Substrate Patterning for Organic Electronic Devices at Fraunhofer IPMS

Christian Rahnfeld, André Philipp, Moritz Hasselgruber, Olaf R. Hild, Christian May

Fraunhofer Institute for Photonic Microsystems
COMEDD - Center for Organic Materials and Electronic Devices Dresden

Plastic Electronics 2010

October 19-21, Dresden

COMEDD

Fraunhofer IPMS

CENTER FOR ORGANIC MATERIALS AND ELECTRONIC DEVICES DRESDEN

COMEDD as trademark of Fraunhofer IPMS

- Opened in 2008
  investments of about 30 M€ (EU, Sachsen, FhG)

Mission

- Customer and Application Specific Research, Development and Pilot fabrication on novel device concepts and manufacturing methods in the field of organic electronics (small molecule)

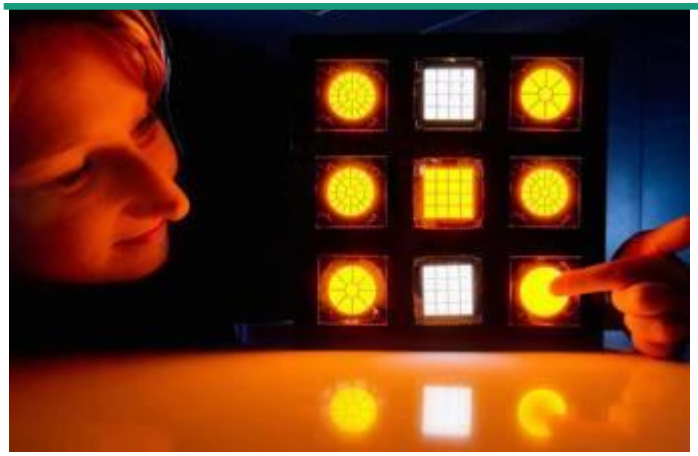
Infrastructure

- Clean room 900 m², Labs 100 m²

Fabrication lines

- Pilot line Gen2 (370 x 470 mm²)
- Pilot line OLED-on-CMOS (200x200 mm²)
- Roll-to-Roll line (300 mm foils)

