



Roll-to-Roll Printed Optoelectronics

M. Tuomikoski

VTT Technical Research Centre of Finland
Printable Electronics and Optics Centre



Business from technology

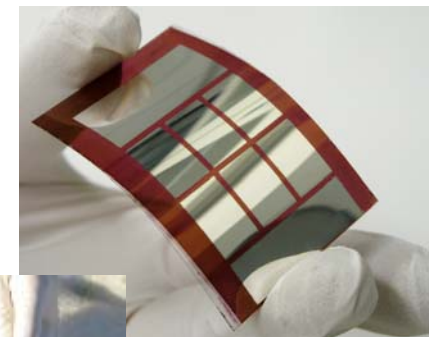
Photonics RoadMap for SMEs

7.5.2009, Oulu

Outline

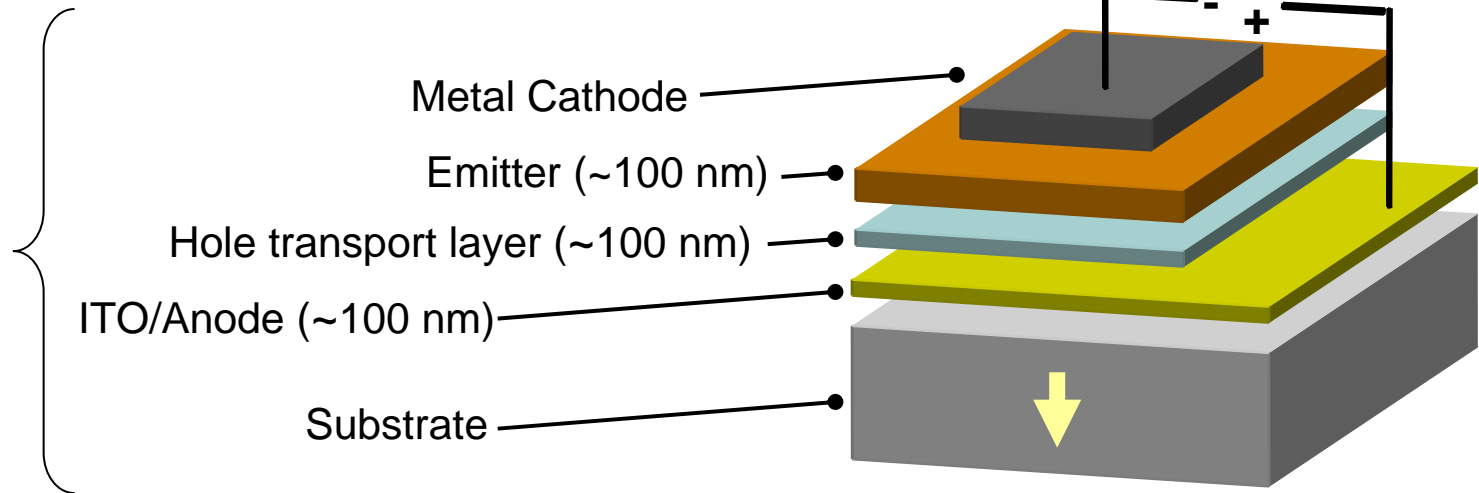


- Why to print organic light sources and solar cells?
- Printed OLED/OSC technologies at VTT
- Benefits of printing
- VTT pilot production facilities
- R2R manufacturing
- Printed demonstrators
- OLED performance
- Challenges in R2R manufacturing

