



Bayer MaterialScience

Bayer MaterialScience Functional Films: Printed Polymer Electronics



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Bayer Group - Business Areas



108,400 employees

Full year sales: EUR 31.2 billion

R&D expenditures: EUR 2.7 billion

As of February 26th, 2010



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Bayer MaterialScience 2009

EUR 7.5 billion and polyurethane and polycarbonate are the two main materials in the portfolio

Aliphatic polyurethane

For excellent durability

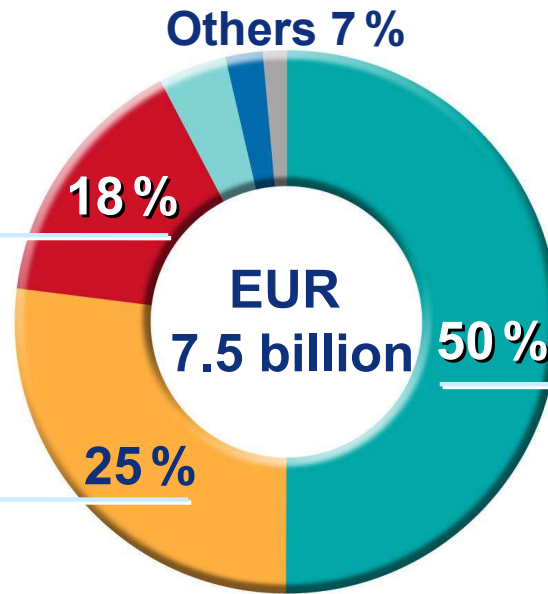


Coatings, Adhesives, Specialties

Polycarbonates

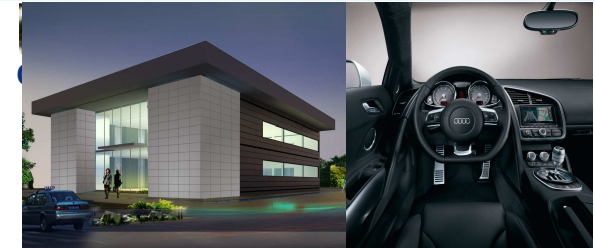
Crystal-clear material with high temperature resistance

resistance



Polyurethanes

Two component elastic and rigid materials for foams, elastic fibers and elastomers



R&D spending EUR 340 million

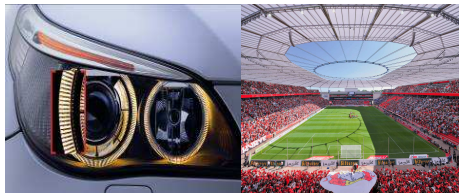


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Bayer MaterialScience – Functional Films

