

Mapping Out the Future of Packaging – OE-A Roadmap for Organic and Printed Electronics

Packaging Management Council
October 14, 2015
Rochester, N.Y.

Barbara M. Fisher
Regional Manager, OE-A North America

a working group within



OE-A
www.oe-a.org



Photo: Intel/Comins

Outline

- Introduction OE-A
- LOPEC
- 6th Edition of the OE-A Roadmap
 - Applications and Technologies
- Demonstrator Projects



What is Organic and Printed Electronics?



Organic and Printed Electronics is

- thin
 - lightweight
 - flexible
 - robust
- and enables
- low-cost electronics
 - new applications
 - single-use disposable electronics

using large-area, high-volume processing

Enables:

- Electronics everywhere
- Ambient intelligence



What is Organic and Printed Electronics?



Active and passive organic devices: transistor, IC, antenna, ...)

Multifunctional systems



Sensors (touch, temperature, pressure, gas, ...)



Power supply (organic photovoltaics, flexible battery, ...)

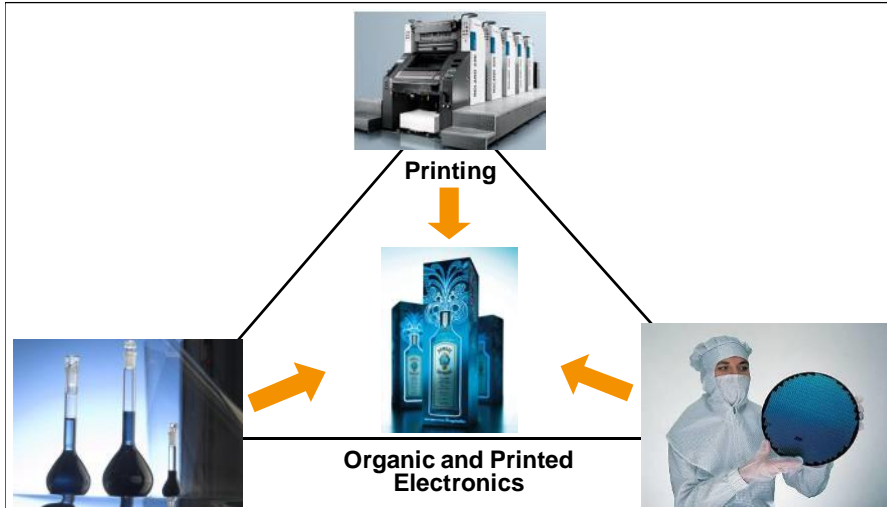


Displays and lighting (OLED, electrochromic, electrophoretic,...)



Source: PolyIC, Fraunhofer ISE, Thinfilm, Plastic Logic

Basics of Organic and Printed Electronics



Source: Heraeus, manroland, Infineon, Karl Knauer

Printing Technologies



<h3>Gravure Printing</h3> <p>© OE-A</p>	<h3>Offset Printing</h3> <p>© OE-A</p>	
<h3>Flexographic Printing</h3> <p>© OE-A</p>	<h3>Screen Printing</h3> <p>© OE-A</p>	<h3>Ink-jet Printing</h3> <p>© OE-A</p>

New Functional Inks / Substrates

- **Soluble Functional Materials**
 - Polymers
 - Metal filled pastes
 - Nanoparticles
- **Substrates**
 - Paper
 - Plastic
 - Glass
 - Stainless Steel
- **The material best suited for specific application depends on process conditions, surface roughness, thermal expansion, barrier properties**



Source: Heraeus Clevis, Cynora

OE-A – Overview

- **Global industry association** for organic and printed electronics, driven by over 240 international members
- **Our members represent the entire organic electronics value chain:**
 - Component & material suppliers
 - Equipment & tool suppliers
 - Producers / system integrators
 - End-users
 - R&D institutes
- **Benefits of OE-A membership:**
 - Networking Opportunities
 - Frequent Working Group Meetings
 - Europe, North America, Asia
 - LOPEC
 - Industry Roadmaps
 - Demonstrator Projects
 - Industry Visibility



New OE-A Board of Directors



Chairman:

Dr. Jeremy Burroughes 

Vice Chairman Asia:

Prof. Dr. Toshihide Kamata 

Vice Chairman Europe:

Jaap Lombaers 

Vice Chairman North America:

Stan Farnsworth 

Members of the Board:

Markus Bamberger 

Prof. Dr. Reinhard Baumann 

Dr. Peter Fischer 



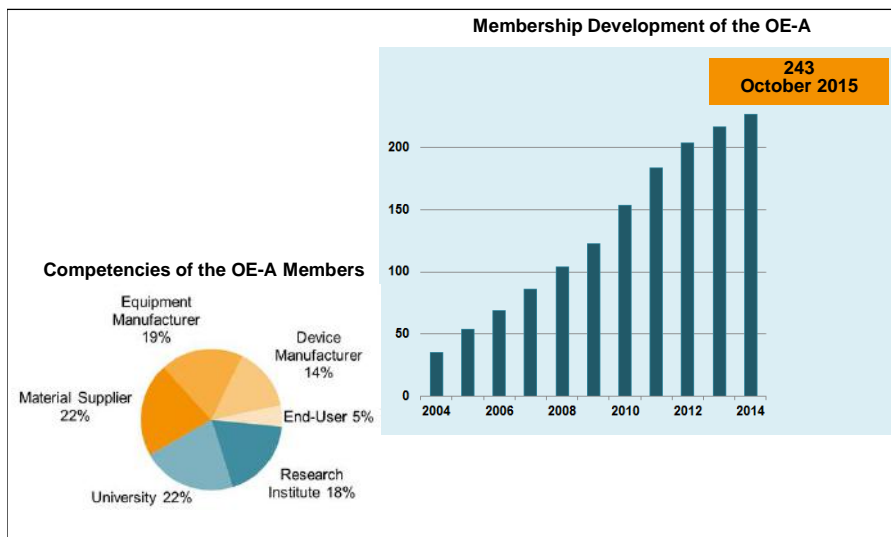
Dr. Stephan Kirchmeyer 

Thomas Kolbusch 

Thibaud Le Séguillon 

Dr. Giovanni Nisato 

OE-A Has More than 240 Members, Representing the Whole Process Chain in Organic and Printed Electronics





240+ Members Representing the Entire Value Chain (1)

Companies

Equipment **Devices** **End-User**

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240+ Members Representing the Entire Value Chain (2)

Research Institutes

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Global Approach

- Establish a global network

OE-A is active in

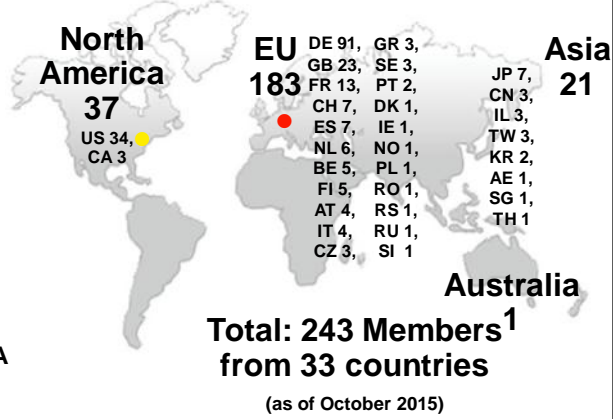
- Europe
- North America
- Asia

Headquarters:

- Frankfurt, Germany

North American Office:

- Pittsburgh, PA., USA



Global Approach North America

- Quarterly Working Group Meetings
- Next Meeting:
 - 23rd North American Working Group Meeting
 - November 17, 2015 San Jose, CA.
 - **Special Topic:** Enabling the Internet of Everything
- Frequent Presentations at Conferences and Trade Fairs in North America
- Installation of a North American Chapter
- North American office
Barbara M. Fisher
+1-412-828-0370
barbara.fisher@oe-a-na.org



Standardization of Printed Electronics IEC

- OE-A supports the international standardization activities
- Technical Committee **TC119 for Printed Electronics**
IEC (International Electrotechnical Commission)
www.iec.ch, founded in May 2012
- OE-A members participate via their National Standardization Organization
- Creation of ad hoc working groups
 - Terminology, Materials Equipment, Parts and Devices, Printability
- TC 119 **Meetings 2015:**
 - November 2015 (parallel to 23rd North American OE-A Working Group meeting in San Jose, CA.)
- **Facts and Figures on the TC 119:**
 - Chairman: Dr. Alan Hodgson, UK
 - 13 "Active" Members ("P-Members", voting rights):
CN, CY, DE, ES, FI, GB, IT, JP, KR, NL, RU, SE, US form national mirror committees
 - 7 "Passive / Observer" Members (O-Members):
BR, CA, CZ, FR, MY, PL, ZA presently signed up



Communication OPE-Journal

- **OPE Journal**
 - Globally circulated magazine for the organic and printed electronics industry
 - Launched in 2012, circulation of 9,500 copies
 - Publication by nimble show & media
 - Includes 12 pages of **OE-A news**
 - Advisory Board by OE-A Members
 - **Benefits for OE-A members**
 - free subscription
 - 15% discount on advertisements
 - articles in OE-A news section
- Next issue will be published in November 2015
- www.ope-journal.com



Networking Initiative



The **oe-a** on **LinkedIn**

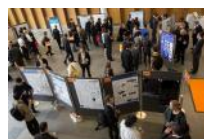
Join the OE-A Group on LinkedIn!

- Open to OE-A members and non-OE-A members
- Network with over 2,200 of your colleagues, contacts and business partners
- Platform for discussions, networking and up-to-date information
- All parties interested in the OE-A are welcome to join this forum!
- www.linkedin.com

LOPEC 2016, April 5-7, 2016



- **New Munich Trade Fair Centre, Germany**
- **Provides the central marketplace for Organic and Printed Electronics**
 - 2,300+ attendees
 - 130+ international exhibitors
 - 190+ presentations
- **Exhibition**
 - Largest industry exhibition in the field
 - On-site production on demo line
- **Conference**
 - Business conference
 - Technical conference /Scientific conference
 - Pre-conference seminars
- **10% discount for OE-A members**
- **www.lopec.com**



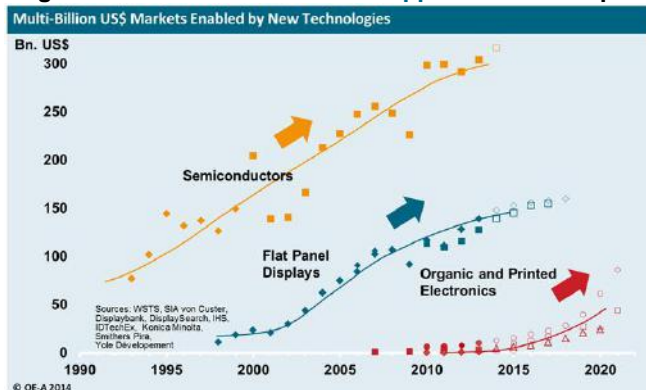
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Organic and Printed Electronics A Future Multi-Billion \$ Market