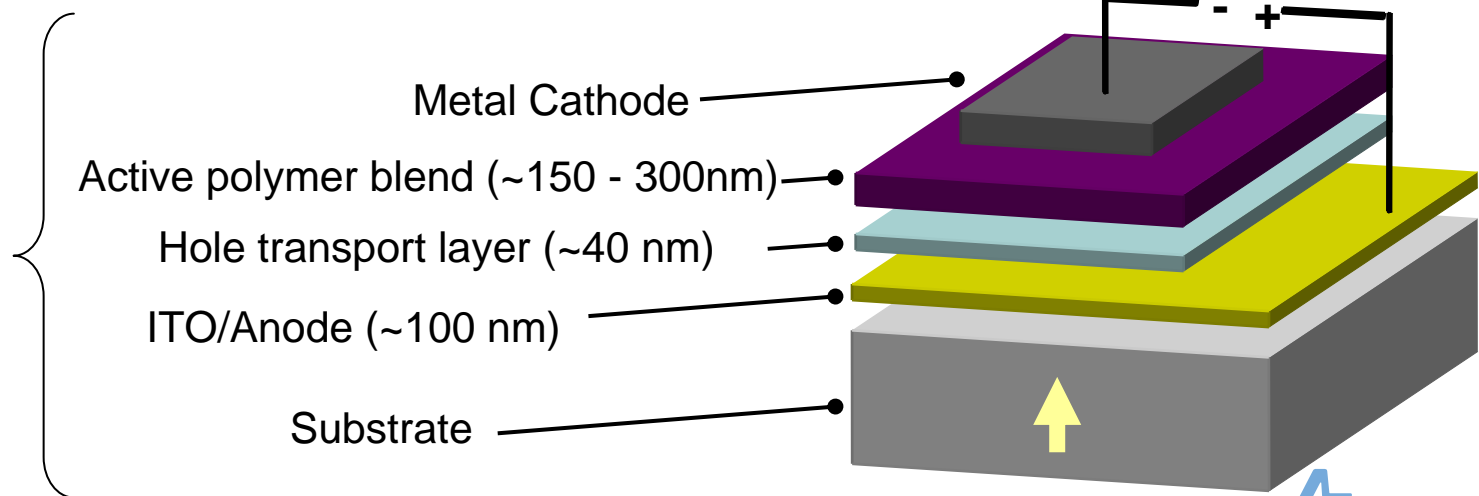


Why to print OLED and OSCs?

OLED
Organic
Light-Emitting
Diodes



OSC
Organic
Solar Cell



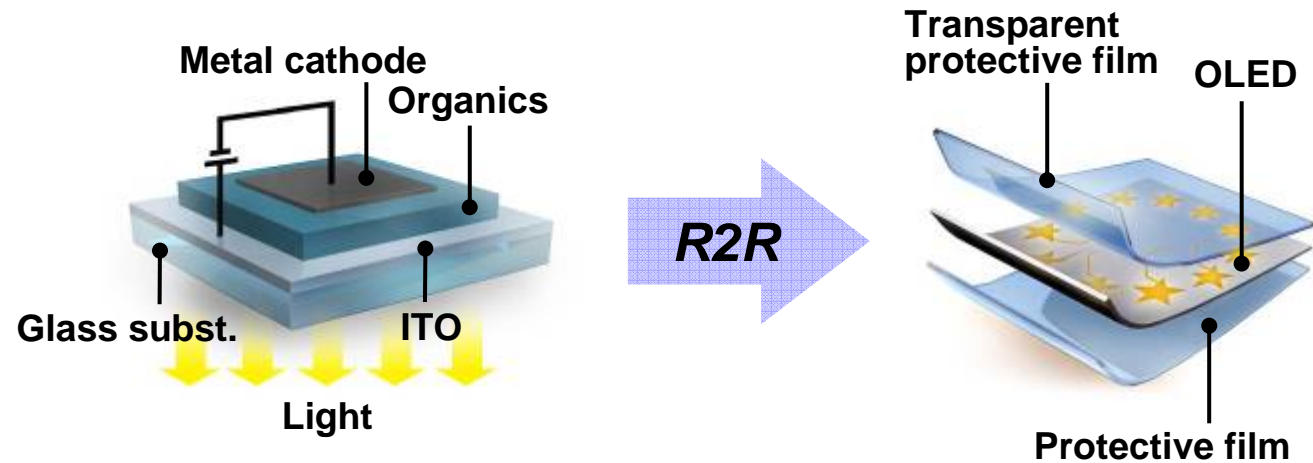
Printed OLED Technologies at VTT

Rigid substrates

- Lighting elements

Plastic substrates

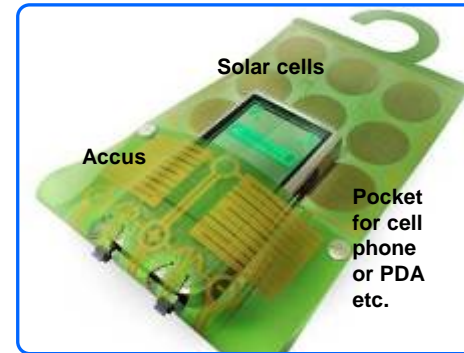
- Signage
- Product packages



Printed OSC Technologies at VTT

Plastic substrates

- Electronic devices
- Consumer packages
- *In the future*, for energy production



FP7- ICT-2007-1-215271
<http://www.vtt.fi/proj/facess/>

Concept of the 1st demonstrator

- Printing of flexible solar module and battery
- Control circuitry
- Temperature, illumination and humidity sensors

