AIM TECH TIP ARTICLE THE REFLOW LIMBO

WRITTEN BY TIMOTHY O'NEILL AND KARL SEELIG

Solder plus Support

The Reflow Limbo: How Low Can We Go?

SnCuNi soldering performance at low temperatures.

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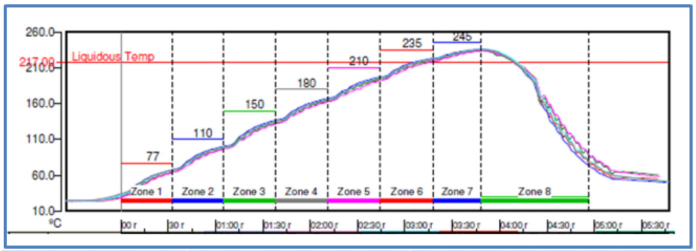
Nickel-modified tin-copper solder, known commercially as SN100C, is a leading lead-free alloy for PTH soldering, rework and hot air-leveled PCB final finishes. Because it contains no silver, it is much more economical than SAC alloys containing as little as 1% of the precious metal, and it produces smooth, shiny, easy-to-inspect solder joints. Why has it not gained major acceptance as an SMT alloy? In large part, fear. Fear of full compatibility with SAC reflow processes.

SnCuNi melts at 227°C. SAC 305 begins to melt at 217°C, reaching its fully liquid state at approximately 220.6°C. Recommended reflow temperatures are typically at least 13°C higher than melting temperatures, hence the SAC 305 peak temperature window of 233° to 255°C. Applying the 13°C guideline to the SnCuNi alloy results in a minimum peak temperature recommendation of 240°C. It's that 7°C difference in minimum reflow temperatures that generates the fear – of cold joints, incomplete wetting, inconsistent IMC formation or other reliability issues – if the peak temperature of a solder joint falls into that questionable space between 233° and 240°C.

Laboratory tests have demonstrated good wetting at lower temperatures, but they're just that: lab tests. Until recently, there was no real-world, production-based data on the soldering behavior of the SnCuNi alloy near the low margin of the reflow window. But a newly published study1 explored exactly that situation. It dropped the SN100C alloy into a reflow process considered cool for SAC 305; the temperature peaked at 234°C with only 60 sec. above 217°. The cool process shown in **FIGURE 1** was dictated by thermally sensitive components on the PCB, which was a mixed-technology industrial controller of low-medium complexity.



TC Location	Peak Temp (°C)	Time above 217°C (sec)
1	234.5	63
2	235.8	66
3	233.8	59
4	233.7	56
5	235.8	65
6	235.5	63
Time to peak temp: ~3:30		

FIGURE 1. Reflow profile used for SAC305 and SnCuNi.

The experiment consisted of two runs, one with SAC 305 solder paste and one with SnCuNi solder paste. Thirty boards of each were built. Both pastes used the same flux, and the two products ran down the assembly line sequentially with no changes to any portion of the SMT process. Following assembly, the boards were subjected to numerous tests and analyses.

Inspection and electrical test. AOI took place on the assembly line, and visual inspection was performed by the line's IPC-certified inspectors. No defects were found by either inspection process. The SnCuNi solder joints formed under the cooler profile did not exhibit the typical luster that is characteristic of the alloy, but were not as dull as SAC 305. **FIGURE 2** shows photos of the typical solder joints produced in this process.

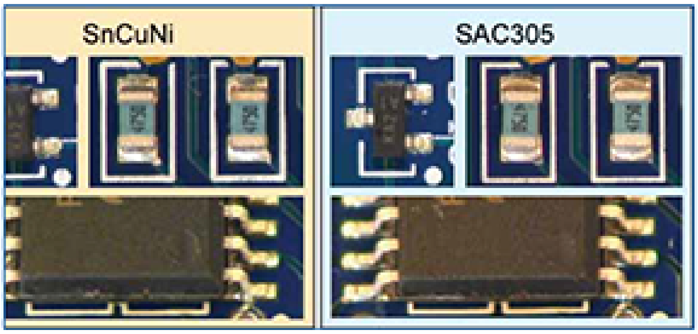


FIGURE 2. Photographs of SMT solder joints produced with a cool reflow profile. Both alloys showed good wetting and fillet formation.

Five PCBs from each alloy group were then fully assembled with PTH, wave-soldered, and installed into chasses for functional test. They all passed, and the assemblies were earmarked for thermal cycling.

X-ray analysis showed more voiding in the SnCuNi solder joints than the SAC 305 (**FIGURE 3**). Although the voiding levels are acceptable, they could likely be mitigated by adding a soak to the reflow profile.