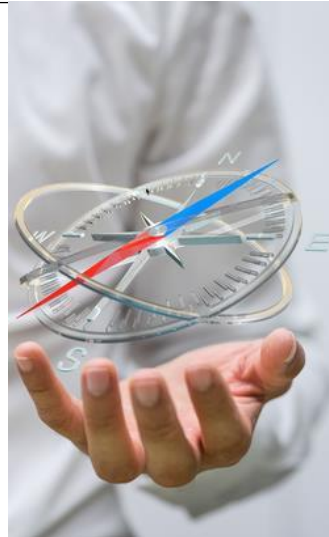
- Organic electronics enables **new applications** and opens **new markets**



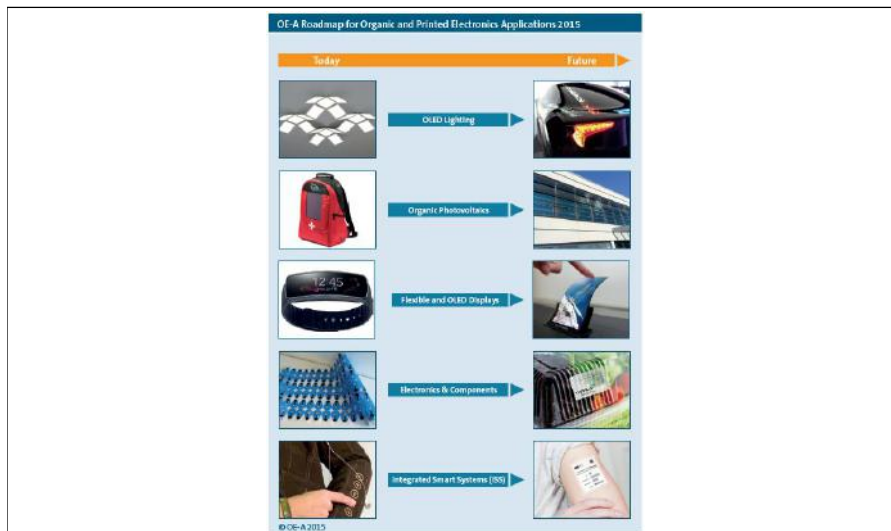
- **2014: US\$23B**, predominately in OLED displays
- **Potential for a US\$50B** market within the next 10 years driven by lighting, displays, OPV, logic, memory/RFID, sensors

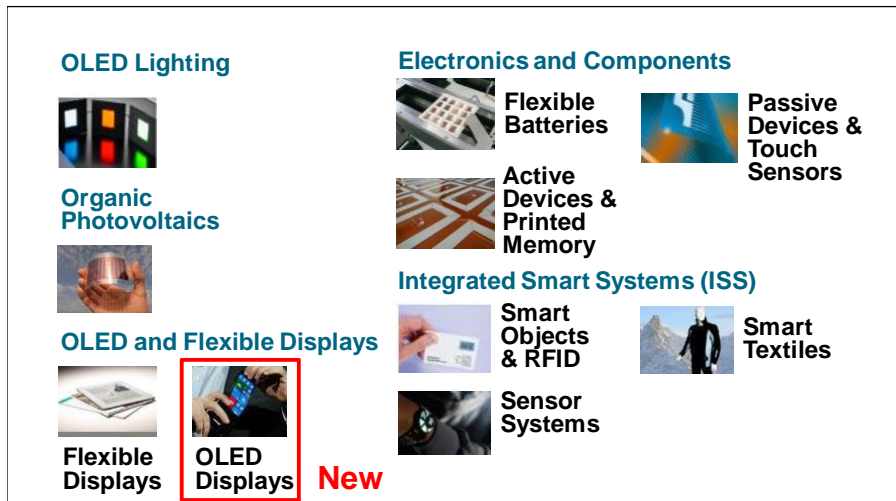
Sixth Edition OE-A Roadmap 2015 for Organic and Printed Electronics

- Roadmap is a key activity of the OE-A
- Forecast: Short-, medium-, longer term for applications and technologies
- Target group:
 - End-users, producers, material suppliers, equipment manufacturers, researchers
 - Public
 - Government and funding agencies
- Represents the common perspectives of the 230+ OE-A members
- Identification of Red Brick Walls
- Updated bi-annually
- 14 dedicated teams
 - Application oriented
 - Technology oriented
 - End-User oriented Roadmap `Health Care`



OE-A Roadmap 2015 for OE Applications Overview





Source: FhG ISE, Plastic Logic, Novalad AG, Samsung, Schreiner PrinTronics, PolyIC, Thin Film Electronics, exax, Plastic Electronic, VARTA, Francital
 © OE-A 2015, October 2015 Page 23

- OLED displays have become a **mass market** item in mobile displays and are starting to penetrate the TV market.
- **Major industry sectors**, such as automotive, consumer electronics, white goods, pharmaceuticals/health care and packaging, are bringing organic electronics products to the market.
- Integration of printed and silicon-based components to make **hybrid systems** looks to be one of the primary paths to further commercialization in the coming few years.
- Mobility of organic semiconductors and efficiency of OPV **materials** are continuing to increase rapidly, and competitiveness with poly-Si is starting to look achievable.
- Patterning **processes** are being scaled to smaller dimensions and improved registration.

