IoT

FlexEnable

Bringing Every Surface to Life

Professor Henning Sirringhaus – Co-Founder

Chuck Milligan – CEO

Wearables

Automotive

Sensors

Displays

FlexEnable
Truly flexible electronics

The Plastic Logic / Flexenable Journey

Technology | Product | Technology Platform

Spun out of Cambridge University

1.2M organic transistors

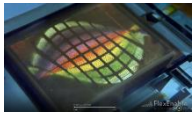
Color Industrialized

Worlds 1st All organic image sensor

Flex AMOLED Demonstrated

MERCK

Plastic LCD – announced February 2015 – partnership with Merck



March 2015 - Colour, Video Rate plastic OLED

2000 | 2005 | 2010 | 2014 | 2015

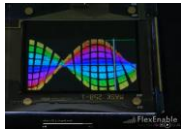
Plastic Logic Founded Nov 2000

Plastic Logic Process Proven Industrially

Distortion-free backplane process demonstrated

Vertical TFT demonstrated

Flex Fingerprint Sensor Demonstrated



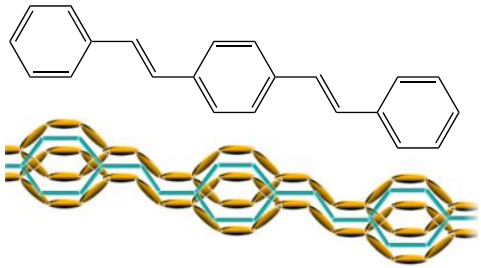
April 2015 - Colour, Video rate Plastic LCD display

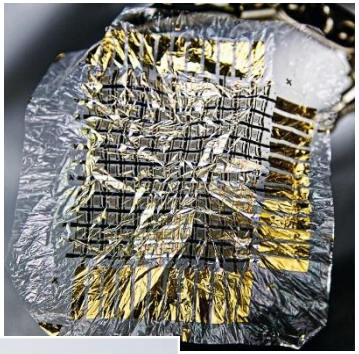
FlexEnable Founded, February 2015

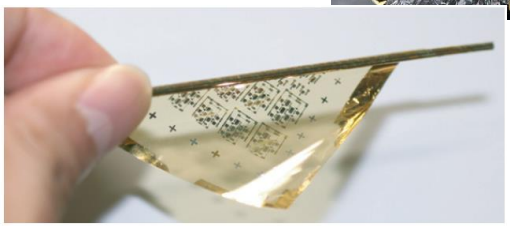
FlexEnable
Truly flexible electronics

Organic semiconductors

- Exhibit semiconducting properties similar to silicon; Can be used in optoelectronic devices (OLED, solar cells, transistors)
- Compatibility with large-area, solution-processing and printing
- Inherently low-temperature, flexible / plastic materials
- **Enabling electronics on low-temperature flexible substrates**







Sekitani et al., Nat. Mat. 9, 1015 (2010)

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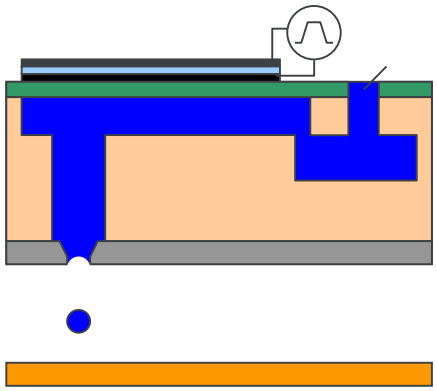
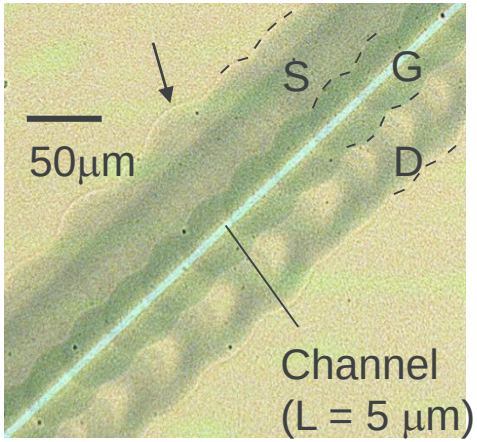
Truly flexible electronics

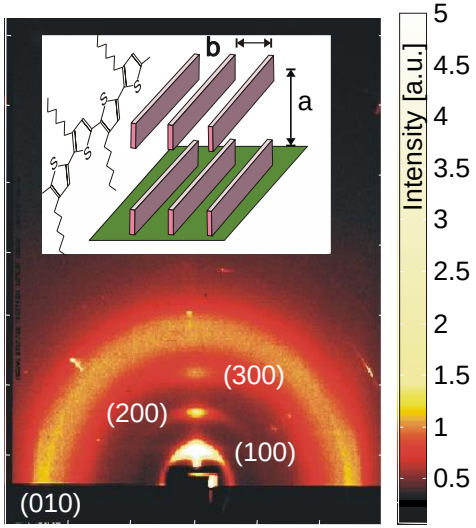
Research breakthroughs in Cavendish Laboratory (1999/2000) - Inkjet printed organic transistors