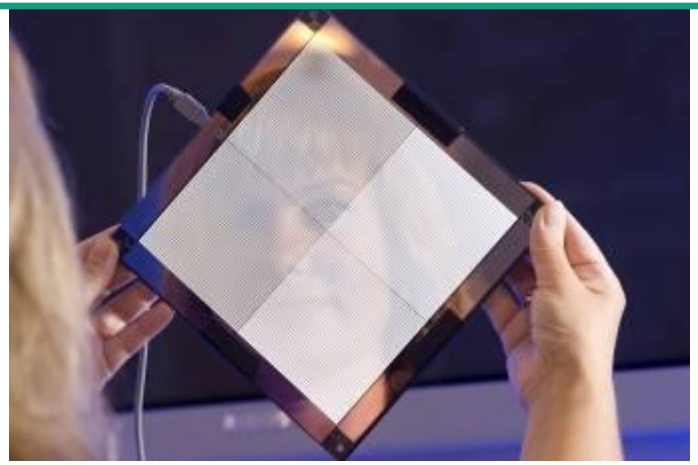
Applications

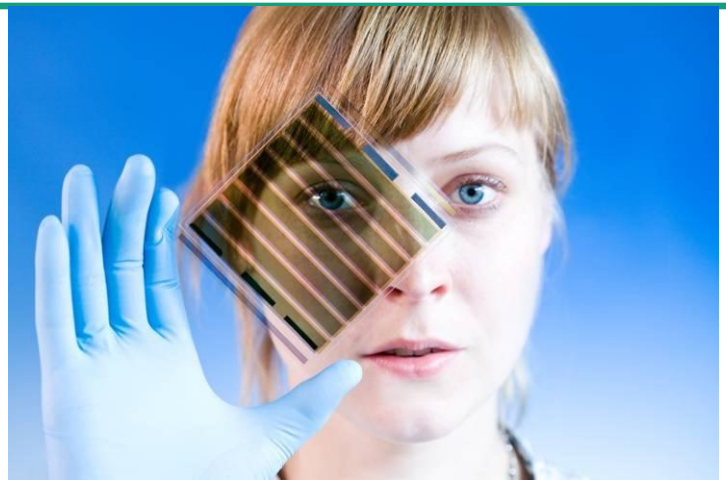


Signage

OLED on CMOS

Lighting



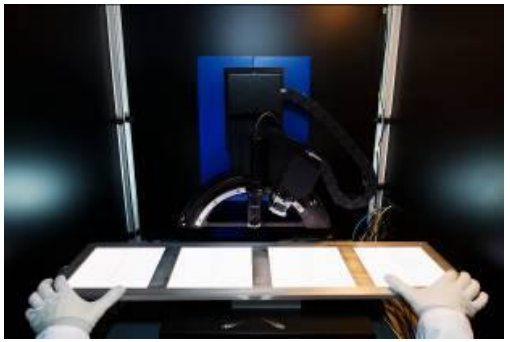


Organic Photovoltaics

COMEDD

Fraunhofer IPMS

Outline

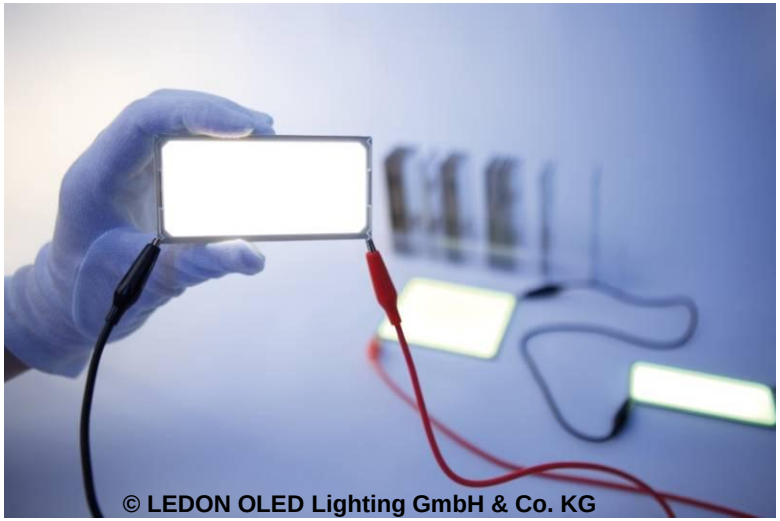


- Introduction to Organic Light Emitting Diodes
- Substrate Patterning Steps
  - Printing of Etch Paste
  - Printing of Metallization Layer
  - Printing of Passivation Layer
- Requirements & Challenges for Screen Printing
- Comparison of OLED Parameters
- Summary