Targets for R2R printed solar module

- 2.5% @ AM1.5, A~100 cm², 250 mW



Benefits of printing

- Cost-effective processing
 - High-speed fabrication
 - Low material consumption
- Low temperature process
 - Flexible substrates
- Well-established techniques
 - Technology exists
- Direct patterning
 - No additional etching required
- R2R capable
 - Large area printing
 - Profit

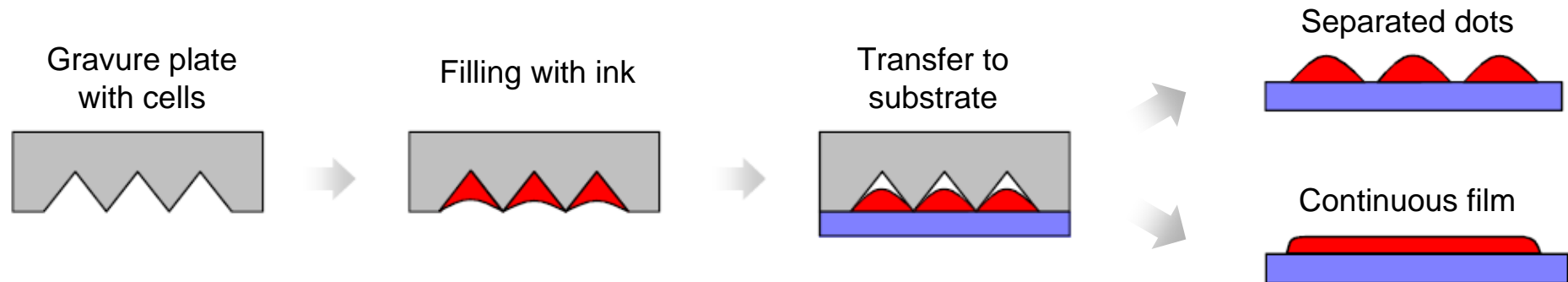
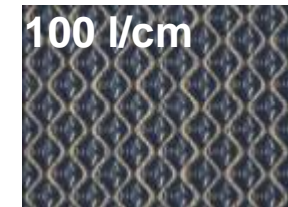
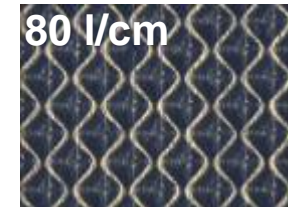
gravure ~
flexo ~
offset ~
screen ~
ink-jet ~

