A Low Cost OTFT Platform for Truly Flexible Electronics

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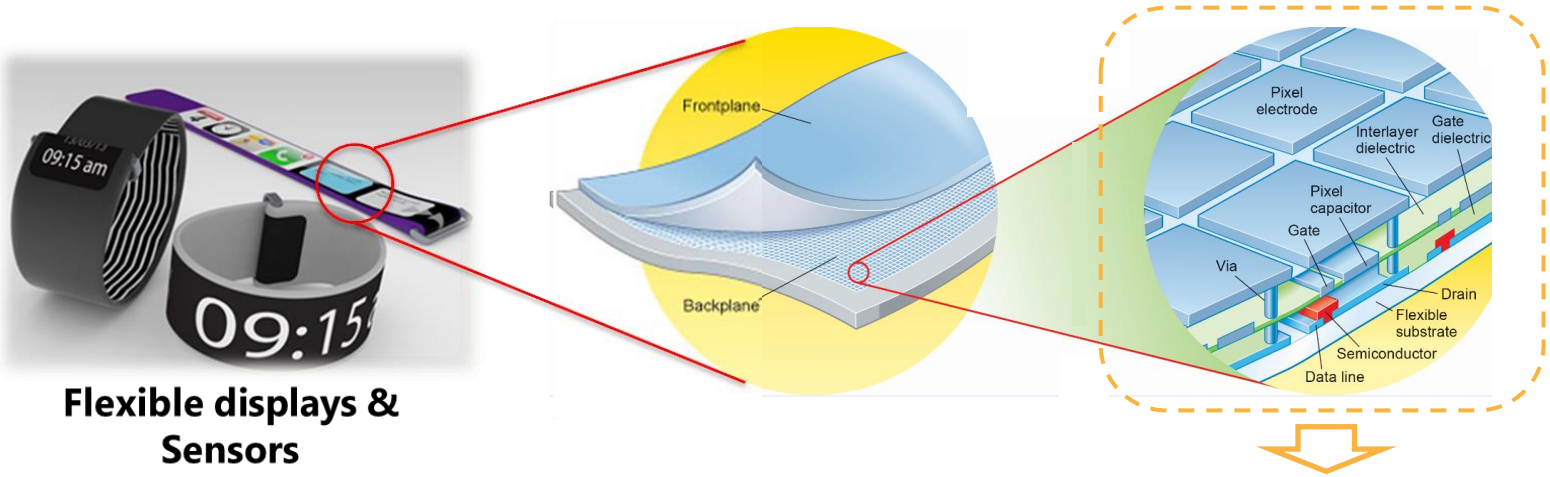
Truly flexible electronics

A Unique Technology…

- The most significant new transistor and flexible electronics platform in decades- based on **high performance** Organic Thin Film Transistor (OTFT)
- Enables true flexibility, bendability and unbreakability – by combining FlexEnable backplane and with partners' frontplanes for LCD, OLED, EP Displays, Sensors & entire electronics systems on plastic
- **Fully industrialised** and suitable for manufacturing production



Flexible displays & Sensors

FlexEnable's value is the processes, architectures, materials and qualification IP to manufacture truly flexible electronics

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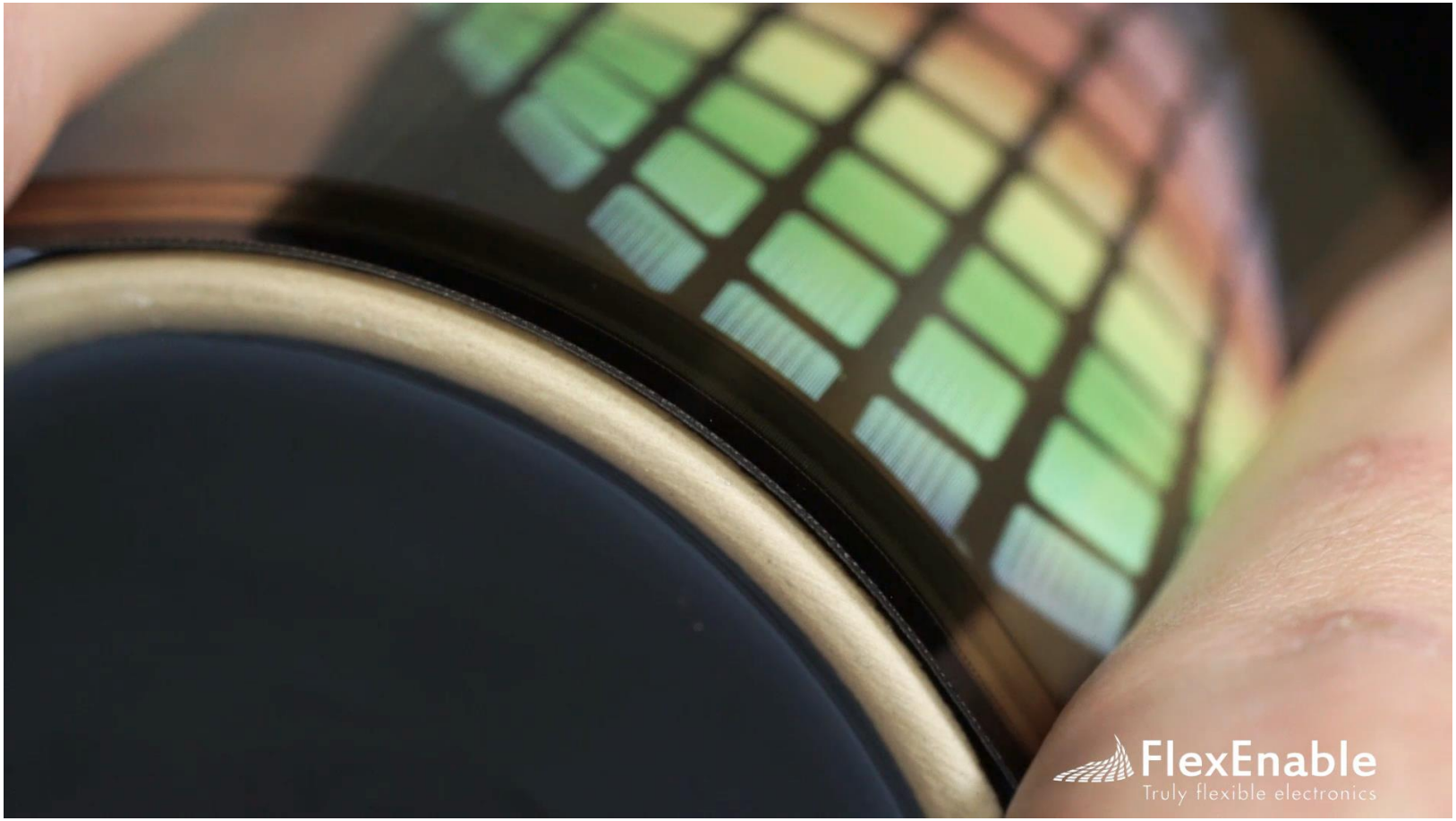
Real Flexible Displays now ready



