



International Electronics Manufacturing Initiative

**Nanotechnology and its
effect on Electronics
Manufacturing**

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- **Overview of iNEMI and the 2004 Roadmap**
- **Situation Analysis from 2004 Roadmap**
- **Identified Gaps from the 2004 Roadmap**
- **Potential Solutions for the Identified Gaps**
- **Current iNEMI Nanotechnology Efforts**
- **Major Trends and Future Challenges**

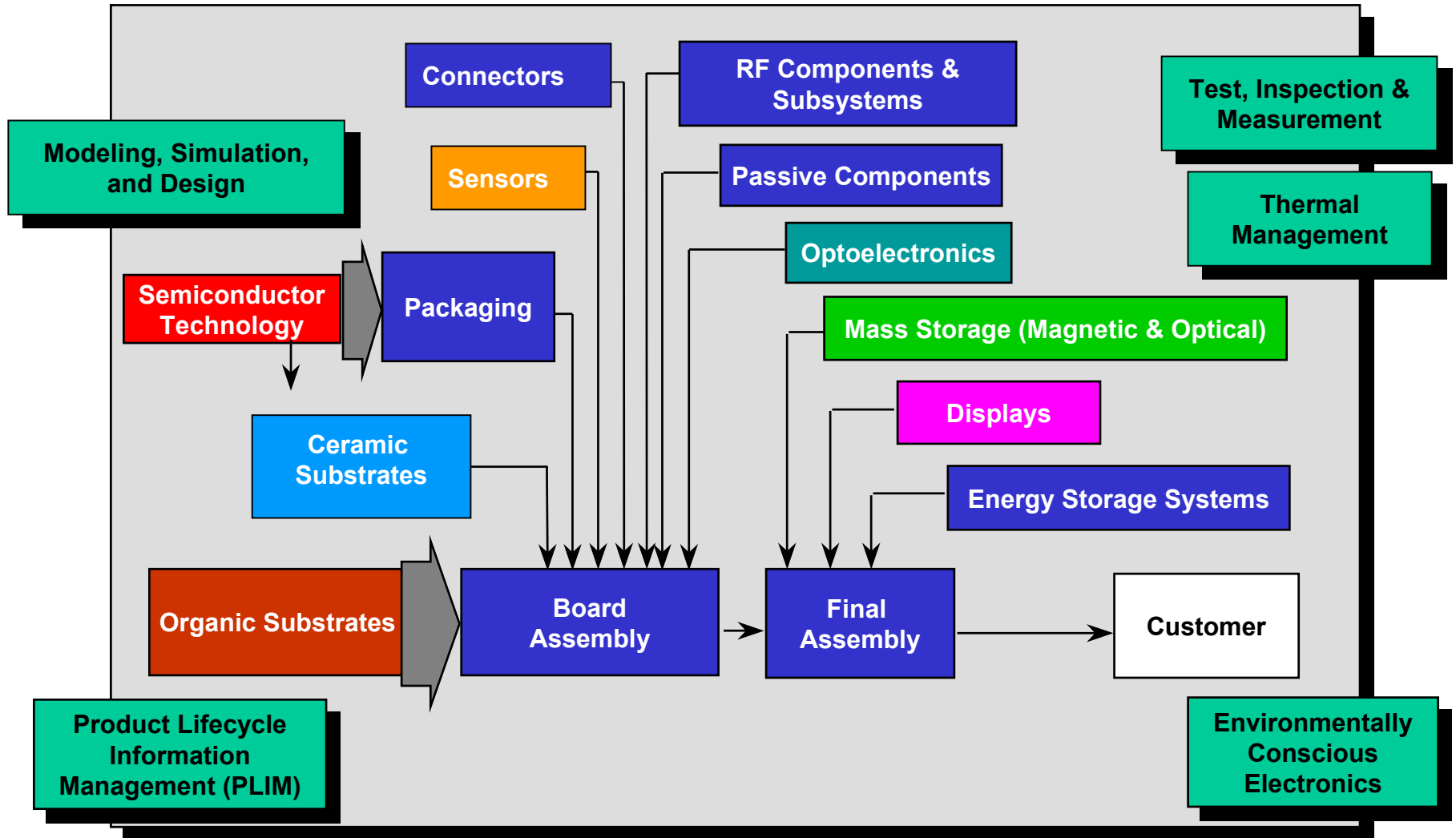
- **iNEMI roadmaps the global **needs** of the electronics industry**
 - **Evolution of existing technologies**
 - **Prediction of emerging/innovative technologies**
- **iNEMI identifies gaps (both business & technical) in the electronics infrastructure**
- **iNEMI stimulates research/innovation to fill gaps**
- **iNEMI establishes implementation projects to eliminate gaps**
- **iNEMI stimulates worldwide standards to speed the introduction of new technology & business practices**

