THE ANALYSIS OF SOLDER PREFORMS IN SURFACE MOUNT ASSEMBLY

Václav Novotný, Radek Vala

Doctoral Degree Programme (2), FEEC BUT

E-mail: novotny.vaclav@azd.cz, radek.vala@sanmina.com

Supervised by: Josef Šandera

E-mail: sandera@feec.vutbr.cz

Abstract: This article is focused on the sphere of solder joints reliability in technology of surface mount assembly and the issue of manufactory of solder joints with solder preforms is introduced closer. It also describes types of solder preforms, their application and different methods of using in surface mount assembly. Text further comprises comparison of the solder joint which is manufactured by printing of solder paste through the cooper stencil and solder joint manufactured by applying of solder preform. The results of these basic processes are compared with method of solder fortification. In conclusion, there are evaluated outputs from experimental manufactory of solder joints with solder preforms and complemented by outputs which are achieved by x-ray machine

Keywords: Solder, Preforms, Reliability, Fortification, Wettability

1. INTRODUCTION

The technology of surface mount assembly is very wide area in these days and new manufacturing processes are included constantly in development and subsequently used in new projects. Surface mount technology involves two main aspects which are SMD components and soldering technology. Technology of soldering further comprises several subchapters where are important mainly method of reflow, soldering profile, methods of mounting of components and finally methods of printing of solder paste. There are two main ways which are used for printing of solder paste. The first method is printing of solder paste through the stencil and it is most often method because it is way of many large companies with electrical manufactory. Production of copper stencils for printing paste is very expensive but the final price of stencil is divided in large series of products. The second method is printing paste by automatic dispenser and it is less frequent and less represented because this method is used mainly by small and medium companies, where production is focused on small or medium sized series of products. The production of stencil for printing is unprofitable in these cases and automatic dispenser is appropriate and cost-effective alternative. This is because there is no need to use stencil for printing and solder paste is printed variably by current requirement.

There also exists an alternative besides these classical methods of printing of solder paste. This alternative is the use of solder preforms. Solder preforms have large range of advantages and disadvantages. It may seem that weaknesses are often bigger than advantages but it is clear that solder preforms are good choice for some specific applications. Solder preforms have large number of different kinds but the main advantage can be identified as mounting of very accurate volume of solder paste to solder joint and another good feature is precise application of flux and this is perfect for testing of reliability of solder joints, where precise of volume of solder paste is very important for final evaluating. Solder preforms are mounted by conventional mounting machine and for some companies isn't necessary to own expensive automatic dispenser for printing of solder paste or machine for stencil printing. For this reason, researching and analyzing of solder preforms can be useful in some applications. [2]

2. APPLICATION AND METHODS OF SOLDER PREFORMS USING

Technology of solder preforms provides very large number of different applications. These preforms are supplied by many manufacturers and it is possible to say that manufacturers of common types of solders provide also solder preforms and these are possible to divide to three basic parts. First part is sphere of solder preforms which can be used for attainment of precise volume in solder joint. It's not critically important in manufactory of large series of products, but it is very important for developmental issues and tests of reliability of solder joints [3]. Solder preforms are typically distributed by manufacturer in usual reel which are compatible with all SMD mounting machines. This method allows mount pieces of solder by the same way as other SMD parts. Similarity with SMD components is also in the fact that various sizes of solder preforms are compatible with sizes of SMD parts. This means that it is possible to find solder preforms with size 0603 and compare with SMD part 0603, both will have same size. There is also need to respect that sizes of solder preforms correspond with sizes of SMD components, but they don't correspond with sizes of footprints, respectively sizes of solder pads. It means, that for each solder pads must be choose the correct size of solder preform. [5]

This can be explained by using of SMD component 2512 for example. SMD component 2512 has typical dimensions 6,3 x 3,1 mm and her solder pads has dimensions 2 x 3,2mm. This means that there is need to achieve volume of solder paste 0,96 mm^3 through cooper stencil 150 µm. Volume of solder paste 0,96 mm^3 for SMD part 2512 can be obtained by application of solder preforms in size of 0603. Dimensions of this preform are 1,6 x 0,85 x 0,45 mm and the total volume of solder paste is 0,612 mm^3 and this result is comparable with volume of solder paste achieved by cooper stencil.

