

IDTechEx

Printed Electronics Markets, Technologies and Trends

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About IDTechEx

Emerging Technology **insight**, **intelligence** and **networking**, helping clients with their critical strategic business decisions.

Areas of coverage:

- Printed Electronics
- Emerging Materials & Devices
- Energy Harvesting
- Energy Storage
- Hybrid & Pure Electric Vehicles
- 3D Printing
- New Mobile Phone Technologies
- RFID and IoT
- Wearable Technology

Global and timely analysis through:

- **Subscriptions**
 - IDTechEx Market Intelligence Portal
 - Weekly market, technology and company assessments
- **Research Reports**
 - Over 70 detailed current studies
- **Custom Consulting Projects**
 - Over 300 conducted
- **Global Events**
 - Held in 3 continents
- **Free Web Journals**
 - e.g. www.PrintedElectronicsWorld.com

With bases in the **US**, **UK**, **Germany** and **Japan**, IDTechEx has served clients in **80 countries since 1999**.

Global Series of Tradeshow and Conferences on Emerging Technologies

The image features a stylized world map with three callout boxes, each representing a trade show event. Each box contains a list of emerging technologies and the event's details.

- USA:** Green callout box. Topics: ENERGY HARVESTING & STORAGE, Internet of Things & WSN, SUPERCAPACITORS, 3D Printing LMB, Graphene LIVE! Event: Printed Electronics USA, November 19 - 20, 2014, Santa Clara, USA, www.PrintedElectronicsUSA.com
- Europe:** Blue callout box. Topics: ENERGY HARVESTING & STORAGE, Internet of Things & WSN, SUPERCAPACITORS, 3D Printing LMB, Graphene LIVE! Event: Printed Electronics EUROPE, 1 - 2 April 2014, Berlin, Europe, www.PrintedElectronicsEurope.com
- Asia:** Red callout box. Topics: ENERGY HARVESTING & STORAGE, Internet of Things & WSN, SUPERCAPACITORS, 3D Printing LMB, Graphene LIVE! Event: Printed Electronics ASIA, 3-4 September 2014, Tokyo, Japan, www.PrintedElectronicsAsia.com

