IMOLA Workshop – Smart Lighting 2014

Technology development for a flexible, low-cost backplane for lighting applications

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Overview

- Application requirements
- Technology specifications
- Process flow
- Technology developments
- Technologies for increased flexibility
- Conclusions

Application requirements

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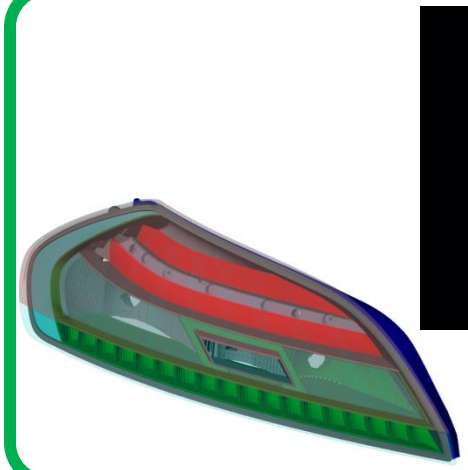
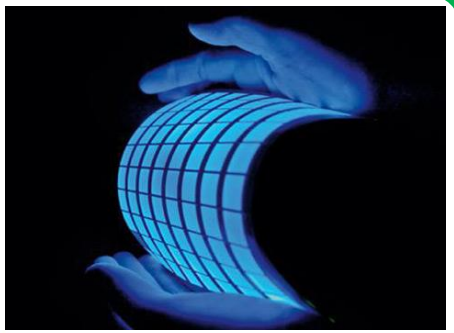
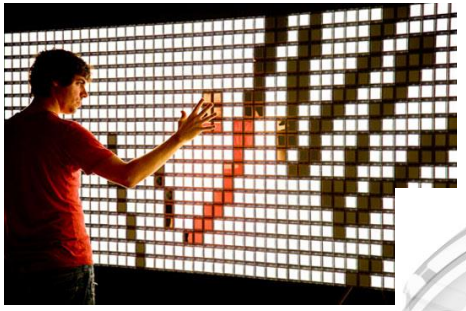
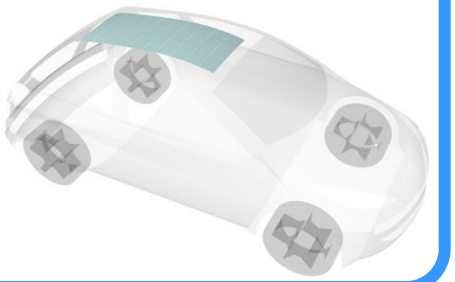
INTELLIGENT LIGHT MANAGEMENT FOR OLED ON FOIL APPLICATIONS

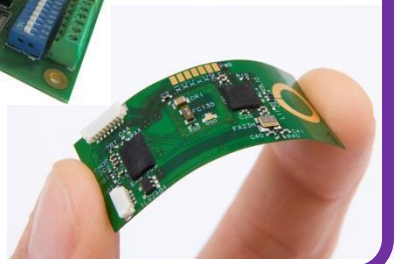


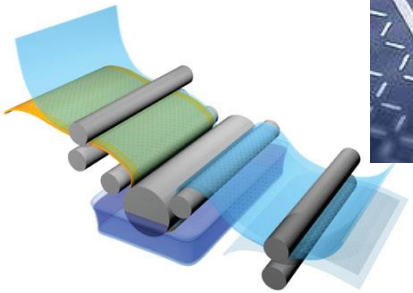


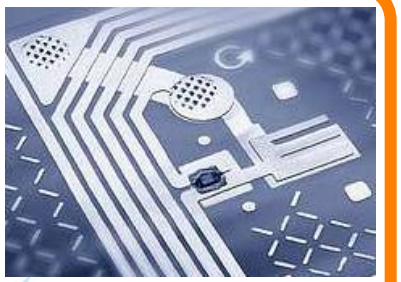




Interactive, modular, flexible, large-area, OLED-based lighting system on low-cost foil with built-in intelligent light management







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Technology specifications

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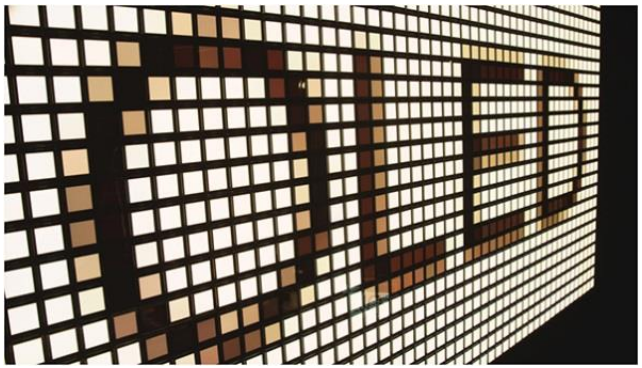
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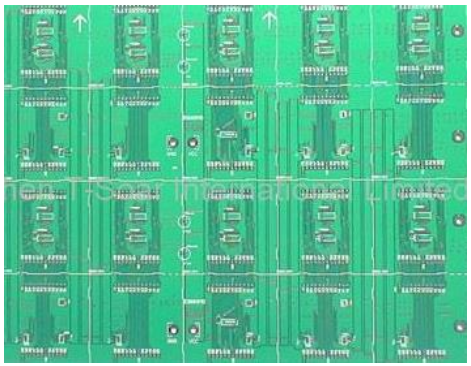
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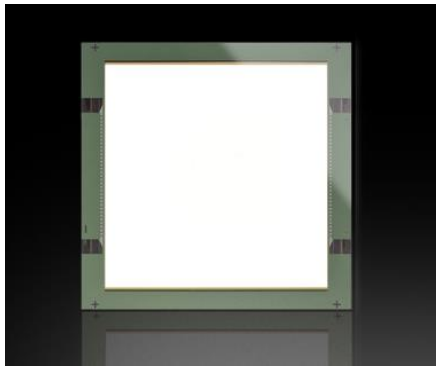

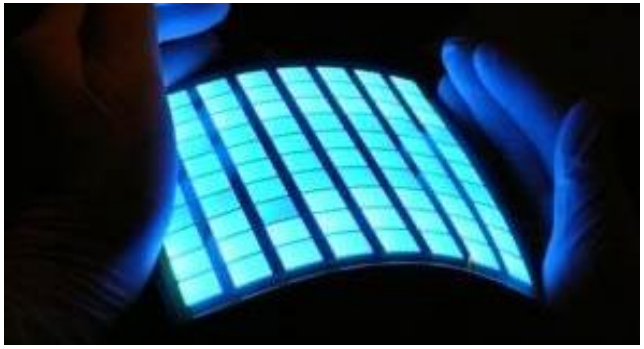
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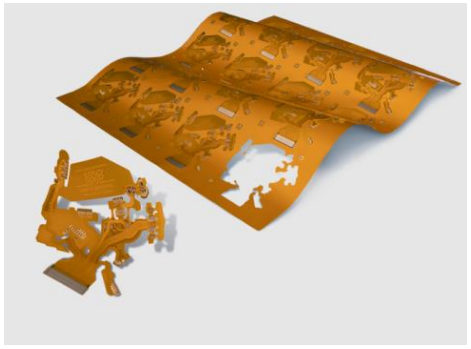
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PI:	€ 20 per m2	PET:	€ 2.0 per m2
Cu:	€ 6 per kg	Al:	€ 1.4 per kg