From a polymer raw material supplier to a downstream solution provider

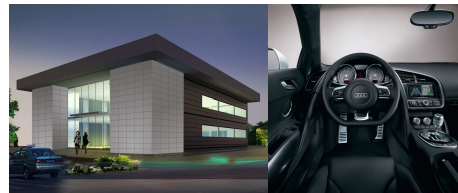
BU Polycarbonates



Polycarbonate films,
optic



BU Polyurethanes



Polyurethane films,
kinetic



BU Coatings, Adhesives and Specialties



Coating raw materials,
holography



Bayer Technology Services



Process and nano-
technology



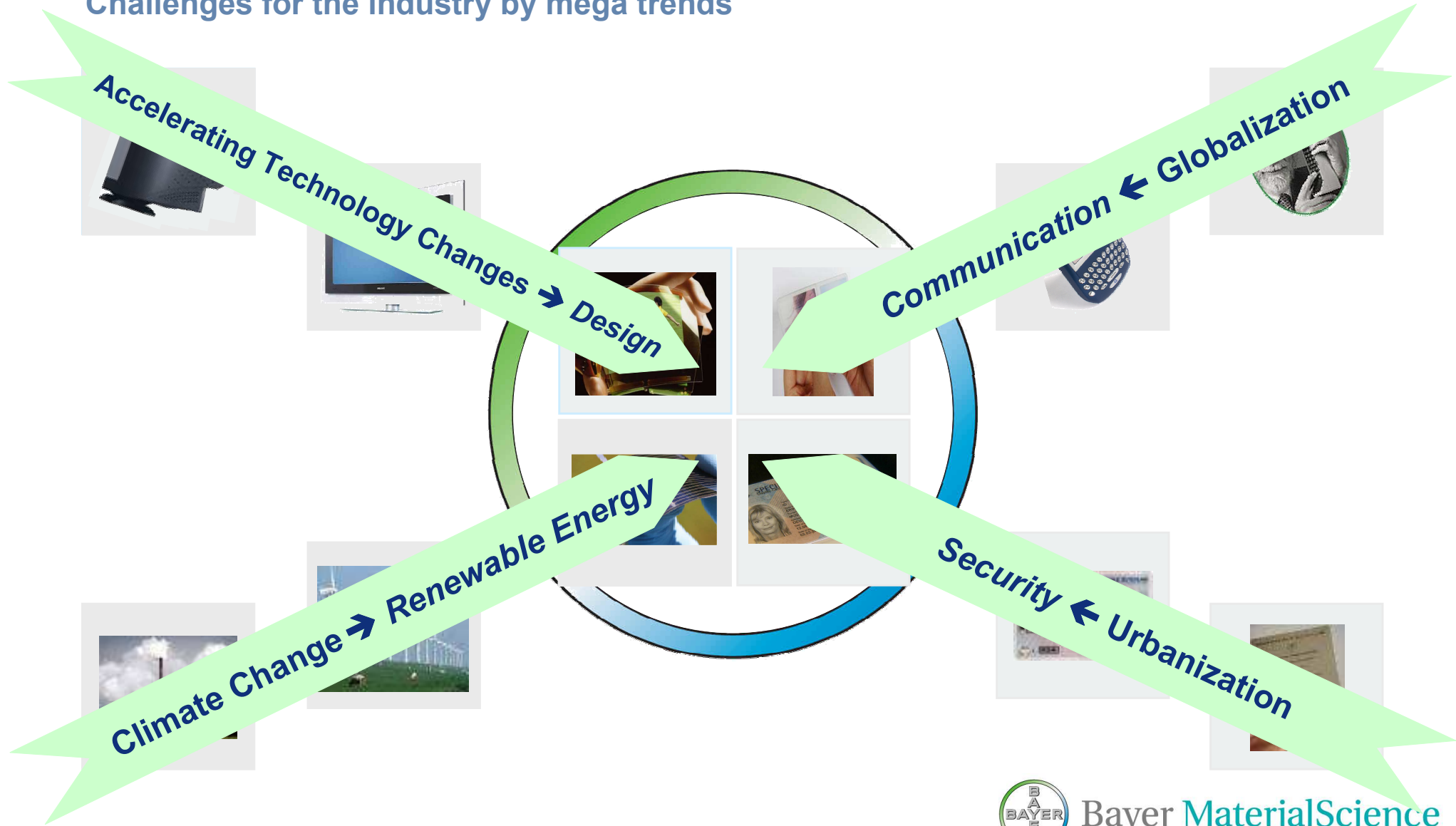
Bundling of selected expertise and resources in
Functional Films
to create added value products for future market trends



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Yesterday – Today – Tomorrow

Challenges for the industry by mega trends



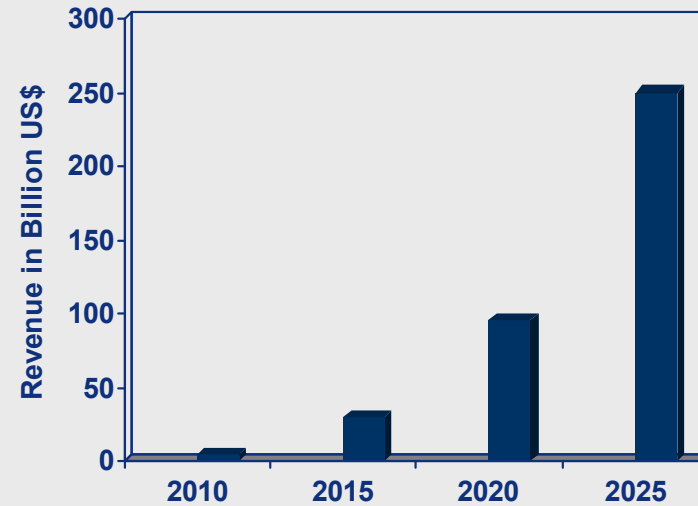
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Evolving Flexible Electronics Market

