Organic & Printed Electronics

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Chair: Dr. Daniel Gamota, Motorola
Co-chair: Dr. Jan Obrzut, NIST
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


Nanoimprint lithography is promoted as a solution to break the nano-barrier
Q1:
Today, what is technically comparable to the semiconductor integrated circuits that were used to help us reach the moon in 1969?
Question 1 of 100

Apollo 11 - 1969

A1: A Furby Doll

Furby - 2004
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

Lighting - $15B

Displays - $20B

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

**Benefits**

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

**Non-Contact Printing**

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

**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

Measured
Simulated

OFET Device Model

Circuit Design

Circuit Layout
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**

INEMI

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?

"If everyone is thinking alike, then someone isn't thinking"

General George Patton
Order your Roadmap Now!

www.inemi.org

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