In partnership with MERCK

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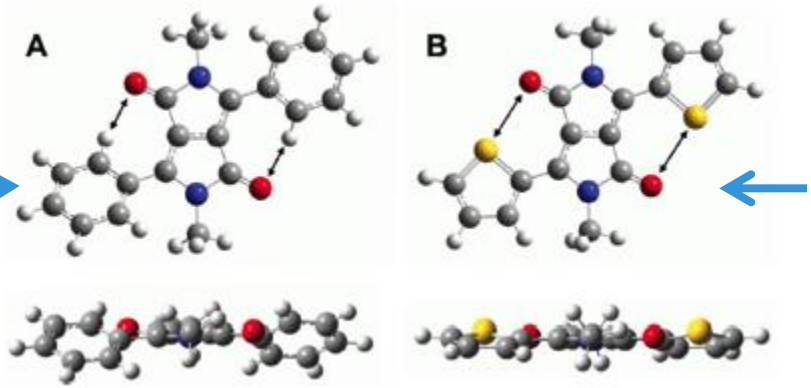
Take another look at OTFT

- Unlike silicon, **OTFT is not one material**, but a family of materials that are always getting better
- Recently there has been a **breakthrough in chemistry** leading to a new class of polymer materials with high performance
- These polymers use coplanar backbone conformation with leads to molecular order through **aggregation rather than crystallisation**
- Creating **greater charge transport** and **consistent processing** conditions

High Torsion Angle
More Crystallization



Low Torsion Angle
More Aggregation

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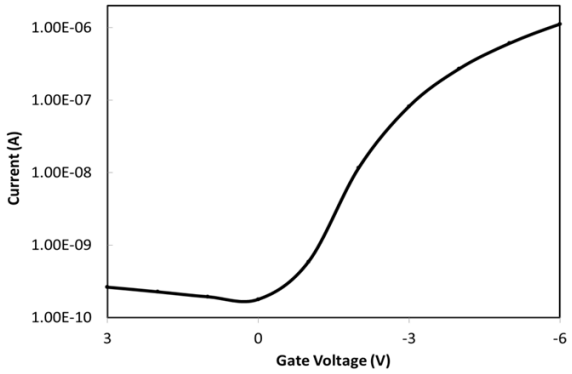
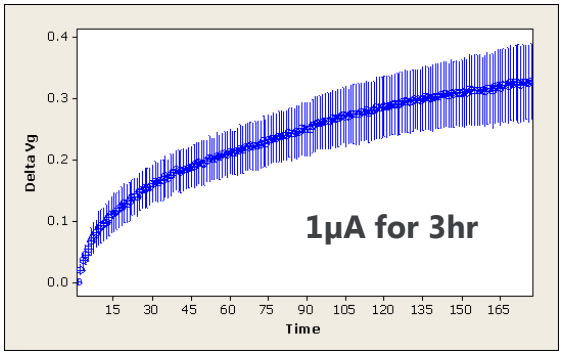
The OTFT performance revolution – now means that:

Fast TFTs to meet customer demands



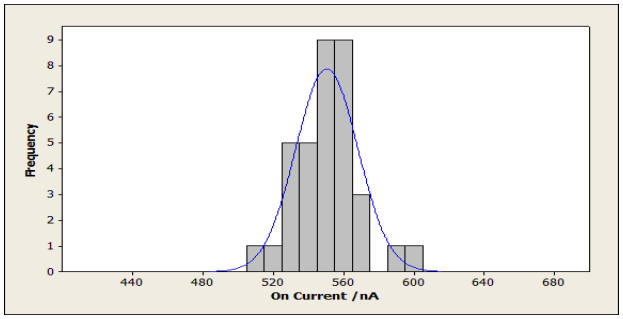
Mobility > 2

Stability to enable long lasting products



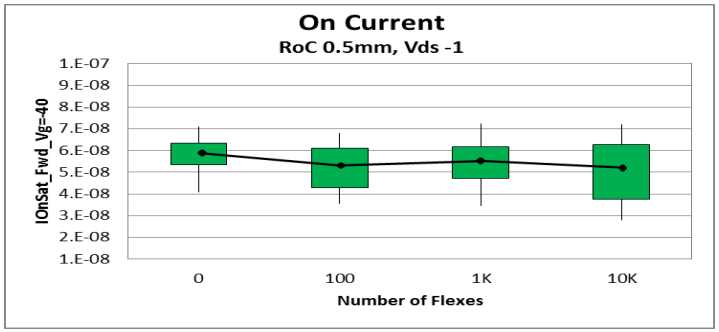
Current stability ΔV_{th} < 0.3V

Uniformity to enable high manufacturing yield



Current Variation < 5%

Flexibility to enable exciting new form factors



Bend radius < 0.25mm

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Capabilities that unlock opportunities for ultra high growth markets…

Wearable Technology

$23Bn market (2020)

http://www.analysysmason.com/About-Us/News/Insight/smart-wearables-forecast-Sep2014/

Sensors and smart surfaces for IoT

$10.5Bn market (2020)

http://www.marketsandmarkets.com/PressReleases/smart-sensor.asp

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Favorable Trends

Curved displays

'Shatterproof' products

Wearable devices

Larger Auto displays

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Display Technologies on Plastic

EPD	LCD	OLED
Benefits: • Bistable (low power) • Paperlike apperance • Daylight readable • Voltage drive • Very flexible **Drawbacks:** • Limited colour gamut • No video rate	**Benefits:** • Video/good colour • Reflective and transmissive available • Manufactured at high yield using existing infrastructure • Voltage drive • Highly scalable **Drawbacks:** • Can it be made?	**Benefits:** • Video/good colour • Excellent optical performance • Potential to be very flexible **Drawbacks:** • Current driven • Cost!! • Questionable scalability • Very good encapsulation required

Only feasible with low temperature oTFT process

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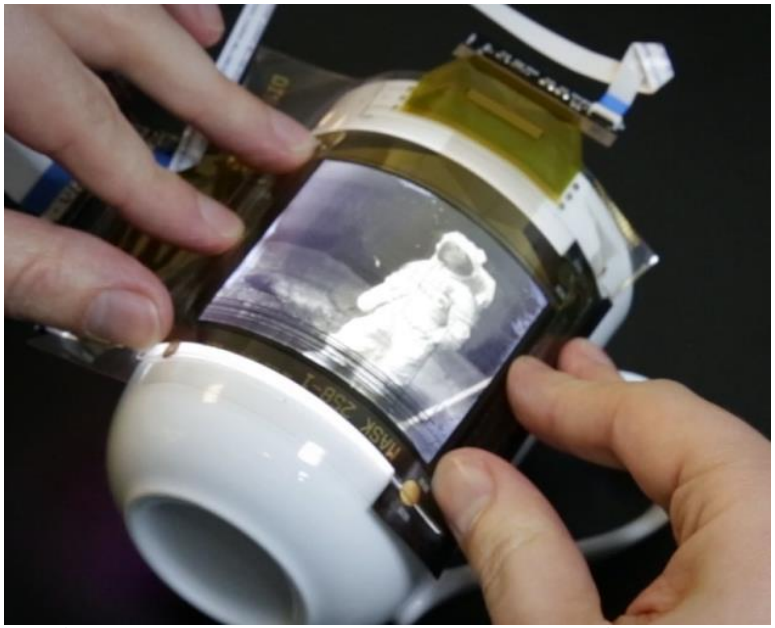
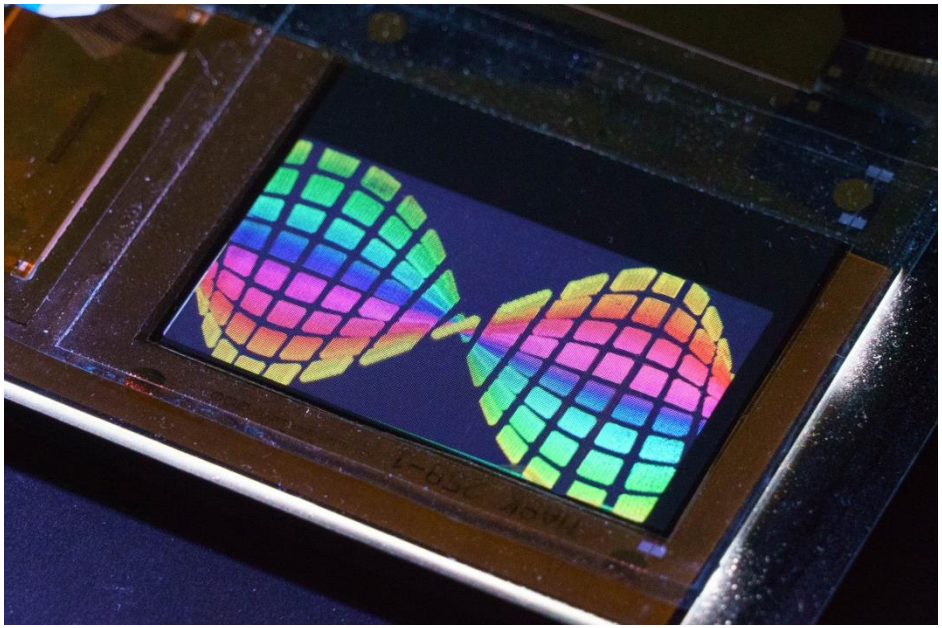
Breakthrough OLCD on ultra low cost substrates



