

**“A failure mode is re-emerging that has been responsible for the loss of billions of dollars worth of satellites, missiles and other equipment – electrically conductive ‘tin whiskers.’”**

*CALCE, University of Maryland<sup>1</sup>*



## The Lead-Free (Pb-Free) Problem

Tin whiskers and Pb-free solder joints present catastrophic safety and reliability threats to mission critical DoD systems. According to NASA, these Pb-free issues have caused terminal failures in F-15 radar systems, Phoenix missiles, AWACS, eight commercial satellites, pacemakers, and a nuclear power facility.<sup>2</sup>

Corfin offers a safe and effective service that allows high reliability semiconductor users to mitigate these catastrophic risks: robotic refinishing of commercial semiconductor terminations with tin-lead (SnPb) – the alloy proven over 50 years ago to avoid these specific issues and to be unquestionably reliable in military and space service.

## A Growing Problem... With a Solution

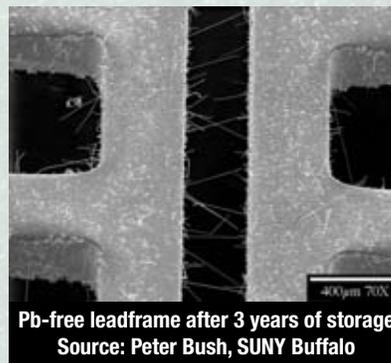
The confluence of two trends is making the Pb-free problem more prevalent:

- 1 Standardized procurement.** High-reliability electronics manufacturers are increasingly sourcing commercial off the shelf (COTS) components instead of MIL-spec parts that specified “tin [finish] be alloyed with a minimum of 3% Pb by weight.”<sup>3</sup>
- 2 Commercial environmental effort.** As the European Union’s Restriction of Hazardous Substances (RoHS) directive came into force in July of 2006, prohibiting the use of lead in most non-defense electronics, COTS electronic component manufacturers rapidly converted their manufacturing processes to Pb-free.

**Corfin’s Robotic Hot Solder Dip (RHSD) process refinishes COTS parts – increasingly available only in Pb-free – to reliable defense industry standards.**

## Tin Whiskers & Solder Joint Reliability Issues

Tin whiskers are crystals that emerge from tin-finished surfaces, such as Pb-free finishes on semiconductor package terminations. Whiskers can grow up to 10mm in length in hours or years, at which point they may cause stable or transient short circuits by connecting with neighboring terminations (often less than 1mm away; see photo below) or by breaking off and bridging other conductive surfaces. Additional risks include whisker debris interference on optical surfaces and low pressure arcing/burning.



As the commercial electronics industry has moved away from the proven lead-bearing solution, additional solder joint reliability issues have surfaced: For one, solder joints formed by mixing different Pb-free

alloys (or mixing Pb-free alloys and SnPb) result in non-homogeneous, weakened joints prone to fracturing during thermal and mechanical stresses of military equipment. Also, the higher melting points of Pb-free solders require increased heat during assembly reflow, stressing components beyond designed temperature limits. Finally, the long-term reliability of Pb-free solder joints remains unproven.

**By using a RHSD process to refinish all components with SnPb, tin whisker risk is mitigated and solder joint reliability is restored.**

## US Navy/CALCE/Raytheon/Corfin TMTI<sup>4</sup> Project

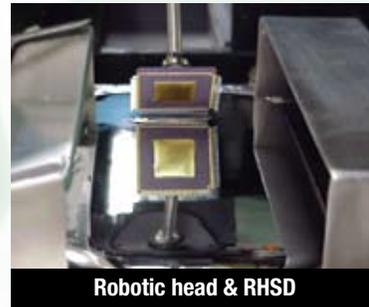
In response to concerns of Pb-free assembly issues and multiple related GIDEP alerts, Corfin worked with Raytheon Missile Systems, CALCE, and the Office of Naval Research (through Best Manufacturing Practices Center of Excellence) to investigate the effectiveness and safety of Robotic Hot Solder Dip (RHSD) via extensive testing and destructive physical analysis of Corfin-processed parts. Corfin's proprietary machinery was used exclusively for the electronics studied. The \$1+ million project proved a tightly-controlled RHSD process can effectively and reliably convert a wide variety of COTS components.

