Traceability Data Integrity: Challenges and Solutions

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The electronics manufacturing industry is experiencing increased demands for material traceability. Competitive pressures for improving product quality, while also reducing cost, dictate a higher level of visibility and control over the assembly process and materials used. Traceability requirements once limited to high reliability applications, such as automotive, aerospace and medical, are rapidly becoming a necessity in other sectors including data communications, telecom, and high end computing.

While demanding traceability from their EMS providers, OEMs are placing an increased emphasis on data integrity. They understand that it is pointless to request traceability if there are no checks and balances to ensure 100% data capture and accuracy. This is motivating assemblers to error-proof their traceability systems. Manual scanning operations and open-loop systems are being replaced by *smart* material detection systems. Safeguards are being incorporated to automatically prevent production unless the specified traceability data has been successfully recorded.

Some factors driving these demands include:

Outsourcing :

OEMs continue to increase their reliance on the outsourcing model to reduce costs and shift focus to core competencies. These OEMs are concerned about maintaining and improving quality levels because this has a direct influence on customer satisfaction and future revenues. The ability to identify the root cause of a field failure, implement corrective actions and limit product recalls are all considered critical to the success of the outsourcing model. Contractual traceability requirements insure an OEM that its suppliers will implement the control systems required to generate and collect the necessary data.

Product Recalls:

OEMs are increasingly sensitive to the enormous expense of product recalls. When a recall is required, cost and customer impact can be minimized if data exists to precisely identify the affected product serial numbers. Without such data, worst-case assumptions must be made when determining which units to recall, resulting in the wasteful and unnecessary removal of good products from the field.

Liability:

Manufacturing contracts with liability stipulations emphasize the importance of being able to prove that your products were assembled according to the proper customer specifications and industry standards, using the correct materials and chemicals.

Lead-Free:

Lead-free conversion schedules vary by OEM, and also by component supplier. Some manufacturers will be required to convert certain products to lead-free around specific date codes. Others will be tasked with managing two processes throughout a transitional period, either lead-based or lead-free, depending on where a particular product serial

number will be shipped and sold. All of this presents challenges to the assembler. The one constant is that lead-free legislation drives the need to know which components, boards, and solder (bar, paste, wire) were incorporated into each work order or product serial number.

Lean Manufacturing:

Lean initiatives are focused on the elimination of waste (*Muda*), error-proofing your operations (*Poka Yoke*), and increasing material velocity throughout the supply chain. While responding to customer requirements for traceability, the assembler will simultaneously uncover proactive opportunities to become Lean:

- On-line material detection systems can validate that the correct materials and tooling are at the required line locations at the right time. This eliminates the creation of scrap (*Pure Muda*) associated with line set-up errors.
- Material tracking systems can provide visibility of the status and location of materials on the shop floor (Figure 1). This eliminates wasted time searching for inventory, while enabling precise material procurement. You can confidently buy materials based on actual requirements, instead of sourcing surplus inventory to compensate for a lack of visibility of components out on the production floor.

Figure-1: Real time Visibility of Materials on Shop Floor

Moisture Sensitive Devices (MSDs):

The logistical nightmare of MSD control, and the related risks of moisture induced component damage, are exacerbated by several current trends including:

- Increased sensitivity levels due to higher Reflow Temperatures with Lead-Free.
- Continued reductions in package body thickness and lead pitch.
- Increased use of plastic over higher cost hermetic body materials.
- Higher Mix production, resulting in longer cumulative exposure time before each tray or reel is completely consumed.
- Transfer of manufacturing operations to extremely humid geographic areas.

A material traceability system that accounts for MSD handling relative to the industry standard, IPC/JEDEC J-STD-033A, helps ensure MSDs will safely survive the reflow process. The long-term risk of field failures due to moisture induced internal component damage is therefore reduced. The assembler also gains data that can be used in liability situations to prove that MSDs were properly managed during the assembly process. Such data will indicate that probable root cause of a moisture induced defect may be attributable to elsewhere in the supply stream.

Defining Traceability Requirements

Although our industry unanimously agrees that *Material Traceability* is becoming more important, much discrepancy remains as to what this term really implies. The definition depends on whom you ask. Before selecting a traceability solution, it is critical that you understand the depth, scope and granularity of your customer's data requirements.

The lowest level of material traceability, frequently termed *Item Traceability*, simply keeps track of WIP to maintain time-stamped data on gross product movement throughout sequential process steps. Item Traceability is frequently deployed in parallel with *Route Control* to validate that each process step occurred in the appropriate sequence, at the correct workstation or station type, while confirming that the product passed all test and inspection points along the way. Item Traceability can be performed per Work Order, but current trends are shifting the focus to individual product serial numbers.

