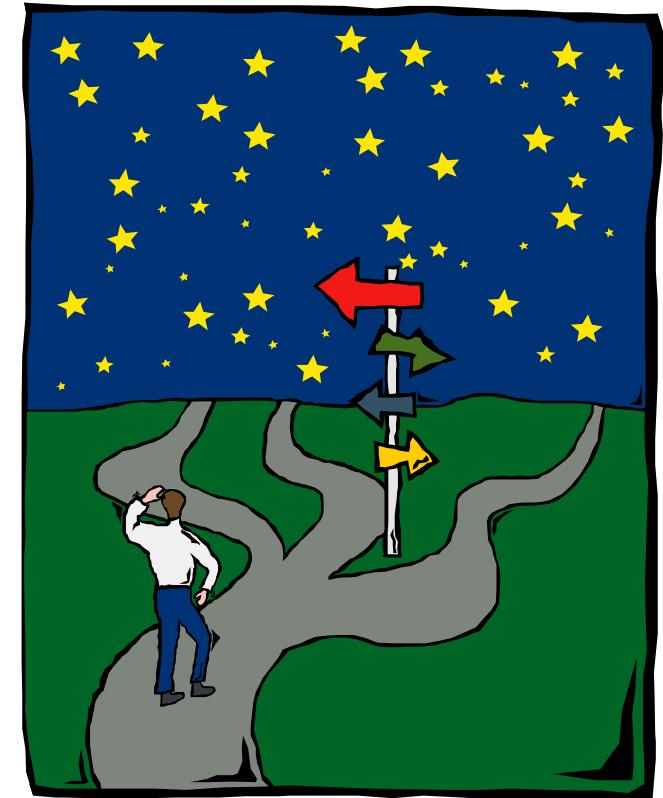


iNEMI Flexible Electronics Roadmap

From Concept to Product

*... many routes can be taken and
a roadmap simplifies the process*



Daniel Gamota, Chair

Margaret Joyce, Co-Chair

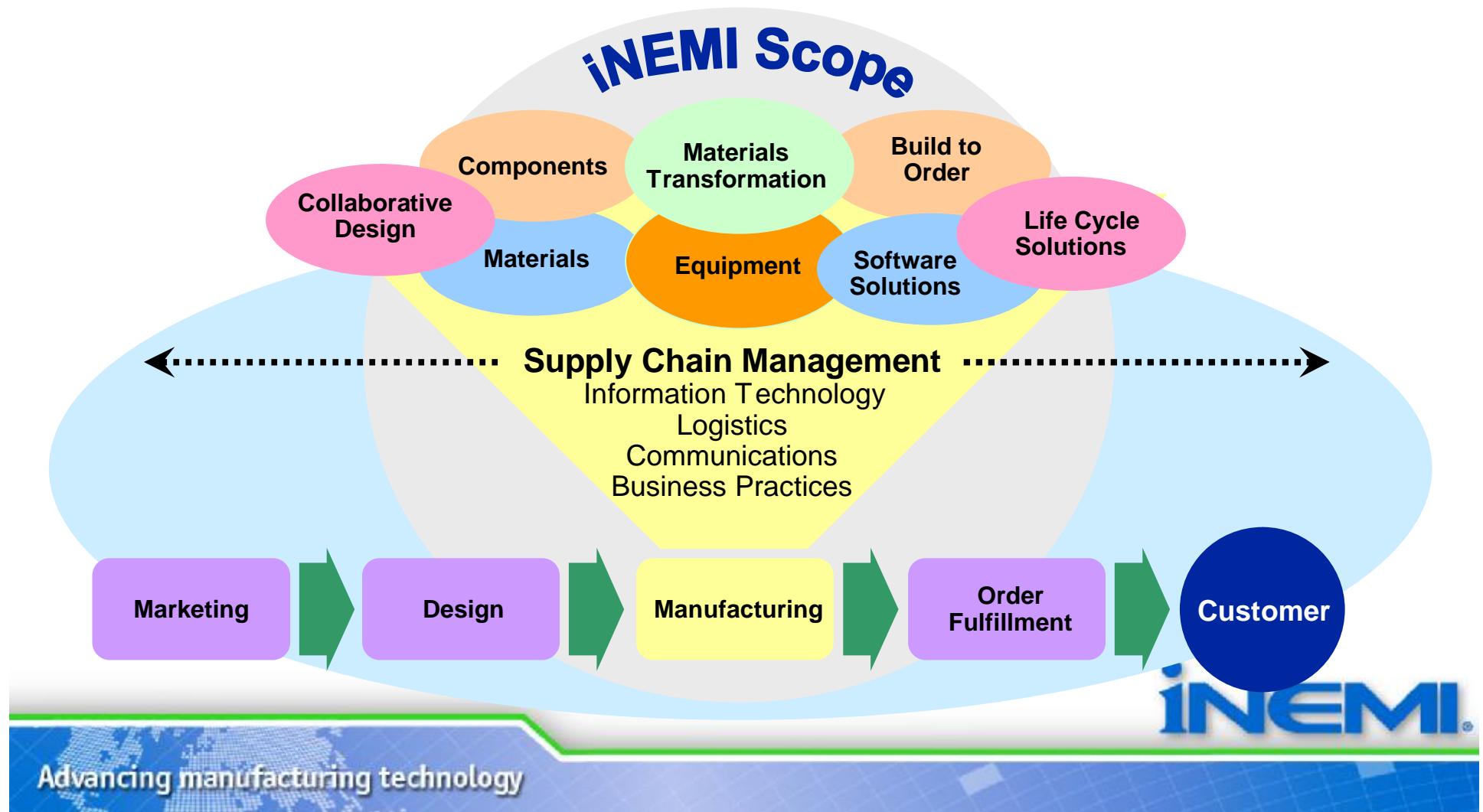
Jie Zhang, Co-Chair

Advancing manufacturing technology

iNEMI

iNEMI Mission

***Assure Leadership of the Global Electronics Manufacturing Supply Chain
for the benefit of members and the industry***



What Does iNEMI Do?

