Printed and Flexible Electronics: Global Markets and Trends 2009-2019

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IDTechEx is an independent strategic analyst covering printed electronics, RFID, thin film photovoltaics, and energy harvesting.

We provide:

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<th>Consultancy</th>
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<td>Clients include:</td>
<td>Independent market and technology research reports</td>
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<td>Hewlett Packard</td>
<td>Printed Electronics World daily</td>
<td>USA, Europe and Asia</td>
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<td>Cazenove investment</td>
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<td>Schiphol Airport…</td>
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2250 developers – up 50% from two years ago

- Photovoltaics: 660
- Transistors: 540
- Displays and Lighting: 510
- Other devices: 540

NORTH AMERICA: 750
EUROPE: 775
EAST ASIA: 600
OTHER Countries: 125
The market for printed & potentially printed electronics, including organics, inorganics and composites

2250 organisations developing printed electronics: up 50% from two years ago

$1.9$ billion 2009 → $57$ billion 2019

71% is mature electronics today

**Conductive inks** (for membrane keyboards, Printed Circuit Boards (PCBs), flex connectors, RFID antennas, membrane keyboards, heated clothing)

**Sensors** (e.g. disposable glucose sensors for those with diabetes)

**Organic Light Emitting Diodes (OLEDs)** on glass substrates and not printed as yet.
The market for printed and potentially printed electronics in 2009

- OLED $800 million
- Photovoltaics $407 million (Excluding CdTe and Conventional Silicon)
- Other inks: $400 million
- Sensors: $110 million
- E-paper displays $80 million
- Inorganic Electroluminescent displays $60 million
- Others $63 million (Transistors, batteries, other displays etc)

35% Predominately Printed
18% Flexible
The market for printed and potentially printed electronics in 2019

- **OLED Display & Lighting**: $18.5 billion
- **Photovoltaics**: $19.5 billion (Excluding CdTe and Conventional Silicon)
- **Transistors**: $8 Billion
- **Other inks**: $2 billion
- **Sensors**: $1.5 billion
- **E-paper displays**: $5 billion
- **Inorganic Electroluminescent displays**: $0.3 billion
- **Others**: $2.36 billion (Batteries, other displays etc)

76% Predominately Printed

73% Flexible
Progress with OLED displays

Estimated investment: $6 to $8 Billion

2x to 10x more expensive than similar size LCDs

2009 (0.4% predominately printed, <0.1% non rigid)

In 2014, used as a small screen LCD alternative e.g. in cellphones, PDAs etc ($15 Billion market for LCDs in 2009)

In 2014, flexible OLEDs will be used for posters, advertising etc, lifetime being a barrier.

Most OLED display makers are in East Asia, but material suppliers are global
Flexible barrier films urgently needed to prevent water and oxygen permeation. OLED is hardest to protect of all – achieve that and conquer all

- WVTR < $10^{-6}$ g/m$^2$/day and OTR < $10^{-3}$ cm$^3$/m$^2$/day
- Optically transparent from 400-700 nm
- Flexible, withstand manufacture processes, adequate lifetime

Cheaper/volume manufacture needed e.g. printing

- Current AMOLEDs are ~20% material spend, 80% manufacture cost

New backplane technology needed for best performance from current driven OLED materials

- aSi used for LCDs and organic TFTs have too low a mobility, LTPS is expensive for large area
- Focus of work on backplane development, including microcrystalline silicon, ZnO TFTs (can be printed and transparent) etc… Has brought display giants such as Sony, LG, Samsung etc into serious TFT development
Progress with E-paper Displays – used in over $1 Billion worth of products to date

Electrophoretic displays will be the first to sell strongly in flexible form. Many new products created e.g. over 20 e-readers are now available... and more to come. These are rigid, on glass with aSi drivers, flexible versions to come in late 2009.

Source: E-ink, Plastic Logic
INORGANIC EL – FINDS NEW OPPORTUNITIES AFTER DECADES IN THE MAKING

1966: Dodge Charger instrument panel with electroluminescent lighting. Chrysler began building cars with EL panel lighting for the 1960 model year.

2005: The world’s first electroluminescent billboard campaign, posted in across Canada. The campaign went on to win Gold at the Media Innovation Awards for best mixed media campaign. Photo by Nick Perry / www.nickperry.ca
## Progress with Photovoltaics

>$5 Billion venture investment, and huge investment internally from companies

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<th>Type</th>
<th>Status</th>
<th>Challenges</th>
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<td>aSi</td>
<td>Usually all rigid, but flexible possible. Orders of several billion dollars</td>
<td>Inertia to move to flexible/printed</td>
</tr>
<tr>
<td>CdTe</td>
<td>Not printed yet, rigid. Orders of several billion dollars.</td>
<td>Rigid, use of Cadmium</td>
</tr>
<tr>
<td>CIGS</td>
<td>High efficiency. Honda and others already in production (rigid). Next 2 years –flexible versions</td>
<td>Move successfully to roll to roll manufacture i.e. maintain yield and efficiency</td>
</tr>
<tr>
<td>DSSC</td>
<td>Printed. G24i, Sony and others in production</td>
<td>Efficiency</td>
</tr>
<tr>
<td>OPV</td>
<td>Lower efficiency, potentially lowest cost. Konarka in production</td>
<td>Efficiency (ROI is efficiency dependent), lifetime, suitable applications</td>
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# Transistors – first significant commercial product in 2009/10

