IoT

Wearables

Flexible Organic LCD: From lab to fab to the next wave of products

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3 November 2017 Cambridge, UK

Automotive

Sensors

Displays

FlexEnable
Truly flexible electronics

15th Anniversary HVM 2017 & Graphene New Materials Conference
www.cir-strategy.com/events

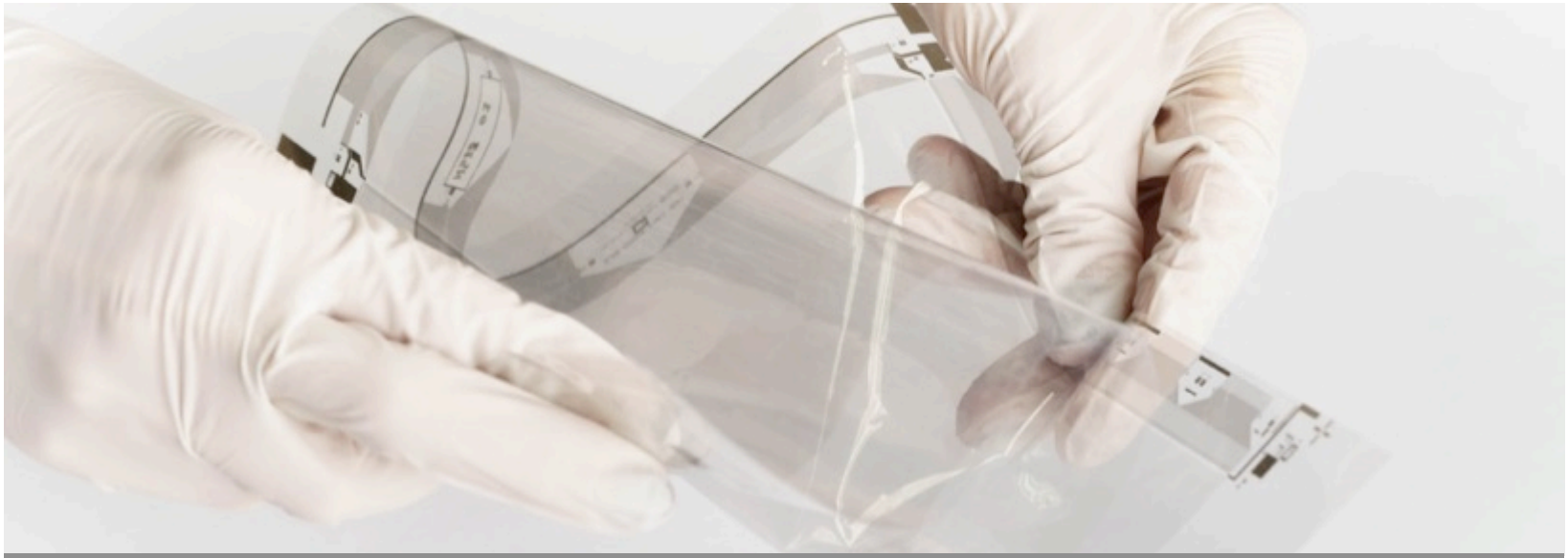
FlexEnable at a glance

- Headquarters – Cambridge, UK
- **World's most experienced team** of plastic electronics engineers with collective experience of over 700 engineering years, >600 patents
- **Lowest cost and most flexible platform** for bringing surfaces to life
- **Focused on mainstream applications** – LCD, OLED and sensor arrays for IoT
- **Proven volume-production technology** and experienced tech-transfer team



Industrially-proven technology platform

- The **lowest cost** flexible electronics platform based on **high performance** organic thin-film transistor (OTFT)
- Enables **ultrathin, ultra-lightweight, shatterproof** and **flexible** displays and sensors
- **Fully industrialised** and **easily transferred** for mass production in existing facilities



Low-temperature OTFT backplane is combined with various frontplanes to create **truly flexible electronics over small and large surfaces.**

