# Novel Blue Charge-Transfer Emitter Materials for OLED Lighting

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# Project Objectives

- Explore alternative *Emitter Materials* than can produce high efficiency and operationally stable blue OLEDs
- Design and synthesize novel hybridized local and charge-transfer (HLCT) emitters w/ short excited state lifetimes
- Leverage unique properties w/ strategic host and blocking layers to enhance operational stability

# Potential Advantages of HLCT Emitters

- Precious metal free
- High exciton utilization
- Reduced dependence of host materials
- Short excited state lifetimes

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# Key Challenges

- Limited molecular design pathways have been identified for HLCT emitters

- Device structure optimization (w/ strategic host and blocking layer materials) to combine high efficiency and good operational stability

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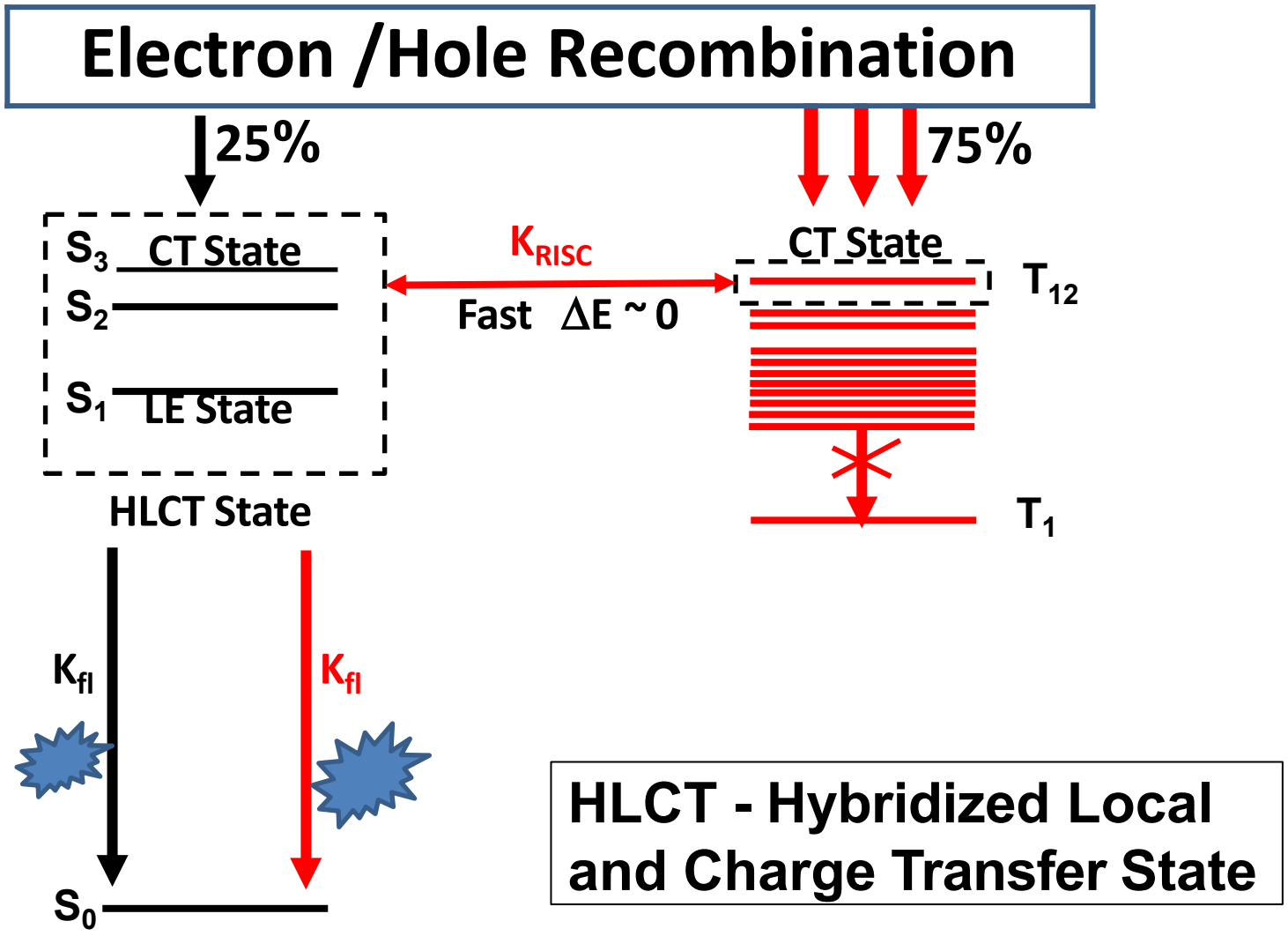
# OLED Emission Model for HLCT Emitters




