iNEMI Flexible Electronics Roadmap

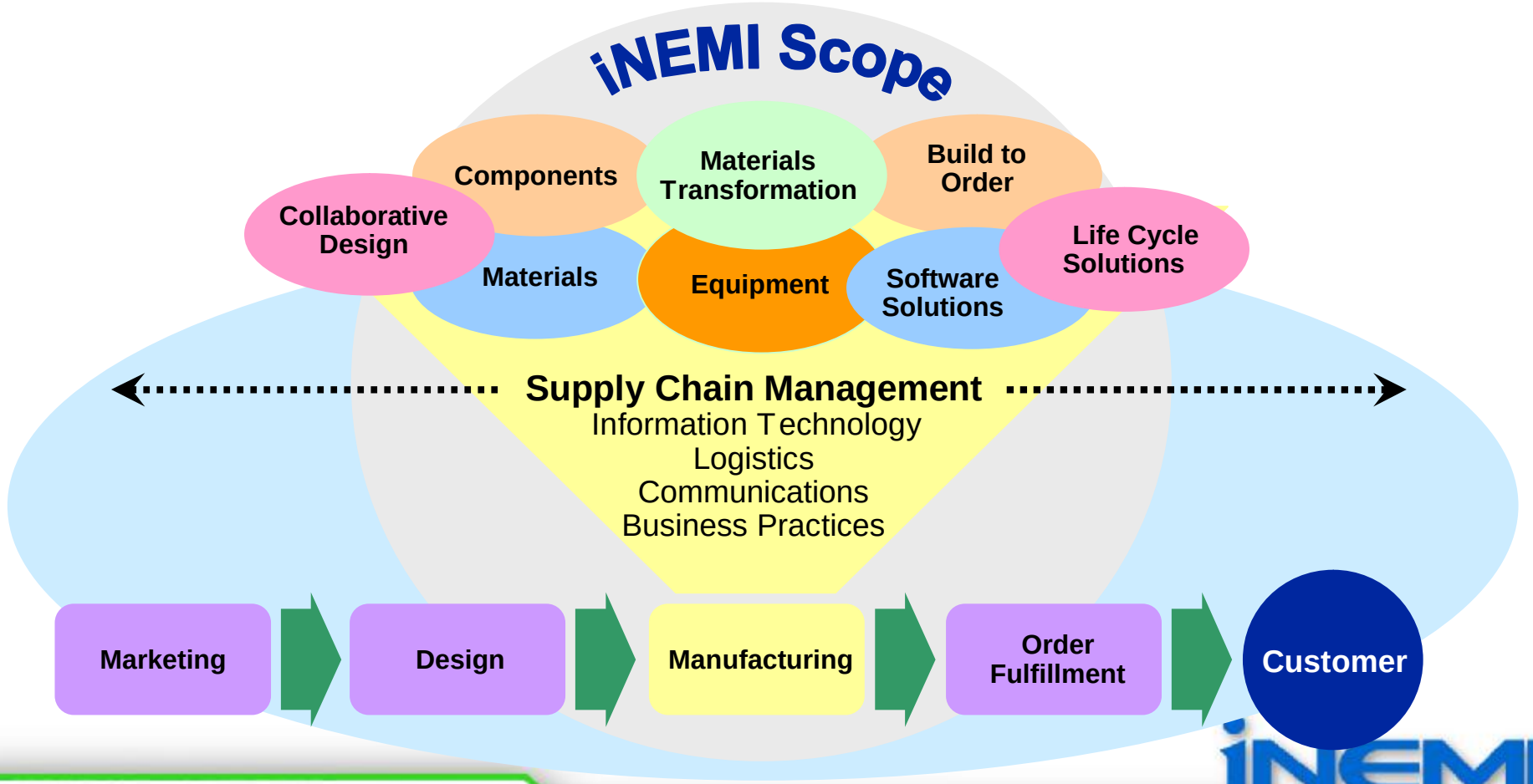
From Concept to Product

… many routes can be taken and a roadmap simplifies the process

Daniel Gamota, Chair
Margaret Joyce, Co-Chair
Jie Zhang, Co-Chair

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

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?