The Value Chain: Printed, Flexible & Organic Electronics

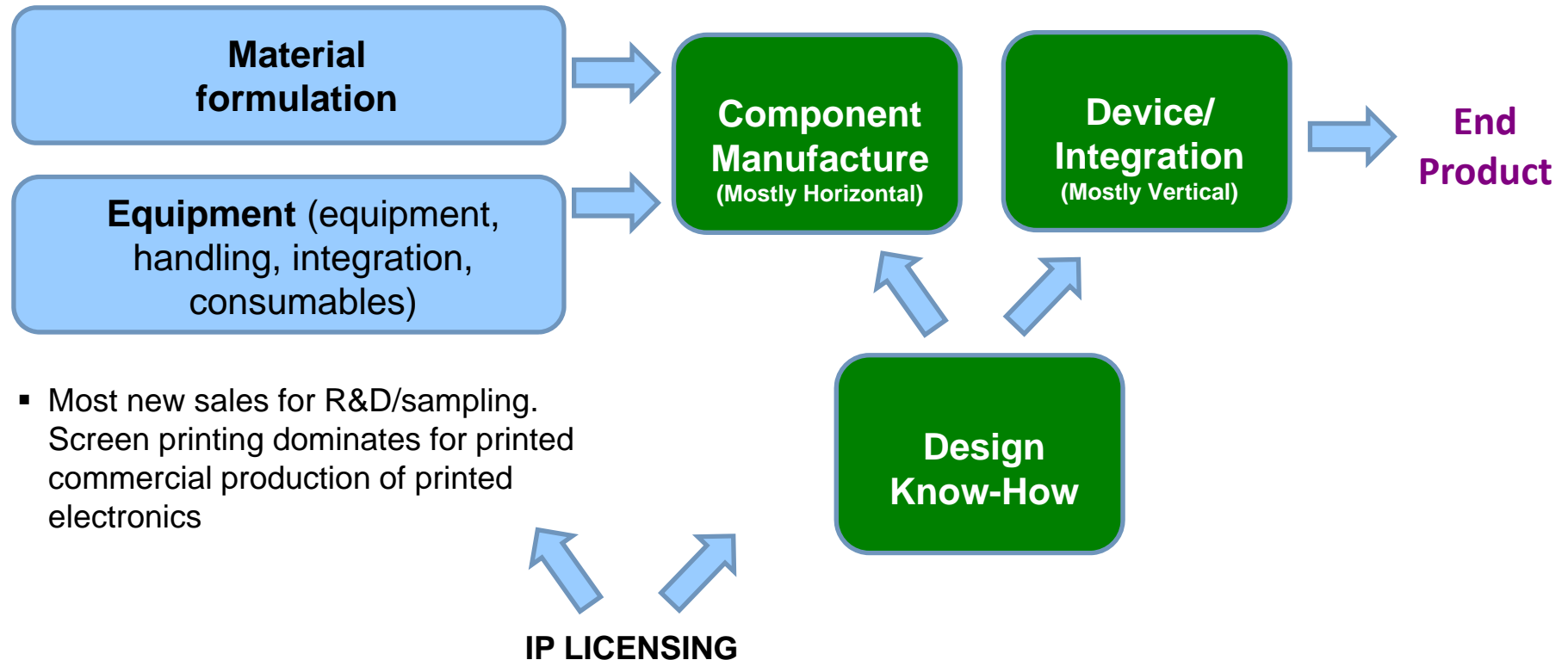
Enabling Technology Supply

TYPICALLY HORIZONTAL

- High, long-sighted investment

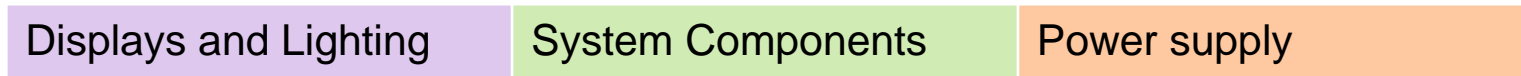
Product Creation

- High levels of investments made
- Few profitable companies today



Current Market Status

Very different points of maturity, revenue, profitability and growth



← Not yet profitable → ← Largest suppliers are profitable →

Below \$50 Mn			\$50Mn to \$1Bn			> \$1 Bn		
OLED Lighting	5+	\$15Mn	E-paper displays	15	\$270Mn	OLED Displays	15+	\$10 Bn
Electrochromic Displays	12+	<\$1Mn	AC EL displays	20+	\$120Mn	20% CAGR 2013-2018		
Logic & memory	10+	<\$1Mn	Sensors	10+	\$400Mn	Conductive ink	15+	\$1.8 Bn
OPV, DSSC	10+	<\$1Mn				5% CAGR 2013-2018		
Printed/thin film batteries	15+	<\$10Mn						

>40% CAGR 2013-2018

Shakeout/consolidation

Years of development
2013 data from IDTechEx

Progress with OLED Displays

Many LCD panel makers became unprofitable

To differentiate, they trend to 3D TV, higher definition TV... and OLED

1. Cell phone displays: 2010 onwards
 2. TV: 2013 onwards but slow ramp up
 3. Printed TVs: 2015...? Increasing barriers to entry
- Repurpose aSi plants with MOTFT
 - New alliances e.g. Samsung-Sharp
 - Printing is challenging – resolution, yield etc
 - Strong differentiation need e.g. launch of curved displays. Working on conformal then flexible.
 - “Simple” displays are not the focus – despite demand
 - Taiwan - out? Japan – can it compete? Korea – currently leading? China – the new Korea?

Source: IDTechEx report “**Printed, Organic & Flexible Electronics 2013-2023**” www.IDTechEx.com/PE

Metal based Conductive Inks

Silver flake inks remain dominant (>99%)

PV biggest contributor, but with consolidation (Heraeus Precious Metals buys Ferro ink business).

Touch screen and automotive have provided growth in flake ink market

High silver cost fuelled search for alternatives – particularly copper. But cost proposition has weakened as silver falls from 45\$/oz in April 2011 to 20 \$/oz in late 2013.