**The US Navy's TMTI study found that, "in all cases, the existing finish was completely removed and no parts were damaged as a result of the process."<sup>5</sup>**

While the US Navy's TMTI study applies to "any company possessing the requisite equipment and expertise [as] a candidate to provide robotic solder-dip services," Corfin cautions potential users to ensure their RHSD provider can replicate the function and tight parameter tolerances of the proprietary Corfin machinery.

## Proprietary Corfin Machinery

Over more than 25 years of service, Corfin has successfully processed more than 400 different component types to ensure that hundreds of thousands of components, and their associated systems, are free from the risks of tin whiskers and weak solder joints. In contrast to



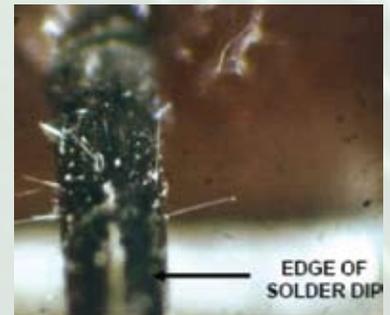
Robotic head & RHSD

hand-dipped processes, Corfin's proprietary automated machines (pictured at left) run customized programs that are optimized for each semiconductor package type. These tight parameters allow for complete and repeatable conversion without the risk of component damage.

Corfin's integrated five-module robotically-controlled process to flux, preheat, solder dip, water rinse, and dry prevents risks associated with competing semi-automated or manual processes. A video of the Corfin process can be viewed at <http://corfin.com/RHSD.wmv>. The video shows an electronic component through the various stages of processing with no human assistance. Please note the precision with which the part is handled by the robotics. Manual or semi-manual processes cannot achieve this precision.

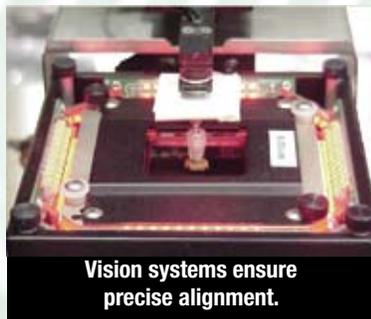
With the benefit of 25 years of RHSD innovation, Corfin machines incorporate integrated vision alignment systems, multi-axis precision robotics, constant specific-gravity monitored dynamic flux waves, inert nitrogen-blanketed dynamic solder wave technology, and continually replenishing ultra-filtered rinse baths. Together these innovations ensure:

- **Consistent immersion depth.** Corfin robotics ensure that processed terminations are refinished with a SnPb coating right up to the package edge. Doing so ensures that tin whiskers do not emerge from otherwise hard to reach surfaces, such as the area near the intersection of the package body and termination. For complex parts, Corfin uses proprietary masks to prevent high-risk whiskers



Corfin robotics & masks enable 100% lead coverage, preventing whiskers in otherwise hard to reach areas. (Source: NASA website)

that can otherwise grow in these areas, as captured in the NASA website photo on the previous page. Corfin's integrated vision alignment systems further guarantee that parts are precisely handled throughout the process (pictured above).



Vision systems ensure precise alignment.

- **Regulated temperature exposure.** Component integrity is maintained by tight controls over preheat time, solder temperature, immersion depth, and dwell duration. Corfin's robotic process enables compliance with GEIA-STD-0006 and, as proven by TMTI, induces no thermal damage.
- **Even solder thickness and coplanarity.** As stated in the TMTI Final Report, Corfin's RHSD machinery allows the angle and rate of emersion from the solder to be "customized for each package type to allow for even solder thickness without bridging of solder between leads. Solder thickness varied based upon the size of the surface area and coplanarity was maintained within 0.004 inch."<sup>5</sup>
- **Process cleanliness.** Cleanliness tests verify that parts typically leave the Corfin RHSD process cleaner than when they were received.
- **Process integrity.** Corfin's integrated five-module system prevents process delays, during which flux residue can accumulate and solidify – another GEIA-STD-006 requirement.
- **Guaranteed yields.** Corfin's machines have been refined over 25 years of global service and Corfin technicians have decades of cumulative experience ensuring customer parts are safe throughout the process.