Conforming an OLCD to a curved surface



FlexEnable's first colour OLCD display demonstrator

- Displays fabricated on TAC film @$1/sqm (vs $100/sqm for FRP)
- FlexEnable's low temp process and compatibility with existing LCD manufacturing processes is ***enabling a cost breakthrough*** for ultra-thin, light, robust and conformable displays
- 130 micron thin glass-free stack, can be laser cut to non-square shapes

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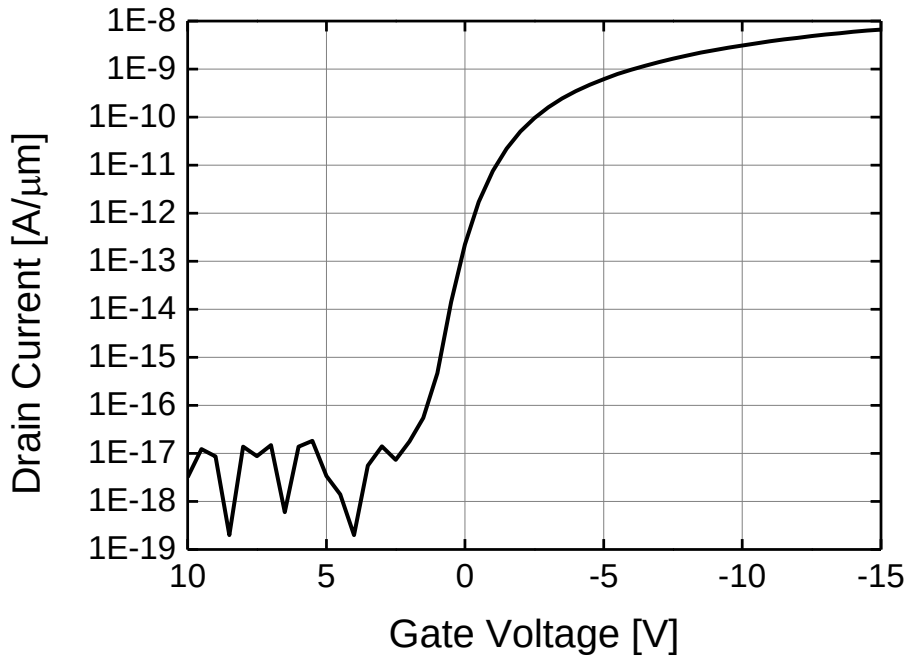
Advantages of plastic LCD vs glass

Property	a-Si Glass	oTFT Plastic	Benefit	Comment
Weight (g/sqcm)	0.25	0.025	10x	Mobile phone = 17g lighter 55" TV = 2.5 kg lighter
Thickness (mm)	~1.2	~0.3	4x	Potential to go thinner with integrated polarizers
Radius of Curvature (mm)	4200	35	100x	Much greater potential for plastic
Freeform	Hard	Easy	-	Plastic display can be easily profiled with laser
Cost	Low	Low	Push	Plastic display is cost competitive in volume with performance benefits
Mobility performance	0.5	2.0	4x	Higher mobility can be used for more efficient or higher density
Electrical Leakage	1e-13	<1e-16	1000x	Lower leakage allows low power driving modes and flexibility in design

Extremely low leakage currents



Vds = -5V

Ioff < 0.01 fA/µm

- Measurements of off current found to be limited by measurement system
- New test structure designed with W of **50,000**µm
- Off current still limited by measurement system
- True on/off ratio in excess of 10^8

