What do the Roadmaps Say?

A Look at What the International Roadmaps say About Lead Free

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What do the Roadmaps Say?

General
OEM Product Sectors
R & D
Current Status
Needs Assessment
Challenges
Summary
Potential Solutions

What do the Roadmaps Say?

- **Lead Free Roadmaps**
  - **2000 JEIDA Roadmap 2000 for Commercialization of Lead Free Soldering**
  - **European Lead-Free Technology Roadmap February 2002**
  - **IPC, US Lead-Free Roadmap 4th Draft**
  - **JEITA, Japan Lead-Free Roadmap 2002**
  - **Soldertec Second European Lead-Free Soldering Technology Roadmap**
- **International Technology Roadmaps**
  - **NEMI Technology Roadmap 2004**
  - **IPC International Technology Roadmap 2004-2005**

What do the Roadmaps Say?

General

What do the Roadmaps Say?

- Changing Environment
- Historically environmental management driven from domestic regulations
- Increasingly, foreign environmental regulations and market pressure are having a significant effect on domestic manufacturing.

What do the Roadmaps Say?

- **Since the focus of domestic environmental regulations can differ greatly from that of our foreign trade partners, PCB manufacturers and EMS providers must now become familiar with numerous foreign regulations and initiatives.**

What do the Roadmaps Say?

- International environmental regulations and “market driven” initiatives

- Focus on the *materials* used in electronic and electrical equipment

- Initiatives started in Japan and Europe, however many U.S. states are, beginning to pass materials bans and product take-back regulations of their own.

What do the Roadmaps Say?

- **New trend …The concept of sustainability**

- **Trend is in response to heightened interest by stakeholders in corporate social and environmental responsibility.**
- **Increasingly, companies are publishing sustainability reports, in place of traditional environmental reports.**
  - **Although these reports are now being called sustainability reports, the general nature and content of the reports has changed little, with the possible exception of additional emphasis on social considerations.**

What do the Roadmaps Say?

OEM Product Sectors

What do the Roadmaps Say?

- Portable & Consumer Product Sector
- Medical Product sector
- Office Large Systems Product Sector
- Netcom Product Sector
- SIP Product Sector
- Automotive Product Sector
- Aerospace and Defense Product Sector

What do the Roadmaps Say?

Forecasted conversion to lead free by product

	2003	2005	2007	2009	2015
Portable	SnPb	Pb Free	Pb Free	Pb Free	Pb Free
Medical	Mixed	Pb Free	Pb Free	Pb Free	Pb Free
Defense	**SnPb**	**SnPb**	**SnPb**	**SnPb**	**SnPb**
Auto	SnPb	Pb Free	Pb Free	Pb Free	Pb Free
Office	SnPb	Pb Free	Pb Free	Pb Free	Pb Free
Networking	SnPb	Pb Free	Mixed	Pb Free	Pb Free

High Performance Systems (Mainframe/Mass Storage)

	2004-2005		2006-2007		2008-2009		2010-2014	
PCB Technology Factors	**RCG**	**SoA**	**RCG**	**SoA**	**RCG**	**SoA**	**RCG**	**SoA**
Materials	FR4	High Tg FR4	High Tg FR4	RoHS FR4, Low Loss Epoxy	High Tg FR4, RoHS FR4	RoHS FR4, L.ow Loss Epoxy	RoHS FR4	RoHS FR4, Low Loss Epoxy

Laminate materials are undergoing change due to RoHS. Many different resins, blends and fillers are available. For this reason, generic descriptions of "RoHS FR4" (for RoHS/lead-free compatible epoxy based) and "Low Loss Epoxy" (for low dissipation factor materials) are used to describe future materials requirements.

IPC roadmap

What do the Roadmaps Say?

Research and Development

What do the Roadmaps Say?

Assembly Materials Forecasts

Parameter	Metric	2003	2005	2007	2009	2015
Solder Pastes	**% US Pb free**	<1%	10%	20%	25%	95%
	% WW Pb free	<5%	50%	75%	90%	95%
Bar solder	**% US Pb free**	<1%	10%	20%	25%	95%
	% WW Pb free	<5%	50%	75%	90%	95%
Wave solder flux	**VOC free**	18<%	23%	27%	30%	90%

NEMI roadmap

What do the Roadmaps Say?

- *"Furthermore, these same environmental drivers will require that board assembly spend research and development funding on developing a fundamental understanding of lead-free solder material metallurgy, reliability, and processability."*

NEMI roadmap

What do the Roadmaps Say?