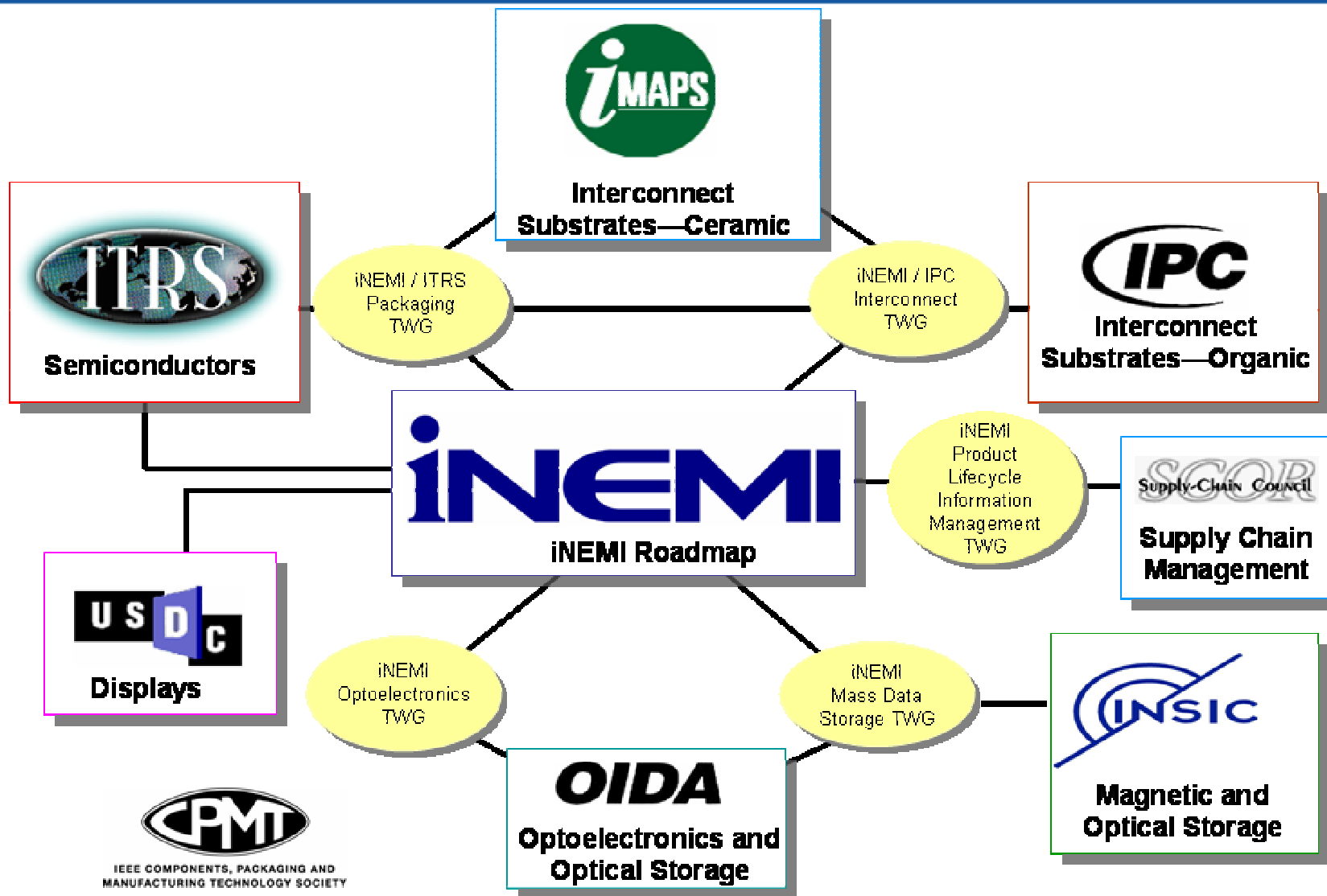
- **> 470 Participants**
- **> 220 Companies/organizations**
- **11 Countries from 3 Continents**
- **19 Technology Working Groups (TWGs) (added Sensors)**
- **7 Product Emulator Groups (PEGs)**
- **Over 1200 Pages of Information**
- **Roadmaps the needs for 2005-2015**

