A SELECTIVE LOOK AT SID DISPLAY WEEK 2015

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Questions triggered by SID

What matters now in displays

- Not size

What technologies are critical

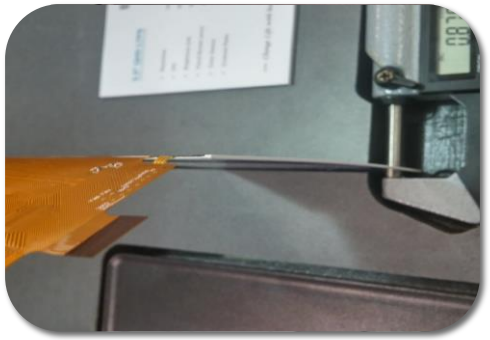
- Materials and processes

What might be coming

- Integration, form factors, conformability, manufacturing approaches

…and a related development

Less size, more performance



Thinner

Flexible

Non-rectangular

Wider Color Gamut

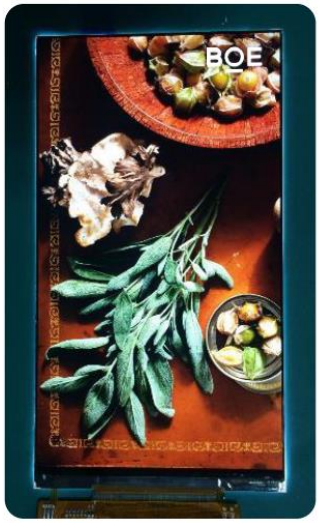
Higher Resolution

Chinese panel makers catching up

110” 8K4K

4.7 UHD LTPS 941 ppi

5.5 UHD LTPS 800+ ppi



5.5 FHD 100% NTSC

BOE talking about avoiding commoditization by moving up performance curve, not down price curve

Feng Yuan, BOE, Business Conference

Some things haven't changed!

