Sensors integrated in displays

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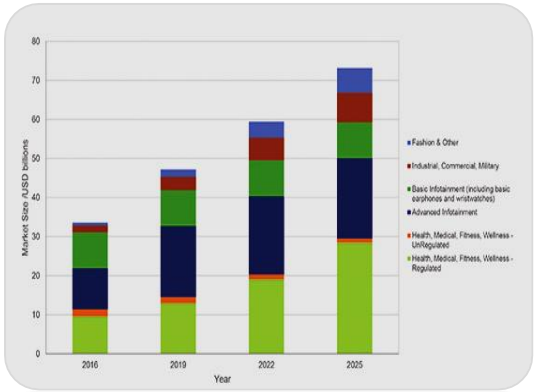

- Technology scouting
- Company profiles
- Market forecasts

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- Custom research
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Show!

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- Berlin, Germany
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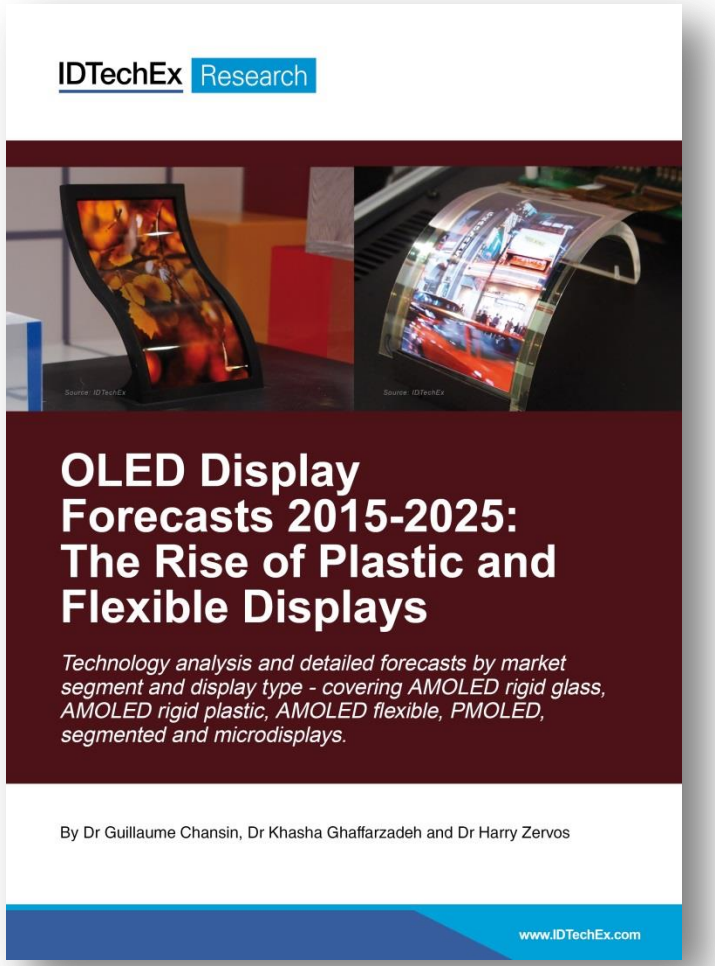
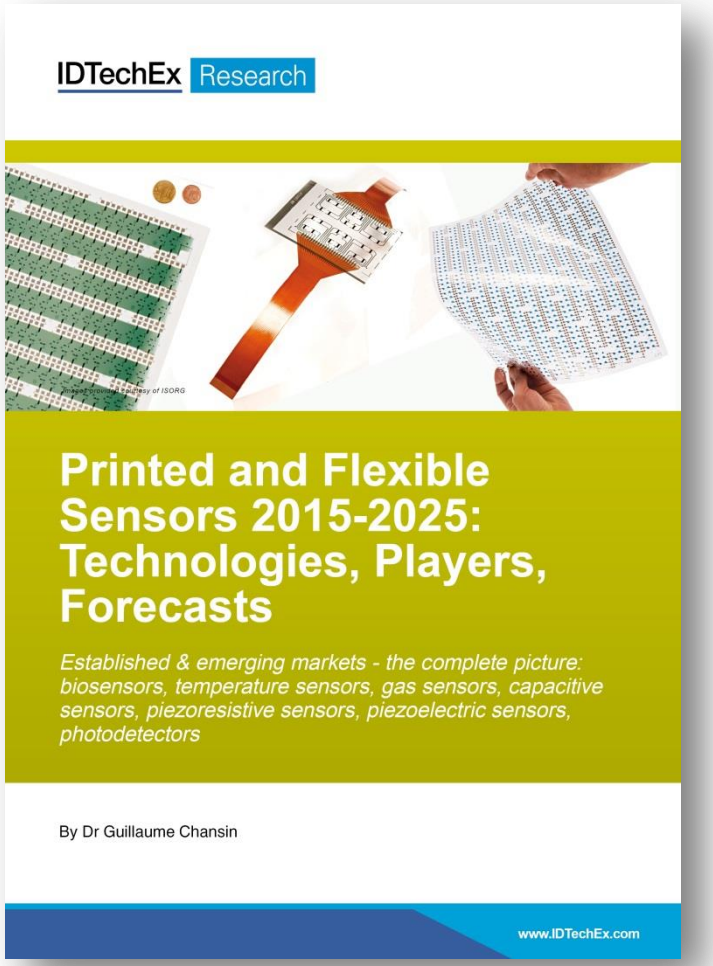
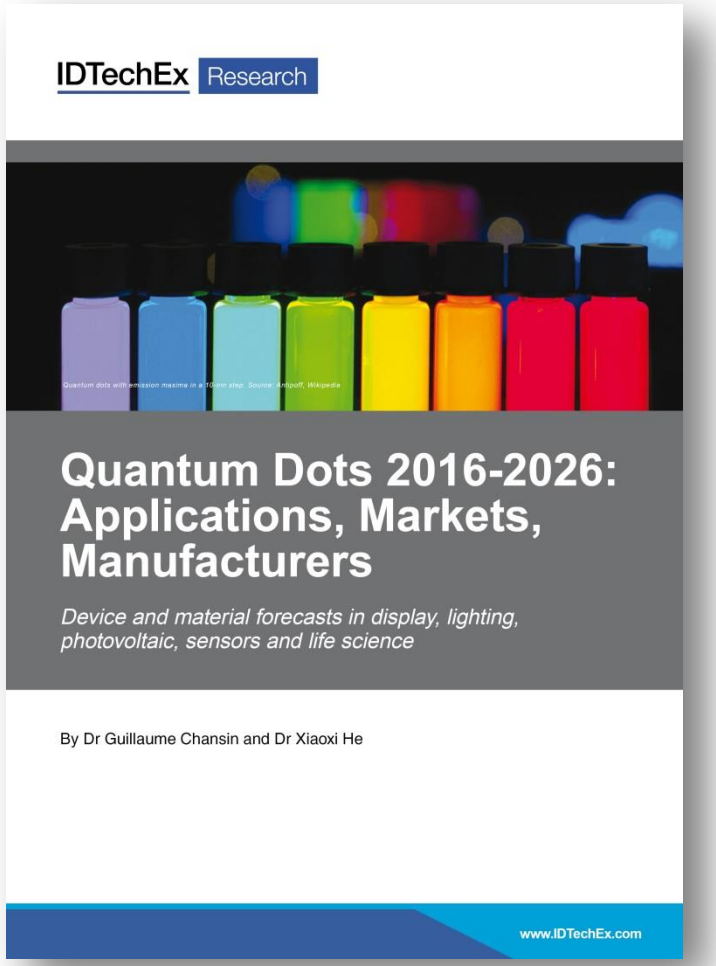
Examples of recent reports







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Sensors are already common in displays

- FOR DYNAMIC ADJUSTMENT
  - Ambient light sensors
  - Proximity sensors
- FOR USER INPUT
  - Capacitive touch
  - Stylus digitizer
  - Camera (scroll)

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Using existing sensors to create new apps

- Example: Touchcode is a printed tag read by the capacitive touch sensor
- Example: force sensor can be used to weigh objects (not just oranges)