Emulators	Characteristics
Portable / Consumer	High volume Consumer Products for which cost is the primary driver including Hand held, battery-powered products driven by size and weight reduction
System in a Package	Complete function provided in a package to system manufacturer
Office Systems / Large Business Systems	Products which seek maximum performance from a few thousand dollar cost limit to literally no cost limit
Network / Datacom / Telecom Products	Products that serve the networking, datacom and telecom markets and cover a wide range of cost and performance targets
Medical Products	Products which must operate within a highly reliable environment
Automotive	Products which must operate in an automotive environment
Defense and Aerospace	Products which must operate in extreme environments

Yellow = Completely new Emulator

Green = Broadened focus







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Situation Analysis:

Technology

Legislation

- The anticipated end to semiconductor scaling c. 2015 will create a major **technology** shift in the industry:
 - Implementation of advanced, non-classical CMOS devices with enhanced drive current
 - Identification, selection, and implementation of advanced devices (beyond-CMOS)
 - Increased need for improved cooling
 - Potential need for high speed optical communications
 - Innovative Packaging for:
 - Nano size devices
 - Hetro systems
- Innovation must begin today to meet these needs

Legislation impacting the design and recycling of electronic products is being enacted throughout the world (including China):

- Environmental legislation in various product segments requires the electronics industry to **share** detailed material content data of products and components.
- To meet regional legislative requirements, manufacturers must **remove** environmental “Materials of Concern,” such as lead.
- The electronics industry is facing producer responsibility (**recycling**) legislation.

- **New energy technologies that may cause disruptive opportunities include fuel cells and high power batteries for hybrid electric vehicles**
- **Nanotechnology has the potential to be a very disruptive technology during the period covered by the roadmap**



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Identified Gaps:

Active Device Technology

Thermal Management

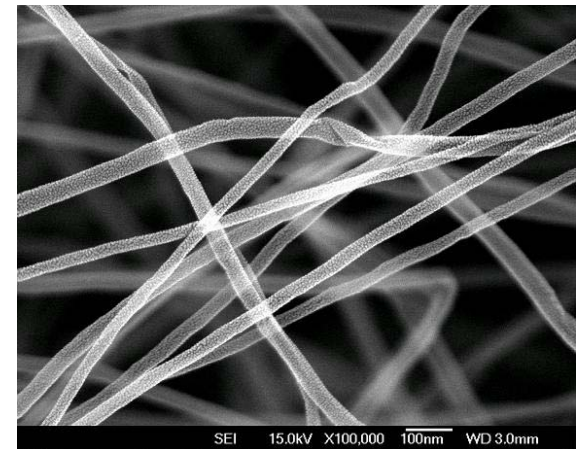
Increased Serial Communications Bandwidth

