Development of a Functional Lead Free Solder Paste for High Volume, High Reliability Electronics Assembly.

Background

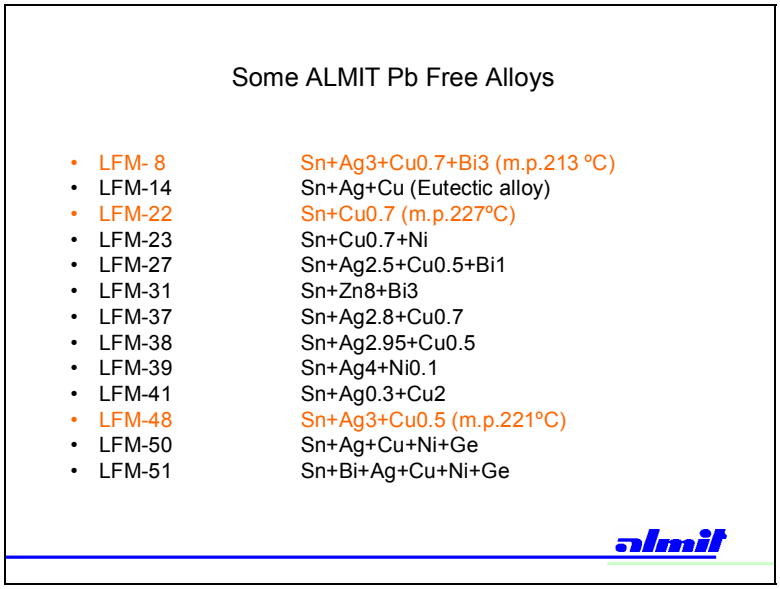
An assembly which operates in a harsh environment must have reliable solder joints. However even if a finished product is not going to be exposed to the most severe operating conditions it is good practise to manufacture the most reliable solder joints possible. A high reliability solder joint must not fail during the normal operation of the product it is a part of.

For many years manufacturers have produced highly reliable electronics circuits using tin/lead based solder alloys. Today the industry is being driven towards lead free soldering products whose soldering properties can be far poorer than the leaded materials they are replacing.

As a manufacturer of high reliability soldering products Almit Technology has developed its' 'TM' range of lead free solder pastes.

Lead Free Solder Alloys

Over the past few years much work has been carried out by many manufacturers and technical institutions to evaluate lead free solder alloys. For surface mount solder paste applications most organisations have settled on a mix of tin/silver/copper as a suitable tin/lead replacement. Almit 'LFM ' range includes this alloy along with many others.



By evaluating a selection of these alloys using basic strength testing procedures, such as thermal fatigue, creep and peel-off we can compare the alloys to standard tin/lead solder. With data obtained from the tests it was possible to select a suitable lead free solder alloy to conduct further trials with.

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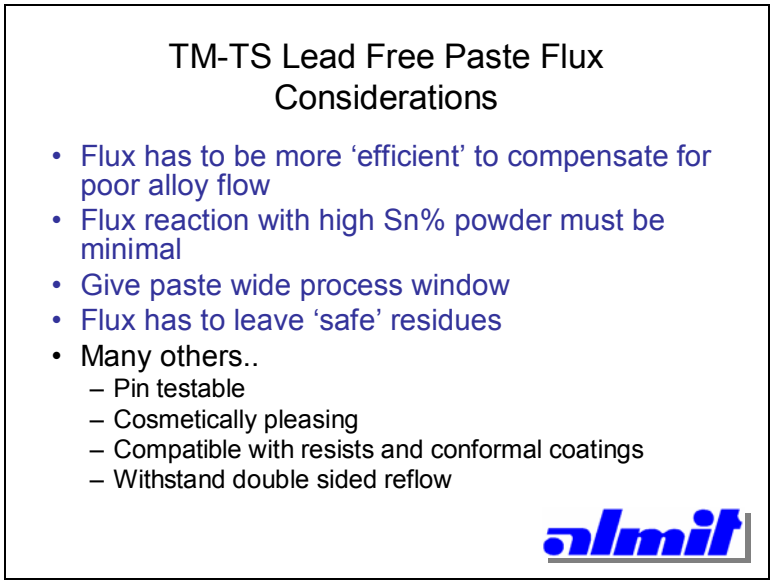
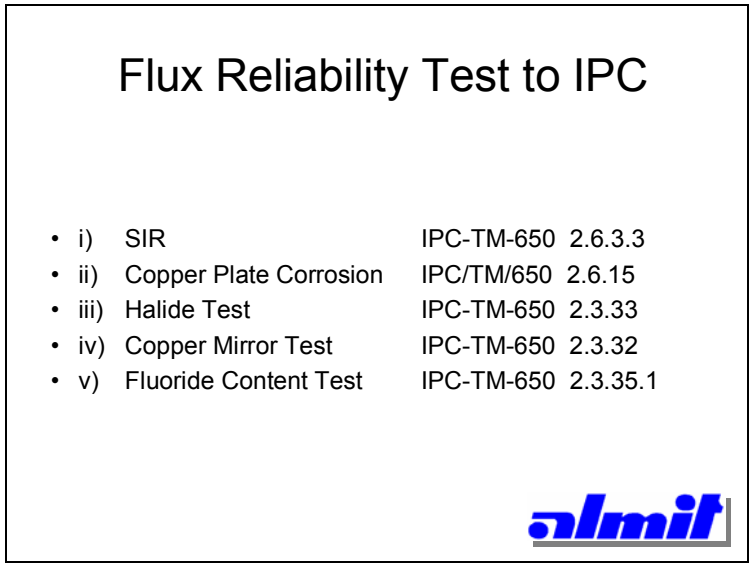
Flux Chemistry

