

Hybrid polymer OLEDs with doped small-molecule electron-transport layers for display applications

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- 7 years at Novaled working on OLED/OPV/OTFT architecture
- Position: team leader display products, principal scientist



Motivation

- › Novaled: small-molecule OLED, vacuum and solution processing
- › CDT: polymer OLED, solution processing

- › Novaled and CDT:
 - › Combine advantages of the two approaches for
 - › **highest OLED performance**
 - › **Large RGB display without limitation by fine-metal masking**

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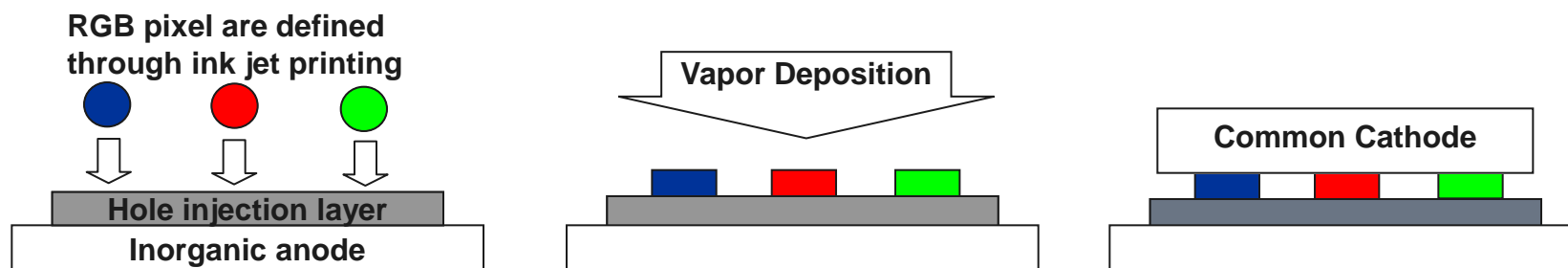
Outline

- › Introduction of hybrid (= polymer + small molecule) OLED
- › Material selection
- › Performance
- › Operational stability
- › Outlook

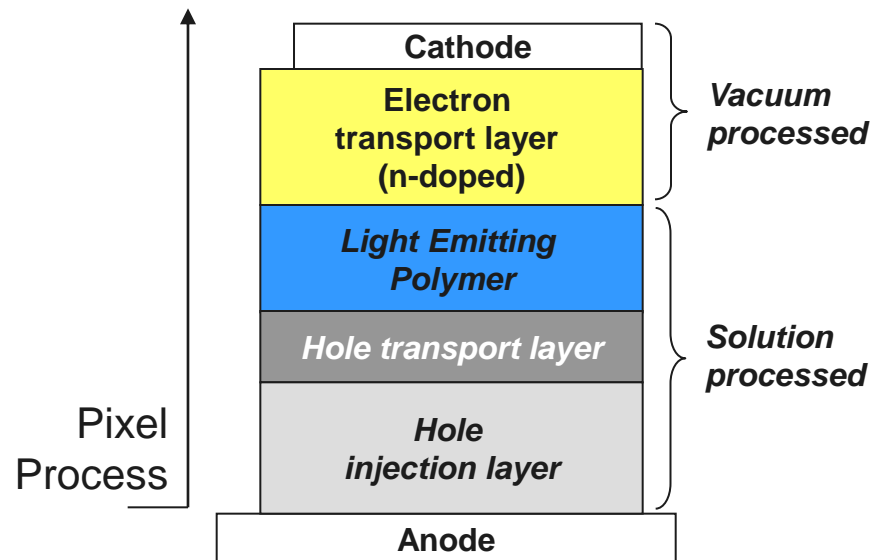
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Hybrid (= polymer + small molecule) OLEDs