Technology specifications

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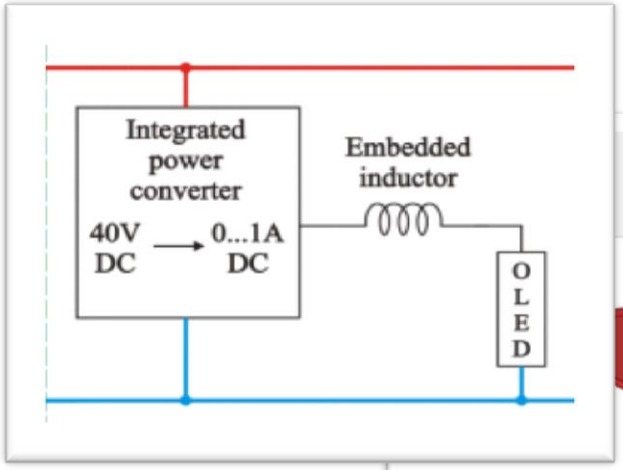
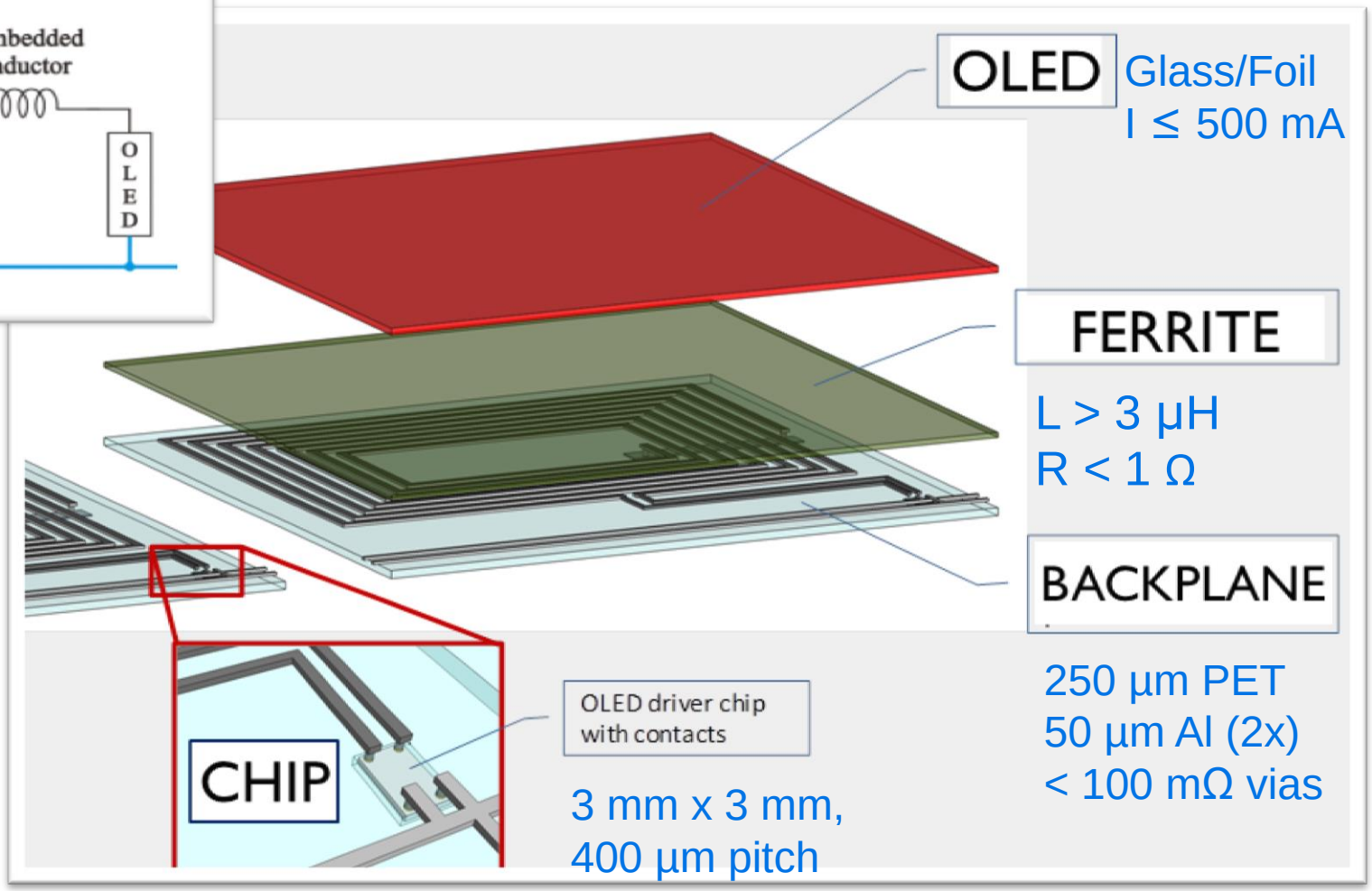
INTELLIGENT LIGHT MANAGEMENT FOR OLED ON FOIL APPLICATIONS