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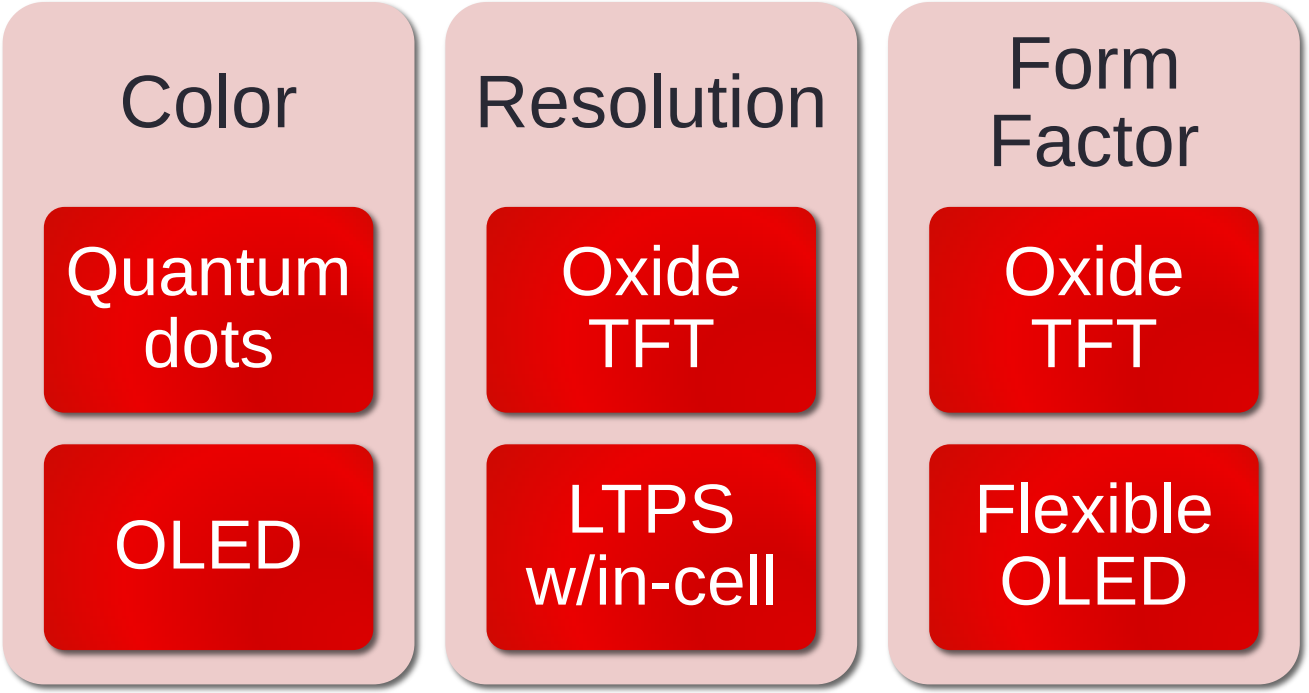
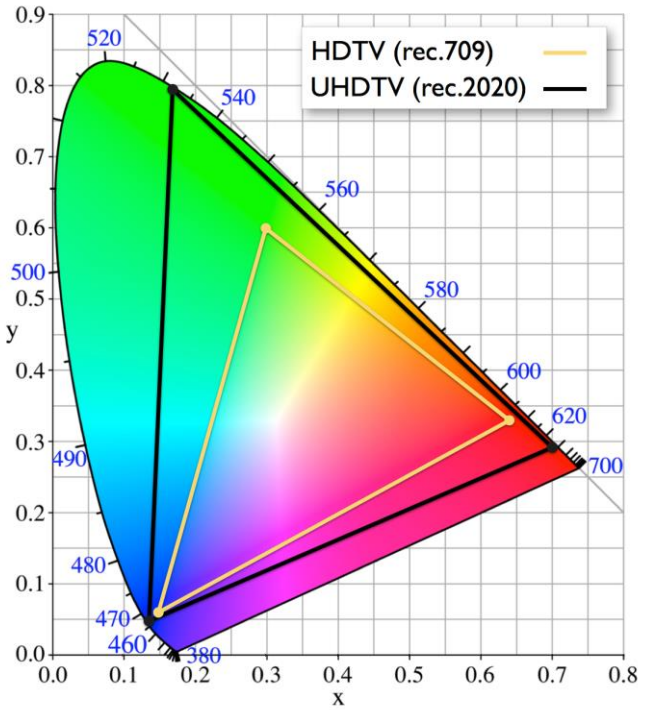
Ways to get to better performance