➔ *Suited for cost-efficient products - printed electronics*

Printing process

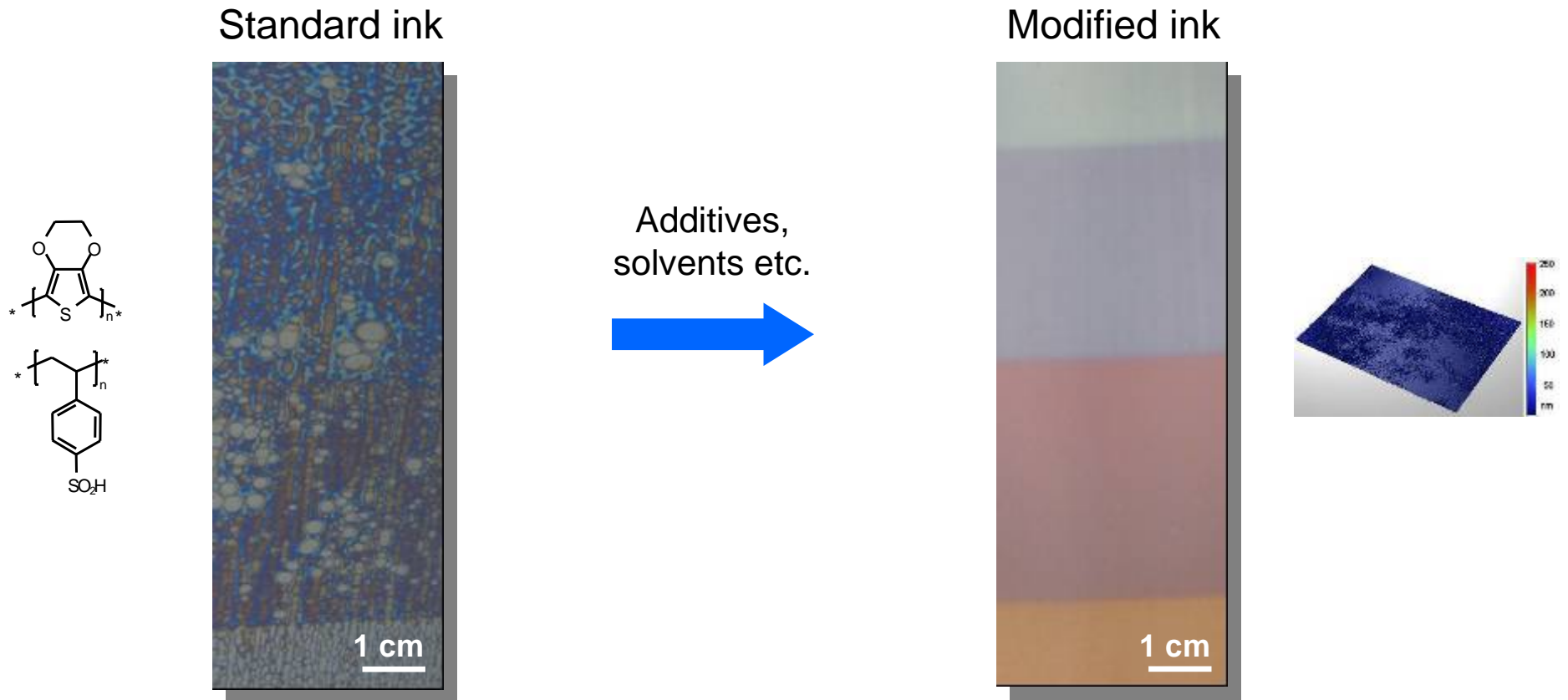
Gravure printing method for thin films

- Direct patterning options
- Large area printing
- Flexible and rigid substrates
- Different solvents possible
- High throughput (up to 60 m²/s)
- Medium registration (>20 μm)
- Low viscosity inks (10-200 mPas)
- Roll-to-roll capable



R2R manufacturing

PEDOT:PSS ink development for OSC and OLEDs



R2R manufacturing

P3HT:PCBM ink development for OSC

Printing parameters:

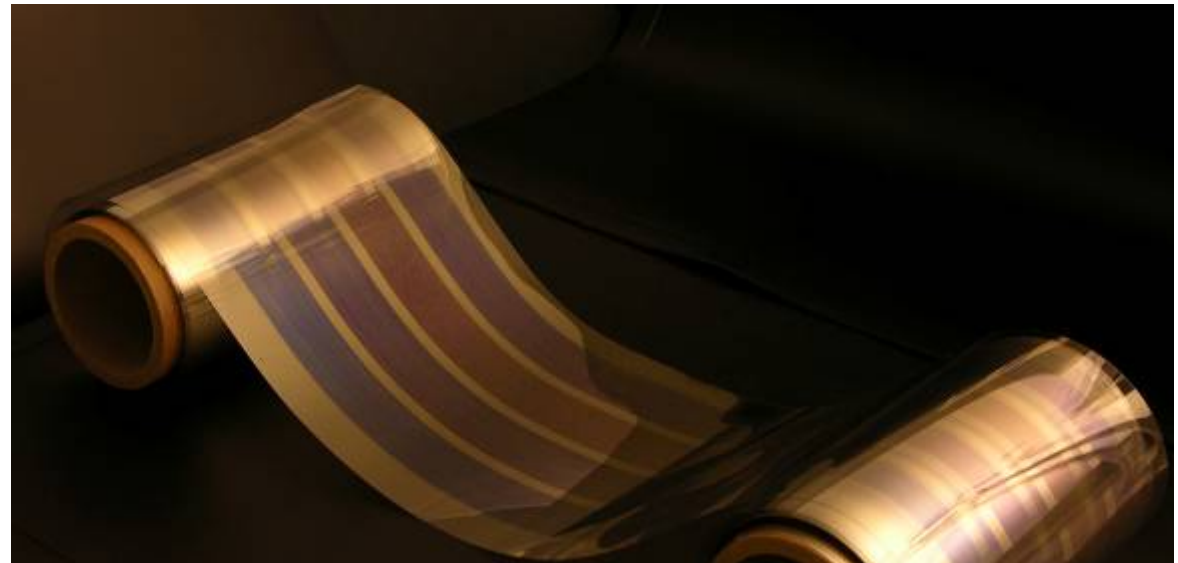
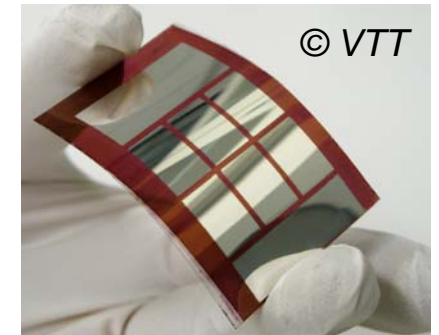
- Cylinder
 - Engraving
 - Mesh
 - Stylus
 - Cell depth
 - Force
- Ink
 - Solvents
 - Viscosity
 - Concentration
- Speed 18 m/min