HLCT - Hybridized Local and Charge Transfer State

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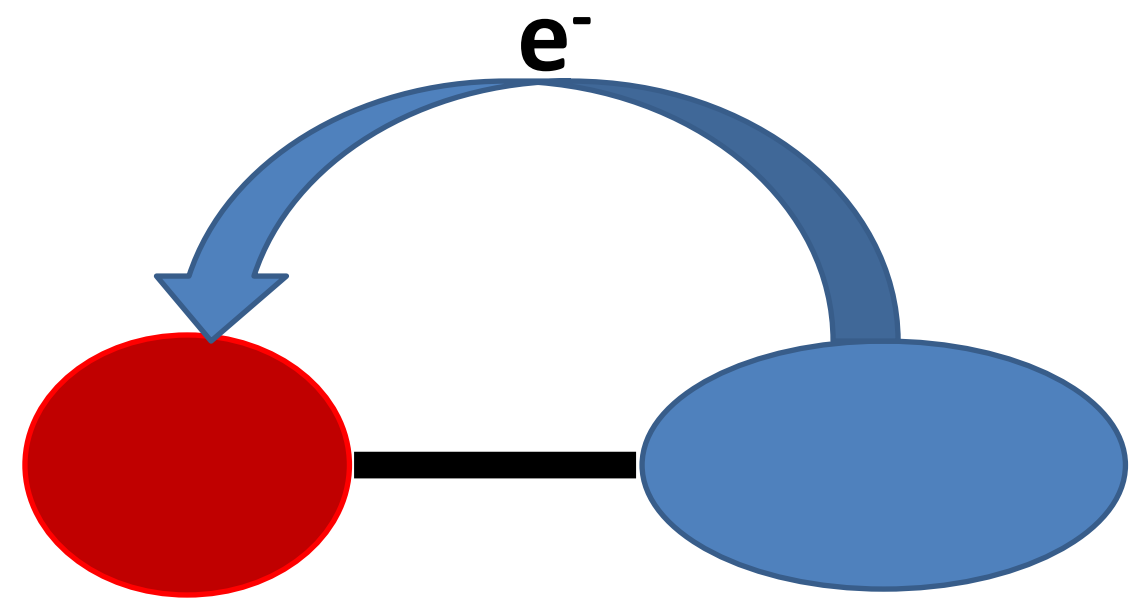
# Design of HLCT Emitters



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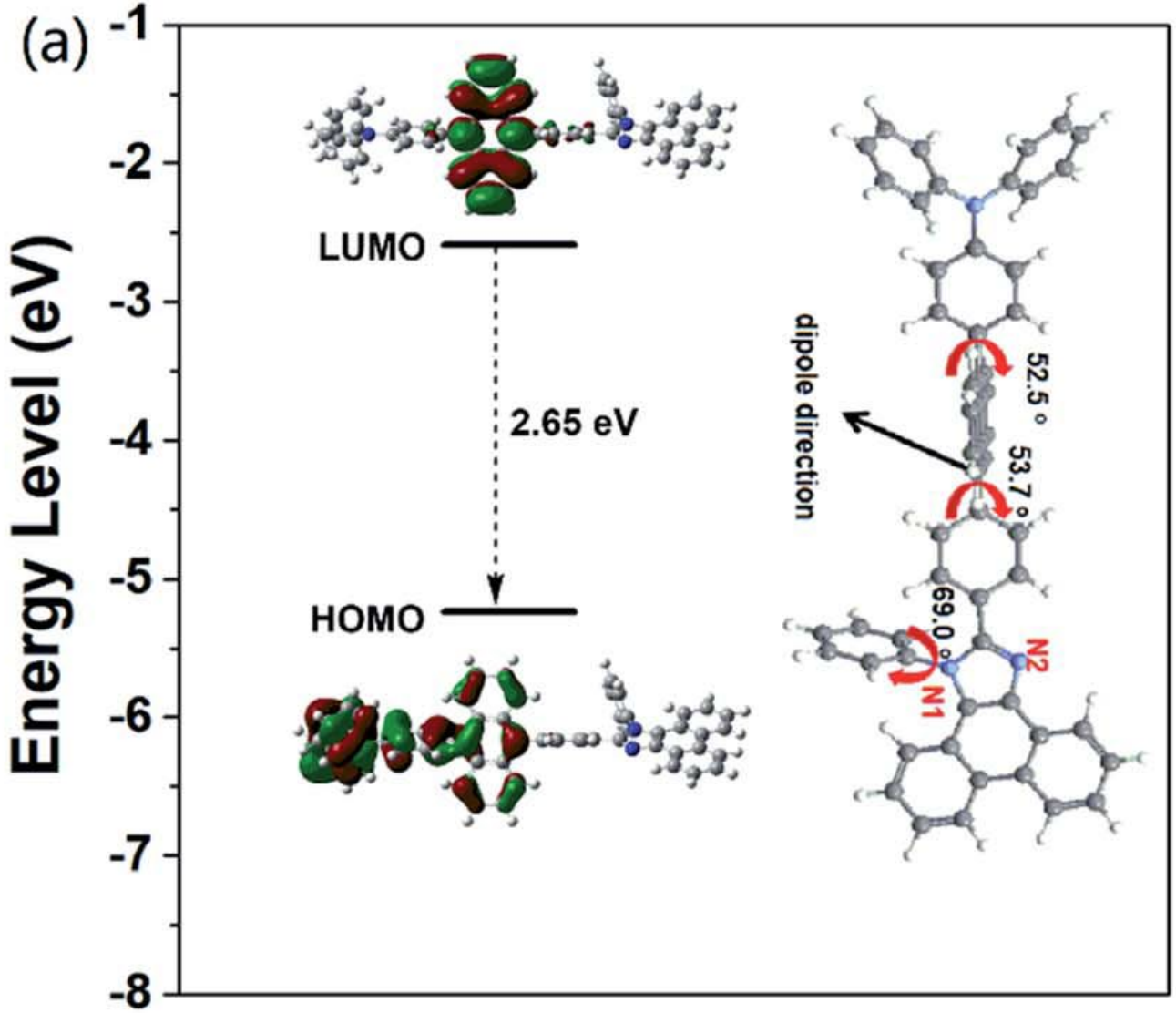
# Blue HLCT Emitter