Photo: GigaOm

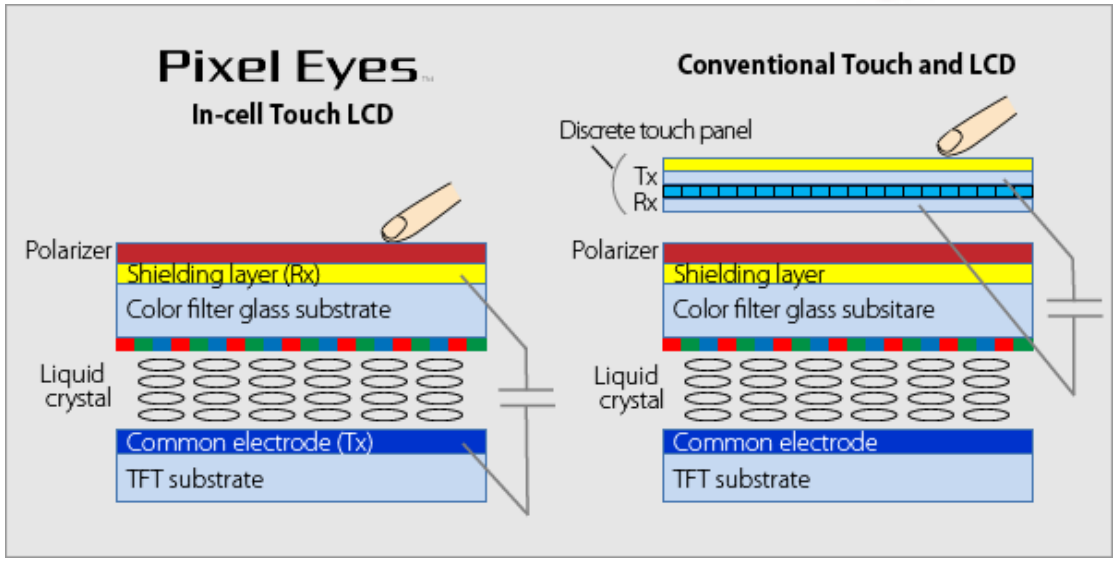
Source: Twitter

Why integrate more sensors?

- The display is becoming the most important platform for integrating new sensors
  - Prime location and large area
  - Need to complement Capacitive Touch
  - Thinner bezel means less space around the display for sensors

Source: Canopy

- Way to avoid commoditization
  - Differentiation
  - Add value as a full solution provider (eg: integration of touch sensor in display)

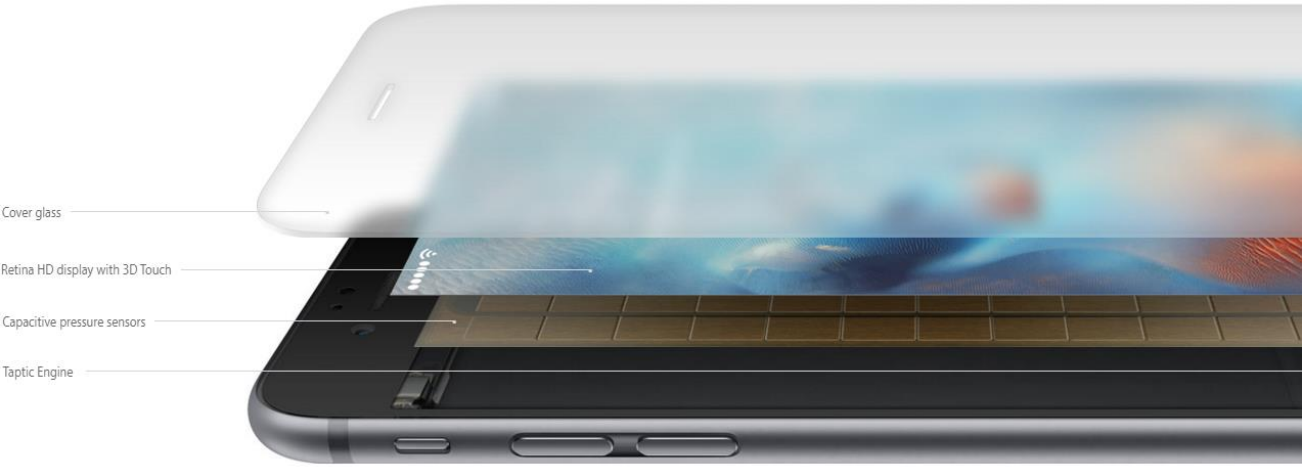


Source: JDI

Force sensing made popular by Apple

- iPhone 6S has force measurement (capacitive sensor behind the LCD backlight)
- Apple Watch and MacBook also come with a force sensor

Source: Teardown.com



Source: Apple

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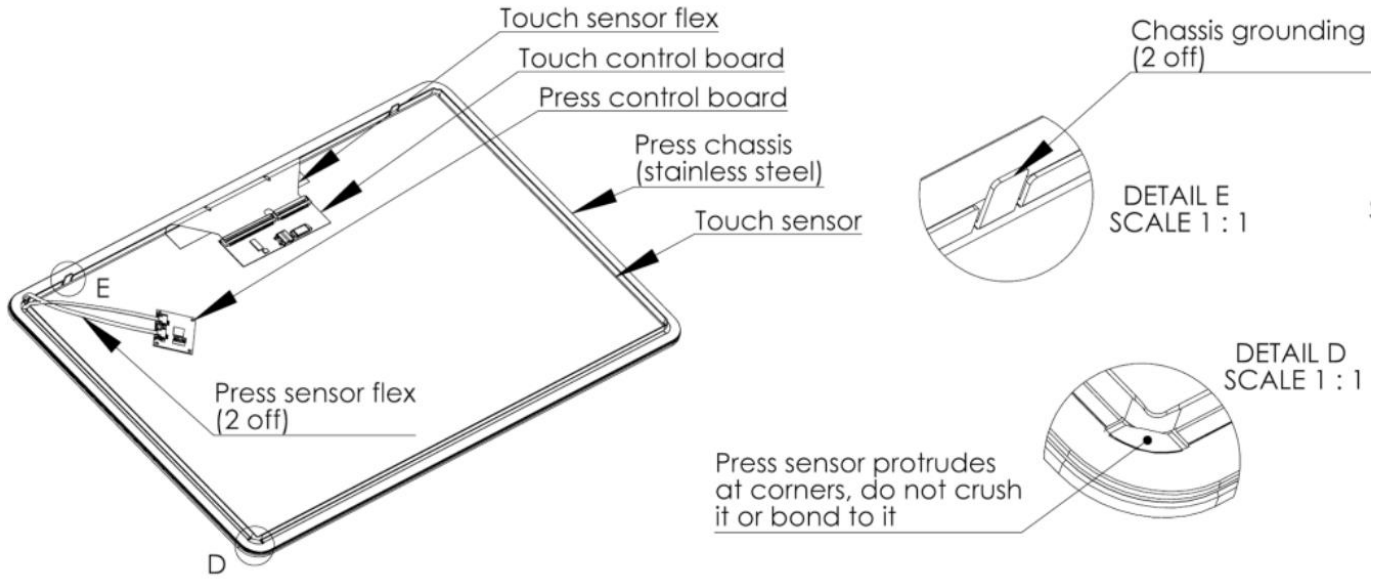
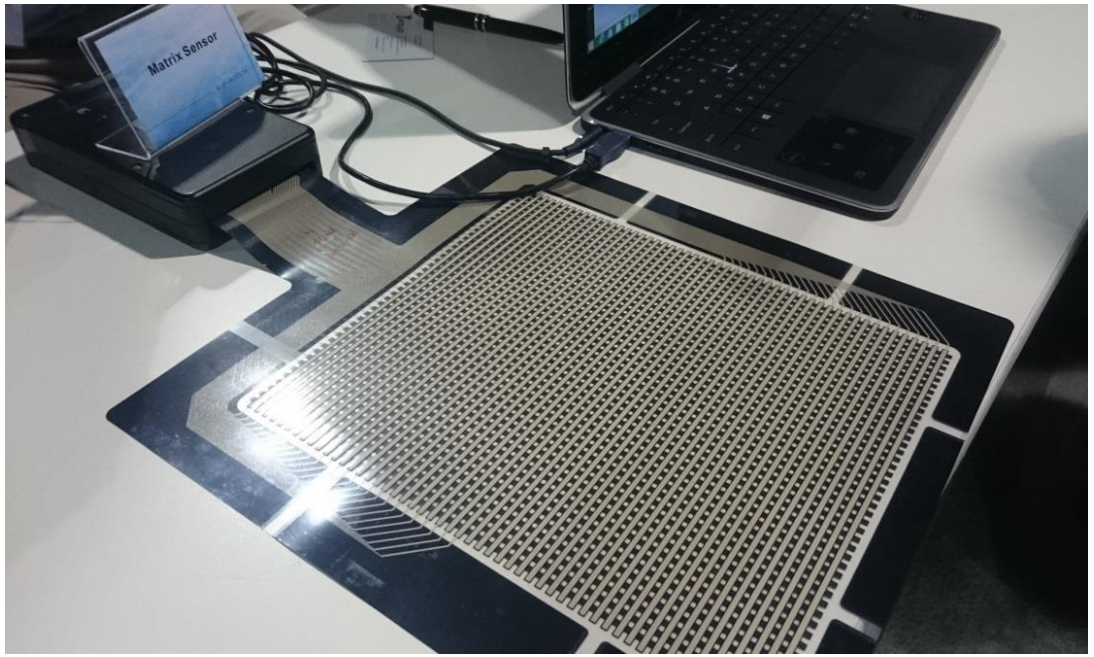
Various ways to add force sensing

