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DEVELOPMENT OF A SUITABLE FLUX MEDIUM FOR CLEANABLE AND NO-CLEAN SOLDER PASTES BASED ON TIN-BISMUTH-SILVER ALLOY

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ABSTRACT

Tin-bismuth alloys were rarely used in the past because of their poor reliability: one of the major drawbacks was the formation of a bismuth/lead compound with a very low melting temperature (96°C) due to the presence of lead in the components and boards finishes. Due to the implementation of ROHS directive in Europe in 2006, lead was banned in most of the assembly materials. On the other hand, the introduction of a small quantity of silver (up to 1%) in the tin-bismuth alloy (Sn42Bi58) improves its reliability as far as mechanical properties and thermal cycling are concerned. Regarding assembly process, with its lower melting point (around 139°C), there are several expected benefits of tin-bismuth-silver alloys: better soldering yield for temperature sensitive components, replacement of some selective soldering by reflow, shorter reflow cycle times and saving energy, thus cost. However, the development of a suitable flux medium is a challenge due to its relatively low melting point and its high surface oxidation. The use of aggressive activators which are efficient at low temperature, as well as solvents which evaporate at a lower temperature is required, making the paste more unstable.

The purpose of this paper is to present two concrete studies. A general description of flux media and the role of their constituting ingredients will be made first. Then, the development of a tin-bismuth-silver solder paste with cleanable residues according to a specific request will be described. Finally, the methodology followed to develop a suitable flux medium for a no-clean paste will be explained. The development steps will be validated by standardized tests as well as home-made testing, and then by industrial evaluations.

Key words: lead-free, low temperature, tin-bismuth-silver, solder paste, flux medium.

INTRODUCTION

The tin-bismuth alloy Sn42Bi58 is eutectic with a melting point of 138°C. Sn42Bi58 has a high strength but is brittle and sensitive to shear-rate. Furthermore, when it is used with leaded substrates and/or leaded components, the risk to form crystals of Sn16Pb32Bi52 must be taken into account: with its melting point of 96°C, this compound may cause solder joint failures at low temperature. For the above-mentioned reasons, SnBi solder wires and solder pastes have been used in some low-cost assemblies for many years. Because of the implementation of the RoHS directive, the ban of the lead in assembly is effective in many countries and industries: the risk to create Sn16Pb32Bi52 is almost zero. Moreover, it has been showed that the addition of small amounts of silver (up to 1%) in the Sn42Bi58 alloy improved its mechanical properties: the high strain-rate ductility in tensile strength at a strain-rate of 10^{-2} sec^{-1} exceeds by at least 20% that of a Sn42Bi58 solidified at the same cooling rate [1]. The small amount of silver allows maintaining a low melting point (139-140°C). As far as thermal cycling is concerned, studies have shown the reliability of SAC305 BGAs soldered with SnBiAg solder paste (-20°C/+85°C, 4000 cycles) [2]. From the environmental point of view, bismuth is not considered toxic. Its availability is enough to cover some of the needs in electronic assembly. The main benefit to expect from the use of this alloy is the production cost reduction brought by the following: typically 0.4 to 1% silver in the alloy compared with 3% silver in SnAg3Cu0.5, less energy consumption for the reflow equipment (lower temperature and shorter cycle time), improved soldering yield for temperature sensitive components, easier and faster oven cleaning, and extend the life of the reflow oven. In addition, the replacement of some selective wave soldering process using SnAgCu by a pin in paste process followed by reflow at low temperature may also be considered. In this paper, two case studies of SnBiAg solder pastes will be described: first, the development of a cleanable dispensable solder paste and second the development of a no-clean solder paste for printing. Before going into details, we will explain the role and responsibilities of the ingredients constituting a flux medium.

COMPOSITION OF A FLUX MEDIUM

The flux medium plays several roles: it is the vehicle of the alloy powder; it provides viscosity and rheology, eliminates oxides films on substrates, protects the powder from oxidation and reduces the surface tension of the alloy during reflow to enhance wettability. During reflow, most of the solvents evaporate, the activators are consumed: the residues left on the board are mainly composed of rosin.

A flux medium contains several kinds of ingredients: resin, activators, solvents, thixotropic agents, additives.