Next Generation Packaging Technology

Design and Simulation Tools

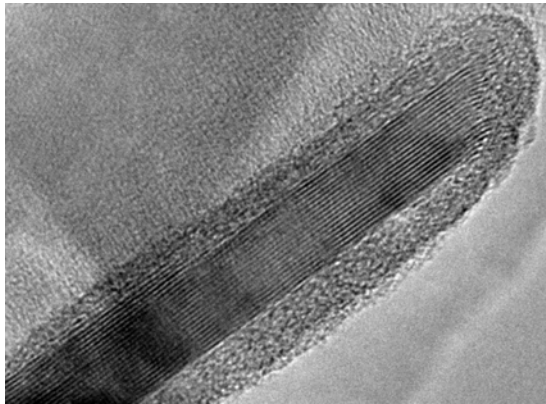
Sustainability Metrics

- **Implementation of advanced, non-classical CMOS devices with enhanced drive current**
- **Identification, selection, and implementation of advanced devices (beyond-CMOS)**
- **Increased need for improved cooling**
- **Potential need for high speed optical communications**
- **Innovative Packaging for:**
 - **Nano size devices**
 - **Hetero systems**



Multi-wall carbon nanotubes (NanoDynamics Inc.)

- **Increased need for improved cooling**
- **Need improved materials and design concepts**
- **Focus is on local hot spots**
- **Must design from device to system level.**



BN coated with Al₂O₃ (ALD Nanosolutions Inc)