Leverage the combined power of member companies to provide industry leadership

- iNEMI roadmaps the global needs of the electronics industry
 - Evolution of existing technologies
 - *Prediction of emerging/innovative technologies*
- iNEMI identifies gaps (both business & technical) in the electronics infrastructure
- iNEMI stimulates research/innovation to fill gaps



What Does iNEMI Do?

- iNEMI establishes implementation projects to eliminate gaps
- *iNEMI stimulates worldwide standards to speed the introduction of new technology & business practices*
- iNEMI works with other organizations to ensure that government policy recommendations are aligned with our mission



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Why do Companies Participate?

- *Excellent opportunity to “test the iNEMI collaboration waters” without committing to membership.*
- The experience leads to a better understanding of the “state of the art” in those areas of participation.
- *Early access to the roadmap chapter’s technical and business information for the participating company.*
- Opportunity to shape the industry’s future priorities concerning R&D.



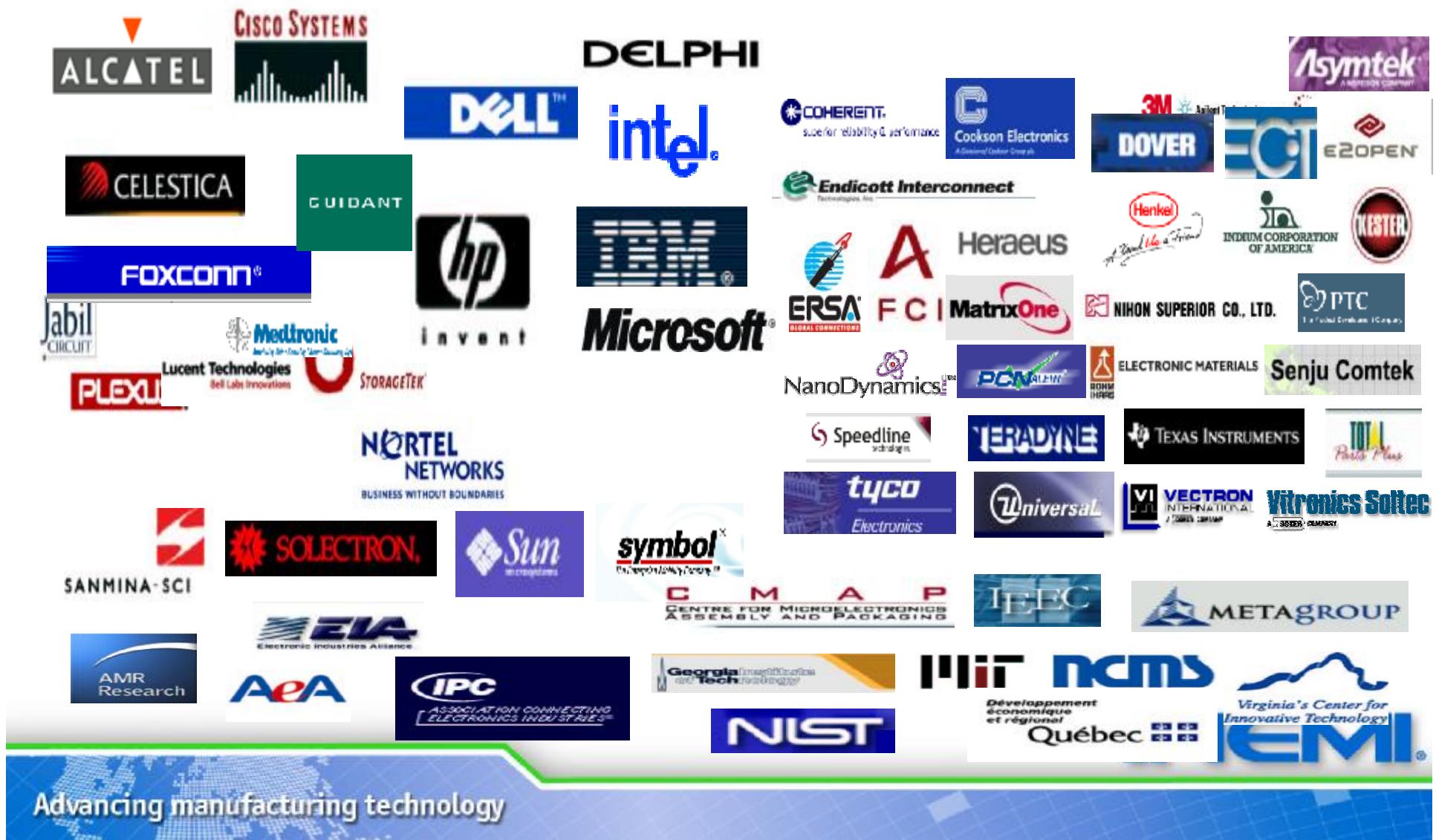
Why do Companies Participate?

