A RESEARCH ON SOLDER MASKS USING LEAD AND LEAD-FREE SOLDERS

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Keywords: leadfree, solder mask, soldering

This paper treats one of the questions concerning the soldering process at temperatures up to 290°C – the steadiness of the used solder masks. This research has been made because of the frequently usage of lead-free in the last years. It is known that the temperature processes of the lead-free solders differ from classic ones. They are characterized with higher temperatures, typically 10 to 30^o C. Time periods are longer, as well. This implies for the research on the heat resistance of solder masks during soldering. A research has been made and some microphotographs of tested examples are shown.

1. INTRODUCTION

The Surface Mounting Devices (SMD) is the main PCB assembly method in contemporary Electronics industry. The reason of its wide application is the number of advantages such as: usage of elements with smaller size; reducing the size of connections between them; the smaller mounting area; the ability of mounting components on both sides of PCB; the ability of constructing multilayer structures; the opportunity of automation the whole production cycle [1].

In Surface Mounting Technology (SMT) two main soldering methods are used – "reflow" and wave soldering. When using "reflow" soldering method preliminarily deposited solder paste is used. In following high temperature processing the solder paste melts and after cooling the solder joint is formed. This process is carried out in special ovens where temperature profile is preliminarily chosen. The temperature profile is the temperature dependency of time. When using wave soldering the pins of components are poured on with molten solder. These components are sticked with glue. This process is carried out in special wave soldering stands and the particular here is that the components' packages also contact with the molten solder [2].

Because of ecological considerations the usage of lead-free solders is necessary. It's due to the toxic of lead. It is known that the temperature processes of the lead-free solders differ from classic one. They are characterized with higher temperatures, typically 10 to 30^o C. Time periods are longer, as well. The substrate stays longer at the pick temperature as shown in the profile on fig.1. [3]

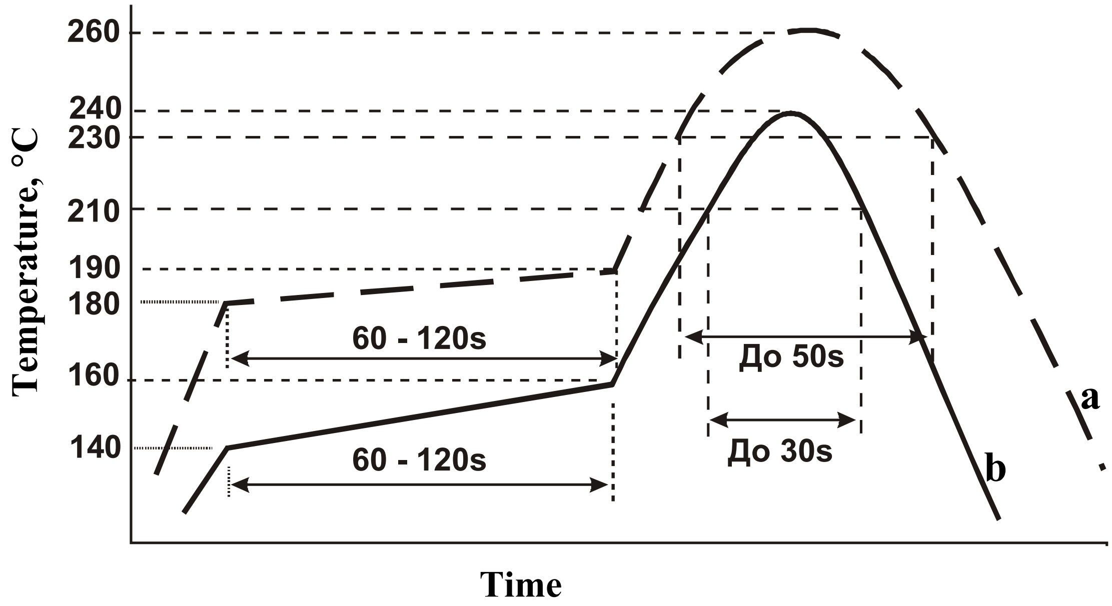

Figure 1. Temperaure profile of:

a)— — - lead-free solder paste; b) ——— lead-containing solder paste ;

All this implies for the research on the heat resistance of used materials and particularly the materials used for solder masks. The choise of the correct solder mask and its topology is important stage of PCB manufacturing. The solder mask reduces the surfaces to be soldered to the technically necessary sizes, prevents the solder gathering when using wave-soldering process. It also prevents the flow out of the solder when using the "reflow " soldering method. The solder mask reduces the risk of short circuits, caused by splattered solder and increases the resistance between tracks.