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Short List of Key Application Parameters

- Different sets of key parameters for different applications

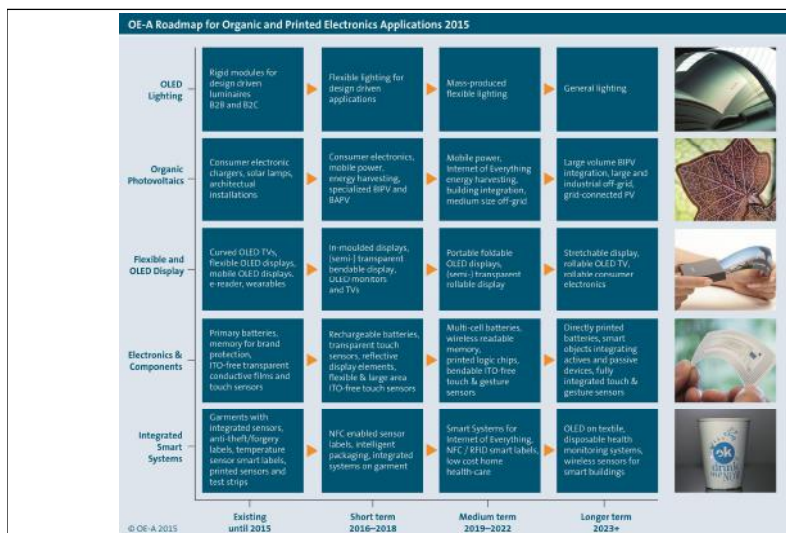
Short list of most important parameters:

- Complexity of the devices
- Flexibility/bending radius
- Lifetime/stability/homogeneity/reliability
- Efficiency/performance
- Environmental and toxicological safety
- Cost

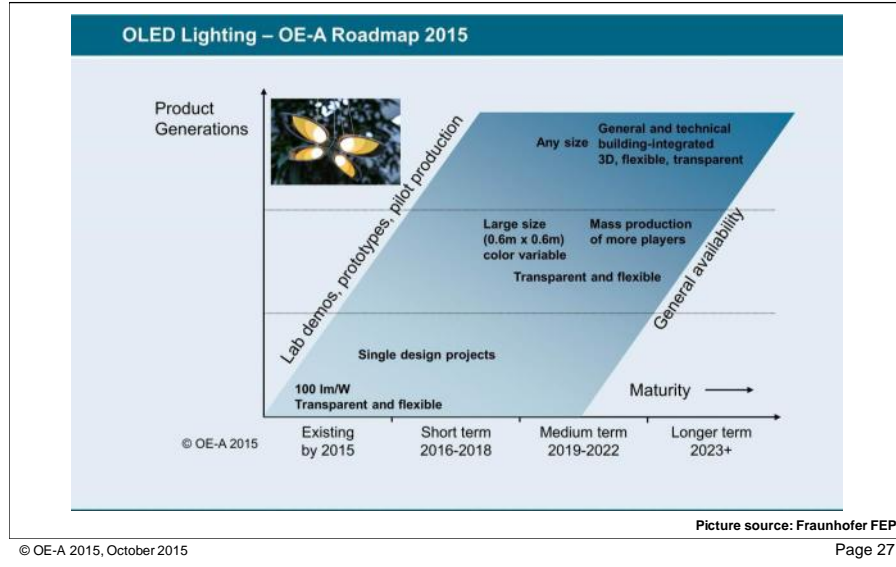


Source: VTT, PostAuto Schweiz AG

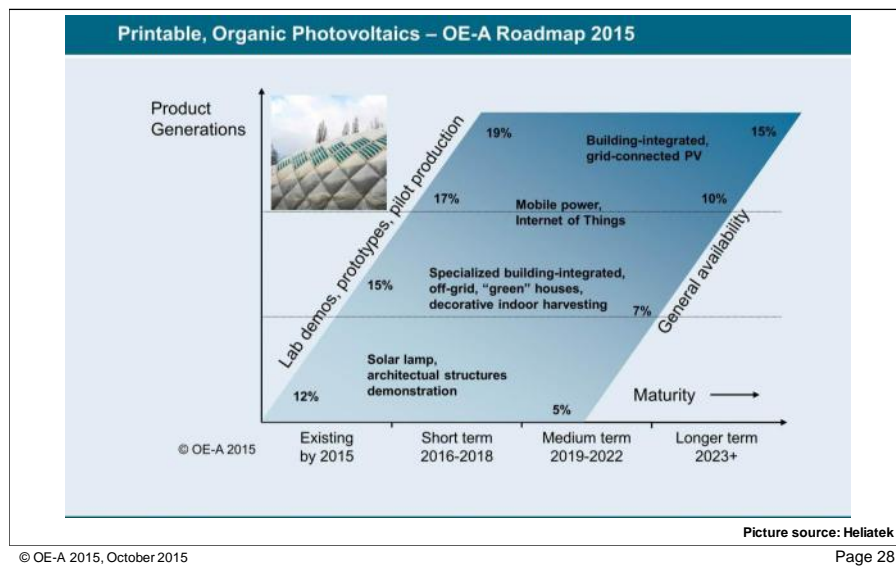
OE-A Roadmap 2015 for OE Applications Forecast for Market Entry



