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

Packaging Management Council
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Rochester, N.Y.

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OE-A
www.oe-a.org

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

Active and passive organic devices: transistor, IC, antenna, ...)
Displays and lighting (OLED, electrochromic, electrophoretic,...)
Multifunctional systems
Sensors (touch, temperature, pressure, gas, ...)
Power supply (organic photovoltaics, flexible battery, ...)

Source: PolyIC, Fraunhofer ISE, Infineon, Plastic Logic
Basics of Organic and Printed Electronics

Printing Technologies

Gravure Printing

Offset Printing

Flexographic Printing

Screen Printing

Ink-jet Printing
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 Clevios, Cynora

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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

Membership Development of the OE-A

Competencies of the OE-A Members:
- Equipment Manufacturer: 19%
- Device Manufacturer: 14%
- Material Supplier: 21%
- End-User: 5%
- University: 22%
- Research Institute: 18%
Organic and Printed Electronics Association

240+ Members
Representing the Entire Value Chain (1)

Companies
- BAW
- BTB
- LG
- NPG
- OND
- PEA
- RPK
- XRON
- ILM
- COHERENT
- T Flex
- ZEON
- COR
- EVONIK
- AGFA
- PEL
- Arbowings
- Polytech
- Schaefer Group
- Heraeus
- LG Technology Center Europe
- Enfucell
- AIP
- Fraunhofer
- CTD
- Mésa & Coordeniers

Equipment
- Braun
- Brauker
- Kiren
- Helotek
- Beco
- Polyta
- Elektronik
- Saint-Gobain
- Solventic
- Messe und Congresscenter

Materials
- DuPont
to
- SunTech
- Inc.
- Messe und Congresscenter
- Messe und Congresscenter

Devices
- Fujitsu
- GE
- LG
- NTT
- Panasonic
- Philips
- Samsung
- Sharp
- Sony
- Toshiba
- Fujitsu
- GE
- LG
- NTT
- Panasonic
- Philips
- Samsung

End-User
- Aiphone
- Evonik
- AGFA
- PEL
- Arbowings
- Polytech
- Schaefer Group
- Heraeus
- LG Technology Center Europe
- Enfucell
- AIP
- Fraunhofer
- CTD
- Mésa & Coordeniers

Organic and Printed Electronics Association

240+ Members
Representing the Entire Value Chain (2)

Research Institutes
- CEFET
- CSEM
- CNET
- CORDIAC
- CPO
- IEMN
- IMMU
- IMST
- INPL
- IRIS
- JST
- MIST
- MRS
- NPL
- NIST
- PTB
- SED
e
- SEMIC
- SVEROS
- VTT
- UF
- UNICAMP
- UMINHO
- UPM

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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

North America
- 37
  - US 34
  - CA 3

EU
- 183
  - DE 91, GR 3, GB 23, SE 3, FR 13, PT 2, CH 7, DK 1, ES 7, IE 1, NL 6, NO 1, BE 5, PL 1, FI 5, RO 1, AT 4, RS 1, IT 4, RU 1, CZ 3, SI 1

Asia
- 21
  - JP 7, CN 3, IL 3, TW 3, KR 2, AE 1, SG 1, TH 1

Australia

Total: 243 Members\(^1\) from 33 countries
(as of October 2015)

Global Approach

North America

- Quarterly Working Group Meetings
- Next Meeting:
  - 23\(^{rd}\) 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

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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
Organic and Printed Electronics Association

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- Introduction OE-A
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  - Applications and Technologies
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Organic and Printed Electronics Association

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

OE-A Roadmap 2015 for OE Applications Overview
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.
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
OLED Lighting – Roadmap 2015

Picture source: Fraunhofer FEP

Organic Photovoltaics – Roadmap 2015

Picture source: Heliatek
Flexible Displays – Roadmap 2015

OLED Displays – Roadmap 2015
Printed Battery – Roadmap 2015

Printed Memory – Roadmap 2015
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
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

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
OE-A Roadmap, 6th Edition

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

  - Full text, all graphics, 130+ pages
  - Members: free access printed and PDF-version
  - Detailed tables available for members

Printing / Packaging / Advertising

- Today
  - Printed interactive cards
  - Interactive journals (displays, PV, batteries, LEDs)
    - e.g. Esquire, TV Movie
  - Interactive price tags 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 Krauser
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

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

**Tomorrow**
- Flexible, color eReader
- Flexible OLED displays
- Rollable OLED TV

Source: Ella Retail, LG, Samsung

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**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, C24 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

Tomorrow
- Touch surfaces / MMI
- Printed seat heaters
- OPV for energy harvesting
- OLED rear lighting
- OLED interior lights
- Flexible OLED displays
- OLED rear mirrors

Picture: Heraeus, PolyIC, Audi
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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
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

2015 Competition
Design Competition

- Design Competition
  - Luminescent Scaffolding Wrap
  - DJ Decks on Paper
  - Temperature Monitoring Table Mat
  - “Tykky” Lamp
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!
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a working group within

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