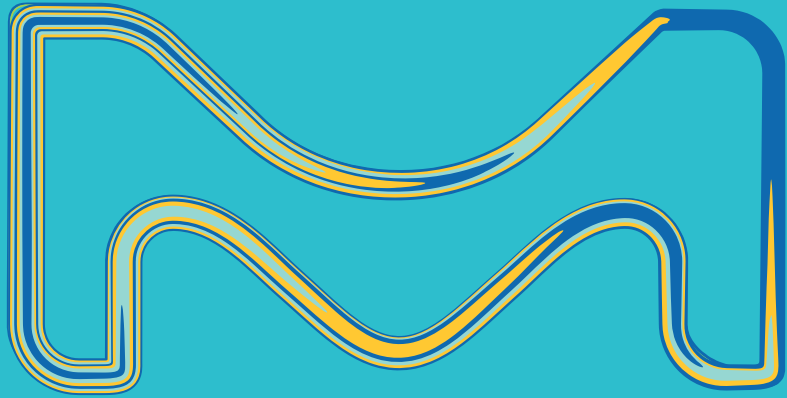


The Electronics business of Merck KGaA, Darmstadt, Germany operates as EMD Electronics in the U.S. and Canada.



# OLED Device Optimization via Host & Transport Materials

January 2022  
DOE SSL Workshop

**EMD**  
ELECTRONICS

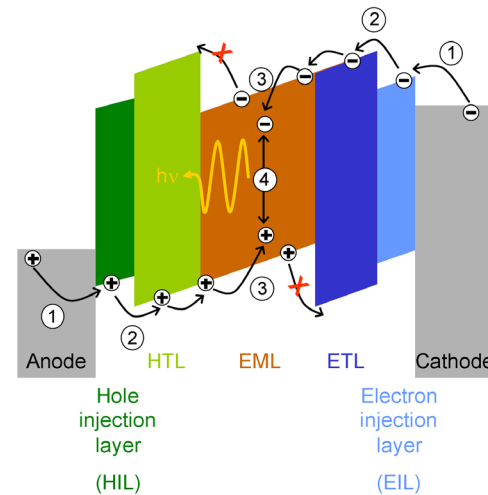
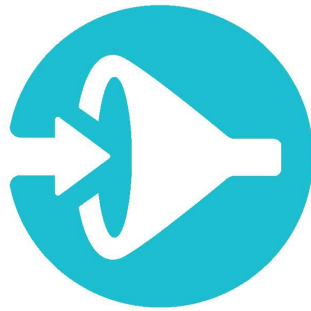
# Developing state-of-the-art materials and device physics understanding

## Optimization of device performance

Customer Requirements

Chemistry  
Physics  
Simulation

HTM  
Host  
Emitter  
ETM



Designed Experiments

Optoelectric Measurements

Analysis

**Device optimization**



# Selected development targets

## HTM/ETM

- HTL for reduced crosstalk
- Fundamental understanding to maximize efficiency & LT
- Expand portfolio of ETMs for charge balance optimization

## Hosts

- Premix hosts
- Optimize host performance with paired emitters

## Key development trends/needs

- **Reduced cross-talk**
- **High efficiency**
- **Low voltage**
- **(Pre)mixed host for green**
  - Efficiency/voltage/lifetime
  - Long-term evaporation stability