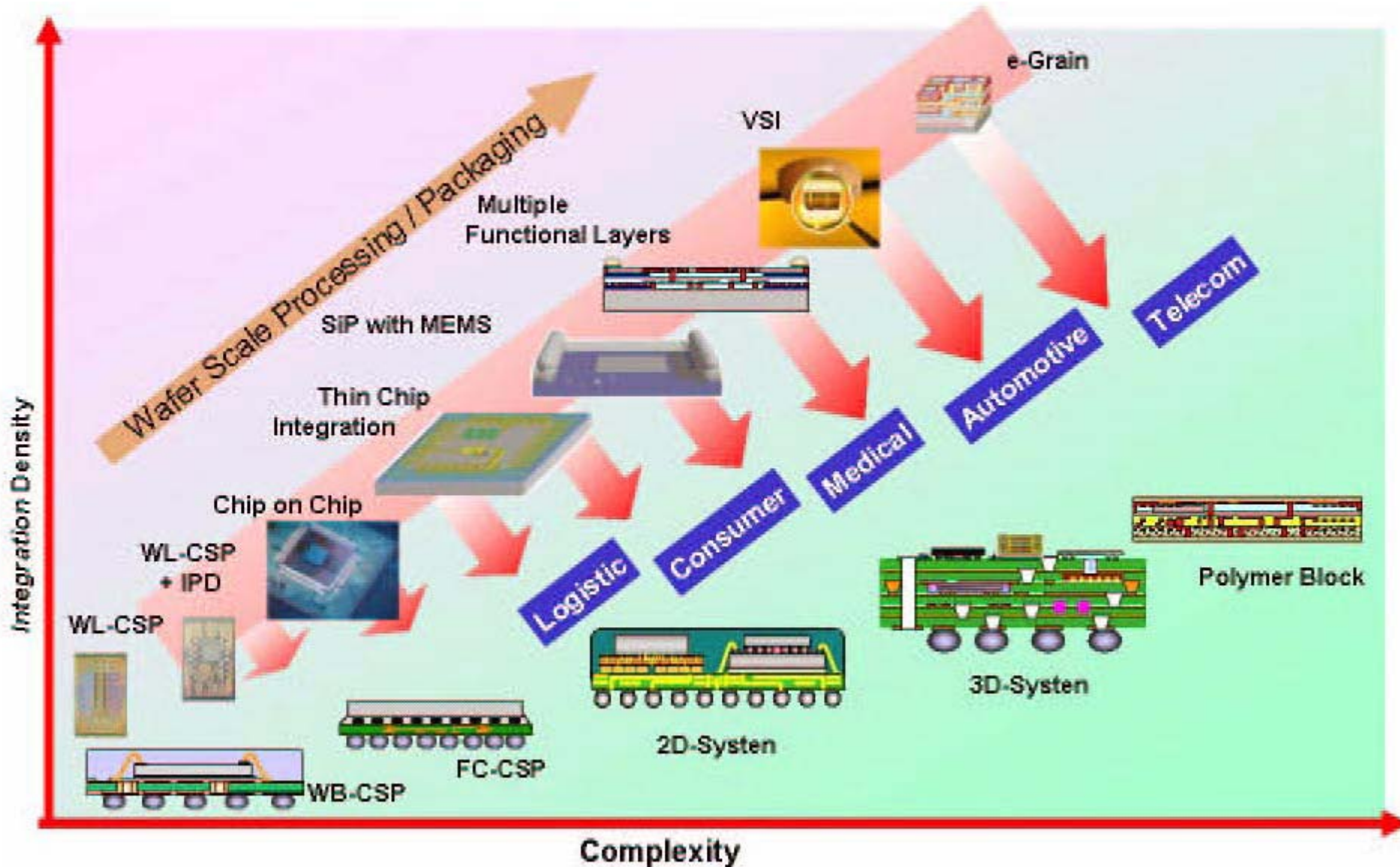
- Copper
- RF
- Optical

- Where?
- When?
- How Fast?
- **At what cost?**

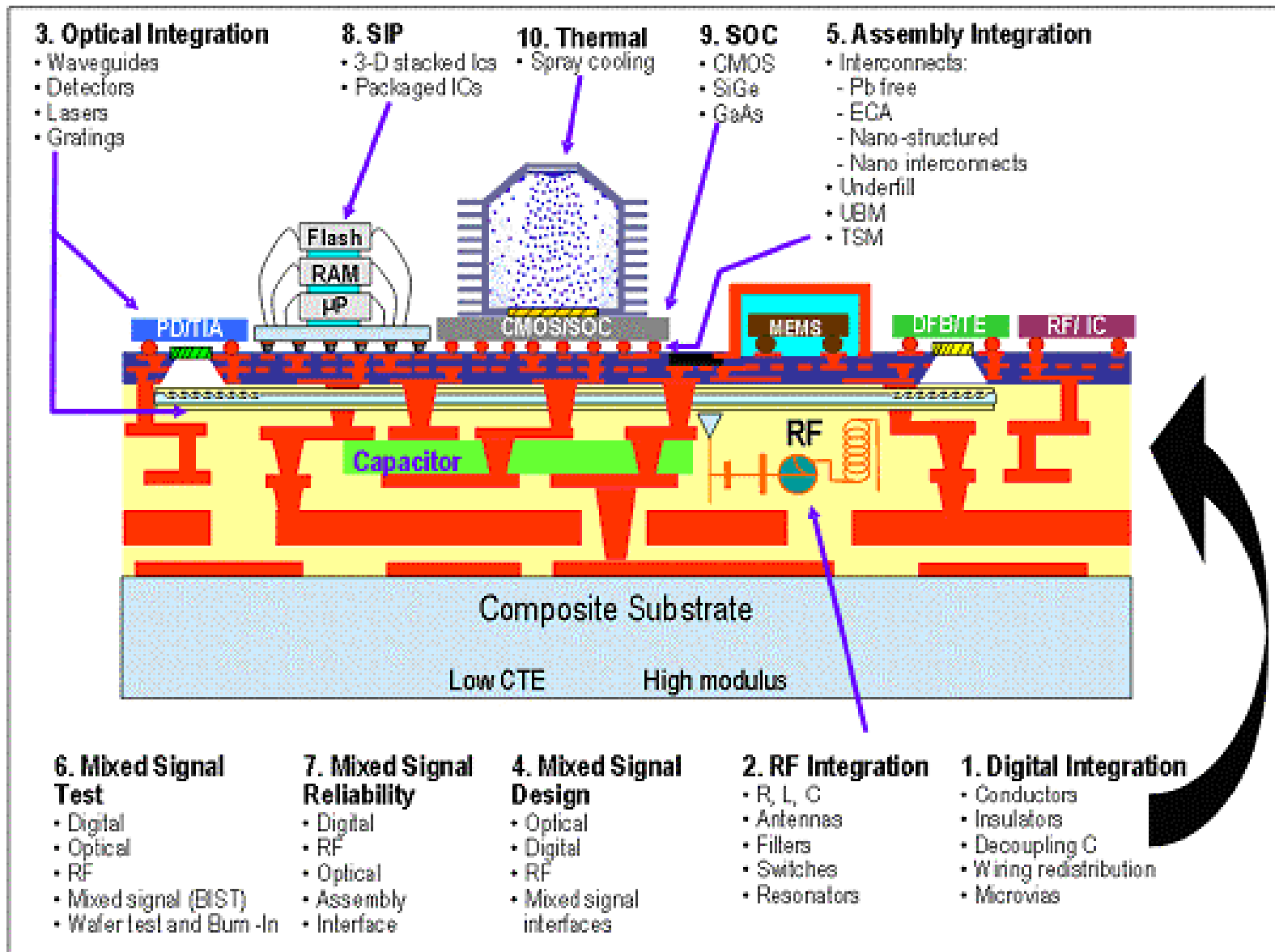


Design & simulation tools are main roadblocks to more rapid introduction of new technologies:

- Mechanical & reliability modeling**
- Thermal & thermo-fluid simulation**
- Co-design of mechanical, thermal & electrical performance of the entire chip, package & associated heat removal structures**
- Simulation tools for nano devices & materials**
- Improved design tools for emerging technologies like embedded passives & optoelectronic PWBs**
- Integrated design & simulation tools (circuit, EM, thermal, mechanical, manufacturing, etc.) for higher functionality in mixed-mode wireless chips & modules.**

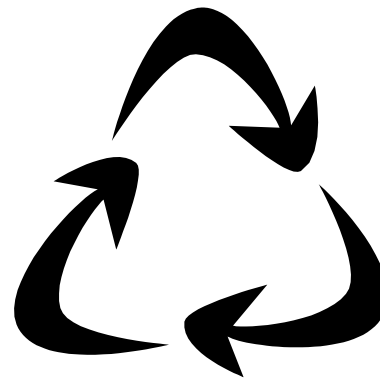


Source: Professor Dr. Reichl, Fraunhofer IZM, Berlin Germany



Source: Professor Rao Tummala, Georgia Institute of Technology-Packaging Research Center.

