On the Board Level Reliability of Lower-Temperature and Low Temperature Solder Interconnects at SMTAi 2018

October 30, 2018

ROSEMONT, IL – This month, the SMTAi 2018 conference was held at the Rosemont Convention Center, Rosemont, IL. One notable topic pertained to the board level reliability of low temperature or "lower-temperature" alloys. LTS assembly is of interest for multiple reasons including lower power consumption, less warpage and higher assembly yields, and a possible path to more complex assemblies. Much work is being performed to compare the reliability of LTS with conventional SAC alloy and some of that work was presented at the conference.

iNEMI's investigations of "third generation" Pb-free alloys, presented by Richard Coyle, showed that such alloys provide significantly better high-reliability ATC performance than traditional SAC alloy, doubling, in one case, 0/100°C characteristic life. Amongst these alloys was an indium containing SAC alloy that one might consider to be a "lower-temperature" solder (202°C-206°C liquidus). A homogenous assembly of this alloy, in which the paste and solder ball alloys are the same, had equal to or better characteristic life as a homogeneous SAC alloy in 0/100°C, 40/125°C, and -55/125°C ATC, though it had earlier first-failure in -55/125°C ATC [1]

In a paper reporting the potential of what is considered to be truly low temperature solder, for enterprise computing and automotive electronics, Paul Wang and his team at Mitac point out that backward compatibility will be important. Their ATC testing is not complete, but they report that their mixed assembly, using tin-bismuth LTS paste (130°C-140°C liquidus) and SAC solder balls, as illustrated in Figure 1, is exhibiting earlier failures in -40/100°C ATC than their homogenous LTS assembly.[2] Other work reported this year, by Satyajit Walwadkar, et. al, at Intel, investigating the use of a novel method to determine the mechanical fatigue performance of solder using only a single solder joint, corroborates what Wang reported. Joints made with tin-bismuth LTS pastes (140°C-150°C liquidus) and SAC405 solder balls did not perform as well as their homogeneous SAC joint.[3]

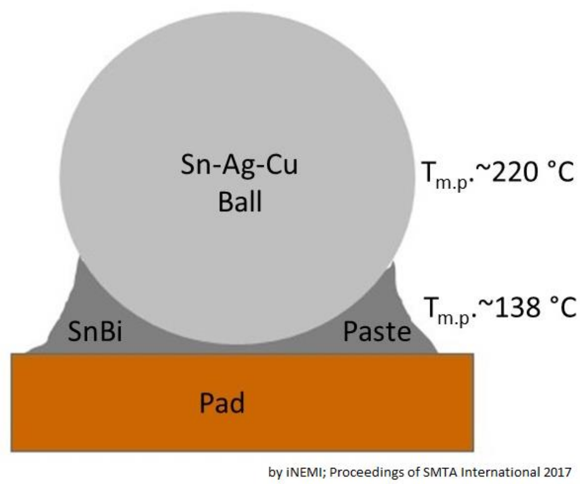

Figure 1. Mixed assembly with SAC ball and LTS paste.

Wang expressed concern that tin-bismuth LTS alloys, being more brittle, will not perform as well in mechanical shock testing. That concern was shown to be well-founded by results reported in yet another iNEMI paper, by Jagadeesh Radhakrishnan, et. al. Tin-bismuth LTS's (liquidus 125°C-139°C) exhibited significantly lower drop test performance compared to SAC305. The iNEMI team also looked at improving performance using solder pastes that create a polymeric reinforcement, referred to by some as a polymer collar. The reinforcement improved drop performance, but it could not match the baseline performance of SAC.[4] In their paper, Wang suggested that an edgebond adhesive might be used to enhance drop test performance. Figure 2 illustrates how such an adhesive would be used.