**Material development targets to meet customer needs and follow customer trends**



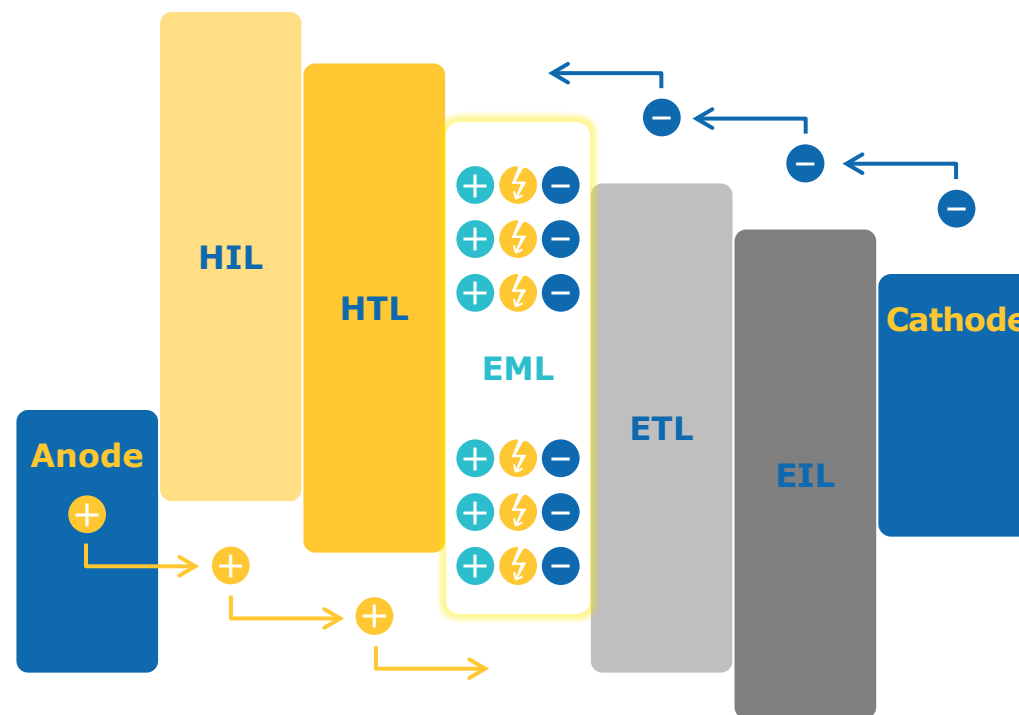
# OLED Hole Transport Materials (HTM) A key enabler



HTM is a critical layer in the OLED stack to adjust energy barriers from anode to emissive layer.



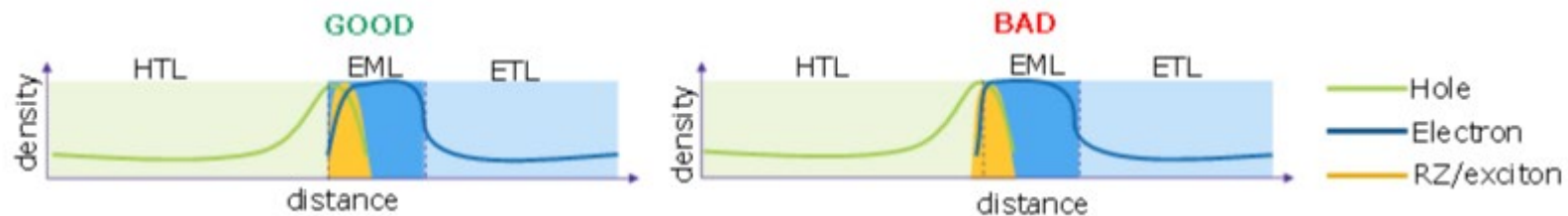
With the proper HTM, driving voltage, lifetime and efficiency can be significantly improved.



