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Solderability of Electrical Components and Copper using Lead-Free Alloys

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ABSTRACT:

As the move towards lead-free soldering gathers pace, there is keen interest in issues of solderability, arguably the key parameter for successful implementation of these new soldering technologies. This report presents the results of a large experiment to generate relevant solderability data using the wetting balance technique. The matrix experiment involved 20 component types (including both surface mount and through hole), copper coupons, 3 lead-free solders, 5 fluxes, a range of superheat temperatures, and two soldering atmospheres. The results were bench-marked against those for conventional SnPb solder.

The results demonstrate that nitrogen inerting is beneficial to solderability when unactivated rosin fluxes are used. Coupled with the lower superheat associated with lead-free solder alloys, this should result in a much wider industrial use of nitrogen inerting. The soldering temperature appears to exert a greater influence on solderability than no-clean flux chemistry. Of the lead-free alloys explored, SnAgCu appear to be the most attractive – it gives the best wetting characteristics, and it has the lowest soldering temperature. SnCu performed poorly, often with unacceptable solderability behaviour, even at the highest superheat. However, a key outcome of this work is that alloy selection for each component type is important, and that optimal selection is possible. The influence on solderability of flux type, temperature and solder type for each of the 20 component types has been calculated in this work. Relevant data, including typical wetting forces and wetting times, are listed in Appendices.

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
Head, Centre for Materials Measurement and Technology

CONTENTS

1. INTRODUCTION

As the issue of lead-free soldering becomes more important as a result of both legislative and commercial drivers, the need to establish alternatives to SnPb solder is being addressed. NPL is undertaking a number of projects to assist in this move to new soldering technologies. This project aims to address the issue of changes in solderability of lead-free solders for different component types, both surface mount and through hole, for a range of lead-free solder alloys and various flux compositions. It is well known that temperature is an influential factor in wetting behaviour and hence a range of superheat temperatures has been used in this study. Some basic studies are reported using copper coupons, and furthermore measurements have also been made in a nitrogen environment.

The well established wetting balance test has been used for this investigation, to give a detailed picture of solderability for an extensive number of component, alloy and flux combinations. Both wetting time and wetting force data are presented.

2. EXPERIMENT

Copper coupons were tested with two fluxes, A and D, and three lead-free alloys over a range of temperatures in air and in nitrogen. Five coupons were tested for each test combination and the alloys were: SnAg, SnCu and SnAgCu. The copper coupons dimensions were 25 x 12 x 0.1mm. Wetting balance measurements were taken in a nitrogen environment of 500ppm oxygen, and in an air atmosphere.

Twenty component types were tested using three lead-free solder alloys and five different fluxes for three superheat temperatures. The test components comprised surface mount and through hole types, and the SOIC components included two termination finishes, SnPb and PdNi. The wide range of parameters gave a matrix, which represented 900 different test combinations, and a Design of Experiment (DOE) approach was used to reduce this number to a more manageable level. The original number of 900 test combinations was reduced by 55% to 400 test combinations. Five terminations were tested from each component type.

All the component tests were carried out in air under ambient laboratory conditions. Tables 1 and 2 give the technical data for the solder alloys and fluxes, and the test parameter combinations. The flux, alloy and superheat codings in Table 1 are used throughout this work. Details of the test matrix from the DoE, 20 conditions in all, are summarised in Table 2. Each component type was tested under these 20 conditions. The parameter combination follows the code in Table 1,and Table 3 lists the test components.

Table 1: Details of Test Flux, Alloys and Temperatures

Code	Flux	Description	
1	A	Pure rosin, 0.5% halide activated flux from Multicore Solders	
2	B	Low solids, no-clean, non-halide activated flux from Alpha	
3	C	No-clean, low solids, activated flux from Alpha	
4	D	Pure rosin, non-activated flux from Multicore Solders	
5	E	VOC-free, no-clean, halide free, low solids flux from Alpha	
Code	Alloy	Composition %	Melting point ^{0}C
1	SnAgCu	95.5/3.8/0.7	217
2	SnAg	Bath: 98/2 Pellet: 96/4	221
3	SnCu	Bath: 99.3/0.7 Pellet: 99.5/0.5	227
Code	Superheat ^{0}C		
1	40		
2	30		
3	20		

Table 2: Test Runs from DoE Analysis

Test Parameter Combination	Flux	Alloy	Superheat ^{0}C
213	B	SnAgCu	20
533	E	SnCu	20
312	C	SnAgCu	30
531	E	SnCu	40
113	A	SnAgCu	20
111	A	SnAgCu	40
513	E	SnAgCu	20
233	B	SnCu	20
322	C	SnAg	30
522	E	SnAg	30
231	B	SnCu	40
532	E	SnCu	30
521	E	SnAg	40
422	D	SnAg	30
133	A	SnCu	20
313	C	SnAgCu	20
211	B	SnAgCu	40
131	A	SnCu	40
432	D	SnCu	30
511	E	SnAgCu	40

