Solderability Measurement of Copper with Different Surface Finishes

Karel Dušek, Michal Novák, Pavel Mach

Czech Technical University in Prague, Faculty of Electrical Engineering,
Department of Electrotechnology, Technická 2, Prague 6, 166 27, Czech Republic
Email address: dusekk1@fel.cvut.cz

***Abstract**: This article deals with solders wettability measurement of materials with different surface finishes, which are commonly used as solder pads on printed circuit board. The measurement was carried out on two type of solders (Sn63Pb37, Sn95,5Ag3,8Cu0,7), two types of fluxes (94-RXZ-M (IPC-ANCI-J-STD-004 - REL0), 323-ITV (C-ANCI-J-STD-004 - REL1)) and as testing material we used one-side plating PCB (FR4) with four types of surface finishes (pasivated copper, H.A.L, immersion tin, chemical gold plating). For the measurement we have used one of the commonly used wettability evaluation methods - wetting balance (meniscograph) method. Wetting balance method measures the wetting force when the test specimen is immersed into the molten solder bath. Wetting force is measured as a function of time and recorded as wetting curve. We marked the wettability, according to the shape of wetting curve, for each testing combination and sorted them into the table.*

1. Introduction

Wettability is an essential characteristic of a soldering system for electronics. One of the most commonly used wettability evaluation methods is a wetting balance (meniscograph) method used to measure the wetting force. The wetting balance test is sometimes called a meniscograph test. The set-up diagram of the wetting balance tester (meniscograph) is shown in figure 1 and in figure 2 is the photo of our used wetting balance tester (meniscograph).

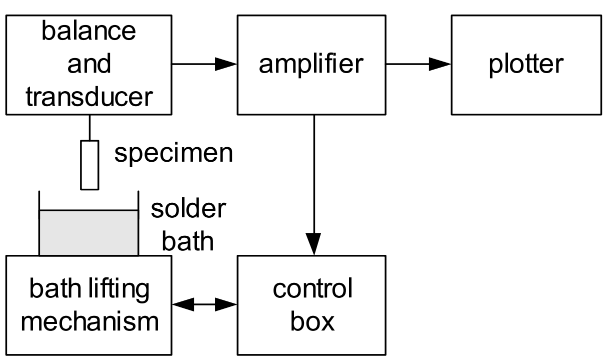

Fig. 1. Set-up diagram of the wetting balance tester (meniscograph)

The meniscograph is able to assess qualitatively the wetting of liquids (molten solders) on various substrates. It is a flexible tool for quality process control, which evaluates the critical parameters of the wetting process.

Fig. 2. Wetting balance tester (meniscograph)

2. Theory

The wetting balance test measures the wetting force when the test specimen is immersed into the molten solder bath. This wetting force is measured as a function of time and it is automatically recorded. Figure 3 shows a vertical schematic illustration of the

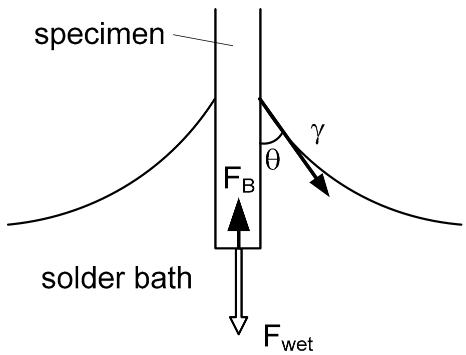

Fig. 3. Schematic illustration of the force equilibrium during wetting

force equilibrium during wetting of the sample. A schematic wetting curve for a stick and non-stick specimen is shown in figure 4.