Resins

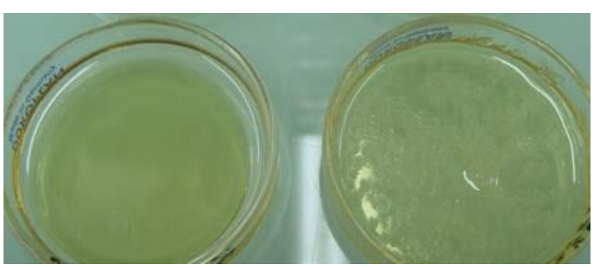
Most resins used in solder pastes are in fact rosins, based on colophonium derivatives (hydrogenated, disproportionated, dimerized, esterified, or chemically modified). These rosins mainly act as binders in the formulation. According to the type of rosin, their color can vary from clear to brown (figure 1). They are often in a solid state at room temperature and have a glass transition temperature Tg in the range of 60 to 150°C: this is the temperature they start to soften. Most of the rosins are acid by nature (except the esterified ones) and are characterized by an acid index (Ia) which is a simple tool to indicate the quantity of acid contained in a substance: the acid index is the mass of potassium hydroxide (in milligram) needed to neutralize one gram of substance. The rosins also partially play the role of activators. Examples of rosins are given in the table 1. The nature of the rosin is also responsible for its solubility in solvents (figure 2). Generally, to get the best performance, a mix of several rosins is used. After reflow, the rosins are the major components of the flux medium which will remain on the substrate as "non volatile residue".

a) clear b) amber

Figure 1. Color of rosins dissolved in the same solvent

Table 1. Examples of rosins

Rosin nature	Ia	Tg (°C)	color
Fully hydrogenated rosin	170	80	white
Partially dimerized rosin	160	95	brown
Acid modified rosin	200	130	white
Esterified rosin	20	<0	amber



a) soluble b) crystallization occurs

Figure 2. Rosin in solution with two different solvents

Activators

Their role is to remove the oxide from the substrate and the powder to promote the solderability. Several types of activators are used in solder pastes: organic weak acids or organic weak acids precursors, hydrochlorides, hydrobromides or molecules containing halogen atoms linked by a weak covalent bond. All these chemicals are characterized by a melting point, a boiling point, sometimes a decomposition temperature, a solubility level in different solvents and are often used in combination with an amine. Polycarboxylic acids and especially dicarboxylic acids with short to medium chains (C2 to C7) like succinic, adipic, glutaric acids are widely used because of their higher acid index compared with monocarboxylic acids which provide more efficiency with the same percentage in the formulation. In general, when the acids have a short chain, the efficiency is high (higher acid index) when short reflow profiles are used but the stability of the solder paste is less: these acids tend to react at a too low temperature (i.e. room temperature). Fatty acids, such as stearic acid, are not strong activators but are able to stand higher temperature; they are easier to dissolve in non aggressive solvents than the shorter acids. Additionally, they may stabilize the formulation. The table 2 gathers some organic acids that can be used for pastes and flux.

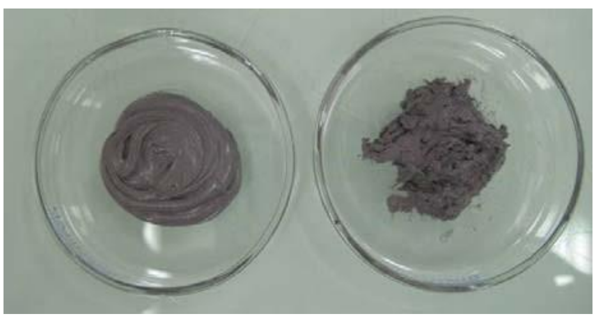
Table 2. Acid index organic of some organic acids

Common Name	Molecular formula	Ia
malonic acid	$HO_2C(CH_2)CO_2H$	1073
succinic acid	$HO_2C(CH_2)_2CO_2H$	950
glutaric acid	$HO_2C(CH_2)_3CO_2H$	849
adipic acid	$HO_2C(CH_2)_4CO_2H$	768
pimelic acid	$HO_2C(CH_2)_5CO_2H$	700
suberic acid	$HO_2C(CH_2)_6CO_2H$	644
azelaic acid	$HO_2C(CH_2)_7CO_2H$	596
stearic acid	$CH_3(CH_2)_{16}COOH$	197
octanoic acid	$CH_3(CH_2)_6COOH$	389
malic acid	$HO_2CCHOHCH_2CO_2H$	837

The organic acids may be used in combination with amines and/or amine hydrochlorides or hydrobromides. These ionic compounds, also called "halides" such as diethylamine hydrobromide or cyclohexylamine hydrochloride, are strong activators and allow larger thermal profile window but are less used than before: the stability of the paste is often reduced and, after reflow, some decomposition products remaining in the residue tend to cause some electrochemical corrosion. The presence of such compounds is easily detected and must be specified according to the IPC-JSTD-004 standard. Chemicals containing halogen atoms linked by a weak covalent bond, also called "halogens" tended to replace the above mentioned compounds. However, halogens start to be banned by several customers due to environmental concerns. In general, several activators are placed in a flux medium to ensure an efficient solderability within the thermal profile window whatever the level of oxidation of the surface finishes and components.