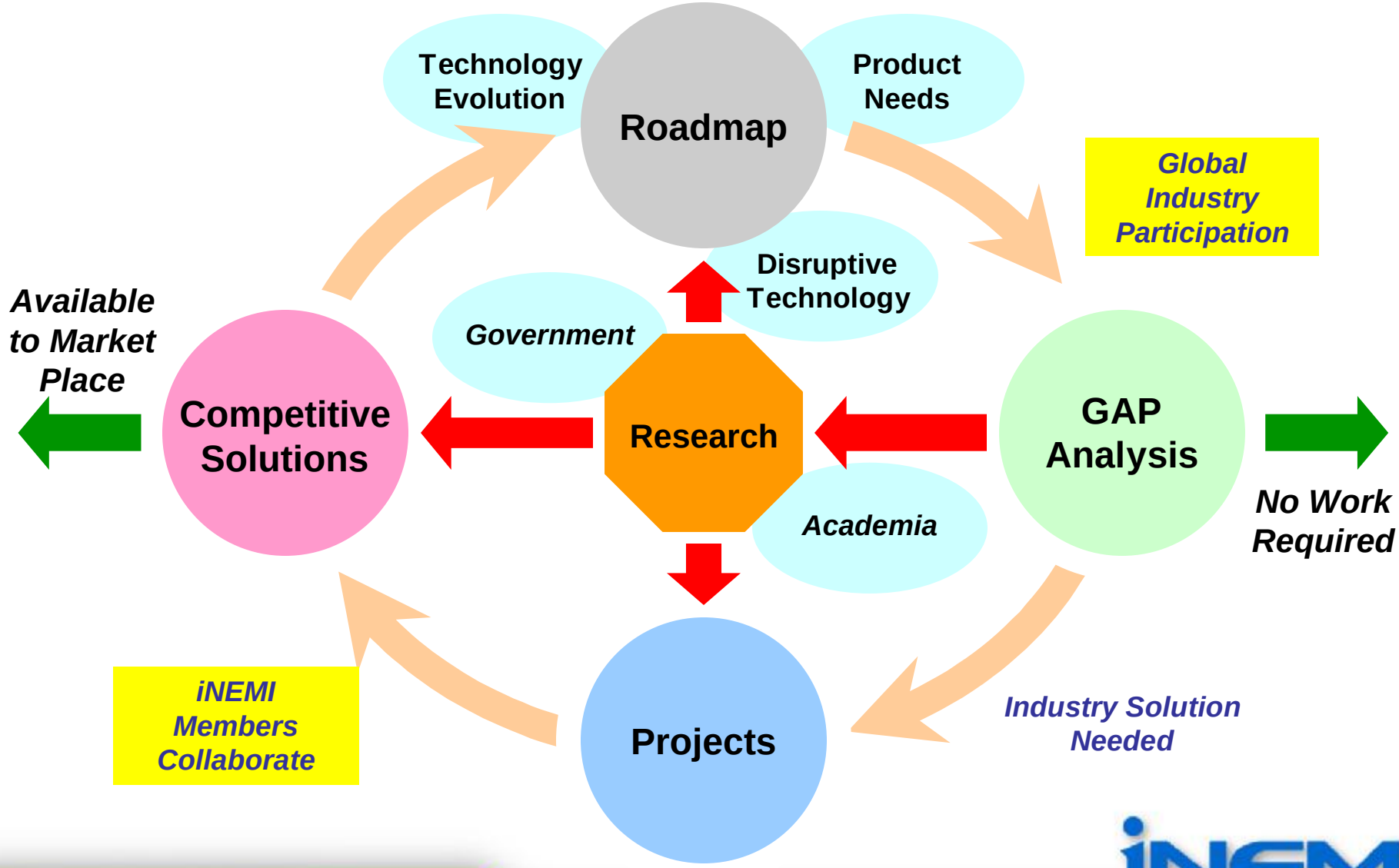
- Opportunity to impact iNEMI's future direction through "technology gap" identification and solutions most important to your company.
- Those who participate in the Roadmap creation get a broad view of the supply chain landscape from customers, competitors and suppliers.
- *Roadmaps can become "self-fulfilling 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