Sluggish silver NP demand. Need user validation that high conductivities lead to less material and low cost. Many large companies at point of launching into market.

Source: IDTechEx report “**Conductive Ink Markets**” www.IDTechEx.com

Printed and Organic Sensors

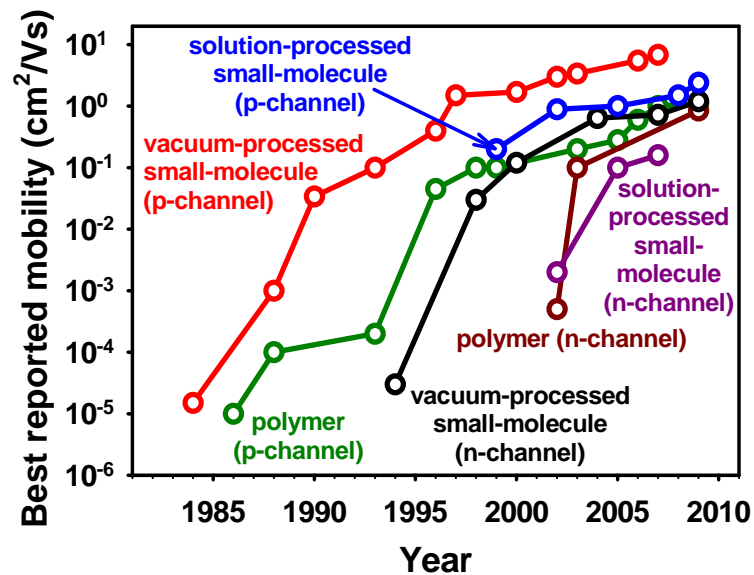
- Printed blood glucose test strips: already a \$6 billion market today (mainly carbon and some silver ink)
- Emergence of organic optical sensors: hybrid CMOS image sensors will combine organic layers with CMOS silicon to out-perform normal CMOS sensors (higher sensitivity and better dynamic range).
- Key drivers for printed and flexible sensors: smartphone sensors, touch interfaces and thin form factors

Hot Sectors: ITO Alternatives (Transparent Conductive Films)

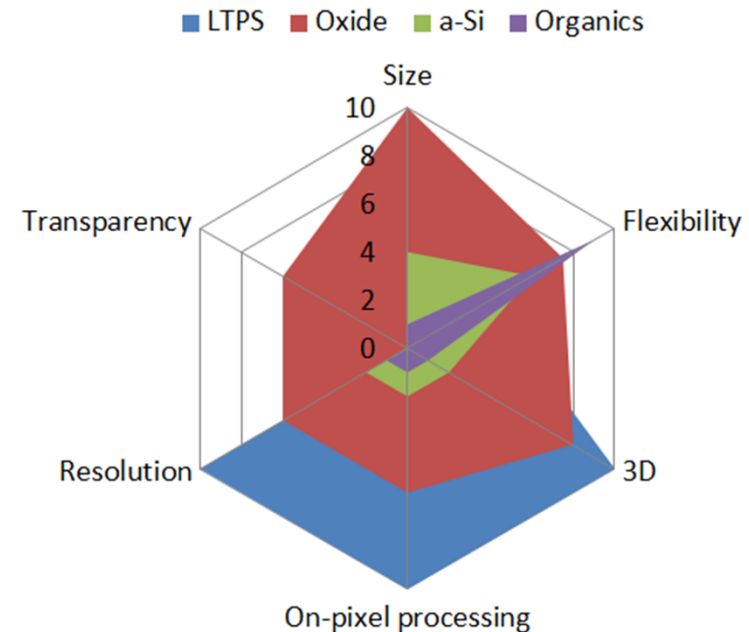
- Rising demand. In touch screens ITO on PET is taking market share away from ITO on glass.
- Changing requirements: Emerging applications are large area and/or current driven, needing sheet resistance of 50-100 ohm/sqr – harder for ITO.
- Many alternatives are being commercialized. There is not one size fits all solution, but silver nanowires and metal mesh are ahead. Focussed on large area touch screen.
- Few buyers but many suppliers so margins under pressure despite demand growth.
- May become commoditised as most offer good performance so cost is the differentiator.