Name	Size (Inches)	Size (Metric)	Shape	Solder weight (each)
-	"	mm	-	g
0201	0.010 x 0.020 x 0.010	0.254 x 0.208 x 0	Rectangle	0.00024
0402	0.020 x 0.040 x 0.019	0.508 x 1.01 x 0.408	Rectangle	0.00182
0603	0.030 x 0.060 x 0.031	0.76 x 1.52 x 0.787	Rectangle	0.00672
0805	0.050 x 0.070 x 0.050	1.27 x 2.03x 1.27	Rectangle	0.0241
1206	0.060 x 0.120 x 0.060	1.52 x 3.04 x 1.52	Rectangle	0.0521

Table 1: Typical names, sizes, shapes and weights of most used solder preforms [5]

Previous solder preforms have one disadvantage in absence of flux in solder. This means that there is requirement to add flux by another way. There are several options to solve this problem for some type of applications and one is using of solder preform which is coated by flux and also is possible to use solder preform in fortification application. Solder fortification is method of using solder preforms in conjunction with solder paste and flux in solder paste is suffice for perfect wetting of solder pads.

Generally, flux is added to the preforms up to 3% by weight; however, much lower amounts of flux rating about 0,5% can be adequate to remove the oxides and promote excellent wetting. The more flux that is used to make the joint, the more residue is either left on the board in a no-clean application or has to be removed if clearing is required. [1]. Solder preforms without flux and solder preforms coated by flux can be recognized by colour difference because there is often added colorant. It is important mainly in case, that are use two types of preforms where are same dimensions and different material composition, for example Pb-Free and Pb-Containing solder. [1]

Finally, it should be mentioned that solder preforms are compatible with solder paste in manufacturing processes. It means that PCB assembly can work with both technologies, solder paste and solder preforms because there can be applied same method of reflow and same thermal profile can be used.

3. TEST OF SAC305 0603 SOLDER PREFORMS ON 2512 SMD COMPONENTS

Solder preforms were experimentally tested on ENIG 70μm FR-4 board with 40 100 Ω SMD 2512 resistors [4] [5]. These resistors with this value were chosen because test boards are ready for cycling in the thermal chamber and evaluation circuit can work only with 300 Ω resistance and any larger resistance will be considered as the crack in solder joint. Testing board includes 20 resistors soldered with Indium SAC305 0603 solder preforms (column A and B on board) and 20 resistors soldered with Indium8.9HF solder paste (column C and D on board) [6]. This is shown on figure (1). Process of manufactory of test board is composed from several steps. Firstly, the flux was printed through the stencil on half of test board and by the same way was printed solder paste through same cooper stencil and to solder paste and flux are mounted SMD 2512 components by SMT Manipulator. Finally, there are mounted 0603 solder preforms on half of test board, where is applied flux. Complete test board as shown on figure (1c) is reflowed by vapors in ASSCON reflow chamber.

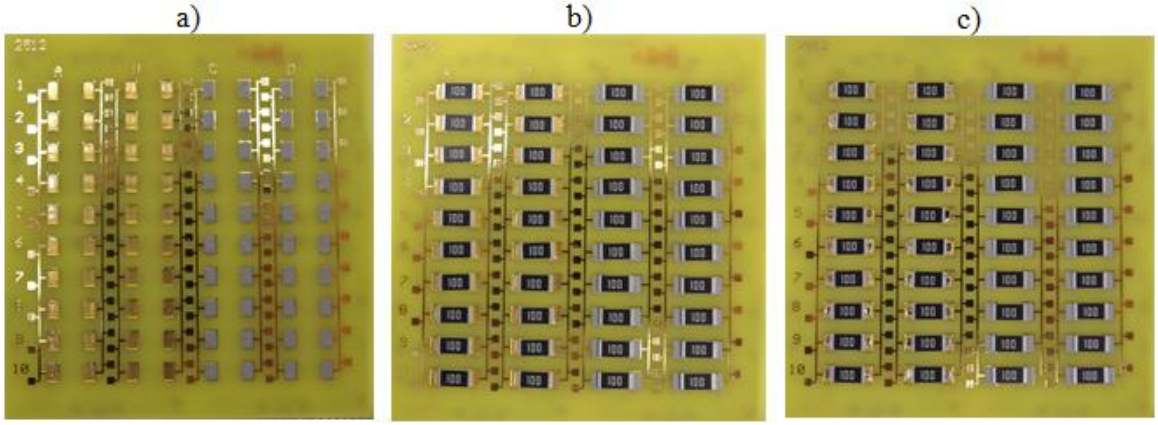

Figure 1: Process of manufactory of solder joint with solder preforms: a) Printed flux and solder paste through the stencil b) Mounted SMD 2512 components to flux and solder paste c) Added solder preforms to flux and SMD 2512 components [4]

Solder joints manufactured by two methods were compared after soldering in vapors and there was confirmed assumption that solder joint with solder preform will have larger volume of solder in solder joint and it can be seen that wettability of solder preforms was better than wettability of solder paste. This is shown on figure (2). Here it is important to add that material of solder preform and solder joint is same, because there is same material composition 96.5Sn/3.0Ag/0.5Cu and manufacturer is also same. Another advantage of solder joint with preform is fact that he has more precise volume of solder and therefore there will ensure the repeatability of manufacture at higher level.

