FAQs About Lead Free HASL

Introduction

During the last several months, a major commitment has been undertaken by Rohm and Haas Electronic Materials to share the technology developed during a joint project with several business partners, including solder manufacturers and HASL machine fabricators, with PCB shops. Questions were answered as they were asked by the different shops, but they were recorded for future use and publication. This paper will present the most commonly asked questions and answers in the form of a tutorial. The questions are listed in no particular order of importance and no information of a commercial nature will be given.

Q. What are the laminate requirements for Lead Free HASL (LFH)?
A. The most commonly used laminates for circuit boards using LFH as surface finish are standard FR4 with a Tg from 130C to 165C, which works well with either black or alternative oxide. Work has also been done with higher performance, multi-functional laminates. Single-sided boards of CEM-1 material have been successfully run with no discoloration or staining of the unprotected back side of the board. De-lamination of MLBs has not been an issue, despite the higher operating temperature of the solder pot and assembly with multiple infrared reflow cycles at higher temperatures. The potential for a problem to arise is greater, but it has not been seen as an issue to date.

Q. How does LFH compare to Tin Lead HASL (TLH) for uniformity of solder thickness or co-planarity?
A. LFH is considerably better than TLH for solder thickness uniformity. This is more easily observed with the horizontal process than vertical. Of course, it is dependent on the set up conditions for the machine and process, but under optimum conditions, the results will be better. This can be demonstrated with the following graphs for QFP and BGA pads.

Figure 1. Comparison of solder thickness for the same SMD feature with TLH and LFH

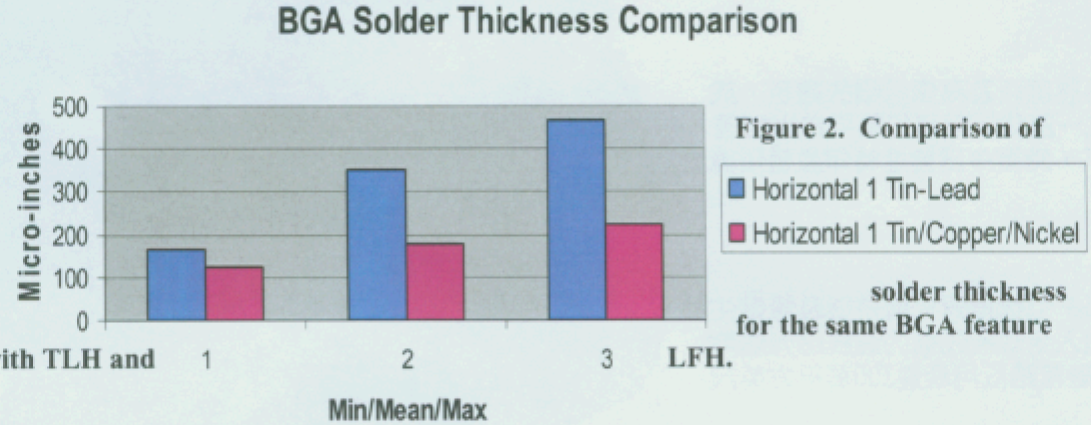

Figure 2. Comparison of solder thickness for the same BGA feature with TLH and LFH.

Q. Why spend engineering time and money now on LFH, when I don't have orders for it?
A. Not much study is needed to be ready for the process conversion, which is quite simple. Remove tin-lead solder from the machine and add back pure tin to remove lead impurities. Repeating a second time will usually result in the lead concentration being <0.1%. No extra equipment investment is required, unless heaters or heating control are not adequate. The time to reach acceptable quality deposits and optimize the machine on a preliminary basis is, typically, about 4 hours.

Q. What process changes are required for LFHASL?
A. Since the melting points of lead free solders, whether tin-copper-nickel or tin-silver-copper, are higher than tin-lead, the solder pot temperature is higher. The operating window comparison is shown in Figure 3.

Alloy	Melting Point (C)	Operating Temperature (C)	Process Window (C)
Tin-Lead	183	250-260	67-77
Tin-Silver-Copper	217	265-270	48-53
Tin-Copper-Nickel	227	265-270	38-43

Figure 3. Comparison of process operating window for HASL with different alloys

With tin-lead solder, the copper concentration must be maintained below 0.3%, while for tin-copper-nickel, the process control range is from 0.7-0.9%. With the tin-copper-nickel alloy, nickel must be controlled between 0.025-0.05%. It is necessary to increase the preheat in horizontal application to aid in clearing holes. The additional heat required depends on the same variables as for tin-lead solder: board thickness, number of inner-layers and amount of copper sandwiched within the layers. With tin-lead solder, it is possible to achieve acceptable results without the use of an etching cleaner. With LFH, the use of a micro-etch for cleaning is required. Lower air knife pressures can be used to clear the holes, resulting in more uniform solder thickness.