High levels of activity (papers, demos) around QD and oxide

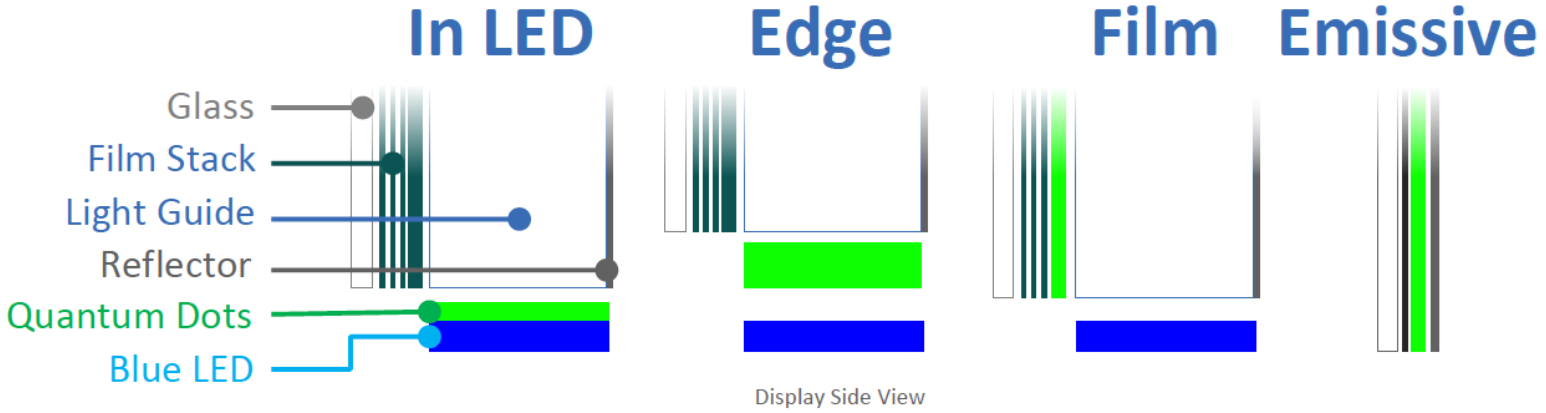
Quantum dots

Rec. 2020 represents an expansion in color gamut, which quantum dots are well-positioned to make happen – soon!



UHDTV vs HDTV Color Gamuts

Multiple ways QDs can impact the LCD stack



Jason Hartlove, Nanosys, Investors Conference

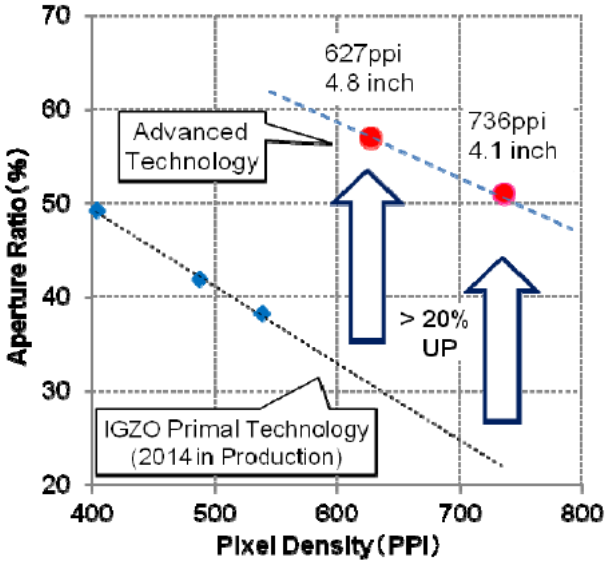
Why oxide

TFT characteristics	a-Si	oxide	LTPS
Mobility (cm^2/V-s)	<1	1-30	30-100
Uniformity	good	good	ok
Reliability	poor	good	good
V_{th} shift	>30	<1	<0.5
Mask steps	4 - 6 (7 for OLED)	4 - 6	5 - 9
Pixel circuit (OLED)	4T + 2C	2T + 1C	5T + 2C
Process temp (°C)	150 - 350	450	250 - 550
Generation	>10	8.5	6.5 - 8.5
Cost/Yield	low/high	low/high	high/low