R2R manufacturing

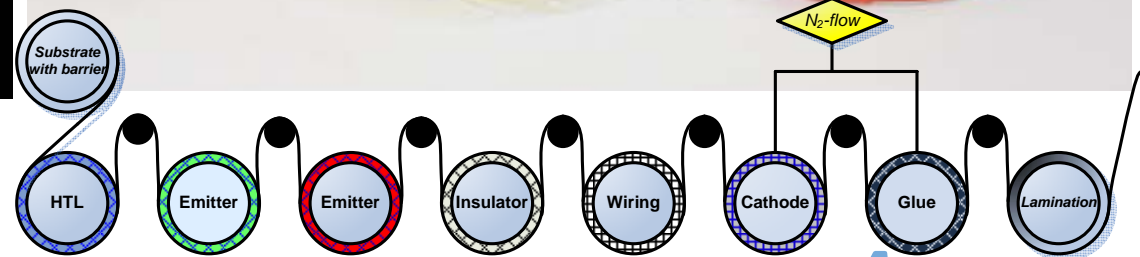
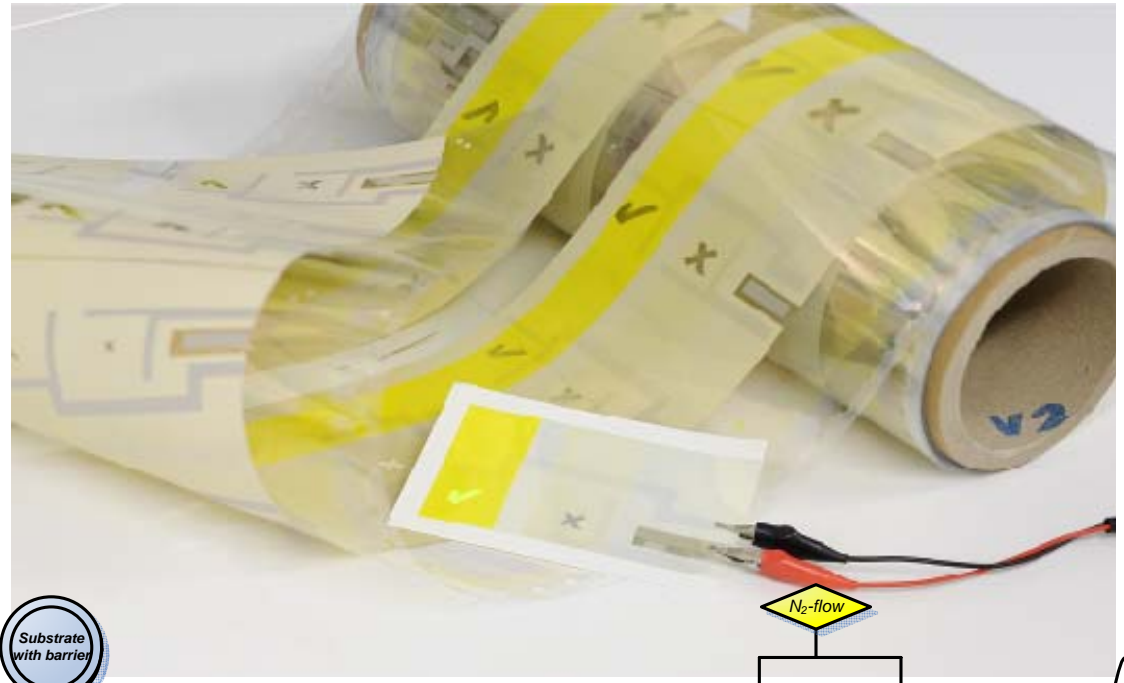
Pilot scale printing

1. Up-scaling of printing inks
2. Designing of printing cylinders
3. Pilot scale printing experiments
4. Film / Device characterization