# Charge balance in blue devices

## Performance tuning

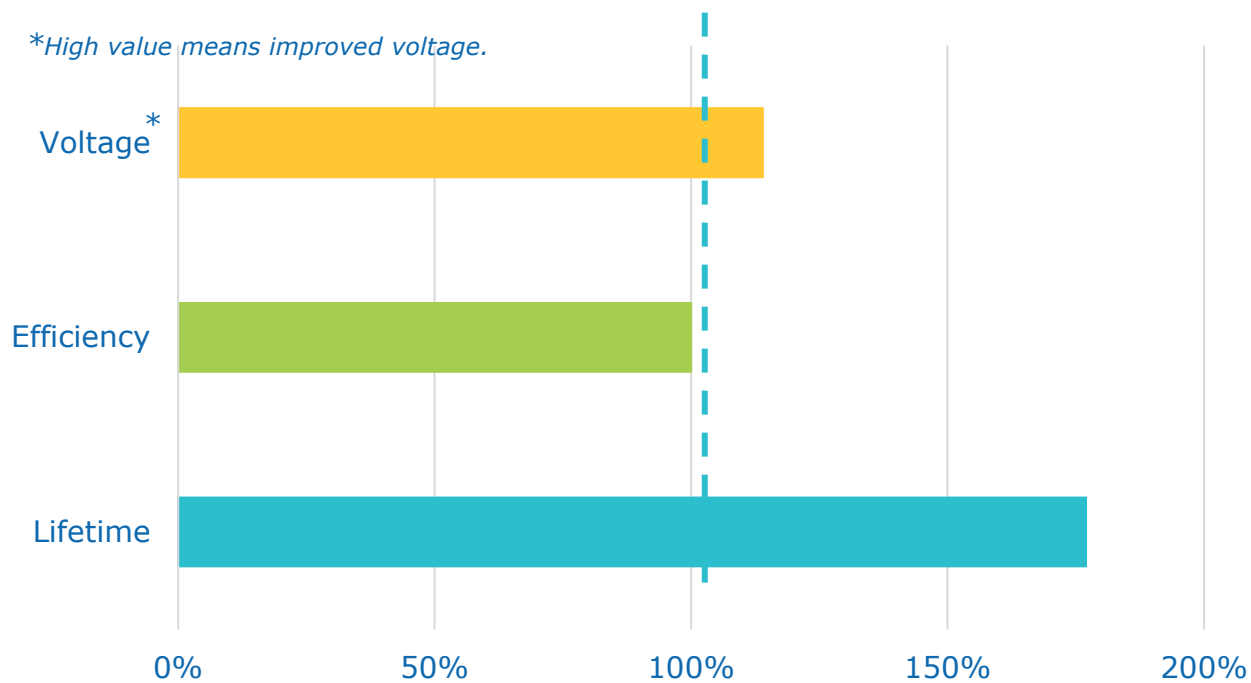
- Pairs of HTMs and hosts were chosen to vary hole supply and transport
- Emission zone location can be tuned by injection and transport
- When the emission zone is near the EML/EBL boundary, performance suffers
  - Low EQE
  - Poor LT
- We can choose materials with the right properties to balance the charge and optimize emission zone location



# An example of our HTM as a Common Layer

## Performance comparison in Blue

### OUR C-HTL VS industry standard



### Our HTM as Common Layer

**Impressive performance improvement with**

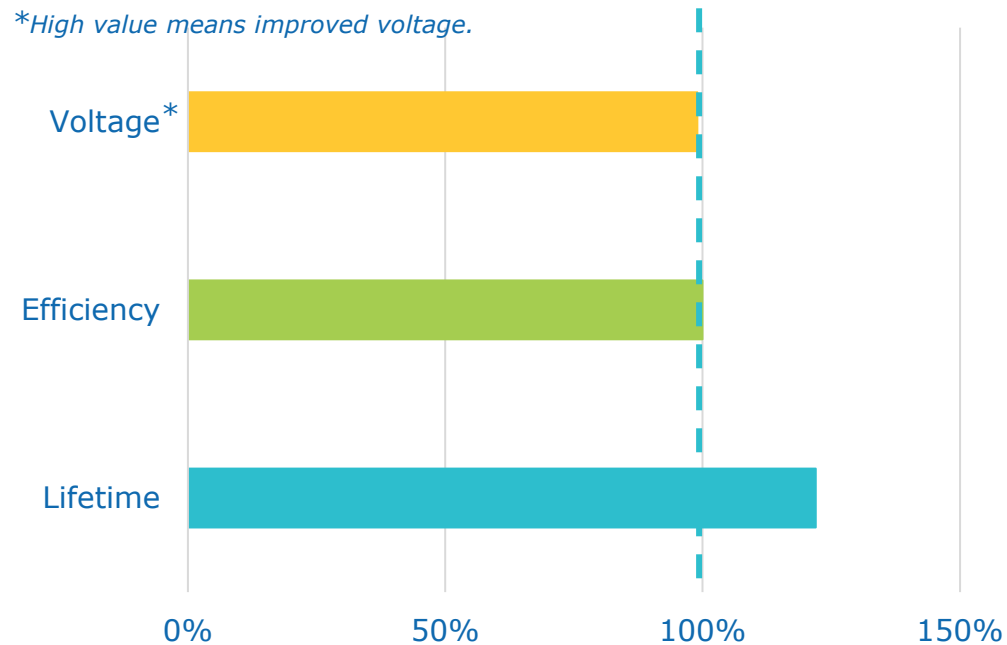
- **LT nearly doubled and**
- **Lower voltage**



