FlexEnable
Bringing Every Surface to Life

Professor Henning Sirringhaus – Co-Founder
Chuck Milligan – CEO
The Plastic Logic / Flexenable Journey

Technology

- Spun out of Cambridge University
- Plastic Logic Founded Nov 2000
- 1.2M organic transistors
- Plastic Logic Process Proven Industrially

2000

Product

- Colour, Video Rate Plastic LCD
- Distortion-free backplane process demonstrated
- Vertical TFT demonstrated

2010

Technology Platform

- World's 1st All organic image sensor
- Flex AMOLED Demonstrated
- Flex Fingerprint Sensor Demonstrated
- Plastic LCD – announced February 2015 – partnership with Merck

2014

MERCK

2015

FlexEnable
- Founded, February 2015
- March 2015 - Colour, Video Rate plastic OLED
- April 2015 - Colour, Video rate Plastic LCD display

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

- **Printing-based manufacturing**
- **Higher carrier mobilities through self-organisation**

- 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

Science 290, 2123 (2000)

Nature 401, 685 (1999)
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)
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

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

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
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)
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
- Strong leadership and committed team
- Courageous and faithful investors
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
Driving the new era in flexible electronics

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 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

<table>
<thead>
<tr>
<th><strong>ProductEnable™</strong></th>
<th><strong>FabEnable™</strong></th>
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</thead>
<tbody>
<tr>
<td><em>Monetisation: Fees from prototypes and projects</em></td>
<td><em>Monetisation: Transfer fees, licences and royalties</em></td>
</tr>
<tr>
<td>Create and source product applications for truly flexible electronics</td>
<td>Tech transfer to upgrade existing fabs to make flexible electronics</td>
</tr>
<tr>
<td><img src="image" alt="Product Design" /></td>
<td>Feasibility study</td>
</tr>
<tr>
<td><img src="image" alt="Prototypes" /></td>
<td>Process design</td>
</tr>
<tr>
<td><img src="image" alt="Field Trials" /></td>
<td>Process implementation</td>
</tr>
<tr>
<td><img src="image" alt="Design of high volume production processes" /></td>
<td>Process upgrades</td>
</tr>
</tbody>
</table>

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<tr>
<th><strong>MaterialsEnable™</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Monetisation: Fees from materials testing and qualification</em></td>
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<tr>
<td>Asses and qualify new materials for flexible electronics</td>
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<tr>
<td><img src="image" alt="Test protocol definition" /></td>
</tr>
<tr>
<td><img src="image" alt="Mechanical testing and qualification" /></td>
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<td><img src="image" alt="Process development" /></td>
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<tr>
<td><img src="image" alt="Demonstrators" /></td>
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</tbody>
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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

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

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

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

Headcount
- CEO
- 1
- Technical Team
- 36
- Strategy and MarCom Team
- 3
- Finance and Admin Team
- 6
- Commercial and FabEnable
- 2
- Total
- 48
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 Udaltsoy  
Advisor  
Deputy Chairman of the Executive Board at Rusnano Management Company LLC
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

FlexEnable’s value is the processes, architectures, materials and qualification IP to manufacture truly flexible electronics
Best in-class Performance and Cost Advantages

More cost effective and more flexible than alternatives

- **oTFT on PET**

  - 60Hz OLED/LCD Flexible full motion video
  - 25µm Substrate Thickness As thin as a human hair

- **oTFT on PET**

  - Low Cost Lowest cost for all areas and surfaces
  - 100 gsm Weight per area As light as a sheet of paper

- **FlexEnable**

  - Truly flexible electronics

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

### Utility – What do you get with glass-free?
- ✓ Conformability
- ✓ Flexibility
- ✓ Thinness
- ✓ Light weight
- ✓ Unbreakable

### Performance
- ✓ Transistors - Better than a:Si
- ✓ Uniformity
- ✓ Reliability

### Cost/Volume
- ✓ 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
Enabling a Wide Range of Applications

**Wearables / Displays**
- Displays on wearables
- Automotive displays
- OLED Smartwatch
- Smartphones

**Sensors**
- Fingerprint and vein sensor
- Gas sensors: CO, H₂S, O₂
- 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, H₂S, O₂
- Lab on Chip
Flexible Displays for Wearables and Everywhere-ables

Enabling New markets and transforming existing markets

Unbreakable Mobile Devices  Automotive and Aerospace  Wearables  Digital Signage
Full Colour OLCD

In partnership with
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
Flexible X Ray 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
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.
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
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