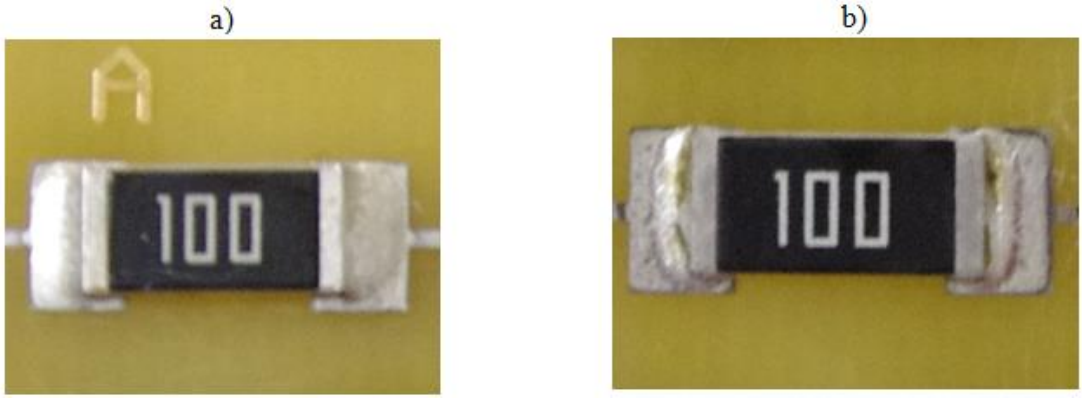

Figure 2: Solder joints soldered by different methods – a) Solder joints with solder preforms in the flux b) Solder joints with solder paste printed through the stencil

The visual analysis of soldered joints with solder preforms and solder paste was further complemented by analysis on x-ray machine. This analysis confirmed that solder joints with preforms have very good wetting of solder and further it is possible to see the integrity of the solder and the amount of voids in solder joints. Solder joints with solder preforms contain amount of fine desirable voids and this is prerequisite for good quality and reliability in operation. This is shown on figure (3a). There is difference compared to solder joints soldered with solder paste where is amount of large voids and in places of these voids can start grow crack of solder joint in operation. This is shown on figure (3b). The difference in the amount of voids is caused by different technologies of solder joints. This means that the flux in the solder paste evaporates during soldering and trying to get to the surface of solder paste while voids grow.

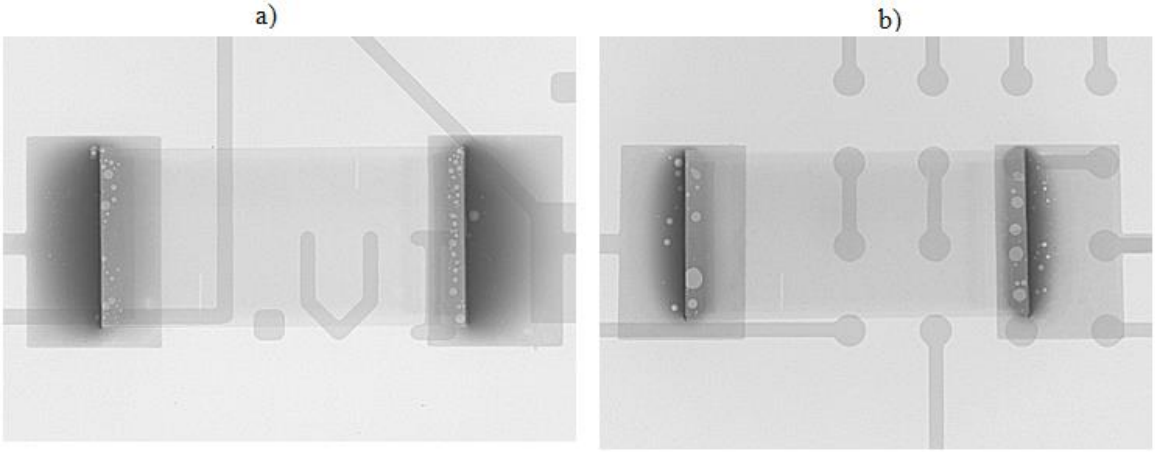

Figure 3: X-ray analysis of solder joints soldered by different methods – a) Solder joints with solder preforms in the flux b) Solder joints with solder paste printed through the stencil

4. TEST OF SOLDER FORTIFICATION METHOD

Solder fortification is method for reinforcement of solder joint for special applications. The main area of application of solder fortification is in THT (through-hole) assembly or in combination SMT (surface mount technology) and THT. There may be problem in stencil printing because cooper stencils for printing of solder paste are very thin due increasing miniaturization and density of components but there are still relatively large components as 2512 SMD parts or chip packages as TQFP-44, SOIC14, SOIC28 and many others [2]. These components need sufficient volume of solder for high-quality and reliable solder joint while most of current stencils have thickness maximally 300 µm or less. It can solve solder preforms in solder fortification configuration and so it is possible to reinforce critical areas quickly and flexibly in PCB. [1]