FlexEnable's OTFT technology highlights

Mechanical

0.25mm
Transistor bend radius
Wraps around a matchstick

25µm
Substrate thickness
As thin as a human hair

100gsm
Weight per area
As light as a sheet of paper

Electrical

1.5cm²/Vs
Better mobility than a-Si

Long Lifetime
Better stability than a-Si

Low-leakage
Better leakage currents than a-Si

Manufacturing

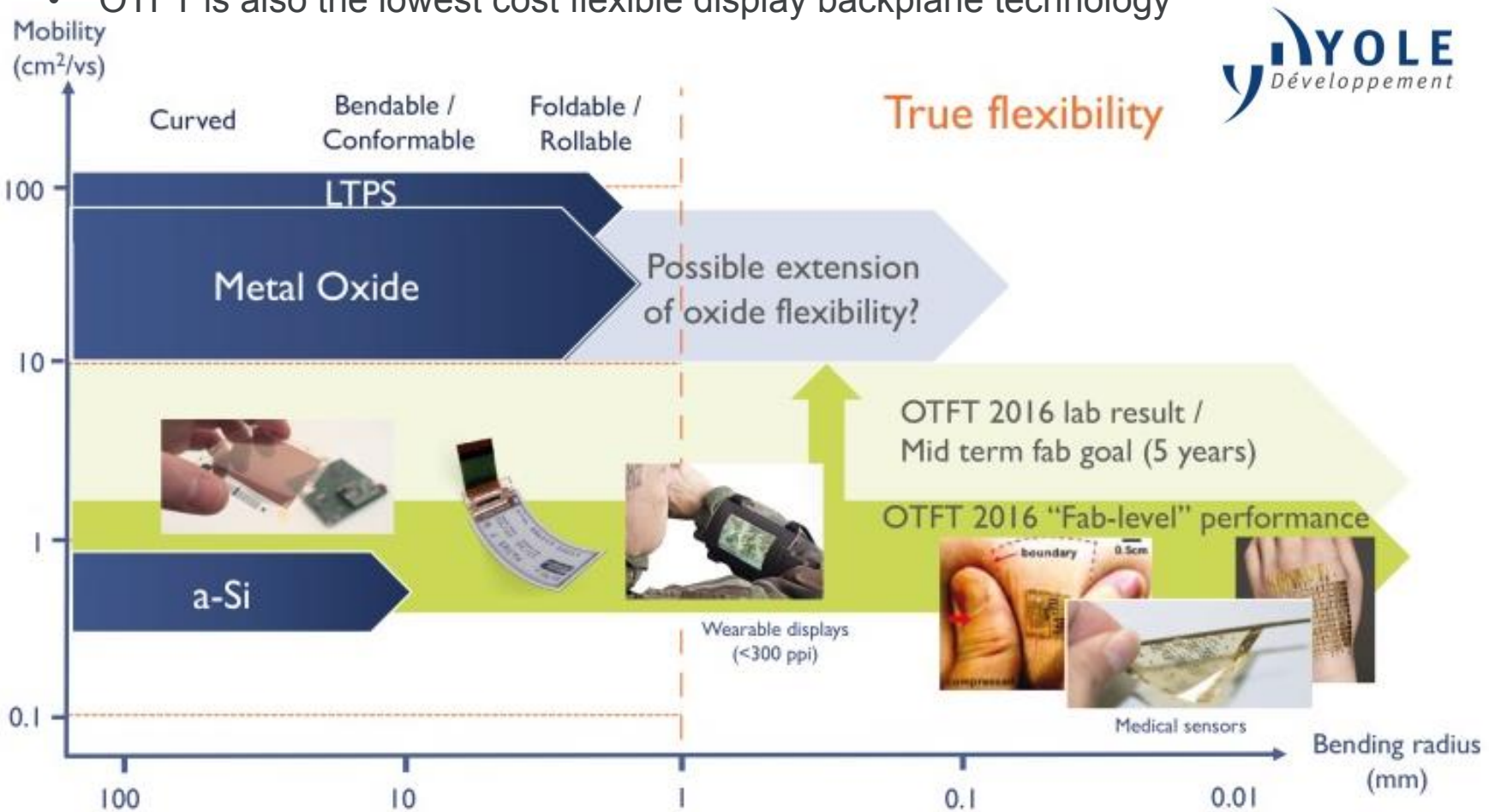
< 100°C
Lowest transistor manufacturing temperature

High Yield

Low Cost
Lowest cost flexible for all areas and surfaces

TFT Trends – OTFT better than a:Si and truly flexible (Yole's view)

- OTFT is now recognised as the most flexible TFT technology, and now has mobility performance significantly better than a:Si
- OTFT is also the lowest cost flexible display backplane technology