Solvents

The role of the solvents is first to dissolve the ingredients of the flux medium such as rosins and activators. High boiling point solvents (usually > 200°C) appear in the composition of lead-free solder pastes. The solvents are characterized by their solvency power, their viscosity, surface tension, boiling point, vapor pressure, polarity, etc. Several kinds of solvents are used to get a stable flux medium: from weakly polar protic solvents like alcohols or propylene glycol ethers to aprotic apolar solvents like hydrocarbons. The choice of suitable solvents is a key factor for preheat and reflow properties as well as for the stability and printability. Generally, a polar solvent better dissolves the activators but their reactivity is thereby increased in respect to the surface of the powder: the viscosity of the solder paste may increase rapidly to a level which makes it unsuitable for printing (figure 3).



a) suitable for printing b) unsuitable for printing

Figure 3. Solder pastes

Thixotropic Agents

Solder pastes are non-newtonian fluids: their viscosity changes according to the shear stress applied. A solder paste has to become less viscous, thus to flow properly, during printing and to return to a gel state with a higher viscosity once the printing is completed, to avoid slump. This property is given by thixotropic agents. In addition, the stability of the flux is often enhanced thanks to such agents. Hydrogenated castor oil remains one of the most famous thixotropic agents for pastes.

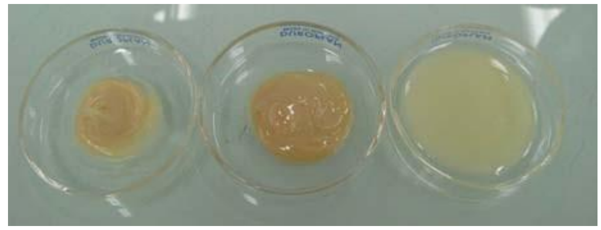


Figure 4. Flux media

a) strong gel b) medium gel c) no gel

Additives

Many additives can be added in the solder pastes: plasticizers, antioxidants or preservatives may enter their composition.

Solder Pastes

The flux medium is necessarily tailored according to the alloy. For example, the boiling point of solvents is different according to the melting point of the alloy (table 3), the activator system is adapted to the oxides nature and level on the surface of the powder, the flux medium contents are also different according to the particle size of the powder.

Table 3. Melting point of some alloys

Alloy	SnAg3Cu0.5	Sn63Pb37	Sn91Zn9	Sn42Bi58
Mp (°C)	217	183	199	138

CASE STUDY N°1: DEVELOPMENT OF A SNBIAG CLEANABLE SOLDER PASTE

The study was launched on request of a customer who already partially migrated its production from tin-lead (SnPb) to lead-free. The use of SAC305 alloy increased significantly the level of defect because of the higher profile required and the temperature sensitivity of some components. The search for an alternative low melting point lead-free alloy was studied.

The requirements of the solder paste were defined as following: Sn42Bi58 or Sn42Bi57.6Ag0.4, thermal shock resistance requirement, type 3, for dispensing, sufficient wetting on ENIG substrate, low microballing, sufficient residue cleanability using a solvent cleaning process. The first step was to compare the mechanical properties of tin-bismuth and tin-bismuth-silver solder joints. According to our know-how and preliminary trials, a first flux medium was chosen and two solder pastes were proposed, the first one with Sn42Bi58 (X1) and the second one with Sn42Bi57.6Ag0.4 to assess their tensile strength resistivity in comparison with the Sn63Pb37 solder paste (I1) after soldering. Although the efficiency of the formulas was not optimum at this stage, the solder joint shape indicated a sufficient wetting. The tensile strength measurements ranked in the following order: SnBiAg0.4, then SnPb and SnBi far behind. SnBi was disqualified due to the poor results and the high standard deviation. The results are summarized in table 4. Thus, the following tests have been done with SnBiAg0.4 type 3 solder powder (SBA).

Table 4. Comparison of Tensile strength resistivity of solder joints

Paste Alloy	Paste	Tensile strength average (Newton)	Std deviation*	Max	Min	A-3 sigma
SnPb	I1	76	5	87	66	60
SnBi	X1	57	23	99	20	-11
SBA	X2	105	11	120	76	72

* 99.7% of the values in the range

Internally, for each formulation, solderballing and wetting performances were checked on a hot plate.

For the solderballing test, the temperature of the hotplate was set at 180°C and several temperatures and times of preheat were tested. The goal was to classify the formulations according to their preheat resistance, and to shape the oven thermal profile. The usual solderballing classification ranks from class 1 to class 5, the balls being counted with 30x magnification (table 5).

