2015 IPC International Technology Roadmap for Electronic Interconnections

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PART A – SECTION 1: ROADMAP OVERVIEW

INTRODUCTION

What is the purpose of this roadmap?

The purpose of the IPC International Technology for Electronic Interconnections Roadmap is to provide users with a benchmark comparison for their current needs and capabilities, but more importantly, to help them to project what they might need to compete over the near term (1-3 years) to mid-range term (~5 years). Some insight into the long term (~10 or more years) period is included, but it is our position that operational-level projections become untrustworthy that far in the future. The goal is to provide users with information that they can use to plan their staffing, equipment, and training investments to address those portions of the predicted market in which they plan to compete. Corporate strategy and pure technology research are not within the scope of this effort, and is well covered elsewhere. However, as a natural side-effect of the projections we provide, we do uncover "gaps" in capabilities, materials, training, etc. for which a solution has not yet surfaced. We will communicate those gaps both within this Roadmap and through our links with organizations involved in longer-lead activities.

There are many different organizations providing technology or market roadmaps, each aimed at specific kind of user or covering a particular segment of the market place over a particular time frame. The IPC concentrates on the operational segment of the electronic interconnect market, only reporting the very broad (overall major corporate strategic plan, e.g., iNEMI and Prismark) and very narrow (Japanese consumer electronics needs, e.g., Jisso) sufficient for our constituents planning purposes. We ALWAYS recommend that users consider the input from other roadmaps where it may pertain to their specific situation.

This Technology Roadmap (like any good, ongoing roadmap activity) is continuously updated to reflect the changes in technology, market, external influences we anticipate MAY affect some of the targeted users. Each release is a snapshot of an evolving body of information. This evolutionary process includes the methodology of data collection, traditional contributor's ability to travel, demands from many sources made on some key subject matter experts, and overall leaner operational staffing. We have adopted a more distributed processing model, with major chapter leaders running their own sections as best fits their contributor's schedules and methods. There is a much greater emphasis on shared data sources among organizations that may all need the same basic facts or numerical projections, in some cases from a very small number of "experts", but may make very different use of the information based on their users' needs. The IPC and iNEMI (just as one example) are sharing the same basic facts as the basis for 4 chapters/sections in each of their roadmaps. The implications of those facts mean quite different things to their target audiences, and what is done with the basic underlying facts is quite different in each roadmap.

The changing landscape of technology resources—flatter, leaner, more short-term focused technology groups at many OEMs, the increased role of the ODM; constrained governmental budgets; and global dispersal of technical resources—encourages new methods of raw data accumulation. This 2015 release places an increased reliance on comprehensive, multi-phased surveys to get the basic technological parametric data in use and projected from the many kinds of markets being addressed, from all corners of the globe. We have been gratified at the support shown this effort, and will expand it further going forward.

Done properly, the IPC Roadmap is a "living" document, with the market dictating shifts in emphasis depending on the user's needs.

Far more information from international sources has been incorporated in the 2015 release than in previous roadmaps, and this relative proportion is likely to increase further in the 2017 release and beyond.

Who uses it? Who is the intended audience?

The stereotypical users of the IPC International Technology Roadmap can be oversimplified into three general groupings;

- Chief technical officer (CTO) of an operational unit of a company engaged in the fabrication or assembly of one or more of the categories of electronic interconnect structures addressed in this roadmap. This could be the chief engineer of a single plant, or the CTO of a family of operations on several continents. The likely uses of this information will be deciding where/if/how/what equipment upgrades will be needed to address the projected technologies over the next few years, and what technical skill sets (including design tools and skills) will need to be in place through training or hiring to address those needs. Both paths will be needed to prepare budget submittals (capital and expense).
- Chief operating officer (VP-Operations and the like) of a company engaged in the fabrication or assembly of one or more of the categories of electronic interconnect structures addressed in this roadmap. Overlapping the CTO in some regards, but more concerned with operational level work flow and processes, operator skill sets needed over the next few years, budgeting for the time, and funding to achieve those skill sets, etc.
- Mirroring those positions are the persons tasked with sourcing the technologies predicted over the time covered (buyers, procurement officers, program managers, etc.). Will the technologies their corporate business direction demands be readily and widely available, or are they likely to be still struggling at the cutting or bleeding edge of producibility, with the accompanying risks to schedule, high and variable costs, etc.? Will their current supply base be capable, or do they need to find or develop new sources for the projected technologies? With the decline in numbers of vertically integrated companies in this area, the in-house sources of practical hands-on knowledge are largely a thing of the past.

We continue to strive to do a better job of using the knowledge coming out of the roadmapping activity to identify gaps or shortfalls in existing standards or committees (or skills within those committees) and identify specific barriers to progress which need to be resolved before specific improvements may be widely implemented. This 2015 release will do a better job of that than in the past, and we hope to do a better job yet in the 2017 release.