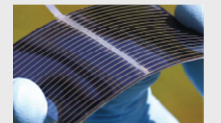
Significant potential foreseen

Main drivers

- Efficient processes
- Freedom in design
- Improved performance



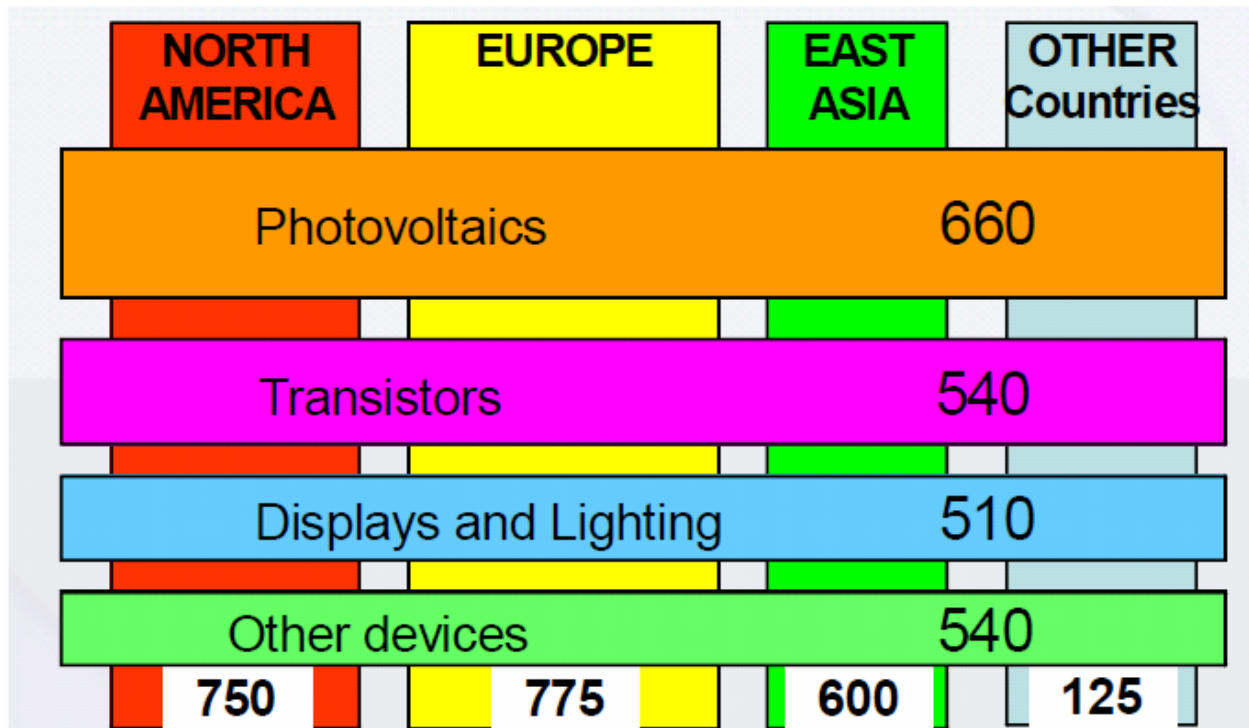
Source: Nano Markets LC (2007) and IDTechEx (2007)



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Unlike in the electronics industry, North America and Europe with strong position in Printed Organic Electronics

More than 2.200 Companies & research institutes active in Printed Organic Electronics



Source: IDTechEx (2009)

Major focus



Applications



Materials



Products

Major focus of each region, might differ depending on industry / market



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OE-A

- **Global industry association for organic & printed electronics**
- **Driven by over 130 international member companies & institutes**
- **OE-A membership includes the entire value chain of organic and printed electronics:**
 - **Component & Material Suppliers**
 - **Equipment & Tool Suppliers**
 - **Device Manufacturers**
 - **Producers/System Integrators**
 - **End-Users**
 - **R&D Institutes**
- **Primary activities of the OE-A include:**
 - **Working Group Meetings & Networking Events**
 - **Industry Roadmaps**
 - **Demonstrator Projects**
 - **LOPE-C: Conference and Exhibition**

A working group within




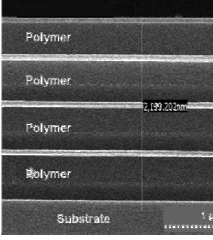



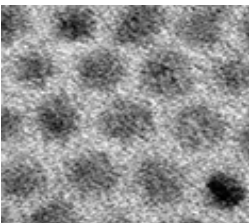

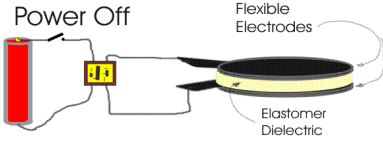


May 31 – June 02, 2010
Congress Center, Messe Frankfurt, Germany

www.lope-c.com

www.oe-a.org, www.vdma.org/oe-a

Functional Films Runs Dedicated R&D Programs with Focus on future trends

Films	Polymer Electronics
<p>ID Cards</p>  <p>Films with optical effects</p>  <p>Formable Hardcoat</p>  <p>Barrier Films</p>  <p>3D Imaging, Display</p> 	<p>Light (EL, hybrid PLED)</p>  <p>Integration of printed electronics</p>  <p>Conductive (nano) Inks</p>  <p>Q-Dots</p>  <p>Actuators, Sensors</p>  <p>Wave Energie</p>

Technical Films Portfolio and Printing

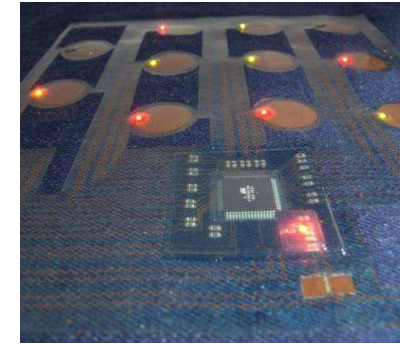
Films

Thermoplastic polyurethanes

- Adhesive films
- Highly elastic films
- Breathable membranes
- Lamination with polycarbonate

