Mass transfer with elastomer stamps for microLED displays.

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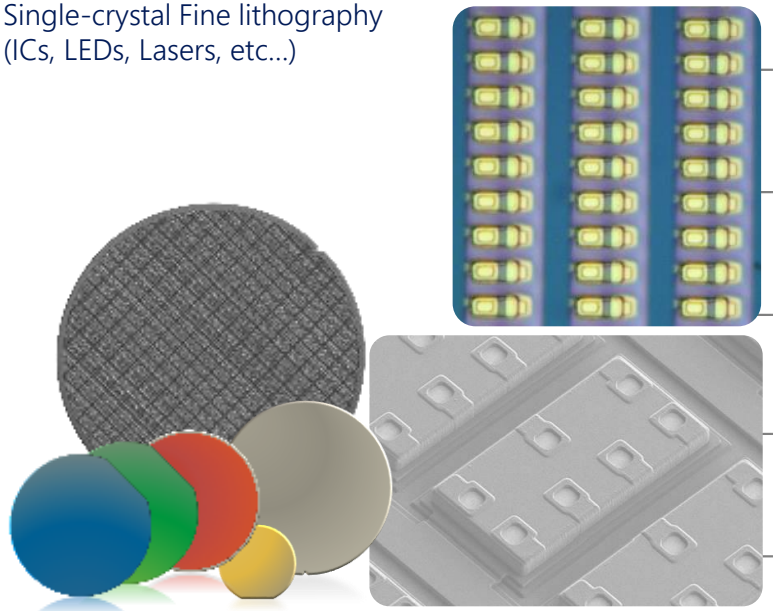
The best materials for the best displays

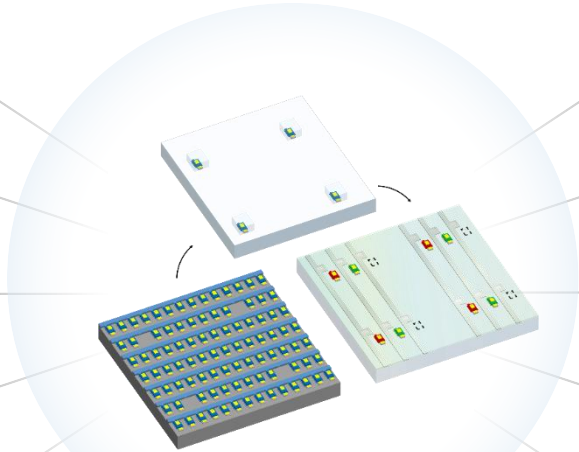
The materials identify the display. The best displays will use the best materials.

Brightest, fastest, most efficient, extra-functional, multi-sensory, computational “systems on a panel”.

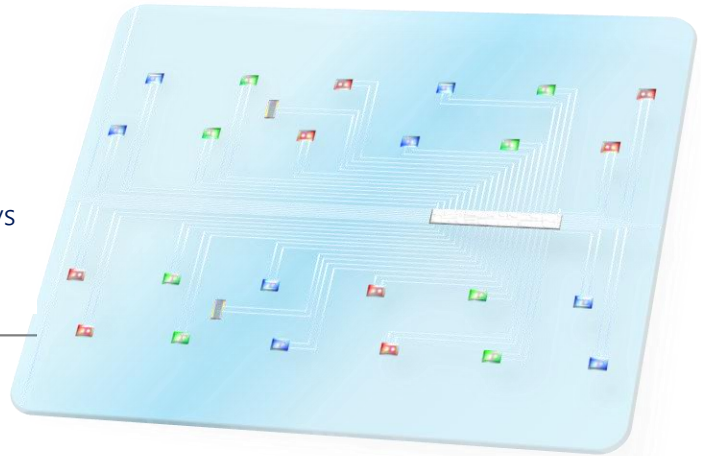
Bridging the gap between wafer and panel is the way to get the best displays.

Wafer Fabricated Devices
Single-crystal Fine lithography
(ICs, LEDs, Lasers, etc…)



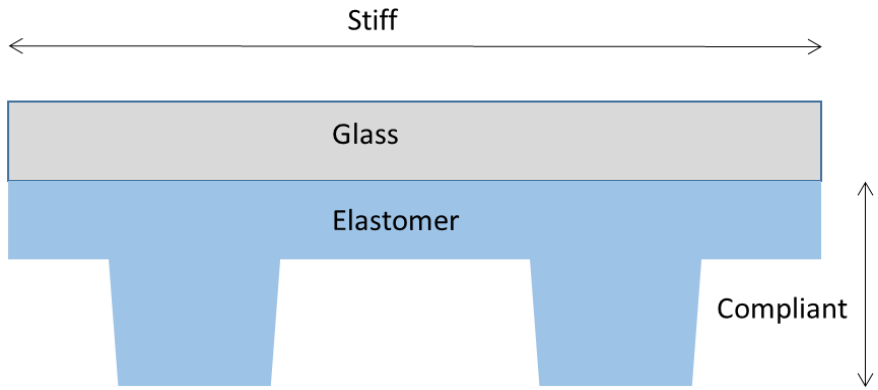


Advanced displays
of all sizes:



The Elastomer Stamp

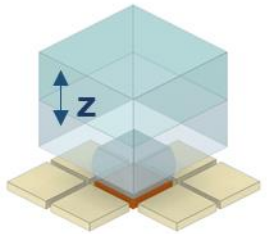
Low-pressure injection molded silicone rubber on glass backing, with lithographically-defined “posts” for selective transfer.



The stamp is…

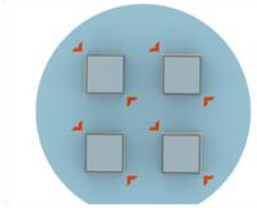
i. …compliant in z…

→ high transfer yield.



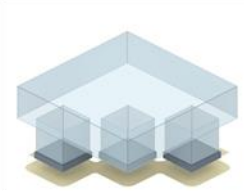
ii. …transparent…

→ high-accuracy placement.



iii. …simple, inexpensive, high-fidelity construction….

