Ročník 2012 electroscope Číslo VI

Usage of inert atmosphere for solderability testing

T. Novák, J. Machač, F. Steiner
Department of Technologies and Measurement, Faculty of Electrical Engineering, ZCU, Pilsen,
Univerzitní 26, Plzeň
E-mail: novakt@ket.zcu.cz

Abstract:
The article presents the results of solderability testing of printed circuit boards. The aim of this paper is to compare different atmospheres for solderability testing with different finishes of printed circuit boards (PCB's). The article contains method descriptions that were used for solderability testing of printed circuit boards. The method of wetting balance test was chosen for this experiment.

The PCB can be made with several kinds of surface finishing. Copper is the most commonly used material in the manufacture of printed circuit boards. The negative copper property is its low chemical stability. When a contact is in an atmosphere that contains oxygen, the surface is covered with a layer of copper oxides. This layer deteriorates copper solderability. Another way how to prevent oxidation of copper soldering pads of printed circuit boards is an inert atmosphere. As an inert atmosphere does not contain oxygen and prevents oxidation of the material used on PCB's. The increasingly frequent introduction of inert atmospheres into soldering processes encourages the introduction of a inert atmosphere also in solderability testing processes.

INTRODUCTION

Soldering is one of the most important processes in electronic device production. The objective of soldering is to achieve mechanically unyielding, electrically conductive, and the long-term reliable joint. There are several tests to estimate how suitable for soldering processes a material is. For use in soldering, materials must have suitable solderability.

Solderability is not only an ability of solder flushing on the surface. Solderability is a complex of properties which designates how much is the material suitable for industrial soldering. These properties are for example good wetting, mechanical and chemical straining immunity during clean process, or thermal straining immunity of Printed Circuit Boards (PCBs). Solderability is not invariable parameter. During time, it changes according to surrounding effects which influence material surface. Solderability gets worse in consequences of surface corrosive change, inception of intermetallic adducts on material surface or the way of holding in storage. The material can be kept on air, where can oxidize, or can be kept in boxes with inert atmosphere.

Wetting is nearly related to solderability, which has already been mentioned. Wetting can be explained as an ability of surface, which determines how the surface could be wetted by molten solder. To achieve good wetting, the surface must be quit of all contaminations. [1, 3]

SOLDERABILITY TESTING

Solderability is one of the most important properties of devices and printed circuit boards for electronic equipment production. Therefore, it is important to test this property. Solderability testing can find out how good or poor the surface solderability is and how the surface will be wetted by a solder.

There are two basic groups of solderability tests. Qualitative tests are mainly based on optical criteria. Disadvantage is subjective assessment. The second group of testes is quantitative tests. These tests are based on measuring of actual wetting characteristics. All tests are described in relevant standards. For this experiment wetting balance test was chosen. [1].

The wetting balance test makes possible to measure the vertical forces (buoyancy force and wetting force), which effect on tested sample, as function of time. The principle of wetting balance test and wetting force chart are shown in Fig. 1. This test is carried out in several steps: flux is applied on a tested sample and then the tested sample is placed on a sensitive force transducer above a bath with a molten solder. Thereafter, the tested sample is immersed into a molten solder and vertical forces are recorded as a function of the time. At the end of test, the tested sample is pulled out of a molten solder. [2,4]

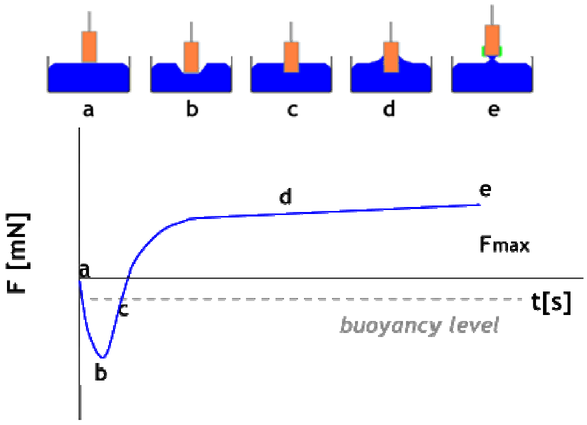


Fig. 1: Procedure of wetting balance test

INERT ATMOSPHERE

Inert atmosphere protects the surface that does not contain any chemical elements that could react with the surface and affect its chemical composition. It has a great importance for soldering, since formation of oxides is well reduced. It follows that the use of inert atmosphere for soldering process is beneficial. Inert gases are used to create an inert atmosphere, for example: nitrogen, argon, hydrogen. A soldering inert atmosphere is often provided by the nitrogen. It is mainly about the availability and economic demands of purchase.