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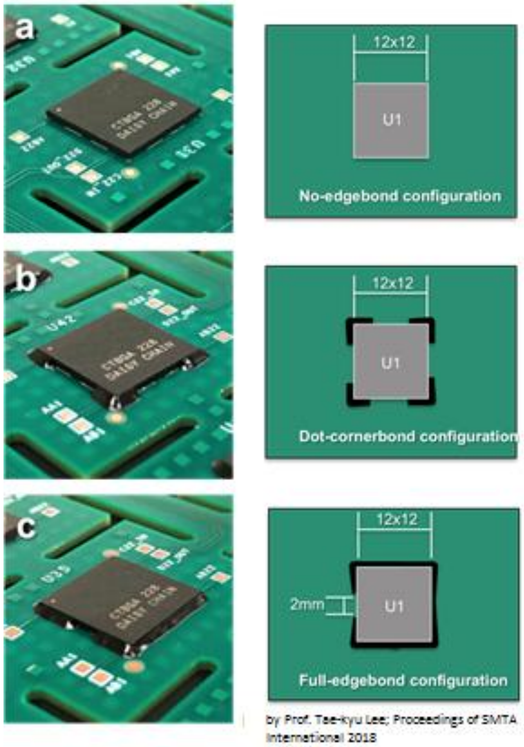

Figure 2. BGA's with and without edgebond adhesive.

Using an edgebond adhesive to enhance mechanical shock performance raises the concern over what effect such an adhesive would have on board level reliability. That matter was investigated and reported on by Prof. Tae-kyu Lee, of Portland State University, et. al. A mixed assembly, in this case SAC305 paste with a "lower-temperature" solder ball (197°C liquidus), exhibited poorer -40/125°C ATC performance than the homogeneous SAC assembly. Lee's team looked into the use of a reworkable edgebond adhesive and found that the ATC performance of the mixed assembly, with adhesive, very significantly exceeded that of the homogeneous assembly without adhesive.(5) Not only can an edgebond adhesive be considered to enhance mechanical shock or drop test performance without damaging ATC performance, it might also be considered as a way to enhance the ATC performance of LTS mixed-alloy assemblies, or, for that matter, that of other ATC-challenged assemblies.

Much additional work is needed in the development and investigation of LTS alloys. Amongst other things, the iNEMI team suggests work to better understand the root cause of the interfacial cracking that they observed in ATC, and proposes the utilization of methods, in lieu of SEM, to identify other phases that appear to be present in the alloys. Their team investigating mechanical shock performance hopes to correlate bismuth mixing and other solder joint morphology, as well as extent of polymer reinforcement, with drop test results. Wang's team plans to push their ATC tests out further and looks forward to performing drop tests on mixed alloy assemblies. Having demonstrated that an appropriate reworkable edgebond adhesive will not damage ATC performance, and can even enhance it, Lee and his collaborators would like to investigate the use of such an adhesive for enhancing mechanical shock performance of LTS assemblies. Walwadkar and colleagues at Intel, having developed and validated a quick-turn test method, can look forward to screening Very Large Sets of Alloys, LTS or otherwise, for fatigue performance. Whose fatigue is of great interest to all and is something we hope to learn at next year's SMTAi conference.

This synopsis was provided by Zymet, a manufacturer of adhesives and encapsulants that welcomes the opportunity to investigate the use of edgebond adhesives for enhancing mechanical shock performance in ways that are relevant to the various segments of the electronics industry. Zymet's products include underfill encapsulants, edgefill adhesives, and edgebond adhesives for enhancing board level reliability.

References:

1. "The Effect of Bismuth, Antimony, or Indium on the Thermal Fatigue of High Reliability Pb-Free Solder Alloys", Richard Coyle, et. al., Proceedings of SMTA International, Oct. 14-18, 2018.
2. "Low Temperature Solder Interconnect Reliability and Potential Application in Enterprise Computer and Automotive Electronics", Paul Wang, et. al., Proceedings of SMTA International, Oct. 14-18, 2018.
3. "A Novel Approach to Determine Mechanical Fatigue Performance of Solder Material Using Single Joint Test", Satyajit Walwadkar, et. al., Proceedings of SMTA International, Oct. 14-18, 2018.
4. "iNEMI Project on Process Development of BiSn-Based Low Temperature Solder Pastes – Part IV: Comprehensive Mechanical Shock Tests on POP Components Having Mixed BGA BiSn-SAC Solder Joints", Raiyo Aspandiar, et. al., Proceedings of SMTA International, Oct. 14-18, 2018.
5. "Low Melting Temperature Interconnect Thermal Cycling Performance Enhancement Using Elemental Tuning and Edgebond Adhesive", Tae-kyu Lee, et. al., Proceedings of SMTA International, Oct. 14-18, 2018.