- **Development & implementation of scientific methodologies to assess true environmental impacts of materials and potential trade-offs for alternatives**
- **Develop a common, straightforward definition of sustainability**





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Nanotechnology- A Potential Solution for some of the Identified Gaps:

Active Device Technology

Thermal Management

Increased Serial Communications Bandwidth

Next Generation Packaging Technology

Design and Simulation Tools

Sustainability Metrics



Nano Composites: stronger, tougher, stiffer, lighter materials (adhesives, structural, thermal, electronic, optical functionality)

Nano displays: Large, lower cost and brighter displays based on embedded carbon nanotubes

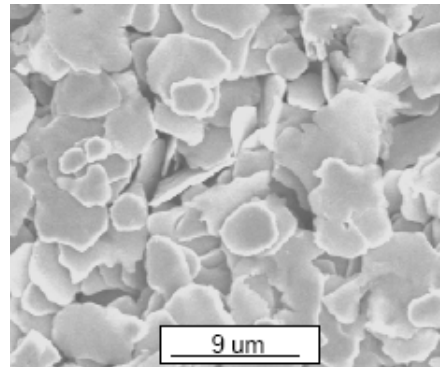
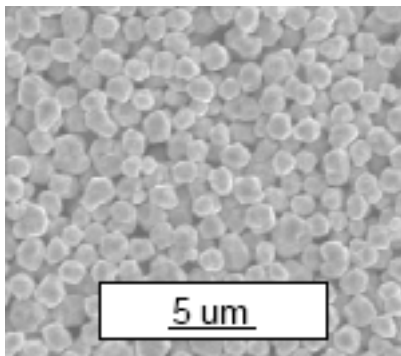
Nano sensors: smaller, more sensitive Nano scale sensors for bio, optical, chemical and physical sensing