Adapted from Toshio Kamiya, Short Course S-3

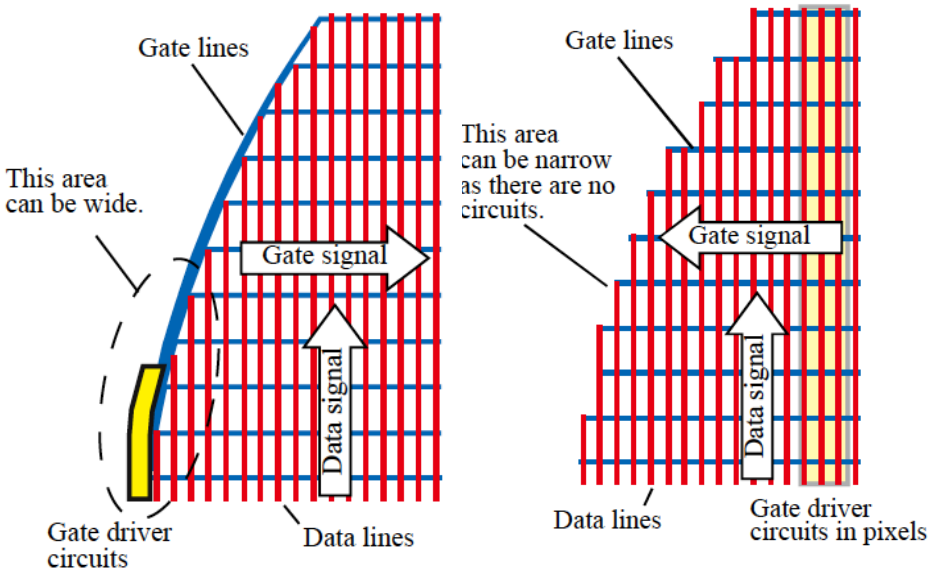
Why oxide

Good aperture ratio at very high resolution, enabled by transparency of oxide semiconductors



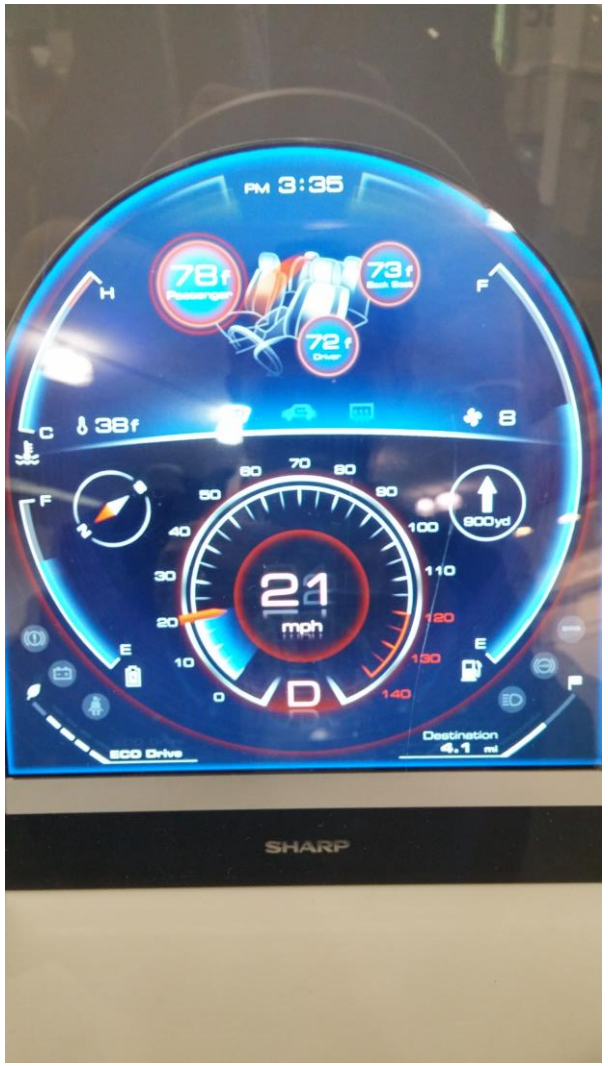
Sharp (63.1)

Why oxide



High mobility enables integration of gate drivers, eliminating bezel

Sharp (59.1)



OLED + oxide

18 inch WXGA AMOLED (IGZO)
0.18 mm thick; bend radius: 30 mm

LGD (65.1)

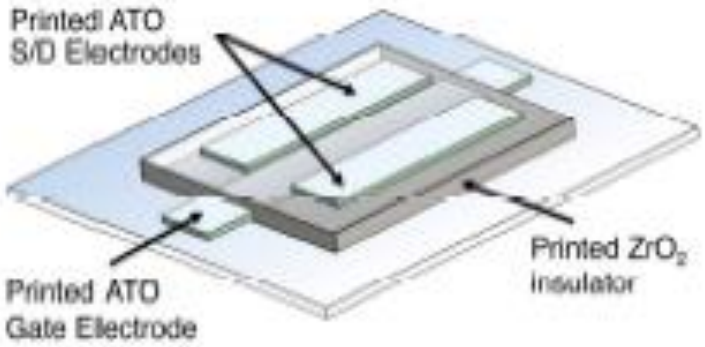
OLED + oxide

13.3 inch 8K (664 ppi) using CAAC-IGZO

Advanced Film Device/
Semiconductor Energy
Laboratory (63.3)

Oxide: printed inorganic TFTs?