Traceability applications often necessitate an additional link to the raw materials and tooling used during product assembly. This can be a history of component Lot Codes present at a workstation or machine when the product was within it. With the emergence of lead-free requirements, there is an increasing interest in also recording raw materials such as solder paste, bar and wire.

When tracking component Lot Codes, a traceability system should account for the product's recipe (machine program or assembly instructions), to screen out on-line components that aren't used on a particular product. This is especially helpful on assembly lines or stations that incorporate a dedicated setup. In such cases, the presence of a component on the line does not necessarily indicate its use on any particular product.

Within each level of material traceability, there is plenty of room for different iterations. When defining one's specific requirements, it is important to ask the following types of questions:

- Do we need traceability of all components, or just the more expensive and failure prone?
- Are we only interested in devices placed by the SMT machines?
- Should we log hand placements and through-hole insertions?
- Should we trace lot code data for other raw materials such as solders, fluxes, cleaning agents, etc.?

- Should we know which operators were involved at each stage of the assembly process?
- Should our system maintain a log of other process parameters such as stencil serial number, oven zone temperatures, or the tooling present at a manual workstation?

100% Data Capture and Accuracy:

"Garbage In - Garbage Out" is a catch phrase that can definitely be applied to traceability systems. A traceability solution is only as good as the data that goes into it. For this simple reason, sources of data loss and error should be eliminated wherever possible. A common source of data loss comes from the need to capture each PCB serial number at strategic scan points throughout the assembly process. In such applications, the PCB serial number is typically denoted by a barcode or 2D data matrix symbol. The PCB S/N can be missed due to quality issues associated with the creation and placement of the PCB identifier, or if scanners along the line are not properly adjusted during product changeover. The risk of data loss is greater in higher mix environments with frequent product changeovers, and a wide variety of PCB form factors.

Product Flow Control can be implemented to control the SMEMA handshake between conveyors and machines at each PCB scan point, and subsequently prevent a PCB from transferring downstream unless the product serial number has been successfully captured (Fig. 2). The mechanisms deployed for product flow control can also be used to prevent further production when a system detects a route step error, a downstream line set-up discrepancy, or a product that failed a prior test step and should not be allowed to progress any further.

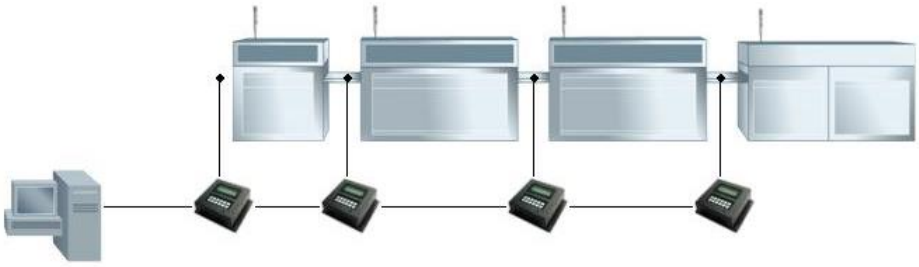

Figure-2: Product Flow Control assures Data Integrity and enforces Route Control

Another common error source stems from manually scanning barcodes while materials (components, stencils, solder paste, etc.) are placed at specified locations along the production line. Automated material detection technologies, commonly termed *Smart Technologies*, are available to replace barcode scanning and associated human errors. One prime example, *Radio Frequency Identification (RFID)*, is an emerging material detection and tracking technology that is garnering much attention.

Tape feeders for an SMT placement machine represent an excellent and practical application for RFID. The average PCB assembly factory has made a significant investment in a large number of feeders for different types of components and different types of machines. RFID tags can be easily and economically attached to each feeder, regardless of feeder type or brand name, to convert any standard feeder into a "Smart" feeder. RF antenna arrays can then be installed within a placement machine's feeder banks, to automatically detect and identify the feeder at each slot. The system subsequently prevents assembly defects by validating placement machine set-up, and automatically collects accurate traceability data during machine setup and replenishment (Figure-3). In addition to improving data integrity, such systems also improve line utilization, by eliminating the transactional overhead associated with manual barcode scanning operations at the SMT line.