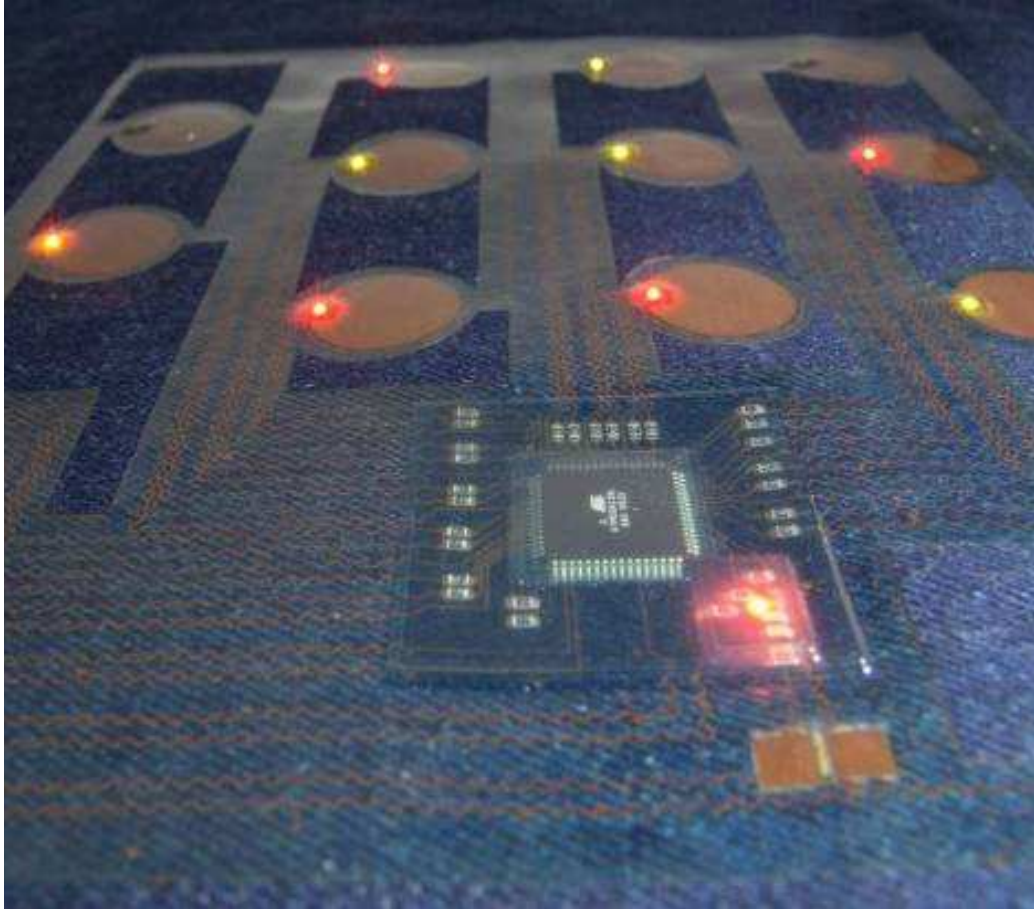
PC Films Products

- Polycarbonate films
- Coextruded
- Polycarbonate blends
- Coated PC films (hard coat, haptic effects, 3D formable hard coats, planarizer)



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Examples for Thermoplastic Polyurethane Films: Post processing: Lamination to textile (EU Project Stella)



→ application to textile in an ironing press process



Stretchable game laminated to denim textile

<http://www.stella-project.de>



Future Trend - New lighting concepts

Blackpanel backlit technology

Strength of polycarbonate films:

- **Excellent forming capability** with good dimensional stability and **mechanical properties**
- Excellent for high quality printing
- **Back-lit functions** can be integrated in a dimensional stable 3D-film part.
- Films with **various surfaces** (gloss to matt, hard coated) support this technology.
- Additional functions such as Anti-reflection, anti-glare, anti-fingerprint, etc. needed.
- Additional **printed electronic functions** such as capacitive switches, printed light can be integrated.



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Integrated printable and formable Light for Innovative Design

Benefits of Printed Light & Integrated Solutions

- Freedom of design: geometry, flexibility, formability
- Cost efficiency integration of different functions

Printed Light technologies

• EL Technology

- Mature technology, ambient light, screen printable
- Constraints: cost, electronic integration.

