TECHtips

Electronics Manufacturing Insights from ACI Technologies, Inc.

Manufacturing Cost Reduction through Automation

Defense systems and its manufacturers are often blamed for not embracing new and innovative technologies to manufacture products compared to its commercial counterparts. Commercial product manufacturers are known to think "outside the box" in coming up with new products which are cheaper, have fewer parts, and easier to manufacture using automation. Automation leads to consistent quality products which are reliable and reproducible. Implementing some of these producibility design practices into defense systems will greatly reduce the cost and insertion time for new products.

Products like the radio frequency (RF) tuner, used in a radar application for the Navy, are complex and involve hybrid assembly. Hybrid assembly in electronic manufacturing can be broadly defined as using automated and manual assembly lines to produce a finished product with enhanced product reproducibility and performance. Defense electronics manufacturers are spending most of their time designing products to meet the cost target, eliminate manufacturing bottlenecks, and develop new manufacturing techniques to increase the automation in hybrid manufacturing processes.

Traditionally, all RF microwave parts are packaged in hermetically sealed packages for performance and reliability reasons. Electromagnetic interference (EMI), cross talk between channels, and corrosion due to the presence of moisture inside the package are some of the reasons why RF modules are always hermetically sealed. RF components have been hermetically sealed for decades and the manufacturers have enjoyed the increased pricing demanded for these parts. Today, customers including naval defense industries are looking for ways to trim cost without compromising performance. Design and manufacturing engineers are forced to look at alternate materials, manufacturing processes, and new hermetic packaging technologies to reduce labor touch time through automation.

The building blocks of a hermetically sealed RF package include a metal casing, ceramic substrate, active and passive components, different melting solders, epoxies, and wirebond interconnects, and a metal cover. Raw material costs are high with the use of metal enclosures and ceramic substrates. The manufacturing process is a mostly low volume, batch process with semi-automatic production lines. This increases the labor touch time which in-turn increases the cost of the part. A typical hermetically sealed part undergoes the manufacturing process steps shown in the Figure 1.

With the advancement in software, detailed thermal and electrical modeling is performed before the substrate is ordered. Ceramic substrate manufacturing has advanced to include designs with multiple layers and embedded high density interconnects and passive components between the layers. Printed resistors, capacitors, and

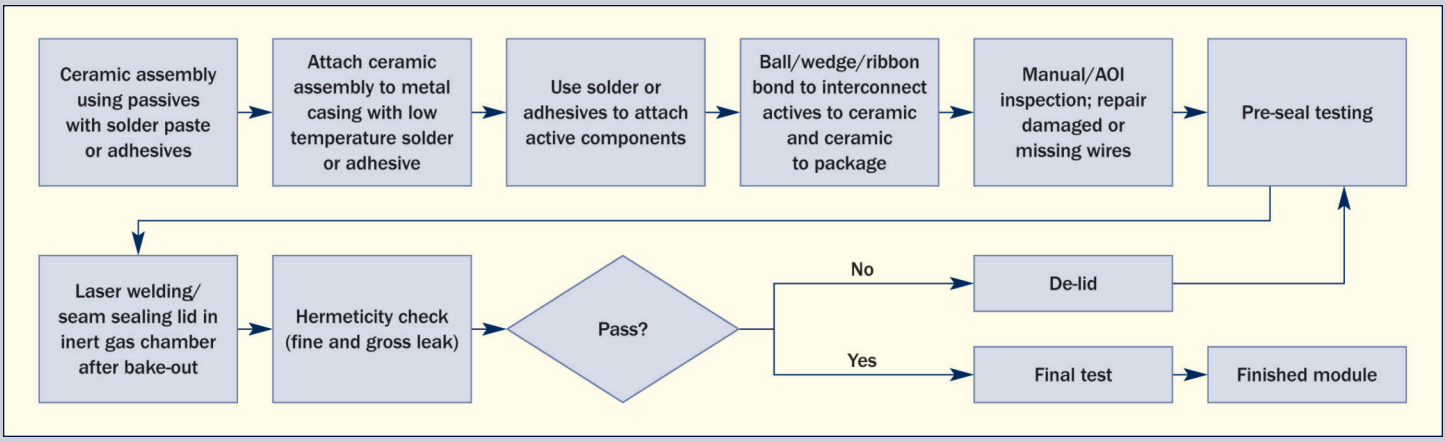

Figure 1: General manufacturing flow for hermetic packaging.