In any soldering process the flux technology has to be optimised to offer the best soldering performance, whilst taking into account many other factors. Typical lead free flux considerations are highlighted below.



During the development of Almit TM-TS flux it was necessary to test it against the IPC standard for flux reliability and 'workabilty'. These standards are recognised as a minimum requirement for soldering fluxes that are to be used for high reliability applications.
The summary of the tests performed for flux reliability and solder paste 'workability' are shown below.

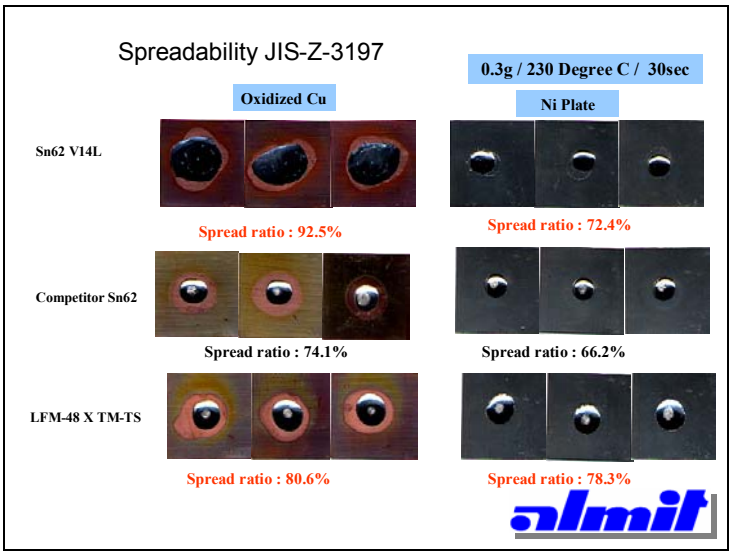


Paste 'Workability' Test to IPC

- i) Slump Test (pass) IPC-TM-650 2.4.35
- ii) Solder Ball Test IPC-TM-650 2.4.43
- iii) Tack Force Test IPC-TM-650 2.4.44
- iv) Wetting Test IPC-TM-650 2.4.45

As part of the final product development it was tested for 'spreadabilty', comparing it to our standard lead containing paste. This spreadability test shows how the lead free paste will solder to oxidised copper and nickel, the main 2 metal surfaces used on pcbs in the electronics assembly industry.

Our aim as a paste manufacturer is to try and emulate the performance of our lead based, no clean paste, with our lead free paste. The spreadability data obtained shows we are close to achieving this on bare copper but actually exceed its performance on oxidised nickel.



The finished product LFM 48 X TM-TS was then submitted to the market for production trials. For one potential user we under took to do some solder 'peel-off' testing, comparing our paste with 3 from competitive suppliers. The results showed a significant difference in peel off strength between the 4 products. All the solder pastes were SAC305 alloy (SnAg3.0/Cu0.5) and all had the flux classification of 'L1' as per the IPC flux reliability standard. LFM 48 X TM-TS was the only material to meet the pass/fail criteria. The joints

formed by the other 3 materials could not be considered reliable enough for the companies' end product.
This highlights that for lead free soldering the characteristics of the flux play an important role in the final strength of the solder fillet. A summary of the test data is shown below. For each paste 66 long plate samples and 66 short plate samples were tested.