Display Process

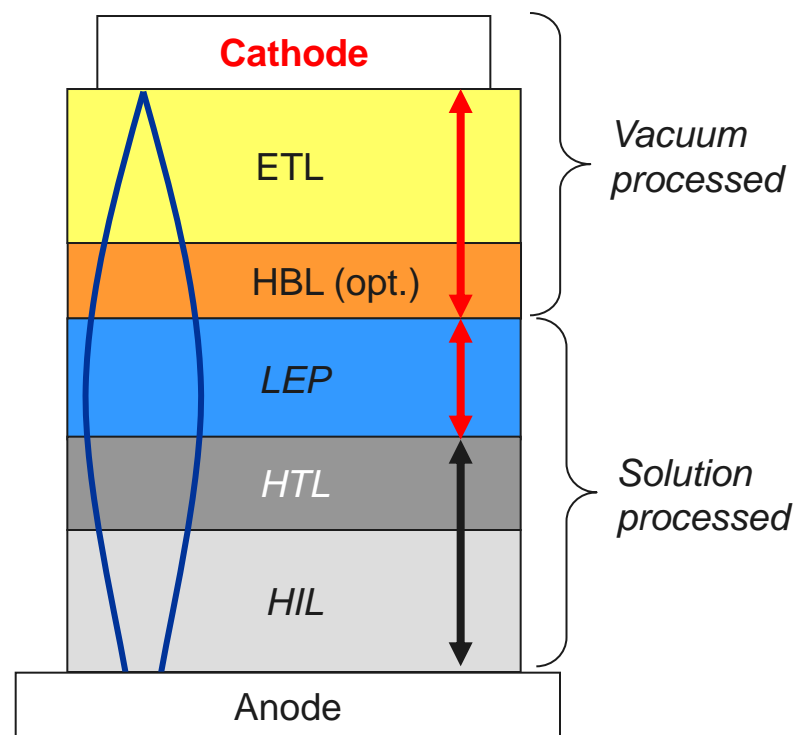


- > Display by printing of RGB pixels
 - > no fine-metal masking required
- > Common ETL can be vacuum processed for better performance
 - > Vacuum ETL will not add significant complexity to the device structure but allow for a wider selection of cathode types and thicknesses



Advantages of vacuum-processed ETL

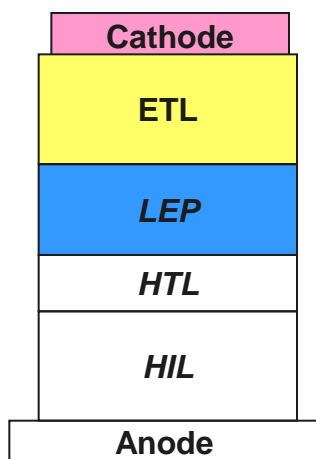
- › Reduction of Voltage
- › Freedom of cathode material: various metals, ITO
- › Hole blocking layer can be incorporated (e.g. for white OLED)
- › Adjust LEP and ETL thickness for optimum performance
- › Allows for thick ETL for improved production yield



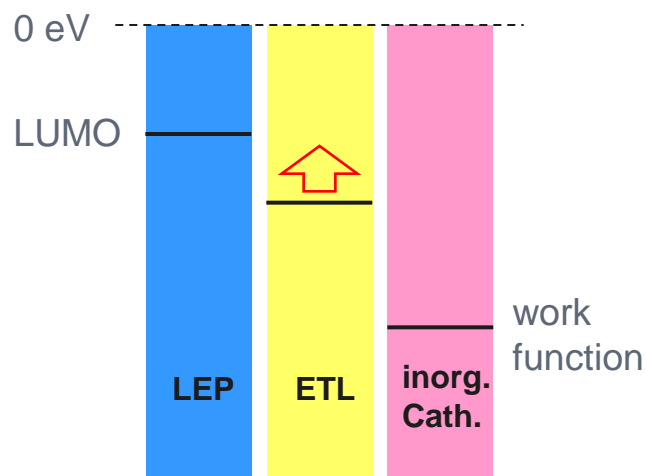
Material selection

- > LUMO level of ETL needs to be adjusted to LEP for best performance
- > Electron injection from inorganic cathode crucial