Chem. Sci., 2020, 11, 5058



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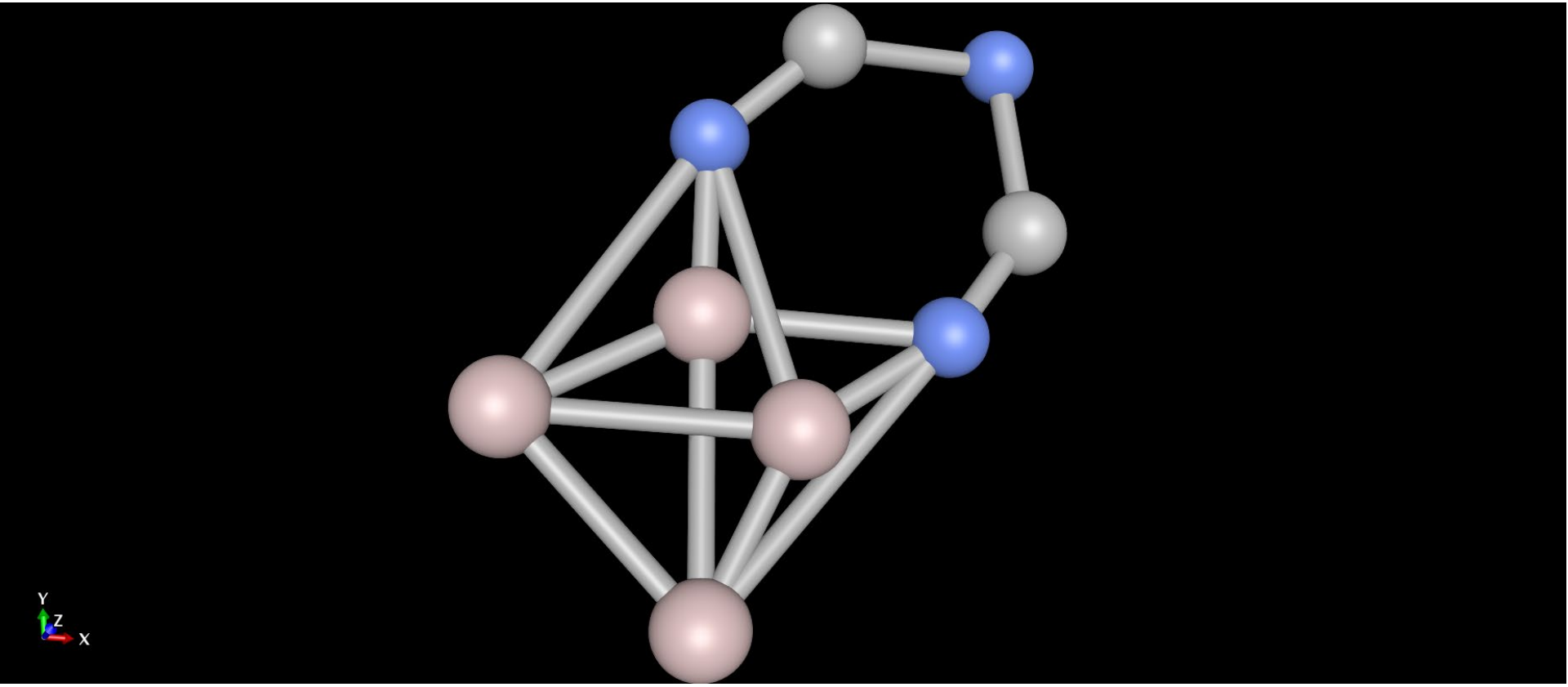
