Workshop
Flexible Electronics
IITC / MAM conference

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troadec@yole.fr
Yole Développement’s 30 analysts operate in the following areas:

- Imaging
- Photonics
- MEMS & Sensors
- Compound Semi.
- LED
- Power Electronics
- PV
- MedTech
- Manufacturing
- Advanced Packaging
4 BUSINESS MODELS

• **Consulting and Analysis**
  • Market data & research, marketing analysis
  • Technology analysis
  • Strategy consulting
  • Reverse engineering & costing
  • Patent analysis
  
  • Reports
  • Market & Technology reports
  • Patent Investigation and patent infringement risk analysis
  • Teardowns & Reverse Costing Analysis
  • Cost Simulation Tool
  
  • Financial services
  • M&A (buying and selling)
  • Due diligence
  • Fundraising
  • Maturation of companies
  • IP portfolio management & optimization
  
  • Media
  • i-Micronews.com website
  • @Micronews e-newsletter
  • Technology magazines
  • Communication & webcast services
  • Events

  • [www.yole.fr](http://www.yole.fr)
  • [www.i-Micronews.com/reports](http://www.i-Micronews.com/reports)
  • [www.yolefinance.com](http://www.yolefinance.com)
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A short introduction on Flexible/Printed Electronics
Main market drivers for flexible electronics are:

The possibility to add new functionalities:
- Conformability for OLED lighting (for the automotive industry),
- Conformability for OPV (energy harvesting),
- Robustness for small OLED displays (for smart phones & tablets)

The possibility to create new applications:
- Wearable electronics

Flexible electronics is NOT meant to be low-cost, and usually uses expensive processes (MOCVD, evaporation)

The main market driver for printed electronics is:

Cost reduction due to high volume (roll-to-roll) manufacturing or by using fewer expensive manufacturing processes (MOCVD, evaporation):
- Potentially lower cost OLED TVs could be built if solution-based manufacturing is mastered and potentially low cost OPV could appear if technical challenges are leveraged
- Up to 30% cost reduction
5 main application families

MAIN FLEXIBLE/PRINTED ELECTRONICS APPLICATIONS

Displaying

Lighting

Sensing

Energy generation

« Smart systems »
## FUNCTIONS VS FLEXIBILITY DEGREE OF FREEDOM

**Applications listed by functions and Flexibility DoF**

<table>
<thead>
<tr>
<th>FUNCTIONS</th>
<th>FLEXIBILITY DOF (&quot;Degree Of Freedom&quot;)</th>
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<tbody>
<tr>
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* Or « contoured »

* Uses printing process
## FUNCTIONS VS FLEXIBILITY DEGREE OF FREEDOM

### Techno Push vs. Market Pull applications

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* Uses printing process
In the next several years, the number of applications using printing processes for Flexible Electronics will grow...
Either the deposition technique causes **material waste** (coating then etching for example), or they have **slow throughput** (inkjet printing).

In any case, equipment dedicated to large volume printed electronics is still **expensive** and **not completely adapted** (nozzle clogging in inkjet, low resolution in screen printing etc.).

Description of various solution deposition methods


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No clear winning technology yet…

PRODUCTION PROCESS THROUGHPUT & RESOLUTION

- **Throughput** (m²/s)
  - Low (< 0.01)
  - Medium (0.01-1)
  - High (>1)

- **Maximum Resolution** (µm)
  - 1 µm
  - 10 µm
  - 100 µm
  - > 500 µm

**Technologies and Performance:****

- **Flexography**
  - Ink viscosity: 0.01 – 0.5 Pa.s
  - Layer thickness: 0.4-8 µm

- **Gravure**
  - Ink viscosity: 0.01 – 0.2 Pa.s
  - Layer thickness: 0.1-12 µm

- **Inkjet**
  - Ink viscosity: 0.001-0.03 Pa.s
  - Layer thickness: 0.01-0.5 µm

- **Nano Imprint**
  - Layer thickness: Down to 0.2 µm

- **R2R Photolithography**
  - Layer thickness: 3-100 µm

- **Screen printing**
  - Ink viscosity: 0.1-50 Pa.s
  - Layer thickness: 3-100 µm

- **Slot coating**
  - Layer thickness: Down to 0.2 µm

- **Ultrasonic spray**
  - Layer thickness: 0.01-0.5 µm

- **Laser ablation**

Source: CEA Liten / OE-A / Yole Développement
MAIN PLAYERS IN EQUIPMENT

Worldwide players
Examples of industrial players developing Flexible and/or Printed products

PLAYERS LANDSCAPE - EXAMPLES (NON EXHAUSTIVE LIST)

FLEXIBLE
Application enabling / Function enabling

Small OLED Displays
Conformable OLED Lighting
Conformable Organic PV

Electronic paper
Systems on foil / polytronics

Large OLED Displays
OLED Lighting

Sensors

Large / high volume Organic PV

PRINTED
(Potentially) Large volume / Low cost

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If we consider the sensors and smart systems to be fully manufactured with a printed process…

~$1B in 2020!
If we consider the few dedicated process steps performed by printed electronics technology within a complete device manufacturing process, the picture is different:

- Glucose sensors already on the market where more than 50% have printed electrodes
- RFID tags could potentially have printed antennas → this could represent billion’s of units
THE INTERNET OF THINGS ROADMAP: SENSORS’ SWARM…

Printed electronics as a possible low cost solution to achieve GEN7 products…
Challenges are mainly present at material level...
We believe Printed & Flex Electronics market could boost to be close to $1B by 2020 with a 27% CAGR if we consider sensors and smart systems fully manufactured by printed electronic process.

On the equipment side, the industry starts from zero and future production will have to be handled by tools bought over the 6 next years.

Industry is looking for a high throughput, high resolution deposition techniques to lower costs.

On the material side, having the right material as replacement to ITO and finding a good barrier technology are short-term technical challenges.

No technology (Material/Deposition process) has taken an advantage over others so far and a breakthrough is expected within the next 3 years (mass production for cost decrease).
Information in this presentation is extracted from the following reports:

Flexible Applications based on Printed Electronics Technologies
Released in May 2013 – www.i-micronews.com

Materials and Equipment for Printed & Flexible Electronics
Released in Feb. 2014 – www.i-micronews.com
A GROUP OF COMPANIES

- **YOLE Finance**
  - M&A operations
  - Due diligence
  - [www.yolefinance.com](http://www.yolefinance.com)

- **BLUMORPHO**
  - Fundraising
  - Maturation of companies
  - IP portfolio management & optimization
  - [www.bmorpho.com](http://www.bmorpho.com)

- **SYSTEMPLUS CONSULTING**
  - Manufacturing costs analysis
  - Teardown and reverse engineering
  - Cost simulation tools
  - [www.systemplus.fr](http://www.systemplus.fr)

- **KnowMade**
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  - Patent assessment
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OUR GLOBAL ACTIVITY

40% of our business

30% of our business

30% of our business