

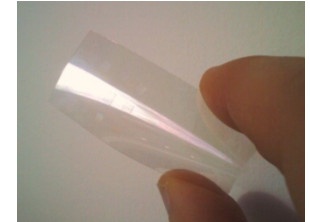


High Value Manufacturing for Low Cost Electronics

10th Anniversary
High Value Manufacturing Conference 2012

14 November 2012 Cambridge

www.cir-strategy.com/events/



PragmatIC Printing enables **printed logic circuits** that introduce **intelligence** and interactivity into a wide range of novel product form factors: **thin, flexible, transparent, robust, disposable, ...**



Introduction and Context

Printed Electronics

(Plastic Electronics, Organic Electronics)

The use of printing or other thin film coating and patterning techniques to create electronic functionality on a broad range of substrates

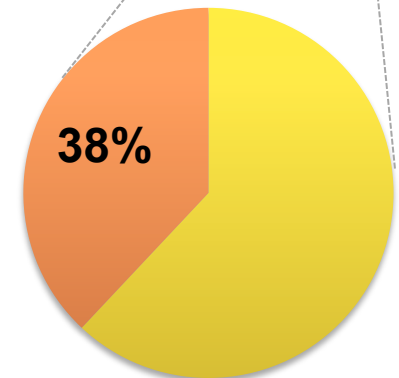
| Power | | Displays & Lighting | | | Conductive inks | Logic & memory |
|----------------|---------------------|---------------------|------------------|-----------------|-----------------|----------------|
| Photo-voltaics | Thin film batteries | Organic LEDs | Electronic paper | Electro-chromic | | |

Printed Logic

*Circuits of active semiconductor devices (transistors and diodes)
i.e. the printed equivalent of a silicon chip*

Source: IDTechEx

2011 \$2Bn → 2021 \$45Bn → 2027 \$330Bn



Printed Logic Challenges

- **Feature size/accuracy, performance and cost**

- Most printing processes developed for $>10\mu\text{m}$ features
- Electronics requires smaller features to improve performance
- Smaller features also reduce footprint, material use and circuit cost

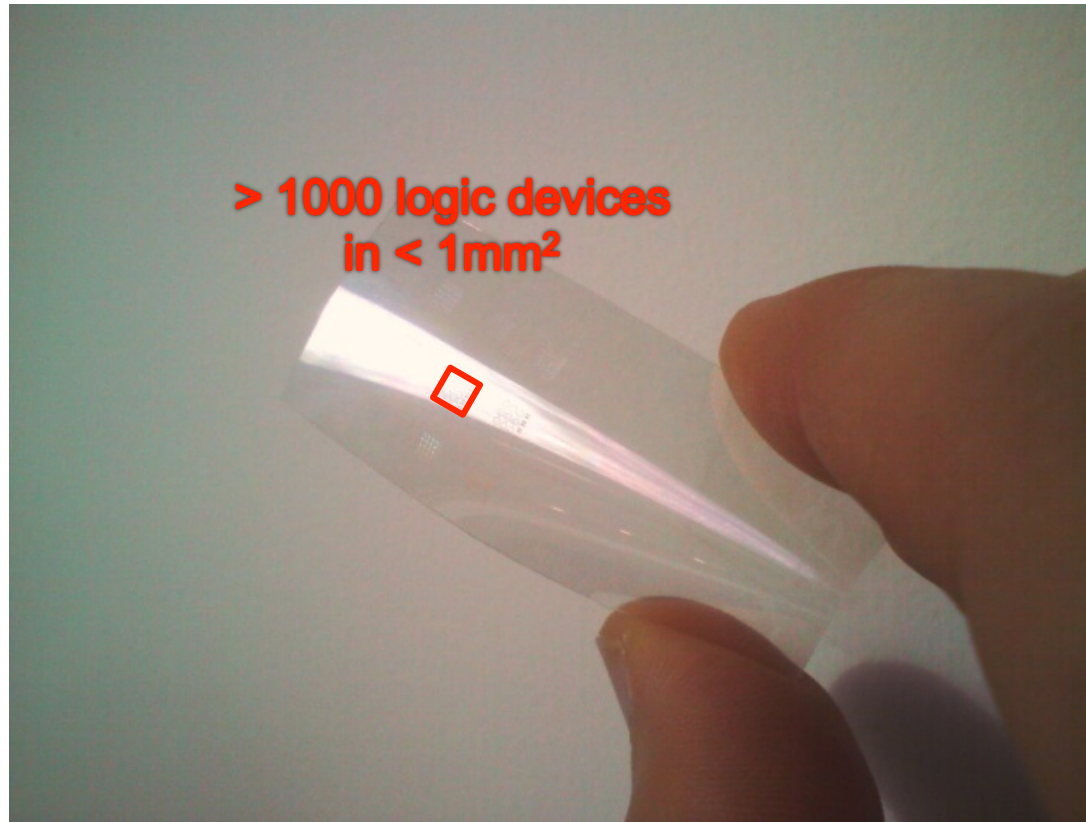
PragmatIC uses imprint (embossing) which combines the benefits of simple printing with a proven ability to achieve both micron & sub-micron scale features with high yield