Table 5. Solderballing classification (NF-C-90550)

Class 1	5 solderballs maximum
Class 2	6 - 10 solderballs
Class 3	11 - 20 solderballs
Class 4	21 - 50 with possibility of a slight lisere
Class 5	> 50 solderballs with clusters and lisere

However, due to the far worse results in comparison with SAC or SnPb powders, the classification needed to be enlarged (creation of new classes, class 6 and class 7) in order to detect even minor improvements (figure 6).

SnBiAg (SBA) has good wetting properties but a high tendency to generate many microballs and oxides during reflow. The figure 5 shows the results of two solder pastes having both SBA but a different flux medium: on the left, the paste exhibits a bad solderballing on alumina, it is also observed during reflow on a copper surface (below); on the right, only a few small microballs are observed.

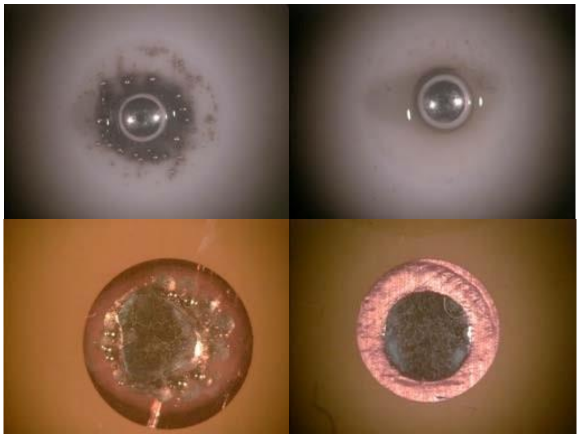


Figure 5. Solderballing test and wetting test

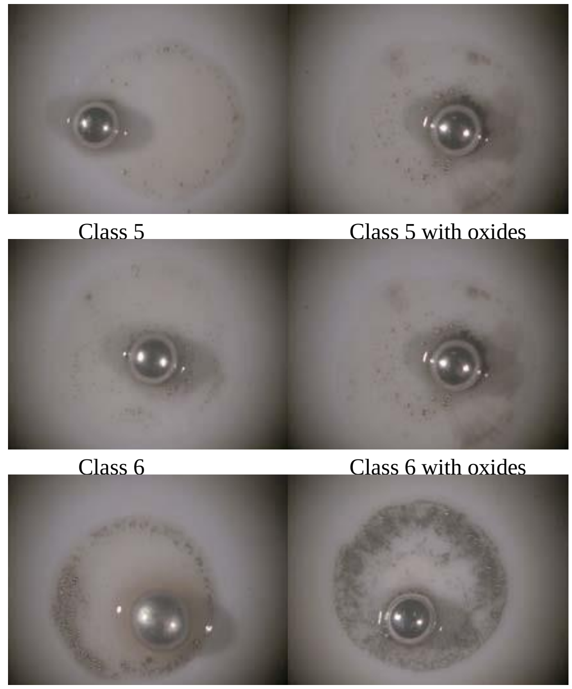


Figure 6. Pictures of solderballing class 5, 6, and 7

In parallel, viscosity and ageing tests of the pastes were done as well as simple manual cleaning test to get a general view of the pastes properties. This step was mostly a screening of rosins, activators and solvents, and clear influences were found. The detail will not be discussed here but the trends are as follows: some strong activators are effective to prevent the occurrence of microballs and oxides whereas some of them cause a premature ageing of the pastes, solvents with lower boiling point improve the solderballing test, most pastes with low microballing are difficult to clean.

Detailed analysis of the results allowed us to build some formulations to confirm the results and to check the interactions. After optimization, three solder pastes (X3, X4 and X5) were fully tested in our lab in comparison with the first SBA proposal X2. Dispensability, solderballing and wettability (copper and ENIG) on hotplate and in oven, then cleanability were assessed. The results were shared with the customer who performed the trials at the production lines: after paste deposition, the components were placed and the boards were passed through the oven using a linear preheat of 0.8°C/s followed by a time above liquidus (TAL) of 60 seconds with a peak at 190°C. After counting the microballs, the boards were cleaned using the industrial process and the **Table 6.** Industrial evaluation of X3, X4, X5 in comparison with X2

	X2	X3	X4	X5
Dispensing	2	1	2	1
Wetting	1	1	1	1
Microballs	3	1	2	1
Cleaning visual	1	3	1	2
Cleaning IC*	1.41	> 4	1.35	2.10

*Ionic contamination expressed in µg/cm^2 eq NaCl

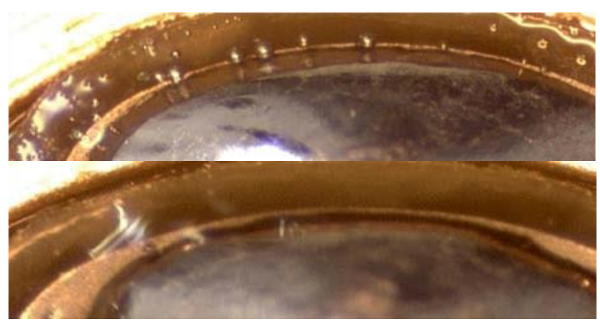


Figure 7. Residue after reflow. a) X2 with microballs

efficiency of residue removal was first observed visually then measured in an ionic contaminometer. These tests run in production have confirmed the results obtained in the laboratory: the pastes having the best performance in terms of microballing are the more difficult to clean and vice versa (table 6).