ROADMAP OVERVIEW

The electronic interconnection supply chain rests on three basic elements:

1 design and fabrication of semiconductors and their associated packaging;
2 fabrication of the interconnecting substrate for both the semiconductor package and the product printed board; and
3 multiple levels of assembly and test.

In the past, the predominant model was one of a more-or-less vertically integrated enterprise (commercially-organized or state-directed). Increasingly these functions are accomplished in a fluid arrangement of business relationships with partners that may be anywhere on the planet. This shift in the business model, developed through outsourcing many of the activities to entities specializing in the individual steps, requires that success will be achieved in direct proportion to the degree that the links between the three elements are strengthened through clear and unambiguous communication. It is also important that each player in the supply chain understands its technical and contractual contribution to the product reliability. It must be stressed that many operating models to accomplish the end result exist simultaneously, generally with the brand-holder [(e.g. OEM) choosing from a broad spectrum of business models depending on its needs, the product, the market, etc. This will be discussed at greater length in section A-2, *OEM/Integrator Expectations*.

In many cases, the EMS provider participates in (and in some cases, controls) the design function. Using the tools at their disposal, they are responsible for the documentation and for procuring component parts as well as printed boards. As the agent of the OEM, the EMS provider also faces the challenges of

requirements to meet new legal directives[1] to remove hazardous substances from the electronic products, implement more robust processes and face greater density packaged in smaller form factors. Another supply chain challenge directed toward the printed board manufacturing is keeping up with the integration of functionality within or supplied as pre-assembled with the printed board. The circuit board increasingly contributes to the electrical function; thus, changes in material and mounting structure can dramatically change the electrical performance of the final product.

Some major individual corporations or specific business units involved in the electronics industry have a history of generating their own, customized technology- or technology-and-market roadmaps tailored to their specific perception of culture, existing strengths, and many other factors. The output of these efforts range from closely-held strategic secrets to widely-promoted marketing tools, though often there is a private, internal-view-only version, and a version designed for public consumption. The same "pull" (i.e., "we believe we will need this technology level from you, our suppliers in the stated years") and "push" ("we claim that we will be capable of delivering these advances in technology in the stated years to you, our customers") apply in the individual company roadmaps as in the industry-wide roadmaps

One area where consortia, made up of users and suppliers, have been successful is hazardous material properties. The EU and other national and international bodies have generated directives that identify materials that are restricted from or controlled in the electronic product market. To cope, companies have banded together to look for alternatives, in part to provide a common industry voice to the sometimes conflicting requirements imposed. These issues have become a global problem, even for companies that have no intention of placing their product in any of the restricted market areas. Component suppliers have already changed termination finishes from the traditional tin-lead to new alloys that do not contain lead in excess of the permitted allowance. Therefore, many of the assembly processes have been reviewed and revised to handle the attachment requirements for the new finishes. Nevertheless, there are still product markets that have yet to fully embrace the idea of using lead-free solders, citing the lack of reliability data.

This 2015 Roadmap identifies some of the difficulties members of the supply chain are facing as well as the research needed to understand the impacts of internationally-driven changes. A great deal of focus is placed on implementing the new global hazardous material eliminations/restriction directives as well as the sustainability of the product over its life cycle. Since companies are dealing with regulations in several different markets, it has become paramount to be aware of the different requirements in each global sector and the manner in which the supply chain must be prepared to provide documentation indicating compliance. The energy and focus of technology drivers has been to define, educate, and recommend how to meet these regulatory requirements. Figure A1-1 shows the different technology sectors leading to the final product.

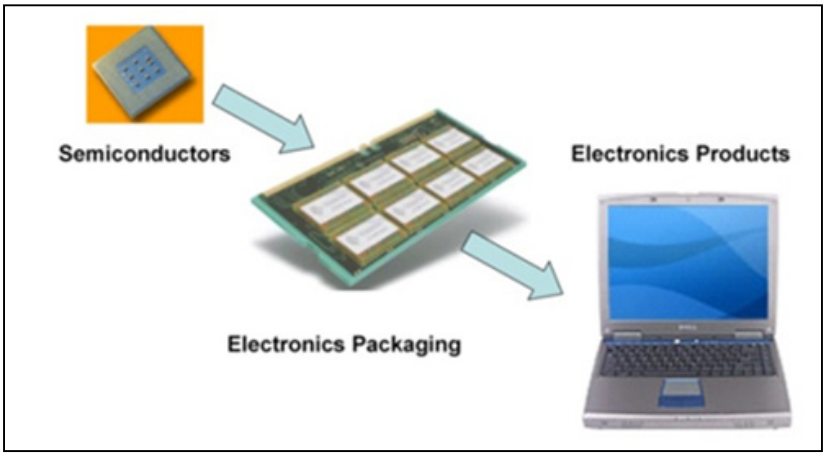

Figure A1-1 – Technology Sector Manufacturing Flow

[1] The "brand holder" [generally, the OEM] retains ultimate legal responsibility for this and essentially all other product liabilities.