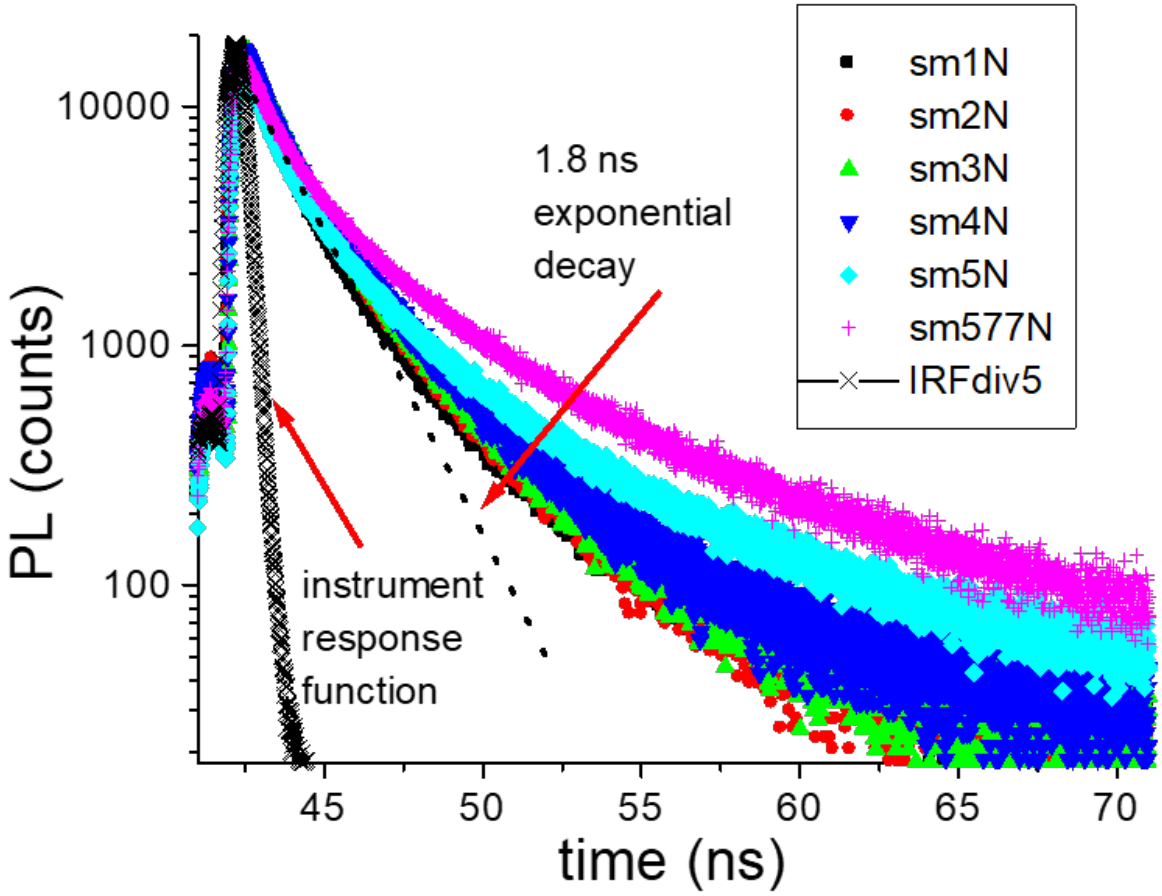
# Novel Metal-Organic Cluster HLCT Emitter