(top) b) X5 without microballs (bottom)

The result of poor cleaning is a high ionic contamination and the presence of white residue (figure 8).

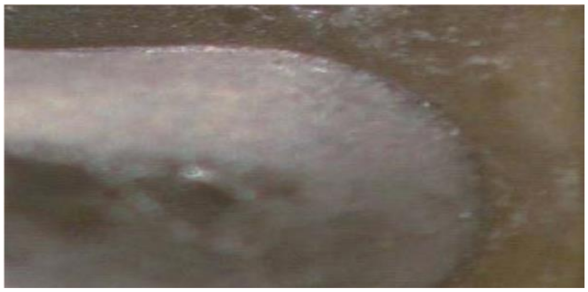


Figure 8. Insufficient cleaning for X3 (white residues)

Although each board is cleaned, the presence of balls is not acceptable beyond a given threshold: the risk of not removing all of them does exist and these balls accumulate in the cleaning equipment, requiring more frequent maintenance. An optimization was conducted to find the best compromise between solderballing and cleanability: two new proposals were presented to the customer. Both pastes showed acceptable performances (table 7): a longer trial run was necessary to finally select the paste X7. The PCBAs passed all the environmental tests. A last adjustment of flux medium content and paste. viscosity was done before the start of several pilot productions

Table 7. Industrial evaluation of X6 and X7

	X6	X7
Dispensing	1	1
Wetting	1	1
Microballs	1	2
Cleaning visual	2	1
Cleaning IC*	0.6	0.8
TSA **(N)	93	93

*Ionic contamination expressed in µg/cm^2 eq NaCl

** Tensile strength average

Internally, the Surface Insulation Resistance test was carried out according to IPC-TM 650 method 2.6.3.3 before and after cleaning: the SIR values without cleaning drop under the limit within the first 24 hours and recover (figure 9). No dendrite growths were observed. X7 could be considered as a no-clean solder paste but the solderballing score remained too high in comparison with SnPb or SAC no-clean solder paste.

SIR 85/85/50V/B24

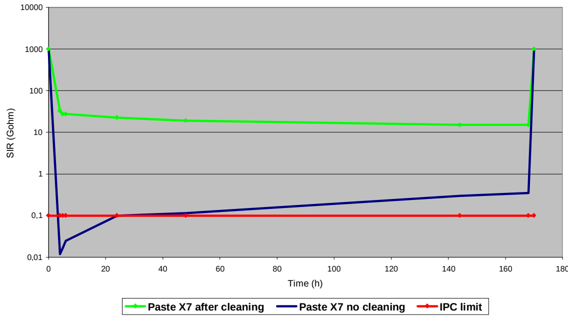


Figure 9. SIR graph of paste X7

CASE STUDY N°2: DEVELOPMENT OF A SNBIAG NO-CLEAN SOLDER PASTE

The requirements were defined internally as following:

- low occurrence of microballs during reflow (assessment by solderballing test on hotplate and in oven)
- printable solder paste (assessment by viscosity test followed by printability test)
- no-clean solder paste (assessment by copper mirror, surface insulation resistance and electromigration)
- halide and halogen free

Solderballing tests were done according to the method described in the first case study (hotplate). For the oven reflow three thermal reflow profiles, with short, medium and long time above liquidus (TAL), were defined to determine the reflow process window: total profile time between four and five minutes, time above liquidus between 35 and 90 seconds (table 8, figure 10).