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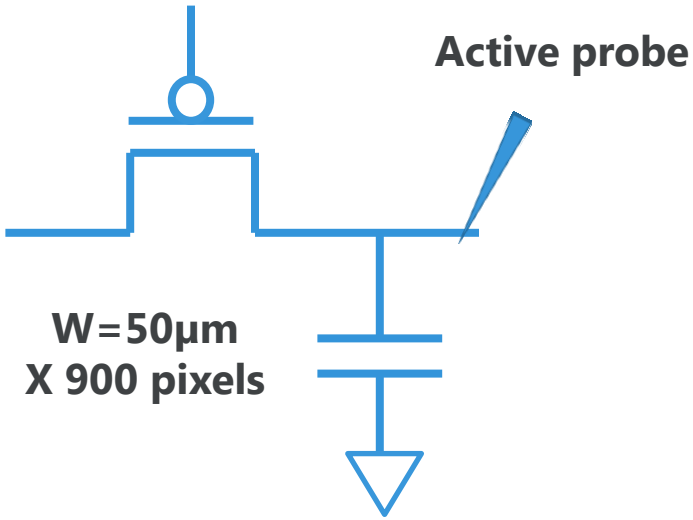
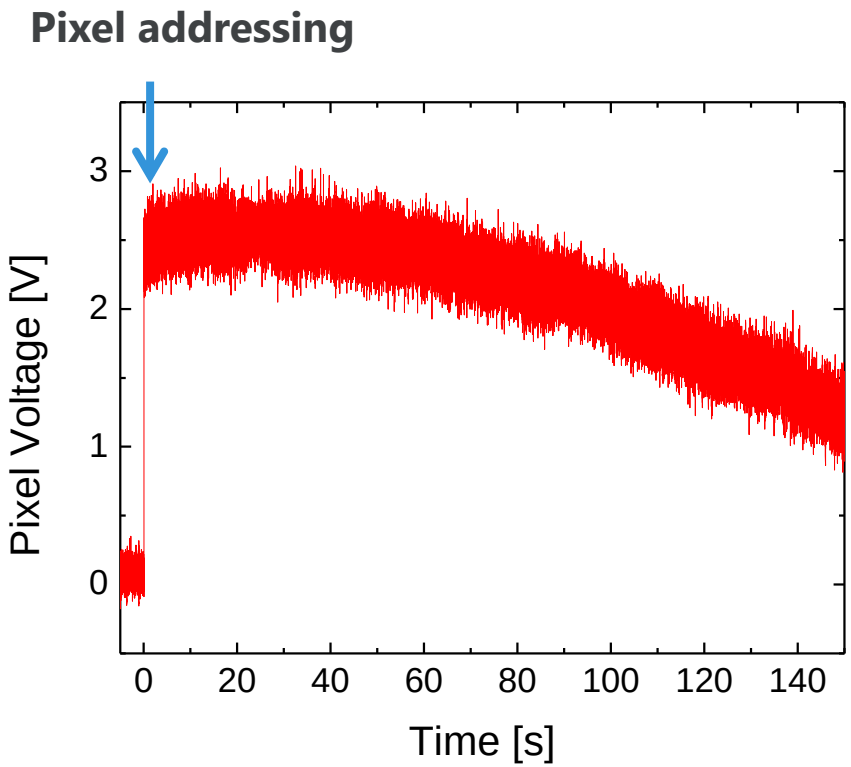
Extremely low frame rates





- The probe consisted of an operational amplifier in buffer configuration
- The pixel capacitors are charged to 2.5V and then left to discharge through TFT OFF current to the data lines kept at 0V
- Noise in the measurement is primarily due to the probe

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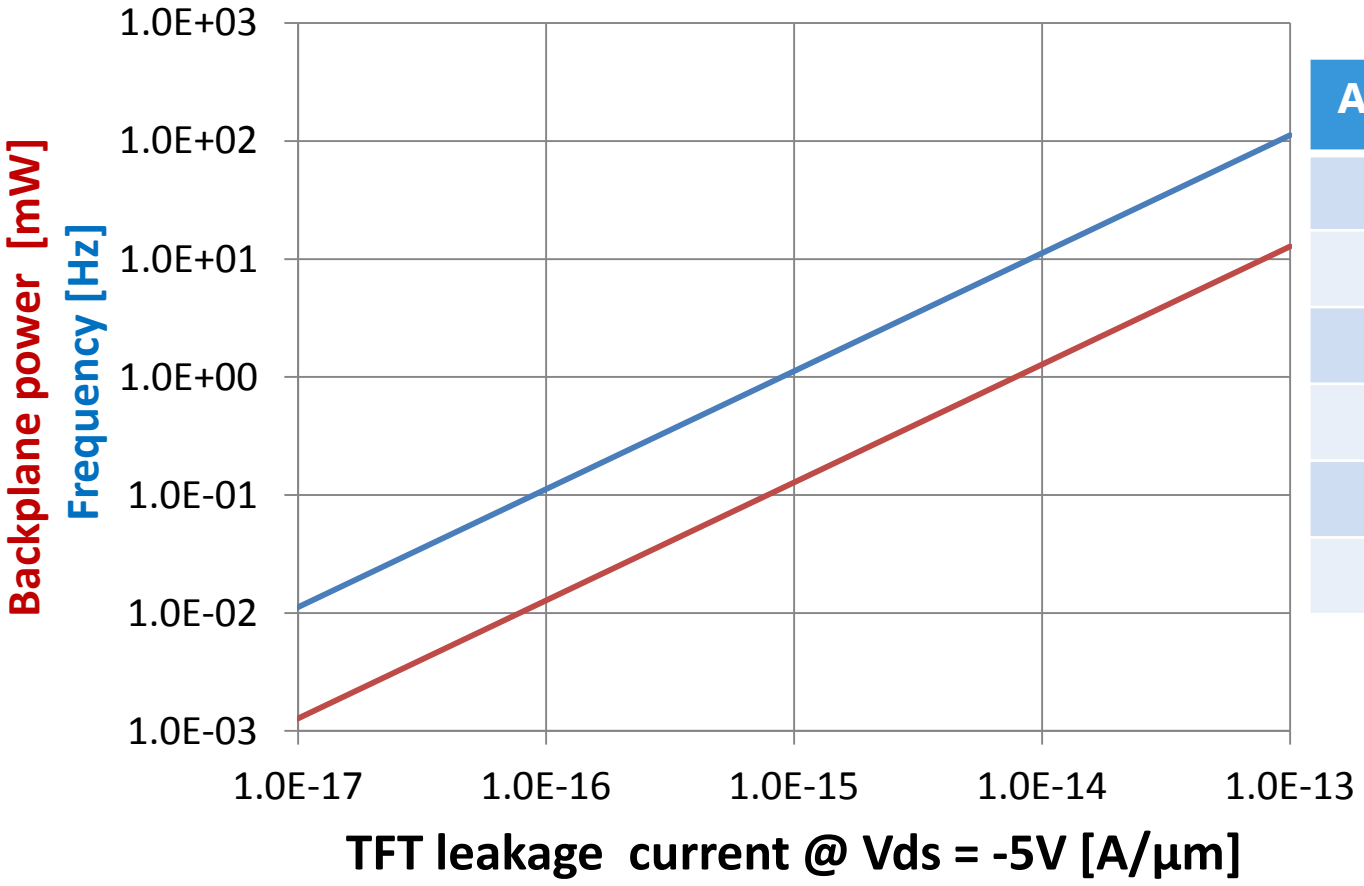
Extremely low power