Advancing manufacturing technology

Methodology



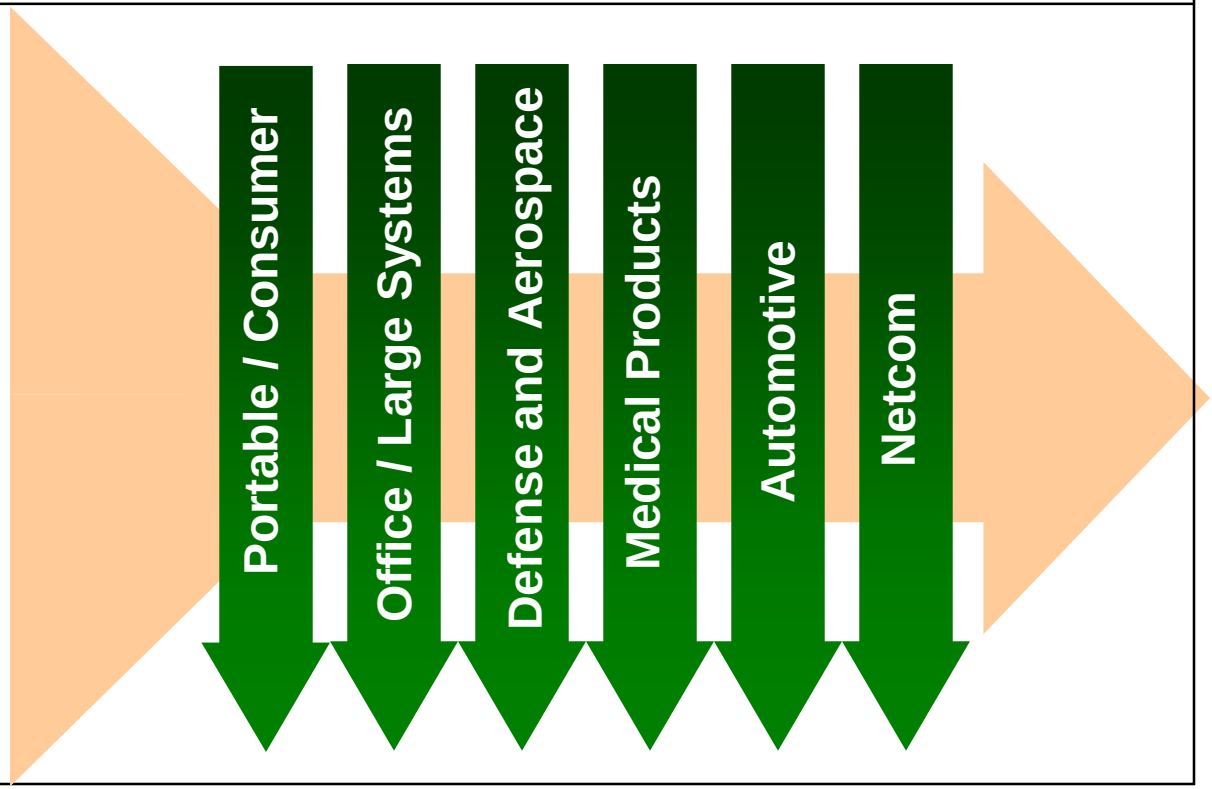
Statistics for the 2009 Roadmap

- > 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

TWGs (21 total)	Product Emulator Groups
Semiconductor Technology	
Business Processes **Prod Lifecycle Information Mgmt.**	
Design Technologies Modeling, Thermal, etc.	
Manufacturing Technologies Board Assy, Test, etc.	
Comp./Subsyst. Technologies Large Area Flexible Electronics, Displays, Packaging, etc.	



