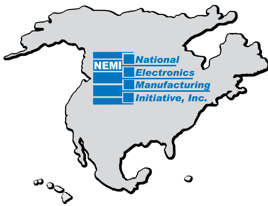

The Road Ahead for Board Assembly

Kirk Van Dreel and Alex Chen

Several process and equipment developments are needed to keep North America in pace with the changing nature of electronics manufac-turing.

Earlier this year, the National Electronics Manufacturing Initiative (NEMI, Herndon, VA) published its 2002 roadmap, which identifies technology and infrastructure developments required to ensure the competitiveness of the North American electronics manufacturing supply chain. The chapter on board assembly discusses business issues, processes and equipment, materials and issues that cut across several technology areas. This article focuses on anticipated changes in board assembly processes and the equipment development required to keep pace with these changes.

Components are becoming denser and more complex and are operating at higher frequencies. Board size is increasing. And industry needs manufacturing capabilities that will cost-effectively support high-mix, low-volume production. All of these factors pose challenges for today's board assembly processes. The NEMI roadmap highlights new process and equipment developments required to accommodate these changes, particularly in the areas of surface-mount solder application, selective soldering, part placement, press fit and aqueous wash.

Surface-Mount Solder Application

Manufacturers are expected to increasingly use large cards (>18 in. x 20 in.) to meet performance demands, and the increased size and weight will present a number of challenges. The challenge for equipment manufacturers and board assemblers is to have large board capabilities and offerings without an increased capital or assembly cost for smaller substrates. In addition, the increased weight of larger cards will create greater assembly stress during processing, and board handling equipment will also need to accommodate a larger range of weight.

With increased board size comes greater component density, and, combined, these factors will create a significant increase in the average number of solder joints per board. Thermal disparity on the same board during oven reflow will be increased, as will the use of radio frequency (RF) shields and high I/O surface-mount connectors. Equipment capabilities must be improved to avoid higher defects per million opportunities (DPMO) rates.

Due to the changing business environment in North America, a large percentage of assembly will be high-mix, high-complexity (density) with comparatively low volume. Data-driven solder paste deposition at surface mount will be required to support quick changeover, variations in pad volume by component/pad type and real-time adjustments via paste inspection. Development efforts need to be undertaken to produce throughput and paste deposition performance comparable to, and ultimately better than, today's stencil printing process technology for the large substrates. Quantification of solder paste will be widely used to actively improve assembly process quality and assembly reliability performances.

Selective Soldering

A need is growing for alternative technologies to solder through-hole assemblies in a selective, reliable, automated and cost-effective manner. Today's electronic package is one where interconnects and functionality are increasing with a concomitant increase in the mix of surface-mount and through-hole devices. As through-hole devices become less common in surface-mount-intensive designs, alternatives to wave soldering for non-surface-mount components become more desirable. Future trends in optoelectronics and microelectromechanical systems (MEMS) will further enforce the need for selective soldering technologies.

Numerous methods of selective soldering are available. The traditional selective wave soldering pallet approach continues to be a viable option, but several alternatives now offer more flexibility. Since the 2000 NEMI Roadmap, several wave solder manufacturers have released machines

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using micro-solder fountains and board handling systems. In addition, point-to-point equipment manufacturers have released several enhancements to increase flexibility.

For micro-solder fountains, future advances with tooling and cycle times are required. Tooling solutions must be optimized to reduce the keep-out region and increase system flexibility. Targeted reductions in cycle time, which currently are as short as 22 sec. and as long as 400 sec., will challenge board handling, fluxing and preheating. Further complications will be caused by the increasing board size and weight and by lead-free requirements (Table 1).

Design tools also need further development. Manufacturers require tools that will satisfy the demands of precise selective soldering fixtures to meet the challenge of high-mix and high-density assembly.

	2003	2005	2007	2010	2013	2016
Parameter	Metric					
Tooling (type)	custom	custom	data driven		data driven	
Cycle time (seconds)	22-400	20-300	15-150		10-50	

Cycle time is the time to process a board divided by the number of joints processed.

TABLE 1: 2002 board assembly roadmap—selective soldering.

Parameter	Metric		2001	2003	2005	2007	2010	2013	2016
		Component Density on PBA							
Automotive and Aerospace Products	I/O÷cm²	2000	100	180	260		1500		
		2002		180	260	260		1500	
Consumer Products	I/O÷cm²	2000	208	256	280		470		
		2002		208	256	280	320	360	
Portable Products	I/O÷cm²	2000	175	240	290		400		
		2002		280	320	350	400	450	
Office Systems Products	I/O÷cm²	2000	160	240	400		630		
		2002		240	400	630		630	
Business System Products	I/O÷cm²	2000	156	196	256		400		
		2002		237	256	278	331	400	494

2000 and 2002 refer to NEMI roadmaps.