- Capacitive sensor
- Strain gauge
- Force sensing resistors



Source: Touchnetix



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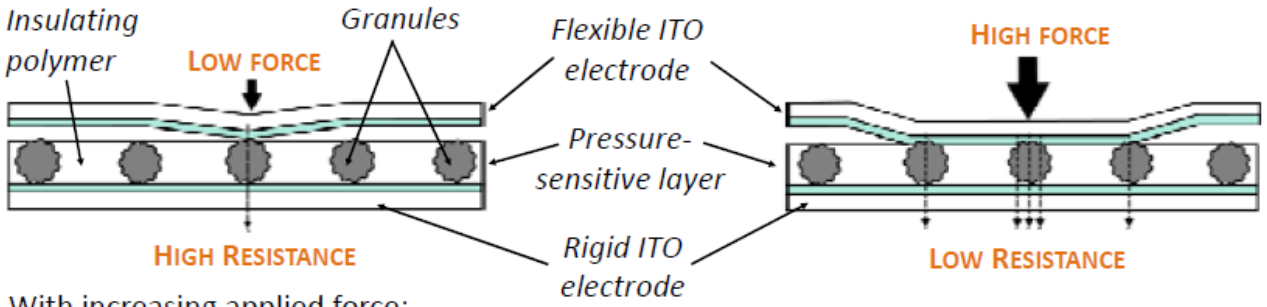
Transparent FSR

Inclusion of Pressure-Sensitive Nanocomposite Layer

The layer comprises is formulated as a **functional ink**, which comprises:

- Transparent electrically insulating polymer
- Semi-conductive pressure sensitive nanocomposites (**granules**)

The ink is **screen-printed** directly onto the lower ITO electrode at a thickness of 7 – 10 µm.



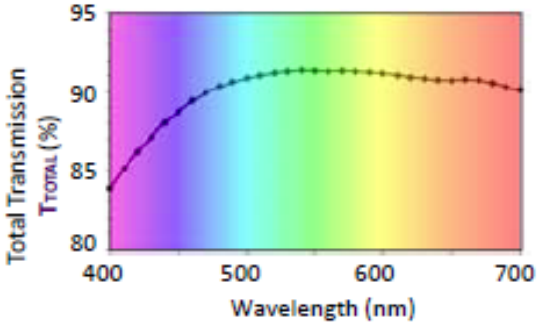
With increasing applied force:

- The upper ITO electrode contacts an increasing number of granules
- The granules are compressed and their internal resistance decreases

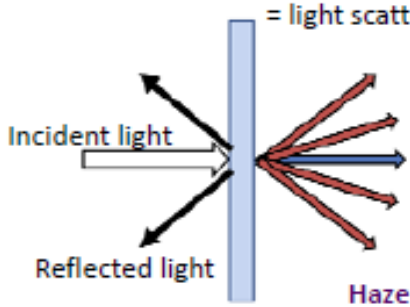
This results in a **decrease in resistance** through the layer **with increasing applied force**.

Optical Properties of Touchscreen

Transmission profile for typical touchscreen with pressure-sensitive layer.



Wide angle scattering ($T_{DIFFUSE}$) = light scattered outside 2° cone



$$\text{Haze} = \frac{T_{DIFFUSE}}{T_{TOTAL}} \times 100\ \%$$

Touchscreen	Composition	Average Granule Size	T_{TOTAL} at 550 nm	Haze
A	0.2 % granules (spherical nanoparticles)	5.9 µm	91 %	1.2 %
B	0.4 % granules (spherical)	6.9 µm	90 %	3.1 %
C	0.2 % granules (acicular)		90 %	1.7 %
Control	0.2% spherical nanoparticles	-	90 %	1.8 %

[2]

Haze increases with:

- Increasing granule proportion in layer
- Acicular constituent nanoparticles
- Ungranulated constituent nanoparticles

Industry standards:
Haze < 2% (for high-end applications such as smart phones and tablet touchscreens)
Transmission > 85%

Source: Durham University,

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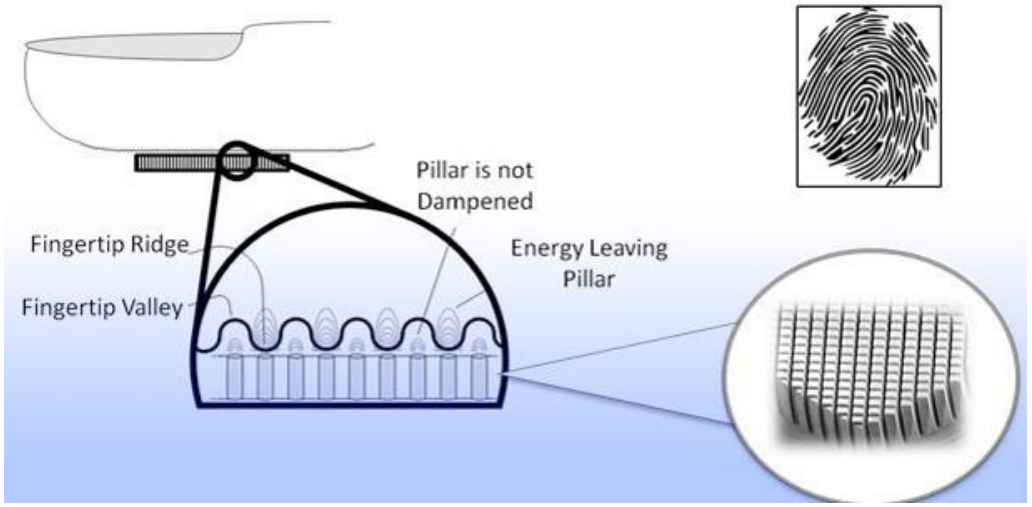
Biometric sensing

- Display as a fingerprint sensor
- Can enhance User Experience
- Technologies:
  - Capacitive
  - Ultrasound
  - Infrared



Source: Sonavation

Synaptics Demonstrates Fingerprint Authentication Through Greater Than 200µm Smartphone Cover Glass

Second Generation Under Glass Biometrics Solution Enables Button, Button-Free Mobile Devices

SAN JOSE, Calif. – Nov. 17, 2015 – Synaptics Incorporated (NASDAQ: SYNA), the leading developer of human interface solutions, today announced sampling and a live demonstration of its Natural ID fingerprint authentication technology under greater than 200µm cover glass, addressing the option of button-free industrial designs for smartphones. This versatile new fingerprint sensor solution is designed to operate through glass buttons as well as thicker cover glass. Synaptics' under glass fingerprint solution is a significant advancement and a critical next step to putting capacitive fingerprint sensors under the smartphone cover glass. Synaptics will demonstrate this new technology at its Analyst and Investor Meeting on November 17, and at CES in January 2016.