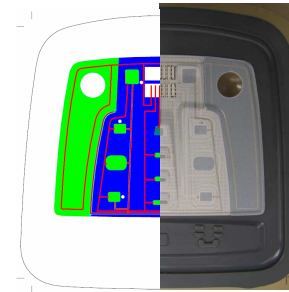
• Hybrid PLED Technology (Add Vision)

- Ambient light, screen printable.
- Constraints: barrier (10-3 WVTR), scale-up

• OLED Technology

- General lighting
- Constraints: barrier (10-6 WVTR), scale-up, Integration

Automotive interior



Home appliance



Design



Mobile

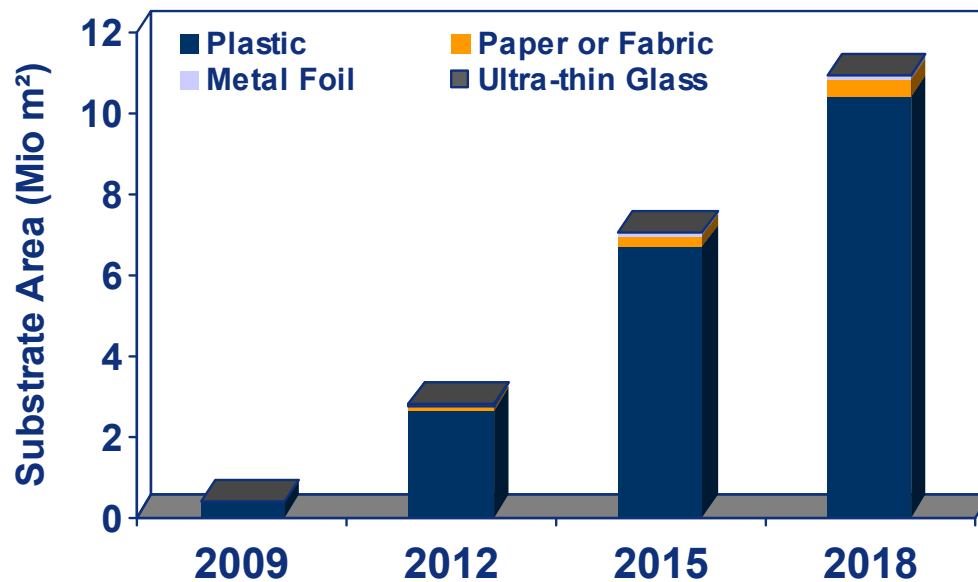


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(Flexible) Substrates - largest share of materials revenue in printed electronics market

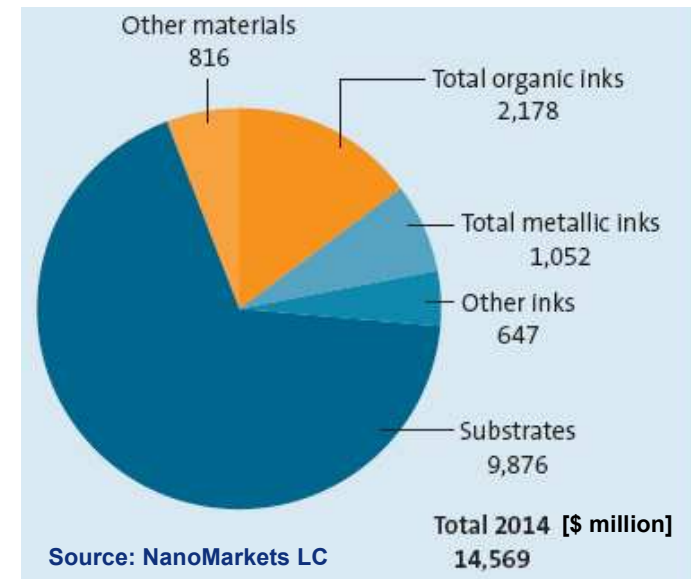
- Advantages of Plastic Substrates:**
- Thinner, more compact
 - More rugged product
 - Larger active display area
 - Design freedom
 - Essential for cost efficient R2R process

Flexible Substrate demand for Displays



Source: "Organic Electronics" Roadmap, OE-A; based on NanoMarkets LC (2007)

Revenue for Printable Electronics materials

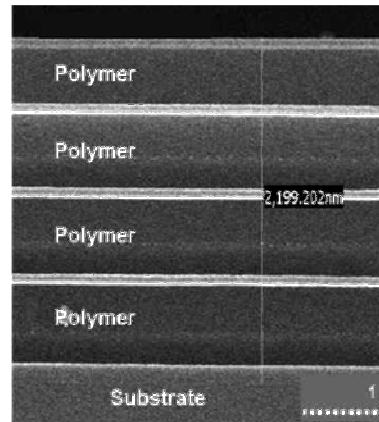


Source: NanoMarkets LC



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BMS' Product Vision: "Customers Request Tailor-Made Films with Integrated Functions"



Conductive Coating (optional)

- Power supply
- Vacuum or wet coating process

Barrier Coating

- Protection against water and oxygen
- Vacuum & wet coating process

Planarizing Coating (optional)