The advantages of the inert atmosphere usage are for example: preventing oxidation of soldered surfaces, better solder spreading, slag reduction, easier cleaning after soldering or fewer defects during soldering of small-pin-pitch components. On the other side, usage of inert atmosphere has also disadvantages, for example: high purchase and operating costs, greater risk of certain defects during soldering – tombstone effect or creation of small solder balls on the PCB. [6]

Soldering process is performed at high temperatures. Heat values are in range from 100 °C to 450 °C for soldering, which is used in electrical engineering. In the air, which is present everywhere around the soldering process is contained oxygen, which adversely affects the soldering process. Oxygen causes oxidation of materials. The problem is the oxidation of solder, solder components and printed circuit boards, which are stored in warehouses or other places designated for this purpose. These oxides can be regulated quite well by fluxes. Flux is applied before the soldering process on soldering pads separately or included in the solder paste. However, the flux can greatly influence the reliability, durability and quality of solder joints. This leads to a reduction or even exclusion flux from the process of soldering. For this reason, looking for other possible solutions to eliminate or more prevent the emergence of oxides in the soldering process. From the process of oxides formation it is clear that one way to prevent their formation during the soldering process is the use of inert atmospheres. The amount of oxygen that can react with the materials during the soldering process is very favorably reduced by the use of inert atmospheres. The residual oxygen values are referred by the acronym ROL (Residual Oxygen Level). Flux removes oxides from the PCB before soldering. Inert atmosphere ensures that there will not form solder oxides during soldering. This implies that using inert atmospheres to prevent access of oxygen into the soldering process. Solder paste with smaller containing flux can be used. The contents of the fluxes and their activities during the soldering process are less and it is easier to clean PCB's after soldering. One reason for easier cleaning is the fact that the flux residues (slag) are not oxidized in an inert atmosphere. Otherwise, it is not in the maintenance and subsequent cleaning of soldering machines. Using an inert atmosphere reaches higher surface tension of the solder material and significantly better wetting on surfaces. This assumption leads to a higher quality of solder joints. Other reasons for the use an inert atmosphere are among others, soldering still smaller devices with smaller spacing between terminals, the growing demand for quality solder joints or more stringent requirements relating to the environment.

Frequent use of inert atmosphere in the process of soldering leads to the introduction of an inert atmosphere in the process of the solderability testing. During testing, we try to bring as much as possible for the conditions in which the tested material is processed. [5]

MATERIALS AND EXPERIMENTAL PROCEDURE

Solderability of PCB coupons with several finish surfaces was measured in this experiment. The wetting balance test was chosen as a testing method. The tester of solderability ConCoat MUST System II (Solderability Test System for Surface Mount and Conventional Components) was used for wetting forces measurement.

Test sample

Test samples (coupons) were made of PCB with dimensions 25 x 15 mm and 0.6 mm thickness, shows in Fig. 2. Metal profile was created on both side of each tested sample. Each side of test sample has six rectangles with dimensions 6 x 3 mm. Test samples have various surface finishes or various metal surfaces. Chosen surface finishes are describe in Tab. 1.

Tab. 1: Chosen surface finishes

Surface finishes of tested samples	
Cu	Copper
SnC	Chemical tin
SnG	Galvanic tin
OSP	Organic Solderability preservative
Au	ENIG

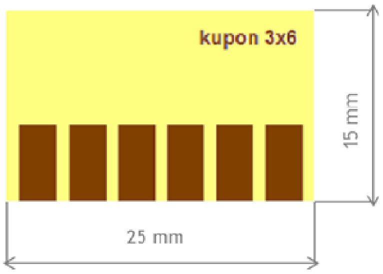


Fig. 2: Tested sample

Experiment procedure

Tested samples were cut from a large PCB. The test samples had flashes around edges after cutting. Therefore, the samples were ground by a metallographic grinder. The last change of tested samples was the flux application before the measurement. Then the solderability test was carried out. For this experiment, lead-free solder alloy SAC 305 (Sn3Ag0.5Cu) was chosen. The tested parameters were: solder temperature 245 °C, immersion depth: 2 mm, immersion time: 10 s, immersion speed: 20 mm/s. When all test parameters were set, there was a need of an inert atmosphere creation around the solderability tester. Solderability tester was placed in a perspex box (Fig. 3), where inert gas (nitrogen) was infused. The residual oxygen analyzer evaluated the atmosphere in the perspex box and controlled the limits of residual oxygen by closing or opening the valve, which launched an inert gas into the box. After reaching the desired value of the residual oxygen, solderability test started. Solderability testing was conducted in a normal and an inert atmosphere.