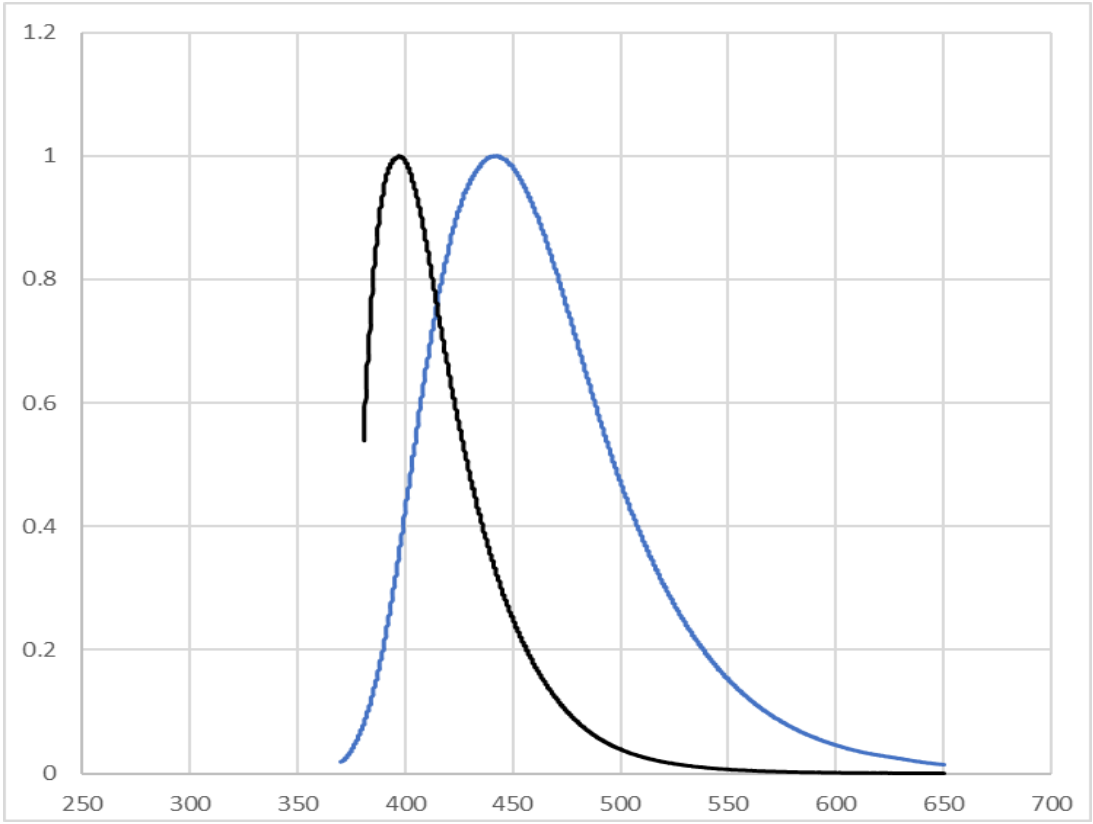

## Molecular Framework of “Acceptor” Moiety

# Transient Lifetime Studies



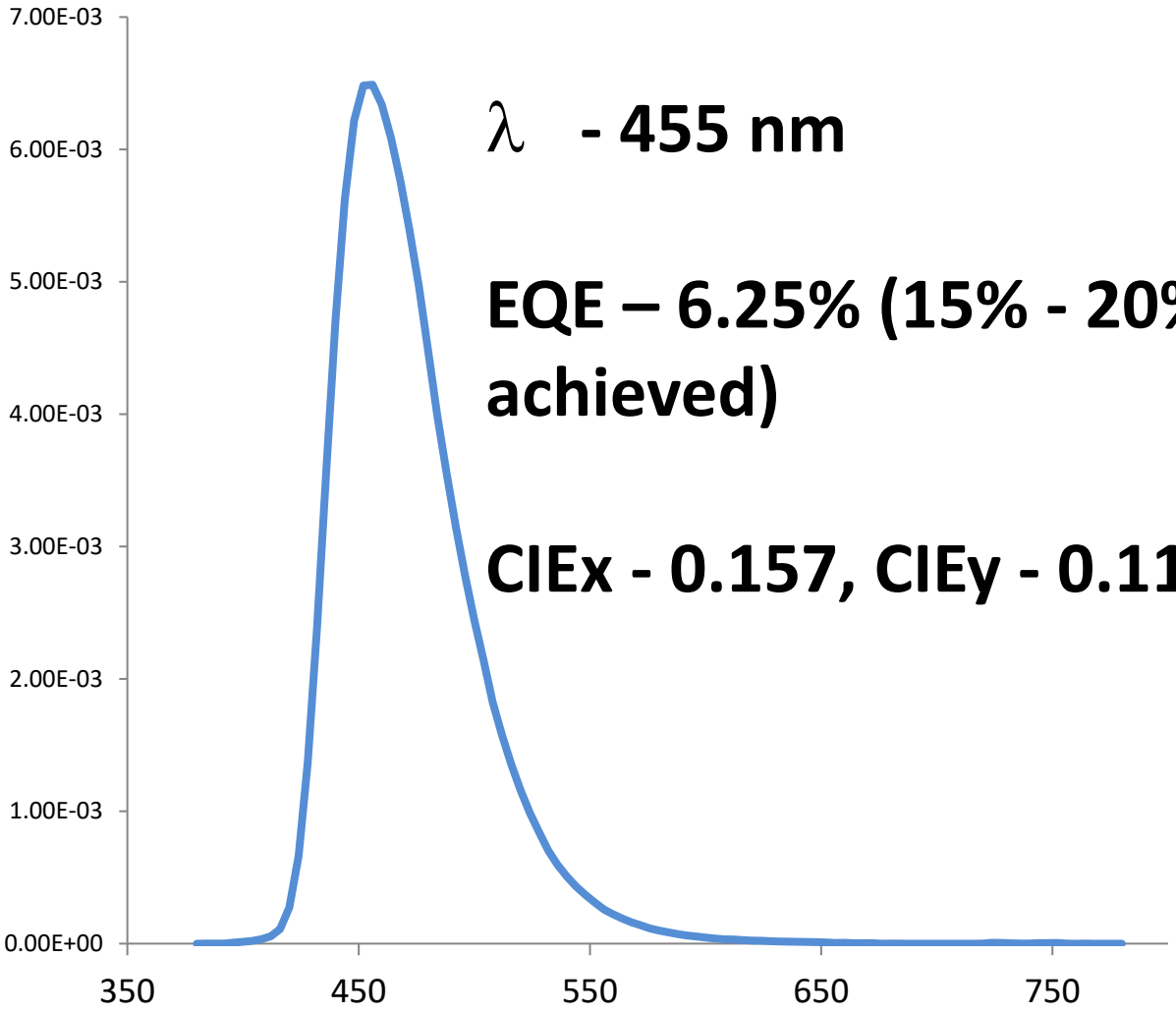

**PL measurements of coated thin-films indicate consistent excited state lifetimes of ~ 2 ns**

# Photoluminescence Studies




**Solvent Polarity Influence Supports HLCT Emission**

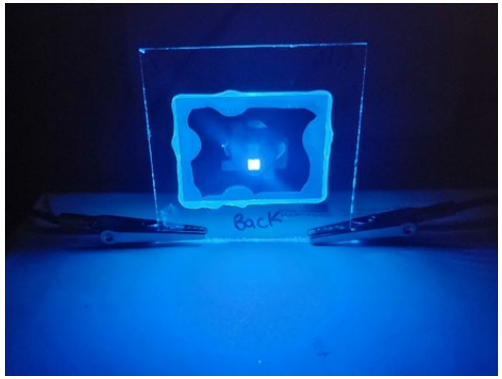
# Early Device Data




**λ - 455 nm**

**EQE – 6.25% (15% - 20% can be achieved)**

**CIEx - 0.157, CIEy - 0.119**



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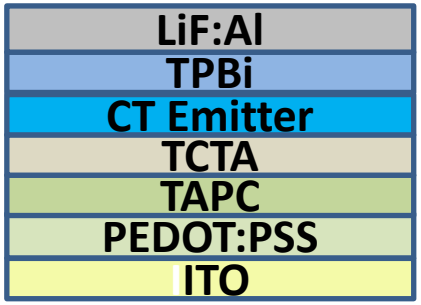
# Device Comparison

| | Initial Voltage (V) | Efficiency (Lm/W) | EQE (%) | CIE (x,y) | Peak (nm) |
|---|---|---|---|---|---|
| RDL-Blue 1 | 1.88 | 12.3 | 5.7 | 0.173, 0.150 | 455 |
| RDL-Blue 2 | 2.13 | 9.88 | 6.25 | 0.157, 0.119 | 455 |
| Lit. Ref 1 | 3.20 | 11.47 | 8.00 | 0.15, 0.22 | 470 |
| Lit. Ref 2 | 3.40 | 12.35 | 11.47 | 0.15, 0.22 | 470 |

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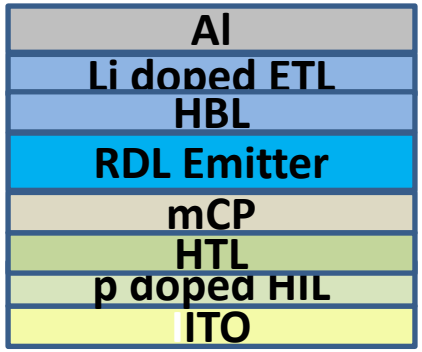