**Organic Thin Film Transistor: Flexible Displays And Other Applications, Yole Dévelopement– Oct 2016* http://www.yole.fr/OTFT_Applications.aspx

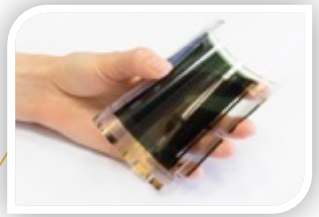
Thin, light, robust and flexible displays and sensors

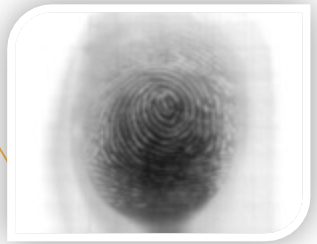
Organic LCD in partnership with Merck

Flexible OLED in partnership with CPT

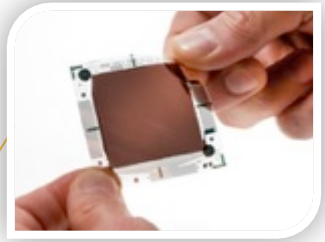
Flexible EPD in production today via Plastic Logic Germany

Flexible fingerprint sensor on plastic with partner ISORG

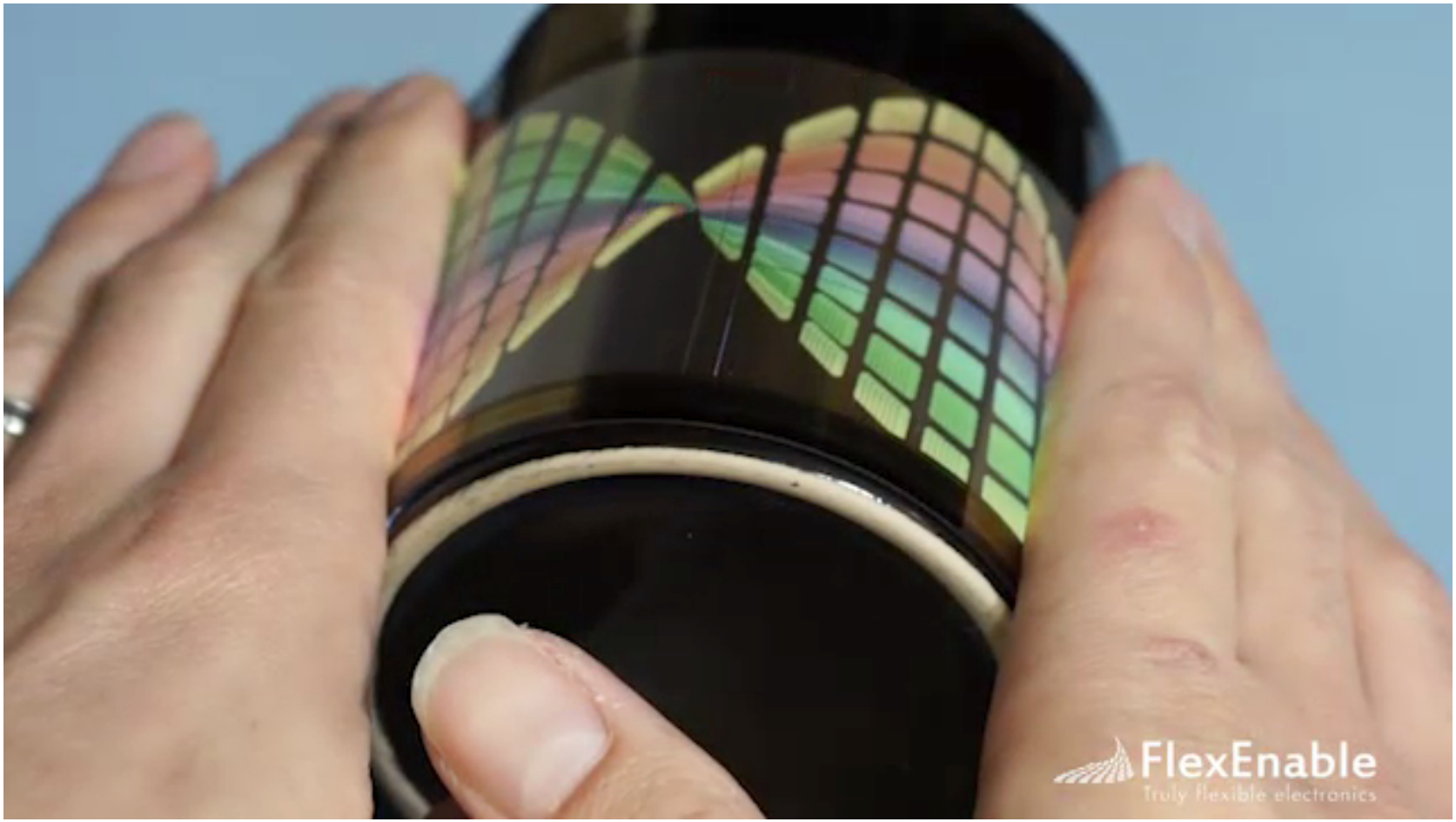




Flexible X-ray image sensor



Breakthrough Organic LCD on ultra low cost substrates