Printing-based manufacturing





Science 290, 2123 (2000)



Higher carrier mobilities through self-organisation

Nature 401, 685 (1999)

- Spin-off company Plastic Logic founded in 2000 with 6 patents/patent applications
- Early-stage materials technology with wide range of potential but unproven applications

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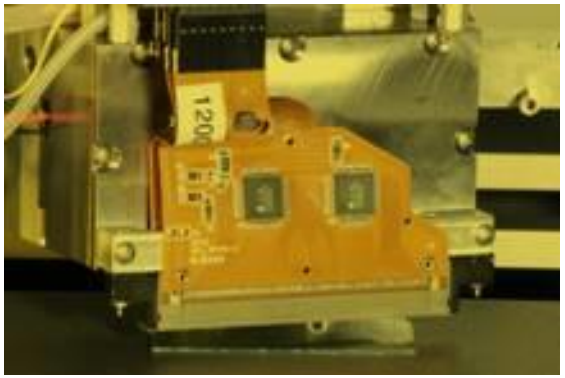
Truly flexible electronics

Considerations at the start

- Strong IP position with clear IP ownership.
- Is timing right ?
  - Commercial focus needed - Need to build a strong, engineering team.
- Solution to a problem ?
  - Emerging interest in flexible displays/electronics
- Support from Technology Transfer Office, local VCs & lawyers.
- Market focus ?
  - Flexible displays with an active matrix of transistors

Technology development in Cambridge (2001-2006)

- With venture capital seed investment we built flexible electronics/display prototyping line (14” substrate capability, manual substrate handling)



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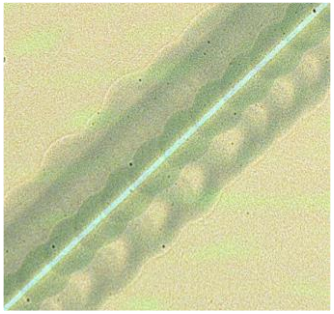
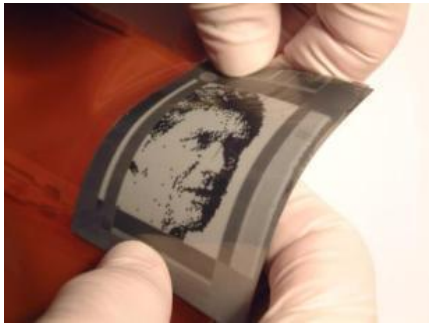
Technology development in Cambridge (2001-2006)
From ten to a million transistors

- Transition from science to process engineering
  - Use available manufacturing equipment whenever possible
  - Invent only where necessary
- First industrial partnership projects





2000

2002

2006

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A big decision (2006) – Investment in manufacturing plant

- Raised $100 million from mainly US – based venture capital funds
- To built world's first flexible display manufacturing plant (Generation 3.5, fully automated)
- Location – Dresden, "Silicon Saxony" (Germany)

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A second big, near fatal decision (2006) – Design of own consumer electronics product

The QUE - An Innovative eReader unlike any other

- Large Display Optimal for Branded Content
- Thin and Light Weight
- Rugged – Will Not Break Like Glass
- Intuitive Touch Screen Interface
- Simple Access to Published Content
- Captures Advertising Opportunity
- Content Partnerships

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Failure of the product (2010)

- Launch of QUE at CES (Jan 9 2010) – voted one of top 10 gadgets of show

- Delays in establishing stable production
- Apple launched iPad (Jan 27, 2010)

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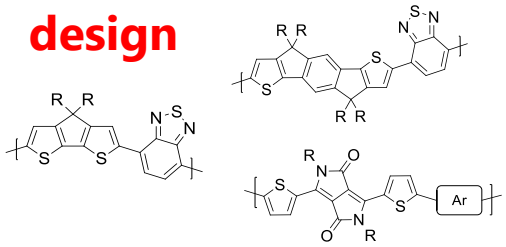
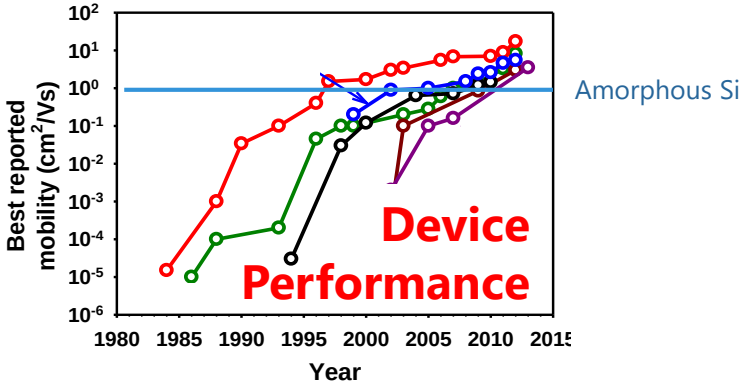
What saved the company ?