- **Registration and alignment**

- Conventional device architectures are complex 3D structures
- Require precise alignment between successive patterning steps

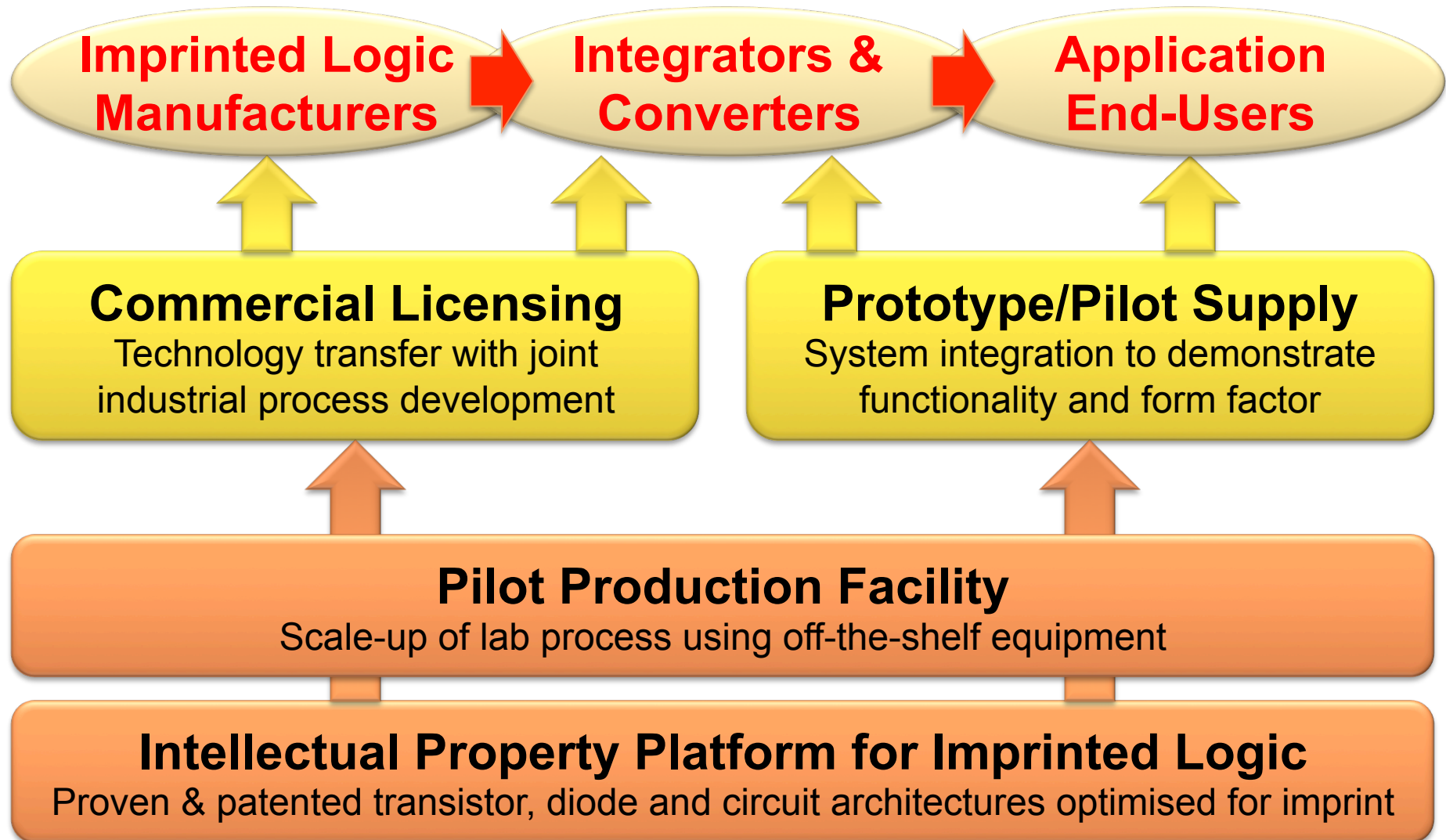
PragmatIC's novel planar & self-aligned device architectures dramatically simplify manufacturing by reducing the number of process steps and minimising registration requirements