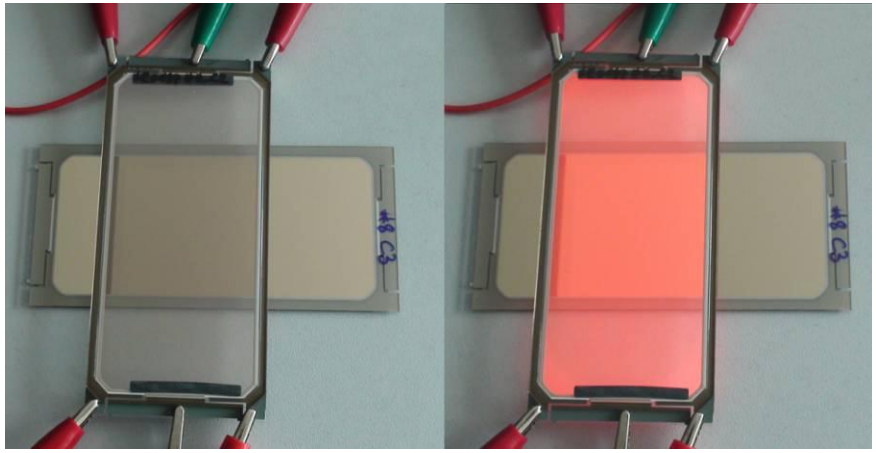
COMEDD

Fraunhofer IPMS

Benefits of OLEDs



Opaque white 5 x 10 cm^2 OLED



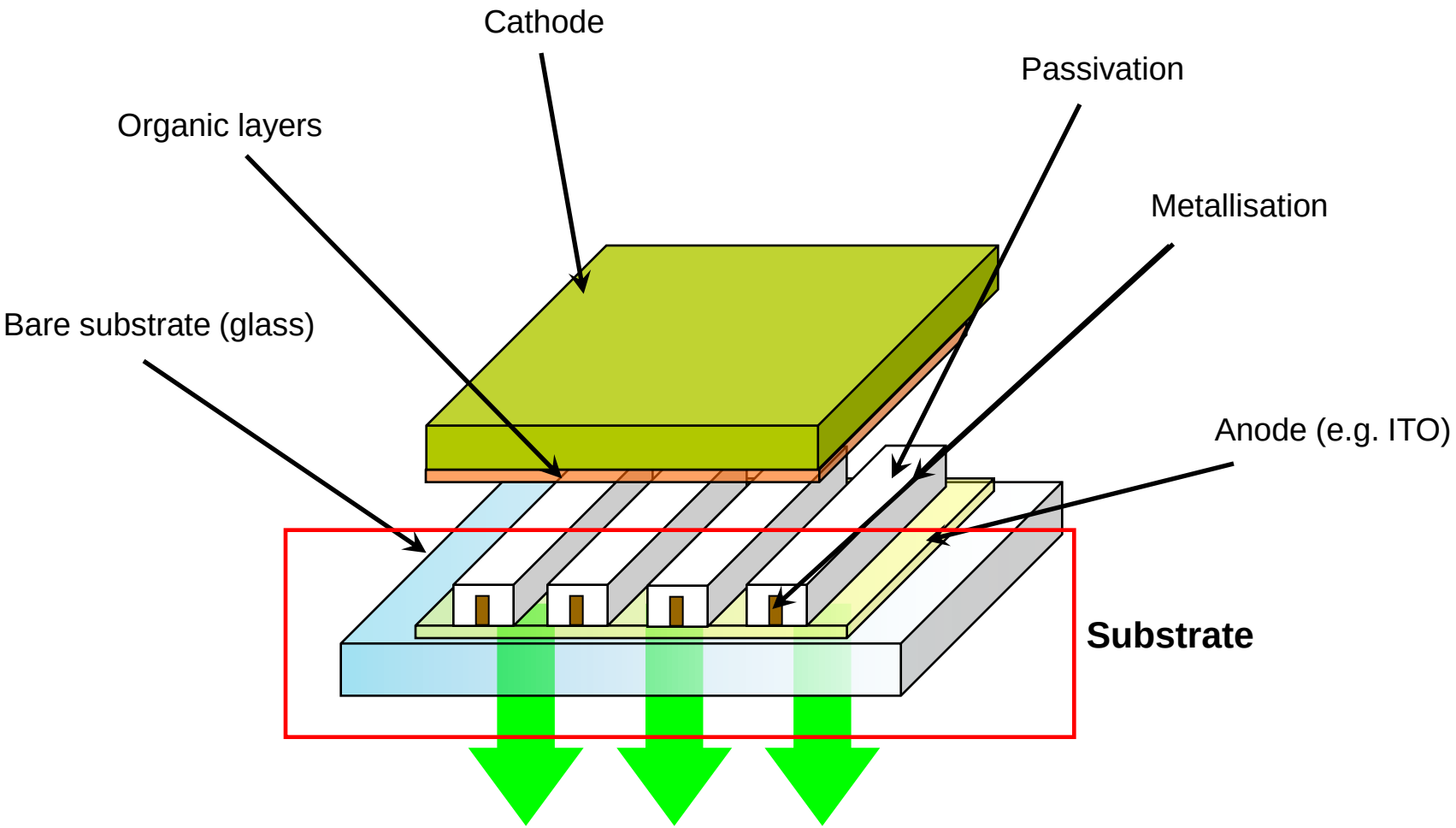
Transparent red 5 x 10 cm^2 OLED

- Area light source
- Low surface heating
- Low energy consumption
- Transparent stack possible
- Bottom-emitting and top-emitting
- Environmentally friendly
- Total thickness < 2mm
- Broad perspective (wide viewing angle)