- Opportunity to impact iNEMI's future direction through “technology gap” identification and solutions most important to your company.
- Those who participate in the Roadmap creation get a broad view of the supply chain landscape from customers, competitors and suppliers.
- *Roadmaps can become “self-fulfilling prophecies” as many within industry focus on the identified challenges and benchmark their company against the user needs.*
- As General Dwight D. Eisenhower was fond of saying, “It’s not the plan (that is created) but the planning (process) that provides maximum insight.”



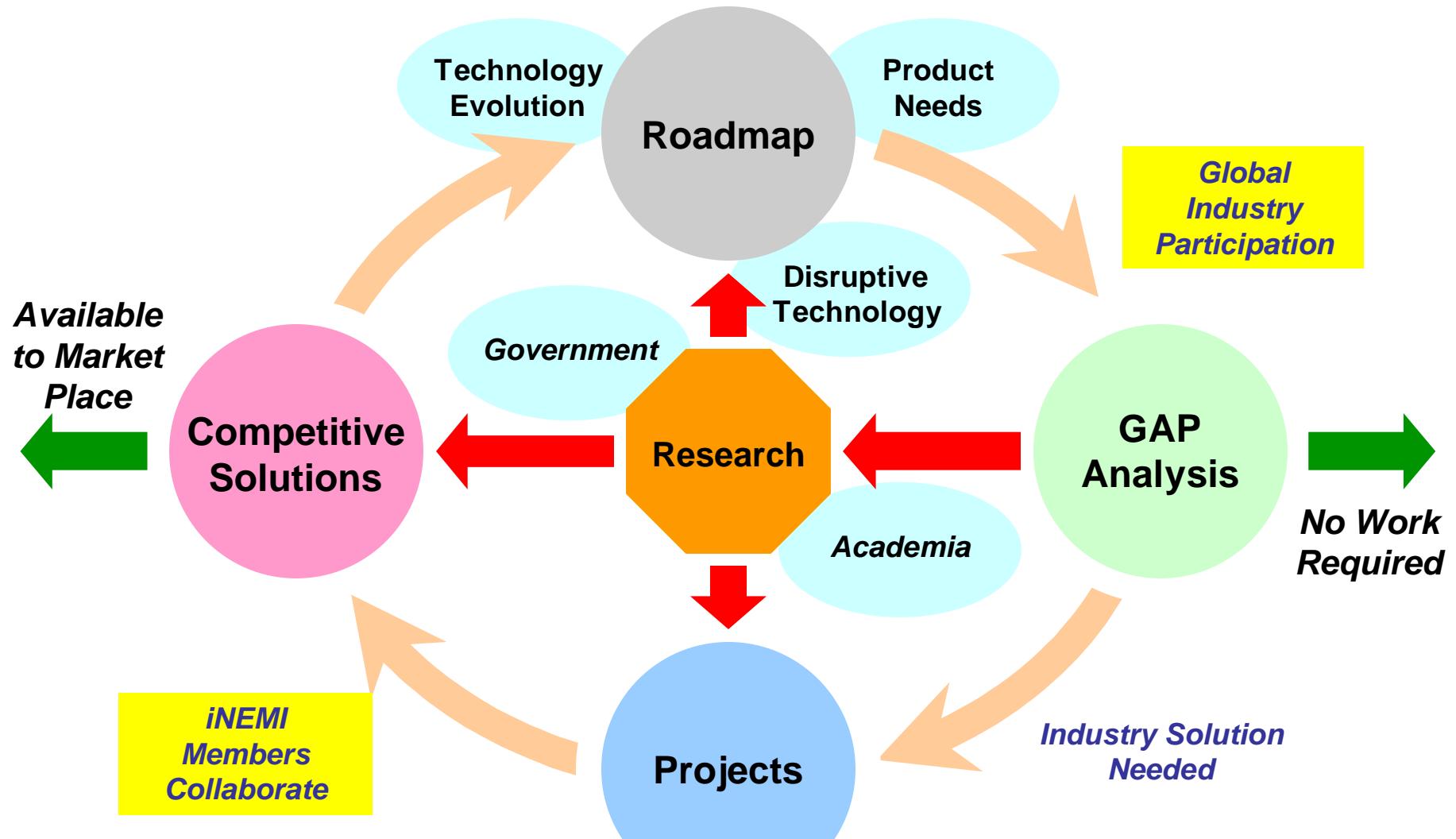
iNEMI Members

OEM/EMS, Suppliers, Government, & Universities



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Methodology

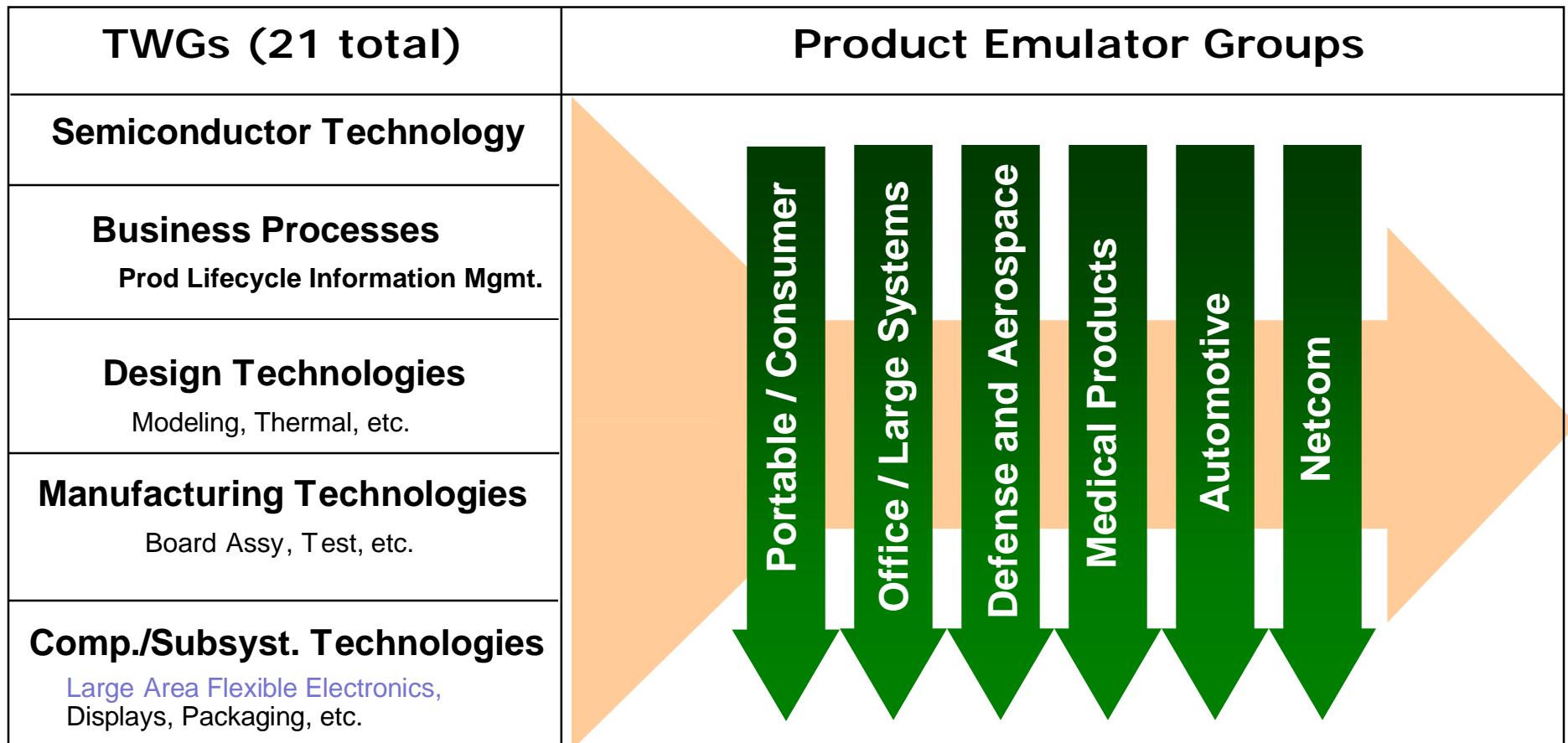


Statistics for the 2009 Roadmap

- > 550 participants
- > 250 companies/organizations
- 18 countries from 4 continents
- 20 Technology Working Groups (TWGs)
 - New roadmaps on Solid State Illumination, Photovoltaics and RFID Item-Level Tag
- 5 Product Emulator Groups (PEGs)
- > 1400 pages of information
- Roadmaps the needs for 2009-2019