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

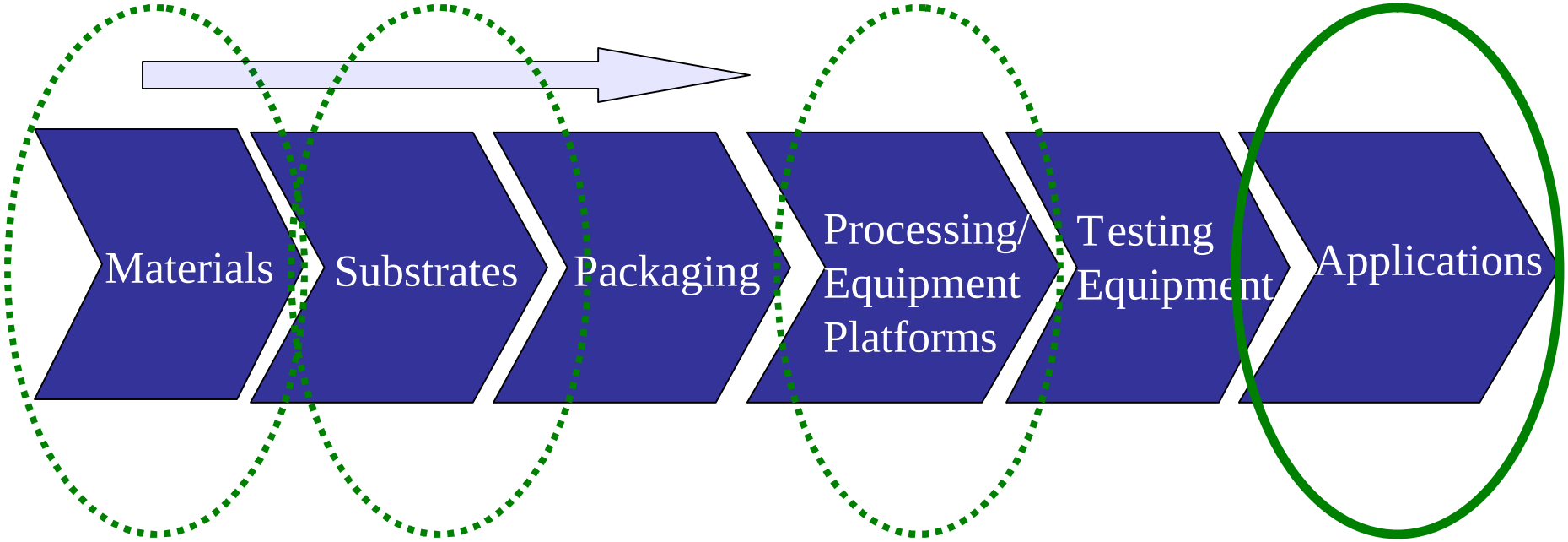
Large Area Flexible Electronics

Contents

Tables

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

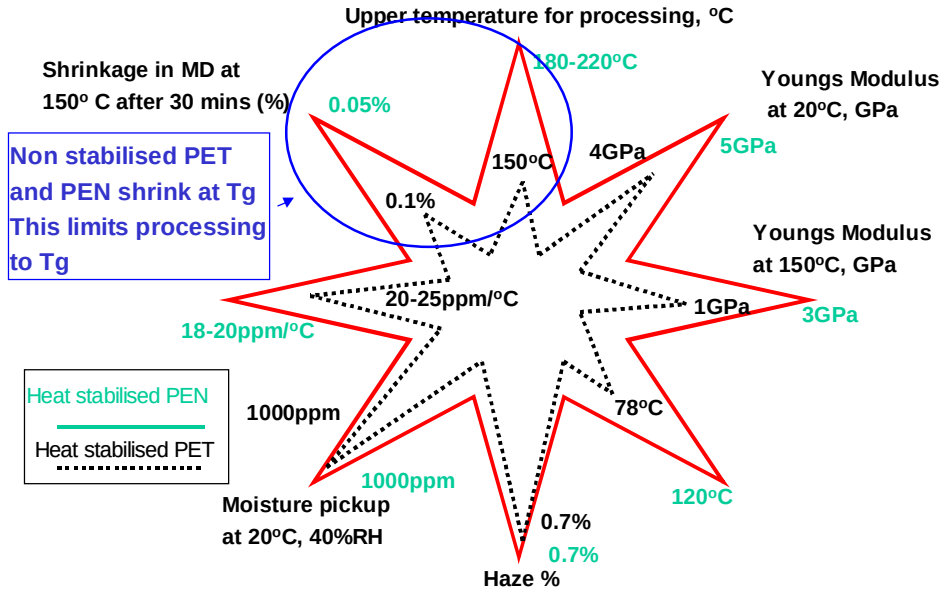
Status and Current Developments

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

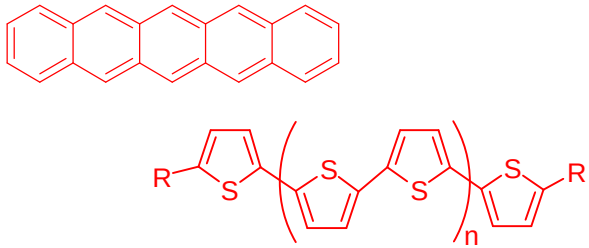
State of the Art (2009)	Mid term (2014)		Long term (2019)	
Attributes	**Attributes**	**Technology needs**	**Attributes**	**Technology needs**
Surface morphology: roughness – bare foil 50nm RMS	15 nm RMS	Development of advanced foil manufacturing technologies	5 nm RMS	Development of advanced, yet low 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/^{o}C	<5ppm	Development and scale-up of alternative materials	<5ppm	Development and scale-up of alternative materials