TABLE 2: 2002 board assembly roadmap—maximum I/O density.

Part Placement

Component part placement has seen significant advances in recent years; however, industry faces new challenges relating to increased component density and conversion costs. As I/O and density increase, the placement precision tolerance zone is shrinking (Table 2). Placement equipment will be challenged to accommodate this increase in density and I/O without sacrificing throughput.

The use of passive components is expected to diminish as manufacturers adopt deposited discretes. Several significant barriers must be overcome to increase the adoption rate, but, as these are addressed, the use of deposited discretes will change the shape of the surface-mount line. Although considerably fewer components will be placed at surface mount, average component complexity (I/O per part) will be greater than today and will demand higher placement rates. Significant challenges will also be seen with the turret placement equipment to support the high I/O per part and the variety of components

The assembly costs of 10 x 20 mil discrete chips are driven by machine/feeder maintenance, process yield, inspection and component fallout. Any increase in machine/feeder maintenance increases mean time between assists (MTBA) for the line. Equipment manufacturers are already developing cost-effective machine maintenance solutions for release in 2004. In addition, feeders need further development to improve accuracy and robustness to reduce component fallout. A narrowing of the process windows for 10 x 20 mil discrete chips requires more detailed control and feedback processes from automated inspection techniques. To further increase the process window for 10 x 20 mil discrete chips and high I/O array packages, feed-forward methodologies need to be deployed. Adoption of the IPC-2500 series of standards, which relate to equipment interoperability and supply chain communication, by all surface-mount equipment manufacturers and the development of adjustment algorithms will be necessary to support these new methodologies.

Lean manufacturing approaches will increase the pressure for soft tooling techniques for part placement in all product sectors, but especially for consumer and portable sectors. For the office and business systems sectors, increased feeder capacity will allow for grouping of assemblies for zero changeover times.

Low-cost, configurable feeders with quick-change tooling are necessary to reduce tooling costs and cycle times for odd-form placement. Even though placement times are decreasing faster than previously forecasted, they remain 10 times greater than integrated circuit (IC) rates.

Developments in optoelectronics may provide new applications for odd-form placement. However, fiber handling issues need to be addressed and can only be done through the development of component and packaging standards.

Press Fit

The press fit process is gaining acceptance due to the product performance enhancements and reduction in DPMO levels it provides over wave solder processes. The use of higher I/O connectors with finer leads and tighter hole tolerances is challenging the drilling and plating capabilities of board fabricators. The process has evolved from a manual, open-loop system to a closed-loop, servo-controlled process. However, the press fit process is still a secondary operation, except in high-volume applications.

Incorporation of the press fit process into surface-mount assembly lines is necessary for the board assembly process to continue to achieve projected cost targets.

To reduce line down time and increase adoption, tooling that supports the press fit process needs to become flexible. This flexibility will allow for rapid changeover in a high-mix, data-driven environment and reduction of start-up costs.

Aqueous Wash

A process once thought to be on the way out, aqueous wash is finding new life in high-frequency products and conformal coating requirements in the harsh environment and portable product sectors. The residue left from board assembly processes may induce parasitic capacitive coupling, which may change transmission characteristics between signal paths on very high-frequency applications. The board cleaning process has several new challenges: lower part profiles, larger components and increased part I/O. Additionally, for the North American market, controls on plant emissions and water consumption need to be addressed by equipment manufacturers.

A continued challenge for aqueous wash manufacturers is drying of assemblies. A common practice is to hand-dry assemblies with compressed air upon exiting the machine. Again, with higher density assemblies and lower part standoff, this practice will be further limiting.

Finally, standards need to be developed for measuring cleanness. Capability to measure cleanness under low-profile components is still lacking.

Recommendations

The board assembly roadmap recommends several process/equipment improvements to help North American board assemblers meet the competitive challenges of the next several years. These recommendations include:

• Adoption and enhancement of tools to support highly flexible surface-mount lines.

• Automation of optoelectronics assembly, which will become a differentiator for the North American electronics industry. A review of existing component standards and development of packaging standards are required.

• Development of smart parameter algorithms for machine parameters to reduce the mean time between assists for new product introduction.

• Integration and development of feed-forward technologies to eliminate the requirement for strong technical competence by operators and to decrease DPMO rates.

• Improvement of throughput and paste deposition performance in data-driven solder deposit methods that will make this method comparable to, or better than, stencil printing technology.

• Accelerated proliferation of tools to optimize the entire manufacturing process.

• Increased aqueous wash cleaning capability under high I/O and large components. ■

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