Antimony tin oxide and zirconium dioxide in sol-gel to create “inks”
TFTs inkjet-printed



UC Berkeley (39.1)

But a-Si, LTPS not slowing down

3.5 inch VGA a-Si AHVA LCD on plastic

AUO (9.3)

55 inch 8K (7680x4320) 120 Hz a-Si IPS

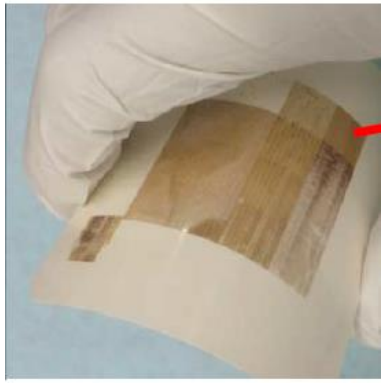
Panasonic (72.1)

8 inch 4K, in-cell touch

JDI (63.2)

4.3 inch FHD LTPS, 0.9 mm thick

AUO (4.3)



Polysilicon TFTs produced at 150°C w/liquid silicon ink

Delft Univ. of Technology, JAIST (29.1)

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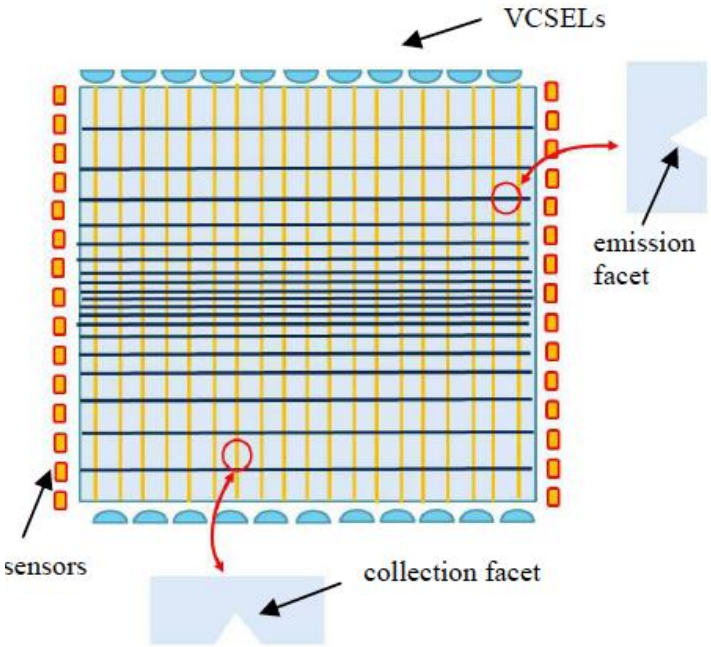
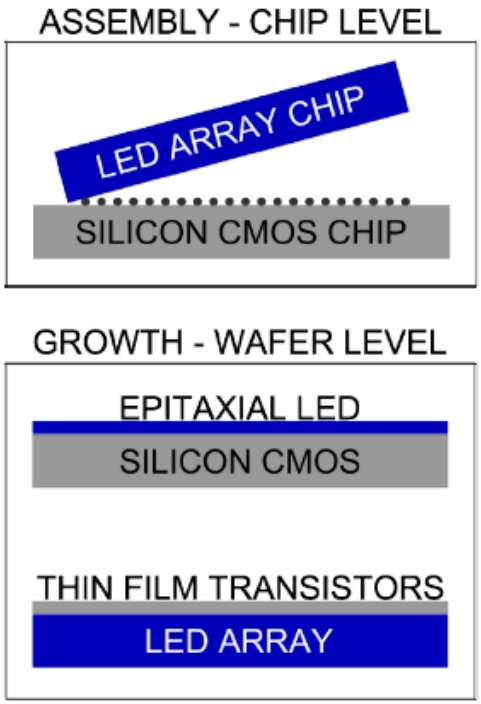
3D user interface