## Pb-Free Control Plans

Corfin works with customers to develop lead-free control plans (LFCP) to both mitigate catastrophic system failure risks and ensure compliance with DoD

advisories. Specifically, Corfin recommends that its customers:

1. Use SnPb-finished COTS parts when commercially available.
2. Require SnPb Robotic Hot Solder Dip (RHSD) termination refinishing using the TMTI process when SnPb-terminations cannot be procured.
3. Alert subcontractors to Pb-free mitigation requirements that clearly specify TMTI-qualified RHSD providers. Note: Subcontractors may miss mitigation language in contract footnotes when not forewarned.

## BGA Reballing

Assembly operations typically experience lower first pass yields through reflow when using BGA's with RoHS-compliant SAC405 solder balls. This is often a result of the mixed-alloy compromise between using increased temperatures for assembly reflow to ensure wetting of SAC405 balls and using lower temperature assembly reflow to avoid component thermal damage to devices designed for lower temperature SnPb reflow. Once BGA's fail to reflow, the reworked components require reballing. To enable BGA rework – and more typically to ensure high first pass yields - Corfin provides the most comprehensive reballing solution available.



Prior to reballing, Corfin performs 100% robotic removal of existing finish.

Corfin uses its exclusive RHSD equipment to fully remove the existing spheres and pad prior to application of SnPb balls.





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## Over 25 Years of Award-Winning Service

Corfin takes great pride in over 25 years of superior customer service in component preparation. Highly-skilled and long-tenured employees are committed to extending a track record of timely delivery, guaranteed yields, and expertise with complex components. Testaments to this commitment include supplier awards and sole-source designations from many long-term customers: Lockheed Martin (Gold-Level Preferred Supplier with ESBA Star), Raytheon, Vitesse Semiconductor (supplier of the year), AT&T, Northrop Grumman, Avnet, Arrow... and a production facility wall containing dozens of emails from satisfied customers.

Working alongside its customers, Corfin has developed additional cost-saving outsourcing expertise in component preparation.

**In two cases, independent prime contractors have found coordinating bundled kitting efforts with Corfin to save millions of dollars.**

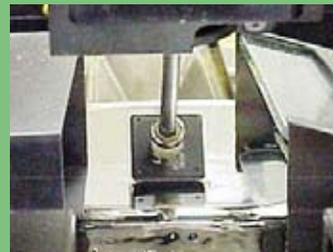
Savings were a result of yield and productivity improvements in areas where Corfin has automated component preparation expertise. Components of these bundled services are briefly described on the separate Corfin Services brochure and include robotic hot solder dip, kitting, tape and reel, trim and form, lead reconditioning, BGA reballing, J-lead attach, and myriad component testing.

For high volume orders, Corfin Industries designs customized tooling to robotically hot solder dip multiple components per machine cycle. With 14 RHSD machines, multiple shifts of trained technicians, and

customized tooling, Corfin services high-volume orders with ease. Please see pictures below of one of Corfin's three RHSD processing suites and a custom manifold processing 14 components in parallel.

Corfin is ISO 9001 and AS9100 registered and certified by Jet Propulsion Labs for less than 50 volts of ESD potential at any work area.

## Corfin's RHSD Process



**TMTI**  
A PQFP undergoes TMTI-process.



**Small Packages**  
Corfin processes packages as small as 0201.



### High Throughput

Corfin easily services high volume orders with multiple shifts, 14 RHSD machines, and custom manifolds to parallel process multiple components per machine cycle (14-component manifold pictured).



**Complex Components**  
Proprietary processes ensure complete SnPb coverage.

1 Source: Center for Advanced Life Cycle Engineering;  
<http://www.calce.umd.edu/tin-whiskers/>

2 Source: <http://nepp.nasa.gov/whisker/failures>

3 Source: MIL-PRF-38535, and also "typical" of MIL-spec language

4 Transformational Manufacturing Technology Initiative (TMTI) project sponsored by the Office of Naval Research (ONR) Manufacturing Technology (ManTech) Program

5 Source: TMTI Final Report; [http://www.bmpcoe.org/news/images/tinwhisker\\_report.pdf](http://www.bmpcoe.org/news/images/tinwhisker_report.pdf)