COMEDD

Fraunhofer IPMS

Layers of an OLED

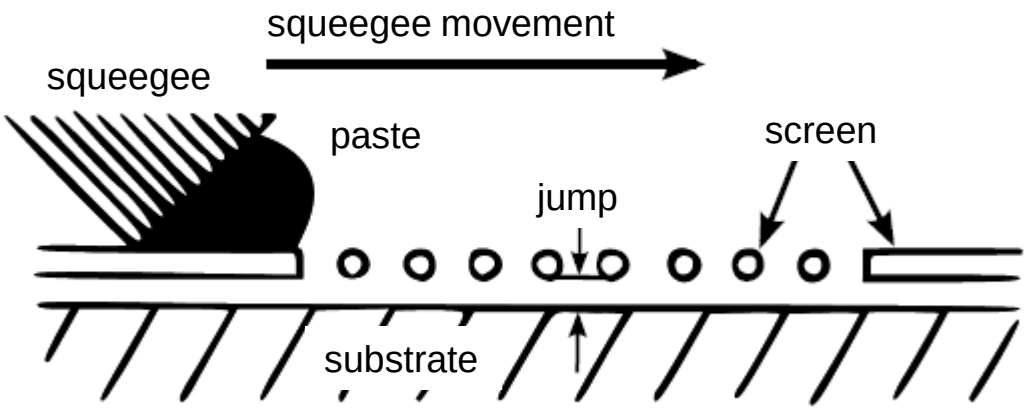


COMEDD

Fraunhofer IPMS

Screen Printing – Introduction

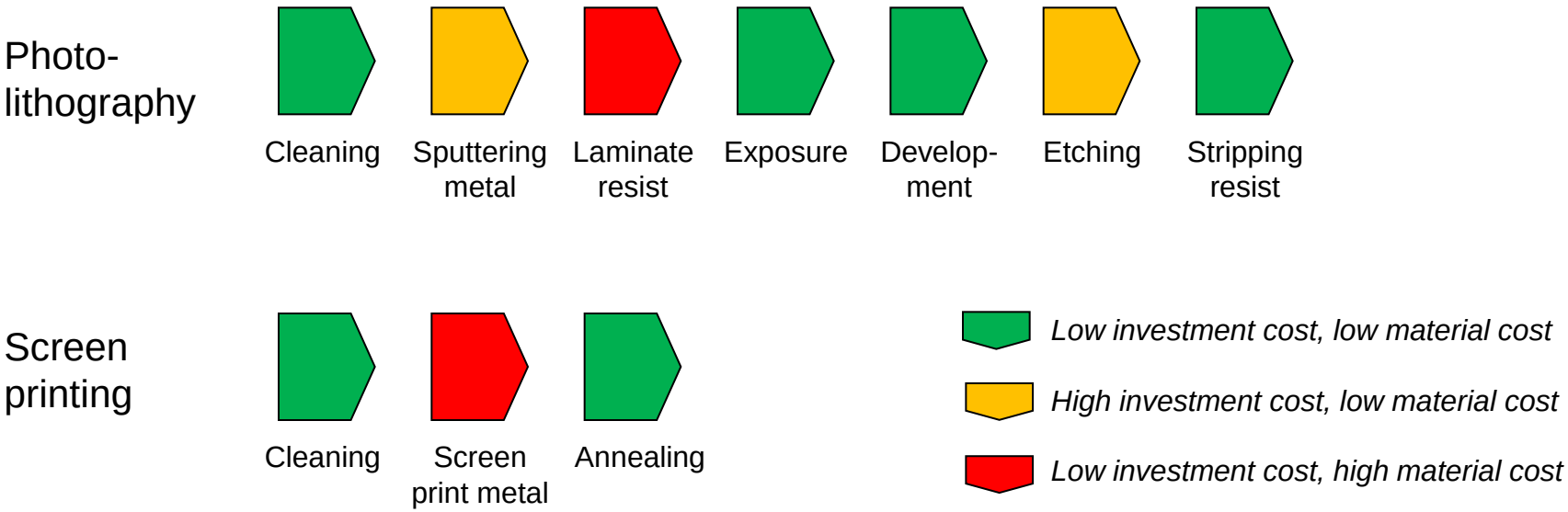
The principle of screen printing



COMEDD

Fraunhofer IPMS

Comparison: lithography and alternative patterning



Standard and alternative production process for metallisation layer (same for passivation and anode layer)

- Reduce costs, flexible in layout
- IPMS reference: lithography-based substrates