- Technology worked
  - Manufacturing yields and reliability of flexible displays as high as in conventional silicon-based display manufacturing

- Improvements in materials performance

Materials design





- Strong leadership and committed team
- Courageous and faithful investors

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Truly flexible electronics

Lessons / challenges for commercialisation of early-stage materials technologies

- Investment risk due to long development timescale - Difficulty in anticipating evolution of technology competition and market needs
  - Identify and address key technology barriers as early as possible
  - Development needs to target future product requirements, not current ones.

- Proving a new materials technology requires significant investment in manufacturing infrastructure
  - Access to public facilities / foundries for prototyping / small-scale manufacturing; Manufacturing partnership with large company

- Establishing place in complex value chain network
  - It is very hard for a technology company to develop a consumer product.

FlexEnable now owns the Field of Plastic Electronics for Surfaces thanks to Plastic Logic's R&D and Manufacturing Investments

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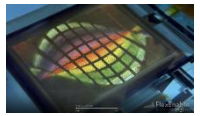

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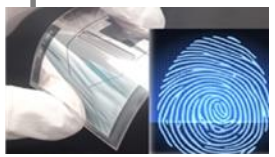

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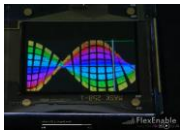

April 2015 - Colour, Video rate Plastic LCD display

FlexEnable Founded, February 2015

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Driving the new era in flexible electronics

FlexEnable

FlexEnable's proven technology platform enables customers to create compelling flexible electronics products and to manufacture these in volume

- IP Company owning all of the IP developed over last 15 years under PL – 133 patent families
- World's leading OTFT technology team – 38 engineers
- R&D/Prototyping Lab
- Focused on new mainstream applications – LCD, OLED, sensor arrays for IoT
- Lowest cost and most flexible platform for bringing surfaces to life
- Proven high-volume technology and experienced tech-transfer team

PLASTIC LOGIC

Plastic Logic Germany develops and manufactures flexible electrophoretic displays (EPDs) in a full range of sizes

Served with a Comprehensive Offering to Create a Supply Chain for Flexible Electronics

ProductEnable™

Monetisation: Fees from prototypes and projects`

Create and source product applications for truly flexible electronics

- Product Design
- Field Trials
- Prototypes
- Design of high volume production processes

MaterialsEnable™

Monetisation: Fees from materials testing and qualification

Asses and qualify new materials for flexible electronics

- Test protocol definition
- Mechanical testing and qualification
- Process development
- Demonstrators

FabEnable™

Monetisation: Transfer fees, licences and royalties

Tech transfer to upgrade existing fabs to make flexible electronics

- Feasibility study
- Process design
- Process implementation
- Process upgrades

FlexEnable
Truly flexible electronics

Management Team

Leading the world's strongest and most experienced team of engineering talent for plastic electronics

Chuck Milligan
CEO

- Joined as CEO in May 2015, after taking PE-backed EM Test to exit
- CEO & Board Member of Heptagon
- Vice President of Industrial & Defense Solutions for Bookham Inc.
- EMEA Director of Sales at Harris Corporation

Dr Paul Cain
Strategy Director

- Over a decade in flexible electronics
- Deep knowledge of displays technologies and industry
- 25 patents for flexible electronics
- Physics PhD – University of Cambridge
- MBA – London Business School

Heads a team of 3

Dr Mike Banach
Technical Director

- Over a decade in flexible electronics
- Led the team that developed flexible OLED, LCD
- Transferred tech from lab to fab
- Physics PhD – University of Cambridge

Heads a team of 36

Simon Jones
Commercial Director

- Joined FlexEnable from Dow Corning where he led several major innovation programs as Business and Innovation Development Director
- Previous roles include VP Business Development at Liquivista (now part of Amazon) and VP Product Development at Plastic Logic

Dean Baker
FabEnable Director

- c.10yr in flexible electronics manufacturing and development
- Project Manager at BOC Edwards
- Previously engineering leadership at Nortel Networks, JDS Uniphase and e2v

James Newman
Finance Director

- 15 years experience in technology sector in UK and US in start up and quoted companies
- Chartered Accountant

Heads a team of 6

Headcount

CEO	1
Technical Team	36
Strategy and MarCom Team	3
Finance and Admin Team	6
Commercial and FabEnable	2
Total:	**48**

FlexEnable
Truly flexible electronics

Board of Directors

Indro Mukerjee
Non-Exec Chairman
Chairman & ex-CEO of FlexEnable; CEO of Quindell

Chuck Milligan
CEO

Lord Alec Broers
Director
Member of the British Parliament, President of the Royal Academy of Engineering

Prof Henning Sirringhaus
Director
Hitachi Professor of Electron Device Physics at the Cavendish Laboratory

Dr Hermann Hauser
Director
Serial Entrepreneur and co-founder of Amadeus Capital Partners