Roadmap Development

Product Sector Needs Vs. Technology Evolution



Flexible Electronics Roadmap History

09/2005 – iNEMI Stakeholders identify Flexible Electronics as Future Growth Market and authorize formation of TWG

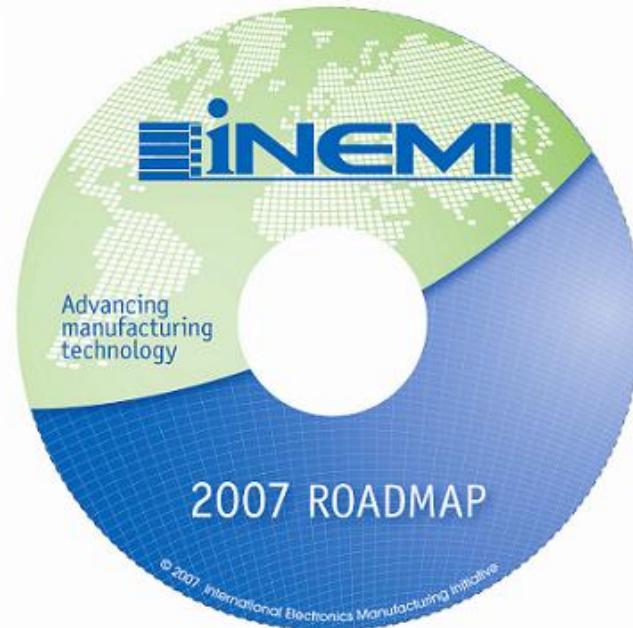
01/2006 – Flexible Electronics TWG formed (25 participants)

09/2006 – 1st Edition submitted for final editing

01/2007 – 1st Edition iNEMI Roadmap released to public

01/2009 – 2nd Edition iNEMI Roadmap released to public (67 participants)

09/2010 – 3rd Edition submitted for final editing



1st Edition Released at
APEX 2007

iNEMI Large Area Flexible Electronics Roadmap

COMPONENT/SUBSYSTEM TECHNOLOGIES

LARGE AREA FLEXIBLE ELECTRONICS

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Standards: Technology Requirements	
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European Union Government Policy Activities	
Global Industrial Market and Paradigm Shifts	
Large Area Flexible Electronics Technology Needs and Potential Solutions	
Concluding Remarks and Recommendations on Priorities	
Glossary	
Contributors 2011 Roadmap	
References	

