Wetting Force Measurement of the Different Types of Solders and Testing Materials

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***Abstract**: We have used one of the most commonly used wetability evaluation methods - wetting balance (meniscograph) method to measure the wetting force. We have made a modification of the measuring equipment to measure a less quantity of the solder. We have measured a combination of different types of the lead and lead-free solders and different types of the testing materials. The measurement was carried out on nine different types of solders (Sn63Pb37, Sn95Sb5, Sn95Sb3,5Cu1,5, Sn96Ag4, Sn95,5Ag3,8Cu0,7, Sn97Bi2Cu1, Sn97Cu3, Sn99Cu1, Sn99,75), three types of testing materials (copper, nickel and brass) and three types of fluxes. All measurements nine solders ware measured in ambient atmosphere and two lead-free solders were (Sn96Ag4, Sn95,5Ag3,8Cu0,7) measured in inert atmosphere. The results of measurements we classified into the table according to he shape of wetting curve and according to the visual control.*

1. INTRODUCTION

Wettability is an essential characteristic of a soldering system for electronics. One of the most commonly used wetability evaluation methods is a wetting balance (meniscograph) method 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.

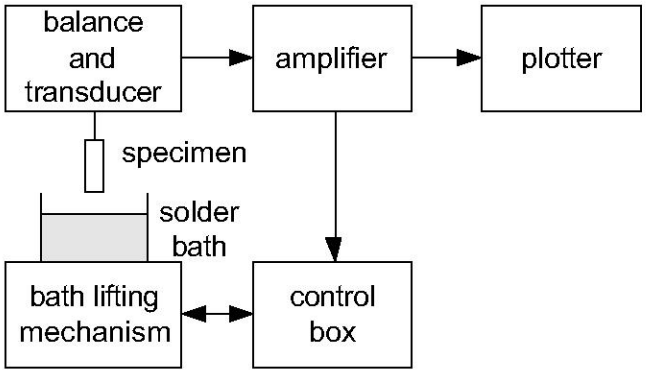

Fig.1. Set-up diagram of the wetting balance tester (meniscograph)

The Meniscograph is able to assess qualitatively the wetting of liquids (molten solders) on various substrates. and provides a flexible development or quality process control tool, measuring the critical parameters of the wetting process.

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 automatically recorded. A schematic wetting curve is shown in Figure 2.

The specimen is immersed to a set depth and time in a bath of molten solder at a controlled temperature. The specimen is subjected to time-variant vertical forces, which consist of the surface tension force and buoyance force.

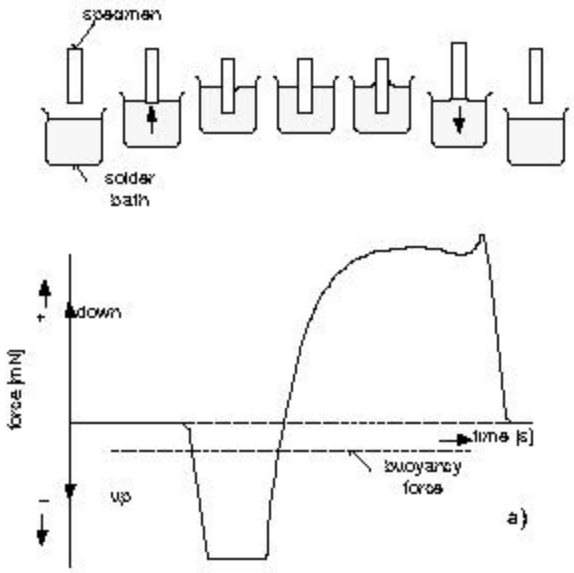

Fig.2. Schematic wetting curve

2. MODIFICATION OF MEASURING EQUIPMENT

The meniscograph modification has been done in order to measure a less quantity of the solder.

The modification is based on the small bucket, which is immersed into the bath of molten solder. The small bucket is filled by concrete solder. We have also checked the temperature of the solder in the small bucket with the temperature of the surrounding solder and the molten solder in the small bucket has the same temperature as the surrounding solder.