MEASURED VALUES AND RESULTS

In Fig. 3-7, wetting force curves of tested samples with various surface finishes are shown. Four test samples were tested for all combination of surface finishes and inert or normal atmospheres. The resultant value of wetting force is an average of all measured values for each combination. Each figure presents one surface finishes and different value of residual oxygen. Some of solderability tests are based on visual assessment wettability. It is also good wetting balance test to supplement this assessment. Fig. 8-12 shows testes samples after testing by wetting balance test in normal atmosphere and inert atmosphere with residual oxygen level 1000 ppm.

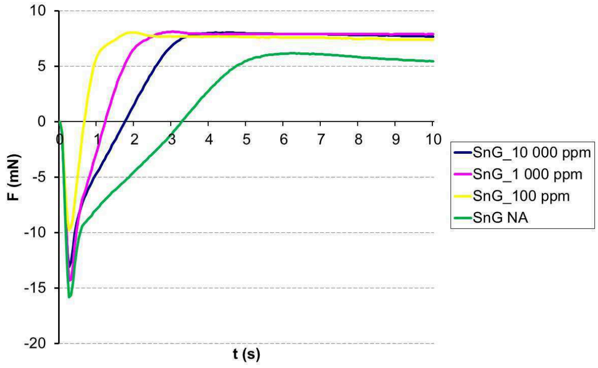


Fig. 3: Wetting balance of galvanic tin

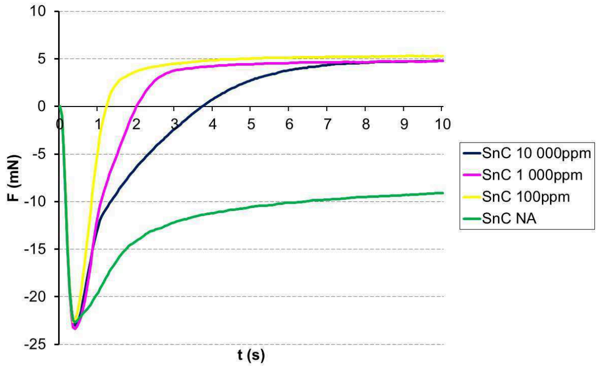


Fig. 4: Wetting balance of chemical tin

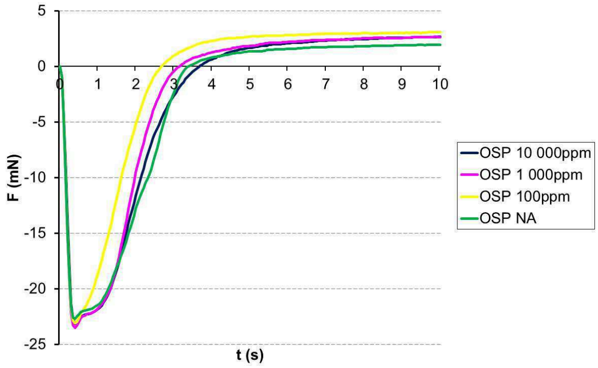


Fig. 5: Wetting balance of OSP

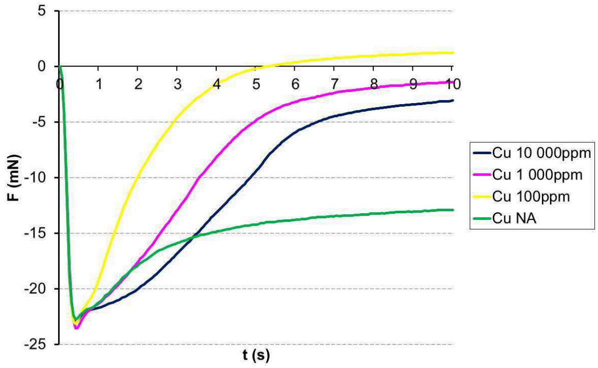


Fig. 6: Wetting balance of copper

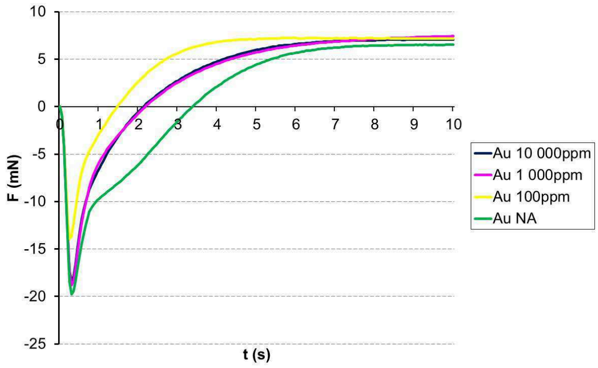
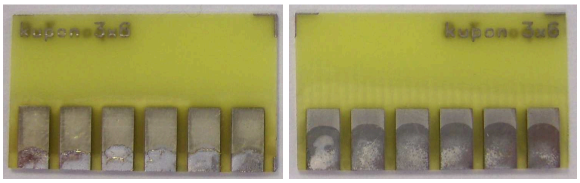


Fig. 7: Wetting balance of ENIG

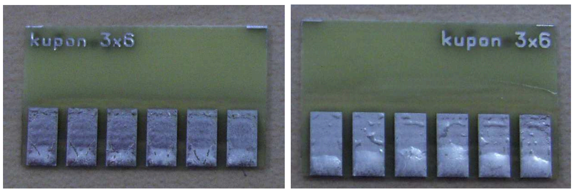


a) b)

Fig. 8: Tested samples SnC: a) NA, b) 1000ppm

a) b)

Fig. 9: Tested samples Cu: a) NA, b) 1000ppm

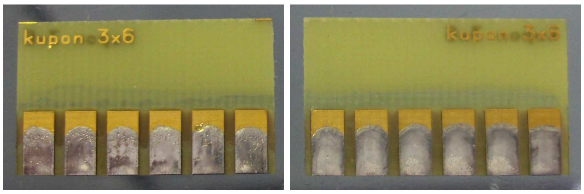


a) b)

Fig. 10: Tested samples SnG: a) NA, b) 1000ppm

a) b)

Fig. 11: Tested samples OSP: a) NA, b) 1000ppm



a) b)

Fig. 12: Tested samples ENIG: a) NA, b) 1000ppm

DISCUSSION AND CONCLUSIONS

The main contribution of this paper was investigation of influence of nitrogen atmosphere on solderability different surface finishes. The influence of an inert atmosphere is advantage for soldering process that is shown from measured values. It was confirmed that an inert atmosphere created by nitrogen improves surface solderability of tested samples. Fig. 4-8 shows that the difference between the wetting force in a normal atmosphere and in an inert