Functional Inks

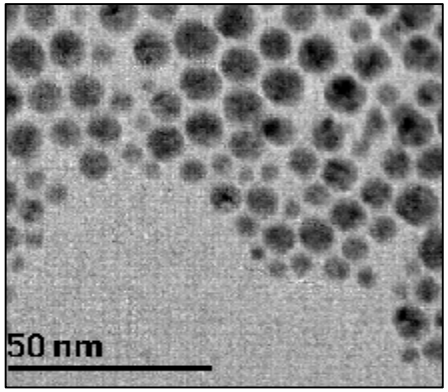
Attributes

- 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

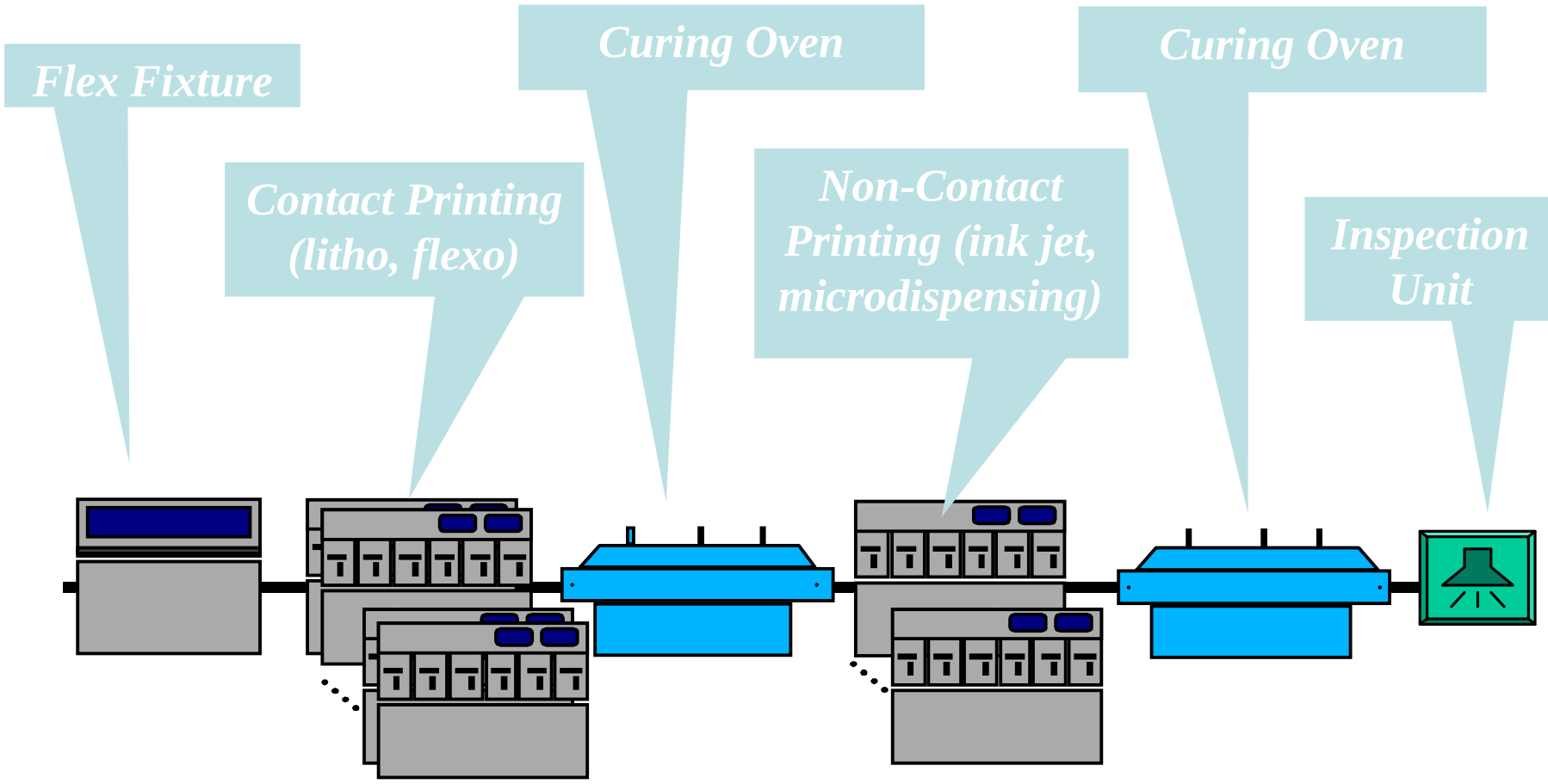
Semiconductor Inks



Silver Nanoparticle Conductive Inks



Manufacturing Platforms and Processing Equipment