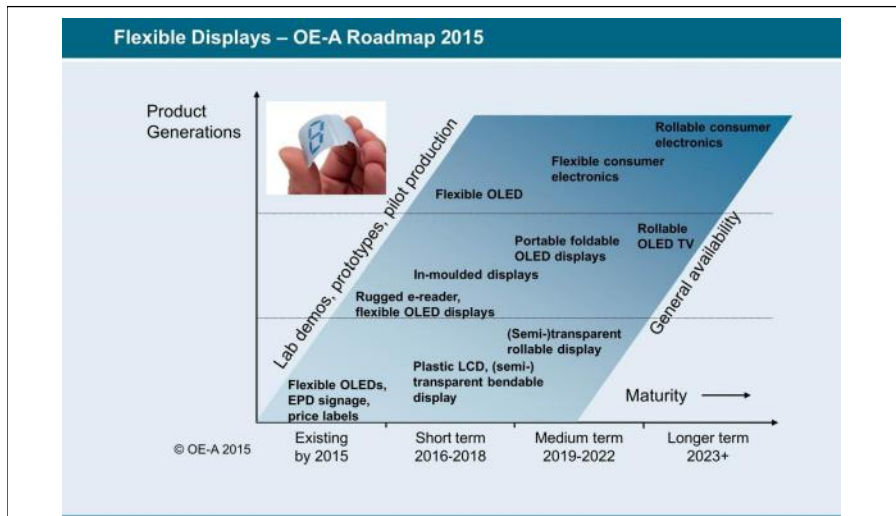
OLED Lighting – Roadmap 2015



Organic Photovoltaics – Roadmap 2015



Flexible Displays – Roadmap 2015

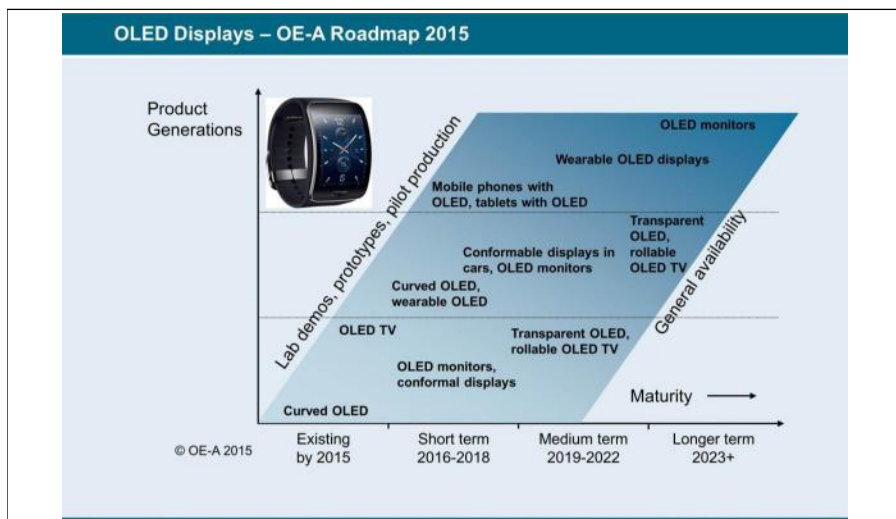


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Picture source: Acree Swedish ICT

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OLED Displays – Roadmap 2015