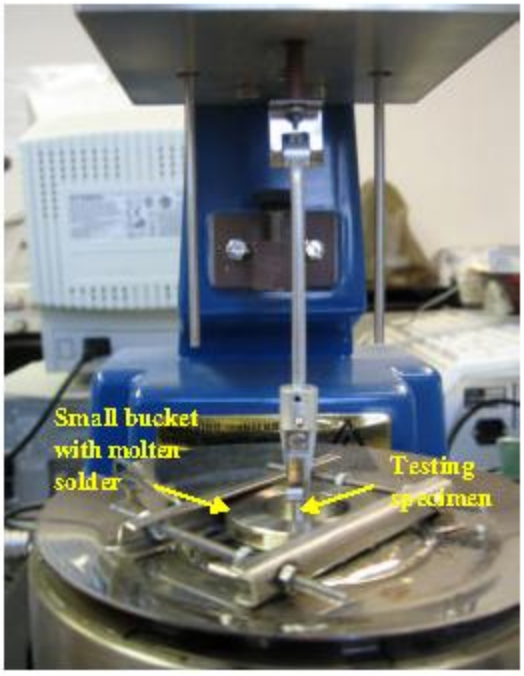

Fig.3. Measurement of the testing sample

3. EXPERIMENTS AND RESULTS

The measurement was carried out on nine different types of solders (Sn63Pb37, Sn95Sb5, Sn95Sb3,5Cu1,5, Sn96Ag4, Sn95,5Ag3,8Cu0,7, Sn97Bi2Cu1, Sn97Cu3, Sn99Cu1, Sn99,75) on three kinds of testing samples (wires with 1mm diameter) copper, nickel, brass and on three types of fluxes: Epsilon 5M (no-clean flux, for lead-free solders), Epsilon 5 (no clean flux, for lead-free solders), Epsilon 2 (universal flux for soldering in electronics assembly)

Used measuring equipment: GEC Meniscograph – solderability tester Mk 6; digital memory oscilloscope (Agilent - model number 54621A") for the force amplitude evaluation. Oxides were sponged away from the surface of the molten solder before each measurement. The measurements were repeated at least several times.

All measurements with nine solders were done in ambient atmosphere and two lead-free solders were (Sn96Ag4, Sn95,5Ag3,8Cu0,7) measured in inert atmosphere.

We compared measured wetting balance curves in nitrogen atmosphere with the measured curves in ambient atmosphere. In figure 4 and figure 5 are examples of measured wetting curves in ambient and nitrogen atmosphere for SnAg4 solder, flux: Epsilon 5 and material of testing specimen: nickel. We can say that the wetting balance curves are almost equal. It is caused by the fact that the oxides ware sponged away from the surface of the molten solder before each measurement. The nitrogen atmosphere also changes a surface tension, but this change is minor [1] against the influence of the oxides. After the measurements of the wettability we made a visual control of the samples surfaces on the microscope.

Than we made a table (tab.1) for the samples which had been measured in ambient atmosphere. In table we classified by marks each testing combination (solder, flux and specimens material) according to the shape of the wetting curve and according to the visual

material	flux	solder				
		Sn63Pb37	SnAg4	Sn95,5Ag3,8Cu0,7	Sn97Cu3	Sn99Cu1
copper	without	10	10	10	10	10
	Epsilon M5	5	9	8	9	8
	Epsilon 5	4	8	6	9	8
	Epsilon 2	1	4	4	9	8
nickel	without	10	10	10	10	10
	Epsilon M5	2	2	2	8	7
	Epsilon 5	2	2	2	5	5
	Epsilon 2	1	2	2	3	3
brass	without	10	10	10	10	10
	Epsilon M5	5	7	8	9	8
	Epsilon 5	5	6	5	6	6
	Epsilon 2	4	3	4	4	4

material	flux	solder			
		Sn95Sb3,5Cu1,5	Sn95Sb5	Sn97Bi2Cu1	Sn99,75
copper	without	10	10	10	10
	Epsilon M5	10	10	9	9
	Epsilon 5	10	10	8	9
	Epsilon 2	10	10	7	9
nickel	without	10	10	10	10
	Epsilon M5	6	9	5	7
	Epsilon 5	6	8	3	5
	Epsilon 2	6	8	3	4
brass	without	10	10	10	10
	Epsilon M5	10	9	8	9
	Epsilon 5	8	8	6	7
	Epsilon 2	7	9	4	6

Tab. 1. Classification table for each testing combination (solder, flux and specimens material)

control. Mark 1 means the good wettability and bad wettability is marked by 10. In figure 5 and 6 is an example of wetting curve for non-wetted (mark 10) and wetted (mark 1) combination of the solder, flux and material of testing specimen. In figure 6 and 7 is an example of wetting curve for non-wetted (mark 10) and wetted (mark 1) combination of the solder, flux and material of testing specimen.