Assumptions	Value
Resolution	320x240
TFT W/L	10
C_{st}	100fF
C_{dl}	30pF
Vd	12V
VHR	95%

Calculation assumes reflective LC mode is used

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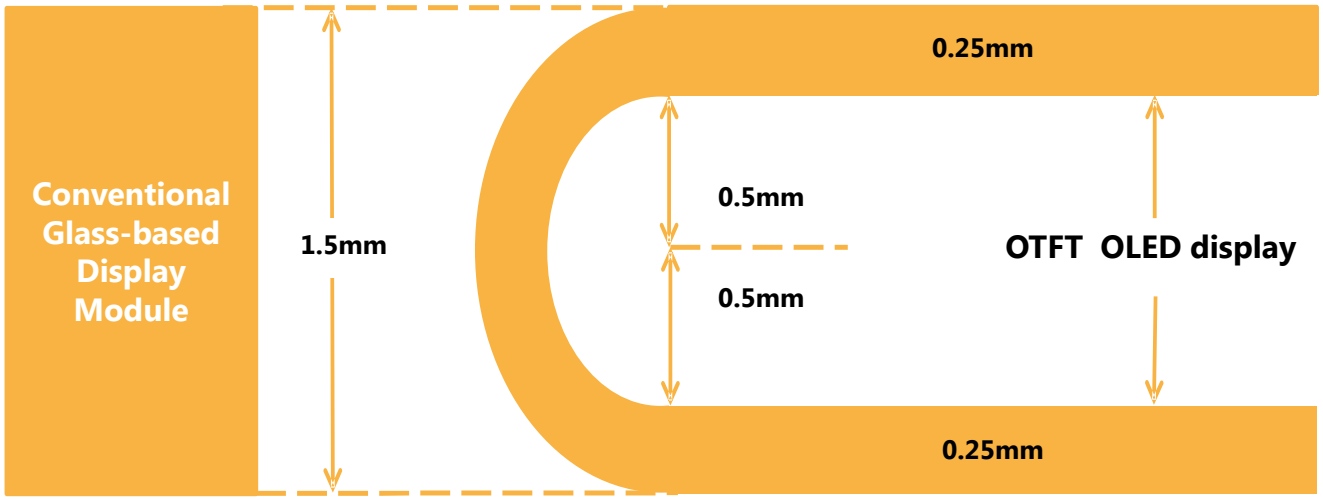
What is foldable