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Process flow

1. Al-PET-Al laminate

2. Structuring Al

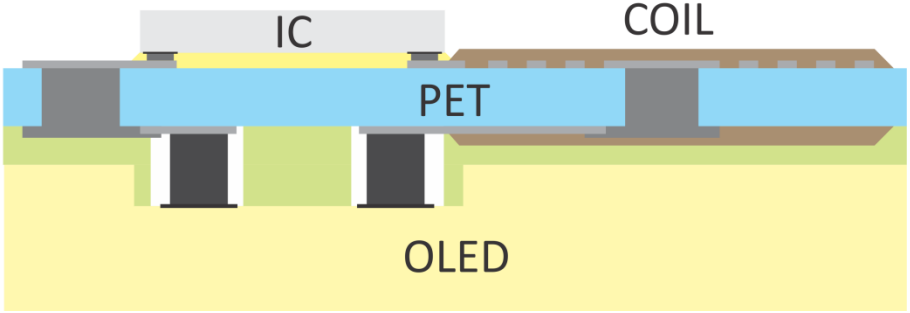
3. Via drilling

4. Via filling

5. Ferrite printing

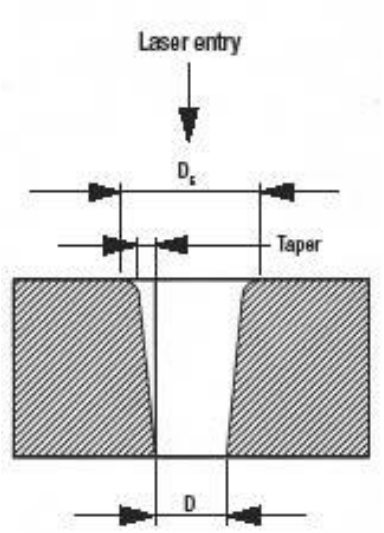
6. Chip mounting

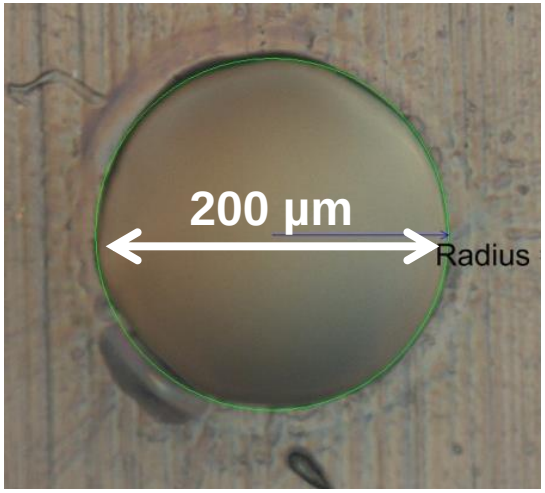
7. OLED mounting

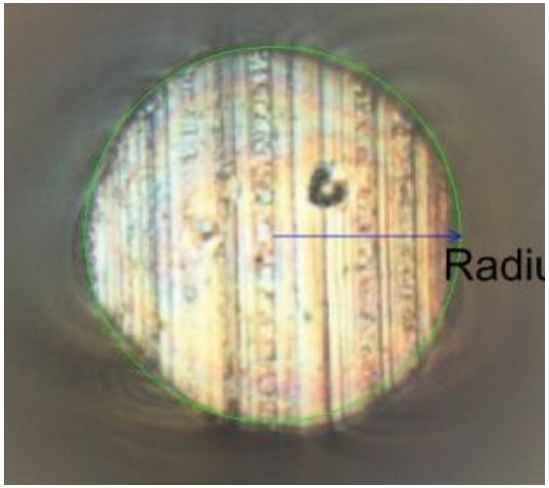


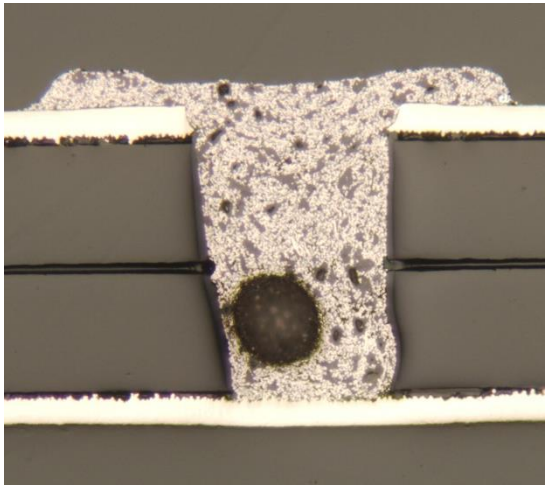
Via drilling

- Via drilling by laser
  - Aluminum is used as hard mask for CO_2 laser drilling
  - Additional UV laser desmear after CO_2 drilling
  - Optimize via tapering for filling process
  - Design compensation to match foil deformation



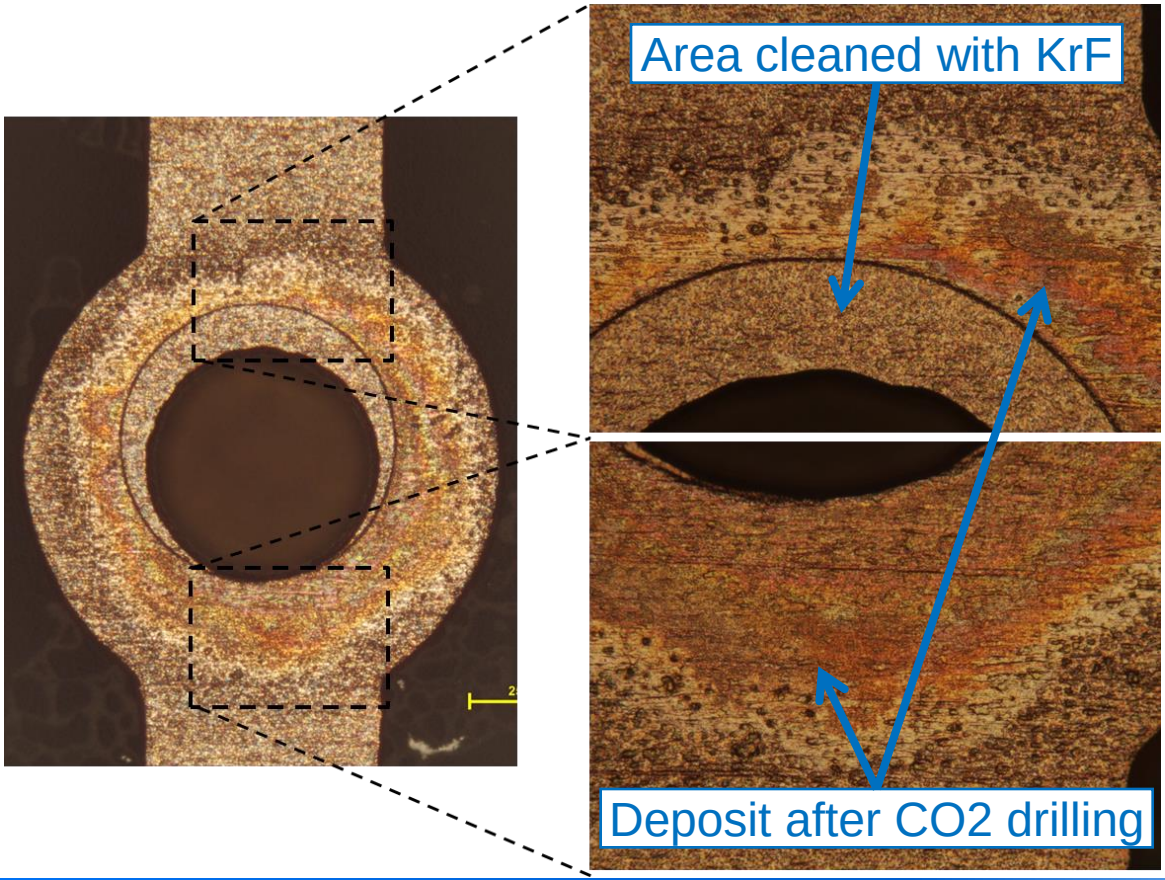


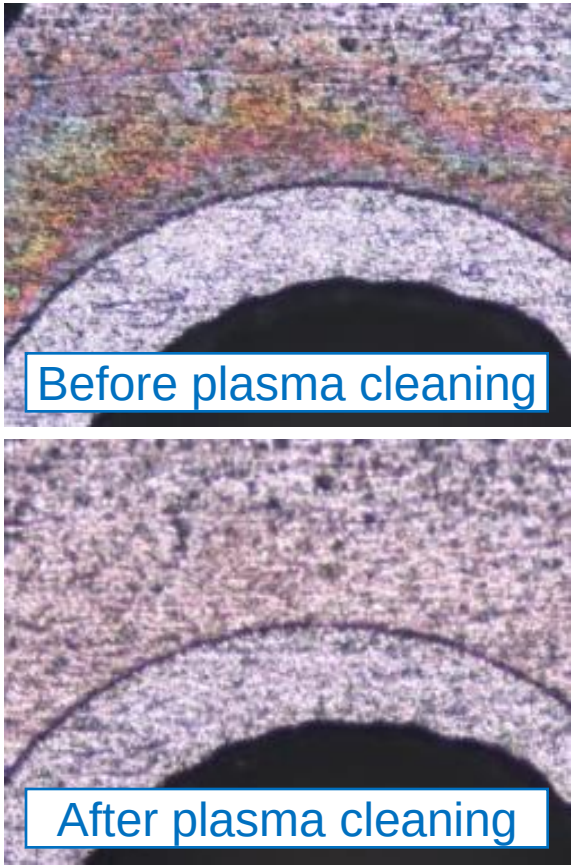




Via drilling

- Desmear after CO_2 drilling
  - Pulsed KrF laser desmear
  - Oxigen plasma desmear