"For eutectic tin lead alloys, basic research was funded in part by military requirements. This governmental funding model allowed for detailed basic research into the materials and allowed for the creation of military standards based upon this understanding. "

"..the current transition to lead-free solders, mandated by the governmental regulations, has been funded by the electronics industry. This funding model is not allowing for the creation of a fundamental understanding of the metallurgy and product reliability"

What do the Roadmaps Say?

- “Development of a production process for 01005 will be necessary in these markets in a lead-free process by 2007 “

  NEMI roadmap

If this doesn’t happen, will the requirement for LF aid embedded passive development??

JF

What do the Roadmaps Say?

CURRENT STATUS

What do the Roadmaps Say?

- **EU RoHS Directive**
- **U.S. State initiatives such as California's SB20**
- **and, international recycling laws such as the EU Waste from Electrical and Electronic Equipment (WEEE) Directive.**

What do the Roadmaps Say?

- **The impact to the whole supply chain is huge.**
- **The ways to handle the take-back and recycle process can lead to the disqualification of some of the existing suppliers in the supply chain.**
- **Many *re-evaluation* activities will be carried out globally.**

What do the Roadmaps Say?

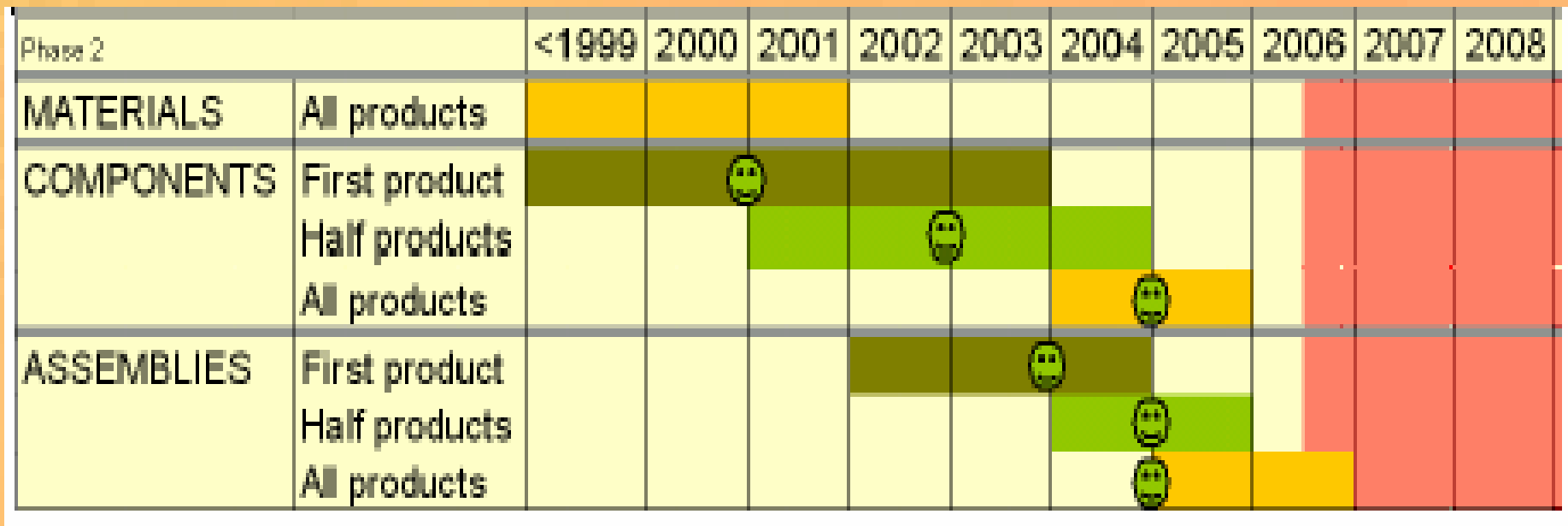
Standards development

Group	Typical process temperature		Alloys (examples)
	Flow soldering	Reflow soldering	
Low temp.	---------	170 °C – 210 °C	Sn-Bi
Medium temp.	---------	210 °C – 235 °C	Sn-Zn-Bi Sn-Zn
Med high temp.	245 °C – 255 °C	235 °C – 250 °C	Sn-Ag Sn-Ag-Cu Sn-Ag-Bi
High temp.	250 °C – 260 °C	---------	Sn-Cu

NOTE 1 Flow soldering applies to both wave soldering and dip soldering.
NOTE 2 Typical process temperatures for flow soldering are identical to the solder temperature. Typical process temperatures for reflow soldering are the terminal and top surface temperature of the SMDs.
NOTE 3 In Group 2 reflow soldering under inert atmosphere (e.g. nitrogen) is required.
NOTE 4 The basic solder alloys listed in this table represent compositions that are currently preferred for lead-free soldering processes. However, other solder alloys when matching with the specified group should not be excluded.