Surface, air detection; multitouch; gesture recognition; finger/stylus



Qualcomm (74.2)

Integrating micro LEDs and TFTs

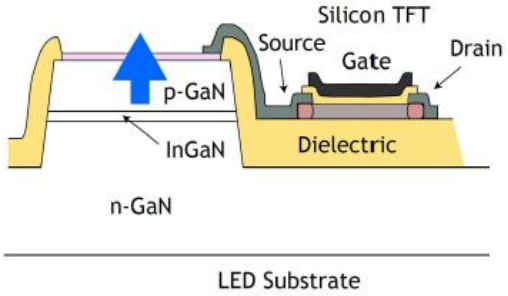


Wafer bonding/ flip-chip: limited density

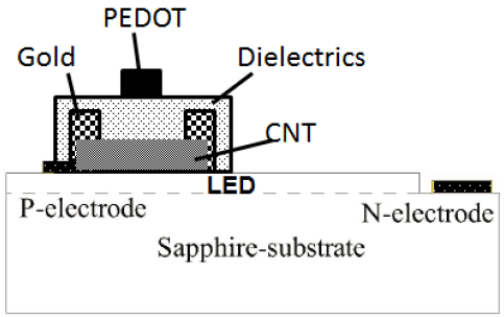
Build LED array, deposit a-Si thin film, laser crystallize to form TFTs

Print SWCNT TFT backplane on top of LED array

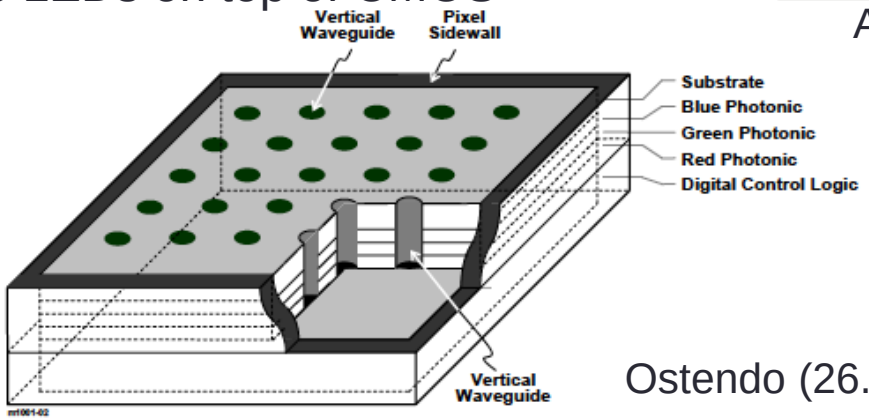
Build 3D stack of red, green, blue LEDs on top of CMOS



Lumiode (26.2)



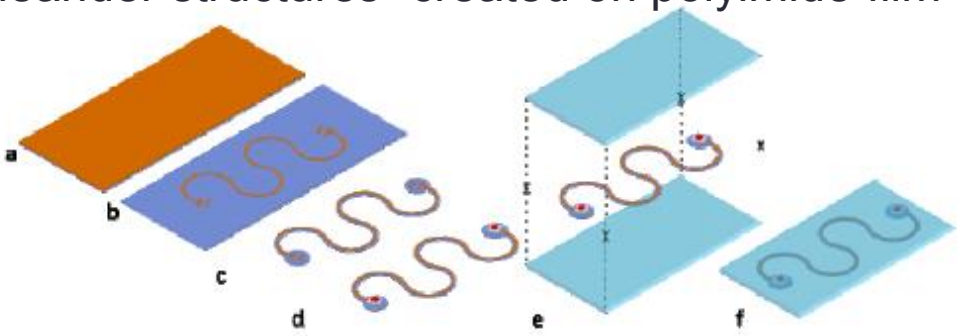
Atom Nanoelectronics (P-151)