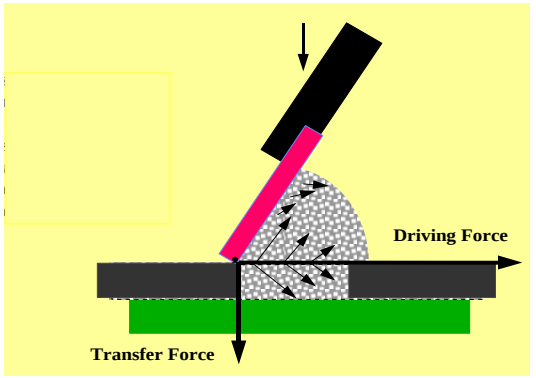


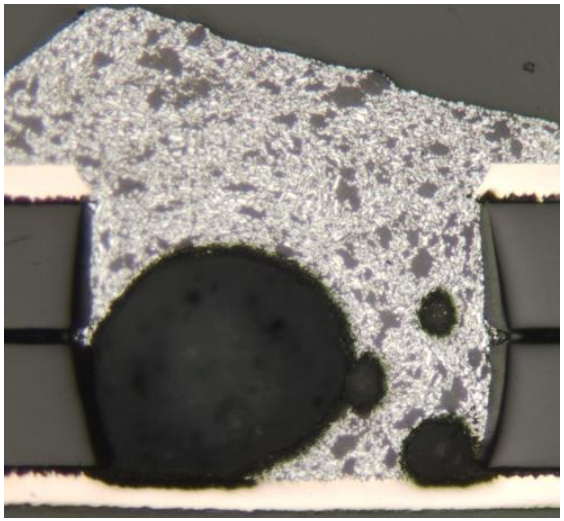


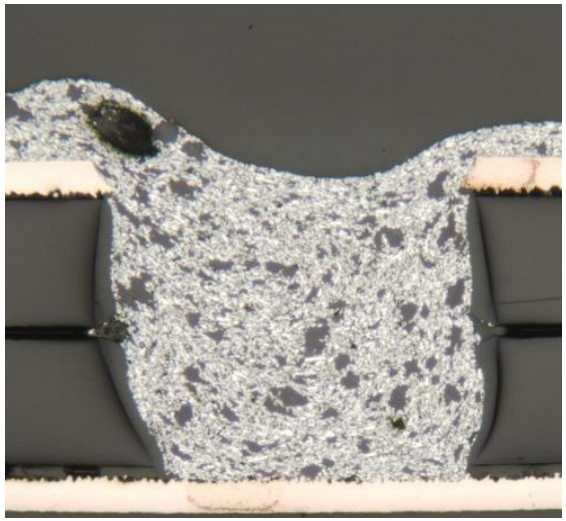
Via filling

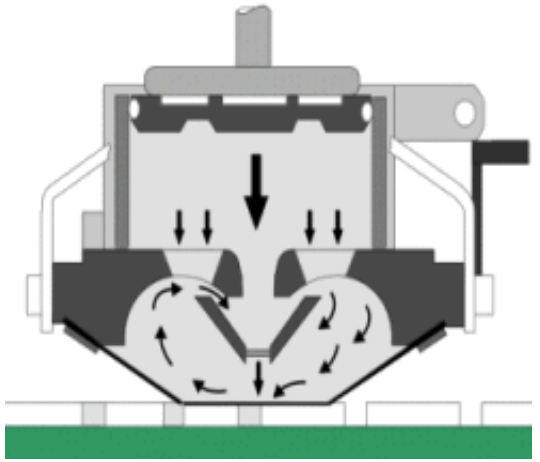
- Via filling by stencil printing
  - Enclosed print head (Dek ProFlow) for high-aspect ratio via filling
  - Design of experiment on Cu-PET-Cu with CE 3103 WLV
    - Minimize entrapped air bubbles
    - Improve contact between ICA and copper
  - Results
    - Single print stroke with medium speed
    - High ProFlow head pressure

Squeegee





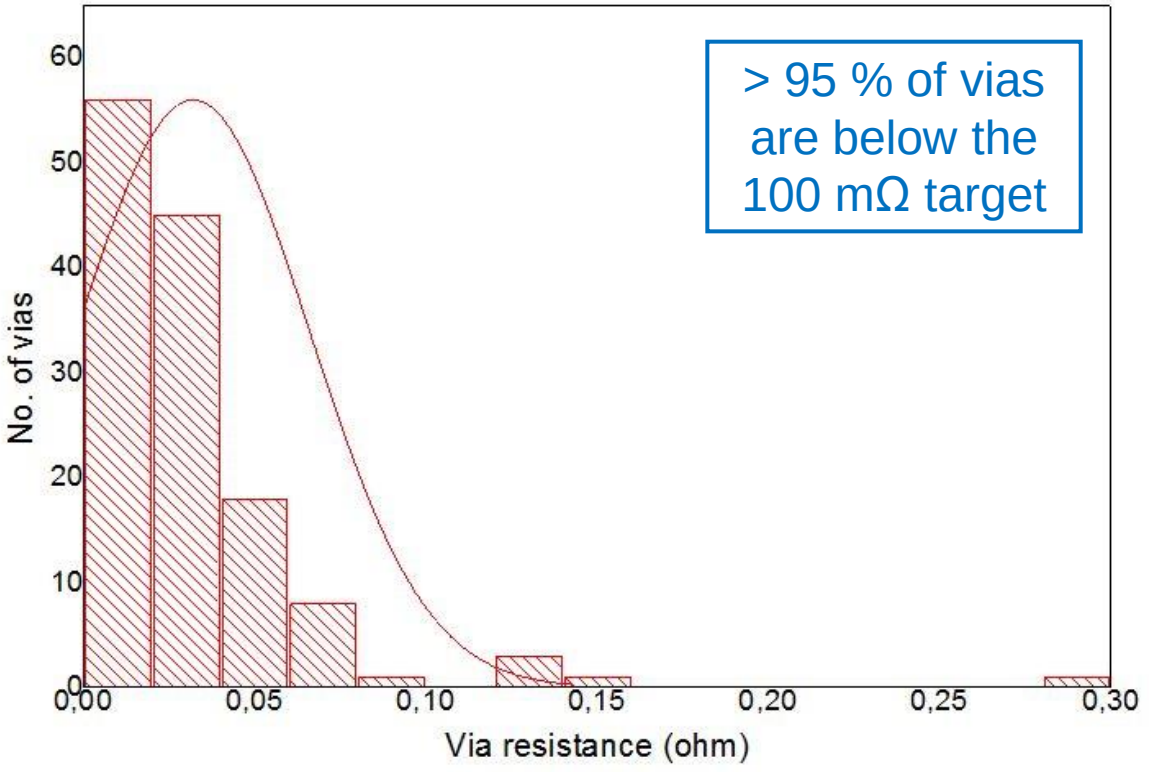




ProFlow

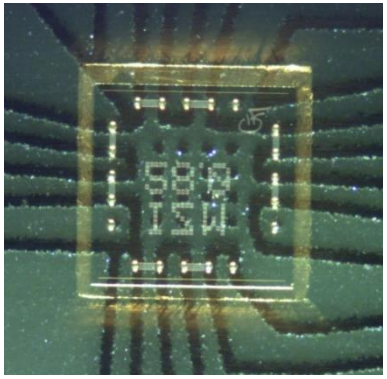
Via filling

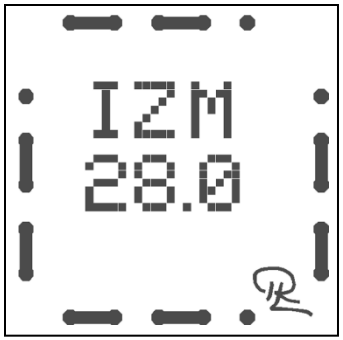
- Via filling by stencil printing
  - Histogram of via resistance (Ω) for 135 vias (9 samples over two printing runs) with an aspect ratio of 4:5 (350 µm depth and 450 µm diameter)