Table 8. Characteristics of the profiles

	Short	Medium	Long
Total duration (s)	240	300	300
Time between 40°C/140°C (s)	145	195	150
Time between 40°C/peak (s)	160	225	220
Peak (°C)	164	165	173
TAL (s)	35	56	90

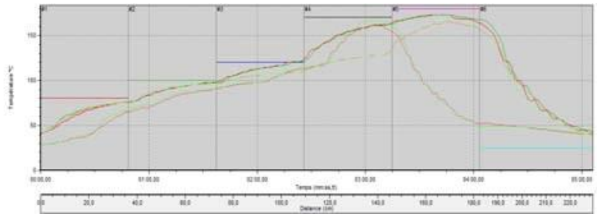


Figure 10. Graph of the three profiles

The printability was assessed by several methods. First, the appearance of the pastes and the simple measurement of viscosity (Brookfield viscometer, 20°C, 5 RPM) were done for each formulation. The evolution of appearance and viscosity of the pastes stored at room temperature was checked every week. Second, the most promising ones were also evaluated using a more drastic viscosity test. The test consists in the follow-up of viscosity over time using a Malcom viscometer (figure 11). The test simulates solder paste ageing when it is submitted to a permanent stirring and reproduces the shearing it undergoes at the printing step. The measure of viscosity evolution versus time during the stirring allows predicting the premature solder paste ageing by correlation.

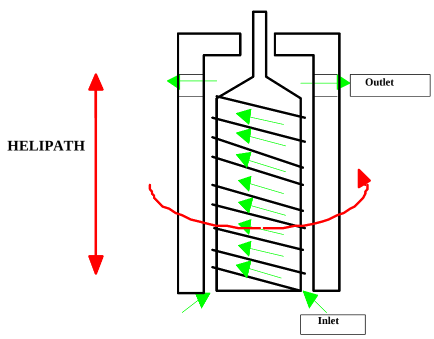


Figure 11. Schematic representation of Malcom viscometer

A stable paste keeps a constant viscosity over time (figure 12.a). On the contrary, an unstable paste leads to a sudden increase of viscosity after a few hours only (figure 12.b).

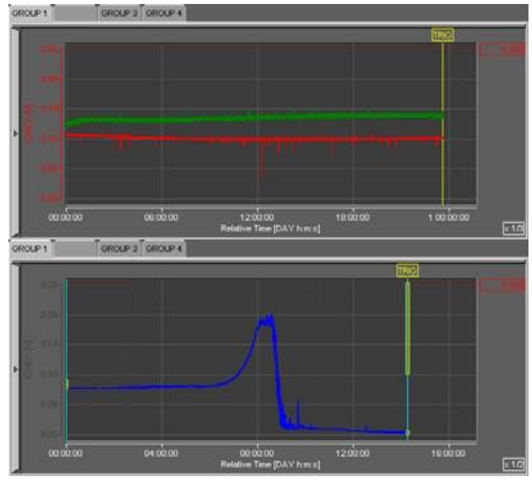


Figure 12. a) stable viscosity (top) b) sudden increase of viscosity after 7 hours (bottom)

As observed in the first case study, the presence of short chain acids/diacids with high acid index is necessary to remove all oxides during reflow and to avoid microballs. Thus, the goal of this development was to keep a high activation level to avoid microballs while stabilizing the paste and making its residue as inert as possible. Ideas were found to stabilize the formulations through existing expertise and through bibliographic searches. A screening of several substances like fatty acids was done in several initial formulas. The following abbreviations were used: R for rosin, A for activator, G for thixotropic agent, S for solvent, B for amine, C for corrosion inhibitor. Among the numerous fatty acids tested, one of them showed efficient stabilizing properties: A3. The paste M50 (table 9), containing 7% of A3, was stable and generated a small quantity of microballs (class 2 maximum). However, the copper mirror was completely attacked (notation H according to IPC-J-STD-004) and the SIR was below 100 megohms. Then, an increase of corrosion inhibitor was done. The resulting formula served as a basis for the first simplex to determine the optimal amounts of rosins, acids and activators. The table 10 presents the matrix of the simplex realized with the chosen parameters, the starting point and the step.

Table 9. Some pastes formulations at different steps of optimization

	R1	R2	R3	A3	A4	A8	A9	G	S1	S2	S3	S4	S5	B1	B2	C	S1	S2	Sum
M1		40			4		6	3	6	18	9			4		0,1	4,9	5	100
M3		36				4	6	3		18		14		4	7	0,1	3,9	4	100
M50	16	21		7		1	4	3				15	15	4	6	0,1	4	3,9	100
M60	18	18		10		1	3	3		9	4	16		3	6	1	4	4	100

M92	18	12	5	10		1	3	3		9	5,2	16		3	6	1	3,8	4	100	

Table 10. Simplex parameters

U1	R1/R2	U10	0,762	deltaU1	0,2
U2	S4/Stotal	U20	0,5	deltaU2	0,2
U3	A8/A3	U30	0,571	deltatU3	-0,4
U4	B2	U40	6	deltatU4	1
U5	B1	U50	4	deltaU5	-1

The table 11 presents the starting matrix of the simplex, the matrix parameters being calculated from the usual formulas of simplex.