Nikolay Tychinin
Director
Investment Director at Rusnano Management Company LLC

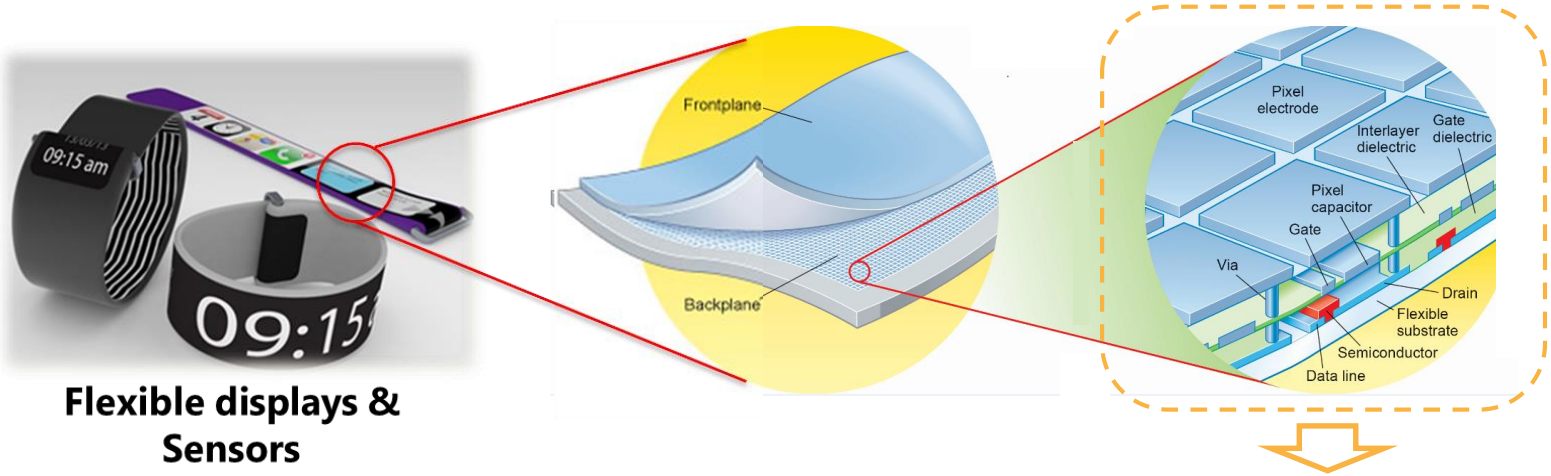
Dr Ronald Black
Director
President and CEO, Rambus Inc – IP licensing

Yurii Udaltsov
Advisor
Deputy Chairman of the Executive Board at Rusnano Management Company LLC

FlexEnable
Truly flexible electronics

A Unique Technology Platform

- Building on more than a decade of development of **high performance** Organic Thin Film Transistor (OTFT) on flexible substrates
- **Fully industrialised** and suitable for manufacturing production
- Enables true flexibility, bendability and unbreakability – by combining FlexEnable backplane and with partners' frontplanes for LCD, OLED, EP Displays, Sensors & entire electronics systems on plastic