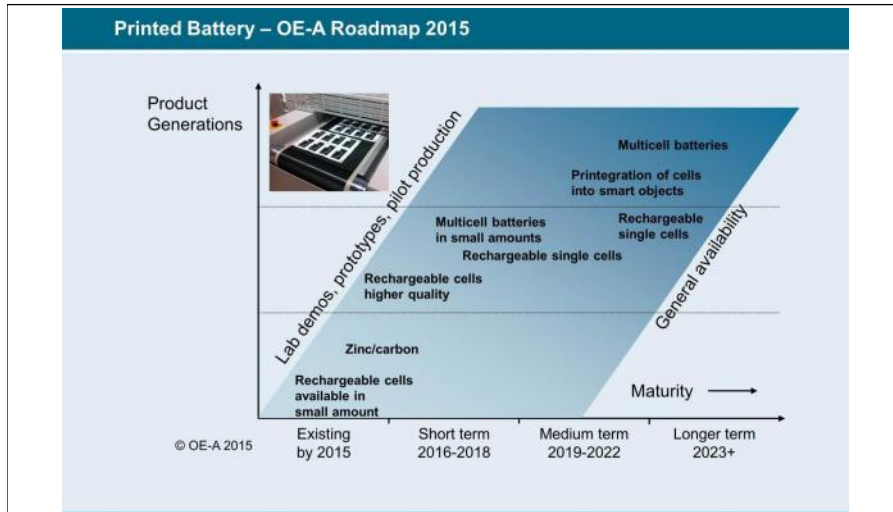


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Picture source: Samsung

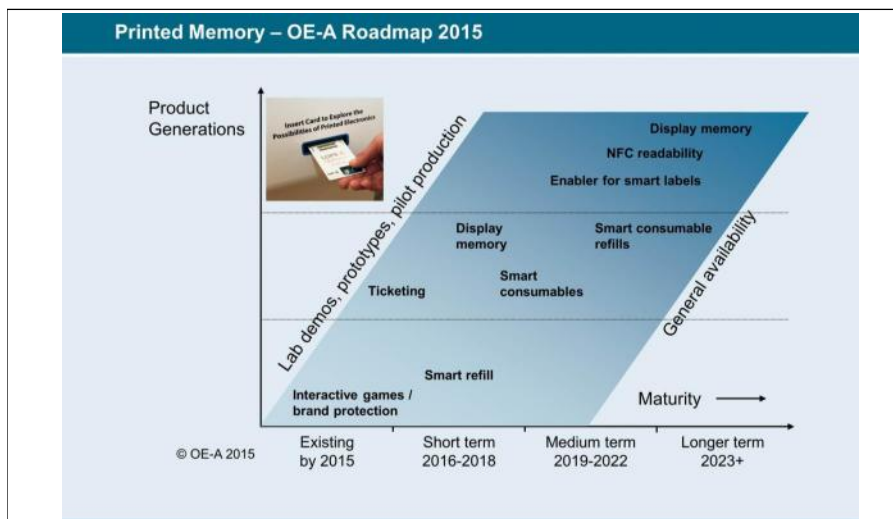
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Printed Battery – Roadmap 2015