Due to the exploatation of the PCB the most suitable solder mask must be chosen. It has to respond to the following requirements: good temperature resistance when using "reflow" soldering method (which is extremely important at high temperature lead-free soldering); high strength; ability to work at high frequencies; to provide high corrosion resistance of metal parts;

2. ASSIGNMENT.

The significance of the solder masks used in technical process, requires to know their behaviour in soldering process. In order to do that it is necessary to research the process of soldering in PCB and the ability of solder mask to restrict the dissipation of solder. The assignment has to be accomplished in cases of higher lead-free soldering temperatures and the diversity of different topologies of masks and tracks.

3. RESEARCH.

When researching the topologies used by constructors of PCB has turned out that the tracks' sizes and topology forms vary from 100 to over 2000μm.

The variety of topology of solder mask is also very large. Topology types used by over than ten Bulgarian firms were taken into consideration. Topologies with angles, even smaller than 90°, are being used (fig.2) and also round, oval and special types of topologies, when working at high frequency. Effects of lifting the solder mask and getting of the solder under it can be observed in this paper. That may be result of topological or technological influence like not properly chosen solder mask, poor adhesion or high temperature.

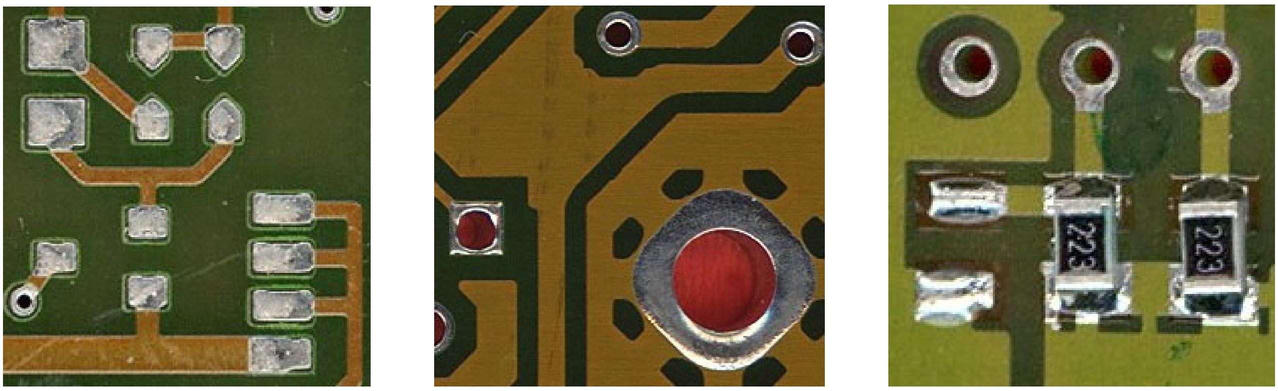

Figure 2. The variety of topologies of tracks, solder pads and solder masks

For the examination of the influence of tracks' and solder mask's topology upon flowing of lead-containing and lead-free solders a test structure has been developed. It includes a number of different types of topologies of tracks and masks and a part of which is shown on fig.3. This test structure gives the opportunity of solder masks with different width (from 40 to 160μm) to be researched. The distance between test structure and the solder source may vary.