12.1” OLCD winner IDTechEx “Best Product Award” May 2017

AWARD WINNER

Printed Electronics
Best Product
IDTechEx Show! Berlin 2017

12.1” plastic LCD (OLCD) – and scalable to large sizes

20mm Bend Radius Achieved with OLCD

- Curved lamination trials using 4.7” OLCD platform to determine minimum bend curvature
- OLCD Bend Radius achieved: 20mm @ 90 degrees bend angle
  - Glass LCD: ~R500
- Lamination Surface: Flat → Curve → Flat

R20 OLCD Demo

R20 @ 90° Bend angle

OLCD Applications

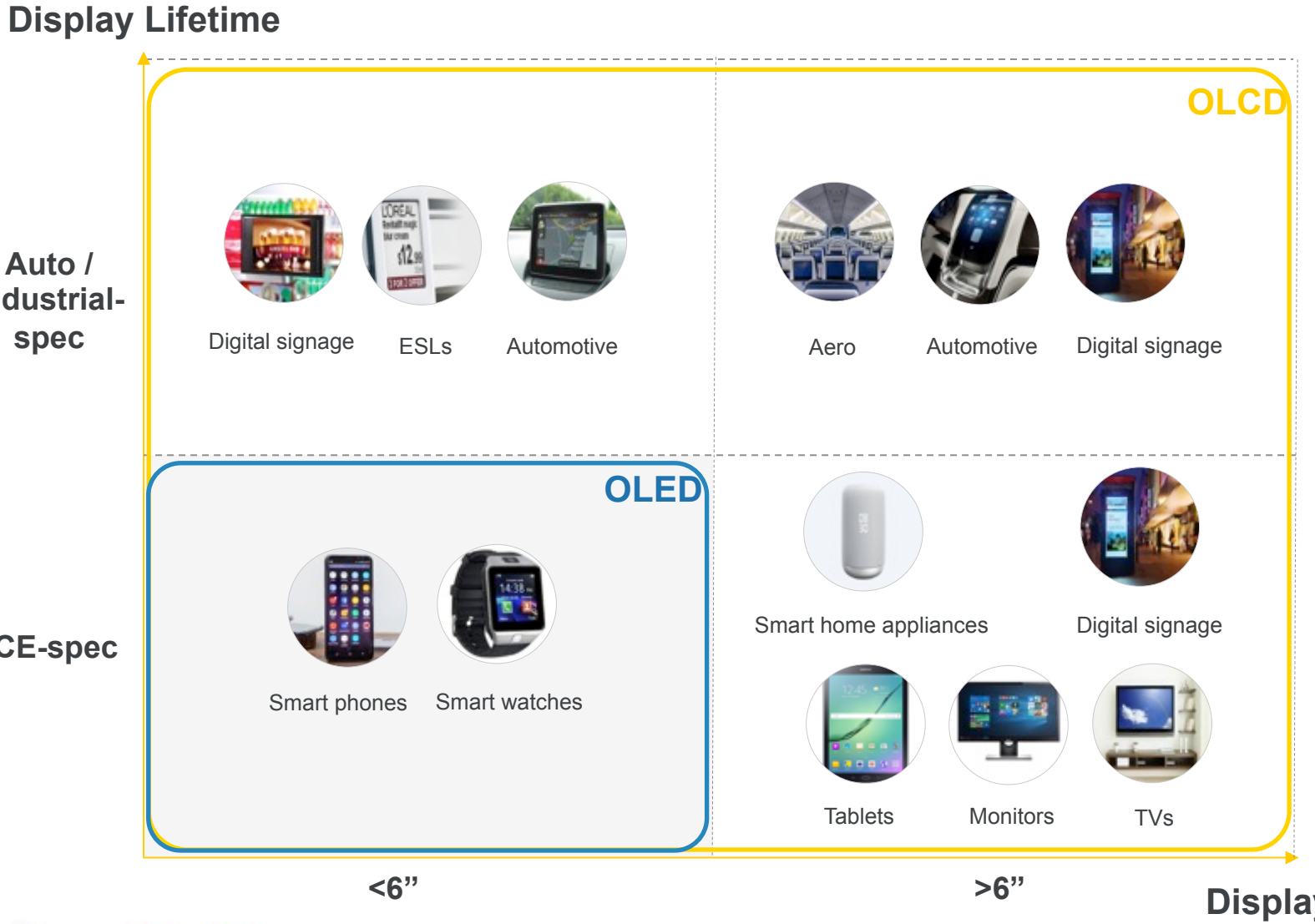
OTFT / OLCD is particularly suited to applications that require:
conformability, unbreakability, light-weight,
AND
Large area, long lifetime, or high brightness