Ni Plate Peel Off Strength on Long and Short Plate
(Part of Cell Phone Assembly. Pass/Fail >2kgf)

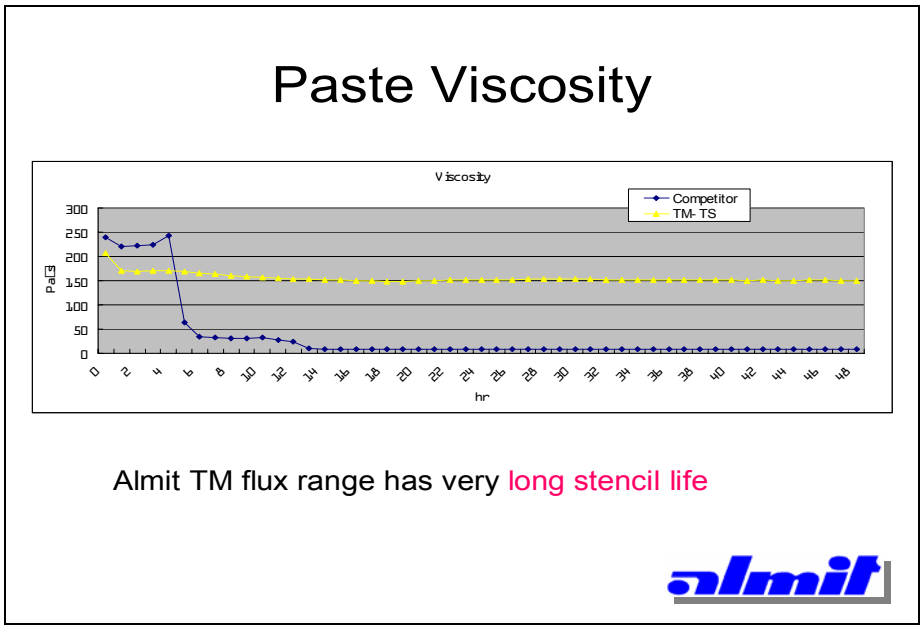
PASTE	Min(kgf) (Long)	Max(kgf) (Long)	Ave(kgf) (Long)	Min(kgf) (Short)	Max(kgf) (Short)	Ave(kgf) (Short)
ALMIT	3.72	8.45	5.82	3.96	11.23	6.76
B	2.67	7.56	3.74	1.37	7.00	3.77
C	2.26	8.05	3.66	1.24	5.83	3.54
D	0.59	5.11	2.75	0.2	4.08	1.87

All solder pastes were SAC305 alloy and 'L1' Flux Classification as per IPC Specification

Lead Free SMT Process Issues

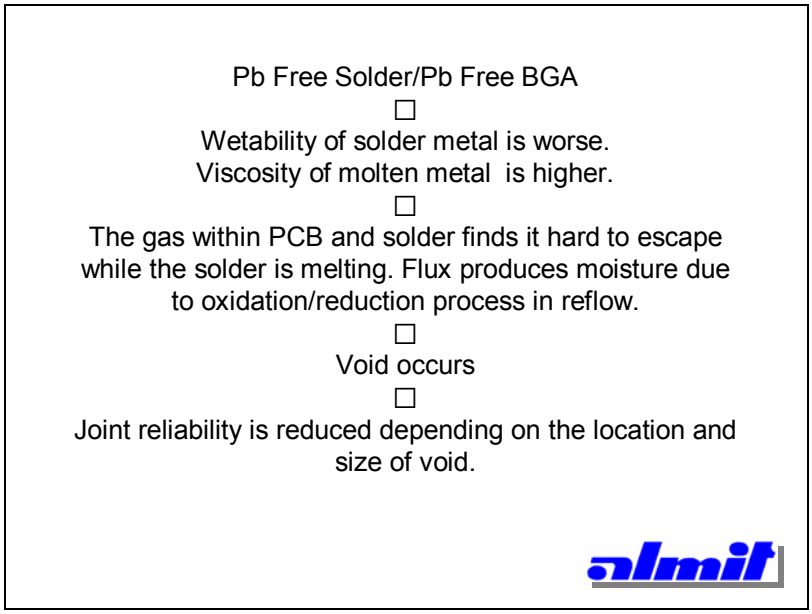
When manufacturing high reliability electronics it is important that all solder joints are of a consistently high quality. Repeatable joint quality starts at the screen printing stage. Lead free pastes are more susceptible to viscosity change over time due to the reaction between the flux and solder powder. This change in product viscosity will affect print performance, which will introduce a variation in the volume of printed paste on each pcb. In extreme cases the solder paste print quality may be so poor that post reflow solder joints may have to be reworked. Any level of rework can affect the reliability of individual solder joints.