atmosphere is considerable. The biggest differences are seen at the surfaces of copper and chemical tin. Conversely, the smallest effect of an inert atmosphere on solderability is seen at the surface of the OSP and ENIG. Solderability test showed that decreasing oxygen content in the soldering process improves the surface solderability. This increases the wetting force and the surface tension. It brings the soldering process that ensures a higher quality of solder joints. For the production of electronic equipment, this phenomenon is very important and determines which direction it is possible to head as far as the issue of lead-free soldering is concerned. It also indicates the importance of knowing the solderability of surfaces for production planning in terms of scrap and error rate.

ACKNOWLEDGMENTS

The paper is part report and has been supported by the research plan of Ministry of Education, Youth and Sports of Czech Republic no. CZ.1.0.5/2.1.00/03.094 “Regional Innovation Center for Electrical Engineering (RICE)” and by the Student Grant Agency of the West Bohemia University in Pilsen, grant No. SGS-2012-026 "Material and Technology Systems in Electrical Engineering“

REFERENCES

[1] WASSINK, R. J. K. Soldering in Electronics: A Comprehensive Treatise on Soldering Technology for Surface Mounting and Through-hole Techniques. 2nd ed. Port Erin: Electrochemical Publications, 1994.

[2] User manual Must systems II, ConCoat 2004.

[3] STEINER F., HARANT P.; Solderability of the lead free surface finishes. The Electronics System Integration Technology Conferences ESTC 2006, pages. 365-369, 2006. ISBN 1-4244-0553-X, Dresden.

[4] IPC/EIA J-STD-003A Joint industry standard – Solderability Tests for Printed Boards, February 2003.

[5] MORAVEC,S.,VALENTA,M.,ARSLANIAN,G. ,K.: Lead-free soldering at inert atmosphere. Proceedings of 3rd European Microelectronics and Packaging Symposium, Prague 16th to 18th June 2004, Czech Republic, ISNB 80-239-2835-X.