- Increase surface smoothness
- Wet coating

Polymer Film

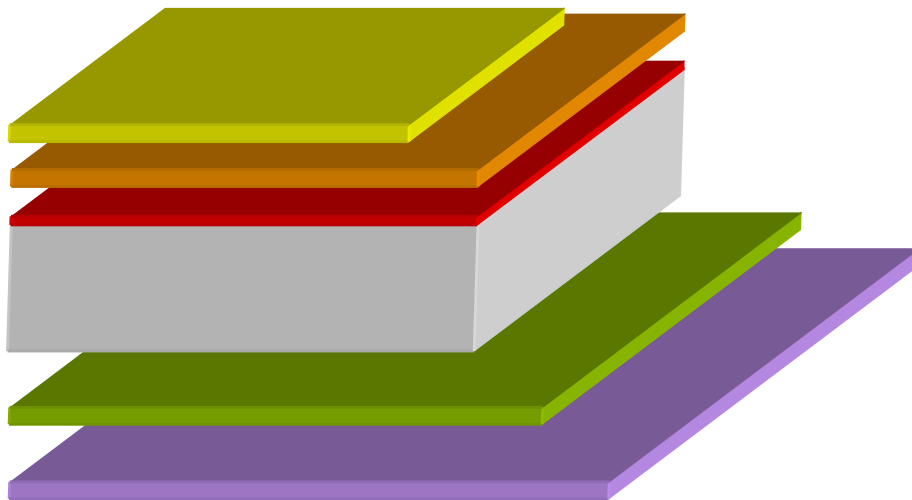
- Mechanical and thermal stability
- Polycarbonate or Polyester

Optical Coating (optional)

- Improved optical properties
- Vacuum or wet coating process

Resistivity layer (optional)

- Protection against scratch or UV
- Wet coating or extrusion process



Polymer Electronics Portfolio

Polymer Electronics

Printed Electronics:

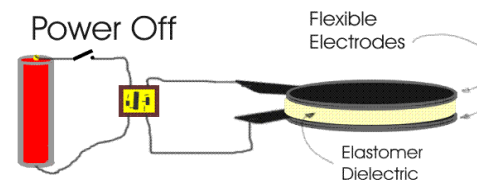
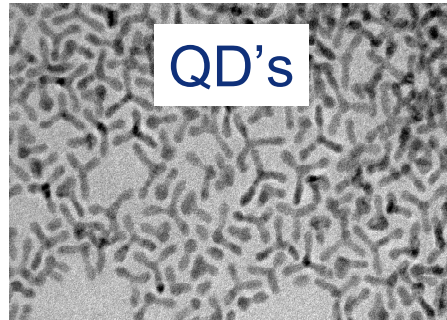
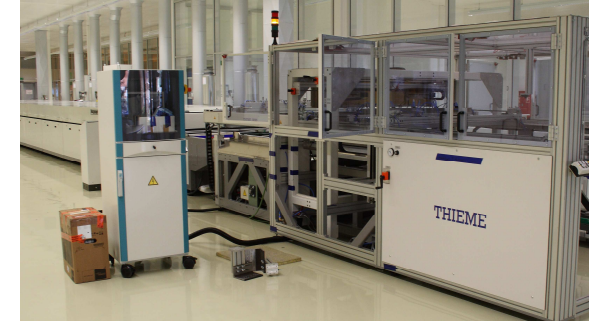
- Printed light and integration of light into technical parts
- Printing lab and printing production expertise in clean room

Functional (nano) Materials:

- Q-dots for OPV, OLED, light conversion
- BayInk: conductive materials

Electro-active Polymers

- Actuators and Sensors
- Energy Conversion



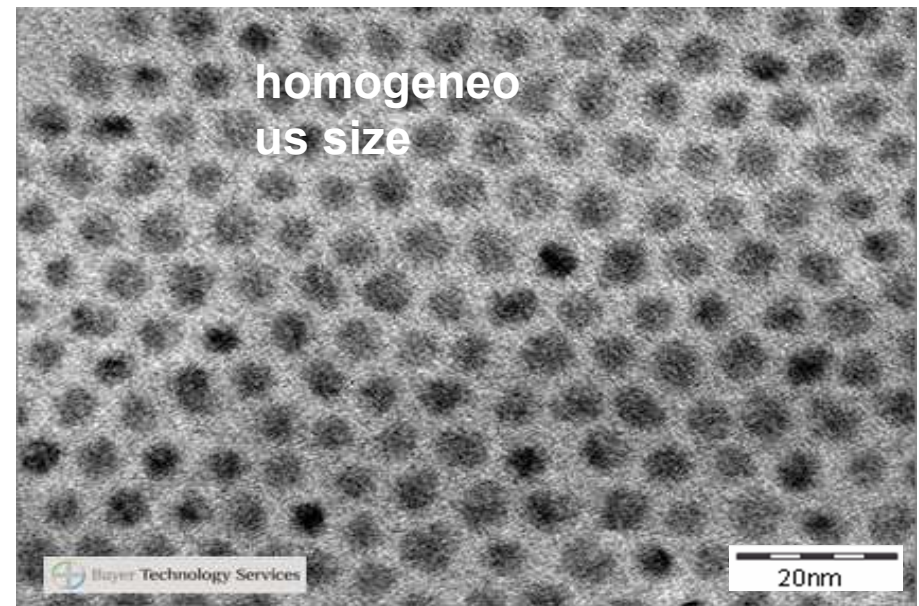
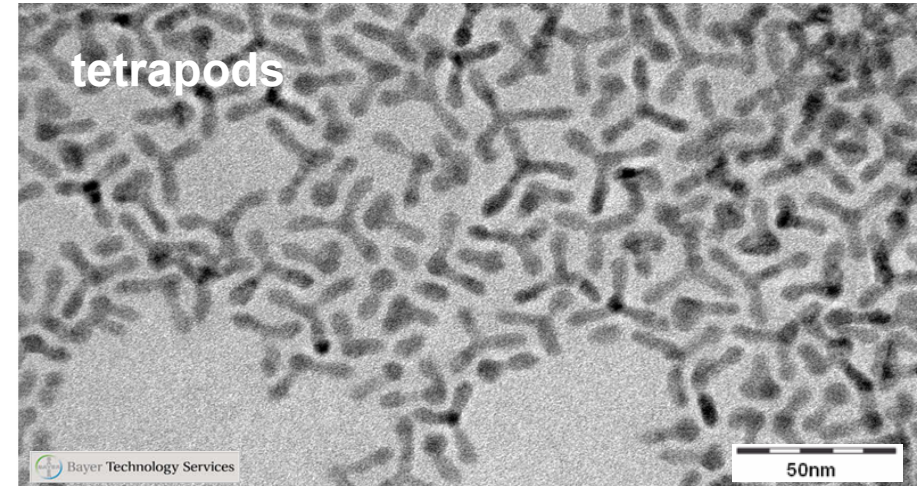
Electro Active Polymers