Automotive

CE, Appliances, Wearables

Digital Signage

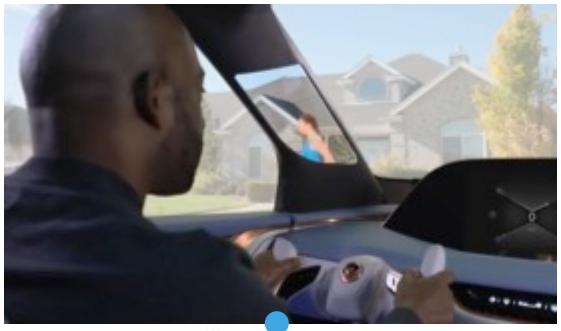
OLCD: Large area and bright, long lifetime applications

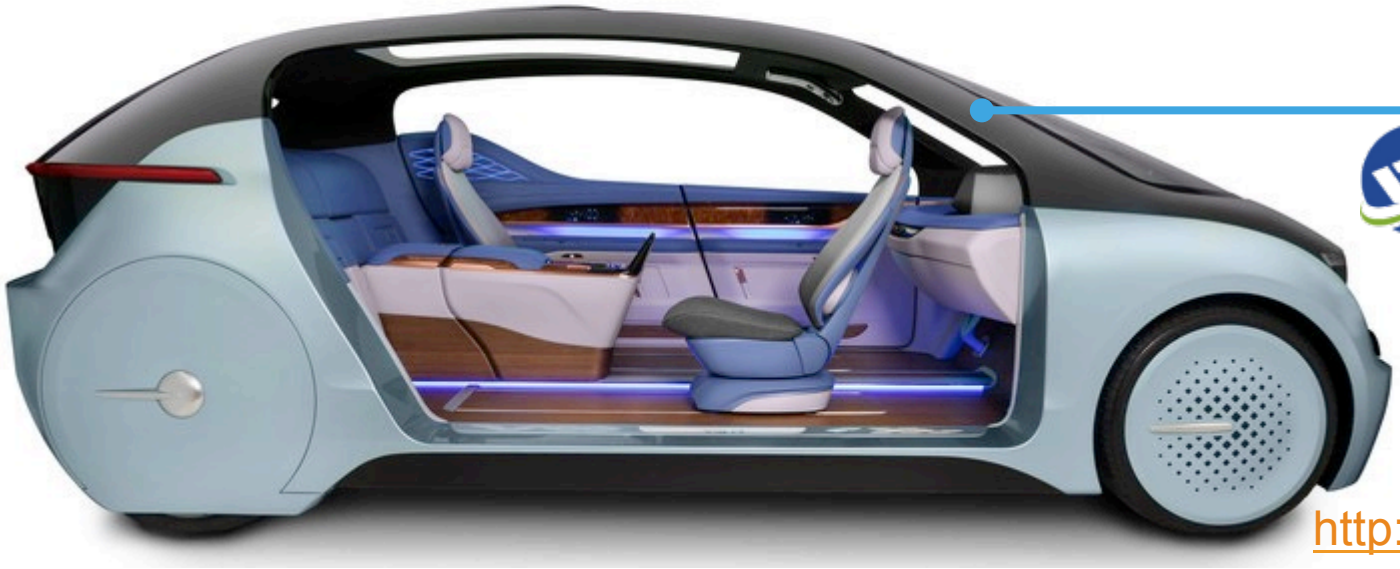


World first: A-pillar display in Yanfeng XiM17 concept car

FlexEnable 12.1” glass-free, conformable organic liquid crystal display (OLCD) has been incorporated into a car’s A-pillar to allow for greater visibility and safety.

The demonstrator was included in YFAI’s XiM17 autonomous concept interior that made its world debut at the 2017 North American Auto Show (NAIAS) in Detroit.