2011 Roadmap Submitted for Final Editing

COMPONENT/SUBSYSTEM TECHNOLOGIES

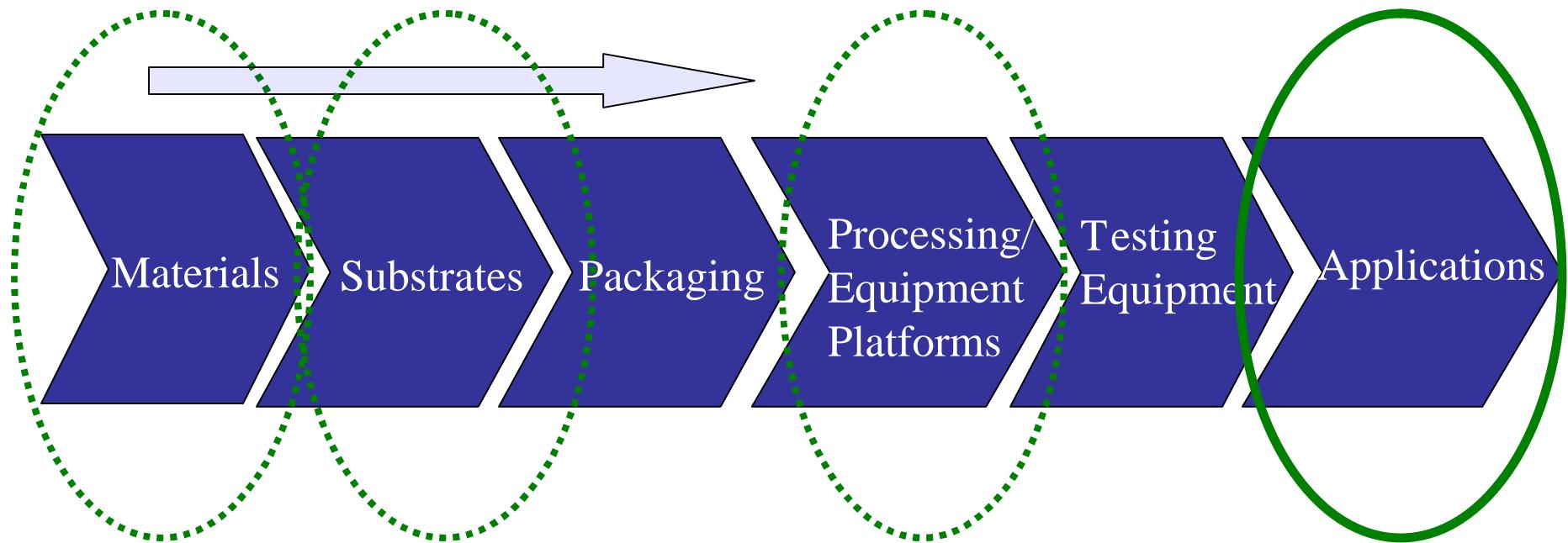
LARGE AREA FLEXIBLE ELECTRONICS

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Shift in Roadmap Topic Participation

– Movement Along Supply Chain



2007 Roadmap greatest participation - “Materials”.

2009 Roadmap greatest participation shifted “Substrates” and “Processing Equipment”.

2011 Roadmap greatest participation shifted “Processing Equipment” and “Applications”.

iNEMI Roadmap Format

Situation Analysis

Substrates

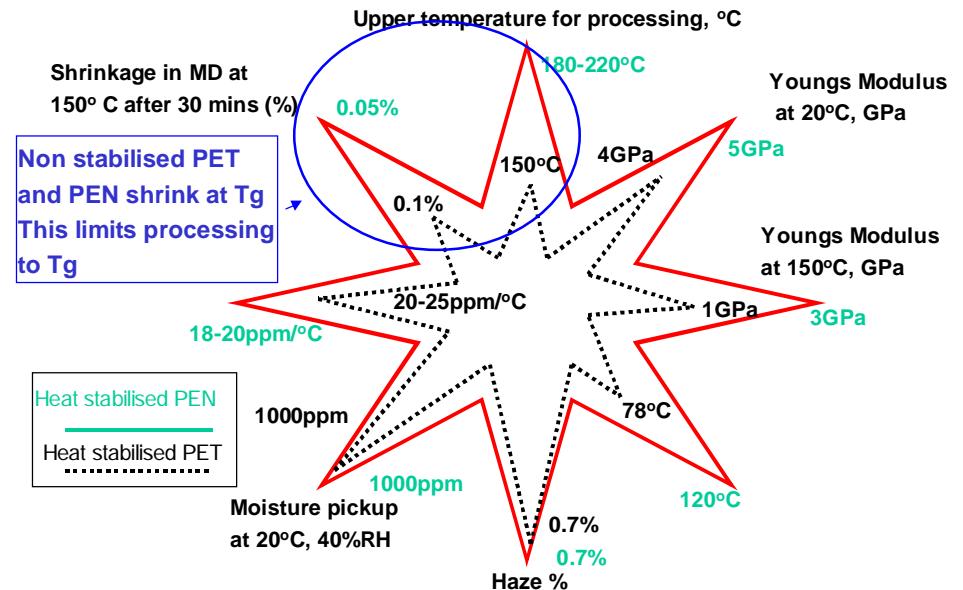
Status and Current Developments

Polymer Films

Polyesters: Applications

Properties

Major Past and Current Developments



Roadmap Format (continued)

