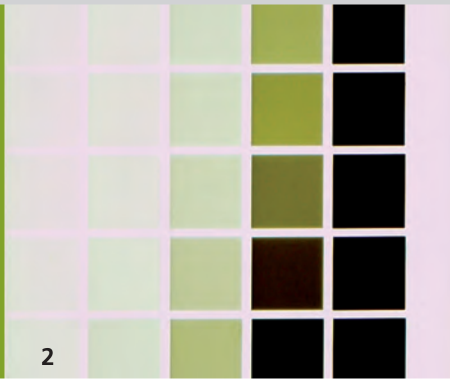
FEP

FRAUNHOFER INSTITUTE FOR ORGANIC ELECTRONICS, ELECTRON BEAM AND PLASMA TECHNOLOGY FEP



1 *Emissive OLED with logo patterned by direct-write electron beam*
2 *Emissive OLED with continuous range of intensity levels from various electron doses*
3 *Test chip with patterned emissive area*

DIRECT-WRITE MICROPATTERNING OLEDS USING ELECTRON BEAM TECHNOLOGY

Fraunhofer FEP is currently investigating the effects and possible applications of electron beam technologies in the field of organic electronics. During this research, a novel approach was developed by which any fabricated OLED device can be patterned individually and at high resolution. The patented technology uses an electron beam process, which takes place after finalizing the OLED including the encapsulation. Therefore it is possible to build the OLED highly productive and completely unpatterned, before the emission is individually modified by an adjusted electron beam process.

The penetrating electrons of the electron beam lead to a local reduction in charge carrier injection. This permanently reduces the local emission level compared to its initial level, which simultaneously results in reduced power consumption.

The process is highly adaptable – regardless of whether the OLED is applied to a rigid medium or a flexible film, what color the OLED is, or whether the substrate is optically opaque, translucent, or transparent. The size of the substrate is universal as well and can be matched to the corresponding application.

The energy of the accelerated electrons determines their penetration depth into the OLED layer stack. A suitable accelerating voltage is selected to specifically deposit the triggering electron energy at a level below the encapsulation layer. This enables the modification of the luminous characteristics of the organic layers without destroying or damaging the encapsulation itself. Depending on the application, even individual organic layers can be directly targeted. Lateral control of the electron beam permits any shape to be structured. The electron dose determines the degree of change in emissivity. The greater the dose, the darker the affected location appears. This allows a continuous range of intensities to be created on monochrome OLEDs.

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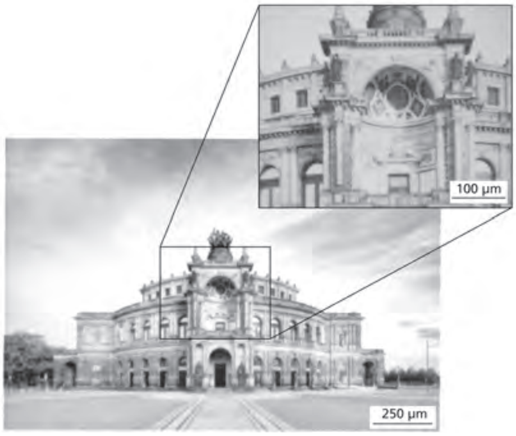
Industry partner

RAITH NANOFABRICATION



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To estimate the penetration depth and energy absorption of the electrons in the OLED stack, specific layer properties and scattering processes at interfaces must be taken into account. Fraunhofer FEP uses Monte Carlo simulations of these complex electron/solid-state interactions to predict the energy absorbed by the individual layers of the OLED fabricated at the Institute. It has been found that the majority of the energy is absorbed in the encapsulation layers and only a fraction reaches the delicate organic layers. By increasing the acceleration voltage, the proportion of the organic layers affected can be increased and simultaneously the electron dose needed to cause the desired change in emissivity can be reduced.

Design example

Image of the famous Dresden opera house (Semperoper)

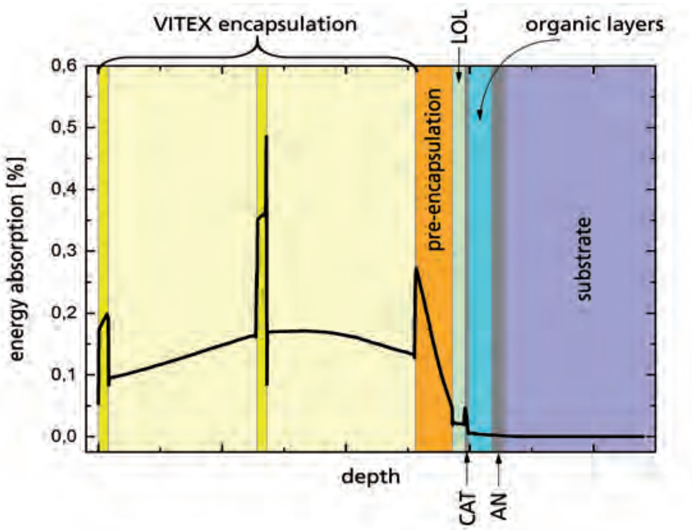
- Image size: 1.8 × 1.2 mm²
- Resolution: 2 µm / 12,700 dpi
- Write time: 105 s

The direct-write patterning of the OLED was carried out with an electron-beam lithography system from Raith GmbH, the leading manufacturer of nanofabrication systems.

Application examples

- Signage
  - Micro and miniature displays
  - Large-area custom-designed lighting components
  - Emissive tattoos / eSkin
- Integrated security features (PUFs – physically unclonable functions)
  - Emissive passport photos
- Emissive measuring devices such as rulers and yardsticks
- Designer lighting components such as transparent substrates with controllable lighting patterns
- Storage applications
  - Electro-optical storage (“emissive microfilm”)
  - PROMs (programmable read-only memory)

6 *Electron energy absorbed in a typical OLED stack*



4 *Emissive OLED area (Semperoper photo: C. Lippmann)*

5 *Test chip with patterned emissive area*