RDL Blue Device

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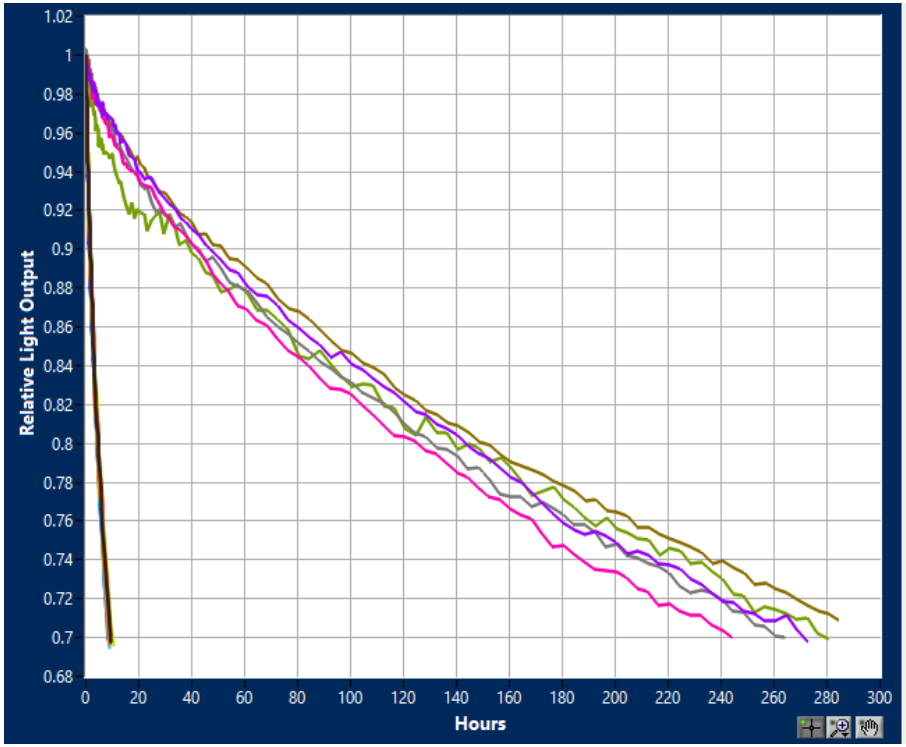
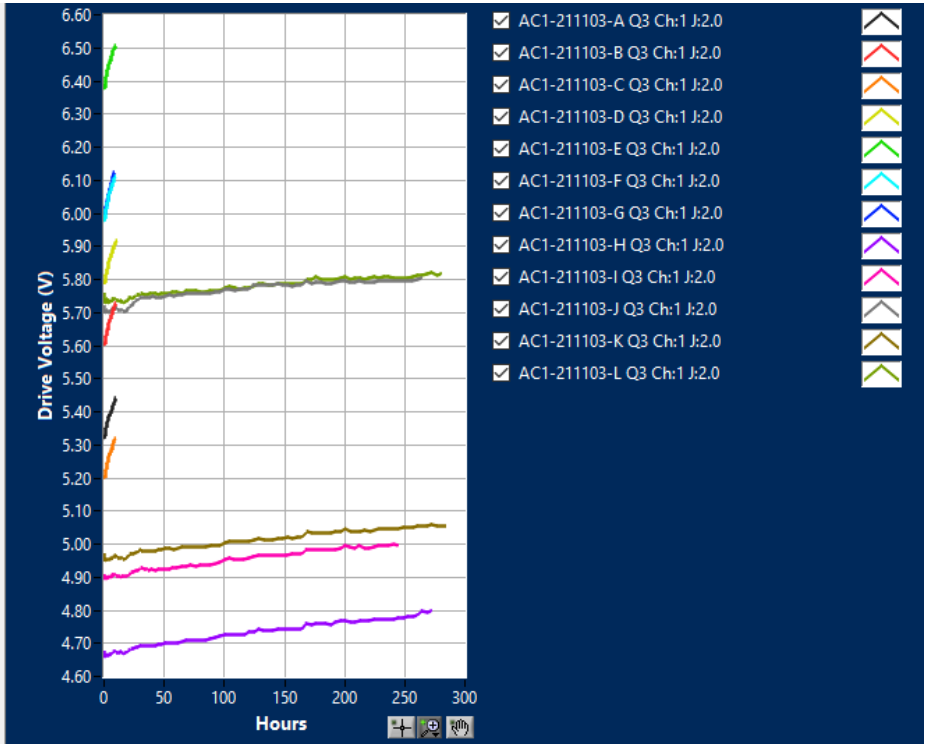
# Path to Operational Stability Indicated