Table 11. Simplex matrix

exp	X1	X2	X3	X4	X5	Y
1	0	0	0	0	0	2,96
2	1	0	0	0	0	3,04
3	0,5	0,866	0	0	0	2,74
4	0,5	0,289	0,816	0	0	2
5	0,5	0,289	0,204	0,791	0	2,67
6	0,5	0,289	0,204	0,158	0,775	2,59

As expected, the simplex resulted in an optimized solder paste called M60. After the evaluation of its properties, further improvements were decided: increase of viscosity and stencil life duration. These improvements were achieved by the introduction of other rosins and through changing some ratios of rosin and some ratios of solvents. Simplex methods were also used to finally get the formula M92 described in table 9. Performances of M92 are given below:

- Solderballing class 3 maximum on hotplate,
- Solderballing class 3 maximum in oven with short, medium and long profile,
- Viscosity 700-800 Pa.s,
- Viscosity ageing test > 24 hours,
- Copper mirror L (no attack of the copper),
- SIR > 100 megohms and no dendrite growth (IPC-TM650 method 2.6.3.7, 85°C/85%RH, 50V).

The Surface Insulation Resistance residues was measured for some of the several optimzed solder pastes: the improvement from M50 to M92 is presented the figure 13.

SIR 85/85/50V/B24

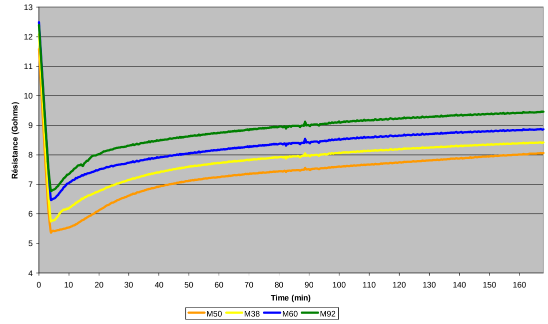


Figure 13. SIR test on B24 for M38, M50, M60, M92.

Printing tests were performed in a printer (DEK Horizon 05) on M92: determination of minimal pressure required according to the speed, printing quality according to the number of prints without cleaning, determination of the maximum idle/abandon time and again, after 500 printing cycles, determination of printing quality. The paste passed the tests with good results: the range of possible speeds with acceptable pressures ranged from 20 to 150mm/s (table 12, figure 14), 8 prints without cleaning were achieved on 0.4mm pitch printing patterns (0.27mm tracks/0.13mm space) using a 120 microns stainless steel stencil, an idle time of more than 90 minutes was found and the cycling did not affect significantly the printing quality. Finally, a complete study of the paste properties was performed internally and the good results were confirmed: the work allowed the development of a suitable no-clean low-temperature printable solder paste based on Sn42Bi57.6Ag0.4.

Table 12. Minimal pressure according to printing speed

Speed (mm/s)	30	50	80	100	120	150
Minimum pressure (kg)	3.5	4.0	5.5	6.5	7	8

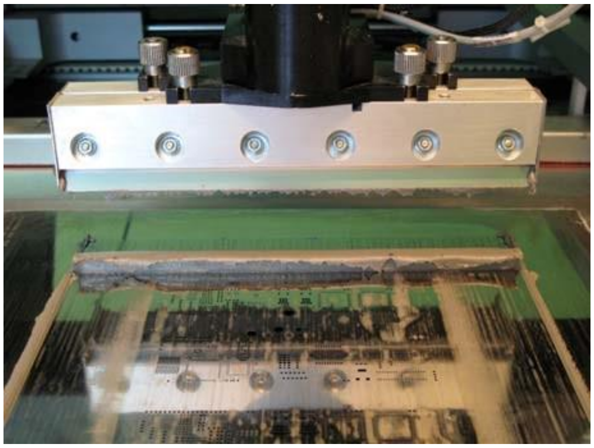


Figure 14. Appearance of paste roll and stencil after printing at 120mm/s and 7 kg.

Then, the paste was used for the assembly of LEDs on a rigid substrate. The boards were inspected by a third lab. The mounted components met the IPC-A610E: no side overhang, end joint width equal to lead width, wetted fillet evidence, solder fillet and component body not in contact, non disturbed solder, wetted fillet (figure 15).

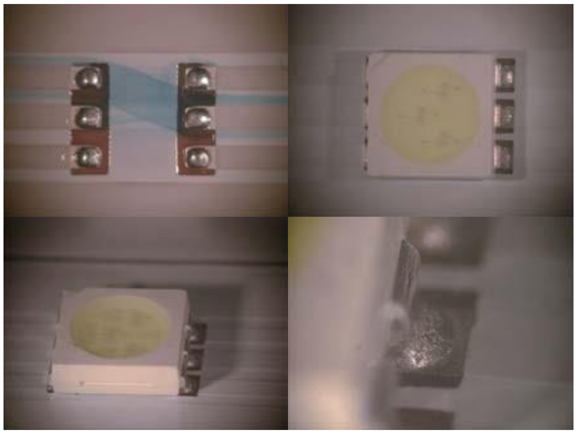


Figure 15. LED soldering with M92

Shear tests were performed on several joints (figure 16): the mean was 10889 grams with a standard deviation of 1548.80 (table 13).