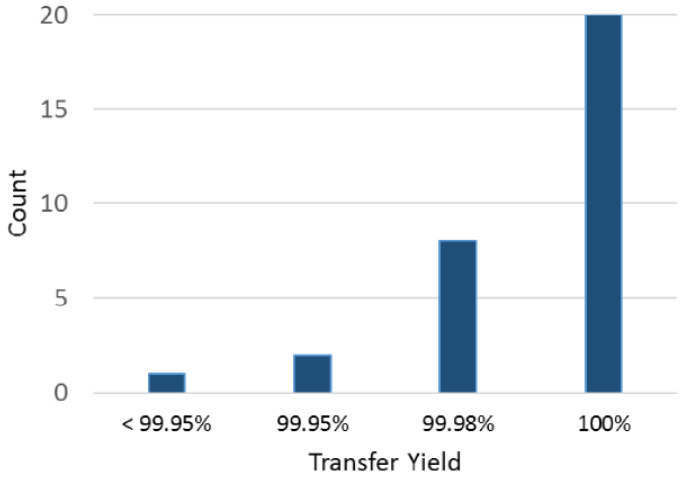
→ scalable, high-throughput

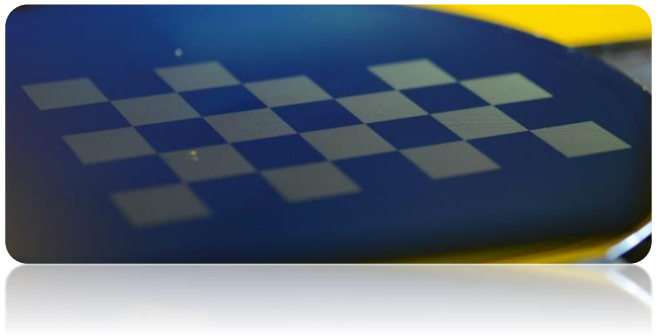


Elastomer stamp capability demonstrations

i. …compliant (forgiving) in z…

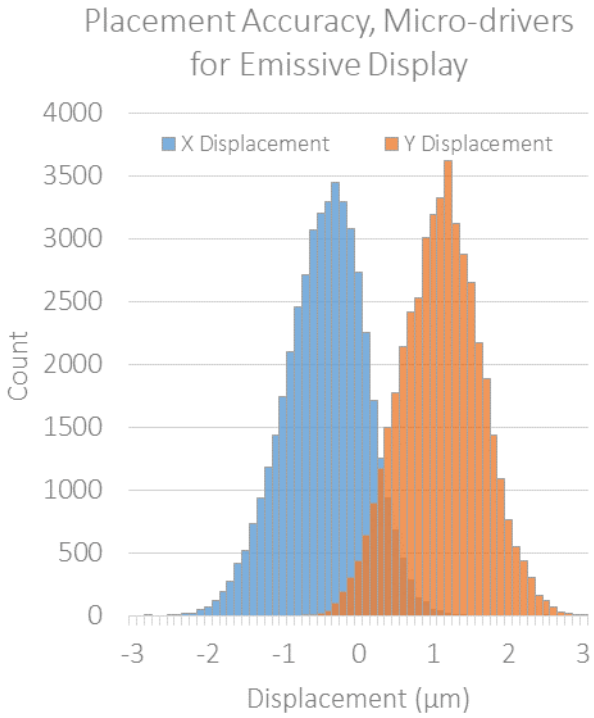
→ high transfer yield.





ii. …transparent

→ high-accuracy placement.

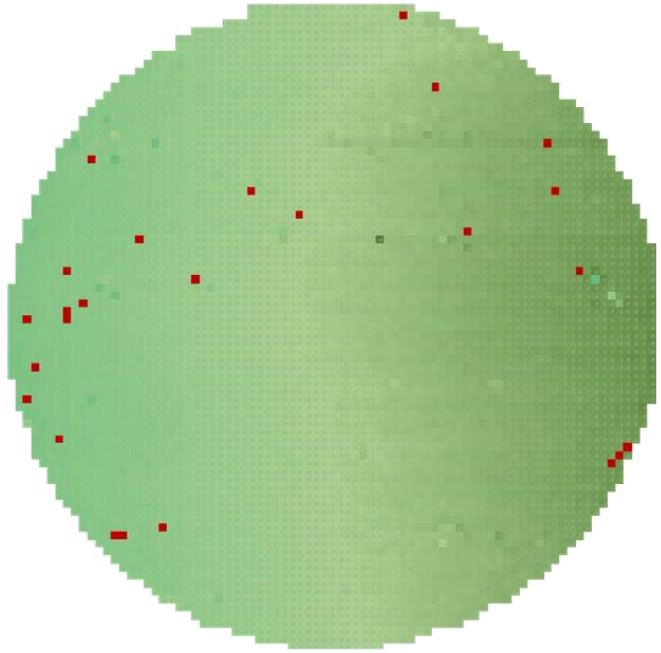


displacement at 3σ: +/- 1.5 µm

iii. …simple, inexpensive, high-fidelity construction….

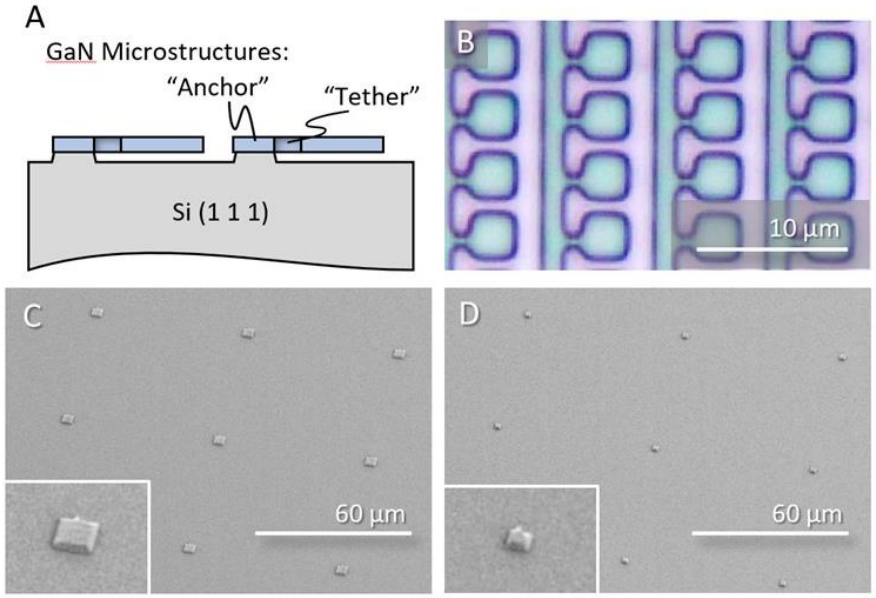
→ scalable, high-throughput

Yield map, 150 mm wafer array transfer:

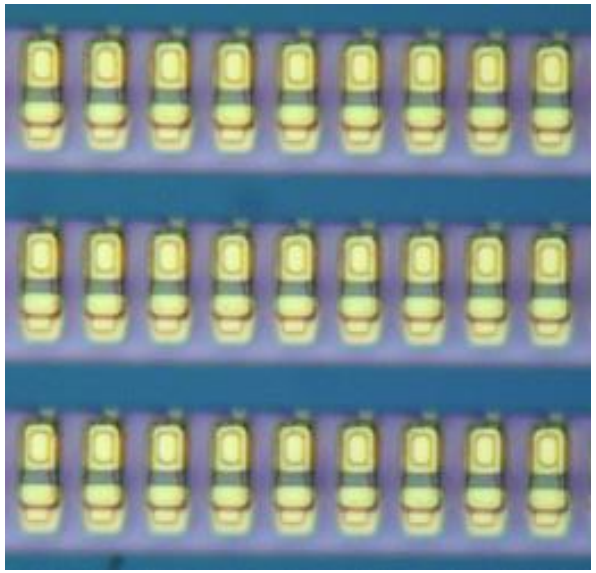


Transferring micron-scale objects with stamp

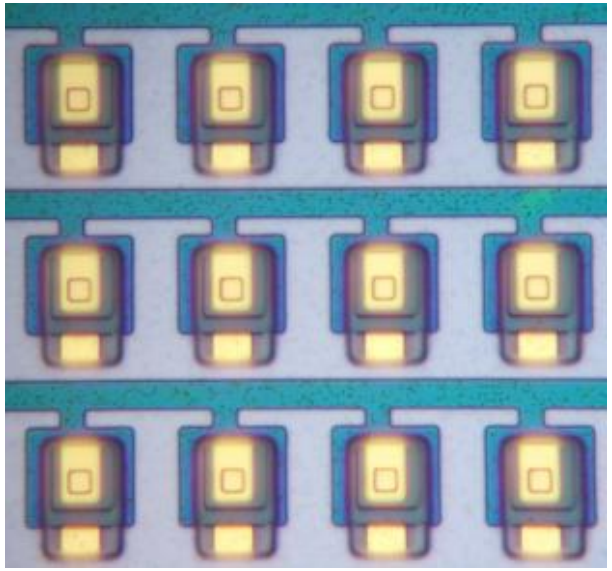
3 µm and 5 µm GaN transferred with stamp:



microLEDs suitable for micro assembly with elastomer stamp:

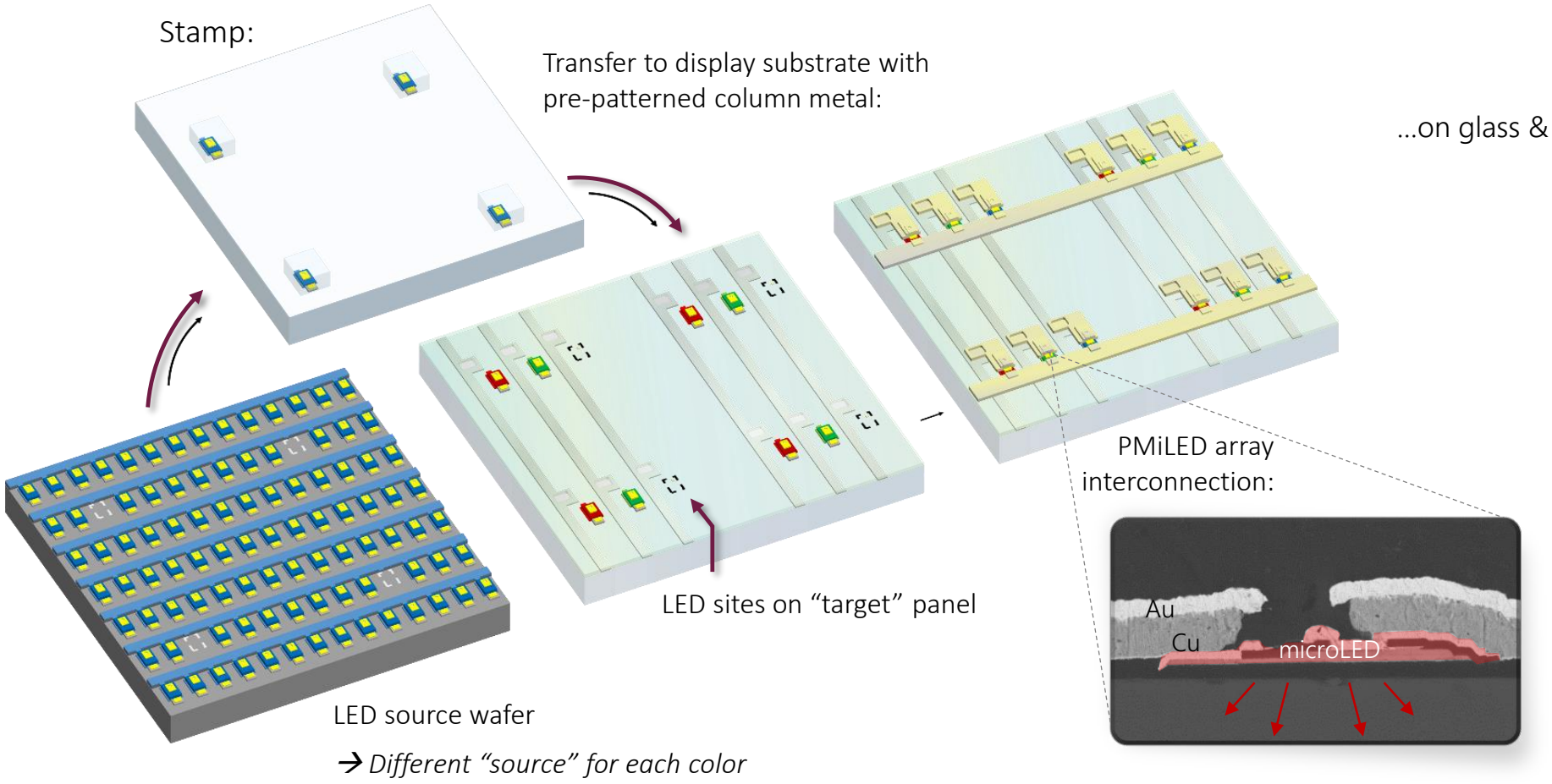


3 x 10 µm^2

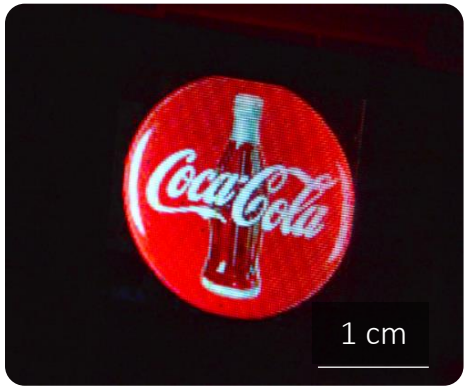


8 x 15 µm^2

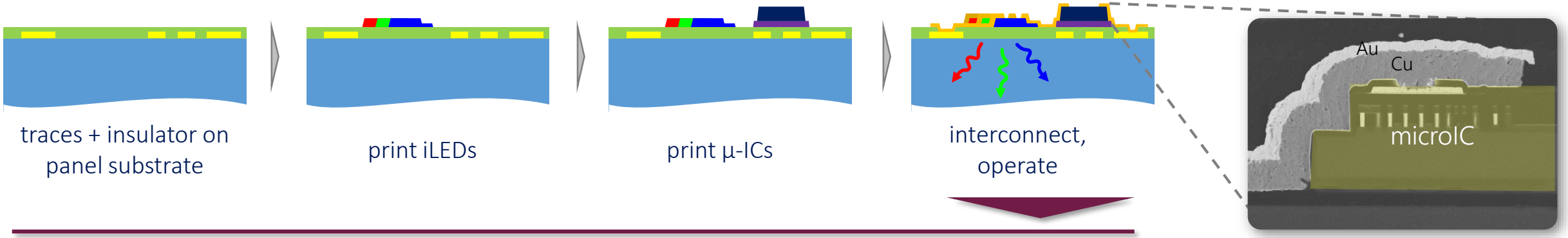
Passive matrix microLED by printing

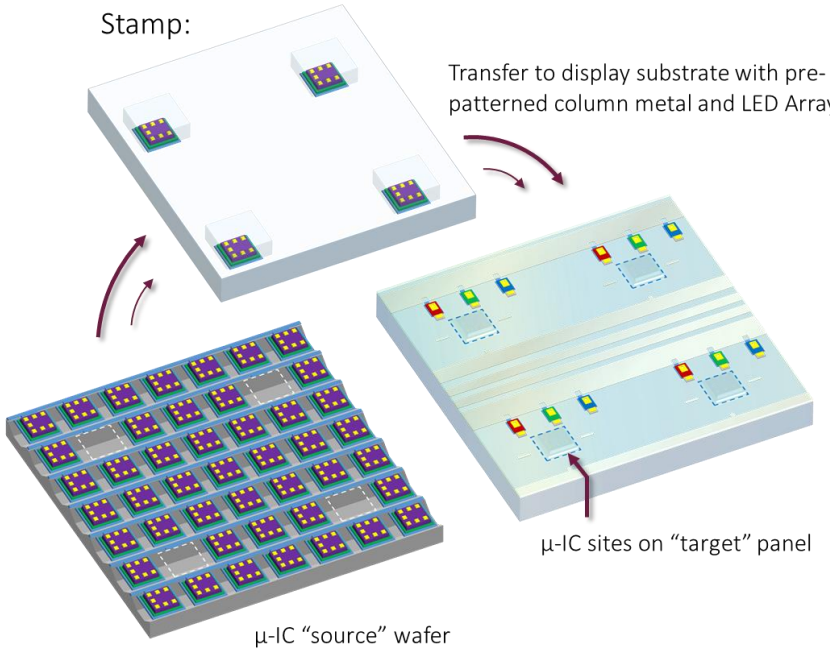


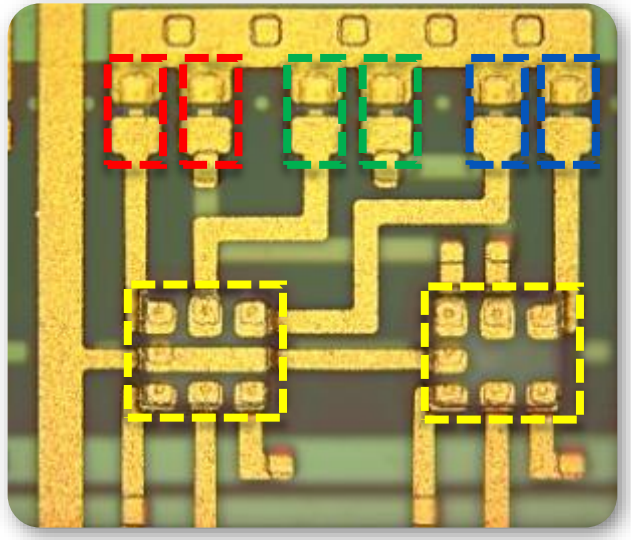
…on glass & plastic:

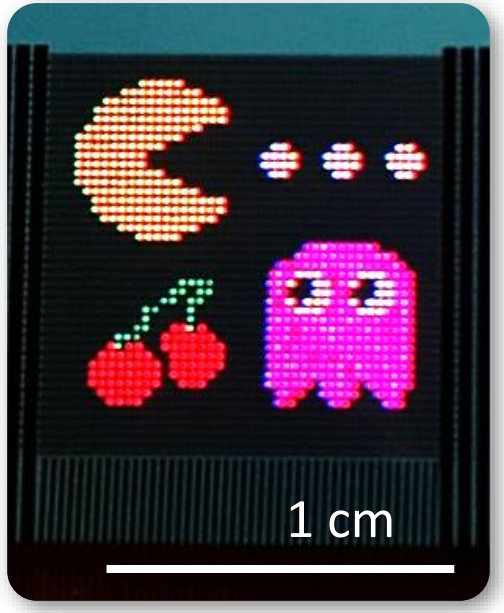


Active matrix microLED



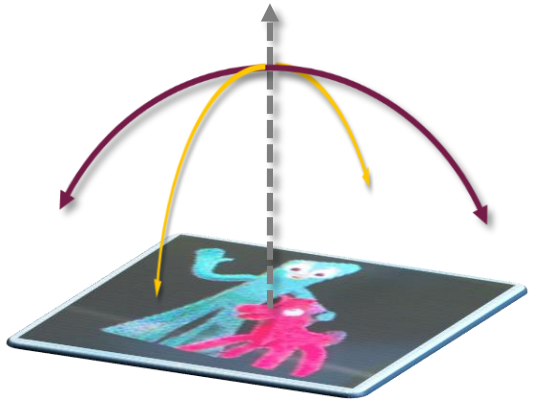


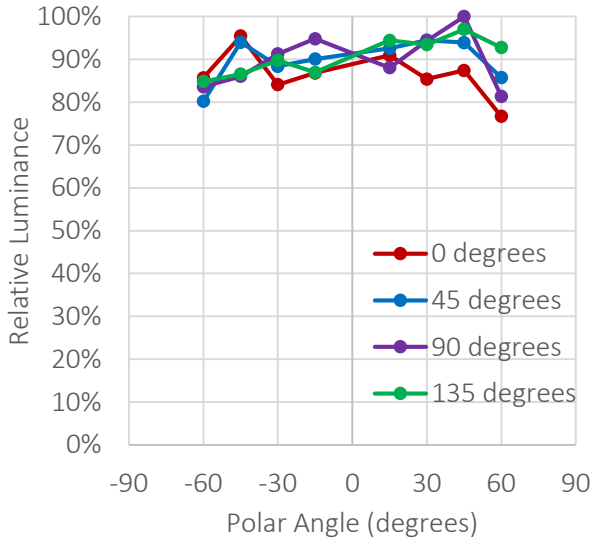




Viewing angle and color

Wide Viewing Angle:

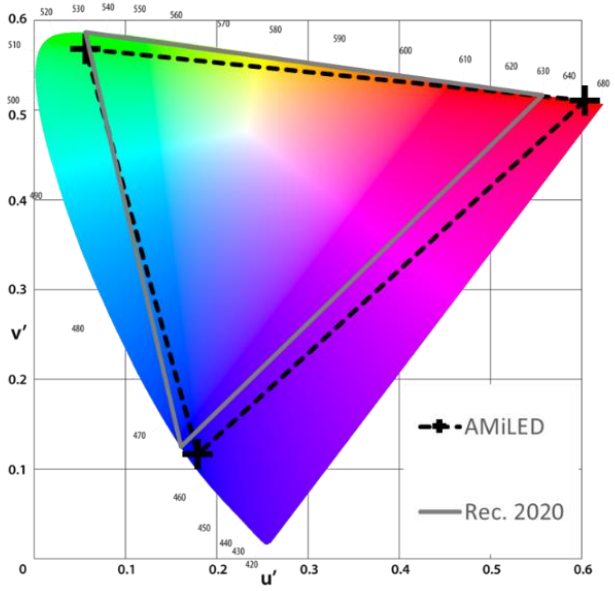


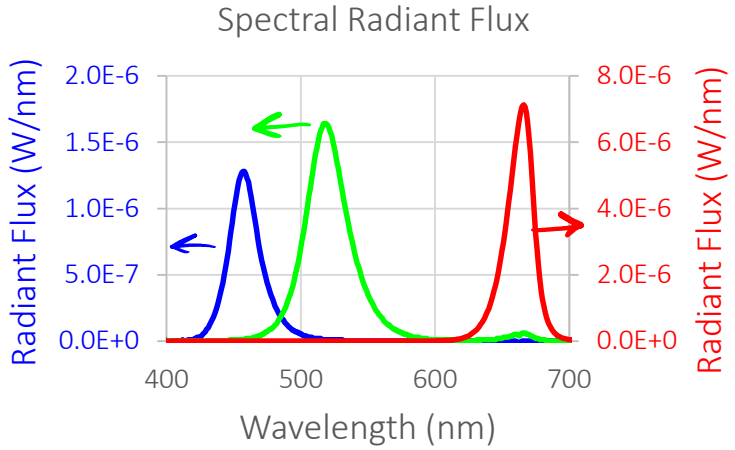


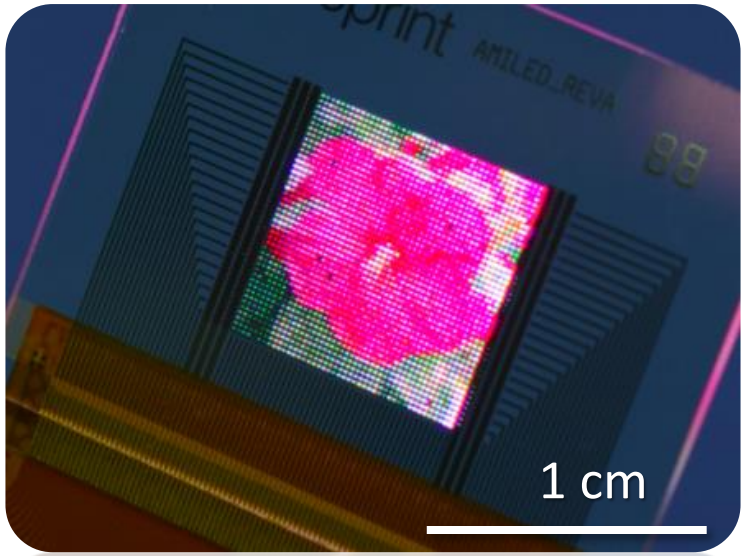
Strong Color Gamut:

Relative to Rec. 2020:

	u' v'	x y
Area	107.1%	90.6%
Overlap	93.3%	84.1%



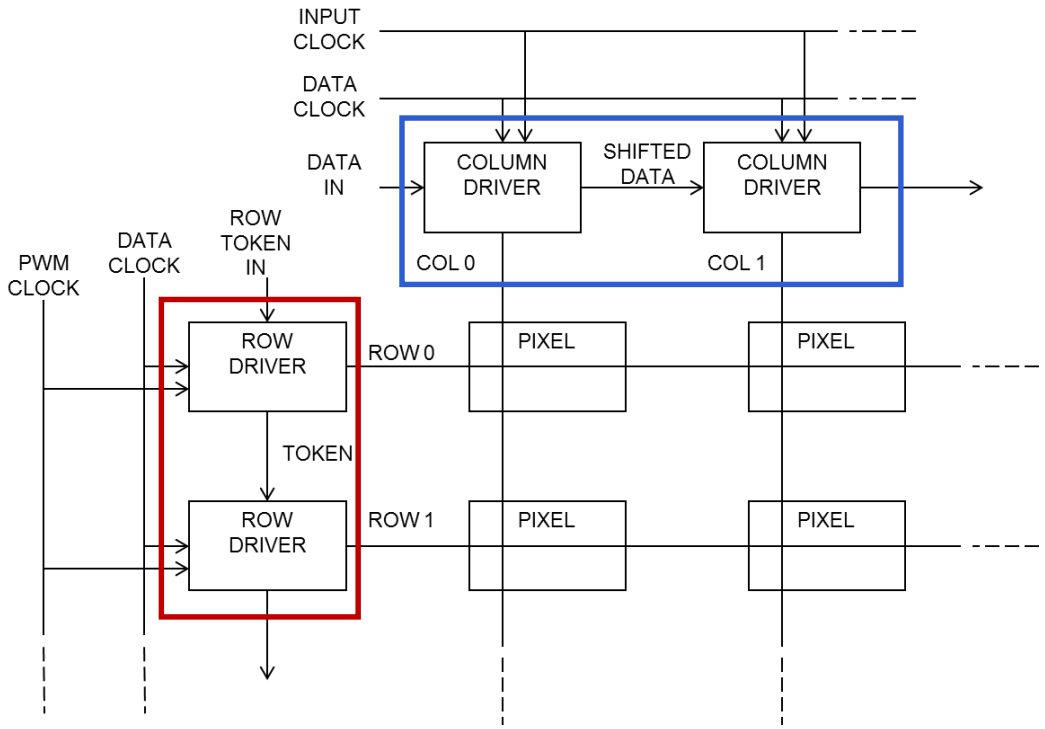




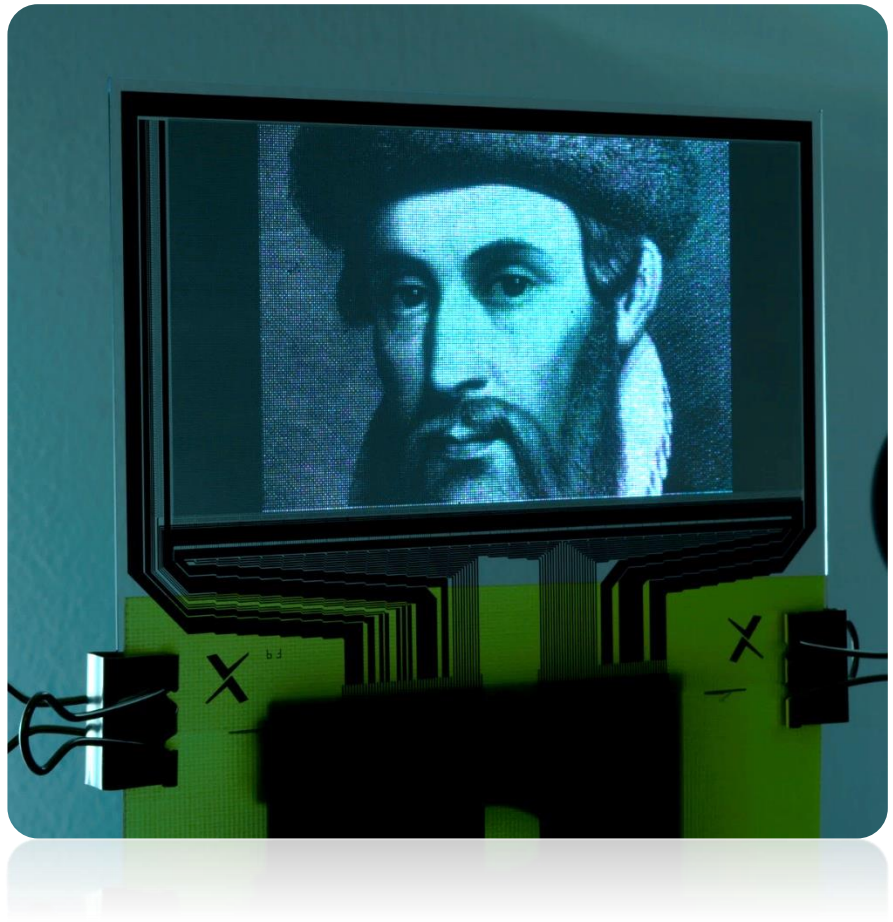
Larger active matrix displays:

Print row drivers and column drivers to reduce external I/O count:

- Column drivers demultiplex data
- Row drivers run progressive scan of data load and PWM

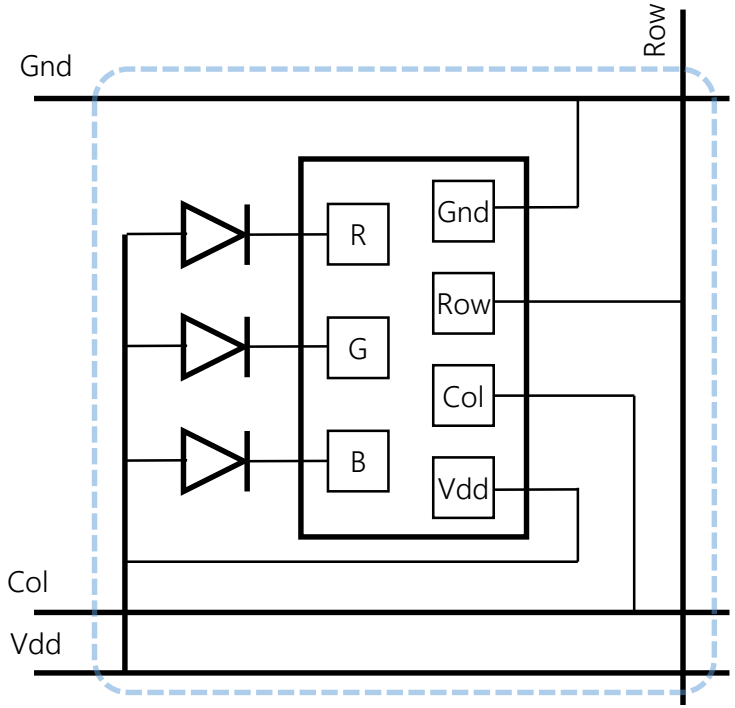


5.1" Diagonal AMILED display 320 x 160, 70 ppi:

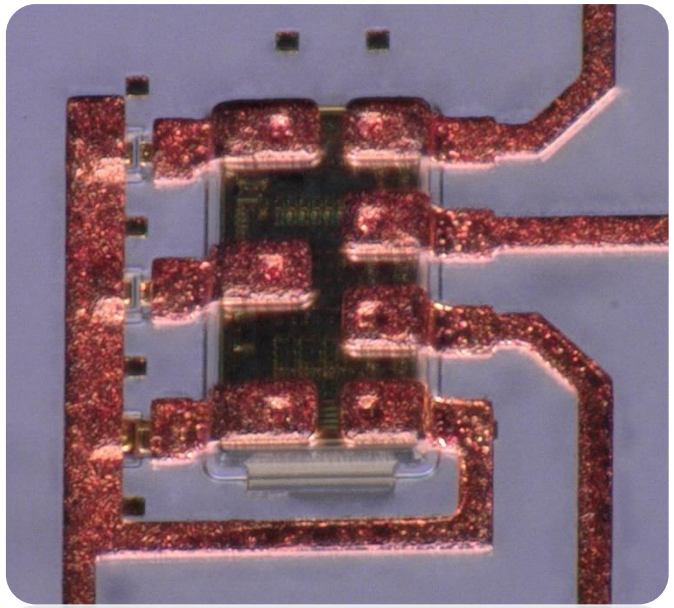


320 x 160 AMILED, 70 ppi

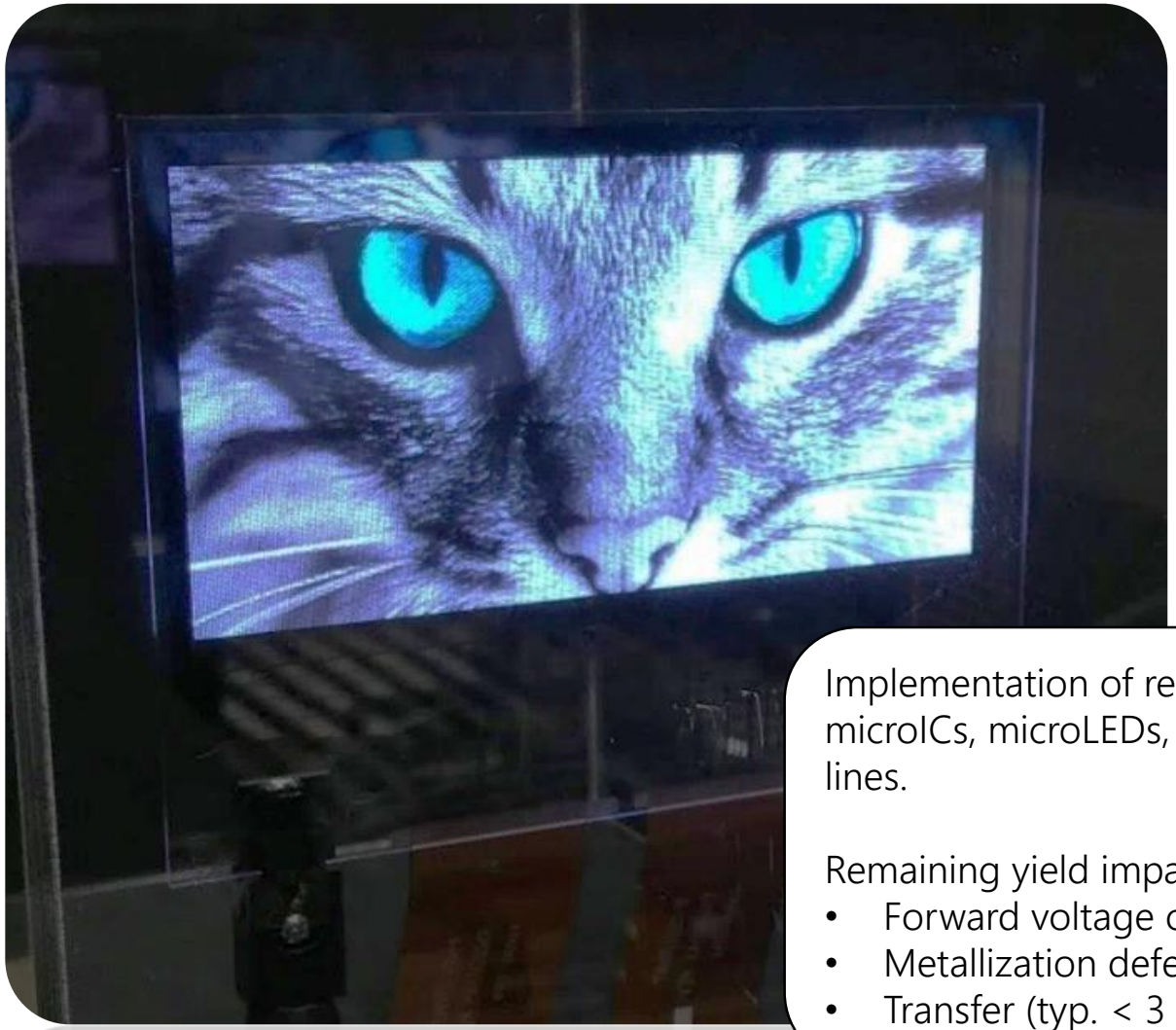
Row, column, power, and ground into each pixel:



Cu redistribution layer interconnects microLEDs, ICs, and row/col drivers (not shown).



Functional Yield of Sub-Pixels in 5.1″ display



Implementation of redundancy in microICs, microLEDs, row & column lines.

Remaining yield impactors:

- Forward voltage of LEDs
- Metallization defects (laser cut)
- Transfer (typ. < 3 sub-pixels)

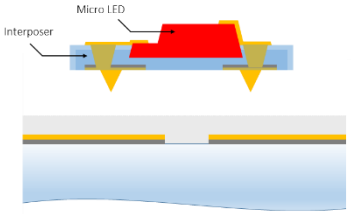
Red: 99.98% (9 dark)

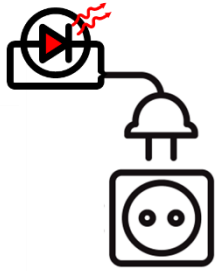
Green: 99.95% (28 dark)

Blue: 99.95% (24 dark)

Display test and additive repair

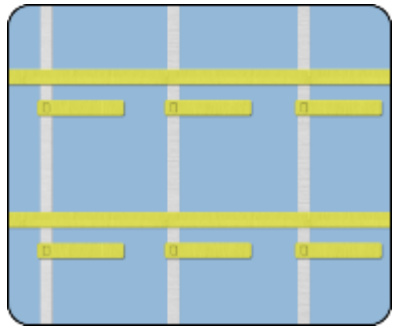
printable components with interconnection structures