COMEDD

Fraunhofer IPMS

Gen2 Pilot Fabrication Line for OLED Lighting and OPV

- Modular & fully automated cluster system
  - Tact time down to 3 min
  - Suppliers: Sunic System (Korea) and Aixtron (Germany)
- Rigid substrate size 370 x 470 mm² (Gen2)
- Plasma pretreatment
- Organic film deposition (up to 12 layers)
  - Organic Vapour Phase Deposit. OVPD
  - Vacuum Thermal Evaporation VTE
- Metal film deposition (e.g. Al, Ag)
- Direct connection to encapsulation system

Screen Printer at COMEDD

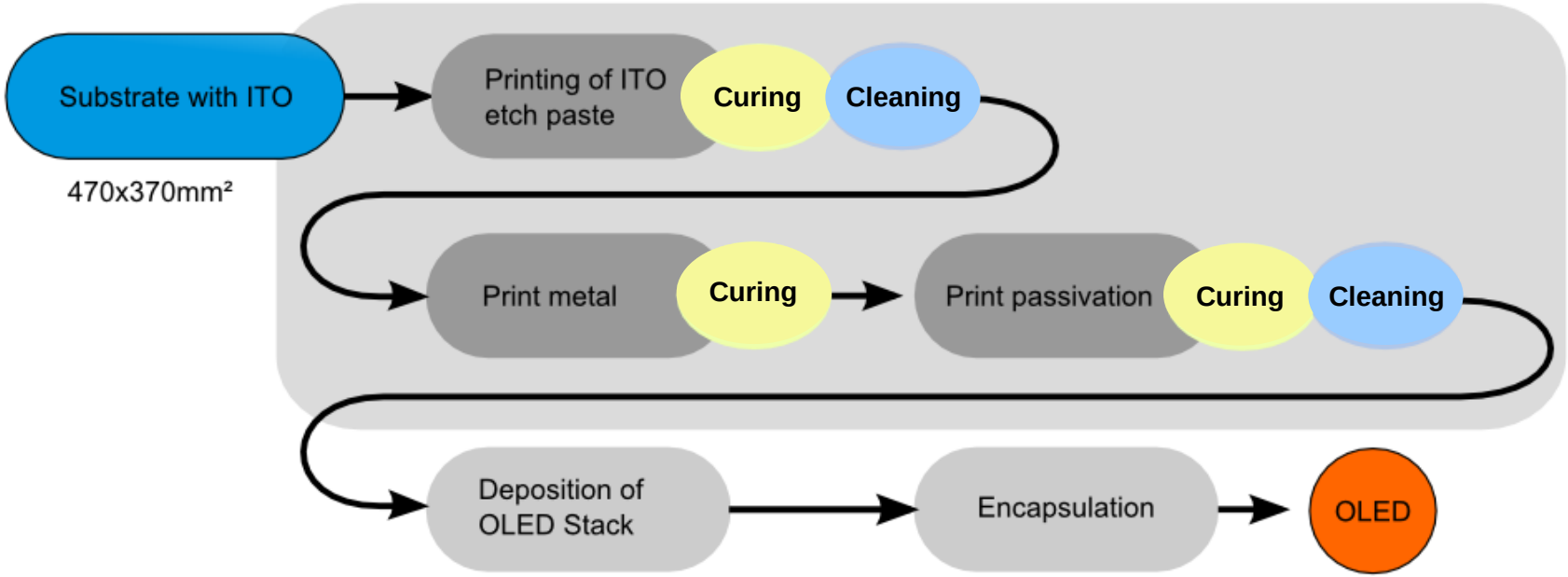
Automatic screen printer

- Print process in clean room class 100
- 0.7 mm glass substrate (470 x 370 mm²)
- Tact time <3 min
- Connected to handling system