OTFT is **only** technology for foldable displays with bend radius ~ 0.5mm



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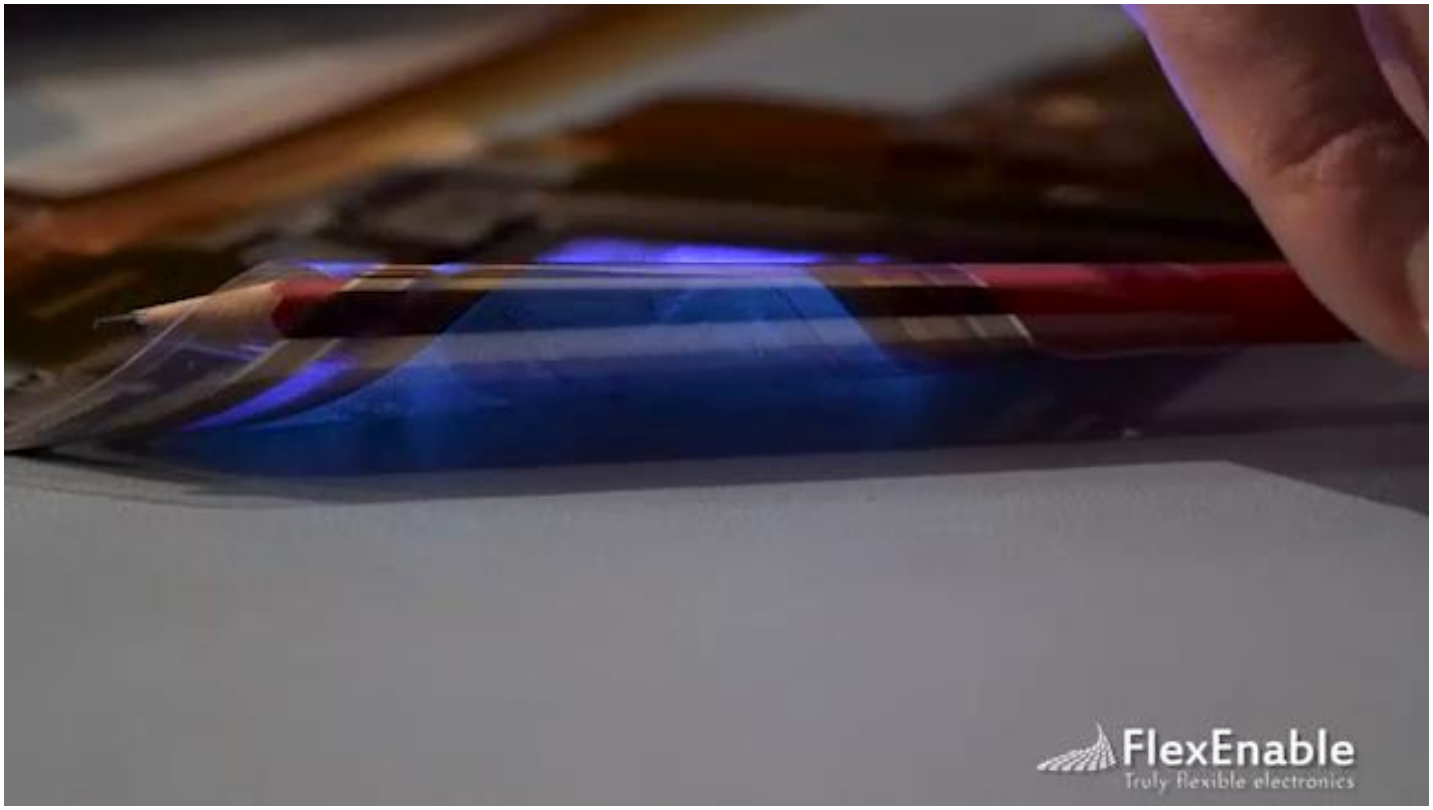
Bending Colour OLED

Route to ‘Foldable’ AMOLED display



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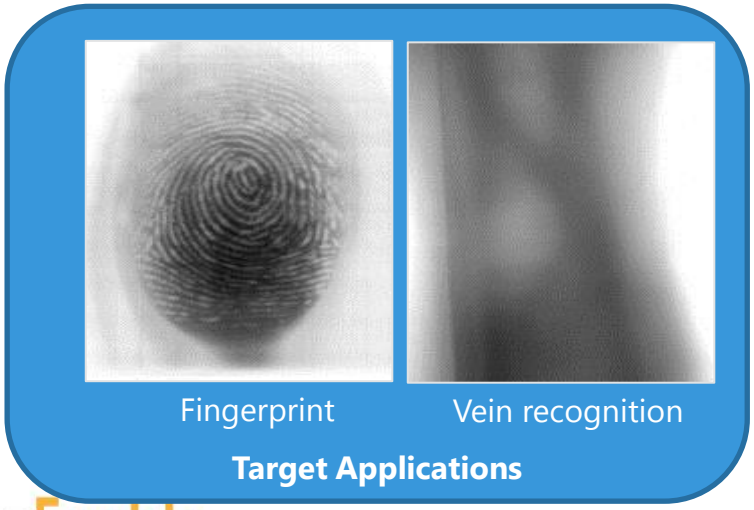
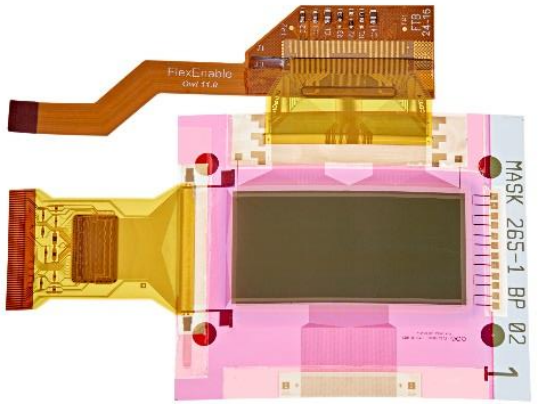
Biometric Imaging Technology

- Better imaging achieved through larger area and better rigid discrimination
- Cost per area similar to flat panel display (FPD) as opposed to crystalline silicon
- Opportunity to combine fingerprint and vein imaging on single sensor
- Thin and light making it easy to integrate into consumer devices
- Power consumption of sensor film is few hundred µW