Source: Synaptics

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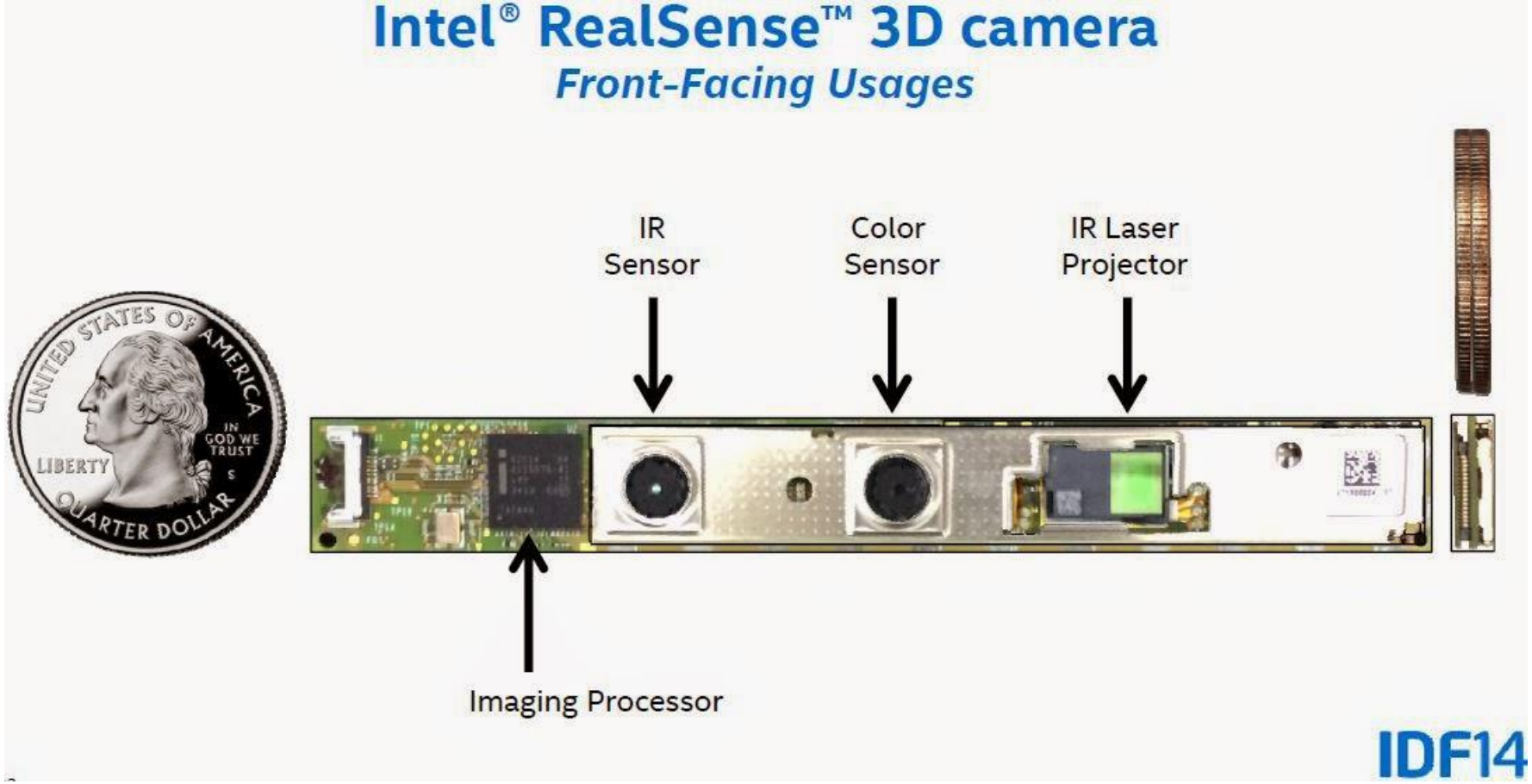
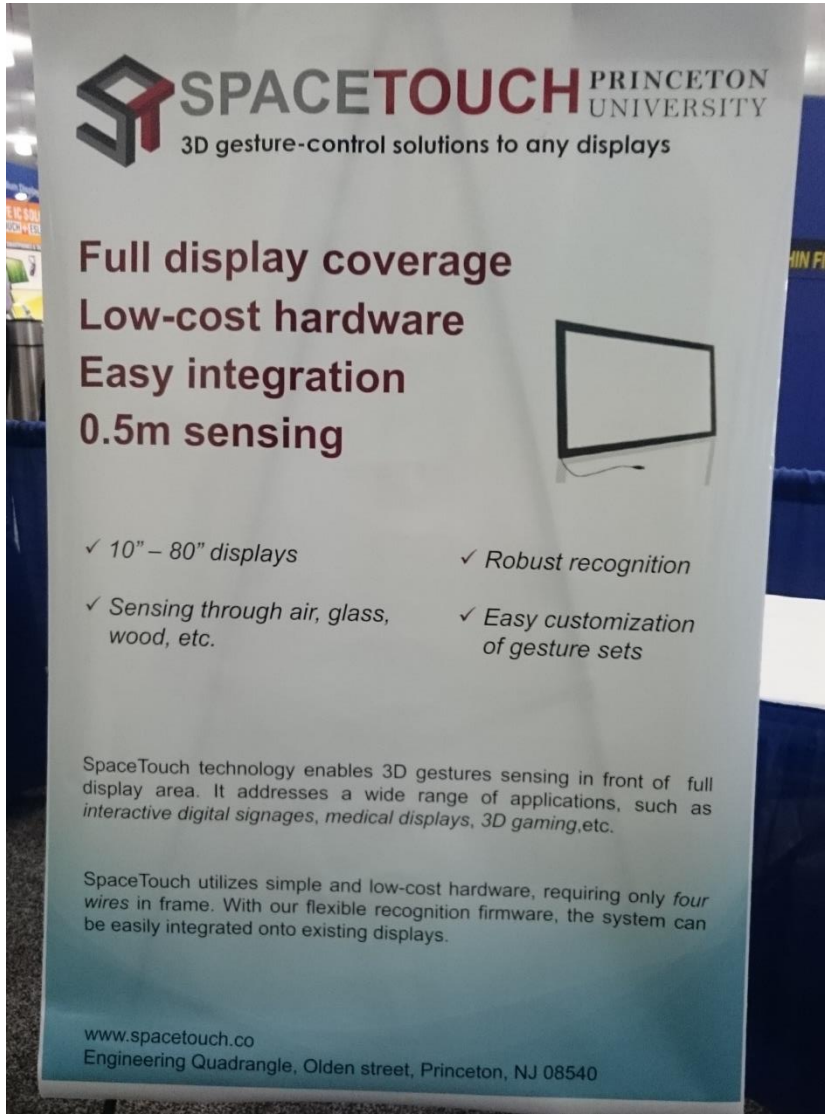
Depth sensors

- Microsoft Kinect
- Intel RealSense
- Google Project Tango

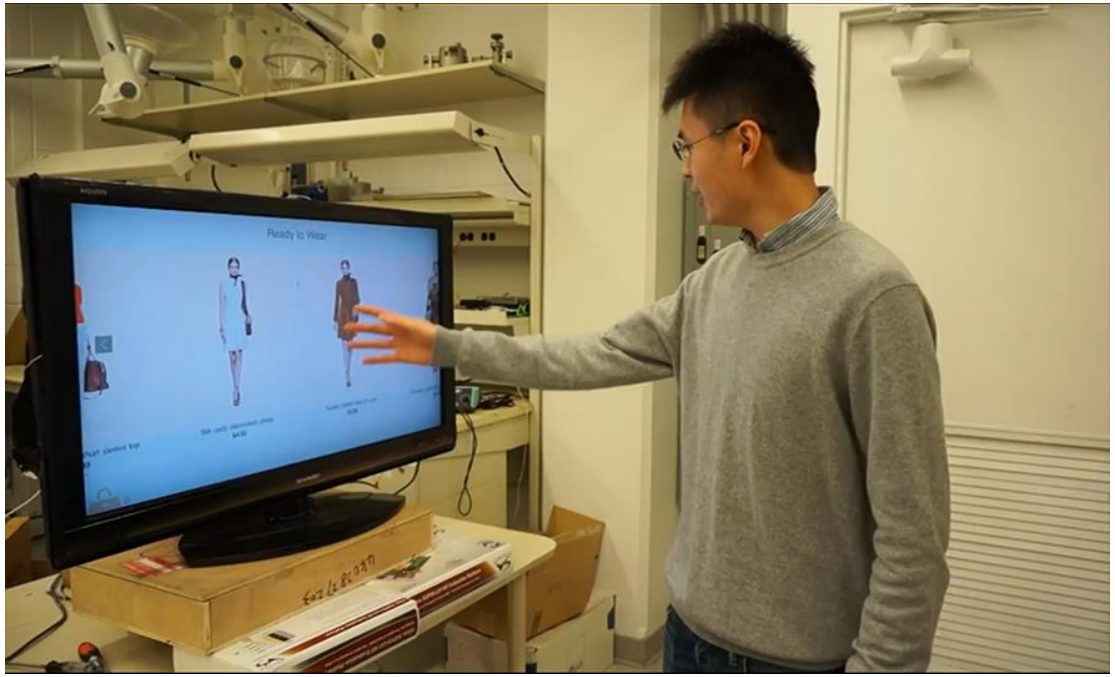


Source: Intel

Gesture recognition without cameras



- Spin out from Princeton
- SID iZone in 2015
- Uses thin sensing frame with 4 copper wire electrodes