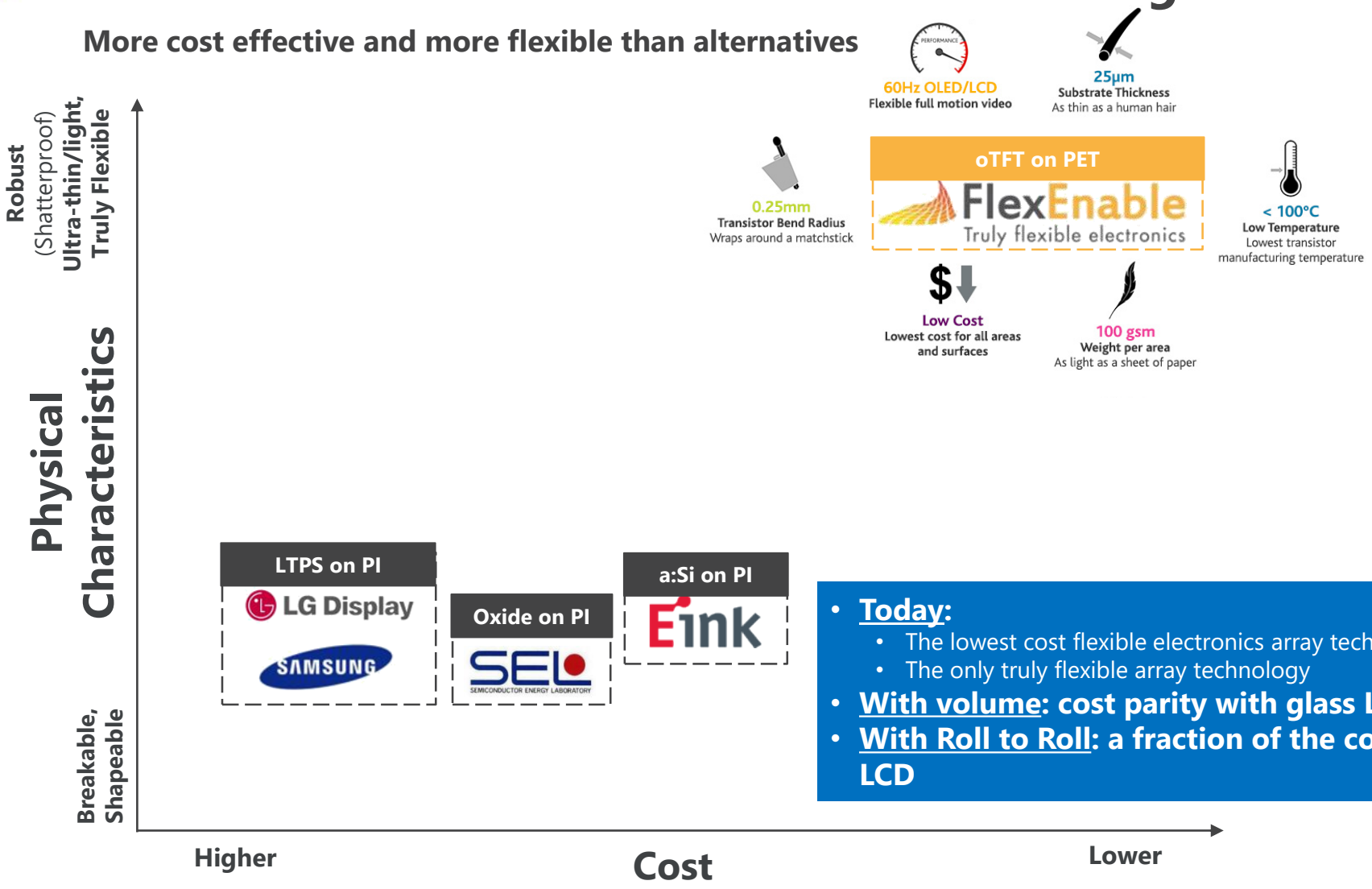
Flexible displays & Sensors

FlexEnable's value is the processes, architectures, materials and qualification IP to manufacture truly flexible electronics

FlexEnable
Truly flexible electronics

Best in-class Performance and Cost Advantages

More cost effective and more flexible than alternatives



- **Today:**
  - The lowest cost flexible electronics array technology
  - The only truly flexible array technology
- **With volume: cost parity with glass LCD**
- **With Roll to Roll: a fraction of the cost of LCD**

FlexEnable
Truly flexible electronics

What is needed for Plastic Electronics over Surfaces to take off?

Utility – What do you get with glass-free?	Performance	Cost/Volume
✓ Conformability ✓ Flexibility ✓ Thinness ✓ Light weight ✓ Unbreakable	✓ Transistors - Better than a:Si ✓ Uniformity ✓ Reliability	✓ BOM ✓ Yield ✓ Existing Manufacturing Infrastructure
OTFT Low-Temperature Process	Organic Semiconductor Solution Processing	Low-Temperature Process FPD Compatible

All the Boxes are Checked – the future is now for LowTemp OTFT Arrays

FlexEnable
Truly flexible electronics

Enabling a Wide Range of Applications

Wearables / Displays

Displays on wearables

Automotive displays

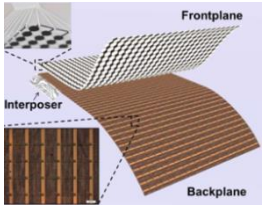
Smartphones

OLED Smartwatch

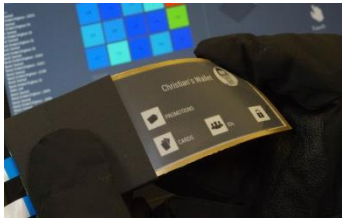
Sensors

Fingerprint and vein sensor

X-ray sensor



Pressure Sensor Array



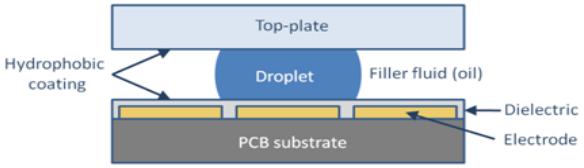
New user interface pressure and strain

System Solutions

Multi-function Printed Smartcard

Smartcard with display and sensor

Gas sensors: CO, H_2S, O_2



Lab on Chip

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Flexible Displays for Wearables and Everywhere-ables