# An example of our HTM as an Electron Blocking Layer

## Performance comparison in Blue

### OUR B EBL VS industry standard



**Our HTM as EBL**



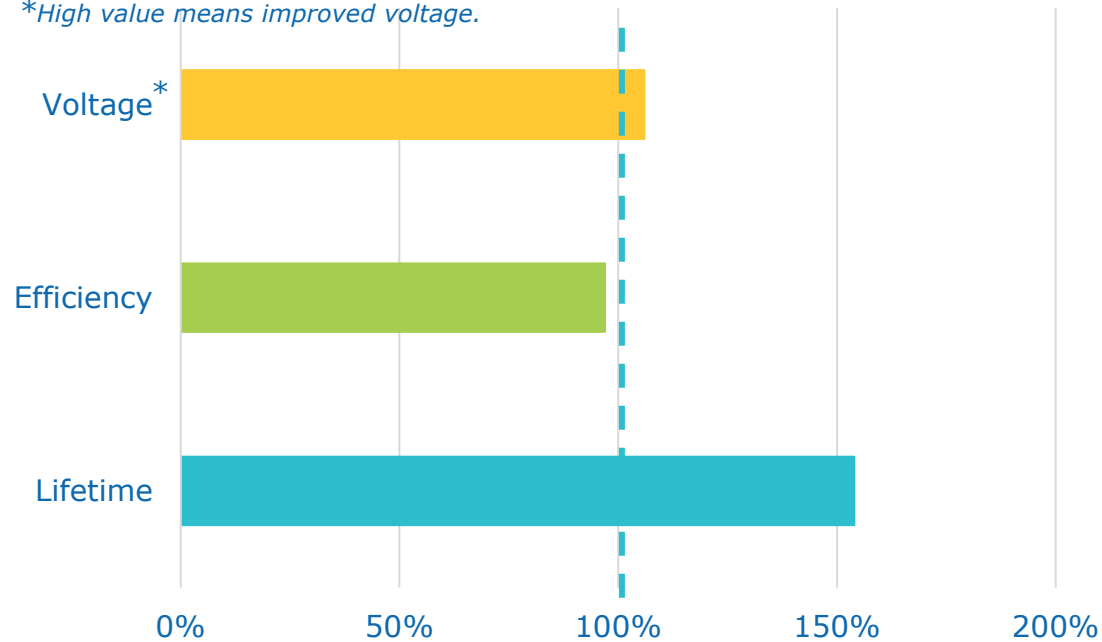
**Our B EBL, delivering longer LT without any trade-off in Voltage or Efficiency**



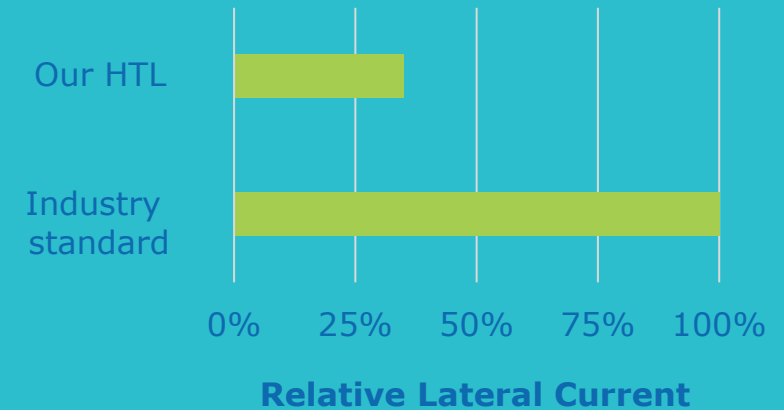
# Combination of our Common Layer and B Prime Performance comparison in Blue