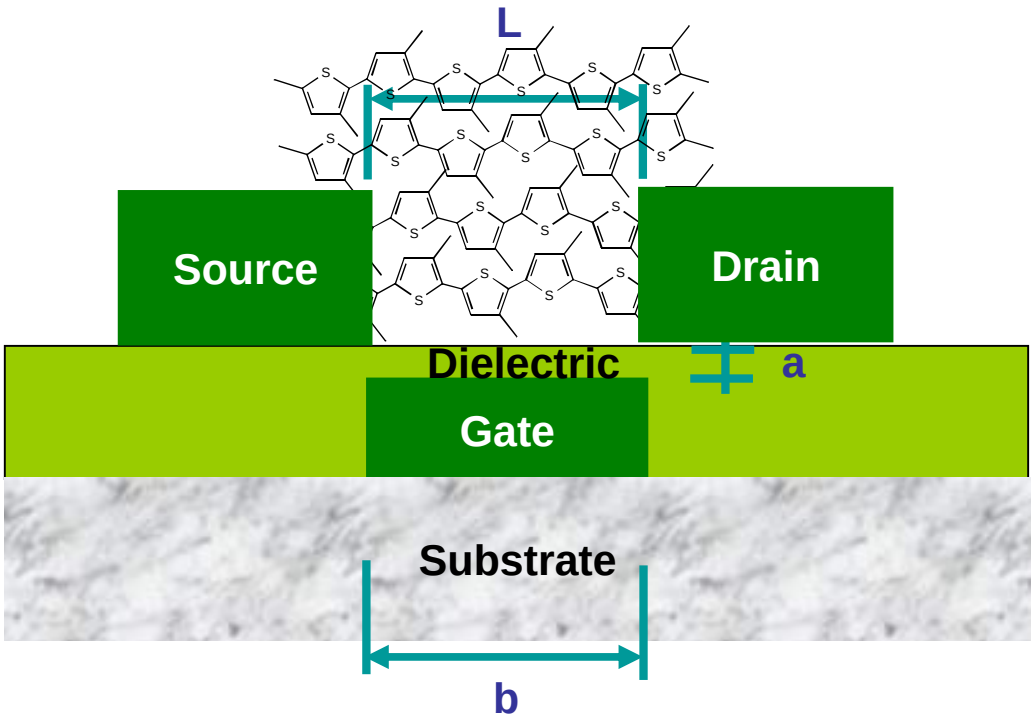


- *Highly integrated hybrid system for high throughput and scalability*

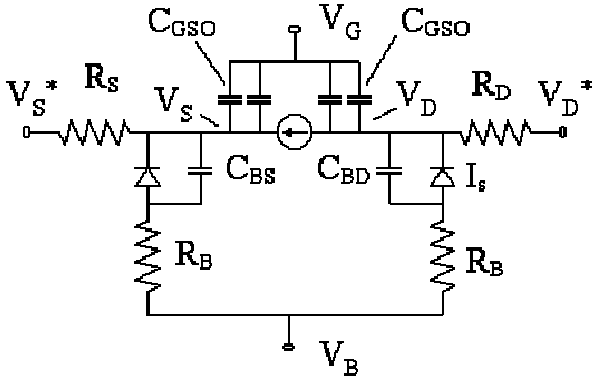
In-Line/Off-Line Characterization Tools

Critical Parameters

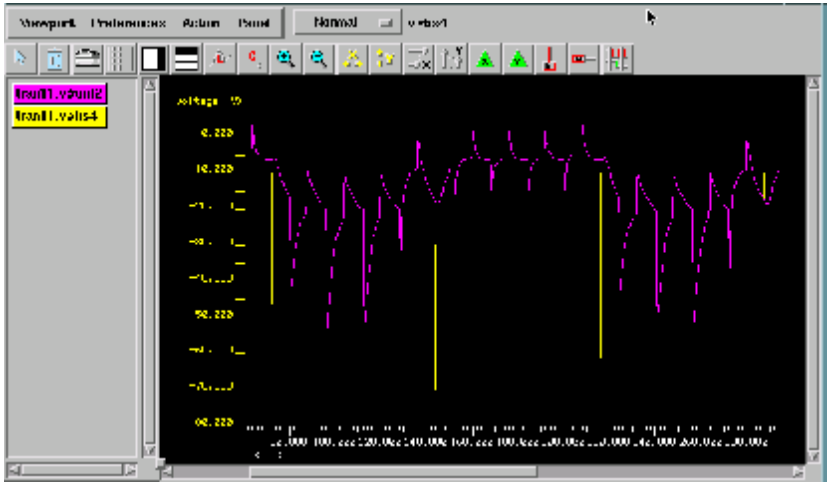
- Resolution
- Registration