Almit LFM 48 X TM-TS has a very stable flux chemistry enabling it to maintain a high quality print performance for long periods of time.



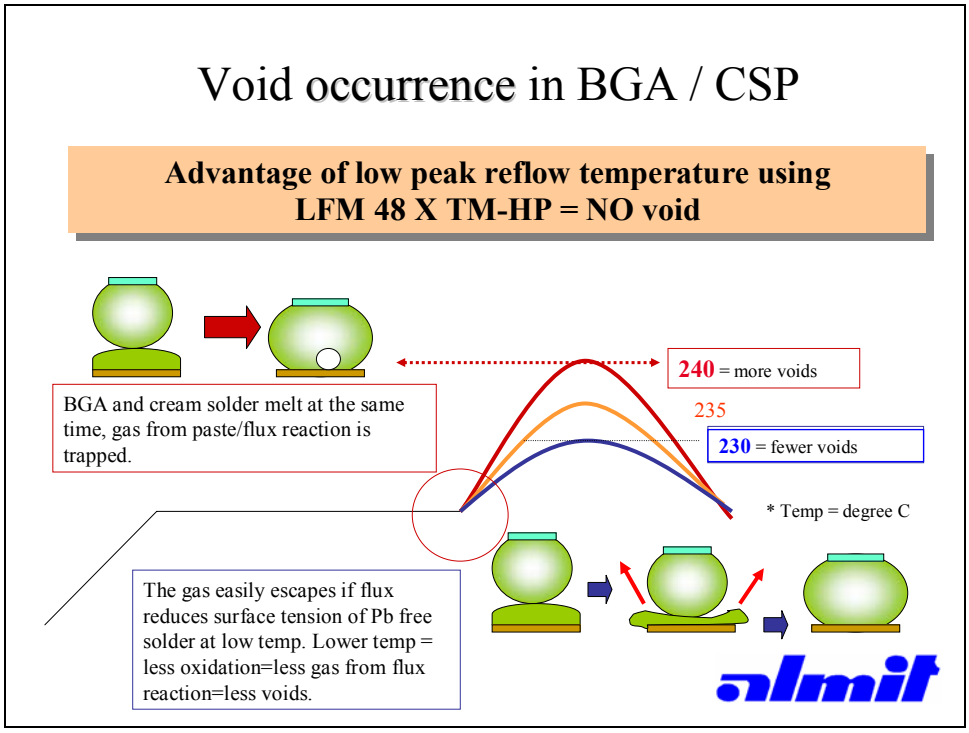
In-order to be fully aware of the quality of the solder joints we are manufacturing it is important to appreciate that when we move to lead free, soldering becomes more difficult and hence the likelihood of solder defects more pronounced. Even if we have the correct amount of solder paste on every pad we still run the risk of generating poor reliability solder joints

Voids in solder joints can be an issue with lead containing pastes, with lead free alloys it can be much worse. Understanding how voids are formed helps us to counteract their formation. The process chart below shows the main cause of voids in lead free solder.



At post reflow inspection joints may look ideal but may contain large area voids which will seriously affect the joint reliability.

With Almit 'TM' range of fluxes it is possible to tailor the reflow curve to give the best possible chance at minimising voids. The fluxes can withstand high preheats for long periods of time without any degradation in solderability. This flexibility in preheat means we can drive off the flux volatiles and moisture generated by the fluxing action before the solder melts. At the point the solder melts the flux helps reduce its surface tension, even at a peak reflow temperature of only 230°C. By only reaching a low peak temperature we minimise the risk of overheating the pcb and components, and reduce the generation of oxides on the pcb/component surfaces which can increase the risk of voiding.



Conclusion

High reliability lead free solder joints can be manufactured providing the solder paste flux exceeds the requirements of IPC and also successfully promotes good wetting.
High volume, high reliability lead free solder joints can be manufactured providing the solder paste being used has a high level of print consistency.

In general terms we can also conclude;

LFM 48 solder alloy is stronger than traditional tin/lead solder.

It is possible to produce a high reliability, no clean paste flux for use with lead free solder alloys.

Fluxes with similar classifications can produce very different joint strengths.

During lead free paste trials it is good practise to assess joints for levels of voiding.

Soldering defects can be minimised by careful selection of paste and reflow profile.

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