Logic and Memory

OSC technology improving: Mobilities over 10, progress with bioelectronics, spintronics and thermoelectrics



Commercial activity on metal oxide TFTs for OLED backplanes



- Collaboration on integrated systems and on creating much needed hardware platforms that can be used for many applications (e.g. Thinfilm, PragmatlC)
- Silicon ICs on flex for hybrid circuits
- Opportunity to reduce cost of logic by a magnitude and unit numbers by two magnitudes

Profitability/Success: Some Examples

OLED Displays (not printed)

Samsung LG
eMagin

OLED Materials

UDC Novaled/Samsung
Dow Chemical

Conductive Inks

DuPont Hereaus Precious
InkTec Metals
Johnson Creative Materials
Matthey

Antennas/touch panels

HiCel Paru
ASK O-Film

Sensors

GSI Technologies Lifescan
Abbott TekScan
Peratech Interlink
Sensitronics

Equipment

Applied Materials Fujifilm Dimatix
(Baccini) Ceradrop
Unijet Optomec

Roth&Rau

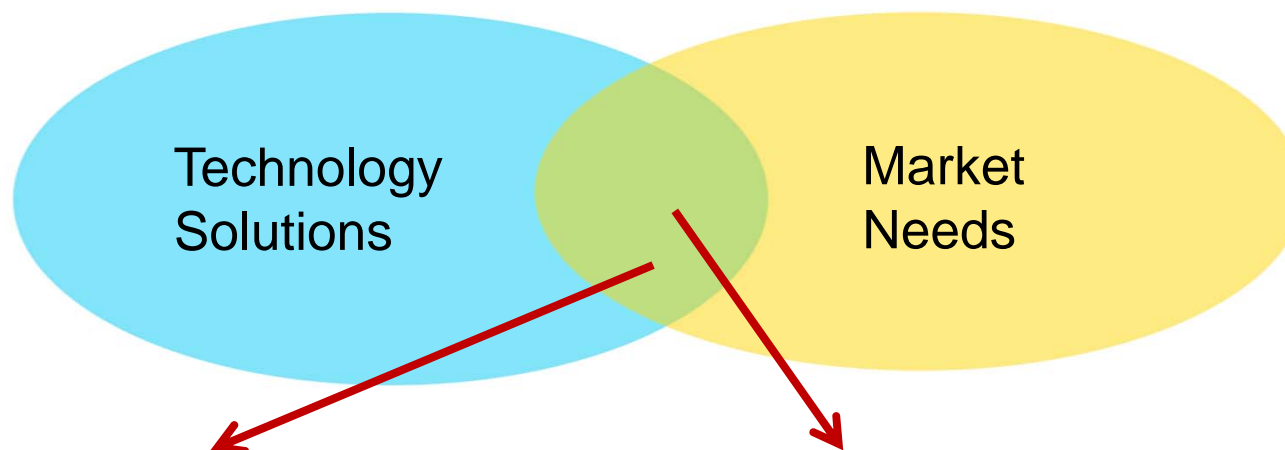
Smart Packaging

T-Ink Avery Dennison
MWV

Other

Zyvex Innovalight
Eink

Market Drivers and Needs



Replacing complete products

Driver: Need for differentiation, higher performance, lower power, ultimately larger area and flexibility
e.g. OLED displays, lighting, TFTs