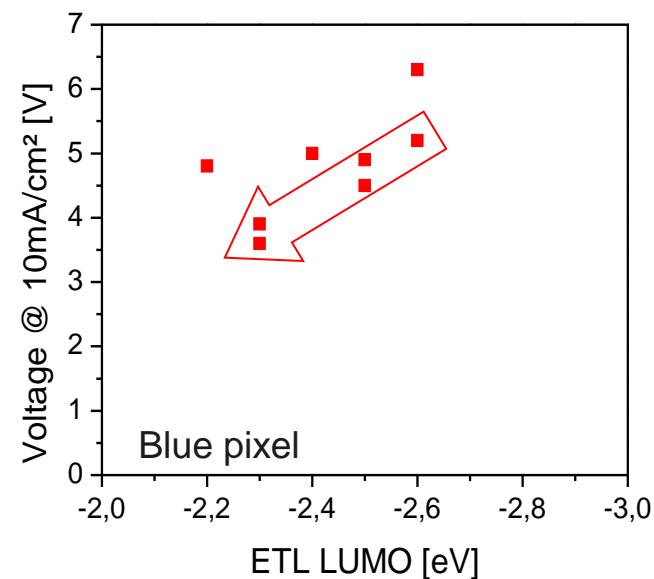
> Architecture



> Energy scheme



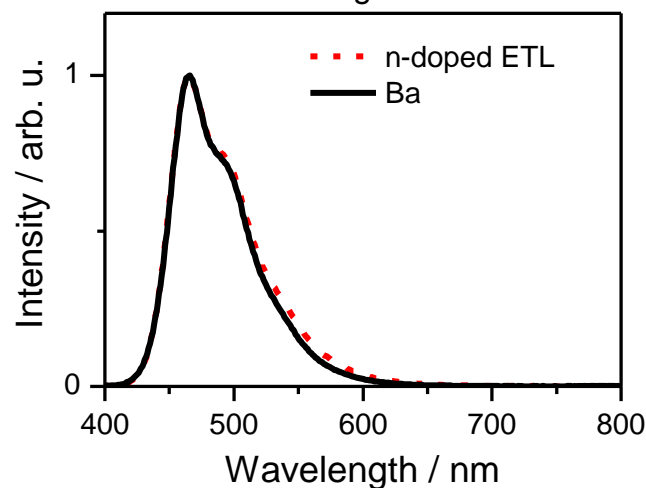
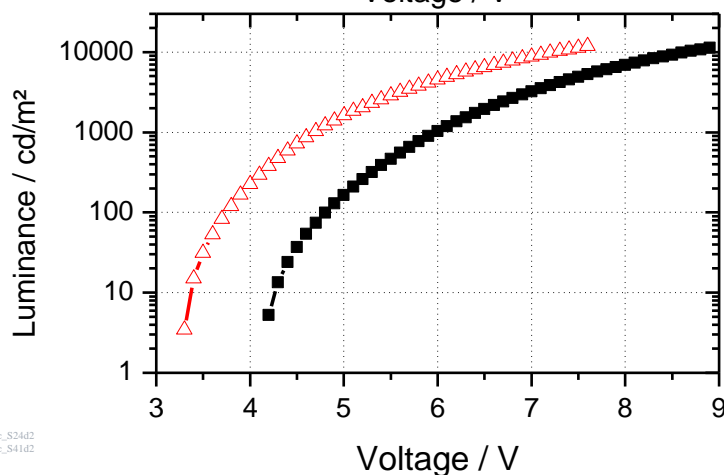
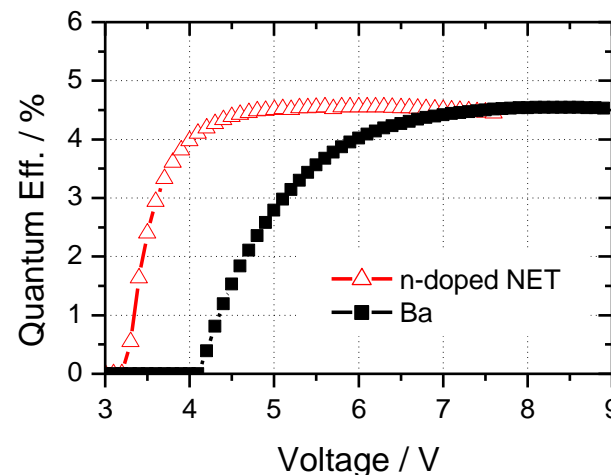
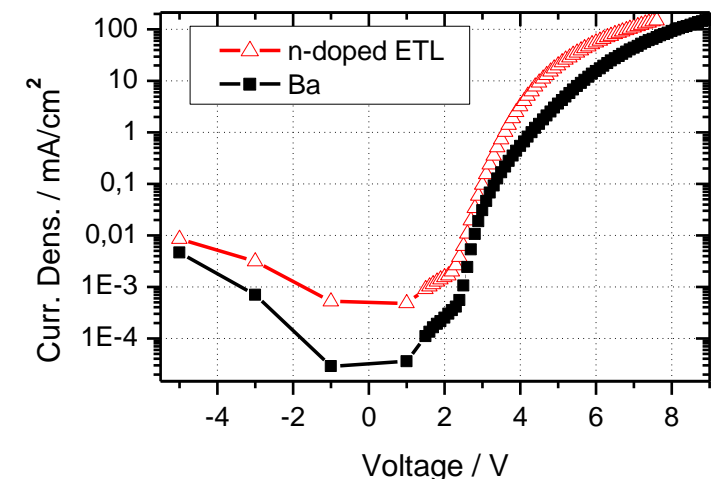
> Experiment