Source: Spacetouch

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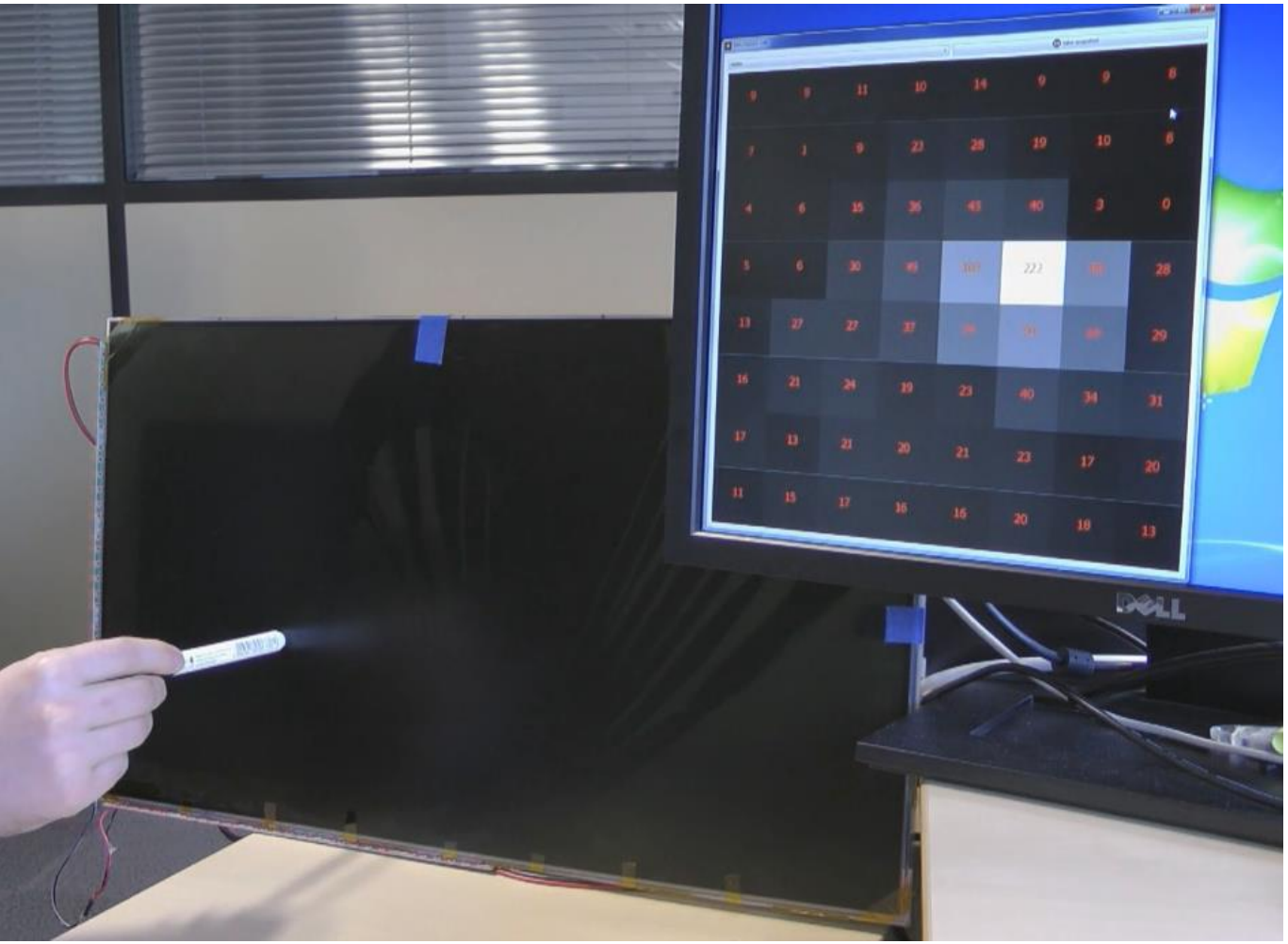
Photodetectors integrated in display



Source: ISORG

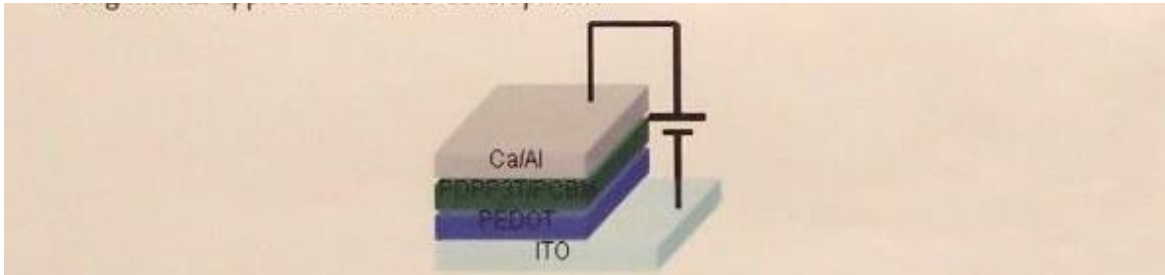


Figure 1. Schematic cross-section of OPD device

2.2 The Characterization of OPD Devices:

- Figure 2 is the external quantum efficiency (EQE) analysis for the NIR device using PDPP3T material served as active layer.
- It is found that the device has an obvious absorption the near-infrared (NIR) absorption spectrum (from 0.7um to 3um). The EQE in the NIR spectrum can be up to 60% which is superior to published OPD device.
- It is potential for PDPP3T material for longer wavelength absorption application, and not sensitive to the visible light. The operation of OPD sensor can only designed for the specialized wavelength used.

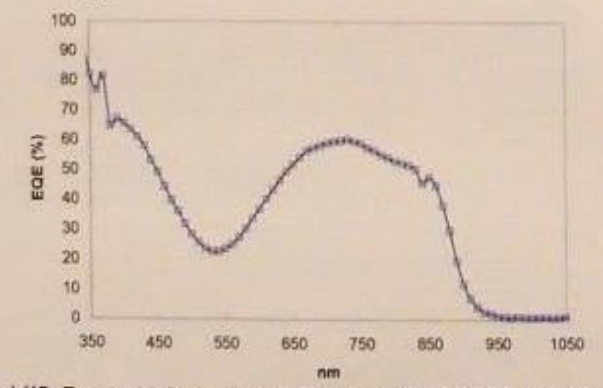


Figure 2. NIR External Quantum Efficiency of PDPP3T devices.

Source: AUO

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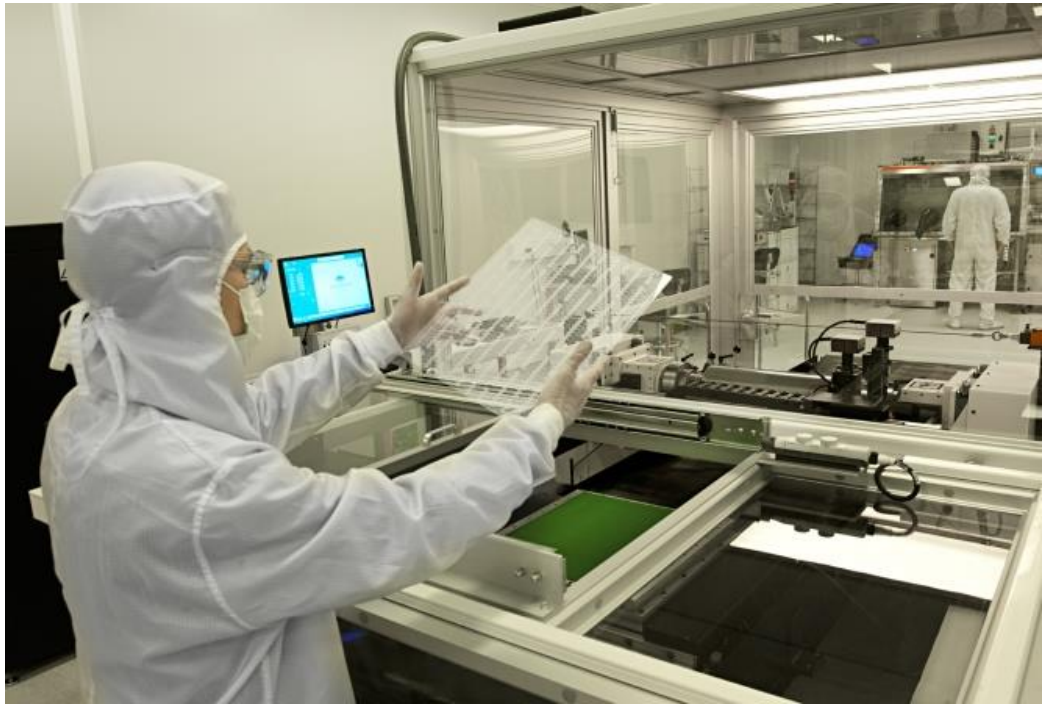
First production line for organic photodetectors