IPC roadmap

MILESTONES IN LEAD ELIMINATION



For Japanese industry

Components
Start supplying components to end 2001
Complete supply of Pb-free terminal components; end 2003
Complete supply of Pb-free components; end 2004

Assemblies
Start introducing lead-free solder; 2002-2003
Totally adopt lead-free solder into new products; end 2003
Complete lead-free adoption; end 2005

These are for average manufacturers, leaders are 1 year ahead and followers 2 years behind.

General Conversion Roadmap (BGA excluded)

	ST	Philips	IFX	Freescale[1]
IC Commodities	Q2 05	Q2 05	Q2 05	Q2 05
IC ASICS	Q2 05	Q2 05	Q2 05	Q2 05
Discrete	Q1 05	Done	Done	N/A
Memories	Q2 05	N/A	Q2 05	N/A
Products for Automotive	05 ?	05 ?	05 ?	Q3 05

The data indicate the completion of the volume conversion to lead free

Information courtesy of Infineon

IC Package Conversion Roadmap

	ST	Philips	IFX	Freescale[1]
L/T/F BGA	Q2 05	Q2 05	Q2 05	Q1 05
M/L/T/QFP	Q1 05	done	Q2 05	Q3 05
QFN	done	done	done	Q2 05
SO	Q1 05	Q2 05	Q4 05	done
TSSOP	Q2 05	Q2 05	done	Q1 05
SSOP	Q1 05	Q2 05	=	Q1 05
PLCC	Q2 05	done	Q2 05	Q2 05

The data indicate the completion of the volume conversion to lead free

Information courtesy of Infineon

What do the Roadmaps Say?

NEEDS ASSESSMENT

What do the Roadmaps Say?

Lead free Surface finish needs

ATTRIBUTE	CURRENT 2004- 2005		NEAR TERM 2006-2007		MID TERM 2008-2009		LONG TERM 2010-2014	
	CONV	SOA	CONV	SOA	CONV	SOA	CONV	SOA
Solderability (# of reflows)	4	5	5	8	5	8	6	8
Shelf Life (months)	6	8	8	10	8	12	9	15
Solderable	Hasl	Ni/Au	OSP/ LF HASL	Imm Silver	OSP/ LF HASL	Imm Silver or Tin	Imm Silver or Tin	New Nano M'tl
Lead free Solders	N	Y	N	Y	Y	Y	Y	Y

What do the Roadmaps Say?

Packaging impacts

- **The majority of packages still are not Pb-free nor are they able to with stand reflow temperatures of 260°C. The few packages that are capable are using materials that are marginal in performance and cost any where from 3 to 10 times the normal material costs.**
- **The material cost for the Pb-free packages are normally 50-70 % of the total allowable (Assembly and Packaging total) package cost. This high material cost is having a financial burden on the suppliers of the packaged devices.**
- **Packaging material cost requirements for Pb-free and Green packages are not achievable with the present materials.**

What do the Roadmaps Say?

- **The following tables list several of the process steps that could be affected by a concerted effort between suppliers, fabricators and users to reduce the environmental impact of identified printed board manufacturing process steps..**

What do the Roadmaps Say?

PWB Process Optimization Innerlayers

Process	Possible changes
Innerlayer	Print Develop permanent innerlayer etch resists to minimize
Etch	waste.Recycle/regenerate/reclaim etchants
Adhesion promotion	Eliminate oxide.
Lamination	treatments.Develop lower temperature curing materials or materials with shorter cure cycles to conserve energy

Several of the process steps where a concerted effort between suppliers, fabricators and users could reduce the environmental impact of printed board manufacturing process steps.

What do the Roadmaps Say?

PWB Process Optimization Outerlayers

Process	Possible changes
Drilling	Develop use for drill dust, develop alternate methods of via generation
PTH Metallization	Develop alternate means of through hole preparation. Develop alternatives to formaldehyde-based electroless coppers. Develop materials that will eliminate or minimize the need to desmear
Surface feature generation	Develop alternatives to tin lead etch resists.
Solder Mask	Develop reliability data on aqueous solder masks to allow for full change to these materials.
Solderability Protection	Develop reliability data on non-solder surface protection. Further develop electroless or replacement solders.