Enabling New markets and transforming existing markets

Unbreakable Mobile Devices

Automotive and Aerospace

Wearables

Digital Signage

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Full Colour OLCD

In partnership with MERCK

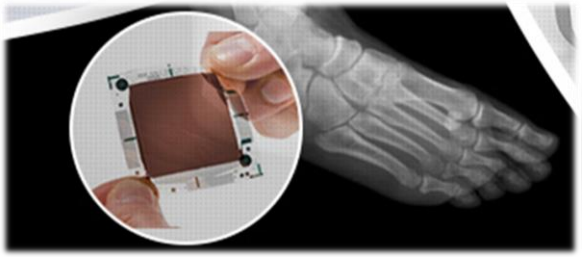
FlexEnable
Truly flexible electronics

Flexible Colour OLED in partnership CPT

Glass-free Wearable and Everywhere-able Sensors

Enabling New markets and transforming existing markets

Flexible, Unbreakable Xray Sensors



Multi-functional Smartcards

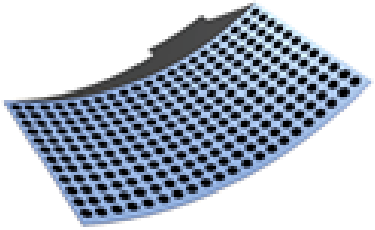
Wearable Sensors

Flexible, Wearable Biometrics

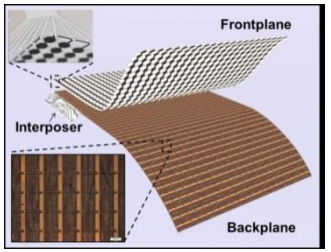
Pressure Sensor Arrays for "Electronic Skin"

Printed Plastic OTFT array backplane

+



Printed Piezoelectric Pressure sensor



Pressure sensor array

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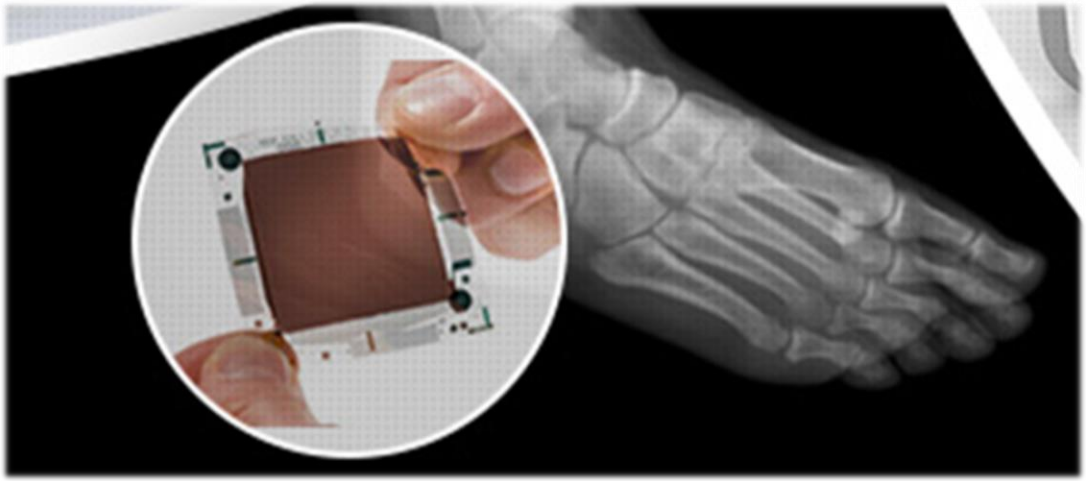
Flexible X Ray Sensors

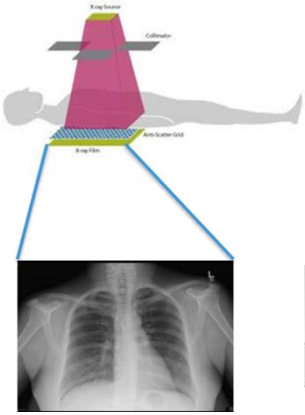
Sensors

- Shatterproof, with near zero incremental thickness and weight
- Enables X-ray systems to go anywhere – to road traffic accidents, around pipework, mobile systems
- Conformable around the body – improves accuracy and patient comfort