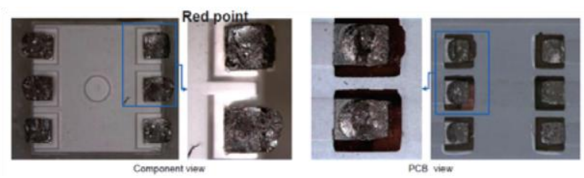


Figure 16. shear test locations

Table 13. Shear test results

	Shear (gram)
Measure on joint #1	12120
Measure on joint #2	9150
Measure on joint #3	11397
Mean	10889
Std Dev	1548.80
Max	12120
Min	950

The micro-section showed an acceptable side joint length with evidence of wetted fillet along the entire length of the lead, an acceptable fillet height with wetting evident on vertical surface of led terminal, small voids inside specifications and no solder defects. A uniform and constant IMC to both surfaces (PCB pad and led pin) was observed: the IMC thickness to PCB pad was comprised between 1.7 and 2.5µm, the IMC thickness to LED side was comprised between 1.6 and 1.7µm (figure 17).

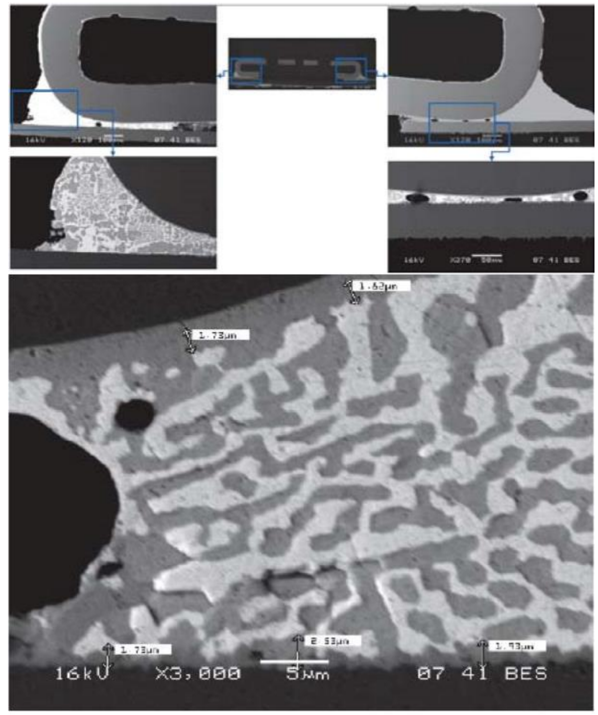


Figure 17. Micro-section

CONCLUSION

The development of two low-temperature solder pastes based on a tin-bismuth-silver (Sn42Bi57.6Ag0.4) powder has been conducted successfully. Due to the specificities of the alloy and its powder (melting point 40°C less than eutectic tin-lead, higher oxide content and different nature of oxides), some adaptations were made in the usual internal laboratory testing methods and new criteria were established. For the first case study, the requirements (Sn42Bi58 or Sn42Bi57.6Ag0.4, thermal shock resistance requirement, type 3, for dispensing, sufficient wetting on ENIG substrate, low microballing and sufficient residue cleanability with solvent process) were clear and precise enough to start internal testing quickly. Additionally, the full partnership with the customer has enabled a rapid progress: production trials were able to confirm the laboratory tests. The development of the suitable flux medium was based on knowledge of the chemistry and on the know-how, on the screening of ingredients, and was realized step by step to find the suitable product.

For the development of the no-clean solder paste, the requirements were defined partly according to standards and partly according to internal criteria. The second case confirmed the observations done during the first one: short chain acids were necessary to achieve a solderballing with little microballs but short acids also made the pastes unstable. The use of other rosins, the change of rosin ratios and solvent ratios was necessary to get the desired properties. Simplex method was used several times to improve the paste characteristics: a special attention was given to the surface insulation resistance criterion. At the final stage, the properties of the optimized solder paste were assessed using industrial tools (test board, printer and oven). Then, a test was performed with a customer and the quality and strength of the joints in the assembly was assessed with positive results.

The successful development of a solder paste implies first a rigorous definition of the specifications. Second, whatever the strategy used, the standardized tests and laboratory tests shall be promptly confirmed by industrial trials. Third, the implementation of an active partnership between supplier and customer accelerates the development of a solder product.

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