Roadmap of Key Technology Needs for Substrates

Roadmap of Quantified Key Attribute Needs, Gaps, and Showstoppers

Substrates

Polyester

Technology Requirements

Needs, Gaps, and Showstoppers

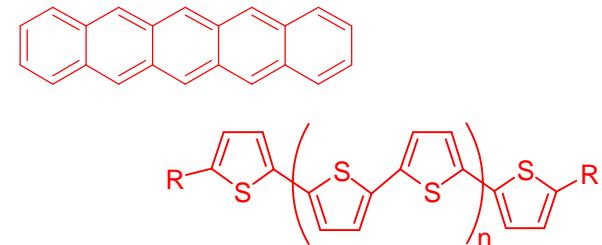
State of the Art (2009)		Mid term (2014)		Long term (2019)	
Attributes	Attributes	Technology needs	Attributes	Technology needs	
Surface morphology: roughness – bare foil 50nm RMS	15 nm RMS	Development of advanced foil manufacturing technologies	5 nm RMS	Development of advanced, yet low cost, polishing technologies	
Flatness (per 500mm of length): 2.0mm	1.0mm	Development of advanced foil manufacturing technologies	0.5mm	Development of advanced foil manufacturing and inspection technologies	
Coefficient of thermal expansion: 10ppm/°C	<5ppm	Development and scale-up of alternative materials	<5ppm	Development and scale-up of alternative materials	

Functional Inks

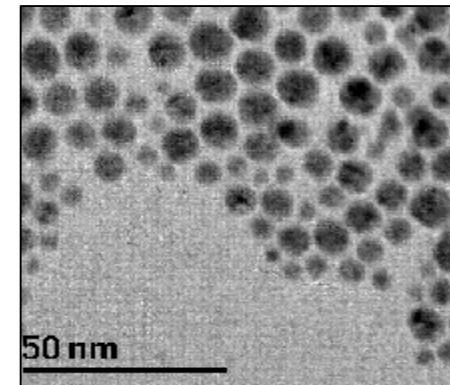
Attributes

- High performance
- Long shelf life and pot life
- Solution processable
- Compatibility with other functional inks (chemical and electrical interfacial integrity)
- Robust synthesis/formulating routes
- Materials and device stability in-air
- Compatible with large area scalable processing platforms

