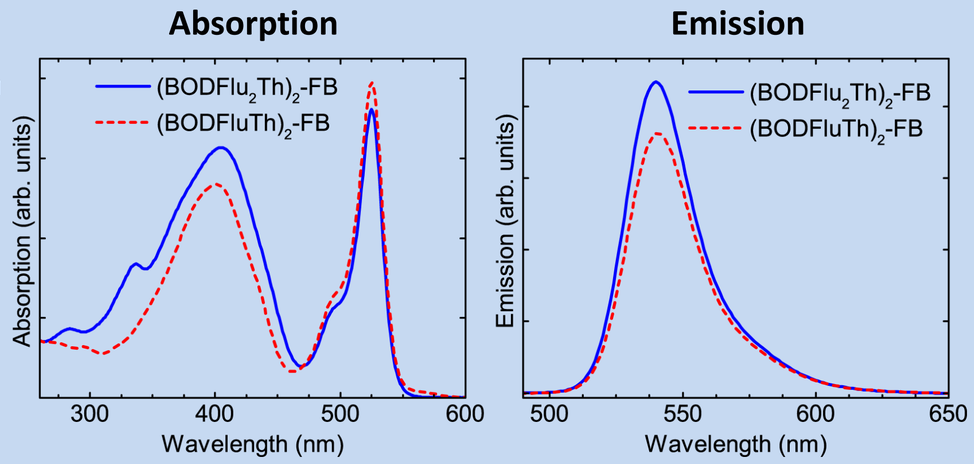
Nanorods coated with $(BODFluTh)_2$-FB (excited through the backside using 405 nm laser diode)

- 1 drop
- 2 drops
- 3 drops
- 4 drops
- 5 drops
- 6 drops
- uncoated nanorods

Synthesis and physical properties of the organic converter

- The organic converter molecule is built up of an absorbing core unit (a fluorobenzene unit with a thiophene and one or two fluorene units on either side) and a BODIPY emitter molecule on both ends
- For increasing the absorption and emission the conjugation of the fluorene unit was extended from one to two
- Absorption shows peaks around 403 nm (core) and 525 nm (BODIPY)
- Exciting the molecule at 435 nm results in emission from the BODIPY at 550 nm





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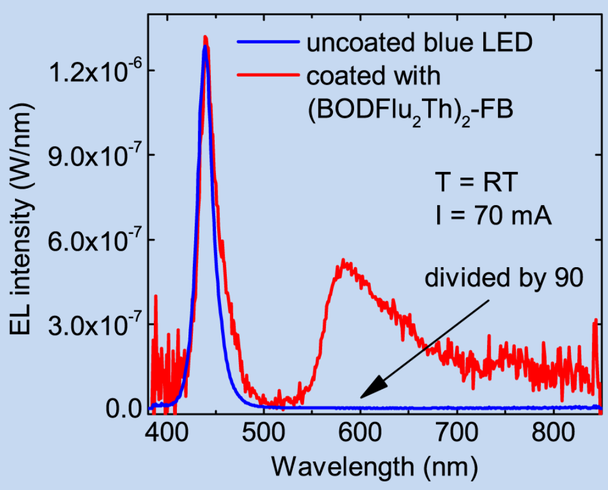
White light generation using a blue LED and energy-down converting organic compound

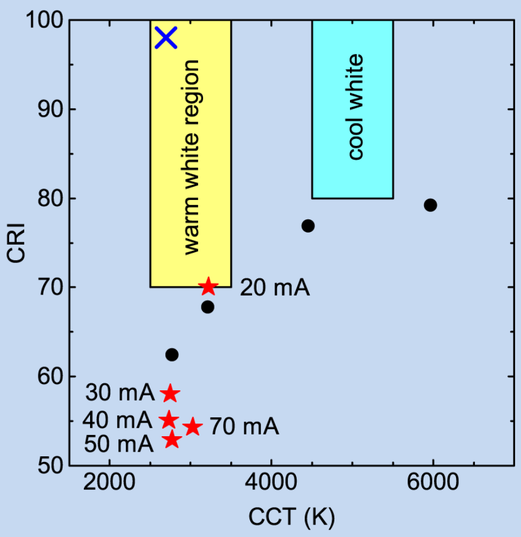
- A fully-processed blue LED wafer (InGaN/GaN MQW structure emitting at 440 nm) was coated with $(BODFlu_2Th)_2$-FB
- Electroluminescence (EL) was measured in an integrating sphere, which measures the absolute intensity in units of W/nm
- This makes it possible to determine parameters such as the colour rendering index (CRI), correlated colour temperature (CCT) and chromaticity coordinates (u', v') characterising the quality of the white light emission
- The best CRI of 70 is obtained for 20 mA with a CCT of 3220 K, which is close to the region of warm white light

Electroluminescence

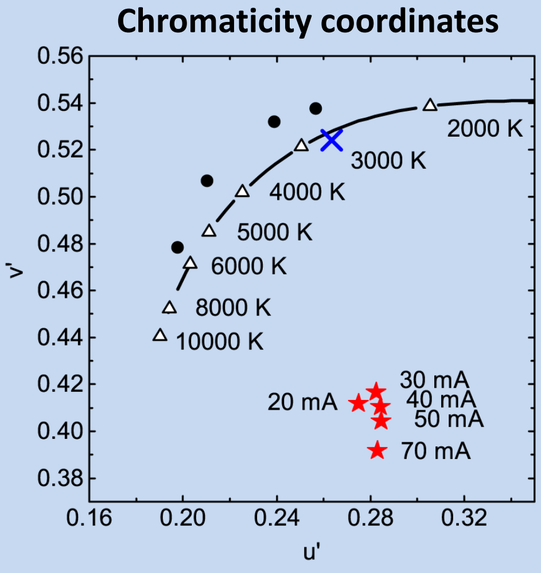


- Increasing the current leads to a decrease of the CRI since more of the blue light contributes to the overall emission spectrum
- Similarly, the chromaticity coordinate v' shifts to lower values away from the Planckian locus since blue light is located at the bottom corner in the chromaticity diagram
- For warm white light the ideal parameters should be similar to the ones for the incandescent lamp, which has the highest CRI

CRI vs. CCT



Chromaticity coordinates



- Commercial white LEDs
- Incandescent bulb
- Planckian locus
- blue LED coated with $(BODFlu_2Th)_2$-FB

Summary

- White light was generated by depositing a novel organic compound, based on the BODIPY unit, on a planar blue LED
- For increased energy transfer the organic material was deposited on a blue-emitting nanorod structure

Acknowledgements

"Lighting the Future"

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