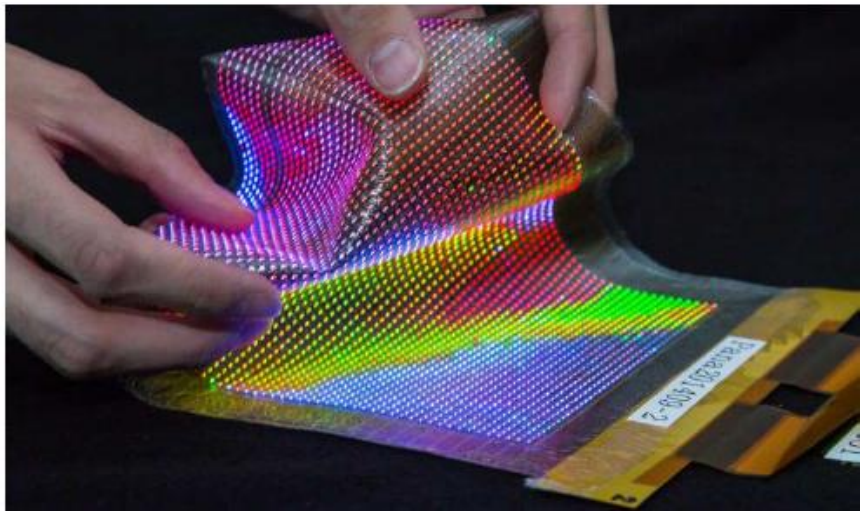


Ostendo (26.1)

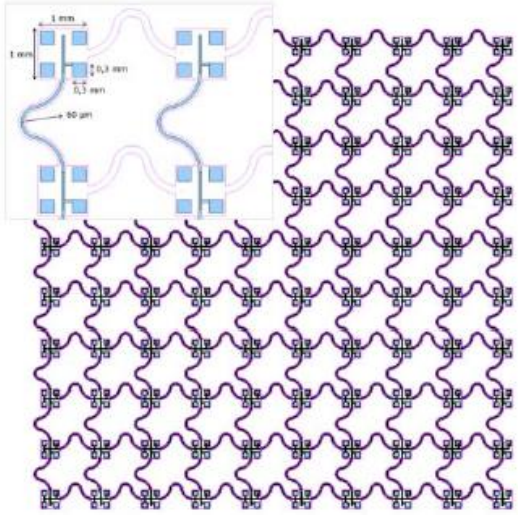
Beyond flexibility: stretchability

"meander structures" created on polyimide film





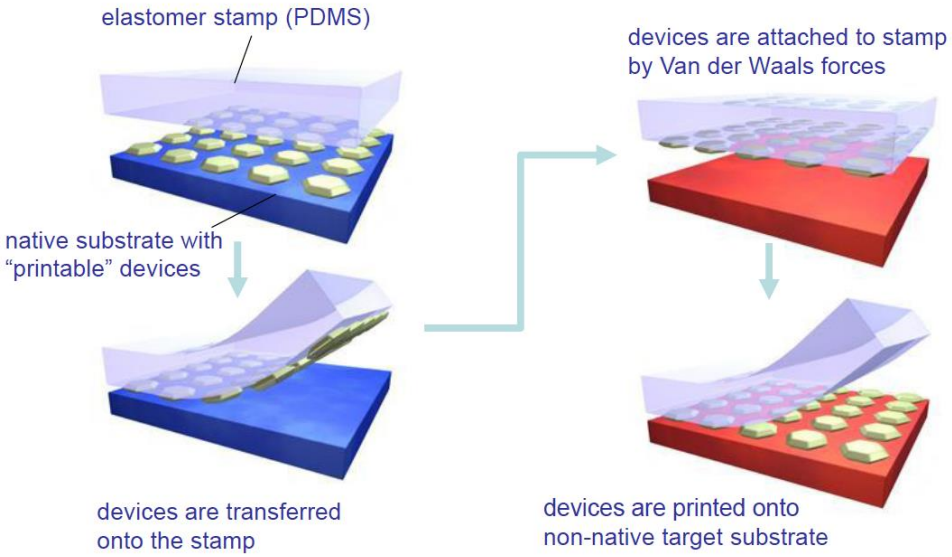
LEDs assembled by pick and place onto circuit array