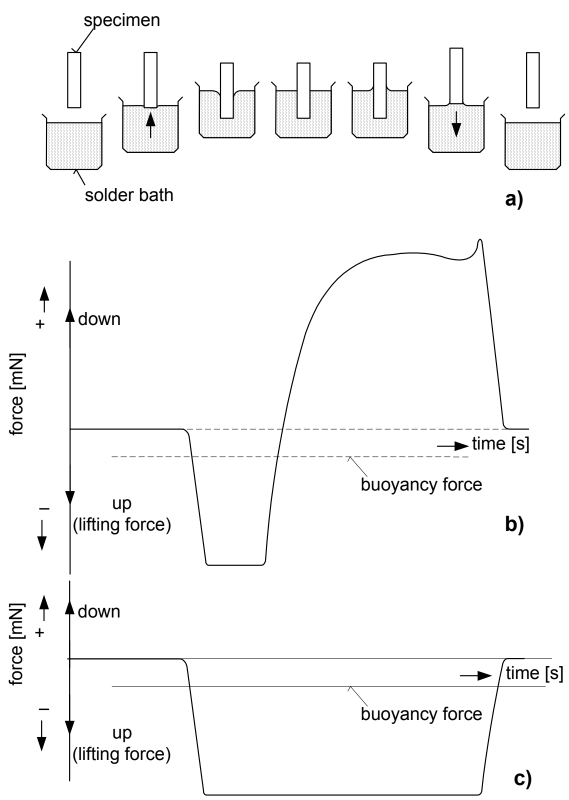

Fig. 4. Schematic wetting curve a) sample position against the molten solder b) wetting curve for wetting specimen c) wetting curve for non-wetting specimen

The specimen is immersed to a set depth and time in a bath of molten solder with the controlled temperature. The specimen is subjected to time-variant vertical forces, which consist of the surface tension force and buoyance force. It is described in the following equation [1]:

$$F_{wet} = F_{\gamma} - F_b = P\,\gamma\cos\Theta - \rho\,g\,V \qquad (1)$$

where:

F_{wet} - measured wetting force (N)

F_{γ} - surface tension force (N)

F_b - buoyancy force (N)

γ - surface tension ($N.m^{-1}$)

P - specimen perimeter (m)

Θ - contact angle of the γ on the solid surface

g - gravitational acceleration (9.81 $m.s^{-2}$)

ρ - solder density ($kg.m^{-3}$)

V - immersed volume (m^3)

The buoyancy force is given by the density of the solder, gravitational acceleration and immersed volume of the specimen. Therefore the buoyancy force is considered as constant. The specimen perimeter is also considered as constant. That's why the wetting force varies as a function of the surface tension and contact angle [2].

3. Measurements and Experimental Results

The measurement was carried out on two types of solders lead (Sn63PB37) and lead free (Sn96,5Ag3,8Cu0,7) , two types of fluxes (94-RXZ-M, 323-ITV) specification of fluxes is in table 1) and as testing material we used one-side plating PCB (FR4) with four types of surface finishes (passivated copper, H.A.L, immersion tin, chemical gold plating). Photo of used samples is in figure 5.

Tab. 1. Specification of used fluxes

Flux	Flux description	Flux Designator
94-RXZ-M	Semi-water flux for lead soldering	REL0
323-ITV	Alcoholic flux for lead free soldering	REL1

Fig. 5. Photo of the used samples (with different surface finishes) after measurement.

As measuring equipment we used GEC Meniscograph – solderability tester Mk 6

Immersion speed was 10 mm/s. Immersion depth of the sample was 5 mm. Time of immersion was 5 s. Oxides were sponged away from the surface of the molten solder before each measurement. The measurements were repeated at least several times. All solder alloys were measured in an ambient atmosphere. Temperatures of molten solders were set at 250 °C. Oxides were sponged away from the surface of the molten solder before each measurement. The measurements were repeated at least several times.