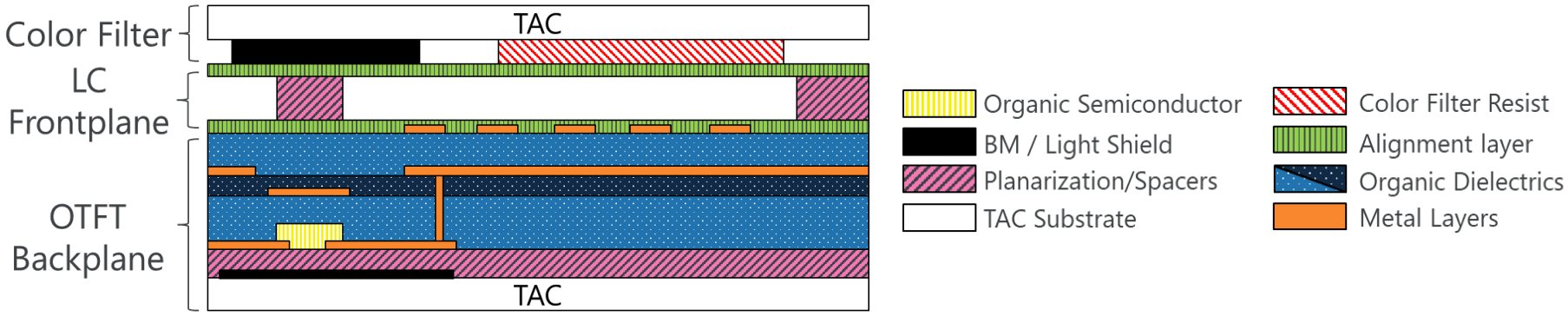




Yanfeng
Global Automotive Interiors

http://www.yfai.com

OLCD can achieve same performance as glass a-Si LCD displays

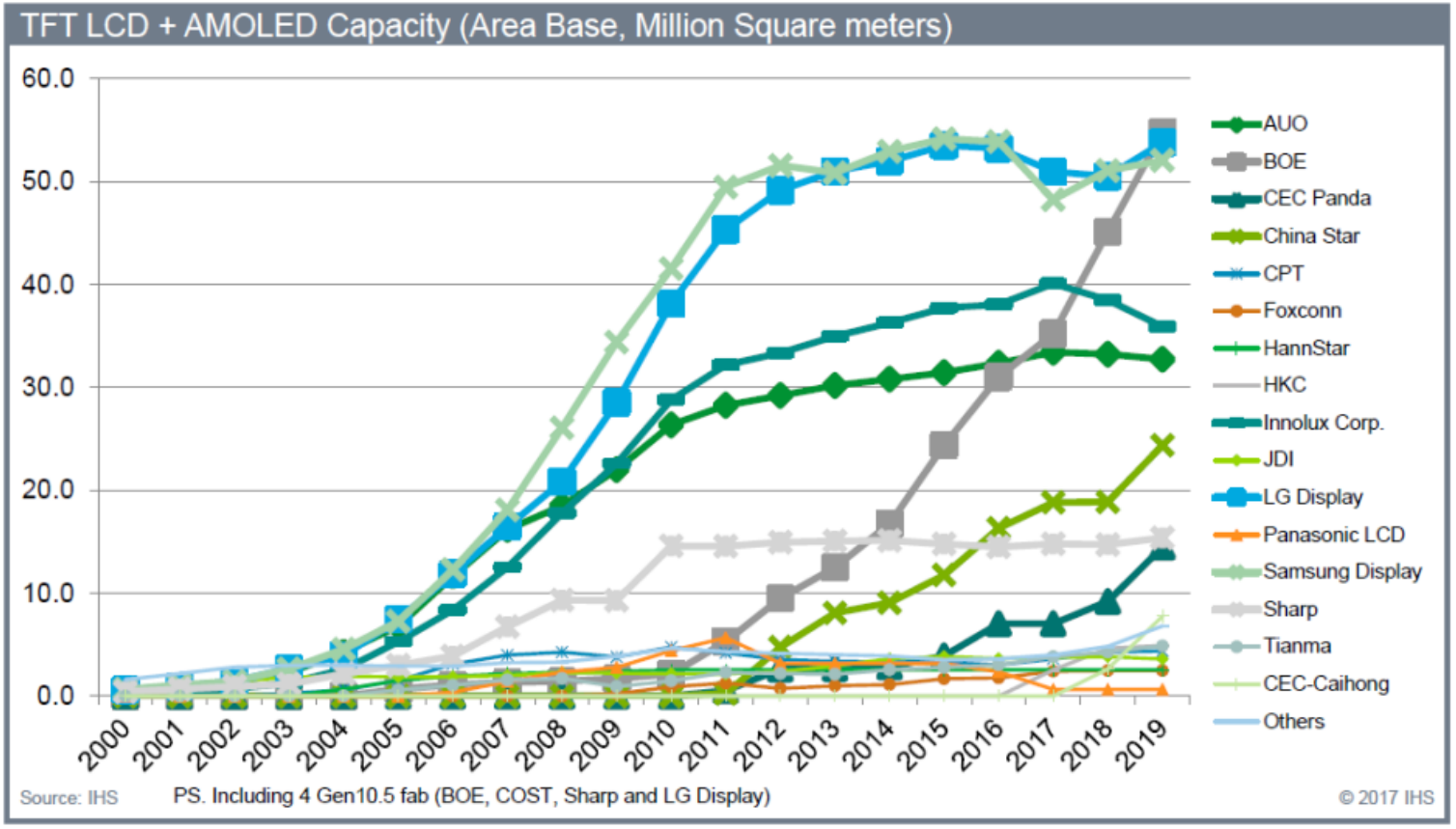


Property	Clear PI	TAC
Thickness (µm)	30	40
Light Transmission (%)	<90%	**>94%**
Birefringence R_{th} (nm)	135	**<10**
Haze (%)	~1	**<0.5**
Yellow Index (b*)	~2	**<0.07**
Cost, Supply Chain	High Cost	**~$1/m^2, Ubiquitous**