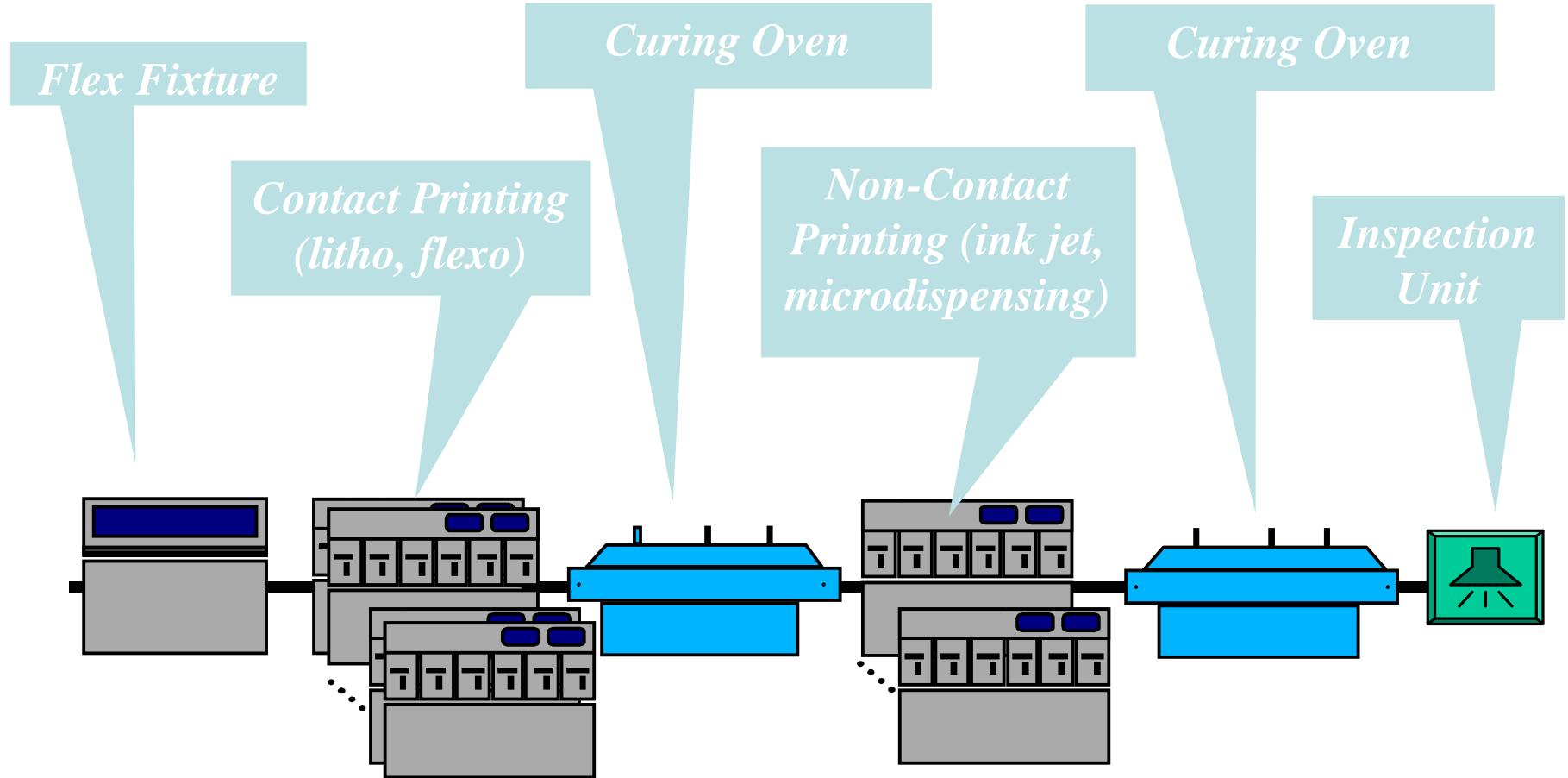
Semiconductor Inks



Silver Nanoparticle Conductive Inks



Manufacturing Platforms and Processing Equipment



✓ **Highly integrated hybrid system for high throughput and scalability**

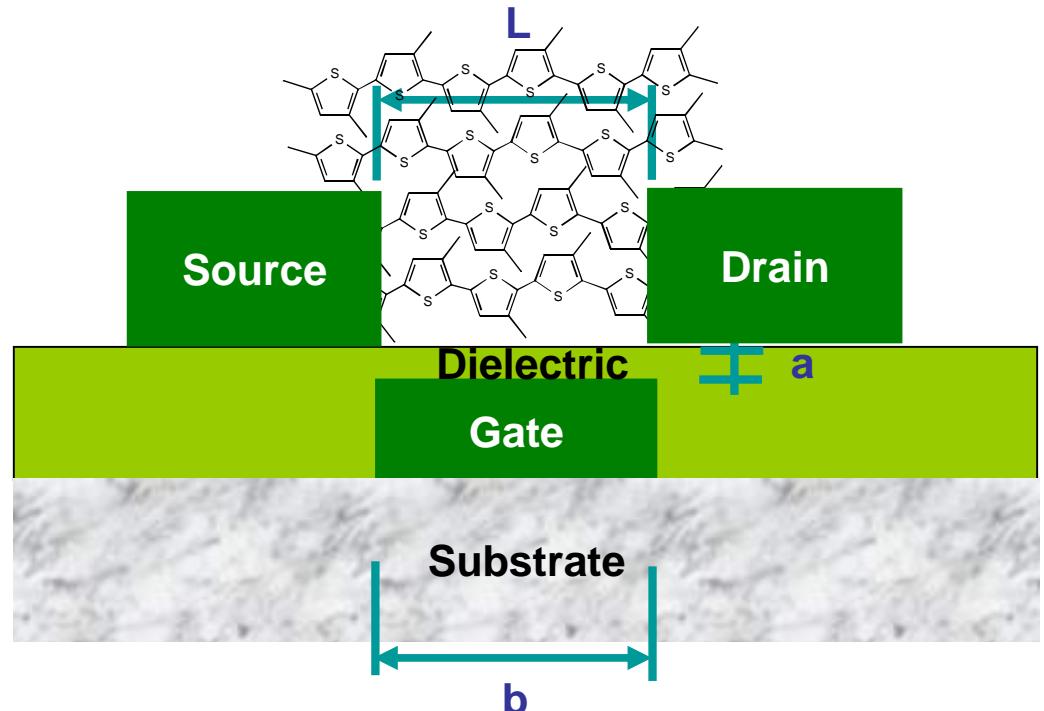
INEMI

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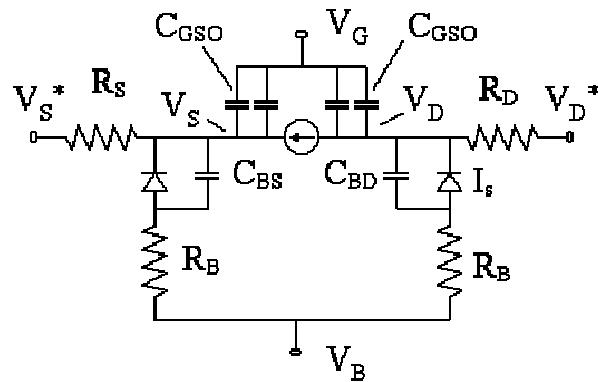
In-Line/Off-Line Characterization Tools

Critical Parameters

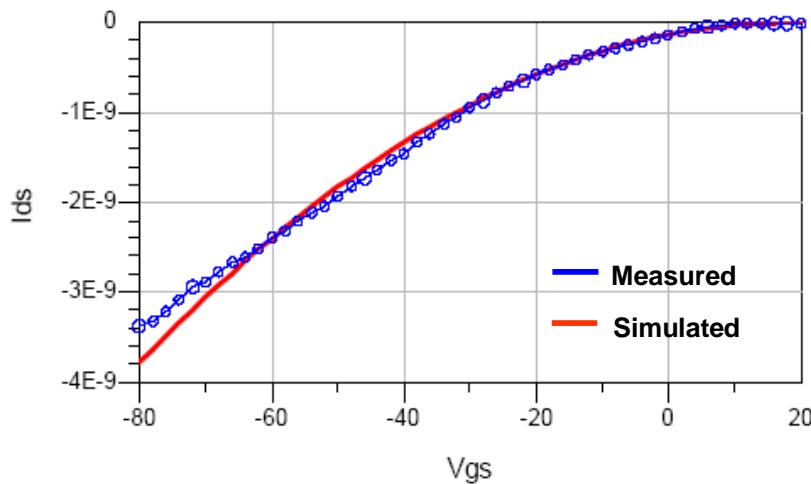
- Resolution
- Registration
- Layer thickness
- Orientation of features
- Dimensions of features
- Processing conditions
- Material quality (pot life)
- In-process electrical testing
- Final product electrical testing