Nano antennas: Nano scale fractal antennas for multiple spectra and broadband

Nano power: High capacity power sources (storage, conversion, advanced fuel cells, photonic energy), parasitic energy harvesting, nanobiotech related functionality

Example Application: Nano copper for circuit formation

- Use like toner in a photocopier
- Overplate to form a circuit.
- Toshiba, IMEC Japan 2004
- Challenge
 - Develop the infrastructure



Pb-free Nano-solder Project:

**The Application of Nanotechnology to Suppress
Non-Lead Solder Reflow Temperature**

(Chair: Andrew Skipor, Motorola Labs)

The goal of the group is to explore and demonstrate the feasibility of melting point temperature reduction of a non-lead solder system, based on melting point depression of nano-scale metal particles. The Nano-Solder Project membership sign-up is currently underway with the release of the project's SOW and Project Statement.

- **Since 1998 iNEMI has proactively roadmapped the technology needs to produce Environmentally Conscious Electronics (ECE)**
- **iNEMI members, with strong support from NIST, have provided the technical and supply chain leadership to meet the two new EU directives on Electronic Products.**
 - **iNEMI and NIST performed the research to identify the preferred solder to replace Sn-Pb**
 - **iNEMI developed the processes and standards for the conversion**
- **iNEMI members support a proactive study of potential environmental risks of nanotechnology in parallel with current research efforts**

iNEMI Possible Time Line for applications of Nano Technology in Electronics

- **Advanced fillers that are reinforcing, thermally conductive, electrically conductive, TCE modifying for mold compounds, underfills, adhesives and board materials; short term**
- Mixed Nano and MEMS sensor technology; medium term
- Display technology based on CNT emitters; medium term.
- Quantum computing
- Transistors based on CNT or spintronics; long term
- DNA strand self-assembly of electronic structures; long term

- **Link identified technology gaps to potential technology solutions**
 - Need a performance AND economic advantage.
- **Involve industry, academia and government**
- **Develop a coherent supply chain**
 - Bridge the chasms from R&D to pilot to scale up to product.
 - iNEMI's strength and charter.
- **Develop ways to monitor and tap into world-wide research.**
- **Build on existing structures and relationships – Sematech, iNEMI, Federal Nanotechnology Centers, National Laboratories**
- **Strengthen communication mechanisms**

- **Prioritize Research needs and gaps based on the 2004 Roadmap and Publish by September 2005**
- **Develop a top-down Vision from the industry on addressing these gaps.**
- **iNEMI hosted an Executive Innovation Leadership Forum to Discuss and Develop the Vision**
 - **Invited key thinkers from industry, academia, and government**
 - **Included high level leaders for keynote or challenge**



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**Major Trends
&
Future Challenges**

- **The predicted end of semiconductor scaling could have major implications:**
 - **Non classical CMOS**
 - **Beyond CMOS**
 - **Increased thermal challenges**
 - **Significant impact to packaging/interconnect**
- **Nanotechnology has the potential to dramatically effect electronics:**
 - **Materials**
 - **Displays**
 - **Sensors**
 - **Power**

- **Electronic Packaging**
 - **The Technology Driver will be multifunctional system in packages (SiPs)**
 - **These needs must be addressed through innovation using new processes and new materials made possible through emerging efforts such as nano-technology**
- **Green Electronics**
 - **As we recover from the recession and from implementing RoHS and WEEE, the electronics industry needs to develop a strategic vision of sustainable electronics**

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