- TAC film gives best possible optical performance at a fraction of the cost of other flexible display technologies

Huge Capacity growth in China over past decade

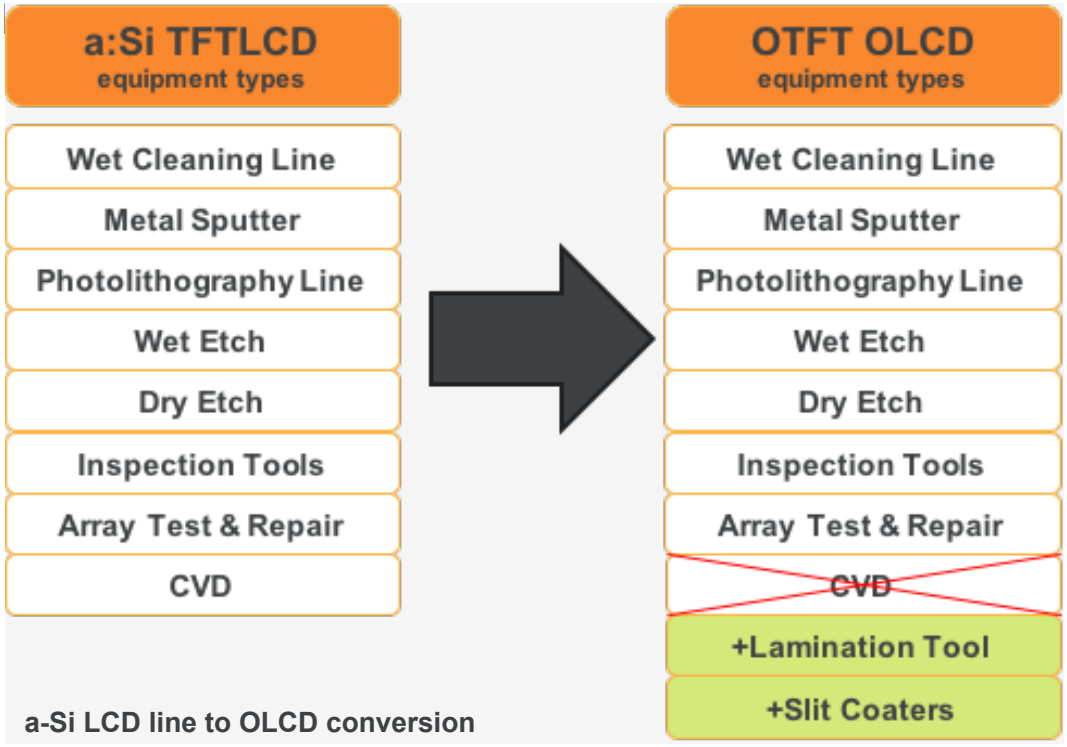
- Rapid growth of FPD Capacity in China – BOE to be #1 globally from 2019
- 230M m^2 of display production by 2021
- Several Gen 10.5 fabs under construction: CSOT: $6Bn project, 0.6M m^2 clean room