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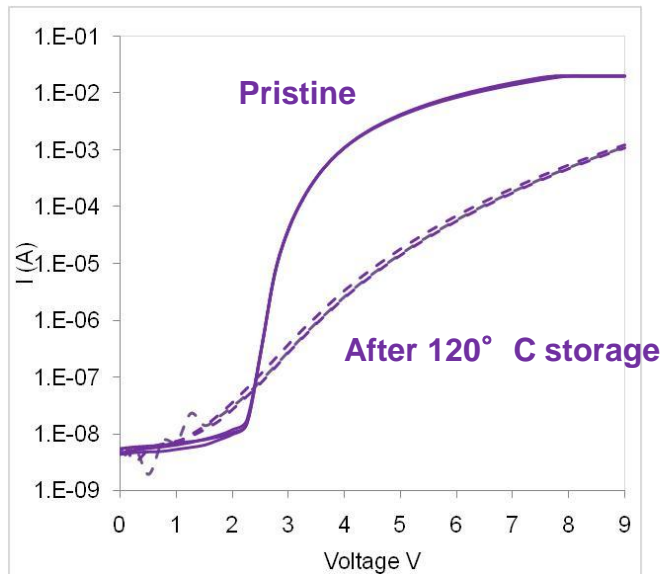
Initial Performance

- > NovaLED ETL reduces driving voltage as compared to Ba injection layer by >1V
- > Efficiency remains unchanged

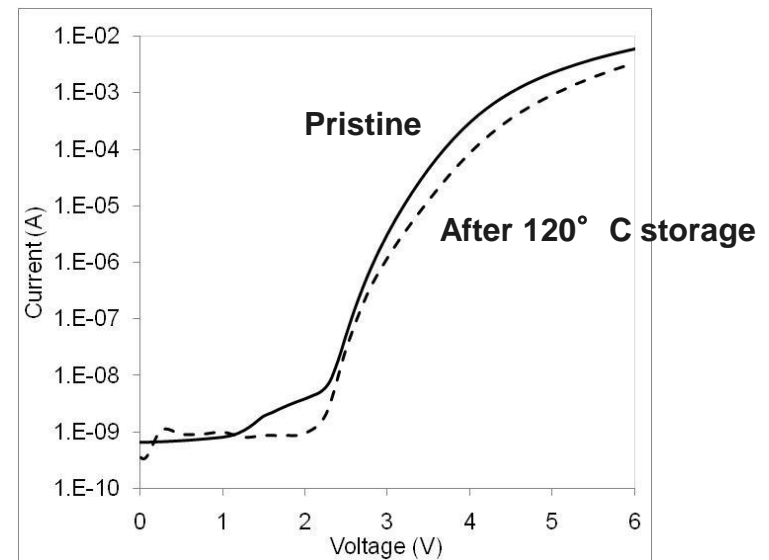


Temperature stability

- › Initial attempts showed poor thermal stability for hybrid devices

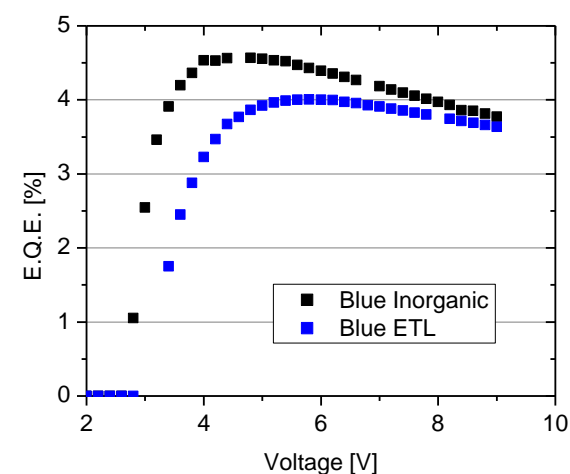
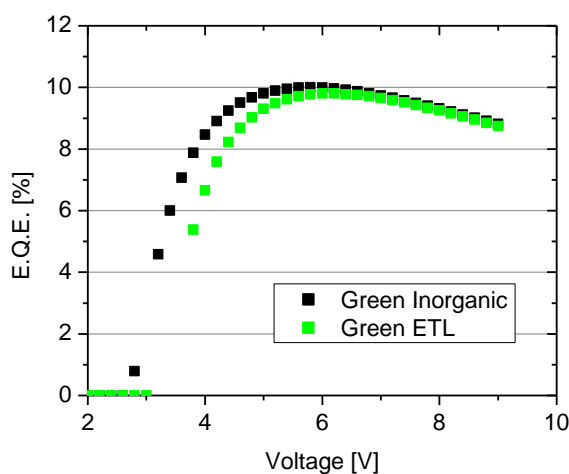
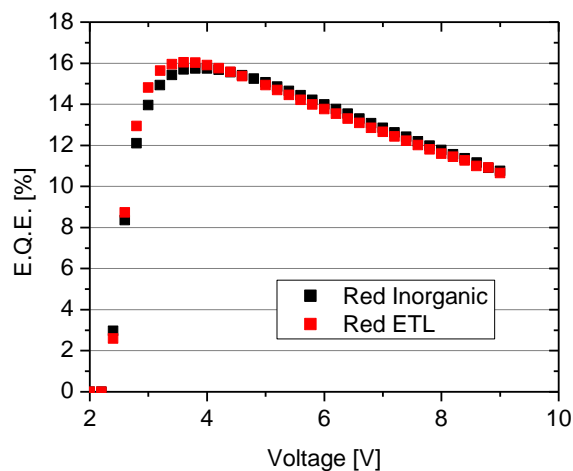