- Layer thickness
- Orientation of features
- Dimensions of features
- Processing conditions
- Material quality (pot life)
- In-process electrical testing
- Final product electrical testing



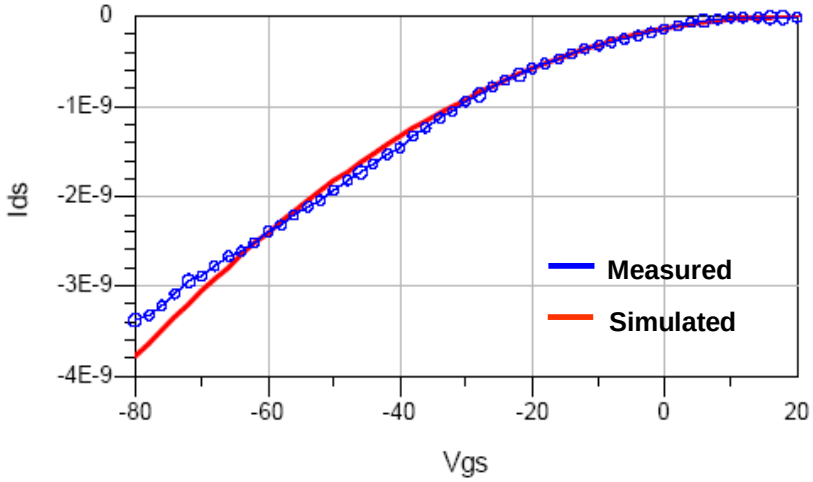
Electrical Design, Layout, and Simulation Tools