Imprinted Electronic Logic



Thin, flexible, transparent, robust, disposable, ...

PragmatIC Business Model



Low Cost Printing?


| Myth | Reality |
|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Printing is cheap | Improving printing sufficiently for electronics makes it expensive |
| Functional inks enable printing of electronics | Controlling quality & consistency of functionalinks is very challenging |
| Additive processes minimise usage of expensive functional materials | Subtractive processes can use lower cost materials; smaller feature sizes enable much lower material usage |
| Digital printing allows designs to be changed easily | Electronic reliability requires standard designs (or at least standard building blocks) so benefit is limited |
| High speed roll-to-roll printing provides economies of scale | Starting and stopping a roll-to-roll process wastes material |
| Conventional printing companies can easily move into printed electronics | Electronics requires expertise in functional testing & yield management |

Manufacture in Far East?


| Myth | Reality |
|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Printed electronics requires a large “fab” similar to conventional electronics | Simplified processes allow smaller scale manufacture and modularity of production |
| Far East labour rates will make production more cost effective there | Printed electronics production can be largely automated, hence maximising utilisation of capital equipment is often a more significant cost driver |
| Far East companies are generally better at manufacturing in high volume on razor-thin margins | Many printed electronics applications are driven by value not merely price (thin, flexible, transparent, robust, ...) so decent margins can be maintained |

PragmatIC Printed Electronics

Ultra small feature size
enabling dense logic
in a small footprint



Minimises material usage
Maximises capital equipment utilisation
High volume production with low throughput processes



High Value Manufacturing for Low Cost Electronics

PragmatIC Pilot Production

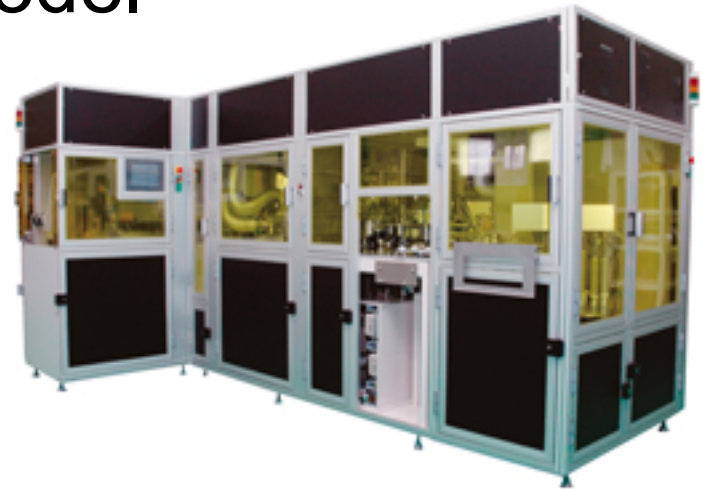
- Printable Electronics Technology Centre (part of Centre for Process Innovation) in Sedgefield, U.K.
- 600m² cleanroom plus 100m² test & inspection lab
- Suitable for projects with 10k – 1M unit quantities



Centre for Process Innovation

Production Scale-up Example

- Optical disc production model
 - Self contained cleanroom
 - Thin film vacuum material deposition (up to 7 layers)
 - Nano-scale imprint patterning (to 50nm)
 - In-line test and inspection
- Throughput 5s/disk: >10Bn circuits per year
- Cost \$1/disk: <0.1c per logic circuit



Origin Azul Blu-ray Disk production equipment

Summary

- Appropriate technology choices can avoid the traditional manufacturing focus on:
 - High throughput
 - Low cost processes
 - Low value products
- **High Value Manufacturing of Low Cost Electronics is feasible**



PragmatlC Printing Ltd

**3 Charles Babbage Road
Cambridge CB3 0GT
United Kingdom**

www.pragmaticprinting.com