<table>
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<tr>
<th>Organic Semiconductors</th>
<th>Zinc Oxide (ZnO)</th>
<th>Nanosilicon</th>
<th>Carbon nanotubes, sheet graphene</th>
</tr>
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<tbody>
<tr>
<td>Mobility ~ 4 cm²/Vs</td>
<td>Mobility ~ 40 cm²/Vs</td>
<td>Mobility &gt;250 cm²/Vs</td>
<td>&gt;100 to 2000 cm²/Vs</td>
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<tr>
<td>Many material suppliers and developers</td>
<td>Samsung, HP, Kodak, Evonik, Inpria. Many players recently enter</td>
<td>Kovio, NanoGram, Uni. Cape Town</td>
<td>Optomec, NEC, Fujitsu, Canatu, Brewer Science etc.</td>
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<tr>
<td>E-paper backplane TFTs in 2010 from Plastic Logic</td>
<td>No planned applications in 2009. Most work on display backplanes (OLED)</td>
<td>RFID to ISO14443 specification (13.56MHz). Display backplanes</td>
<td>Early stage research/demonstrators</td>
</tr>
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Shakeout

Too early to know relative costs, yield etc

- **$10 million 2009**
- **$350 million 2014**
How printed electronics is being applied to products

Imaginative product design needed to create new markets

Fully printed electronics only – lowest cost

Lowest cost

High value through unique e.g. flexibility, efficiency, thinness etc

Reduce manufacture cost of conventional electronics

Printed electronics combined with conventional electronics for best performance
Market opportunity

- Battery Testers
- RFID
- Interactive games
- Skin patches
- E-readers
- OLED TV

Lowest cost

High value through unique e.g. flexibility, efficiency, thinness etc

High volume
Low volume

Low cost
High cost
But the emerging value chain is unbalanced

**Supplier push**
- Great interest from suppliers of chemicals, inks, film and paper, production machinery
- Huge number of functions becoming possible from different suppliers
  - Texture change, sound, radio, recording, moving color display, sensing, monitoring, locating....

**User pull**
- Little questioning of what users want, little market pull until recently
- Few integration companies or creative designers involved

Who can make me a few PRODUCTS to evaluate? Who can make my custom logic?
Printed Electronics in the Global Recession

- Most consumer markets slow or contract, but new technology can appeal where it provides differentiation e.g. cell phone displays
- IDTechEx has witnessed huge interest from major global brands and healthcare companies who are largely recession proof – many have set up printed electronics divisions over the last six months
- Small projects may find funding difficult but it is still there e.g. Konarka, Novaled. Many large organizations have long term view and commitment, despite fairly poor returns to investors so far.
- Innovation has not slowed – read www.PrintedElectronicsWorld.com for proof
- More likely, growth may be slowed by pursuing materials and manufacture processes inadequate for simple high volume applications, or delays in product development, and from lack of creative product design.
Printed electronics will tackle many needs

Consumer goods brands are being commoditised – they are boring in function and appearance and become less profitable

Demographic timebomb – the greying of the population means inadequate medical assistance

One in three people have difficulty reading instructions - dyslexic, illiterate, sight impaired, shaking...

Non compliance with medication causes 125,000 deaths yearly in the US alone
Some urgently seek product differentiation/brand enhancement

From www.bbc.co.uk Aug 2009:

Drinks giant Diageo says it will take legal action against supermarket chain Sainsbury's. Sainsbury's said it would "vigorously defend" the claims.

Diageo said the case should not affect its relationship with Sainsbury's, a key customer.

"Sainsbury's is a valued customer of Diageo and we hope will continue to be so for many years," said the drinks firm.
Smart Blister packs

OtCM system

Blood pressure-, Gluco meters etc.

GSM - Bluetooth
USB-NFC Devices

NFC/RFID

URL
dataBase
Server

GPRS network
Internet

services

DataGators
DataTakers
NFC mobile phones

Patient

Electronic Medicine
packages & bottles

Source: Compliers Group
Smart Blister packs

Diabetes patients measure their glucose levels and the values measured are transmitted via the same GSM devices to the server database. You see this.

Source: Compliers Group
Estee Lauder Smart Patch delivering cosmetic through skin

3-Pack, $50
8-Pack, $100
1 million per month

Screen printed MnO2 Zn battery +Ag electrodes
CASE STUDY: FACIAL REDNESS

Baseline

20 minutes post treatment
CASE STUDY: ANTI-WRINKLE

Baseline

20 minutes post treatment
MEDICAL PATCHES
THIN AND FLEXIBLE MICROELECTRONICS INSIDE

Diagnostic Patch

Local Pain Relief

Active Acne
Treatment Patch

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Lessons from the Silicon Chip

We need

**PROGRAMMABILITY AND MODULARITY**
The same basic hardware platforms will be sold horizontally from military to consumer packaged goods to achieve

**LOW COST achieved only at HIGH VOLUME –**
For silicon chip based products: MILLIONS TO BILLIONS YEARLY
For printed electronics: BILLIONS TO TRILLIONS YEARLY
Some Basic Hardware Platforms on Flexible Film or Paper

- Winking
- Scrolling message (instruction, promotional message, game.....)
- Speaking
- Timer (glue setting, cooking, hair dye........)
- Sensing (self adjusting use by date, aroma/sound/vibration/music when someone comes near.....)
- RFID
- Sending liquid into skin (drug, cosmetic, tattoo...)
- Video
- Electroactive shape change (3D vision, locking, suction......)
Basic Hardware Platforms

- Saleable to every sector from military to consumer packaged goods, healthcare, leisure, industry.....
- Basic platform made in at least tens of billions yearly
- Dedicated/ programmed at manufacturer and sometimes at brand owner and user as well
- Shared modular design
- Basic hardware platforms can be combined to create more functional, more expensive products.
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