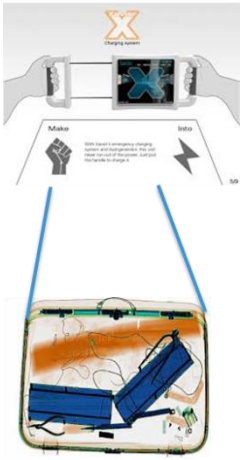


Industry Applications

Medical



Security



Oil & Gas

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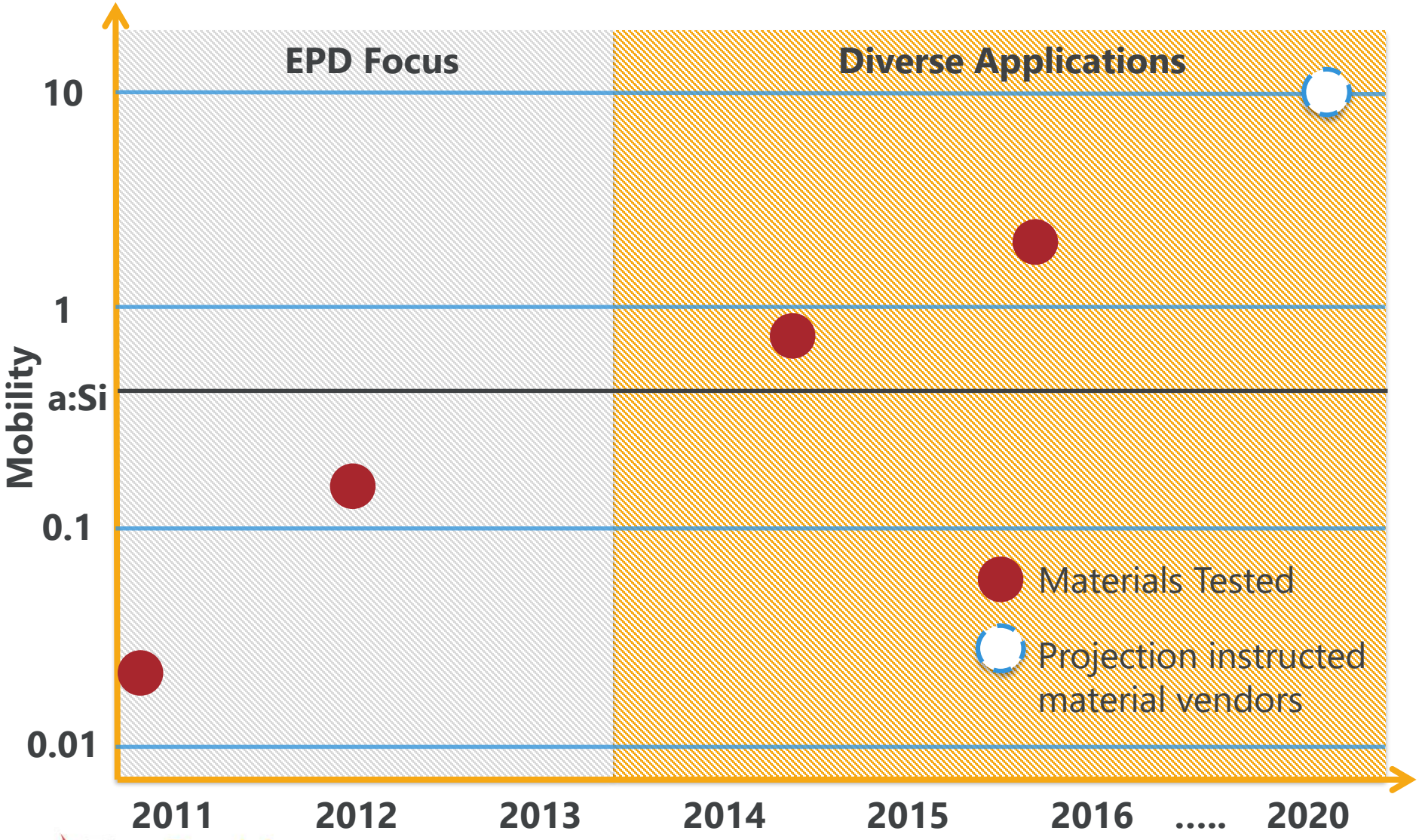
Mobility Performance Progression