- ISORG has developed the manufacturing process
- Raised €7.9 million to build first production line in Limoges, France
- Production to start in 2017
- Capacity of 120,000 m^2/year
- Visible and Infrared detection



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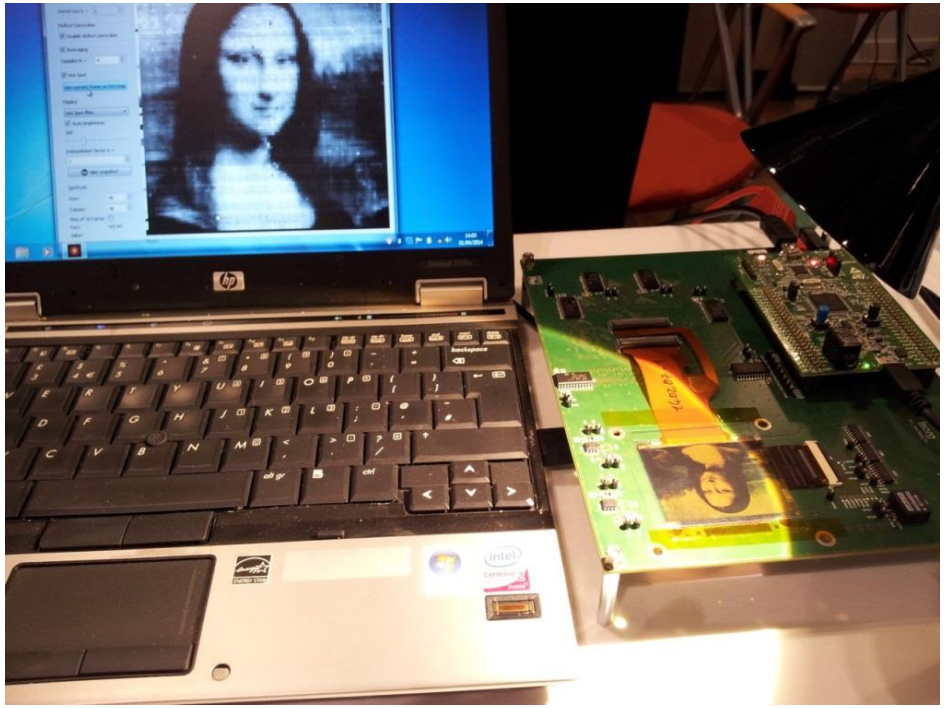

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Bidirectional display

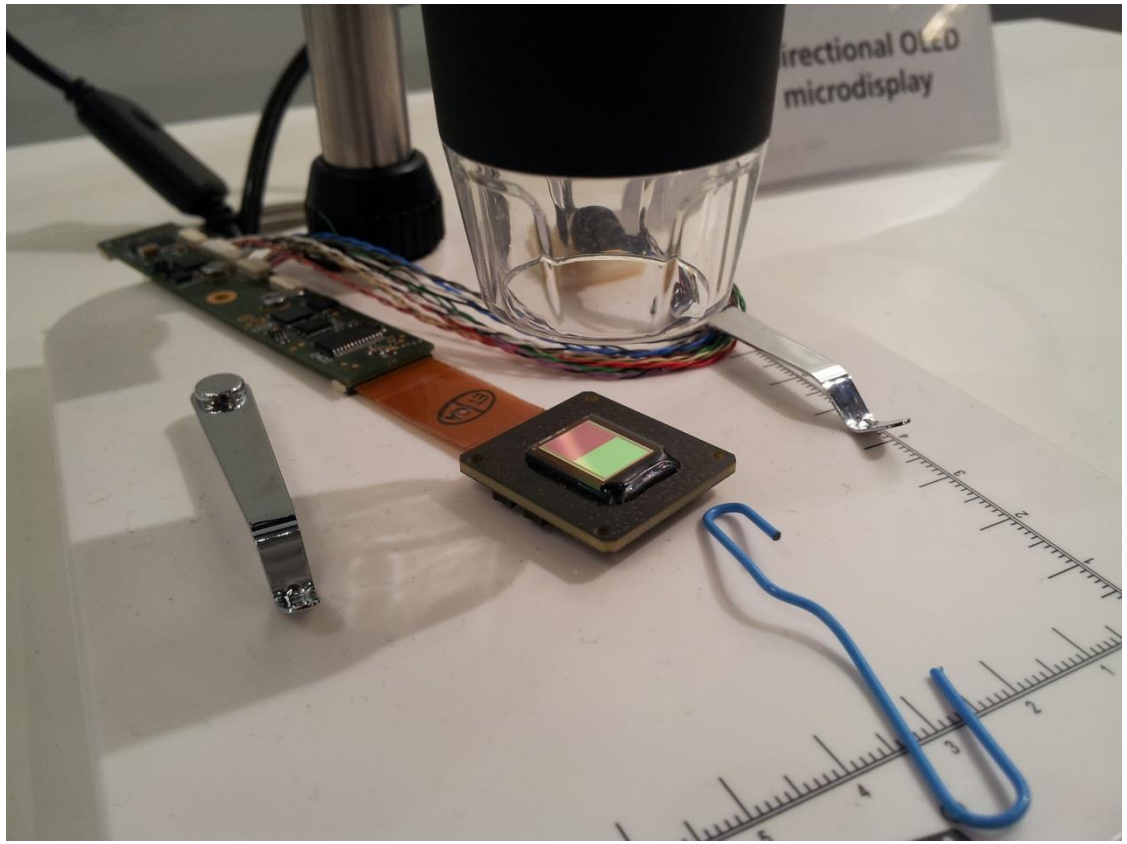

Photo: IDTechEx

- Fraunhofer COMEDD have fabricated a bidirectional OLED microdisplay
- Displays and captures images at the same time
- Example: eye tracking