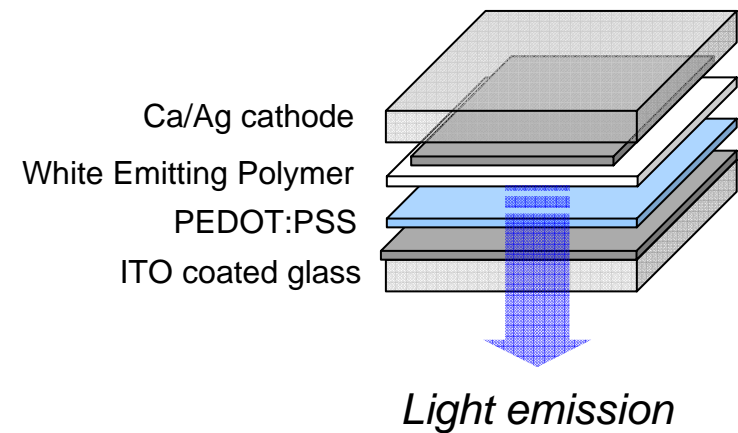
Printed demonstrators

OLED in a package - RF-Driven antitamper OLED box



Printed demonstrators

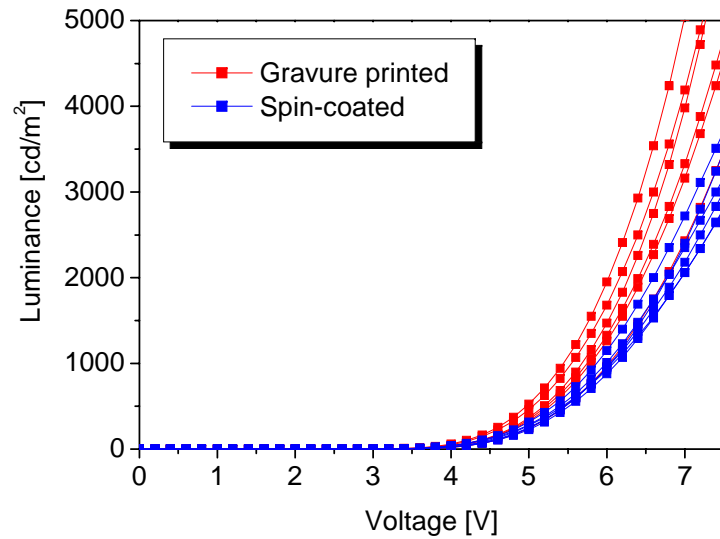
OLED EXIT sign demonstrator



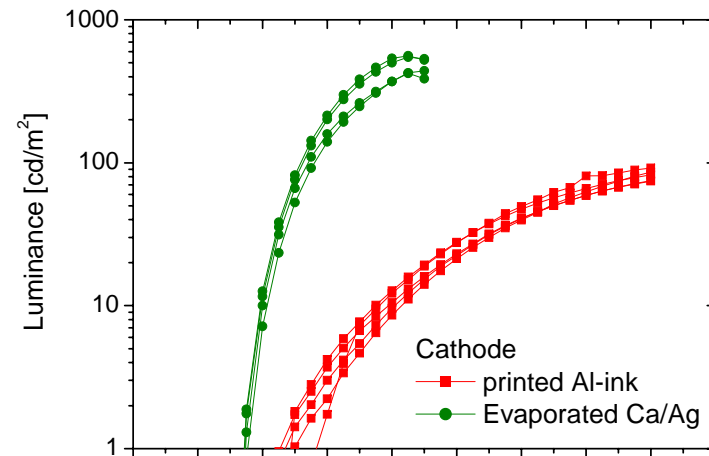
Gravure printed large area OLED with an active area of 35 cm²

OLED performance

Spin coated vs. printed OLEDs



Partly vs. Fully printed OLEDs



Challenges in roll-to-roll manufacturing

- High quality and low cost gas barrier foils
- R2R patterned ITO-anode electrode
- Conductivity of ITO for large area applications
- Compatible and high performance printed metal-ink cathode electrode
- R2R fine-line registration accuracy
- Web: handling, stretching, physical variations vs. temperature
- Purity of electronic and organic inks
- Compatibility of printed organic and electronic inks
- Process dust particles
- High production yield of R2R printed devices
- Online characterization of thin films and devices during processing

Acknowledgements

- IST priority of the European 6th and 7th Framework Program for financial support
 - OLLA partners
 - ROLLED partners
 - FACESS partners
- Co-workers in Printable Electronics and Optics Centre

Thank you for your attention!