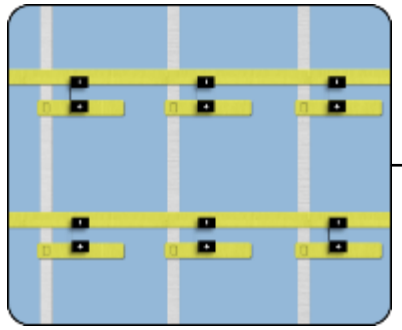


+

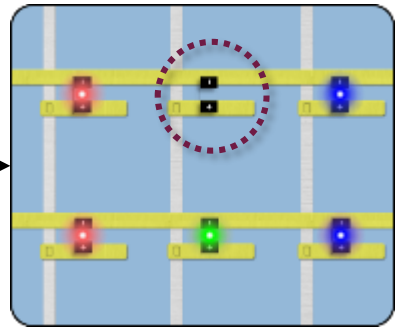
target substrate



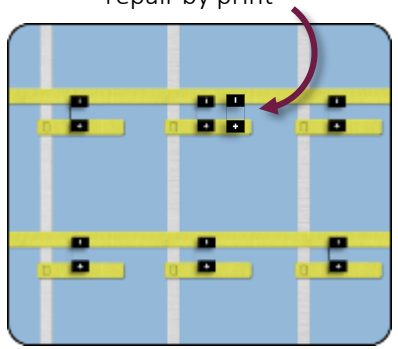
populate target



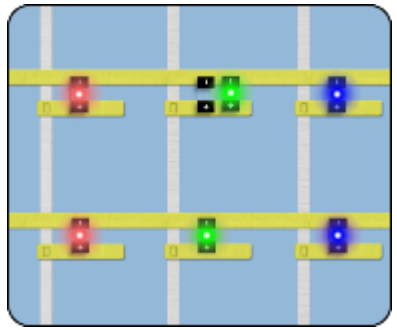
Operate display; identify defects



repair by print

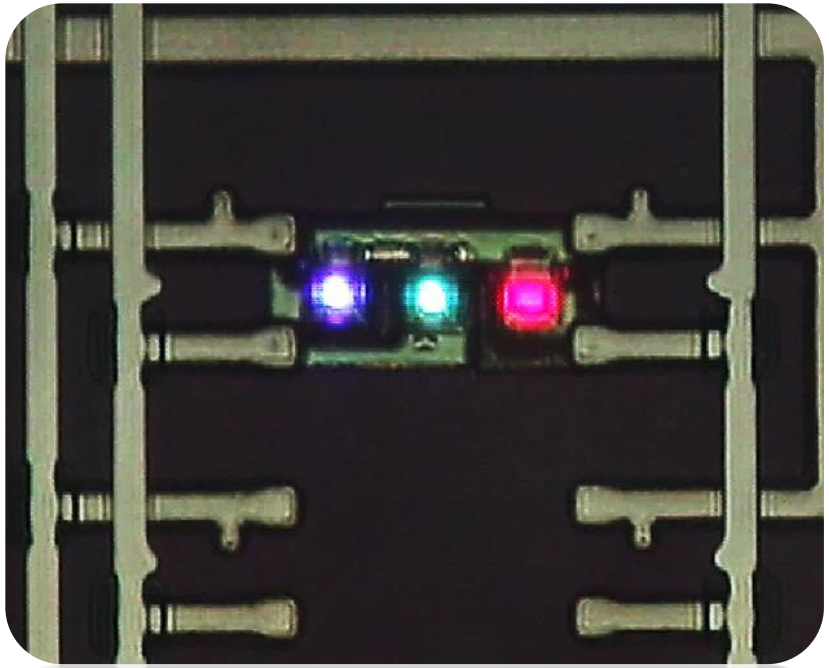


repaired system

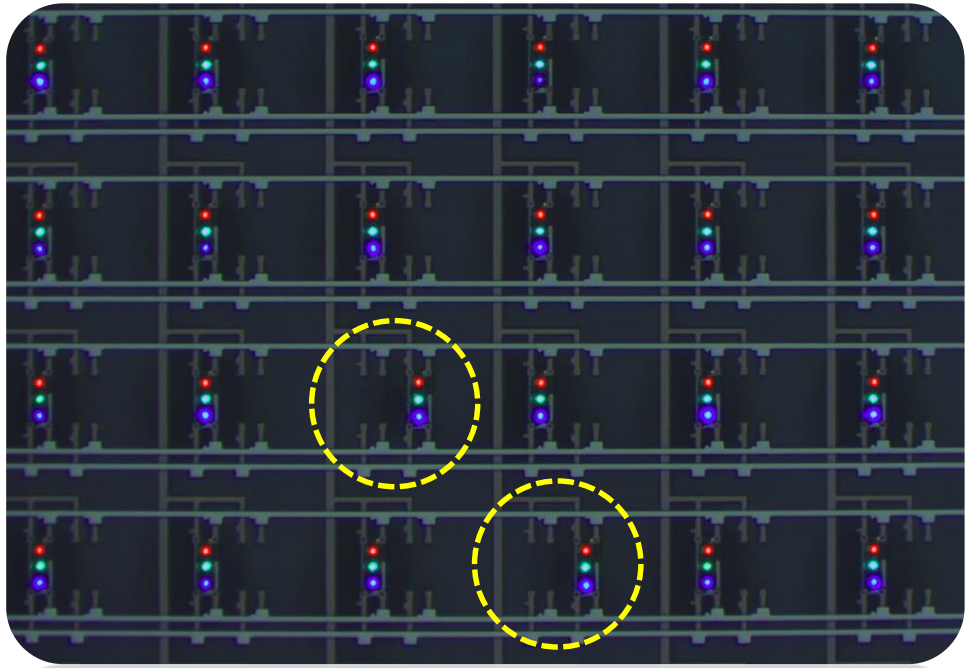


Simple passive matrix display prototype:

Display prototypes by interconnect-at-print with spikes



Looking through substrate, see “divots” produced by spikes contacting metal at four corners of interposer.



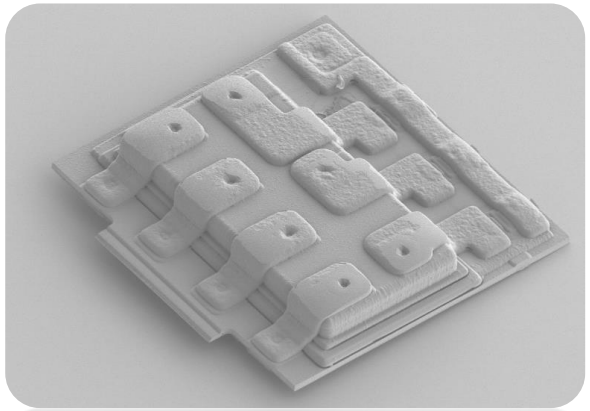
Note repaired pixel on 2nd row from bottom, 3rd column from left: engine printed in redundant site by single-post stamp.

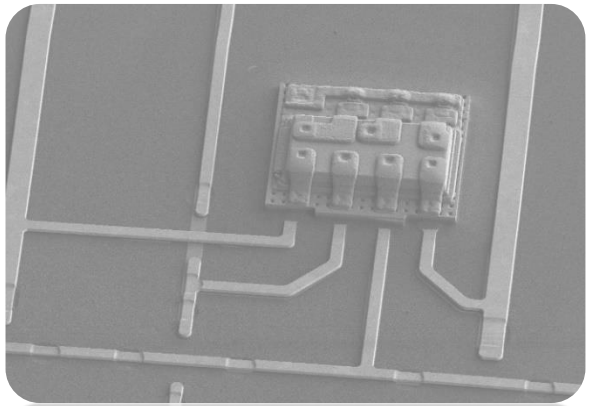
Simple passive matrix display prototype.

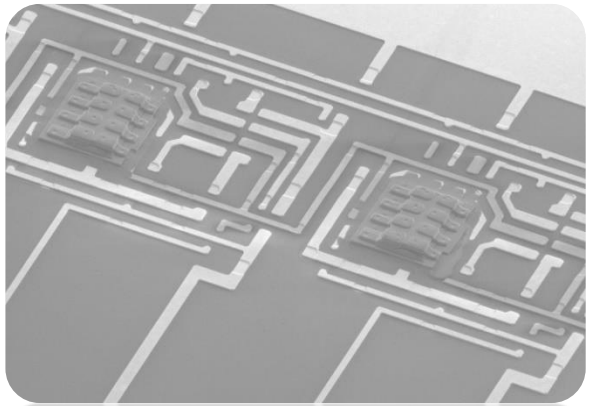
Active matrix “pixel engines” with interconnection structures

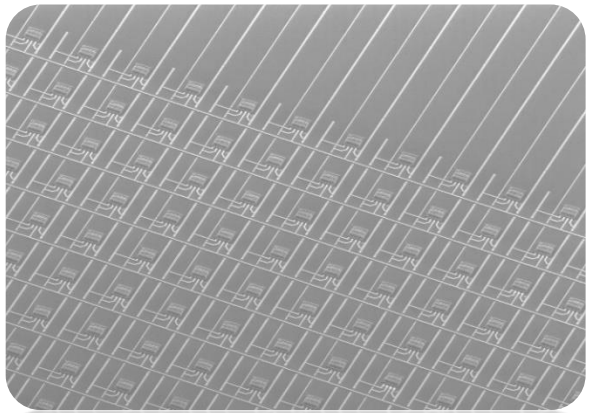
Interconnect-at-print pixel engine

The SEM images of this slide show a fully formed pixel engine that uses thin film metal to interconnect micro LEDs, a micro IC, and conductive spikes at the bottom of the device. The images below show the devices interconnected in arrays on a display substrate.







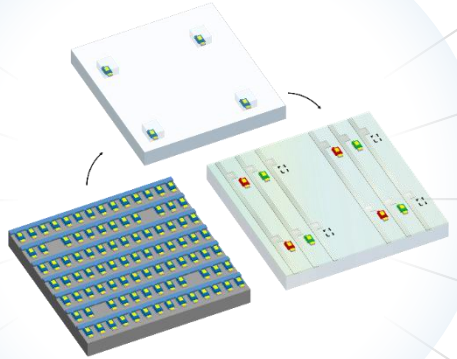


An assembly-centric display fab

Additive assembly with electrical interconnection can finish displays at the “print, test & repair” process modules.

Pixel engines (supplied on wafer)

Metallized panels



Mass-transfer Micro-assembly,
Test & repair.

Advanced flat panel displays…

…of all sizes.

Thanks from the X-Celeprint team