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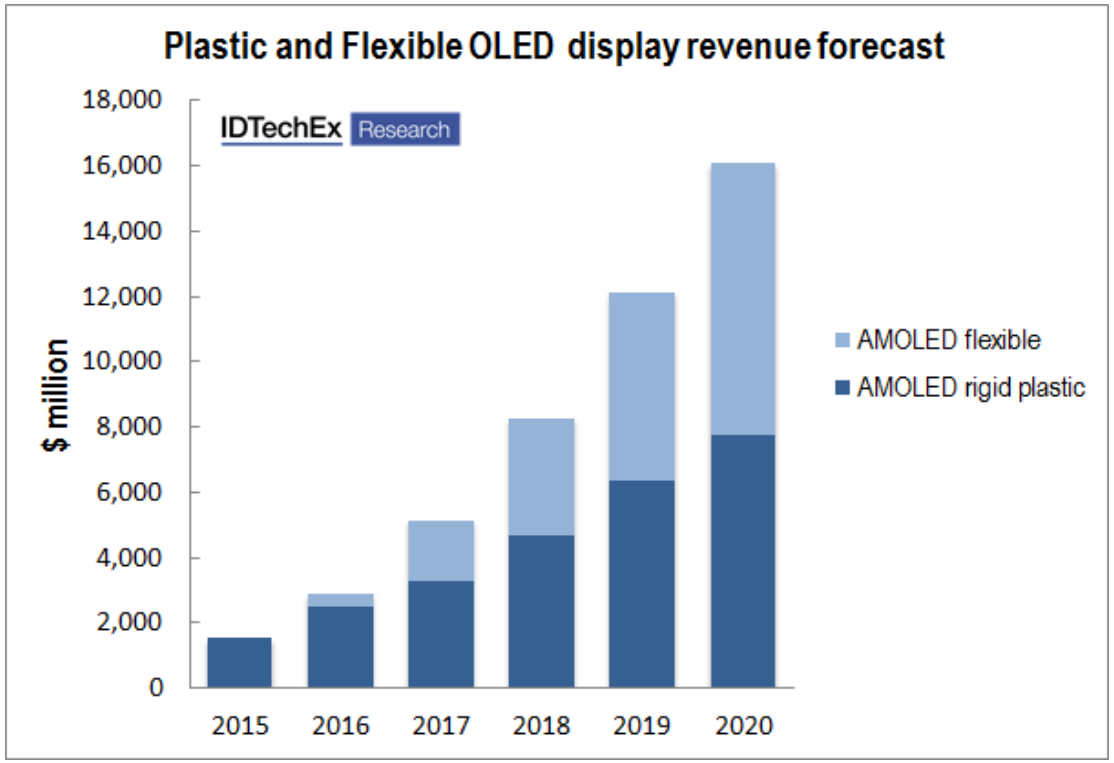
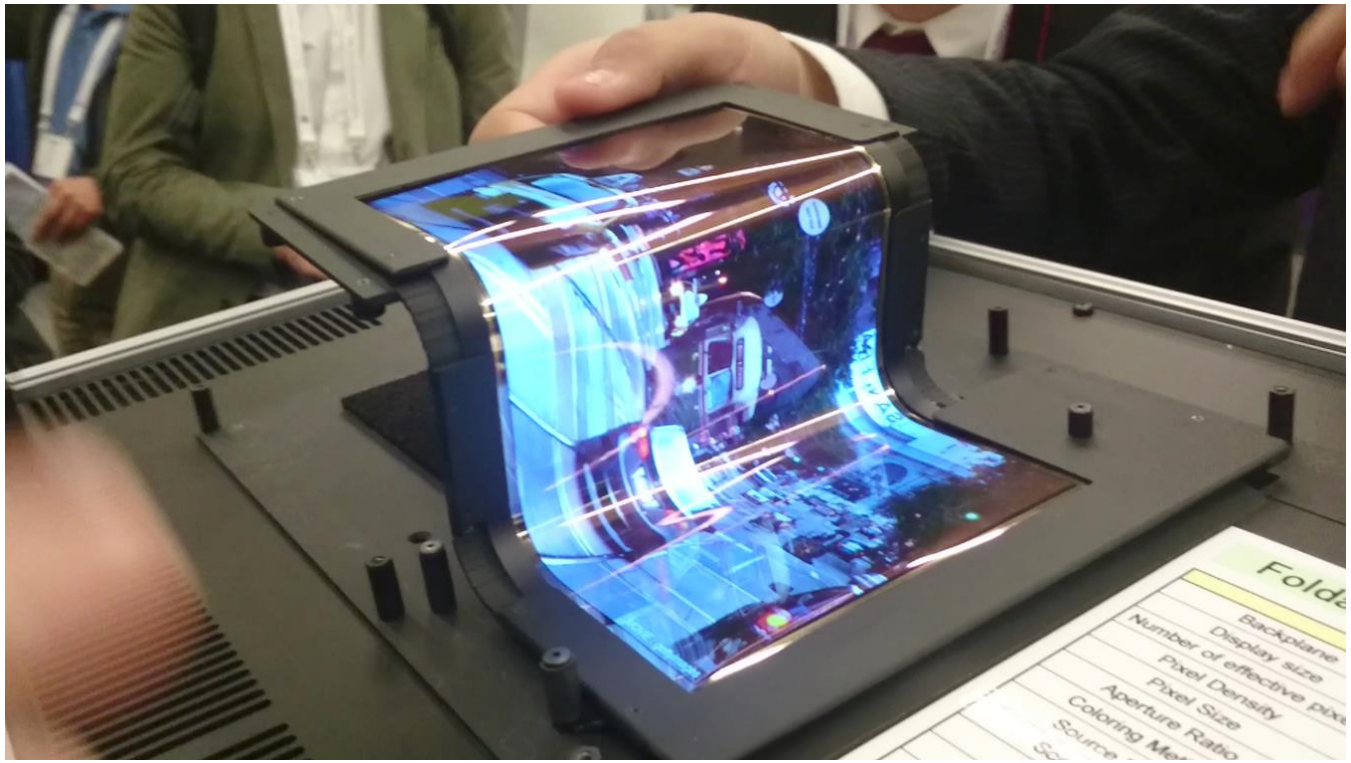
Sensors with OLED displays: main differences

- No backlight
- Risk of burn in
- Can be a transparent display
- Can be flexible





Source: IDTechEx report
"OLED Display Forecasts 2015-2025: The Rise of Plastic and Flexible Displays "

Photo: G. Chansin

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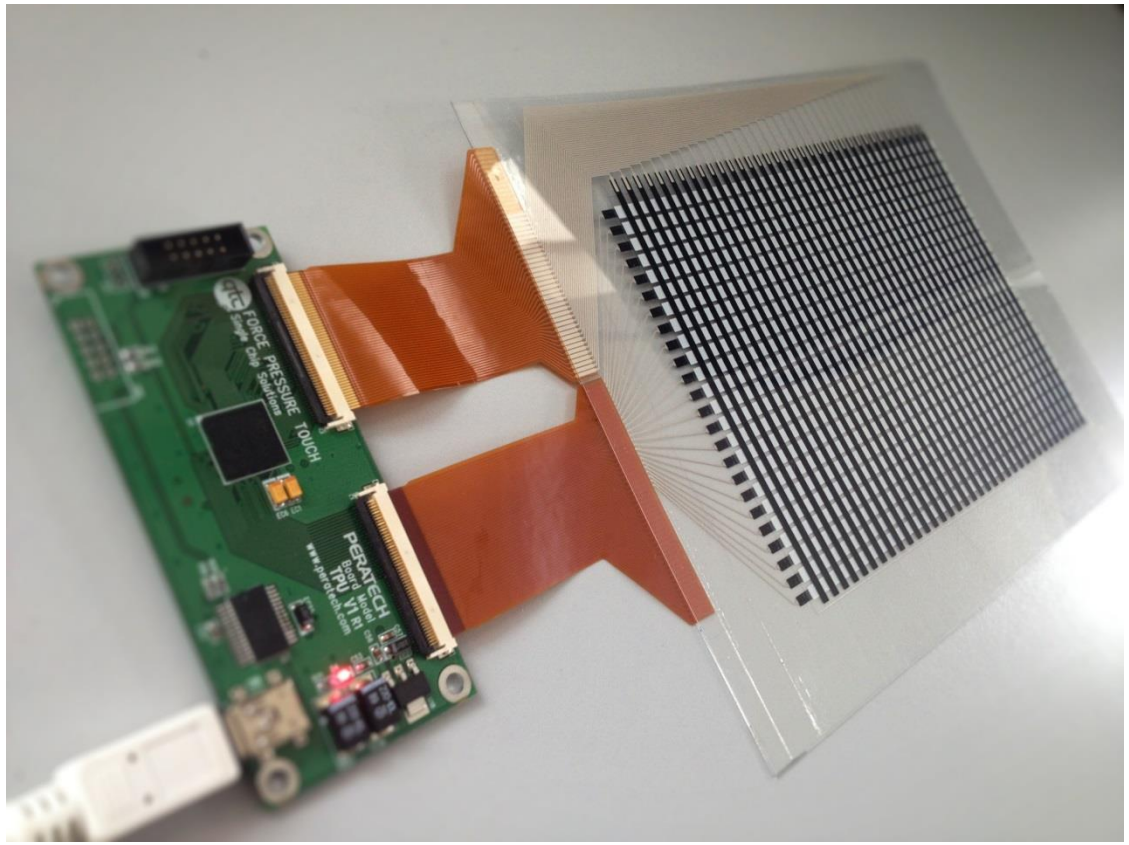
Sensors for flexible displays

Source: Human Media Lab



Source: Peratech

Piezoelectric sensor

- In 2014, the Pyzoflex team and Microsoft Research developped a concept called FlexSense

- “FlexSense is a self-contained device made of a thin and transparent sheet onto which 16 piezoelectric sensors have been printed. The researchers created two algorithms to measure and reconstruct the bending of the sheet using the sensors. They then gave potential applications of FlexSense, such as switching between two different layers of an image, hiding information, mimicking a flip book and controlling a video game character.”