What do the Roadmaps Say?

Assembly Environmental Needs

Process	Current	Near Term	Long Term
Semi-aqueous cleaners	Develop on-site recycling methods	Same	Eliminate flux cleaning requirements
Aqueous Cleaners	Optimize on-site recycling and biodegradable	Same	Development of closed loop systems
Lead-free solder replacement	A. Evaluate commercially available adhesives. B. Evaluate lead-free solder. and evaluate ASF to replace HASL	Same	Switch to lead-free Solder

What do the Roadmaps Say?

Assembly Environmental Needs

Process	Current	Near Term	Long Term
Conformal coatings	Low VOC or UV coatings. Eliminate conformal coatings when not required	.Same	No VOC coatings
Adhesives	Develop safer alternatives (epoxy, acrylic, or isocyanate sensitization). Evaluate non-VOC or water-based adhesives	Same	Implementation of new adhesive blends
Fluxes	Evaluate low and No VOC fluxes	A. No VOC Fluxes B. No Clean Process	Fluxless attachment

What do the Roadmaps Say?

Process	Current	Near Term	Long Term
Flip Chip Package	Soldering without flux	Evaluate and enhance production technology	Produce Flip ChipAssemblies without flux and with lead-free solder

What do the Roadmaps Say?

Law of unintended consequences

- **Certain regulations have the opposite effect from their intended goals.**
- **For example, RCRA's hazardous waste regulations can actually encourage the land disposal of recoverable materials, essentially wasting valuable and easily recoverable metal constituents.**
- **The industry needs environmental regulations that promote spent material recovery and recycling instead of encouraging their disposal.**
- **Loss of these recoverable materials results in the mining of new virgin materials with the concomitant environmental degradation that mining extraction entails.**

What do the Roadmaps Say?

CHALLENGES

What do the Roadmaps Say?

- Customers heavily control PCB manufacturing, more so than almost any other manufacturing sector. They not only dictate board design and conformance to deliverable product specifications, but also the materials used during manufacture and most internal process methods. Approval from customers is routinely required before incorporating process changes or new manufacturing methods.

What do the Roadmaps Say?

Conflicting needs for assembly - Solders with a low melting point so that constituent parts aren't damaged, yet high enough melting point so that they don't melt during subsequent processing.

The new materials that are being selected for the Pb-free applications do not have a long history of reliability and quality so they are very high risk to the industry to make the transition.

Changes to the present RoHS requirements are confusing Requirements are not actually changing but exemptions for Certain materials are . Each new exemption causes even more confusion creating a delay in the conversion to Pb-free.

What do the Roadmaps Say?

SUMMARY

What do the Roadmaps Say?

Material Replacement Issues

Materials	Constraints
Solvent recovery and closed loop techniques	Capital intensive or limited availability of aqueous substitutes. Develop water based or solvent free systems for materials production Capital intensive, increased cost for raw materials, water is a poor solvent for the components now used to produce laminates. Requires new technology
VOC elimination in cleaning	Techniques exist. Capital intensive and specs are not realistic.
Aqueous soldermasks, resists, etc.	Specifications and capital requirements.

What do the Roadmaps Say?

Material Replacement Issues

Materials	Constraints
Additive processes and direct plating	Capital-intensive processes exist in US and Japan for essentially permanent electroless plating baths. Fully additive processes exist but have numerous specification issues and process limitations. Electroless copper is at least as good as electroplate.
Beryllium Oxide Ceramic Non-conductive Substrate in Hybrid, MCM and Gate Array Packages	Cost of replacement to meet high voltage >12-13 kV still not mature

What do the Roadmaps Say?

- **One of the challenges is accurately tracking the costs associated with waste generation and management. Few companies have sufficiently sophisticated accounting systems in place to capture the costs associated with wasted raw materials, waste treatment, pollution control, and EHS compliance, or to allocate these costs to their generating process. The costs and benefits associated with avoided penalties, reduced liabilities, and societal impacts are also very difficult to capture in an accounting system since they are usually ‘‘avoided costs’’ and difficult to value accurately.**

What do the Roadmaps Say?

POTENTIAL SOLUTIONS

What do the Roadmaps Say?

- Cooperative programs between industry and the government to seek alternative methods
  - **NCMS**
  - **NEMI**
  - **SPVC**