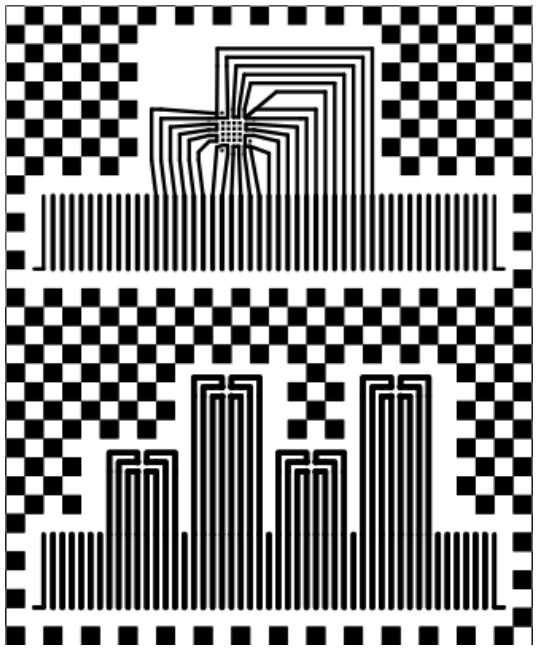


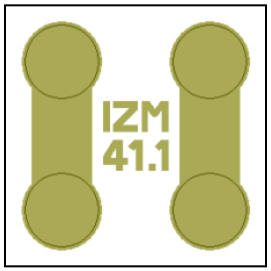
Chip mounting

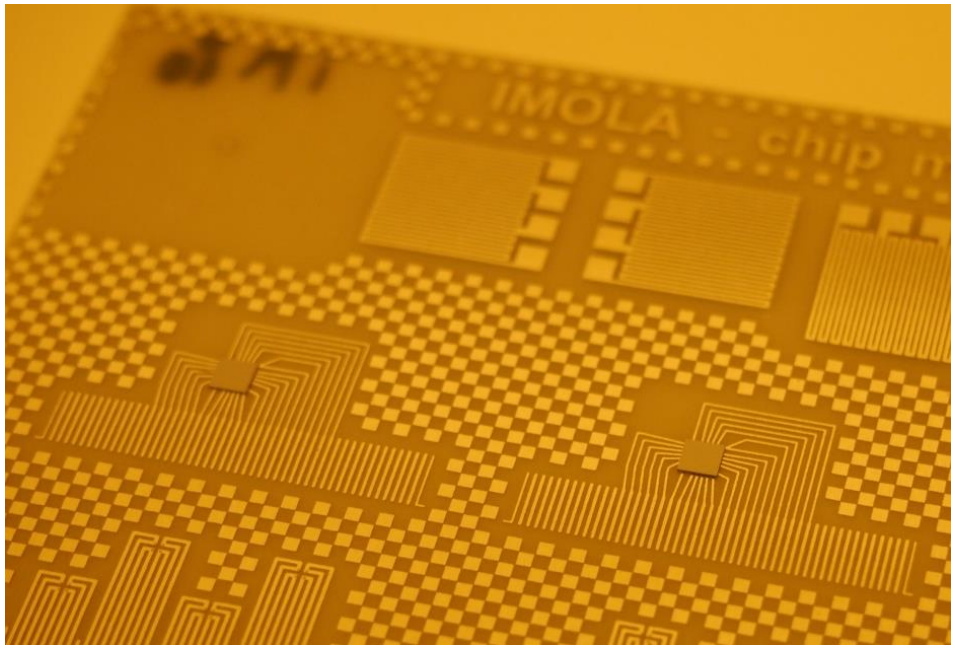
- Flip-chip mounting using stencil printed ICA bumps
  - Two test chips
    - IZM28 (2.5 mm x 2.5 mm, 300 µm pitch, 20 contacts)
    - IZM41 (0.9 mm x 0.9 mm, 500 µm pitch, 4 contacts)
  - Bonding parameters: 3 min @ 180 °C and 0.5 N pressure
  - Small contact pads on IZM28 incompatible with ICA printing











Chip mounting

- Flip-chip mounting using stencil printed ICA bumps
  - Low and reproducible resistance on PET-Cu
  - Large variation in contact resistance on PET-Al

COPPER

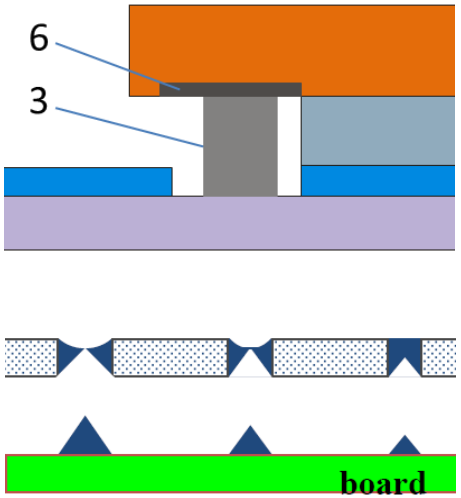
1		2		3		4	
A	B	A	B	A	B	A	B
62,2	67,4	61,5	61,8	71,5	59,7	67,4	59,2
62,2	67,4	61,5	61,8	71,5	59,7	67,5	59,2
57,5	63,9	61,1	55,9	57,5	60,2	61,1	58,5
57,5	63,9	61,1	55,9	57,5	60,2	61,1	58,5

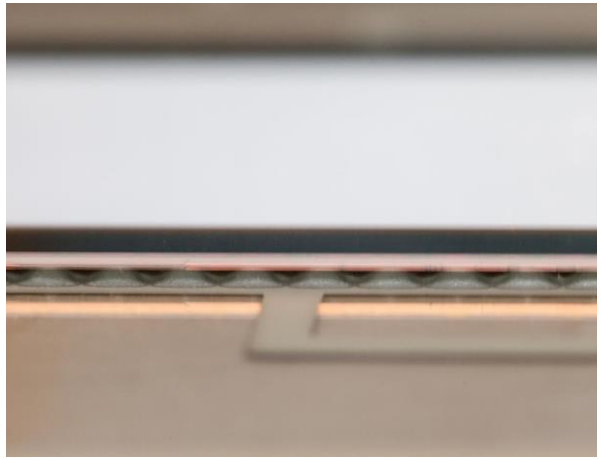
ALUMINIUM

1		2		3		4	
A	B	A	B	A	B	A	B
295,7	5000	89,5	672,1	110,9	1214	1718	3706
297,4	15700	89,6	675,6	111	1219	1759	3760
12085	9856	97,7	332,9	145,5	503,4	808,1	782,3
11900	10170	97,4	330,8	144,9	499,6	807,6	782,4
188,9	784,6	1232	755,3	238,9	799,6	306,2	464,5
190,3	791,5	1297	758	241,6	802,6	307,3	465,1
279,6	1866	1002	15000	291,4	614	91,8	11065
278,9	1866	1002	50000	289,4	611,7	91,8	10900