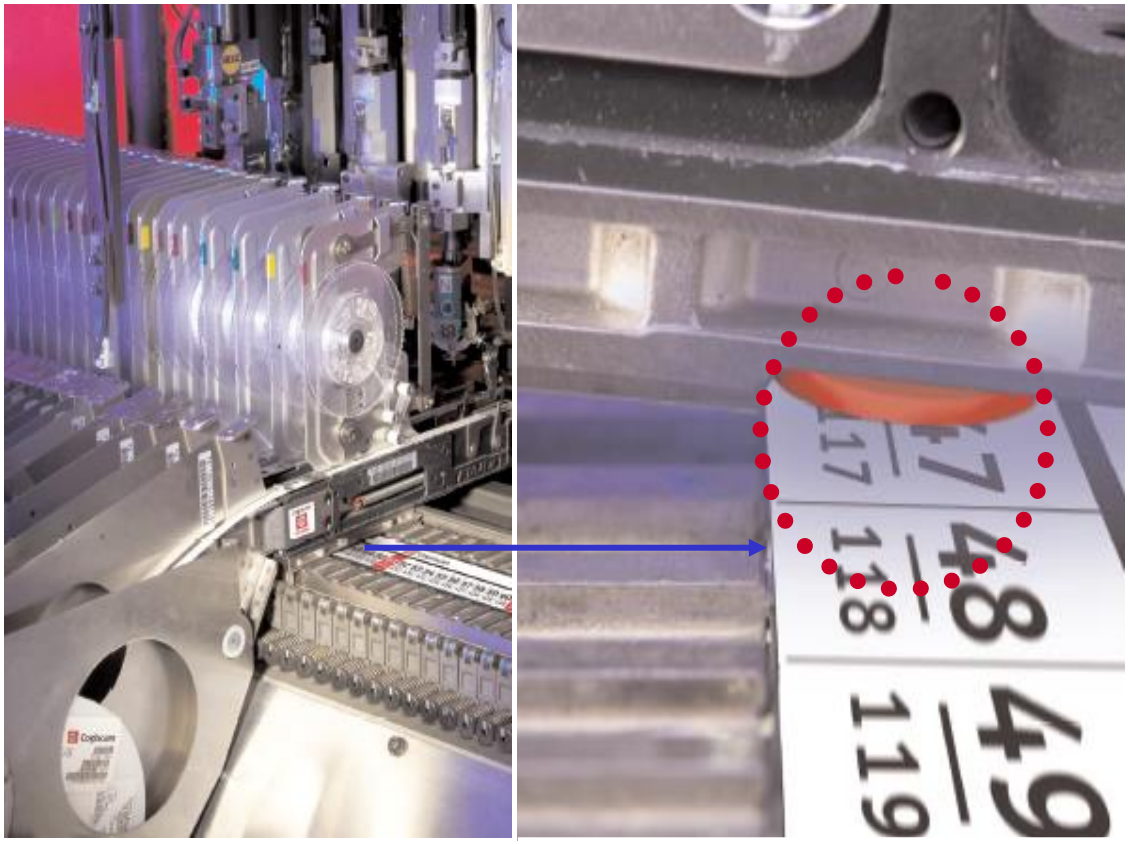

Figure-3: RFID tags on Feeders, and RF Antenna Arrays on Feeder Banks

RF antenna arrays can also be retrofitted within off-line changeover banks and feeder storage racks, making it possible to also track feeders, including any reels of components left on the feeders, throughout an entire factory (Figure 4). This leads to a more efficient production operation. If you know the real-time location of all feeders and reels on your production floor, then time is never wasted searching for them. Furthermore, it becomes unnecessary to purchase surplus components, or to release more components than necessary from stock, because you no longer have to compensate for a lack of visibility of shop floor inventory.