COMEDD

Fraunhofer IPMS

Process Flow Substrate Manufacturing



COMEDD

Fraunhofer IPMS

Anode Patterning – Printing of Etch Paste

Potential separation of anode

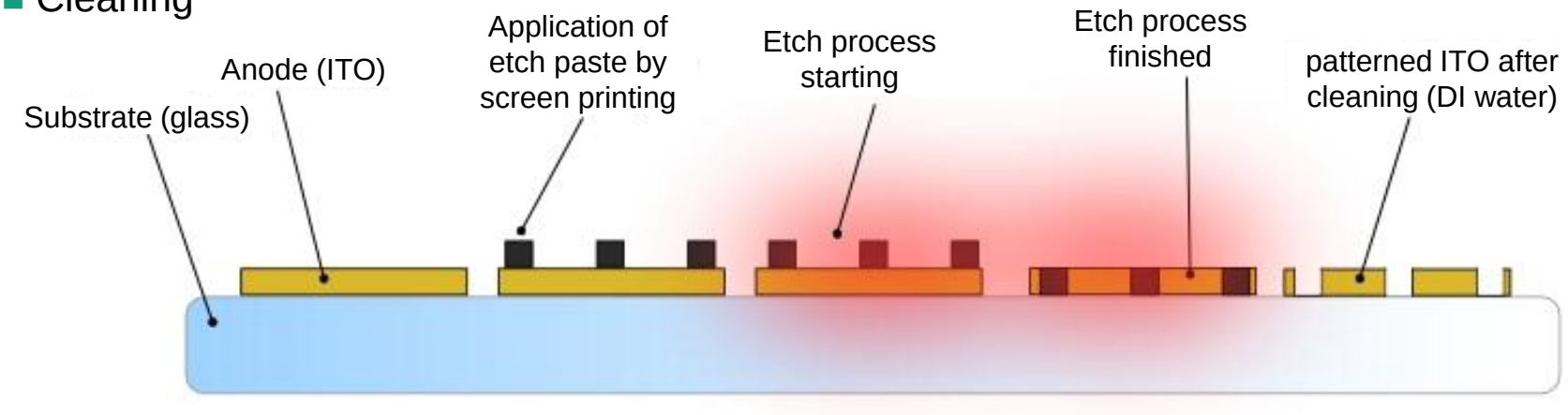
- ITO etch paste with phosphoric acid
- Activation > 120 °C

Features:

- Etch rate depending on applied temperature
- Min. Line & Space of 150 µm

Challenge:

- Cleaning

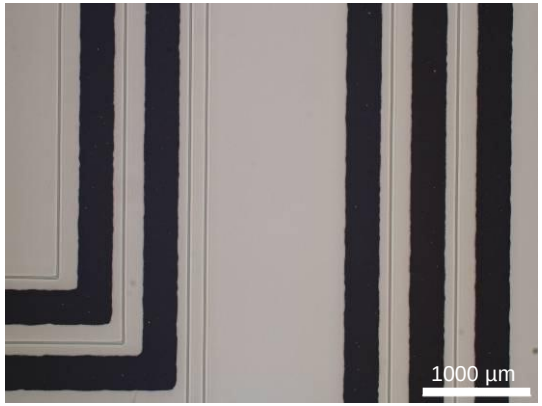


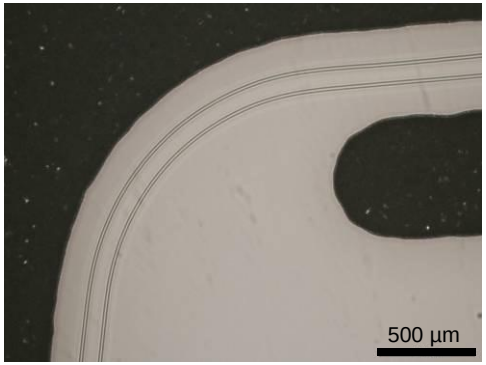
Process flow for ITO patterning at IPMS

COMEDD

Fraunhofer IPMS

Anode Patterning – Laser Ablation





- 355 nm picosec. laser
- Line & Space down to 12 µm / 10 µm
- Speed: up to 1.5 m/s