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Nano-materials – our competence

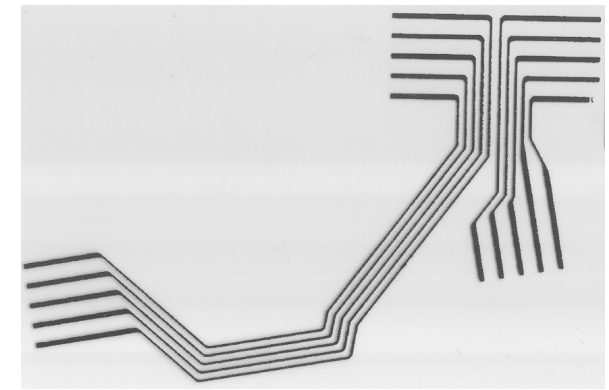
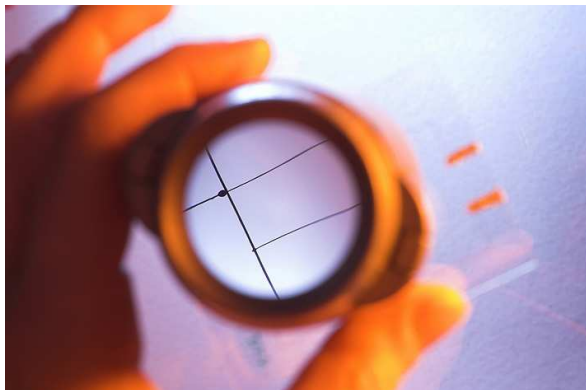
- Low cost production process (micro-process reactor technology)
- High quality, customized (absorption and electronic properties) nano particles (e.g. Q-dots)
- Extremely well-defined particle geometry (size + size distribution)



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Nano conductive silver inks - BayInk Systems

	type	key benefit	process
BayInk TP S	Nano silver dispersion	high resolution, low sintering temp.	Inkjet
BayInk TP FS	Flexible silver pastes	flexible and robust conductors	Screen, Flexo, Gravure
BayInk TP CNT	CNT dispersions	low cost conductive inks	Inkjet, Screen



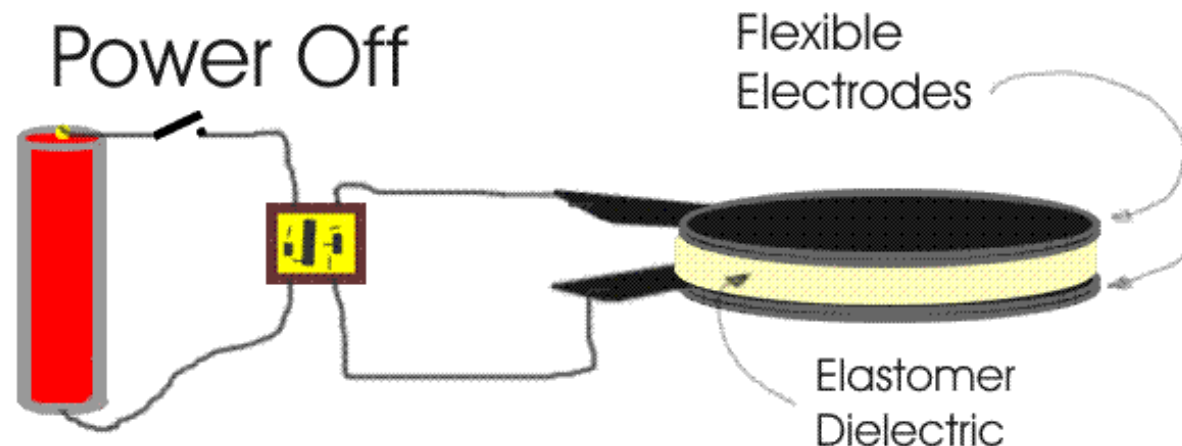
Introducing Electroactive Polymer Artificial Muscle (EPAM)