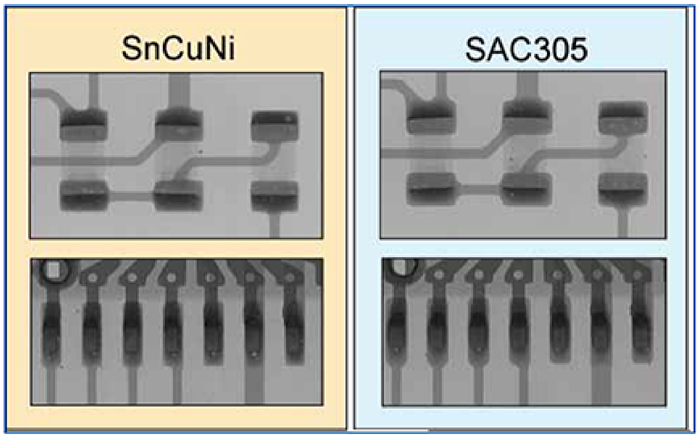


FIGURE 3. Photographs of SMT solder joints produced with a cool reflow profile. Both alloys showed good wetting and fillet formation

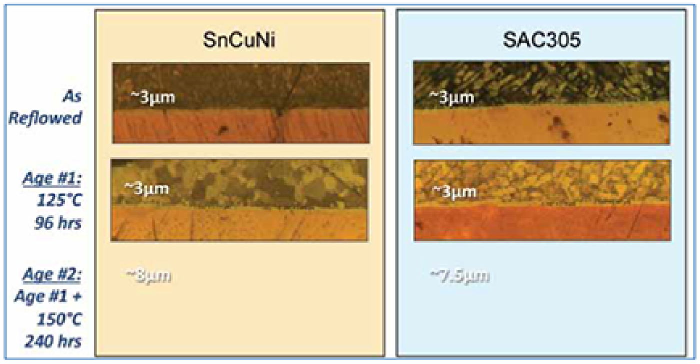


FIGURE 4. Intermetallic compound growth after thermal aging. The initial thermal aging had no significant effect on IMC growth; continued aging at higher temperature showed similar effects on both alloys.

Microstructural analysis. Optical microscopy showed good wetting to both leaded and leadless terminations, and good IMC formation. In the asreflowed state, both alloys formed continuous IMCs approximately 3µm thick. They were then subjected to two thermal aging cycles: an initial one at 125°C for 96 hr. and a subsequent cycle at 150°C for 240 hr. The initial cycle had no significant effects on the IMC or the solder joint shear strength. Both alloys demonstrated similar IMC growth during the second aging (**FIGURE 4**).

Joint strength. Next, 0805 components were shear tested at 15° angles before and after thermal aging. Shear strengths averaged 4 to 6kg, typical for this component size and comparable to previous tests run on assemblies with peak temperatures of 245°C. Thermal aging had no significant impact on shear strength values (**FIGURE 5**).

Thermal cycling. Original experimental plans included thermal cycling five full assemblies from each alloy set. However, given the good appearance, microstructure and solder joint strength, it is highly unlikely any solder joints would fail during cycling, and no new knowledge would be gained from the effort. A similar study that compared the two alloys on a more complex PCB completed 3000 cycles (0° to 100°C) with no remarkable results. Therefore, thermal cycling was eventually eliminated from the test plan.

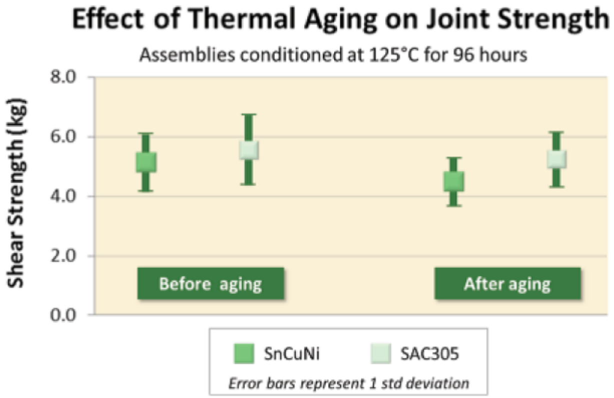


FIGURE 5. Shear stengths of 0805 components before and after thermal aging.

The results of this test were eyeopening. A reflow process with a peak temperature of only 234°C and 60 sec. above 217°C is considered the low end of the window for SAC 305. Despite SnCuNi's higher melting point, it formed good joints, passing every standard test to which it was subjected. It demonstrated full compatibility with the cool range of the

SAC 305 window, establishing itself as a viable drop-in replacement for almost any SAC-based SMT process.

The silver-free alloy is currently used in numerous consumer applications, but concerns over low temperature reflow processing have slowed broader implementation and delayed its resulting cost reductions, which can be substantial. Replacing SAC 305 with SnCuNi can save as much as 20% on solder paste costs due to the elimination of silver.

This study was instrumental in generating production-based data for the previously uncharted area of the reflow window. It should help to dispel fears of poor reliability if SnCuNi is soldered on the low end of the established SAC 305 process. Many thanks to Andy Monson and Walter Machado of Hayward Industries for making this experiment possible and sharing the results with the industry.

References:

1. The data presented here are part of a larger study presented and published at SMTA International; it can be downloaded at aimsolder.com/technical-articles or at CircuitsAssembly.com.

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