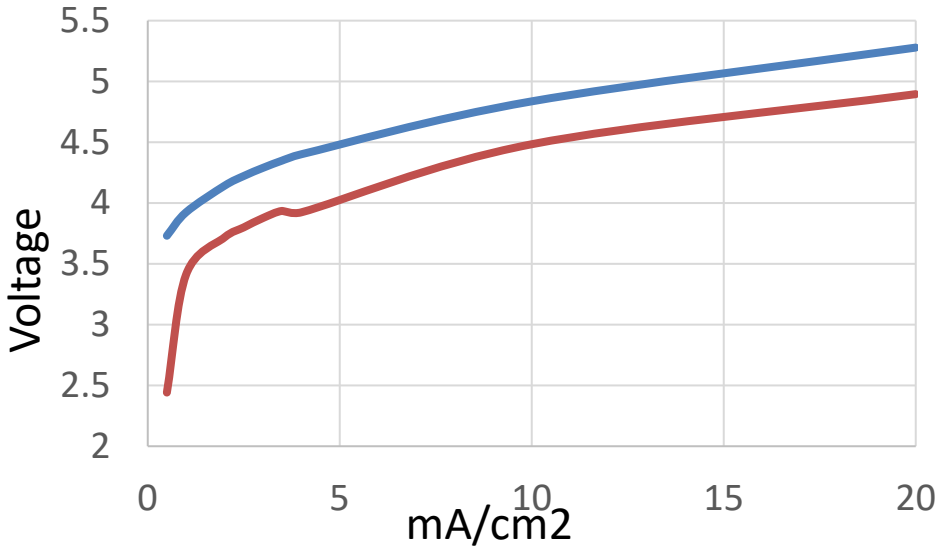
## HIL/HTL/mCP/mCBP + BE/HBL/ETL/EIL

## HIL/HTL/mCP/mCBP + BE + BH/HBL/ETL/EIL



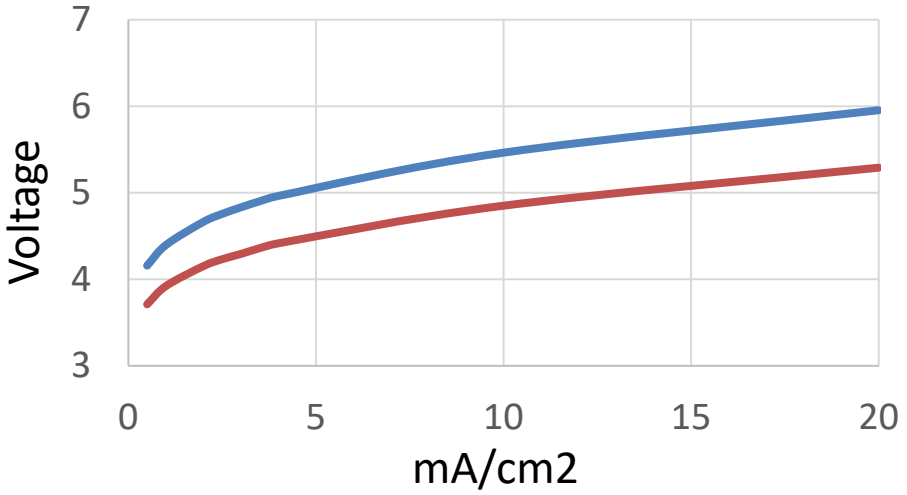
# Low Voltage Conductance




**mCP Host**

**10% Emitter**

**20% Emitter**




**mCBP Host**

**10% Emitter**

**20% Emitter**

**“We see the emergence of systematic studies of electrical transport in MOFs as both necessary and highly important for the field as a whole.”**

ACS Cent Sci. 2017 Jun 28; 3(6): 554–563.

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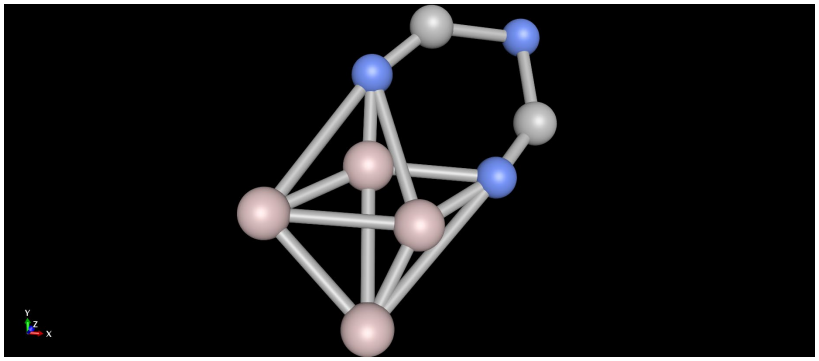
# Potential Advantages of Conducting MOF



- **Material Stability**
- **Enables fast electron/ion diffusion**
- **Structural flexibility for electronic tuning**
- **Broad Applications: Sensors, Electrical Energy Storage, *Electroluminescence and Photovoltaic devices***

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# Summary

- Novel conducting MOF materials show promise for blue OLED devices
- Observed low voltage is consistent with stabilizing charge delocalization
- Efficiency advancements through device optimization required (i.e. stable high Et blocking and host materials)
- Method to potential improvement in operational lifetime demonstrated
- Low voltage conducting properties provide path to broader applications

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# Acknowledgements


- Department of Energy Testing Program
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