The Operating Principle

- Thin elastomere dielectric
- Printed flexible electrodes
- Electrostatic pressure causes motion

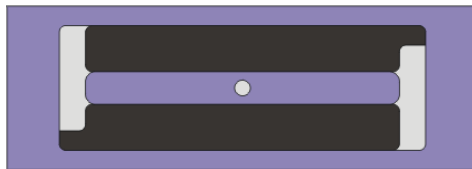
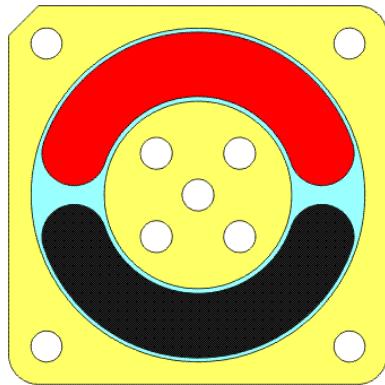
Benefits of EPAM

- Versatile
- Fast response
- Energy efficient
- Small, lightweight & quiet
- Cost parity to existing solutions



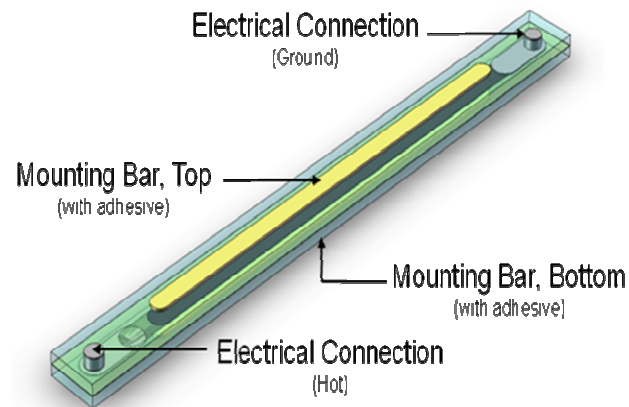
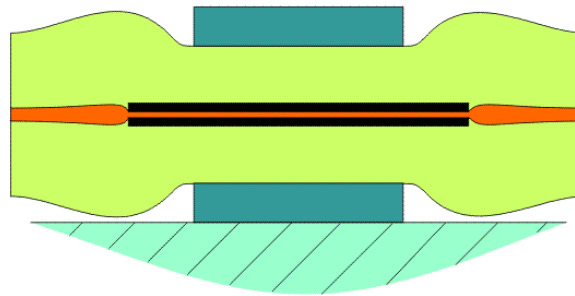
Reflex Platform Actuator Implementations

X-Mode (Planar Actuator)



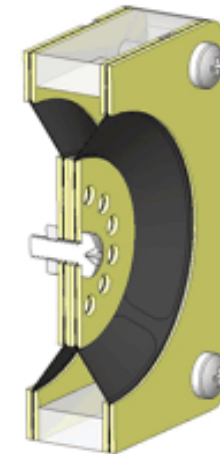
In-Plane Motion

Z-Mode Actuator



Out-of-Plane Motion

Diaphragm Actuator



Out-of-Plane Motion

Reflex™

A High Fidelity Haptics Platform



Portable Electronics

- Smartphones
- Mobile Internet Devices
- GPS Navigation
- E-Books



Laptops

- Touchscreen
- Touchpad
- Keyboard



Large Format Screens

- Countertop VoIP
- Industrial Controls
- Casino Gaming

Universal Benefits
High Fidelity Haptics
Interactive experience
Real time effects
Inherently quiet
Cost competitive



Peripherals

- Mice
- Game Controllers
- Remote Controls



Thank you for your attention!



1970



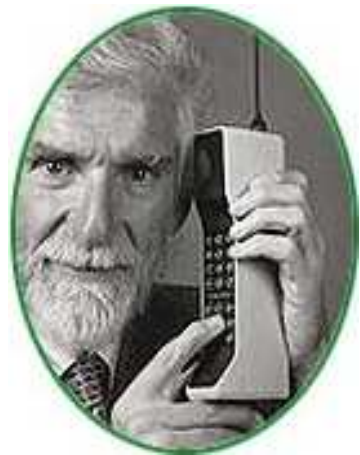
2000



2008



The Future



1983



2004



The Future



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