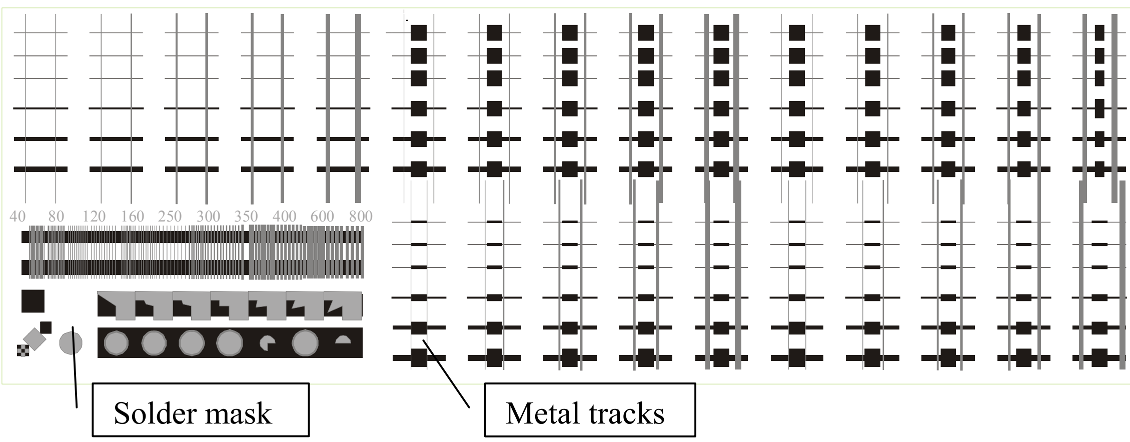

Figure 3. Examples of masks for testing the influence of topology in process of soldering.

A research of the behaviour of solder mask with different topology angle has been made and results of which are shown on microphotograph in fig.4.

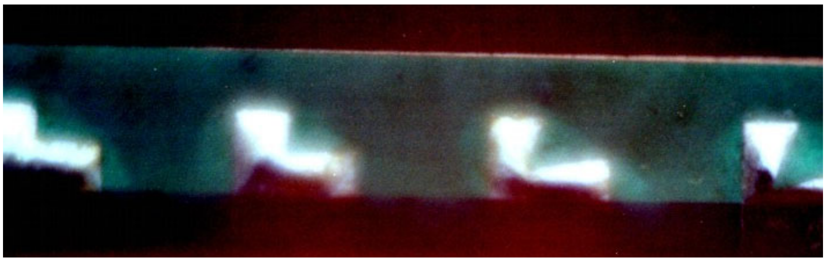

Figure 4. Examining the behaviour of solder mask with different topology angle.

It is very important to know the behaviour of solder mask when using topologies with angles smaller than 90° because appeared that the force with which the molten solder impacts the dividing line with the solder mask is considerably bigger in this cases, which is precondition for appearance of defects.

In this paper some of the most frequently used tests for solder masks are made using products of "Peters" [4].

The next test to be performed, consist in applying a definite amount of solder on the pads. Then, the distance the solder goes in the soldering process, moving along thin track (100µm) until it reaches solder mask which stands at distance of 240µm, is being recorded. This experiment is made in different soldering temperatures. In Table 1 the test results are shown and their graphical presentation can be viewed on fig.5.

Table 1		**Time, s**								
		2	4	6	8	10	12	14	16	20
DISTANCE, µm	T, 190°C	80	105	145	160	175	185	205		
	T, 210°C	95	115	160	185	210	235	240	240	240
	T, 230°C	130	180	225	240	240	240			

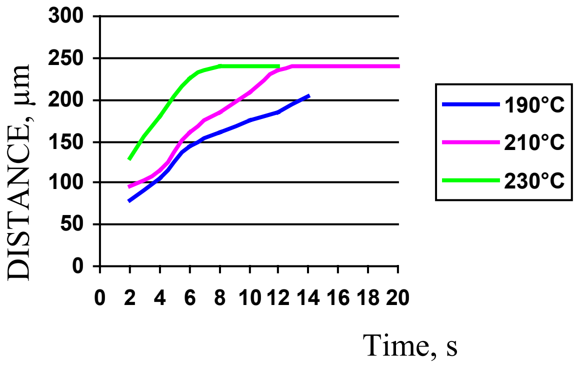

Figure 5. Graphical presentation

The conclusions to be made, is that at temperature of 190°C the wetting ability of the solder is poor. During the soldering process the copper plating of the track oxidizes and operates as resisting layer for the molten solder and prevents it from reaching the solder mask.