## OUR HTM+B PRIME VS INDUSTRY STANDARD

\*High value means improved voltage.



### Cross-talk improvement with our HTL



**Material combination: strong performance improvement in Lifetime and Voltage combined with low lateral current for best quality panel**

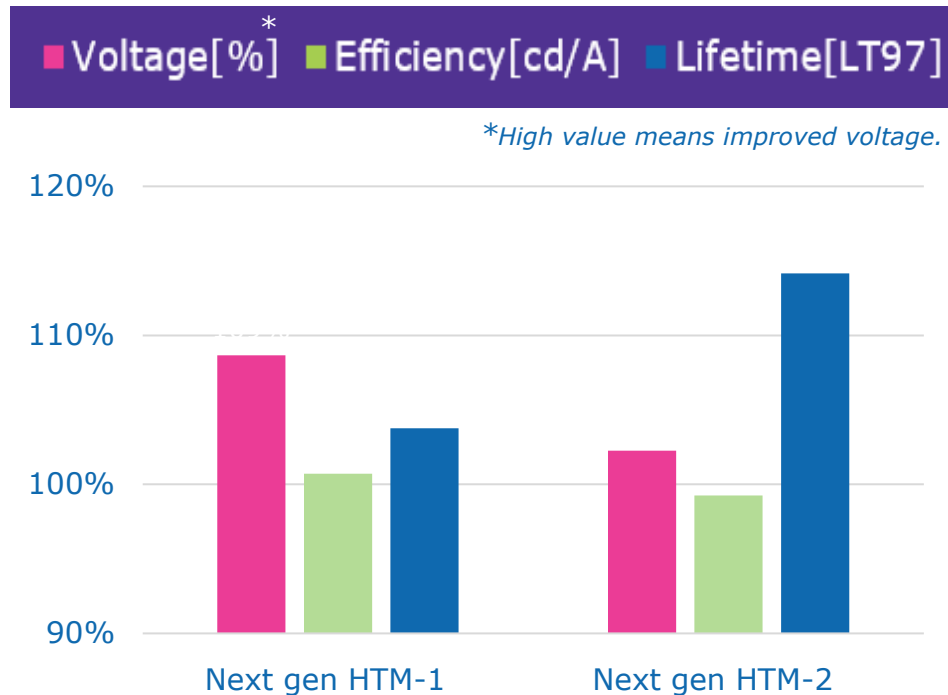




# Our newest generation of HTM as a Green Electron Blocking Layer

## Performance comparison in Green

### our next generation G prime vs our industry standard



#### Our HTM as EBL



**Our G EBL, state of the art G prime in the OLED display industry (performance, processability, IP protection,...)**



**Next Generation bringing better performance, adjusted to customers needs.**

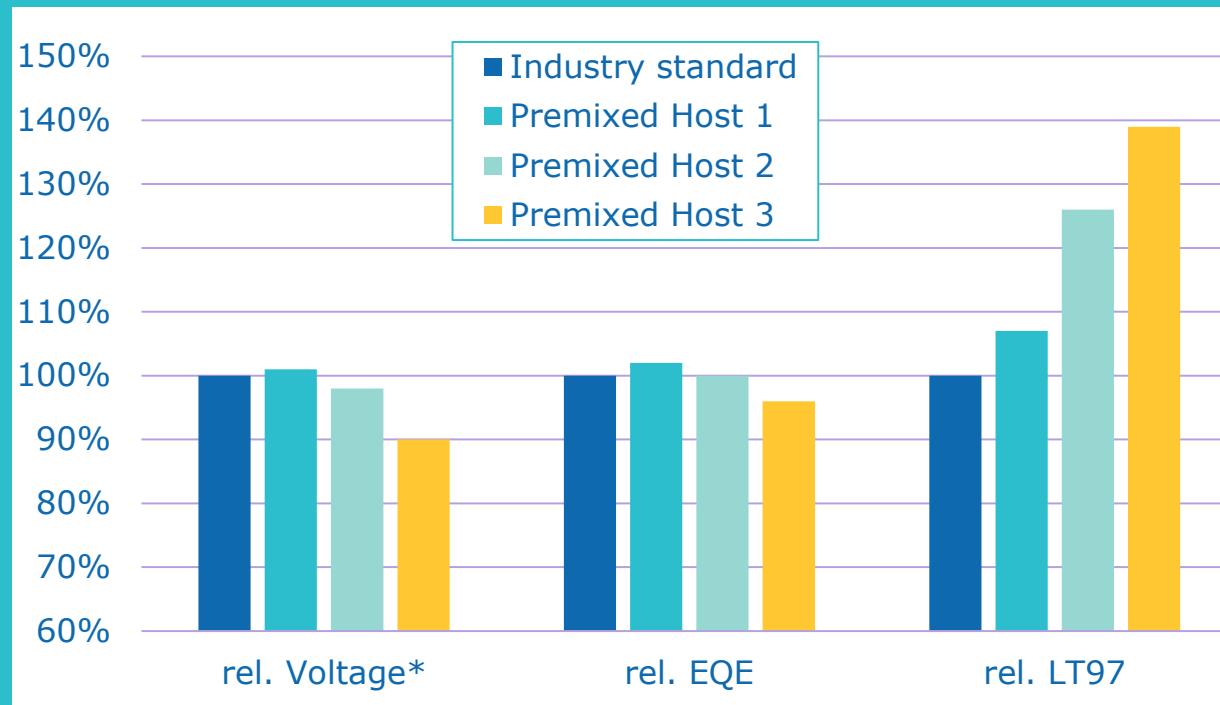


# Examples of our Green Premixed Host Development

## Performance comparison

(combined with industry standard dopant)

### OUR GREEN PREMIXED HOST VS INDUSTRY STANDARD



\*High value means improved voltage.