OLED mounting

- Structural film adhesive combined with printed ICA bumps
  - Very high bumps required to bridge glass encapsulation
  - Even distribution of OLED contacts for optical uniformity
  - Pre-structured film adhesive applied to backplane before printing
  - Dek PumpPrint technology for printing >1.5 mm high bumps
  - Optimized stencil design and print process make it possible to reliably print pyramidal dots with a 1:2 aspect ratio
  - Higher aspect ratios are possible with optimized material





Increased flexibility - OLEDs

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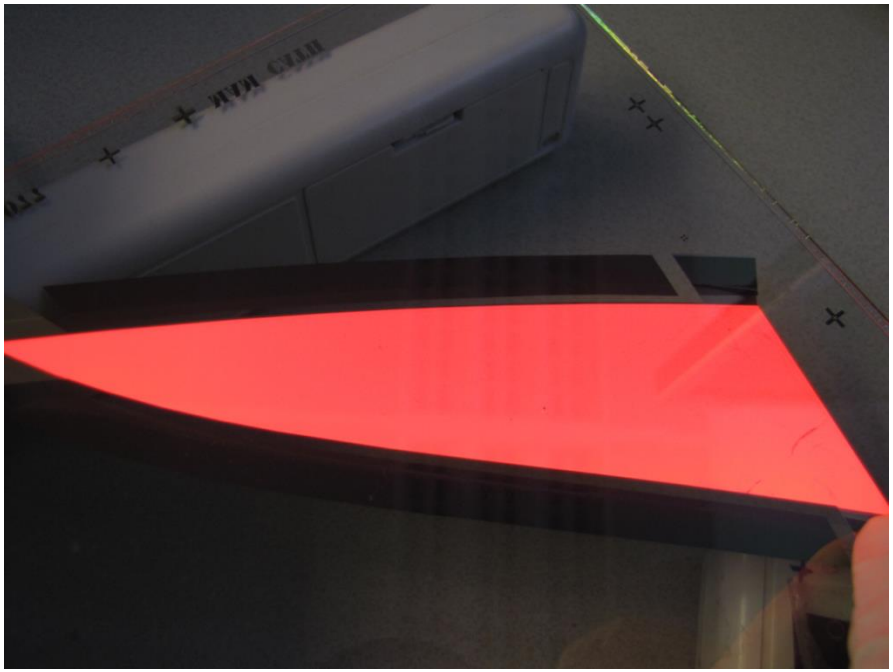
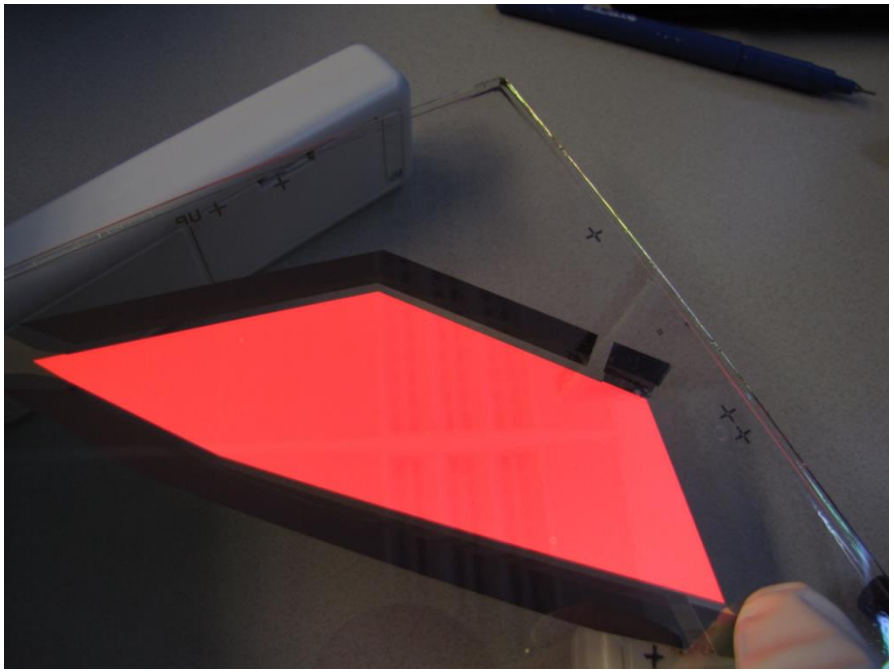
- Flexible OLED technology (Holst Centre)
  - Bottom emission type, fabricated on PEN foil
  - Efficiency of up to 47 lumens per watt (white light)
  - SiN-OCP-SiN barrier stacks (Holst Centre IP) on cathode and anode sides
  - Customized design for IMOLA applications





Increased flexibility - OLEDs

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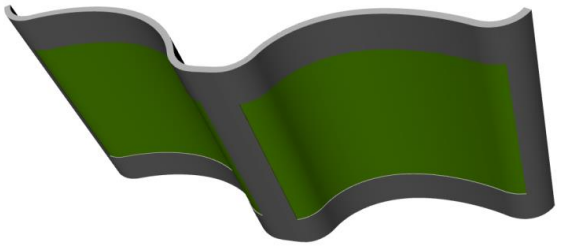
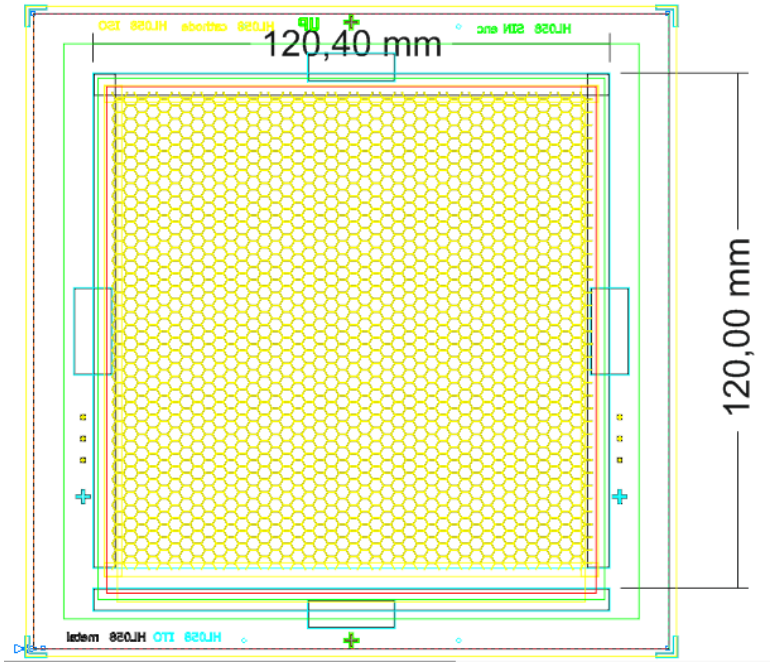
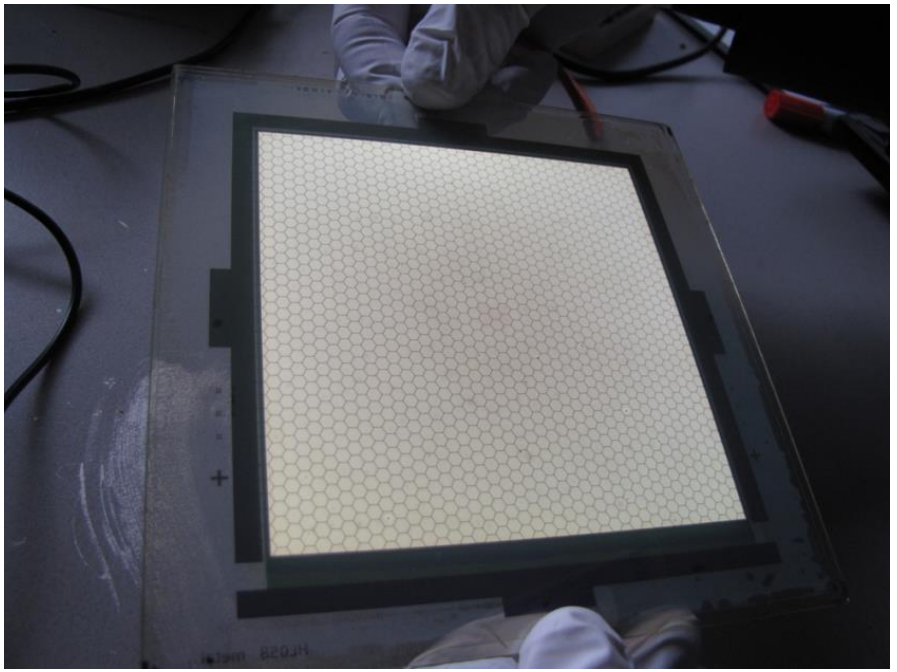
- Flexible OLED technology (Holst Centre)
  - Honeycomb shunt lines for uniform current distribution over large area (> 10 cm x 10 cm)