We classified by marks each testing combination (solder, flux and specimens material) according to the shape of the wetting curve. Mark 1 means best wettability from measured file of samples and worst wettability is marked by 10. The results are sorted the into the table 2

The following examples describe some of the characteristics shapes of the measured wetting curves marked by 1 and by 10. In figure 6 is an example of wetting curve for immersion tin, Sn95,5Ag3,8Cu0,7 solder and flux 323-ITV. This combination was marked by 1 - best wetting combination. In figure 7 is an example of the wetting curve for passivated copper, Sn63Pb37 solder and none flux. This measured curve was marked by 10 – worst wetting combination. In figure 6 and 7 we could see the little

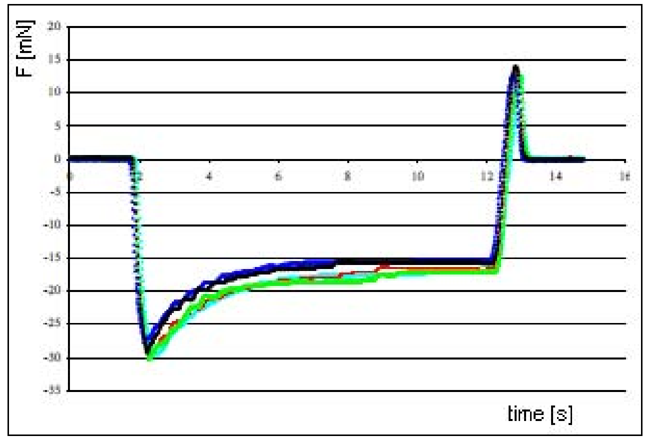

Fig. 6. Example of measured wetting curve for immersion tin, Sn95,5Ag3,8Cu0,7 solder and flux 323-ITV.

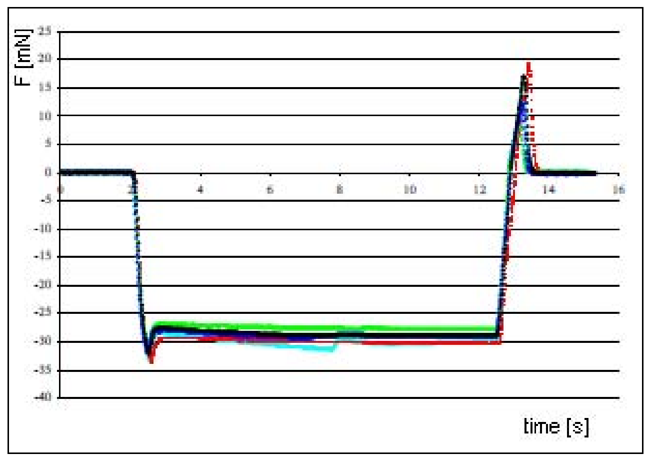

Fig. 7. Example of measured wetting curve for pasivated copper, Sn63Pb37 solder and none flux.

Tab.2. Wettability quantification from measured file based on shape of wetting curve. (mark 1- best wettability, mark 10 worst wetability)

solder	Flux	Testing material			
		pasivated copper + FR4	H.A.L. + FR4	immersion tin + FR4	chemical gold plating + FR4
Sn96Pb37	without flux	10	10	10	9
	94-RXZ-M	4	7	9	5
	323-ITV	2	4	9	3
Sn95,5Ag3,8Cu0,7	without flux	10	10	10	9
	94-RXZ-M	3	5	6	7
	323-ITV	1	6	1	5

“waves” on the shape of the wetting curves. This waves is given by the roughness of the own base material FR4. The results of the worst and best wettability of used solder fluxes and testing material are obvious from table 2.

4. Conclusion

We have measured combination of the different type of lead and lead-free solder and different types of fluxes and testing materials. The results of measurement we classified into the table according to the shape of wetting curve. The results of the worst and best wettability of used solder fluxes and testing material are obvious from table 2.

5. Acknowledgment

This work was supported by grants: MSM No.6840770021 – Diagnostic of Materials and by the Grant Agency of the Czech Technical University in Prague, grant No. SGS10/062/OHK3/1T/13

References

[1] Wassink, R.J.K.: Soldering in Elecgtronics. Second Edition. Electrochemical Publications Ltd, Ayr Scotland 1989. ISBN 090115024X.

[2] Dušek K., Urbánek, J. Mach P.: Study of Influence of Working Conditions on Changes of the Surface Tension of Solders, SIITME 2006, Iasi, Romania 2006 str.23-27 ISBN: 978-973-896-4