- › Optimized devices (improved LEP and ETL)



RGB Efficiency – Status 2011

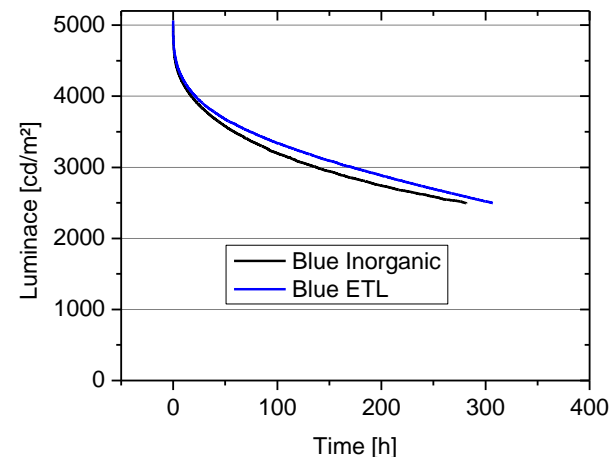
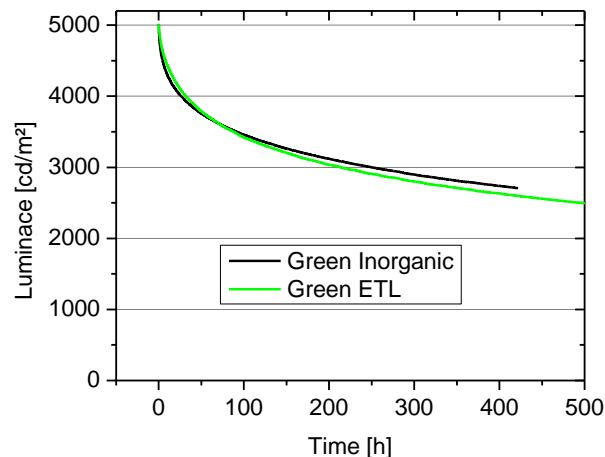
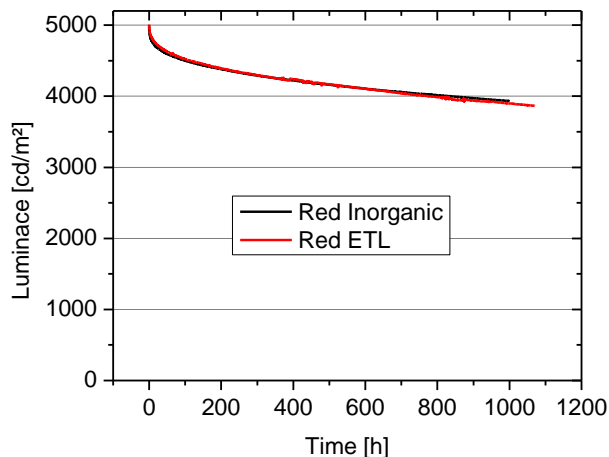
> Quantum efficiency unchanged as compared to PLED