- Many older Gen 4/5 fabs now a decade old – fit for repurpose.

OLCD: Retrofit existing a:Si TFTLCD lines

- OLCD has been specifically designed to be retrofitted into existing a:Si TFTLCD lines
- The process uses nearly all of the same equipment, but CVD is not required – it is replaced



a-Si LCD line to OLCD conversion

- In many existing lines the process can be implemented / tested with almost no capex, in order to prove the process

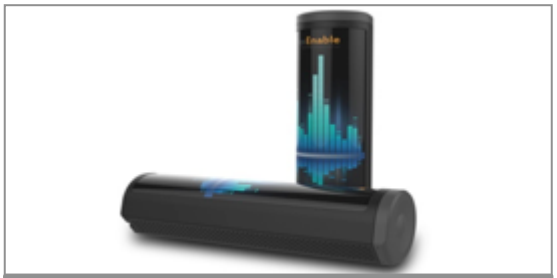
Partnering to bring OTFT Technology to displays and sensors

FlexEnable
OTFT platform

FlexEnable
Truly flexible electronics

Prototyping
(ProductEnable)

Tech transfer and
license
(FabEnable)



Product Companies

Production

TFT Fabs

Truly and FlexEnable sign License Agreement to bring low-cost, scalable flexible display production to China

Chuck Milligan, CEO of FlexEnable (left) and Dr James Wong, Chief Operation Officer (COO) and Group Executive Director of Truly (right)

- Truly and FlexEnable signed a technology transfer and license agreement in July 2017
- Truly Semiconductors is the first display maker to adopt OLCD
- Truly will implement the process into its existing production lines in Shanwei, China
- Volume production is expected in 2018

"FlexEnable's OLCD technology is a breakthrough in the TFT-LCD industry and with its characteristics of thinness, lightweight, and more durability it is going to create lots of possibilities for innovative product design. We have been receiving many enquiries for flexible display from the market, specifically, wearable devices, smart home appliances, electric cars and self-driving cars etc. This is a pretty exciting display technology and we do believe there is a considerable potential market size."

TRULY® 信利 Truly Semiconductors Ltd.

KK Ho, General Manager, R&D center, Truly Semiconductors Ltd

Summary

- OTFT is widely recognized as the best technology to enable **fully-flexible, low-cost** and ubiquitous displays and sensor arrays.
- **OTFT has already been transferred from Lab to Fab** – FlexEnable's technology is the only OTFT technology used in display manufacturing, and commercial products, today.
- We have in production a **mobility >1.5 cm^2/ Vs** (well beyond a:Si) – and this is continually increasing
- OTFT today has **better stability than a:Si**, and **excellent uniformity** – key to achieving low cost manufacturability.
- **Fundamental and broad IP portfolio** with key patents that enables low-temperature processing of OTFTs on plastic, and brings a step-change in OTFT stability
- These technology advantages drive an exciting roadmap with ever-improving performance, **large area flexible displays**, decreasing cost and new applications

Thanks!

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