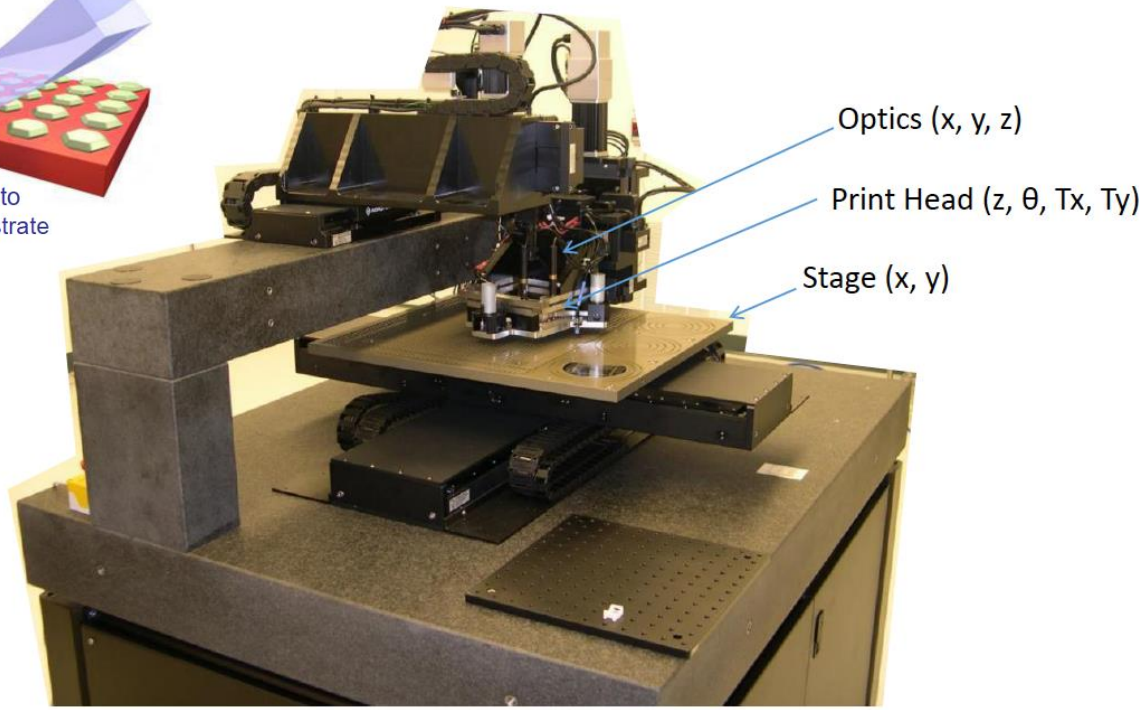


Panasonic, Holst Centre, imec (9.4)

Also, Bao group at Stanford (9.1), others investigating strechable polymer and CNT TFTs

A new manufacturing approach?





Adapted from John Rogers, Seminar M-11; X-Celeprint

Re-starting manufacturing in the US?

National Network for Manufacturing Innovation (so far)

DMDII
DIGITAL MANUFACTURING AND DESIGN INNOVATION INSTITUTE

Coming Soon:

http://manufacturing.gov/

Flexible Hybrid Electronics
Integrated Photonics
Clean Energy
Revolutionary Fibers and Textiles

THANK YOU

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