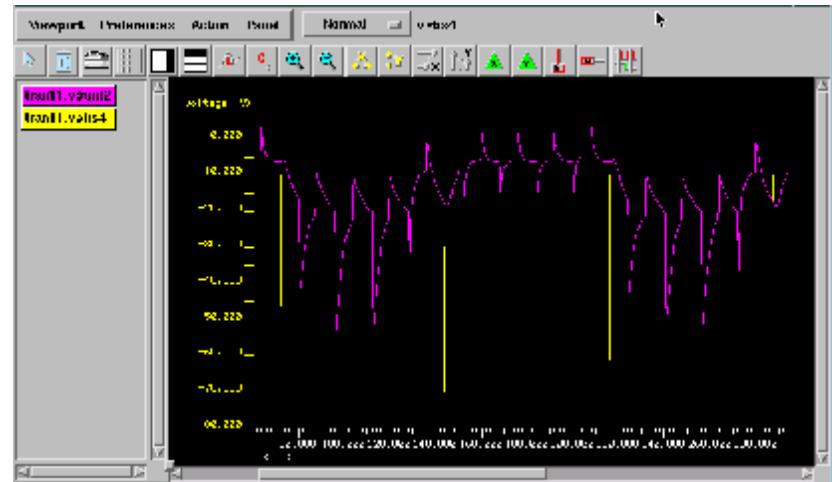
Electrical Design, Layout, and Simulation Tools



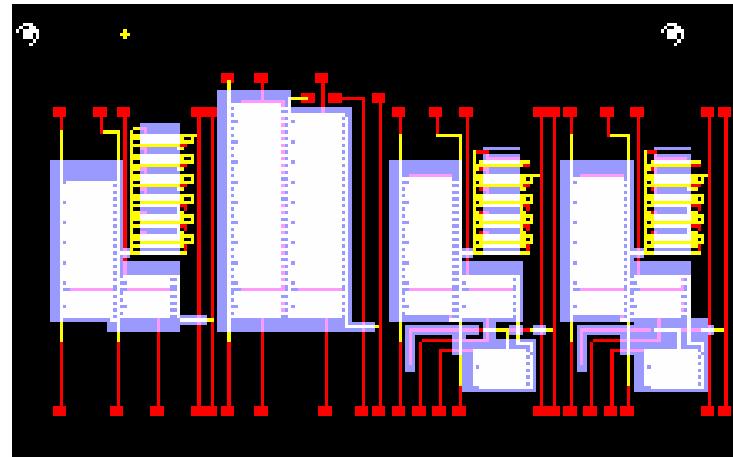
Circuit Design



Confirmation of Experimental to Simulation



Circuit Simulation



Circuit Layout

Products and Applications

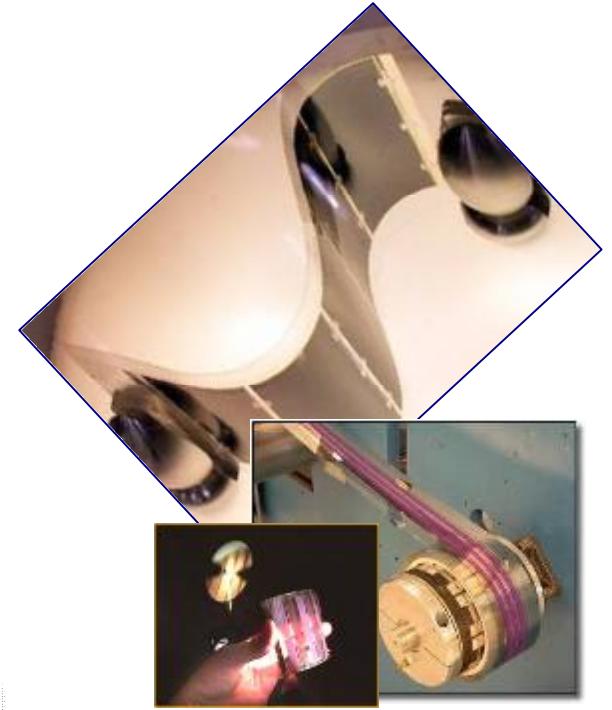
Lighting & Displays



RF Enabled Sensors



Photovoltaics



Reliability Testing Methods and Equipment



Reliability Testing Parameters

- 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

INEMI

Standards



IEEE Printed and Organic Electronics Working Group 1620™ Established in 2003



Device Level Test

[http://grouper.ieee.org/
groups/1620/1/](http://grouper.ieee.org/groups/1620/1/)

Approved in 2004



2008 update complete
and IEEE-SA approval
received

Ring Oscillator Test

[http://grouper.ieee.org/
groups/1620/1/](http://grouper.ieee.org/groups/1620/1/)

Approved in 2006



RF Sub-System Test

Assembling
Working Group



Need for printed RF
measurement standard



Flexible Electronics

“*Top Four*” Needs and Gaps

- #1 In-line inspection and testing equipment
- #2 Higher performance inks (semiconducting, OLED, PV active, etc.)
- #3 Simulation and design tools
- #4 Robust manufacturing platforms





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