Lead-Free Solder Joint Voiding:
The Causes are Starting to Surface

by Mark Currie, the electronics group of Henkel

While there are conflicting opinions on the effect of voiding in lead-free solder joints in relation to how much is too much and whether or not voiding causes any long-term reliability issues, one thing remains clear: Pb-free solder joints are more prone to voiding than tin-lead joints and there are a variety of contributing factors.

Much research work has been conducted into the cause of voiding and Henkel has studied in-depth the materials relationship to voiding. When using SAC alloys, in order to achieve the desired wetting and ultimate interconnection, the fluxes in the paste formulations have to operate at higher temperatures than those of their SnPb counterparts. Not only do the fluxes work harder, the SAC alloys also have a higher surface tension than tin-lead, increasing the possibility that unwanted volatiles are trapped within the molten solder. These volatiles cannot escape as easily, and voids are created when these compounds remain in the body of the solder once the material is solidified. Previously published works by our company outline the benefits of utilizing a low voiding solder paste formulation to alleviate both mechanical and electrical issues associated with Pb-free solder joint void formation. (http://www.smtmag.com/whitepapers/556) Using a low voiding solder paste formulation such as one of Henkel's Multicore® LF series materials serves to significantly reduce the incidence of voiding, but there may also be other factors that should be considered for void reduction and improved long-term reliability.

Recent research conducted by Henkel has revealed that not only do solder paste flux and SAC alloy selection have an impact on the volume and size of Pb-free solder joint voids, but the pad surface finish plays a major role as well. For the purposes of the study, Henkel's scientists focused on the effects of materials parameters only – and not process parameters -- on voiding. These included the lead-free alloy type, PCB pad finish and the content of the flux medium constituent. The research compared a SAC with a Sn-Ag solder alloy and evaluated various PCB pad finishes (bare Cu, OSP Cu, immersion Ag and Au/Ni) along with 4 different levels of the flux medium component. Voiding levels were measured in the solder joints/solder bumps from three different BGA components: a BGA56, TBGA132 and a UCSP98.

The results of the research revealed that the amount of voiding was affected by the flux formulation, the surface finish (bare Cu and OSP Cu resulted in more voiding than Au/Ni or immersion Ag finishes) and solder alloy (SnAg solder produced solder joints with much fewer voids than those produced using a SnAgCu solder). Though further study is required, this data would suggest that using a SnAg alloy or at least an alloy such as SAC305 with a lower concentration of copper would serve to significantly reduce void levels in Pb-free solder joints. It should be noted, however, that tin-silver, while producing lower voiding levels, does require additional analysis to assess long-term reliability issues.

But what about the surface finish? Why were the Cu and OSP Cu finishes inferior to that of Ni/Au or immersion Ag? One likely explanation centers on wetting speeds of the different surfaces. When attempting to wet onto copper, the spread factor is less because

the surface tension or contact angle is higher with solder onto copper than that of solder onto gold. In other words, the speed at which the flux will clean the surface and the solder wet across the pad is slower with copper and much faster with gold. With slower wetting, the likelihood of more volatiles being trapped is high and, therefore, void creation may be increased. While it is not practical to suggest that all manufacturers migrate to ENIG (electroless nickel immersion gold) finished pads, this surface finish clearly gave the best results. This cannot be considered the definitive solution, however, as there are other process and reliability issues – such as "black pad" during reflow -- that are associated with ENIG. For those firms that will continue to use bare copper or OSP finished pads, Henkel's low-voiding formulation solder pastes -- Multicore LF318 and Multicore LF328 – will give better results than standard Pb-free pastes, as these advanced materials' flux formulations provide superior cleaning, which results in fewer voids.

As we all move through the lead-free labyrinth, we continue to uncover more potential challenges – and solutions –within this unique manufacturing environment. Henkel still maintains that, although some voiding may be acceptable, taking all necessary measures to reduce voiding is the best and most reliable approach. Clearly, the optimum Pb-free voiding result will come from a multi-faceted materials solution: the right flux chemistry, the right surface finish and the right alloy.

For more information on Henkel's line of low-voiding lead-free solder pastes, including Multicore LF318 and Multicore LF328, log onto www.electronics.henkel.com or call the company's Irvine, California headquarters at 949-789-2500.