Solder paste has also disadvantage that she contains only about 50 % volume of allow powder. Process of manufactory of solder joint as fortification is very simple and was also tested on SMD 2512 resistors and same PCB FR-4 board with ENIG 70µm. It was made experimentally only for one 2512 SMD resistor and will be tested further. For this reason, x-ray analysis was not performed and it is not possible to evaluate voids in solder joint now, but very good wettability and shape of joint was confirmed by visual analysis and therefore there is presumption of high reliability of this type of solder joint.

Preparing of solder joint can be seen on figure (4a). Firstly, the solder paste was printed through 150 µm cooper stencil, then was mounted SMD 2512 resistor and finally was mounted two SAC305 0603 solder preforms on each solder pad by SMT Manipulator and complete assembly was soldered in vapors. Result after soldering is shown on figure (4b).

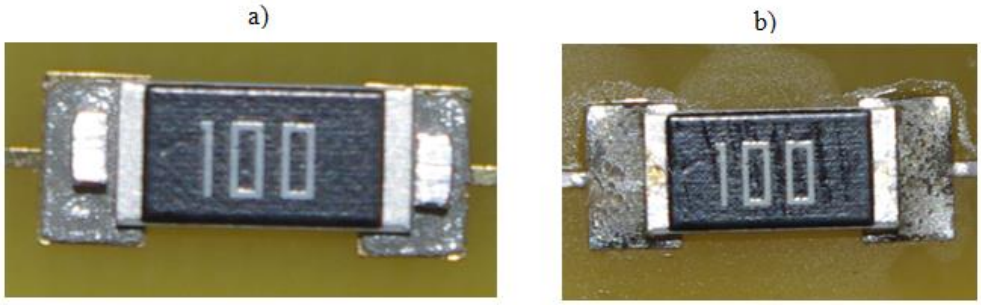

Figure 4: Solder fortification method – (a) Solder preforms mounted to paste before soldering in vapors (b) Solder preforms and solder paste after soldering in vapors

CONCLUSION

Article provides theoretical information about the area of solder preforms and possible reasons for application in surface mount assembly. There was made test board with solder preforms in the experiment and was compared with solder joints manufactured by solder paste. Differences between joints were evaluated and significant facts were identified. It was confirmed better wettability of solder joint with solder preform and very good shape of this solder joint. Then there was favorable size and number of voids and it is prerequisite for high reliability of solder joint. Main advantage of solder preforms is precise volume of solder in solder joint and it was verified on test boards because shapes of solder joints were very accurate and this is good for high level of repeatability of manufacture. Finally, it is possible to say that solder preforms have great importance and firm place in SMT assembly because solder joints with preforms had very good properties compared with solder joints achieved by solder paste. Interesting results were also obtained with solder fortification method. Solder joints with solder preforms will be further investigated in thermal cycling chamber.

ACKNOWLEDGEMENT

Funding for this research was obtained through grant project FEKT-S-14-2168 “Research for advanced and innovative technologies for interconnection and packaging in microelectronics”.

REFERENCES

[1] SOCHA, P. 2009. *Solder preforms basics* [online]. SMT ONLINE 2009 (Indium Corporation), 4p [cit. 2016-03-12]. Available from: http://www.indium.com

[2] ŠANDERA, J. 2010. *Technology and reliability of solder connection electronic modules and compoments [i.e. components] in surface mount assembly: short version of habilitation thesis*. Brno: VUTIUM. ISBN 978-80-214-4221-4.

[3] ENGELMAIER, W. 1989. *Surface Mount Solder Joint Long-term Reliability: Design, Testing, Prediction*. In: . AT&T Bell Laboratories, Whippany, New Jersey, USA: MCB UP Ltd, s. 9. DOI: http://dx.doi.org/10.1108/eb037660. ISSN 0954-0911.

[4] ŠVECOVÁ, O. 2012. *Reliability of lead-free solders and the selected methods to estimate its lifetime*. Brno. Doctoral thesis. Brno University of Technology, Faculty of Electrical Engineering and Communication. Supervisor of doctoral thesis Doc. Ing. Josef Šandera, PhD.

[5] *Solder fortification: Product datasheet* [online]. 2014. Indium Corporation [cit. 2016-03-02]. Available from: http://www.indium.com/

[6] *Indium8.9HF Pb-Free Solder Paste: Product datasheet* [online]. 2014. Indium Corporation [cit. 2016-03-02]. Available from: http://www.indium.com/