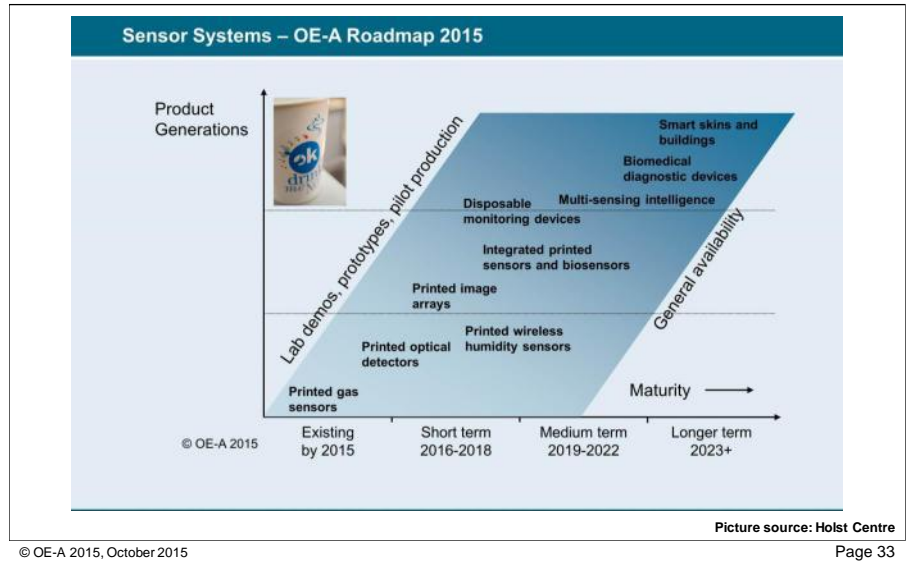
Picture source: TU Chemnitz

Printed Memory – Roadmap 2015

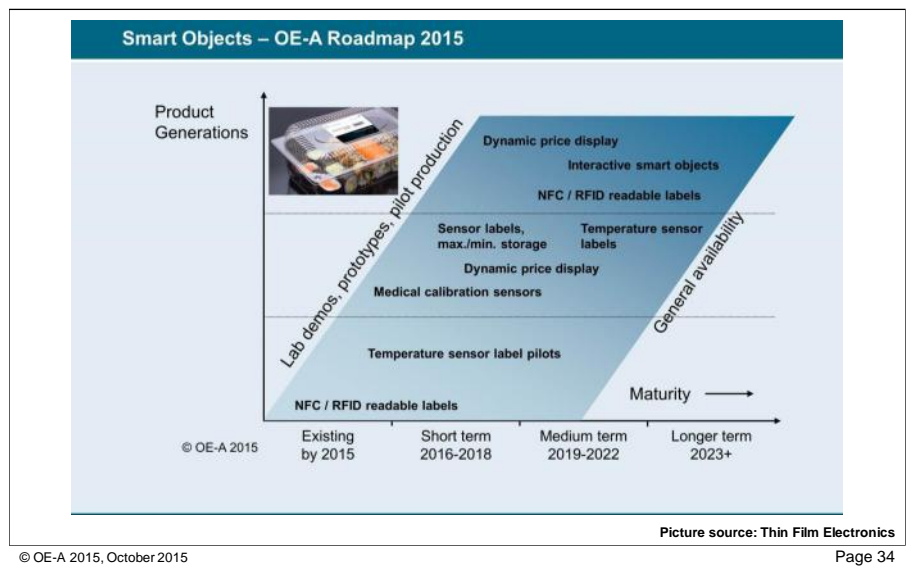


Picture source: Thin Film Electronics

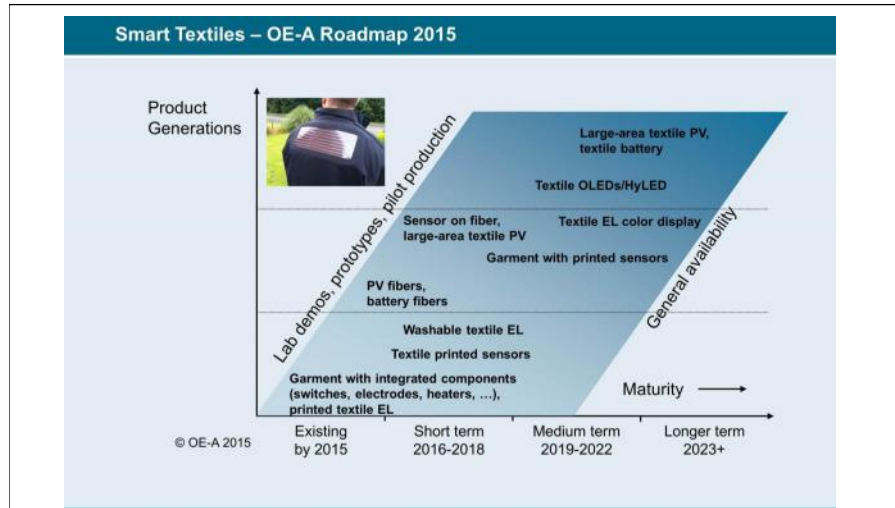
Sensor Systems – Roadmap 2015



Smart Objects – Roadmap 2015



Smart Textiles – Roadmap 2015



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Picture source: G24 Power

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Functional Materials



- **Conductors:**
 - Polymer
 - Metal filled pastes
 - Carbon nanotubes
 - Metallic nanoparticles
- **Semiconductors:**
 - Small molecules
 - Amorphous polymers
 - Semi-crystalline polymers
 - Carbon nanotubes
 - Printable metal oxides
 - Graphene
- **Electrochromic and electrophoretic materials**
- **Substrates**
 - Paper, cardboard, film, foil, thin glass, stainless steel
- **Dielectrics**
- **Encapsulation**
 - Hybrid organic/inorganic barrier
- **The material best suited for a specific application depends on process conditions, surface roughness, thermal expansion, barrier properties**



Source: Cynora, Heraeus

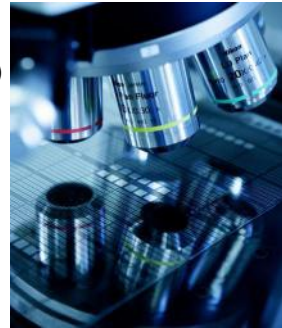
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Short List of Key Technology Parameters



- **Electrical performance**
(mobility, efficiency, conductivity, voltage, current)
- **Resolution / registration / uniformity**
- **Barrier properties / environmental stability**
- **Fit of process parameters**
(speed, temperature, solvents, ambient conditions, vacuum, inert gas atmosphere)
- **Yield**



Source: CPI

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Key Challenges / Red Brick Walls



Major breakthroughs are absolutely necessary:

- **Processes**
 - Resolution, registration, uniformity and characterization improvements are needed
- **Materials**
 - Electrical performance, processability (especially formulations in non-toxic solvents) and environmental stability need to be improved further
 - Producing materials that combine high uniformity with high mobility in industrial quantities in high, reproducible quality is still a challenge
- **Encapsulation**
 - Achieving high-quality flexible, transparent barriers at low cost continues to be a challenge
- **Standards**
 - Suitable new standards for organic and printed electronics are required since comparison to classical electronics is both highly challenging and not always relevant



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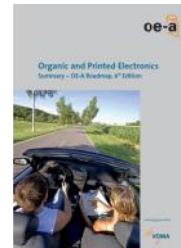
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OE-A Roadmap, 6th Edition



OE-A brochure “**Summary** – OE-A Roadmap, 6th Edition”, March 2015

- Includes
 - Roadmap summary article
 - Information on OE-A and its services
- Available from www.oe-a.org/downloads



● **White Paper** “OE-A Roadmap for Organic and Printed Electronics”, 6th Edition, June 2015

- Full text, all graphics, 130+ pages
- Members: free access printed and PDF-version
- Detailed tables available for members
- Non-Members: White Paper for sale www.oe-a.org



Printing / Packaging / Advertising



● Today

- Printed interactive cards
- Interactive journals (displays, PV, batteries, LEDs) e.g. Esquire, TV Movie
- Interactive pricetags and smart shelves
- Interactive posters: electroluminescent, motion sensors
- Tickets
- Smart packaging with printed lighting elements

● Tomorrow

- Smart labels: e.g. time-temperature indicators
- Intelligent packaging
- Interactive newspapers
- Interactive billboards
- Printed RFID tags



Source: Thin Film, Bauer Media, ISORG, Karl Knauer

Healthcare Applications



● Today

- Diagnostic electrodes
 - Printed blood glucose test strips
 - Printed flexible electrodes for ECG, EEG, EOG
 - Printed cholesterol test strips
- Therapeutic electrodes
- Laboratory analytical electrodes
- Smart pharmaceutical blister packaging for field trials



● Tomorrow

- Smart packaging to ensure patient compliance
- Flexible displays integrated in packaging for patient information
- Anti-counterfeiting
- RFID for logistics
- Smart clothing with embedded motion and physiological sensors
- Flexible textile sensors in mattresses to prevent sores
- Smart patches: light therapy, drug delivery, temperature
- OLED blankets for phototherapy

Source: Holst Centre, Philips, Acreo Swedish ICT
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Displays / Consumer Electronics / Wearables



● Today

- Electrophoretic displays
- OLED displays for smart phones, tablets, wearables
- Flexible eReader
- OLED TV (55")
- Smart pricetags (electrochromic, e-ink)
- Smart Watch, Fitness tracker



Source: Ella Retail, LG, Samsung

Lighting

● Today

- Designer luminaires
- Electroluminescence, night lighting, ambient lighting



● Tomorrow

- Smart windows with OLEDs
- Flexible OLED wallpaper
- Integration in textiles
 - Bags
 - Safety clothing
 - Fashion and sportswear