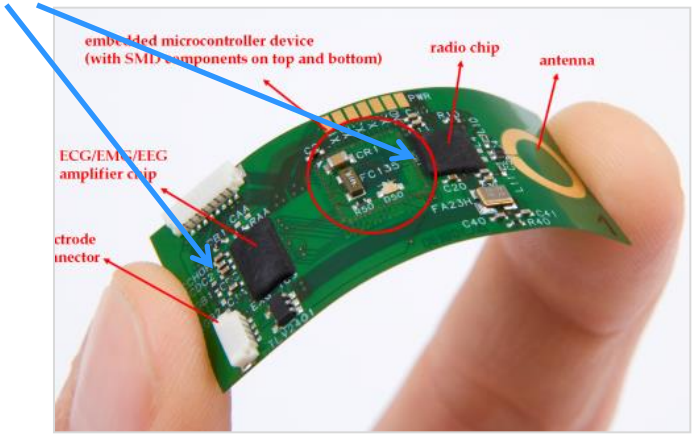




Increased flexibility - UTCP

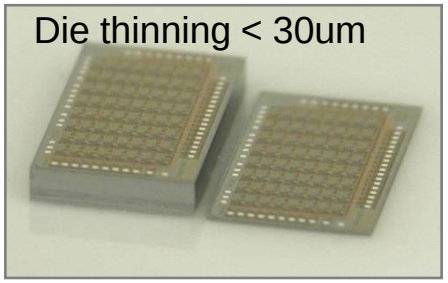
Once the backplane is flexible ….

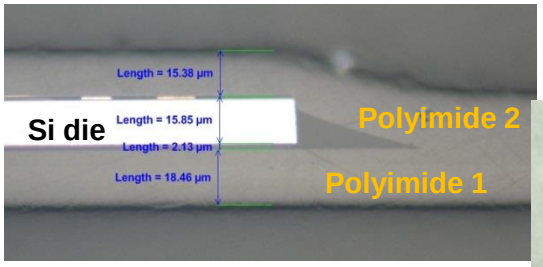
… flexibility is limited by the rigid components

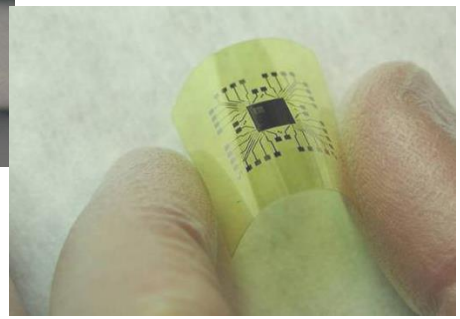


A solution :

- Thin down chips, down to foil-thickness
  (± 30 µm, by grinding)



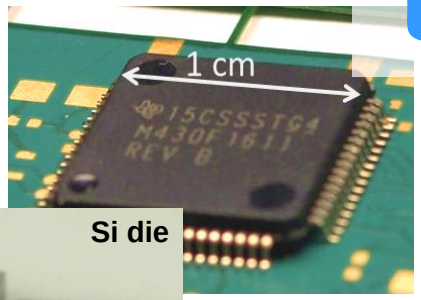


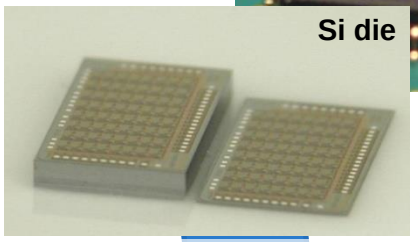


- Make a flexible interposer
  (e.g. based on polyimide)
- Embeddable in or on the flexible backplane

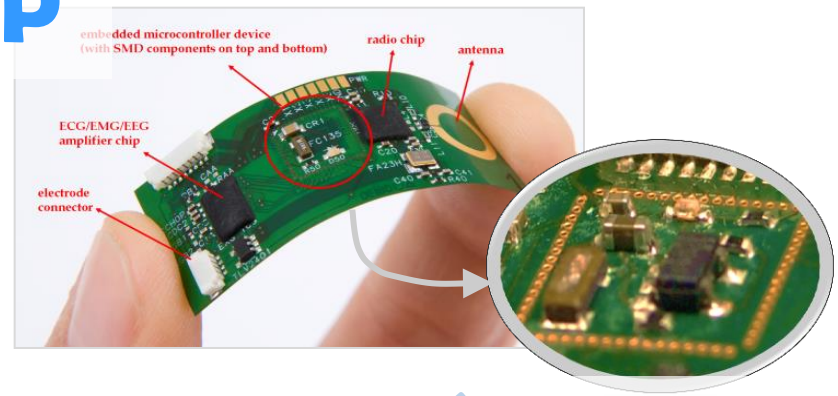
Increased flexibility - UTCP

UTCP

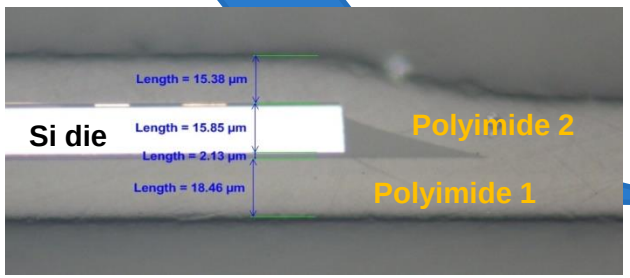




- Small I/O pitch (< 100µm)
- 300-700 µm thickness



- PCB I/O pitch (~ 500µm)
- Flexible



- UTCP interposer
- Flexible
- Known-Good-Package
- 60-80 µm thickness

Increased flexibility - UTCP

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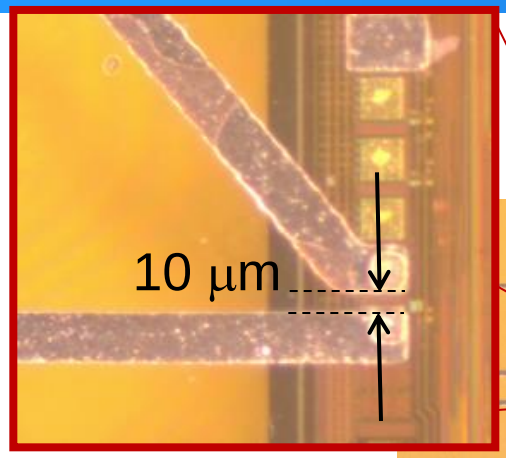