EQE [%]	Inorganic IL	Organic ETL
Red	15	16
Green	9.4	9.8
Blue	4.4	3.8

RGB Operational stability – Status 2011

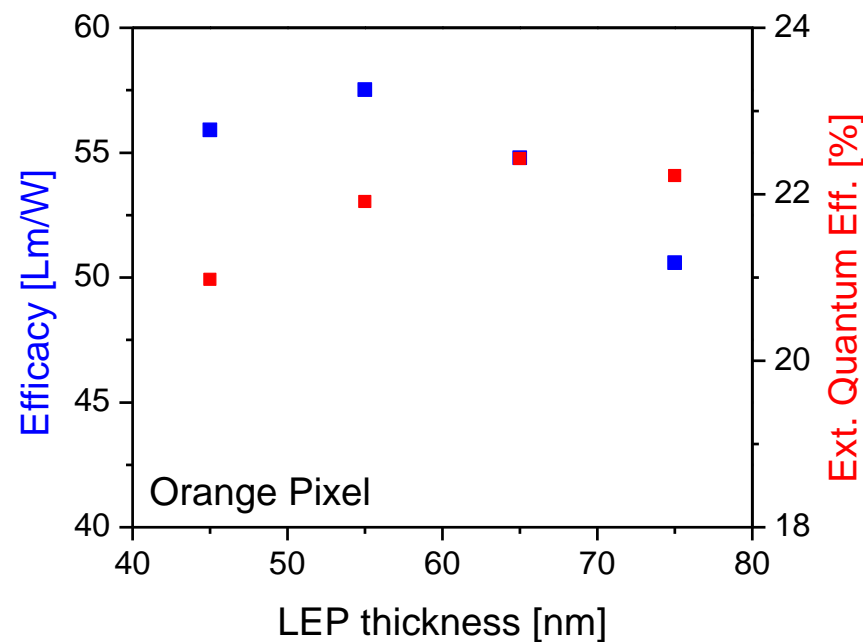
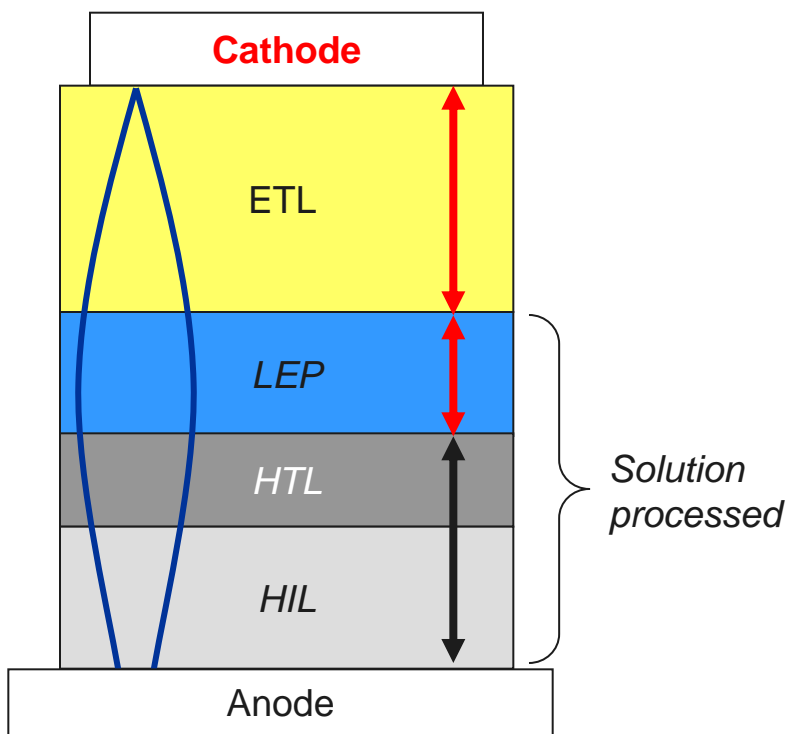
› OLED Lifetime unchanged as compared to PLED



50% LT [h]	Inorganic IL	Organic ETL
Red	565	778
Green	255	250
Blue	300	280

Further Optimization

- > Adjust LEP and ETL thickness for optimum performance



- > Improved lm/W for thinner LEP only with NovaLED ETL possible

Summary

- › **Successful combination of PLED concept with small-molecule electron transport layer**
 - › Voltage significantly reduced
 - › Quantum efficiency unchanged
 - › Lifetime unchanged

- › **Outlook**
 - › LEP thickness optimization and color tuning
 - › Higher stack flexibility and improved out coupling
 - › ITO top contact and weak-cavity top emission
 - › More simple architecture, air-loading



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