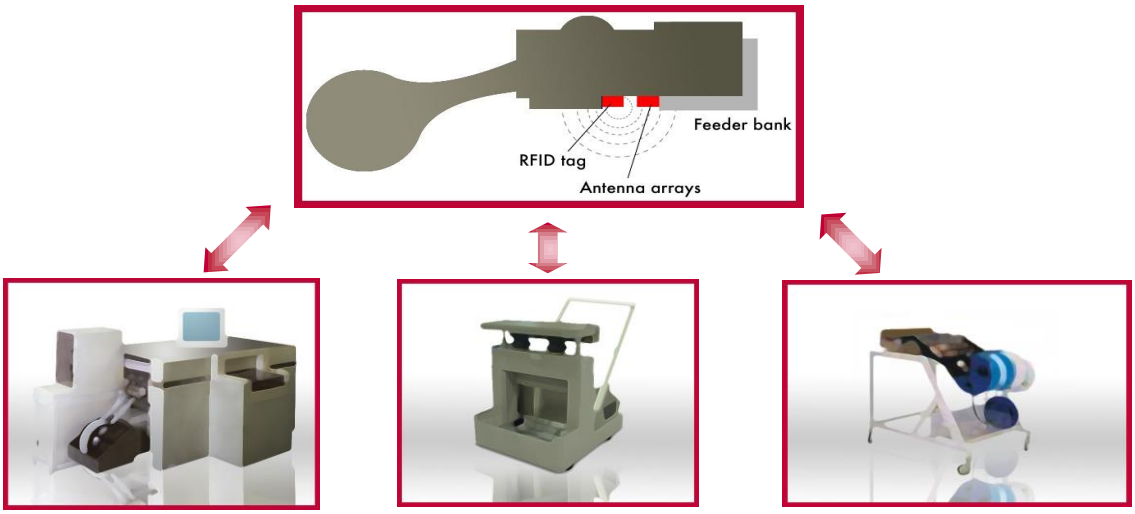

Figure-4: RFID Smart Feeders on Equipment, Off-line Banks, and Storage Racks

The use of RFID technology to validate set-up and automatically collect traceability data can be extended far beyond the placement machines, to any other type of assembly station. For example, RFID can be used to validate that the correct stencil and solder paste are present at a screen printer, or that the correct bin of components resides at a manual assembly station. With these applications the goal is exactly the same; to eliminate the inefficiencies and possible errors associated with human transactions, such as manual barcode scanning operations.

It isn't too late for electronics assemblers who have already invested in barcode-based MES solutions for set-up validation and traceability. They can still benefit from RFID technology and automated product flow control, without having to replace their legacy systems. This is because current and standards-based SW integration methodologies, such as web services, enable interoperability between otherwise disparate systems. RFID hardware and SMEMA handshake controllers can be seamlessly integrated with an electronics assembler's legacy SW system, to exchange material tracking event data. This type of integration can be applied with internally developed MES or Shop Floor software systems, or a commercial 3rd party MES, or SW supplied by leading assembly equipment OEMs.

The most robust traceability systems incorporate a combination of product flow control, and automated material and tooling detection, at multiple assembly stations (Figure-5). This ensures all specified materials are recorded and validated, with minimal human intervention, before the product is allowed to proceed to the next assembly step or station.

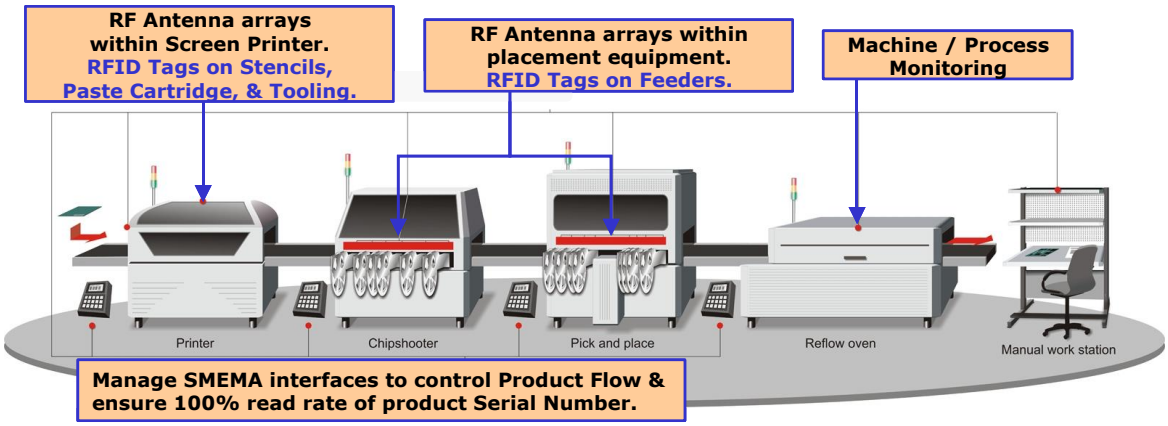

Figure-5: Robust Traceability System

Conclusions:

To fulfill its intended purpose, a material traceability system should ensure 100% data capture and accuracy. This reinforces the importance of automated data acquisition to eliminate the risk of human error wherever possible. A robust traceability system is one that will also prevent production until all required data has been captured, to confirm that the correct materials are at the right locations, at each assembly step, for the product being assembled.

When a customer demands material traceability from the shop floor, it is important that you clearly understand the specific requirements. When selecting a traceability system, it is critical to choose a solution that is scalable and open in architecture, to ensure you can react to your customers' specific needs, no matter how simple or complex, both now and in the future.

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