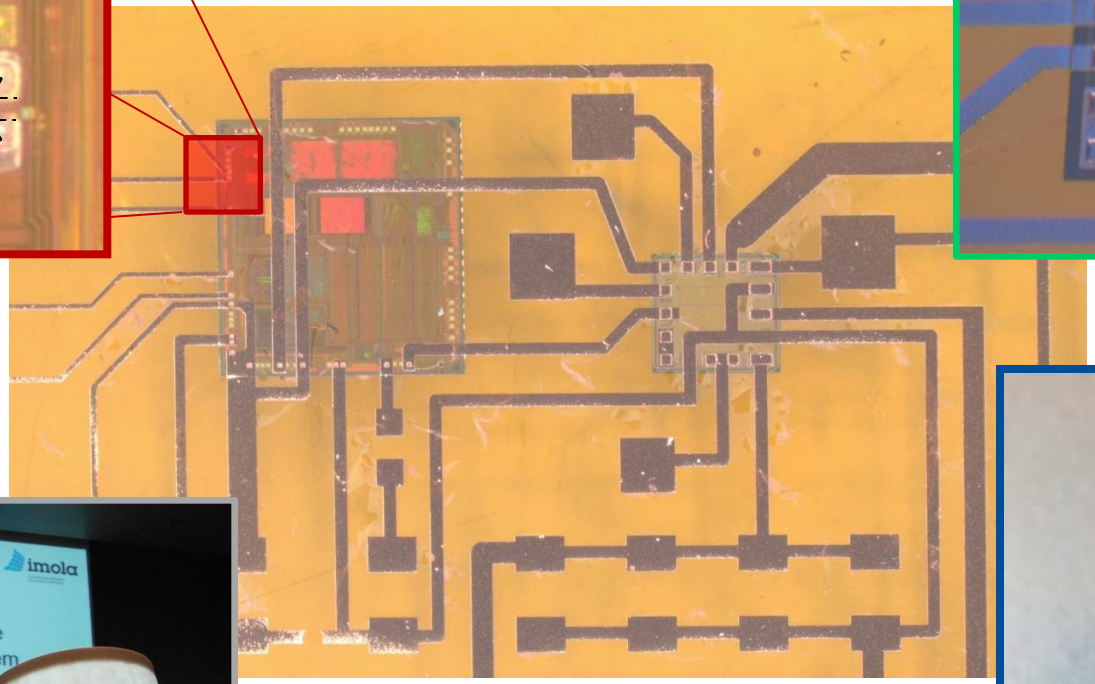

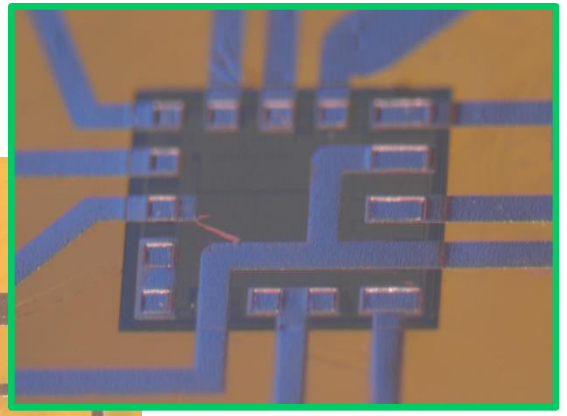

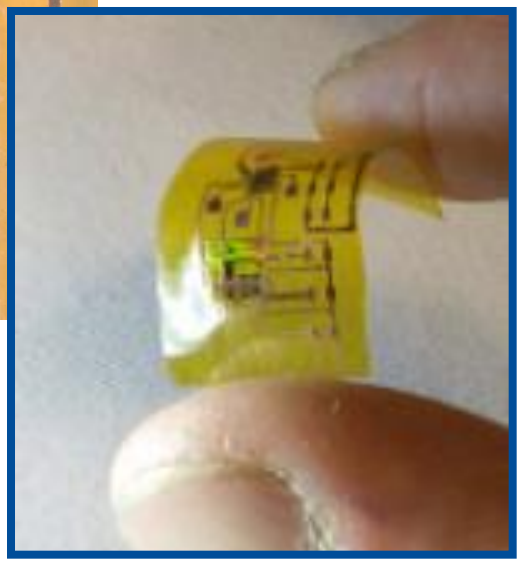

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Conclusion

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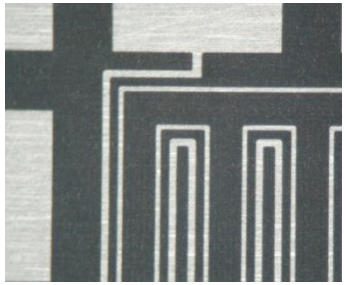
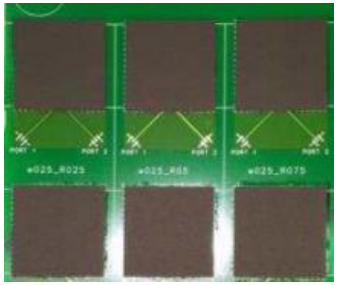
INTELLIGENT LIGHT MANAGEMENT FOR OLED ON FOIL APPLICATIONS

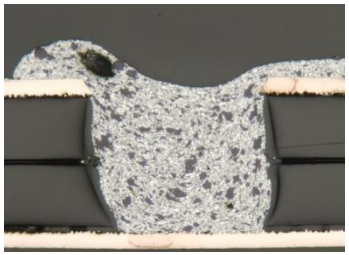
Al etching

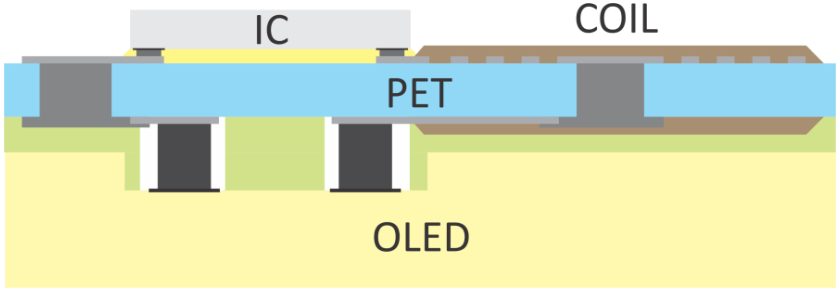


Ferrite printing

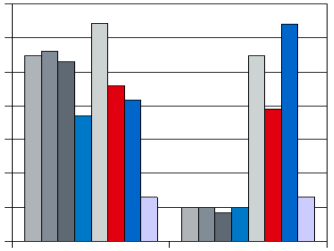


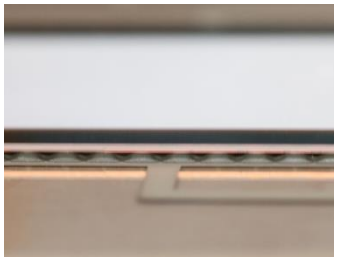
Via filling



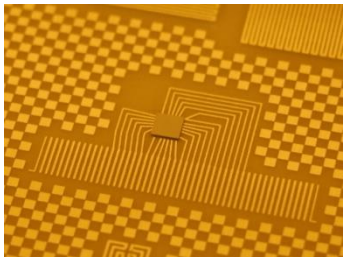


Adhesive selection





OLED mounting



Chip mounting

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