Q. What is the shelf life of boards using lead free solder from the HASL process?
A. Data shows the shelf life of lead free solder to be more than 1 year under proper storage conditions, which is the same as for tin-lead solder.

Q. How many PCB shops are running LFH in their machines at this time?
A. 53 shops are running LFH globally.

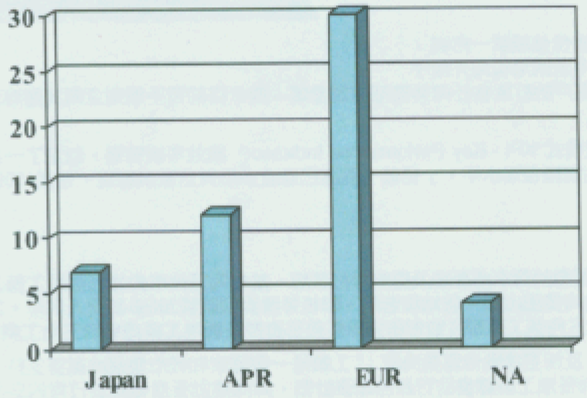

Figure 4. Number of shops running LFH globally

Q. Can tin-copper be used to replace tin-copper-nickel to reduce the cost?
A. No. Tin-copper has been tried before several times. Deposits of tin-copper suffer from a grainy surface and show increased IMC growth compared to tin-copper-nickel. It has been found that the presence of nickel in the lead free alloy leads to a finer grain structure and has a definite role in controlling the growth of IMC.

Q. Can LFH using Sn-Cu-Ni be reworked?
A. Yes. In some instances, improved solder uniformity can be seen by running panels a second time through the machine. There is evidence that a 2 second immersion in a vertical solder pot will remove approximately 0.7 u of copper and a second dip will show a total copper removal of 1.0 u, which is well within acceptable limits for tin-lead solder.

Q. What is the maximum permissible lead concentration in LFH?
A. To meet lead free requirements, the lead concentration in the electronic component must be <0.1%. A thorough job of removing tin-lead solder from the solder pot will include 2 cycles of purging with pure tin, prior to adding the lead free solder and result in a lead concentration of

<0.04%. The bigger risk of lead contamination will come from reworking tin-lead panels through lead free solder.

Q. What is the difference between a flux for TLH and LFH?
A. Flux for LFH is more thermally stable with lower activity and is less corrosive to the solder pump and solder tank. RHEM has completed a study showing that an ideal LFH flux can promote good solder coverage and still be rated non-corrosive and non-flammable and be shipped and stored as a non-hazardous material.

Q. How are the copper and nickel concentrations maintained in balance, when using tin-copper-nickel alloy in the LFH process?
A. Samples of solder must be taken daily or weekly, depending on the frequency and duration of operation, from the solder pot and analyzed for copper and nickel. Both elements are already being analyzed in the tin-lead solder analytical scheme, but adjustments must be made to analyze them at higher concentrations. Bath dilutions are made with tin, to reduce the copper concentration, and nickel to increase its concentration.

Q. There are reports that nickel in the IMC can cause weak, brittle IMC and cracks in the solder joints. Does the same thing happen with LFH, when tin-copper-nickel is being used?
A. There are reports in the literature that document the effect of high concentrations of nickel on the reliability of solder joints. This is not the case in LFH where the source of nickel is the solder itself. In all cases where this behavior was reported, the source of nickel was an electroless nickel barrier layer to protect copper from migrating and penetrating the thin gold top layer. There have been no reports of weak, brittle solder joints from wave soldering with tin-copper-nickel.

Q. Does a special solder mask have to be used for LFH or will standard products work?
A. Standard solder masks will work for most applications. In areas where solder mask is used for hole plugging, testing should be done to be sure the holes will remain good adhesion without peel-off at the higher LFH temperature.

Q. Is it possible to skim lead free solder by reducing the temperature as it is done with tin-lead solder?
A. Work is still in progress to optimize the skimming process, but indications are very good that tin-copper needles can be removed from the solder by holding the temperature in 235-240C range, just slightly above the melting point of tin-copper-nickel. The effect of skimming on nickel concentration is being studied at the same time.

Figure 5. Photograph showing tin-copper needles being removed from solder by a skimming tool

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