Organic & Printed Electronics

Speaker: Andreas Schaller, Motorola
Chair: Dr. Daniel Gamota, Motorola
Co-chair: Dr. Jan Obrzut, NIST
Just Imagine …Printed Electronics
What If ??

• A printing press could produce electronic products “on-demand”......
  PRODUCTION TIME GOES FROM WEEKS TO MINUTES

• Integrated circuits were so inexpensive that they could be placed everywhere print media is used today......
  PRODUCT COST FALLS FROM DOLLARS TO CENTS

• A new electronics industry were created where “Insert Your Company’s Name Here” is the dominant player......
  YOU GO FROM FOLLOWER TO LEADER
Silicon Transistor Channel Length Trend

Graphic Arts
Printed Electronics
OPPORTUNITY TODAY

Nanoimprint lithography is promoted as a solution to break the nano-barrier

Nominal feature size

Gate Width

Nanotechnology

130nm
90nm
70nm
50nm


Advancing manufacturing technology
Intel 4044 Processor

- Introduced in Nov, 1971
- 2300 transistors
- 10µm channel length
- Composed of 5 layers
- Four-bit microprocessor,
  - Four-bit adder for doing additions
  - An accumulator for keeping track of partial sums
  - 16 registers for temporary storage.
Printed Electronics Market Opportunities

Where the products are cost sensitive, and relatively low functionality
Printed Electronics Market Potential*

- Signage - $10B
- Power - $16B
- Displays - $20B
- Lighting - $15B

*Data compiled from press and industry reports
Printed Electronics Market Potential*

Sensors - $10B

Air Baggage/Freight, Ticketing, RFID - $20B

Logic/Memory - $30B

*Data compiled from press and industry reports
Printed and Organic Electronics Roadmap - Why Now?
Recent Printed Electronics Activity

- Announced $100M financing deal to build a production facility in Dresden, Germany
- Announced production of RF tags during 2007
- Launched initiative for developing flexible, printed, and organic electronics market
- Expanded investment; partnered with UC Berkeley
- Acquired by Weyerhaeuser
- Raised US $20M in most recent funding round
- Creo purchased by Kodak, now Kodak Graphic Communications Group
- Spun off from Philips Research; teamed with Innos Ltd.
R&D Transfer to Manufacturing Environment

• R&D
  – Development of new concepts
  – Develop and explore new technology space

• High-Volume Manufacturing
  – Distribute technology to consumers
  – Generate new businesses
Barriers and Gaps for Market Introduction & Diffusion (Captured in 2002)

- Awareness & Education
- Value Chain
- Infrastructure: Materials, Manufacturing Platforms, Control Architectures, etc.
- Standards: Circuit Design, Reliability, Platforms, etc.
- **Roadmaps (technology, products, etc.)**
New iNEMI Roadmapping Activity for 2007

What is Significant this Year?
• Organic & Printed Electronics Roadmap debuts in the 2007 iNEMI microelectronics roadmap
• iNEMI members selected organic & printed electronics as future electronics high growth market

What transpired?
• Kickoff of iNEMI Technology Working Group held on 02/2006 (Anaheim, CA)
• Engaged companies, academia, and government to provide an outlook for large-area electronics products (51 participants from 33 organizations/companies)

What is next?
• Revisit and update Organic & Printed Section as necessary
iNEMI P&O Electronics Roadmap

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Supply chain is being established in preparation for commercialization of printed electronics based products
Printed Electronics Product Opportunities

Printed Displays

Printed Sensors

Printed Power Source

Printed RFID

Advancing manufacturing technology
ILT Roadmap – Why now?

- Major barriers exist at ILT RFID implementation
- To provide RFID stakeholders guidance for ILT infrastructure and supply chain development
- To drive ubiquitous deployment of RFID solutions
- The ILT roadmap effort is being driven by the RFID supply chain members
- This roadmap activity is open to all RFID stakeholders. Your participation is most welcome!
Functional Electronic Inks - Conductive, Semiconductive, and Dielectric Inks

Attributes

- Characteristics similar to traditional electronic materials
- Solution processable for low cost manufacturing
- Robust synthesis/formulating routes
- Materials and device stability in-air
- Large area processing routes demonstrated
- Devices fabricated on graphic arts manufacturing printing platforms

Semiconductor Inks

Silver Nanoparticle Conductive Inks
Printing Electronics Manufacturing Platform

- **Flex Fixture**
- **Curing Oven**
- **Curing Oven**
- **Inspection Unit**

- **Contact Printing** (litho, flexo)
- **Non-Contact Printing** (ink jet, microdispensing)

- **Highly integrated hybrid system for high throughput and low maintenance**
**Printing Technologies**

**Contact Printing**

- **Offset**
  - Plate cylinder
  - Inking
  - Damping
  - Blanket cylinder
  - Printing substrate

**Benefits**
- Commercially available
- Low-cost, high-speed parallel processing
- Commercially available functional materials
- Demonstrated repeatability

**Screen Printing**
- **Gravure Printing**
- **Offset Printing**
- **Flexo Printing**
- **Stamping**
- **Inkjet**
- **Microdispensing**

**Non-Contact Printing**

- **Ink Jetting**

**Benefits**
- CAD data driven enables fast change-over “on the fly”
- Fast prototype
- Suitable for printing on 3D substrates
**Critical Parameters**

- Printing resolution
- Printing registration
- Layer thickness
- Orientation of features
- Dimensions of features
- Processing conditions
- Material quality (pot life)
- In-process electrical testing
- Final product electrical testing
Electrical Design, Layout, and Simulation

- Circuit Simulation
- OFET Device Model
  - Measured
  - Simulated
- Circuit Design
- Circuit Layout

*INEMI*
Advancing manufacturing technology
Reliability Testing

- Reliability testing methods and conditions
  - Air to air temperature cycling (-20°C to +60°C, 30 min dwell)
  - Liquid to liquid thermal shock (-20°C to +60°C, 5 min dwell)
  - Flexure (30 degree off-axis bend)
  - Humidity exposure (60°C at 90% R.H.)
  - Oxygen exposure
  - Solvent resistance (Bleach, water, ammonia, etc.)
  - Tearing, crumpling, crushing

⚠️ Reliability is application specific
Standards and Roadmap Efforts to Establish the Printed Electronics Infrastructure

**Standards**

IEEE 1620™, IEEE 1620.1™, IEEE P1620.2

http://grouper.ieee.org/groups/1620/
http://grouper.ieee.org/groups/1620/1/
http://grouper.ieee.org/groups/1620/2/

**Roadmaps**

To be released at APEX 2007

http://www.inemi.org

**Presentations & Publications**

Printed Organic and Molecular Electronics (ISBN 1-4020-7707-6)

http://www.inemi.org
Look around you...

At home

At Work

At the Store

On the move

Printed Materials are everywhere

The logic, intelligence and communication should be embedded into all printed matter

We are talking about a future with pervasive printed electronics seamlessly integrated into everyday life
QUESTIONS?
Order your Roadmap Now!

www.inemi.org

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Backup
Q1:
Today, what is technically comparable to the semiconductor integrated circuits that were used to help us reach the moon in 1969?

Apollo 11 - 1969
Question 1 of 100

Apollo 11 - 1969

Furby - 2004

A1: A Furby Doll