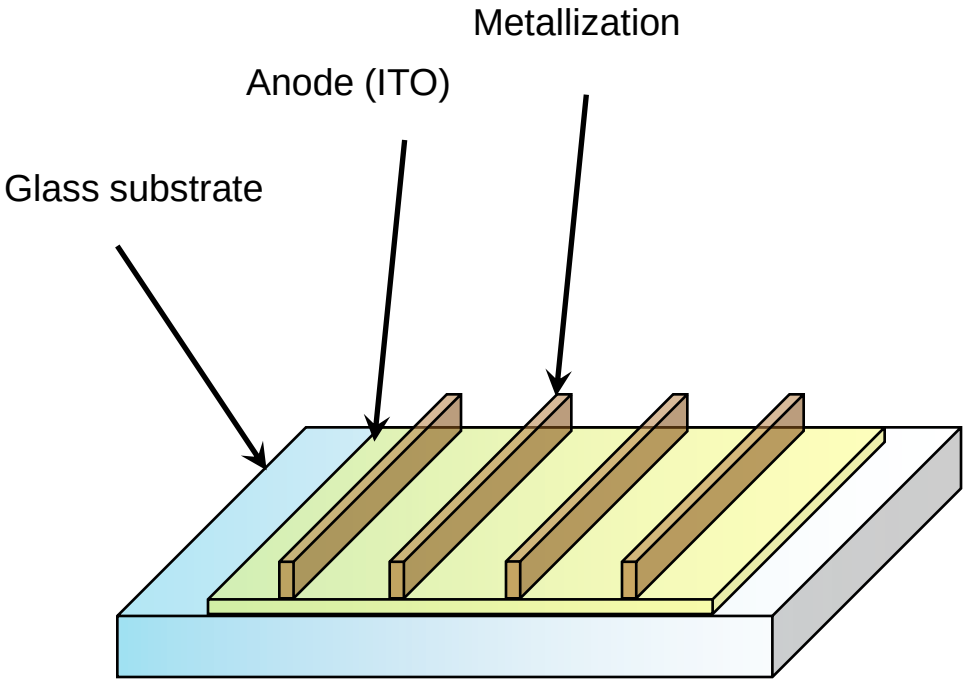
COMEDD

Fraunhofer IPMS

Printing of Metallization Layer

Application: contacts and grid

- Silver filled polymer metal paste
- Annealing > 100 °C



Features:

- Line & Space of 150 µm feasible thickness: ~10-20 µm
- Contact resistivity to ITO very low: R_k = 0.027 Ωmm²
- Sheet resistance very low R_s = 0.022 Ω/□ (@ 10 µm thickness)

COMEDD

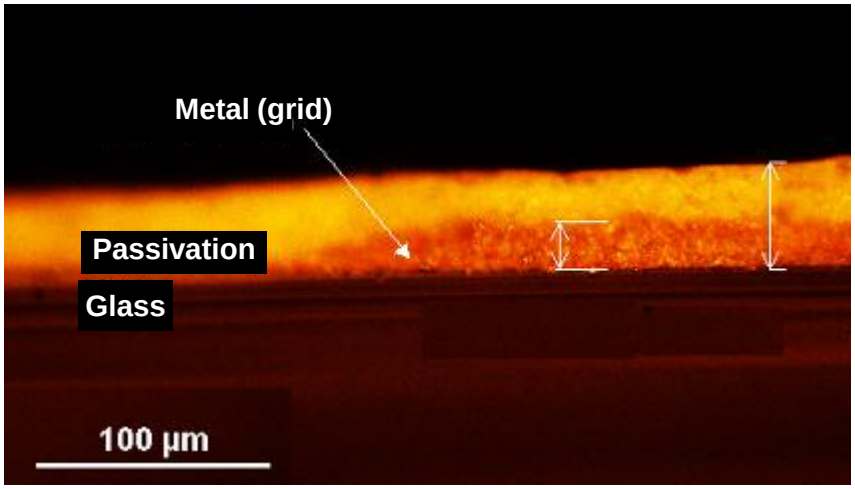
Fraunhofer IPMS

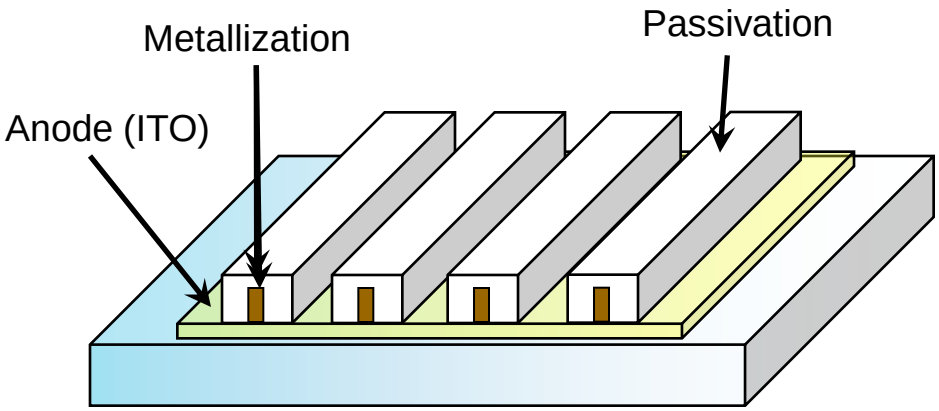
Printing of Passivation Layer

- Polymer passivation paste
- Thickness: ~10-20 µm
- Annealing > 100 °C

Challenge:

- No open areas and pinholes





COMEDD

Fraunhofer IPMS

Requirements & Challenges for Screen Printing

- Combination of thin and thick film processes, especially critical particle size of the metallization, organic layer stack only a few 100 nm thick
- Screen printing of small structures, pastes must not clog printing screen
- Printing pastes must not leave any residue on the ‘active’ ITO areas
- Low annealing temperature of the printing pastes → polymer based pastes (high temperature can change ITO → potential of short-circuits)
- High standards for all printing components needed:
  Pastes: long pot life, low annealing temperature
  Screens: no holes in emulsion, high reproduction accuracy
  Squeegee: high resistance to chemicals

Patterning Comparison – OLED Parameters

Driving voltage U [V] @ 1000 cd/m²			
Substrate type	min	typ.	max
Lithographic	2.55	**2.62**	2.68
Screen printed	2.39	**2.60**	2.74

Reverse current density J [mA/cm²] @ -5V			
Substrate type	min	typ.	max
Lithographic	0.002	**0.05**	0.87
Screen printed	0.004	**0.03**	0.88

Parameters for PIN orange OLED at IPMS

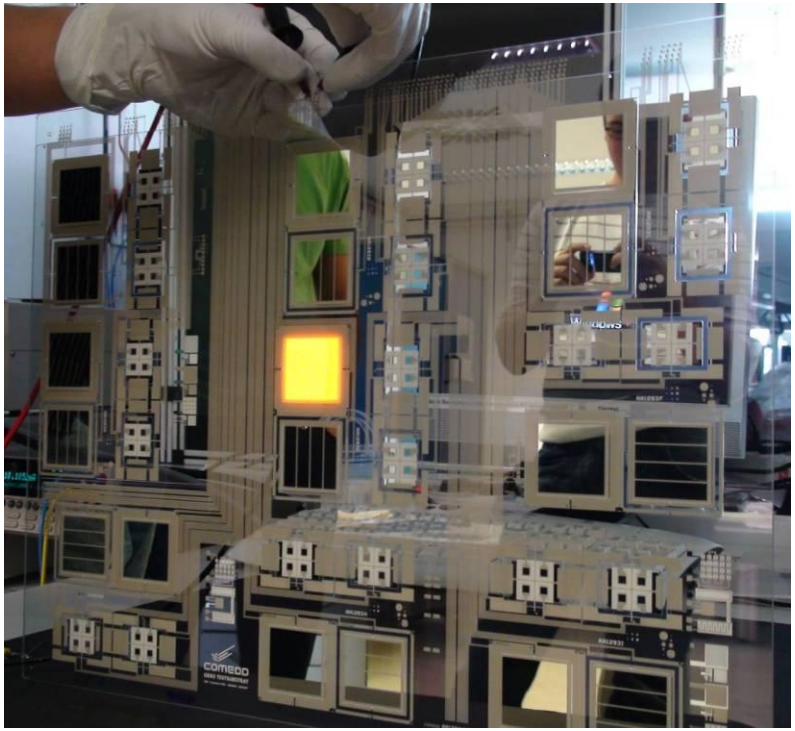
- Driving voltage → Indicates quality of metallisation layer
- Reverse current density → Indicates quality of passivation layer

COMEDD

Fraunhofer IPMS

Summary

- Litho-free process in Gen2 size-based on screen printing established at COMEDD
- No difference in the OLED parameters compared to litho-substrates could be shown
- Process is more flexible concerning the layout
- Low-cost process



OLED tests on a Gen2 substrate

COMEDD

Fraunhofer IPMS

Acknowledgement

This work was partly supported by the German Federal Ministry of Education and Research within the project So-Light (FKZ: 13N10527).

Thanks to all involved colleagues at Fraunhofer IPMS.


COMEDD
Center for Organic
Materials and Electronic
Devices Dresden
OLED LIGHTING
TABOLA
OLED on CMO

Thank you for your attention!

COMEDD

We shape the light.