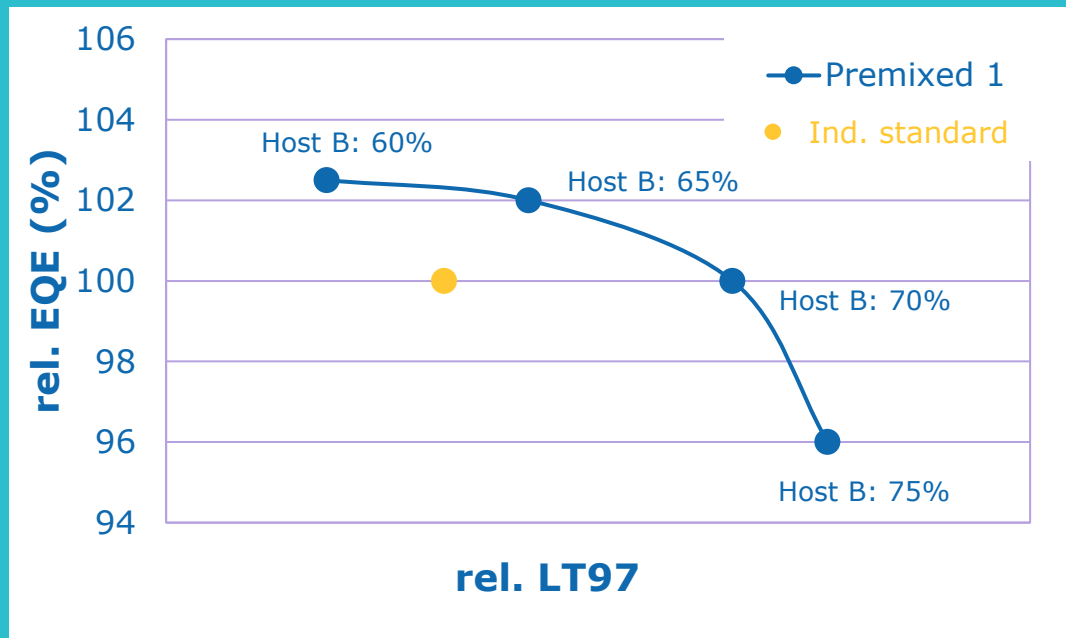


**Our premixed hosts show improved lifetime**



# premix enables performance tuning

Effect of host ratio change (Host A vs Host B) in the premixed



Efficiency and lifetime performance