At temperature of 210°C the molten solder reaches the solder mask at the 14th second of the beginning of the process. This demonstrates good wetting ability of the solder at this temperature and the ability of the mask to provide its restriction.

At temperature of 230°C the process goes very rapidly and the solder mask is reached at the eighth second of the beginning of the process. In the time remaining to the end of soldering process the mask is in contact with the molten solder. In this case additional tests must be made in order to define whether the solder has lifted the solder mask.

These processes are shown in photographs of fig.6, where is also shown an example using wider track and thicker layer of solder mask. Getting of the solder under solder mask isn't being observed.

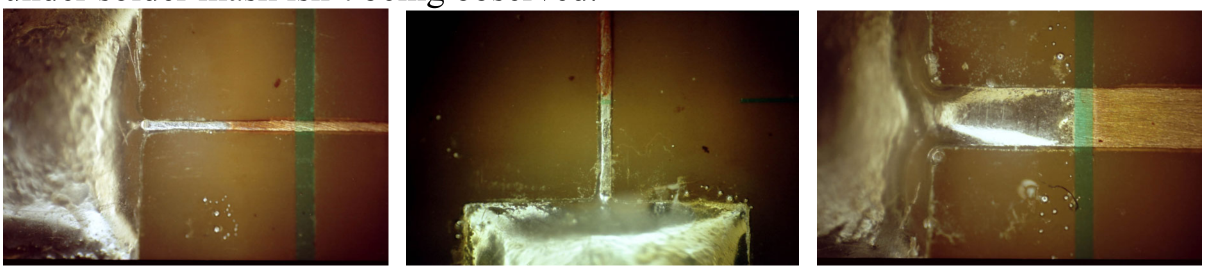

Figure 6. Microphotographs of made tests.

A number of experiments have been made in which an excessive amount of solder has been deposited at both sides of layer of solder mask and it's observed whether the molten solder will get upon the mask and blend in one drop during the soldering process. That was not observed which is evidence of good adhesion of solder mask to the surface it had been deposited on. This result also shows that the deposited layer is wide enough. This experiment is shown on the photographs in fig.7. Tests have also been made for determinating the behaviour of solder masks when using lead-containing and lead-free solders.

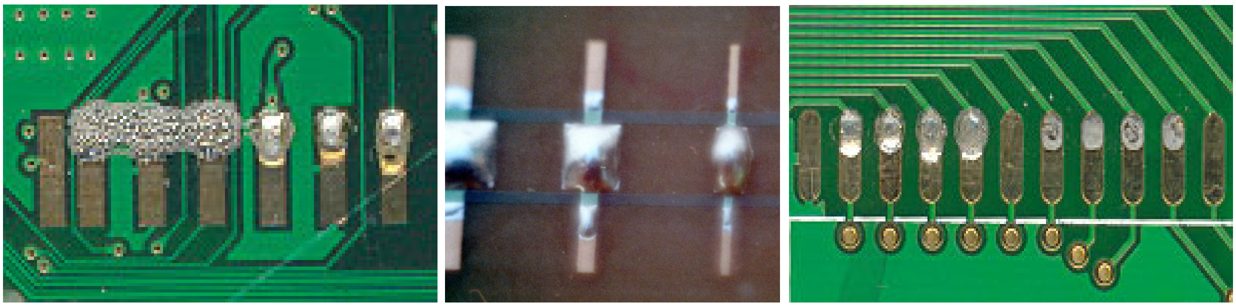

Figure 7. Microphotographs of tests made with lead-containing and lead-free solders

4. CONCLUSION

In this paper the problem of changed conditions for soldering with entering of the lead-free solder pastes have been examined. It's paid attention for the significance of the solder mask in the soldering process. For defining the functions as a protection mask the different topologies of tracks, solder pads and solder mask have been researched. For this purpose a special test structure have been invented. The researches in the temperature diapason 190°C - 290°C with lead-containing and lead-free solder pastes have been made. The effects, which the constructors can use in the designs, are shown.

5. LITERATURE

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[3] Marc Peo, Don DeAngelo – "Guide to Lead-Free Soldering" – SMT magazine – June 2001;

[4]Peters CD – "Merkblatthandbuch Report Manual" – Oct. 2003;