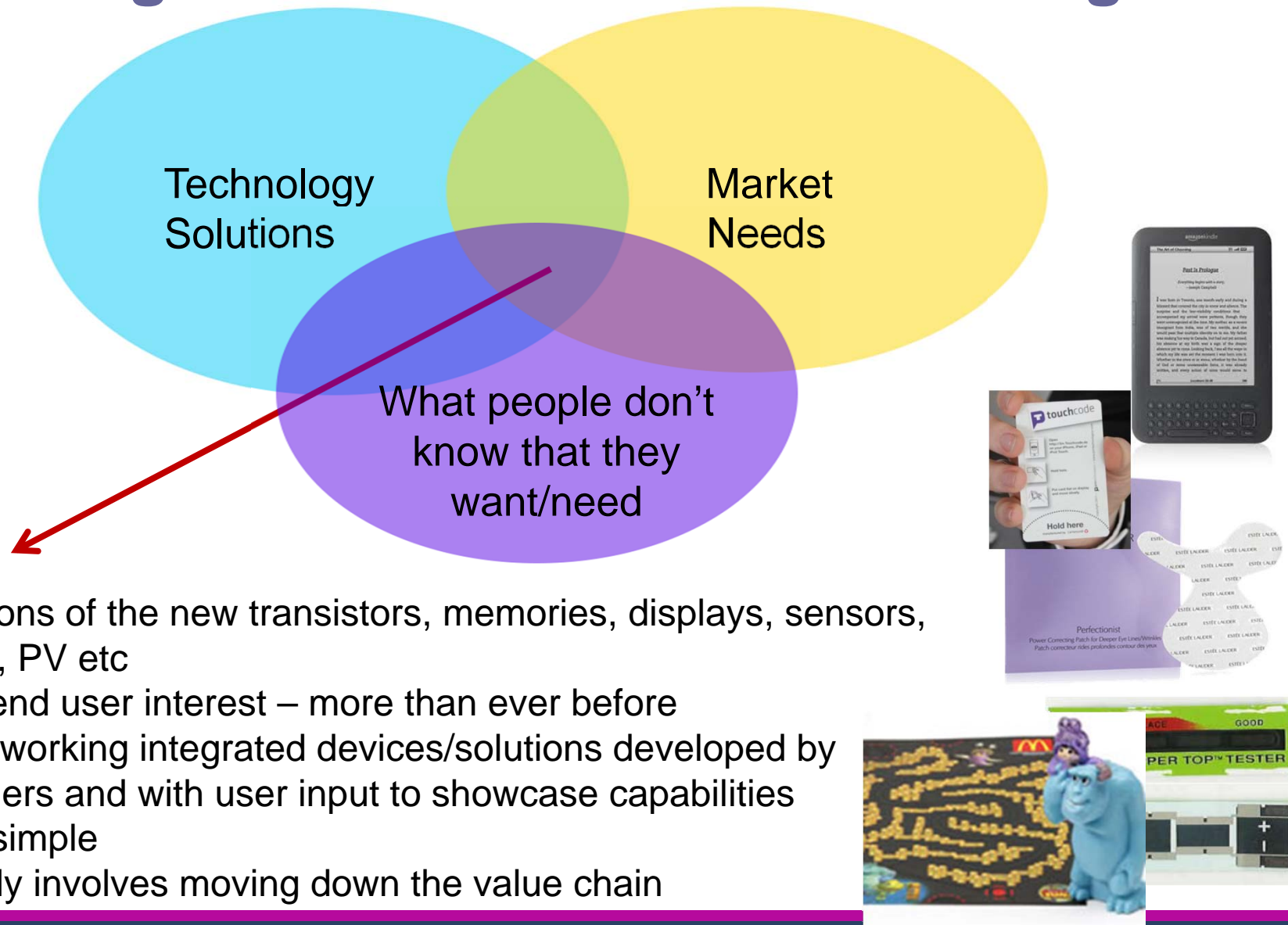


Improving an Existing Layer/Component

Driver: Higher performance, form factor, lower cost, cheaper manufacturing
e.g. ITO replacement, better Li-ion batteries, supercapacitors, lightweight sensors,



Creating New Products – The Challenge



Summarising Thoughts

- Four Billion \$ success stories so far (OLED, e-paper, conductive ink, sensors), with large future potential opportunity
- Some reposition from the very difficult to the easier, shorter term potential
- New market creation lacks integrators (but increasing focus) and leadership
- Cost is volume dependent
- More end user interest than before
- Components developed separately with little thought for convergence
- Topic is far broader than most think – reaching supercapacitors, batteries, sensors, 3D printing, stretchable electronics, the Internet of Things v2, smart packaging, bioelectronics, micro energy harvesting, touch surfaces...



IDTechEx supports your strategic business decisions on emerging technologies

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