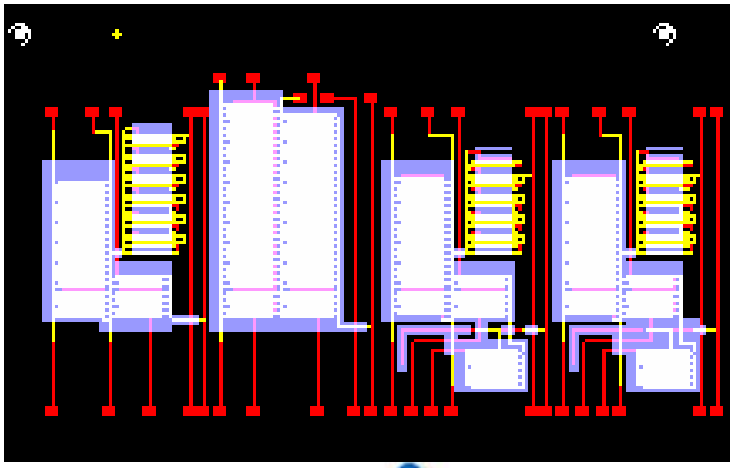
Circuit Design



Circuit Simulation



Confirmation of Experimental to Simulation



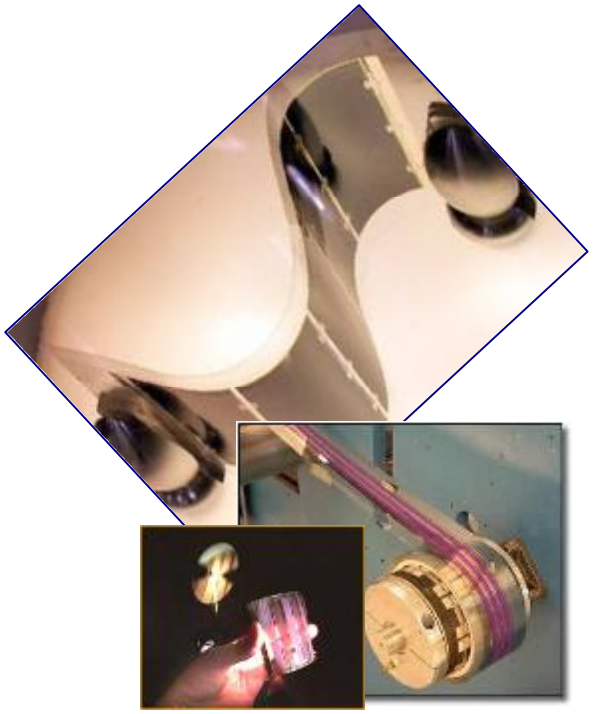
Circuit Layout

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

Standards

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

1620-2004™ → **1620.1-2006™** → **P1620.2**

Device Level Test
http://grouper.ieee.org/groups/1620/1/

Approved in 2004 ü

2008 update complete and IEEE-SA approval received

Ring Oscillator Test
http://grouper.ieee.org/groups/1620/1/

Approved in 2006 ü

RF Sub-System Test

Assembling Working Group ?

Need for printed RF measurement standard

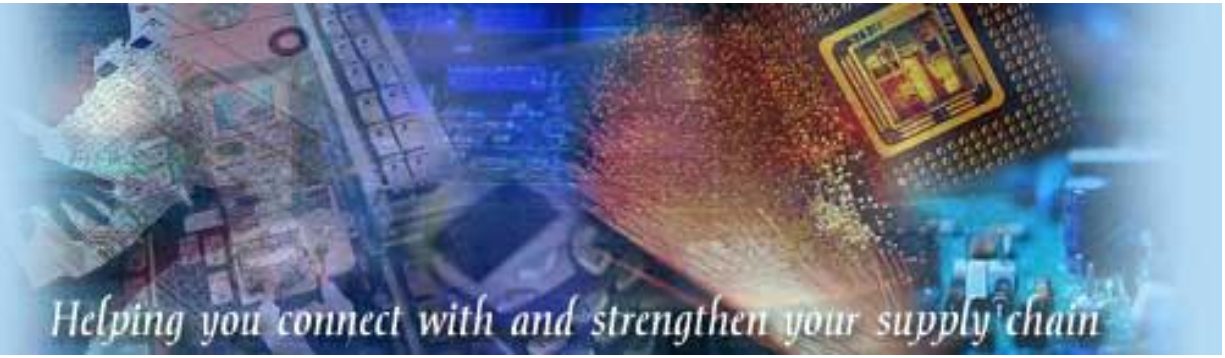
Flexible Electronics
"*Top Four*" Needs and Gaps

#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



www.inemi.org

Daniel Gamota
dan.gamota@printovatetech.com
Chuck Richardson
chuck.richardson@inemi.org
Bob Pfahl
bob.pfahl@inemi.org