Parameter	Array Specifications
Sensor size	2" (4.8" also available)
Resolution	540 x 256 (1024 x 1024)
Pixel Density	300 dpi
Thickness	0.35mm
Weight	2.94g
Pixel Size	78µmx78µm
Pixel pitch	84µmx84µm
Active Area	21,5x45,35mm (86x86mm)





Plastic image sensor

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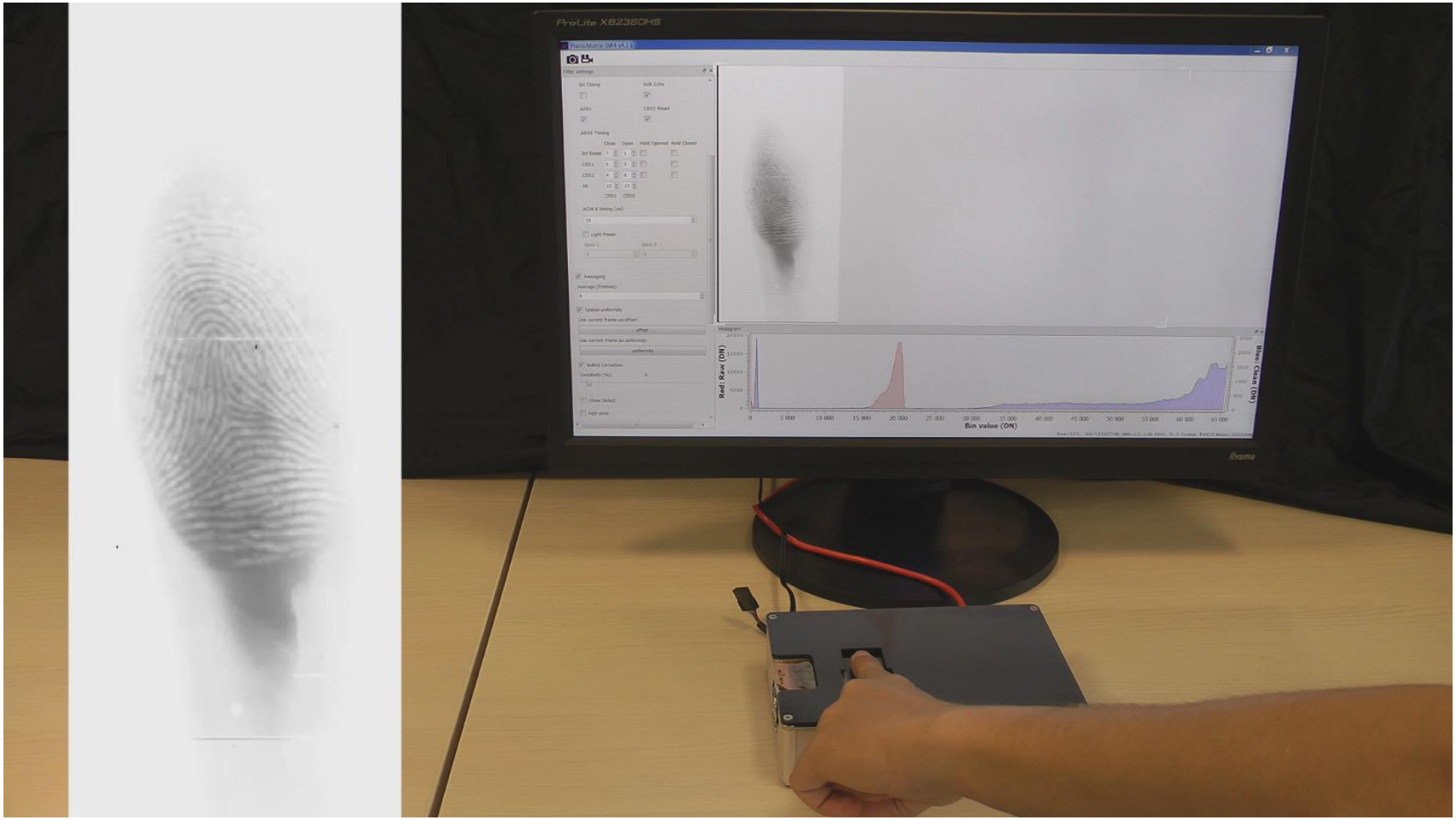
Fingerprint



Transforming cost through under-utilised FPD capacity

FlexEnable qualified materials set from established global suppliers

Existing FPD assets + FabEnable License

Truly Differentiated Displays and Products

- Today there are 37 million m^2 of unutilised capacity in the global FPD industry – across all Gen sizes[1]
- Overcapacity higher at older, earlier generation lines (Gen 6 and below)
- FlexEnable process brings improved economics through product differentiation and diversity (sensors) using today's Sheet-2-Sheet equipment

- (1) – DisplaySearch

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Activating surfaces with flexible displays and sensors

- FlexEnable has developed a revolutionary and low cost way of making flexible electronics
- Unbreakable, ultra-thin, light and flexible displays and sensors will enable game-changing products which have been impossible until today.
- We are excited to work with like-minded companies to bring these exciting concepts to market.

Mobile Devices

Wearables

Clothing

Biometrics

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