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inductors are now commonly designed into the substrate. These increase the substrate component density, reducing overall size and cost. Standalone modules placed discretely on the circuit card assembly (CCA) are being redesigned in a single system on chip (SoC) approach. As major components condense, the associated circuitry also condenses. Input and output control lines along the RF transmission lines are now designed closer together with a smaller width. This has forced tighter component spacing and pad sizes to shrink. Manufacturing technologies once used to dispense, attach, and interconnect are finding it difficult to meet these needs and are lagging in technology. Defense manufacturers are finding ways to automate these hybrid modules to keep the cost low. Some of the innovative approaches for manufacturing RF tuner modules for radar applications are explained below.

Ceramic to Case Attach: This is traditionally a manual batch process. The ceramic substrate is attached to the metal casing with low temperature solder paste or preforms. The process involves expensive graphite fixturing to position the substrate accurately inside the case and reflow oven. This area will be closely considered for automation as it involves excessive manual labor touch time. Alternatively, a B-stage epoxy preform could be tacked on the case and the substrate is placed and attached using the force and temperature generated by the pick and place machine. Excess epoxy bleed out (if any) is trimmed by a laser. Fully automated, this process can produce a uniform bondline thickness between the metal casing and the substrate. Automation can reduce labor touch time, eliminate expensive graphite fixtures, and improve throughput and product quality.

Active Component Attach: This is mostly an automated process. Adhesive is dispensed using an automated dispensing machine with a time/pressure valve or a positive displacement pump. Components are placed using an automated die placement machine. With the advancement in ceramic design, the dispensing accuracy and component placement accuracy should greatly increase to prevent any shorting. Manufacturers are looking into using advanced dispensing solutions like jet dispensing technology where the adhesive can be jetted as discrete dots or a rapid succession of dots to form a line. Adhesive dots with diameters as small as 100 µm can be jetted with good repeatability. Die placement machines with placement accuracy as fine as ±5 µm are used to place active components to meet the placement requirements.

Interconnects: Fine wire or ribbon (25.4 µm) is used to connect the SoC to the substrate and the substrate to the package. This is a fully automated process. The package and wire configuration is programmed into the machine with wire parameters. The operator loads parts in Auer boats and bonds the components. New bonding techniques are being evaluated using trace lines smaller than 20 µm to eliminate the manual bonding process.

Automatic Optical Inspection (AOI): Manual inspection under the microscope is time consuming and inefficient. A hermetic package like the RF-tuner can have hundreds of components and thousands of fine wire bonds. The location and position of the wires inside the package can be pre-programmed into an AOI system and parts inspected. Missing or damaged wires or parts are identified and sent for repair. Non value-added cost is significantly reduced using these inspection systems.

Pre-Seal Testing: This step is a semi-automatic process. While the software is automated, testing one unit at a time is time consuming. The RF-tuner in particular requires a lot of tuning to meet the product specification. Tuning is done by either replacing some parts or by modifying the RF trace lines of the printed resistors, capacitors, or inductors. Defense manufacturers are looking into ways to tune these parts in-line using a laser based system to modify the trace line and re-test. Pre-seal testing is usually the biggest bottle neck in any hybrid assembly line.

Pre-Bake and Lid Sealing: This is a batch automated process where the bake out cycle and the sealing parameters are programmed. Lids are either laser or seam sealed in an inert atmosphere.

Hermeticity Check: Package hermeticity is checked by gross and fine leak equipment after pressurizing the packages. Any minute leak is detected and the units are set aside for rework.

Final Testing: Results from the pre-seal testing are verified. This is an automated test and done as a batch process. Units that pass are packaged for final inspection and shipping.

Hybrid modules are here to stay for the foreseeable future. The manufacturing process steps are well defined. Defense manufacturers use lean manufacturing techniques to determine bottle-necks in the line and to find innovative ways to redesign modules by combining multiple functions into a single chip. ACI Technologies is working closely with manufacturers to develop new manufacturing techniques for an RF-tuner and to qualify new materials and manufacturing processes to meet the stringent military environmental requirements.

For more information about automating the hybrid assembly, contact the Helpline at 610.362.1320 or via email to helpline@aciusa.org.

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