can be optimized as function of h-host concentration



Better performance vs industry standard



# premixed stability



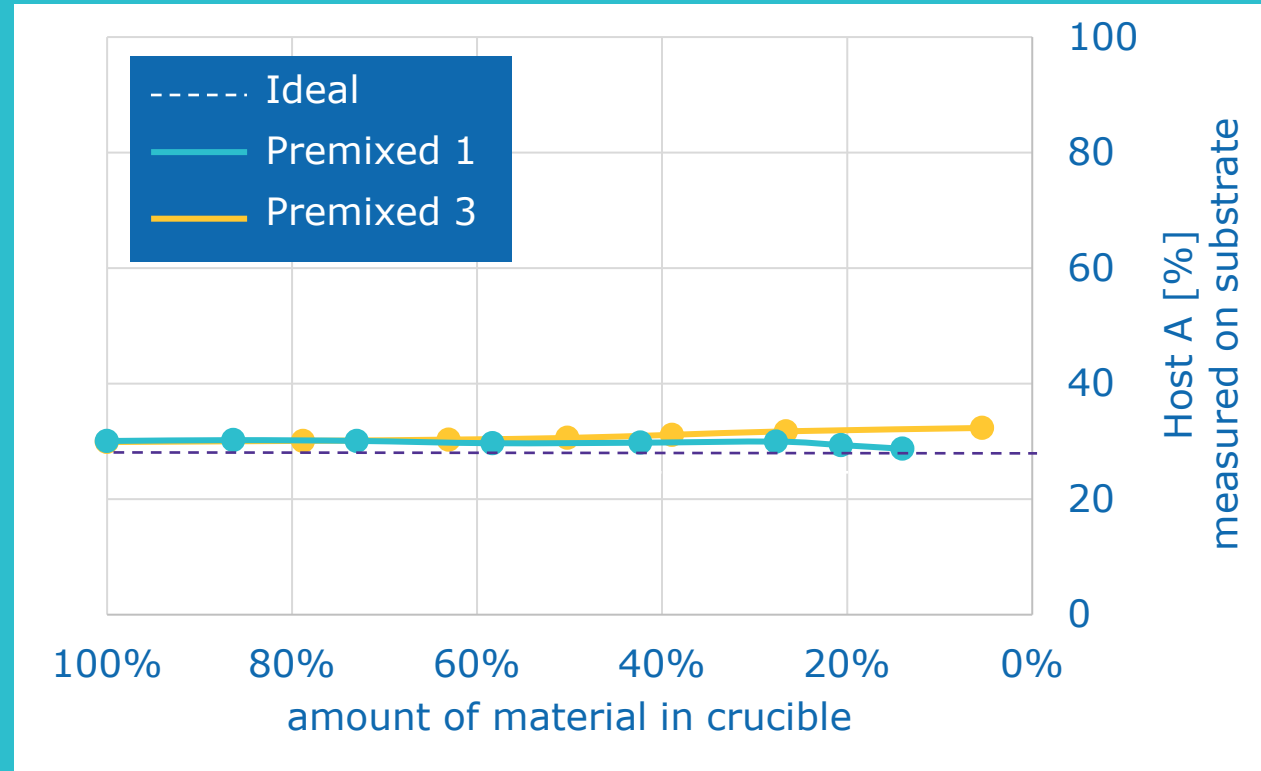
Evaporation stability of our premixed materials is close to ideal