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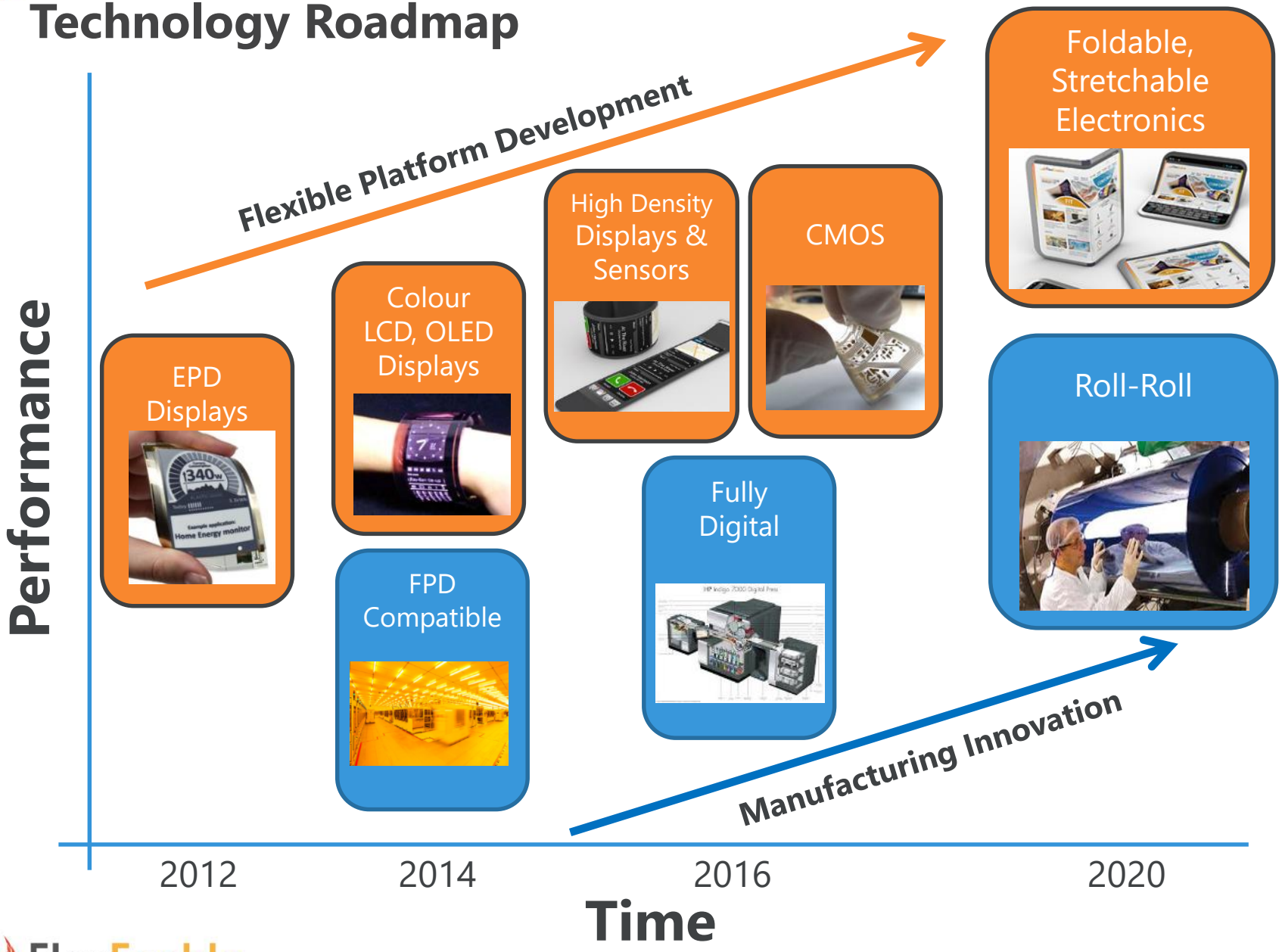
Technology Roadmap



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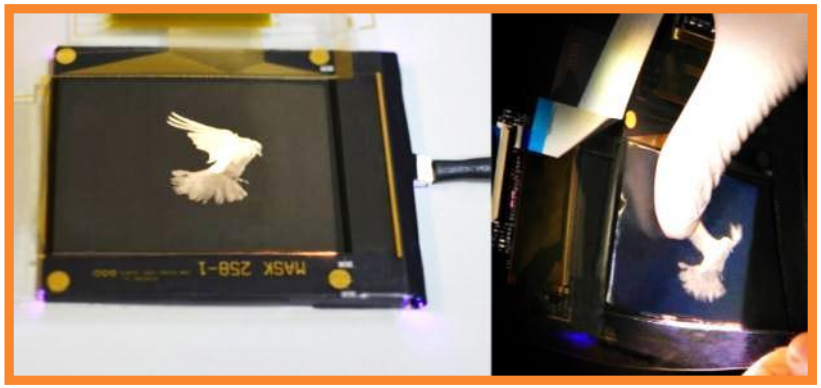
Truly flexible electronics

FabEnable: Plastic LCD Brings Superior Production Economics

Traditional Approach

- **Expensive substrate** = Fiber reinforced plastic (FRP) ~ $100/sqm
- **Glass is destroyed** during cell assembly process
- **Not a practical process** for volume manufacturing



FlexEnable Approach

- Substrate **100X lower cost**: Triacetyl Cellulose (TAC) ~ $1/sqm
- **Glass removed from BOM** (re-used in the line)
- Process **industrially proven** for volume manufacture.

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Repurposing existing Assets and supply chains

Existing a:Si Supply Chain and production facilities

+

Organic Dielectric

Organic Semiconductor

Low cost, conformable OLCD

+

Flexible Barrier Layers

Truly Flexible and Foldable AMOLED

FlexEnable
Truly flexible electronics

A few take-aways

- For a technology start-up, especially in hardware/manufacturing, too narrow a focus prior to real commercial traction can lose huge time and money and potentially lead to ruin
- There are several leaps from technology to a commercial product. From technology to product to manufacturing to commercial success. As a start-up, if the leaps are big and there is no one pulling/guiding, the probability of success is small. The chance of success gets much higher when an established player in your target market has skin-in-the-game.
- Management need to think like owners. Management needs to own strategy, with investor buy-in, and re-validate strategy constantly.
- Survival may depend on flexibility in business model – requiring courage and clear strategic vision to reorganise company and adjust to changes in industry/market before it is too late
- Never lose track of the customer – his voice needs to be heard in every meeting and play a part in every decision
- FlexEnable now has a business model based on industrial partnerships and technology licensing – enabled by the convergence of proven technical capability and a validated market demand for the benefits of plastic electronics

Thank You

FlexEnable
Truly flexible electronics