Source: OSRAM

Energy

● Today

- Flexible batteries
 - Smart packaging
 - Mobile and other electronic devices
- Flexible OPV for consumer goods, e.g. bags or backpacks
- OPV powered keyboard



● Tomorrow

- Building Integrated Photovoltaics (BIPV)
- OPV canopy
- Automotive applications



Source: G24 Systems, Heliatek

Smart Textile Applications

● Today

- Safety clothing
- Fashion: keypads and solar cells integrated, sensors in sports jackets



● Tomorrow

- Smart clothing with
 - Batteries
 - Loudspeakers
 - OPV
 - Lighting
 - Sensors
- Smart carpets with pressure sensors
- Textiles for health monitoring: temperature, respiration, blood pressure
- Seat heaters for cars and furniture



Source: Cetemmsa, Fraunhofer IZM, G24 Power

Automotive Applications

● Today

- Printed antennas
- Airbag sensors (seats)
- Electrochromic rear mirrors
- Electroluminescence: ambient lighting, instrument cluster
- Printed window defrosters
- Electrochromic glass roofs
- Touch displays
- Switches with OLEDs



Picture: Heraeus, PolyIC, Audi

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- Demonstrator Projects



Collaboration is the Key to Success OE-A Demonstrator Projects

- OE-A supports and facilitates cooperation
- Key activity of the OE-A since 2005
- Illustrate the **potential** and the **integration possibilities** of organic and printed electronics



2006



2007



2008



2009



2010



2011



2012



2013



2014



2015

2015 Competition Freestyle Demonstrators

● Freestyle Demonstrators

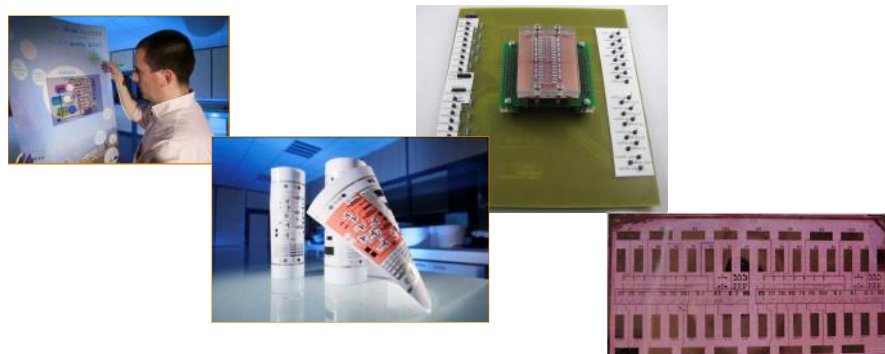
- Paper Piano Keyboard
- Piezoelectric Transparent Loudspeaker
- OLED Drinking Glass
- Emergency Beacon
- Outdoor Survival Blanket
- Autonomous Power Supply
- OLED Enlighted Purse
- Wine Tester



2015 Competition Publicly Funded Project Demonstrators

● Publicly Funded Project Demonstrators

- Gas Detecting Safety Label (A5/A0)
- Analog to Digital Converter



2015 Competition Prototypes and New Products

● Prototypes and New Products

- Smart Packaging
- Smart Yoga Mat
- Temperature RFID Tag
- Temperature NFC Tag
- 3D-Touchslider

ARJOWIGGINS
creative papers

CETEMMSA
TECHNOLOGICAL CENTRE

印刷电子产业研究院
Institute of Printed Electronics Industry

OU
AD

Heraeus



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2015 Competition Design Competition

● Design Competition

- Luminescent Scaffolding Wrap
- DJ Decks on Paper
- Temperature Monitoring Table Mat
- “Tykky” Lamp

FTB
Forschungszentrum für Textil und Membran
Research Centre for Textiles and Membranes

N

UAB
Universitat Autònoma
de Barcelona

VTT



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Conclusions

- Organic and printed electronics enables **new business opportunities**
- **Commercial products are now appearing** in most of the application clusters
- **Key industries like automotive, healthcare, consumer electronics already employ organic and printed electronics on a large scale**

- The OE-A catalyzes joint efforts to further grow this industry:
 - **OE-A Roadmap** describes the **path to the future** and supports the industry, research and governments in planning the transition
 - **Major societal and economic trends** cross-fertilize printed electronics
 - **Cooperation along the value chain** is key for success
 - **Standards** create a common language
- OE-A provides the international industry platform and supports the companies in **managing the transition to business**



Increase Your Visibility – Make Your Voice Heard

- **Meet your future partners, customers and suppliers**
- **Promote your company at LOPEC, the premier industry event**
- **Showcase your company in the OE-A brochure, website, newsletter and magazine**
- **Contribute to the OE-A Roadmap and benefit from the results**
- **Team up in Demonstrator projects**
- **Actively participate in shaping this revolutionary industry**

Strategize for the next multi-billion dollar market...
Join the International Leaders in Organic & Printed Electronics –
Join the OE-A!



Contact

Headquarters

Dr. Klaus Hecker
Managing Director
+49-69-6603-1336
klaus.hecker@oe-a.org

North American office

Barbara M. Fisher
Regional Manager North America
+1-412-828-0370
barbara.fisher@oe-a-na.org

a working group within



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Frankfurt, Germany
www.oe-a.org



Photo: Hecker