Benchmark

Case Study

# High-Yield Microelectronics for Complex Hybrid Assemblies

**An industry-leading technology company partnered with Benchmark to improve yields on a complex hybrid microelectronics and SMT assembly for a high-reliability aerospace and defense application. Benchmark worked with the customer to develop reliable manufacturing processes and implement complex test procedures. Benchmark's successful partnership enabled dramatically improved yields and streamlined overall system assembly, preparing our customer to launch its product on-time.**

## The Challenge: High-Reliability Requires Precision Manufacturing

The customer's innovative design met a long list of RF, environmental, and size, weight, and power requirements. But optimizing the design for that combination of factors led to low design margins, a common obstacle to bringing complex designs to reality for aerospace and defense.

One assembly, in particular, required exceptionally sophisticated hybrid surface mount technology (SMT) and microelectronics assembly built to IPC Class-3 standards. When Benchmark began working with this customer on the assembly, challenges around achieving desired yields on previous generations of a similar product were fresh in their minds. The new design presented several manufacturing challenges. The customer identified four pain points with the potential to lead to low yields

1. **Epoxy attached die pedestals:** A molybdenum copper pedestal must be attached to the aluminum chassis with conductive adhesive. The differing expansion of the two metals, along with the contraction patterns, can cause fissures if not dispensed and cured correctly. This critical step is early in the production process sequence, so any irregularities disrupt subsequent processes.
2. **Lamination of PCB into chassis:** Multiple boards have to be laminated using laser-cut conductive epoxy sheets and then cured in an oven. Time, temperature, and other variables all need to be perfectly controlled.
3. **Bare die bond with epoxy attach:** Precision placement for the bare die bond is imperative; even though the epoxy is only paper-thin, slight variations in epoxy placement can de-tune the radio. Repeatability is essential yet challenging to achieve.
4. **Wire bonds:** The highly complex design requires more than one hundred one-mil diameter wires to be placed and individually pull tested. The high number of precise bonds means many potential points of failure and dozens of parameters to perfect.

## The Solution: Vertically-integrated SMT, Micro-e, and Test

The customer chose Benchmark to manufacture this assembly based on our unique ability to act as a true manufacturing partner. Most EMS providers follow customer instructions to the letter; when a problem arises, the provider reports the issue and awaits further instructions. Benchmark is different; we work collaboratively with our customers to diagnose production problems and find the best solution. Benchmark's model is optimal for complex products such as hybrid assemblies and RF products, and the customer recognized that.

Our vertically-integrated engineering, PCB fabrication, SMT, micro-e, system integration, and test facility in Phoenix, Arizona, was an ideal fit to produce this assembly. There were three phases to this partnership with this customer for this project: developing a manufacturing process to address the four pain points in the current process, implementing the new processes and production, and ramping up test procedures.

Working with the customer's engineering team daily, Benchmark's engineers applied their extensive experience in developing microelectronics manufacturing processes that solved the four pain points. For each step, engineers designed a set of controlled experiments to evaluate the parameters affecting yields. For example, to perfect the epoxy attached die pedestal process, engineers conducted a set of experiments to define the thermal curing profile and identify characteristics of a good vs. bad insert. Recognizing that this process had to be precisely controlled, samples were subjected to temperature cycles for long periods then inspected with an ultrasonic microscope to eliminate any possibility of defect. Similarly, strict experimentation and test procedures were applied to the other three challenges until repeatable processes for reliable production were ready.

The customer then asked us to implement these processes and begin the production of the assemblies. IPC Class-3 standards were the foundation of the processes, per standard operating procedure at Benchmark's aerospace and defense-optimized Phoenix location. Experienced technicians hold IPC J-standard 001-FS certifications and have experience building to MIL-STD-883 for microelectronics for defense and aerospace systems.

## The Result: A Dependable Supply of High-Reliability Sub-Systems

The combination of improved processes and skilled staff was successful; yields on Benchmark's first production run were higher than projected. As production continued, Benchmark and the customer developed an increasingly collaborative relationship to address any problem that arose, and yields continued to improve faster than anticipated.

Initially, the customer conducted the stringent test protocols required for this product at their facility; they later transferred test and certification to Benchmark. The Benchmark Phoenix facility offers cleanroom space and the expertise needed for the eight test procedures, including abbreviated functional testing, vibration testing, full functional test, and full functional test over temperature. Benchmark uploads test data directly into the customer's system for complete transparency. Conducting testing at the same site as production allows for rapid rework and troubleshooting, generating further cycle time improvements.

Today, the customer benefits from reduced overall assembly time for complete systems based on a consistent flow of tested, ready-to-install assemblies from Benchmark. Since testing moved to Benchmark, the customer no longer needs to triage good units from those that require rework at the final assembly site, simplifying system assembly. Improved yields reduce uncertainty and risk throughout the system, improving time to revenue.

With a product this complex, production is never static, and the ongoing relationship between the Benchmark and the customer's teams remains active and productive. The customer invited Benchmark to join their Agile system and Sharepoint site for configuration management and daily activities. The dedicated program team and the customer's team are in daily communication, and a weekly status check uses data to illustrate production and supply chain status.

For Benchmark, our goal was always the customer's goal: to get high-reliability, high-tech systems into the field faster. This broad view influences Benchmark's entire approach, demanding a higher level of transparency to ensure the customer has any information that might impact the overall program, such as the massive data set we collected through the process improvement experiments.

Sharing data about materials, optimal time, and temperature for processes, and more will help develop the customer's future products. Benchmark's focus on a customers' overall success makes us a true partner, and we are proud to be working with this customer on their next innovations.

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