Source: Youtube

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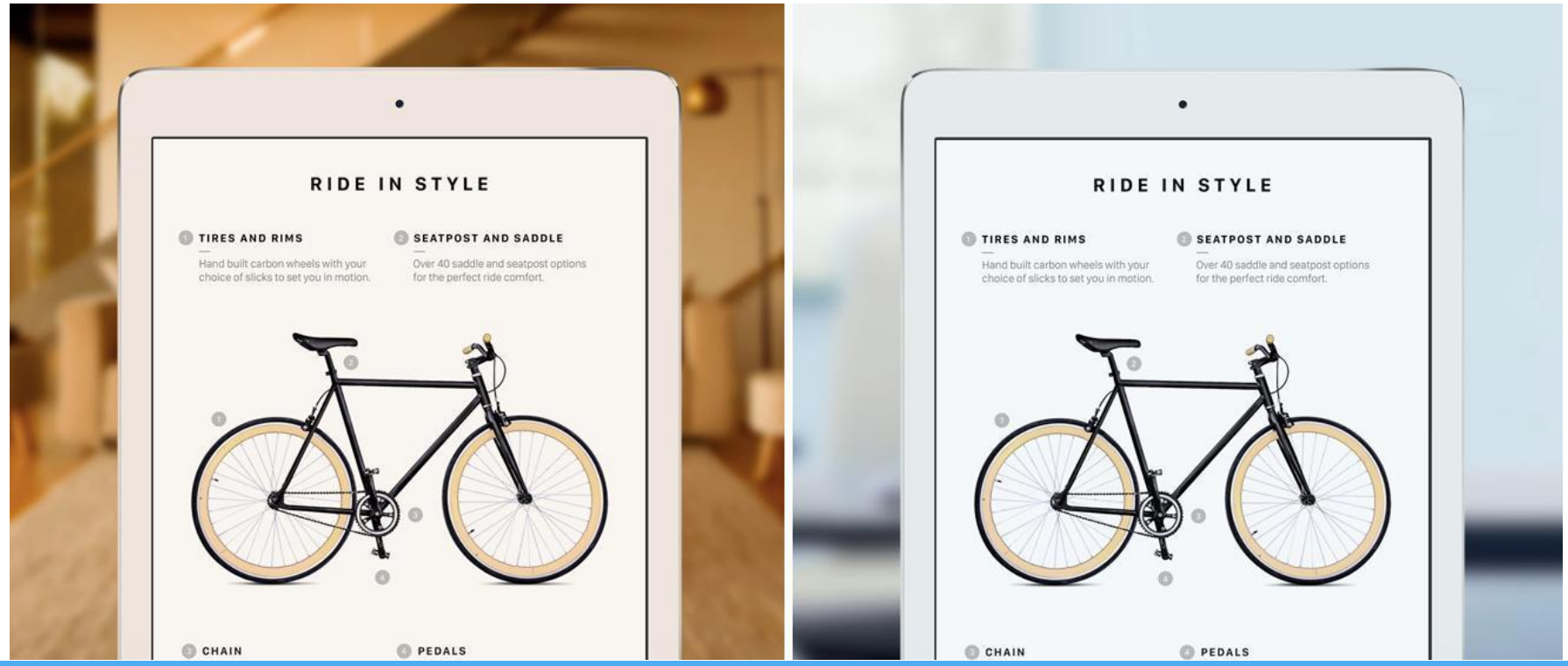
Color accuracy

- New iPad Pro 9.7” has True Tone display
- “It uses advanced four-channel ambient light sensors to automatically adapt the color and intensity of the display to match the light in your environment.”



Source: Apple

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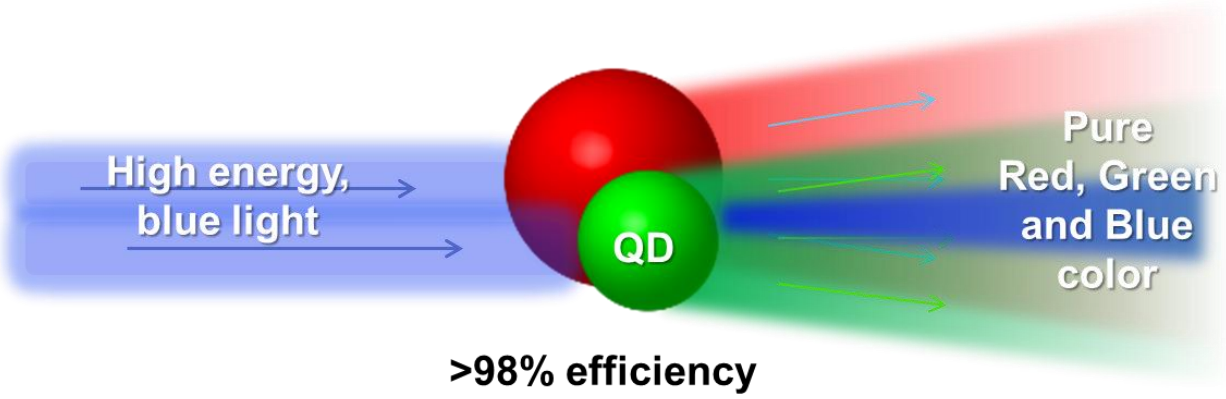
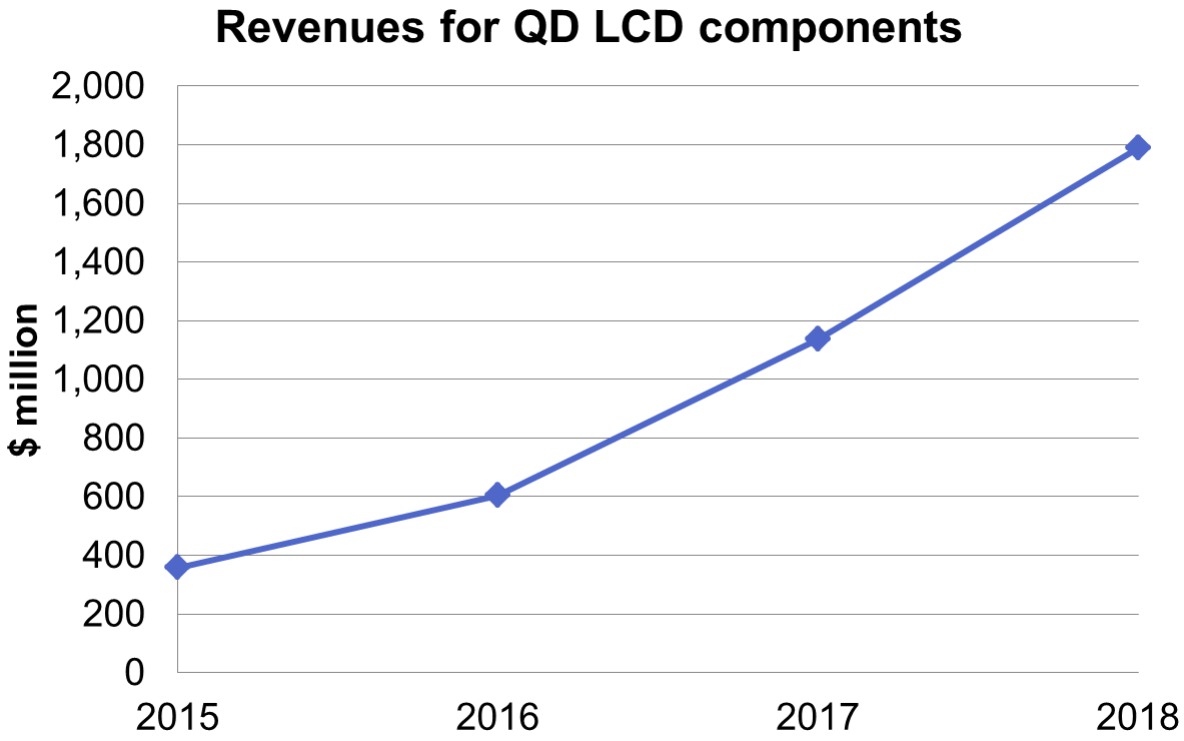
Color correction with quantum dots

- Quantum dots can dramatically increase the color gamut
- This can be used to compensate for ambient light



Source: QD Vision



Source: IDTechEx report
"Quantum Dots 2016-2026: Applications, Markets, Manufacturers"

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Summary

- Many sensors can be integrated on a display

- What will they be used for?
  - User input
  - Automatic brightness/color adjustment
  - Interaction with other objects/devices
  - Identification (biometric)
  - Pixel compensation

- New possibilities with flexible displays and wide color gamuts

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