For premixed development, we test the stability by evaporation of premixed material from crucible to substrate

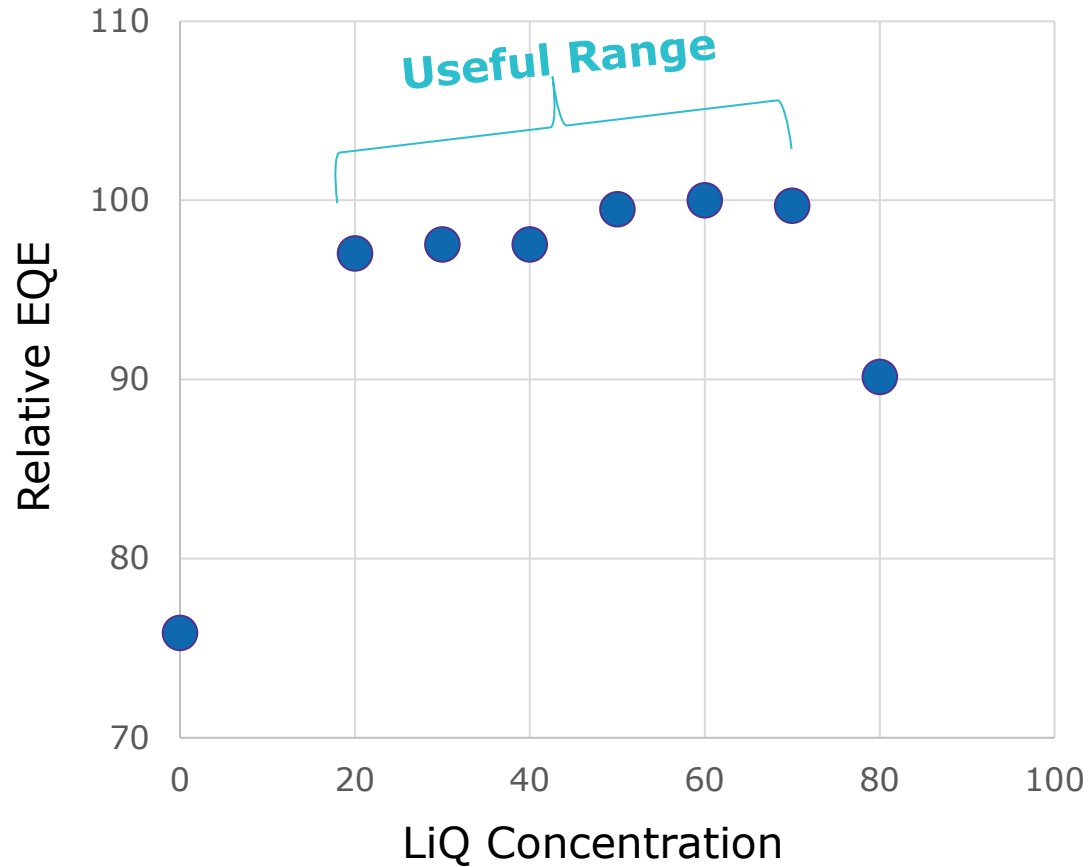


The ratio of material on the substrate is then checked by HPLC



# Performance tuning with LiQ

## ETM



**Broad portfolio of materials to mix with LiQ in the ETL**



**Wide range of LiQ concentration yields devices with high EQE**



**Within the acceptable range, LiQ concentration can be used to tune other properties, such as LT, V, ...**



The **WORLD** is  
**CHANGING**  
and so  
**ARE WE**

Performance Materials is now **Electronics**

Our product and service portfolio has been designed to enable the future of **electronics** in our data-driven world.

We are unlocking the potential for **smaller, faster, more powerful** and **more beautiful** electronics.