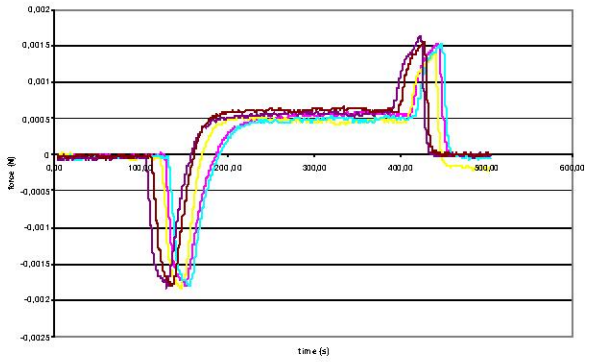

Fig. 4. Measured wetting curves in ambient atmosphere for SnAg4 solder, flux: Epsilon 5 and material of testing specimen: nickel

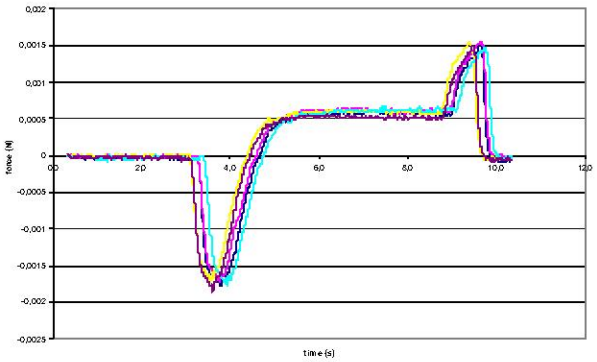

Fig. 5. Measured wetting curves in nitrogen atmosphere for SnAg4 solder, flux: Epsilon 5 and material of testing specimen: nickel

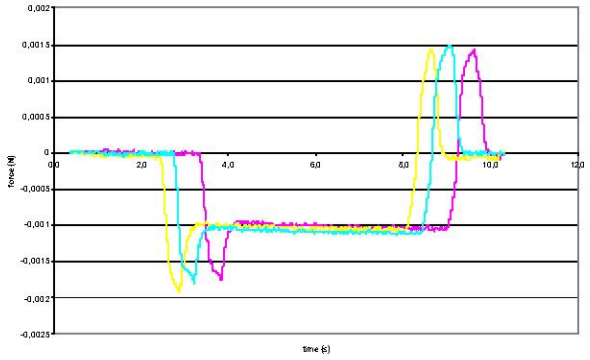

Fig. 6. Measured wetting curves (mark 10) in ambient atmosphere for Sn63Pb37 solder, without flux and material of testing specimen: copper

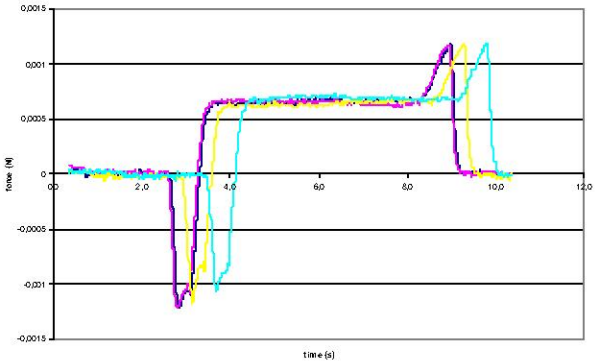

Fig. 7. Measured wetting curves (mark 1) in ambient atmosphere for Sn63Pb37 solder, flux: Epsilon 2 and material of testing specimen: copper

4. Conclusion

We have made a modification of the measuring equipment to measure a less quantity of the solder.

We have measured combination of the different types of the lead and lead-free solders and different types of the testing materials. The results of measurement we classified into the table according to the shape of wetting curve and according to the visual control. We have measured two solders in ambient and nitrogen atmosphere. The influence of nitrogen is minor if we sponged oxides away from the solder level before measurement.

From table is perceptible that the combinations of specimen material and solder without usage flux are nonstick. The major influence on wettability has using of flux. From overall assessment we can say that the flux Epsilon 2 is generally most suitable. From overall assessment we can say that the best wetability has lead solder Sn63Pb37. In complex view Sn95,5Ag,8Cu0,7 solder has best wet ability compared to all lead free solders.

Acknowledgments

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References

[1] Dušek K. Urbánek J.: Influence of the reduced oxygen concentration on the wetting force, 29th International Spring Seminar on Electronics Technology 2006, Dresen Germany str.: 195-199, ISBN:1-4244-0551-

[2] Hwang, J.S.:Environment-friendly Electronics: Lead-free Technology. Electrochemical Publications Ltd.