Table 3: List of Component Types Used in Solderability Tests

Component Type	Description
R0603 Rohm	5% 1K ohm resistor
R0805 Rohm	1% 1K ohm resistor
C0603	COG 50V 10pf capacitor
C0805	COG 50V 10pf capacitor
C1206	COG 50V 22pf capacitor
SOIC14 PdNi	Texas 74HCT02M SOIC14
SOIC SnPb	Motorola 74HCT04AD SOIC14
SOT23	BAV70 switching diode
SOT223	134W-500D SMT Triac
Through Hole resistor	0.125W metal film resistors 1K ohm
R0603 Neohm	1% 1K ohm resistor
R0805 Neohm	1% 1K ohm resistor
R1206 Neohm	1% 1K ohm resistor
Tantalum A	4.7uf 6V capacitor
Tantalum B	33uf 6V capacitor
Tantalum C	6.8uf 20V capacitor
Tantalum D	4.7uf 35V capacitor
Through Hole dip	74HC00AN
QFP 0.65	160pin dummy
Minimelf	FDLL300: Diode

The wetting balance test conditions are given in Table 4.

Table 4: Wetting Balance Test Conditions

Component Type	Immersion Depth mm	Immersion Speed mms^{-1}	Duration Time secs.	Preheat Time secs.
Copper	4.0	20	10	0
R0603 Rohm	0.1	0.5	10	0
R0805 Rohm	0.1	1	5	0
C0603	0.1	1	5	0
C0805	0.1	1	5	0
C1206	0.1	1	5	0
SOIC14 PdNi	0.2	1	5	0
SOIC SnPb	0.2	1	5	0
SOT23	0.1	1	5	0
SOT223	0.25	1	10	0
Through Hole resistor	0.5	1	10	0
R0603 Neohm	0.1	0.5	10	0
R0805 Neohm	0.1	1	5	0
R1206 Neohm	0.1	1	5	0
Tantalum A	0.2	1	5	0
Tantalum B	0.2	1	5	0
Tantalum C	0.2	1	5	0
Tantalum D	0.2	1	5	0
Through Hole dip	4	20	10	0
QFP 0.65	0.2	1	5	0
Minimelf	0.25	1	5	0

3. RESULTS AND DISCUSSION

3.1 COPPER SAMPLES

The wetting times for copper coupons are shown in Figure 1, plotted against superheat temperatures for four different solder alloys and using the activated rosin flux in air. Superheat temperature is defined as the difference between the soldering temperature and the solder alloy melting point. This Figure shows that there is little difference in wetting times at any given superheat temperature between the three lead-free alloys and the SnPb solder. Above a superheat of 35^0 C, the difference is very small. On a superheat basis, therefore, the wetting characteristics for the conventional SnPb solder are no better than those for the lead-free solder alloys, when using an activated rosin flux in air. Figure 2 shows the same conditions as those for Figure 1 but using a rosin flux, and the results show that the lead-free alloys do not perform as well as SnPb alloy even at superheat temperatures above 35 ^{0}C. The wetting times for lead free alloys in air are significantly higher than those values for SnPb solder at all superheats with SnCu being the poorest performer (note the change in the wetting scale between Figures 1 and 2).

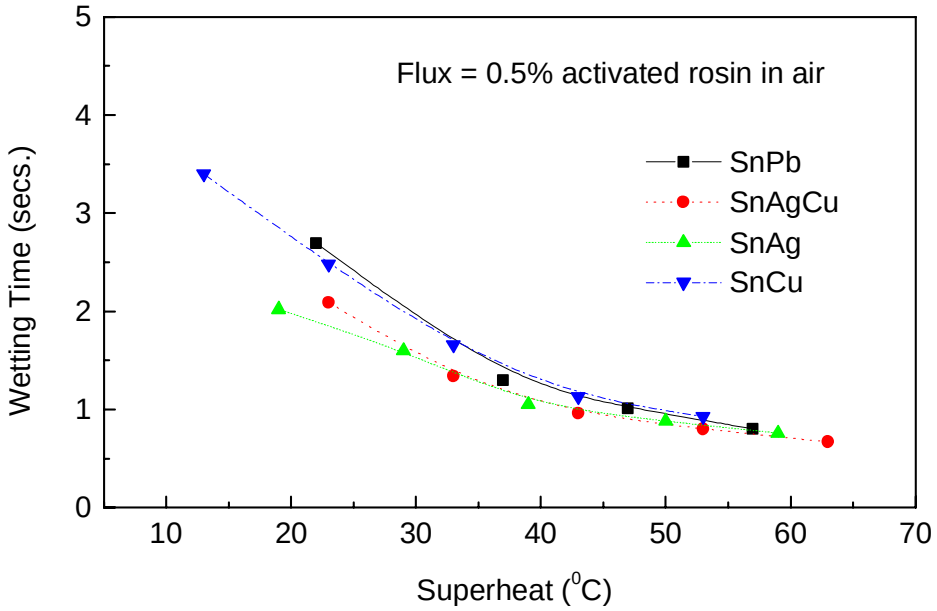


Figure 1: Wetting time with superheat for four alloys using activated rosin flux in normal atmosphere

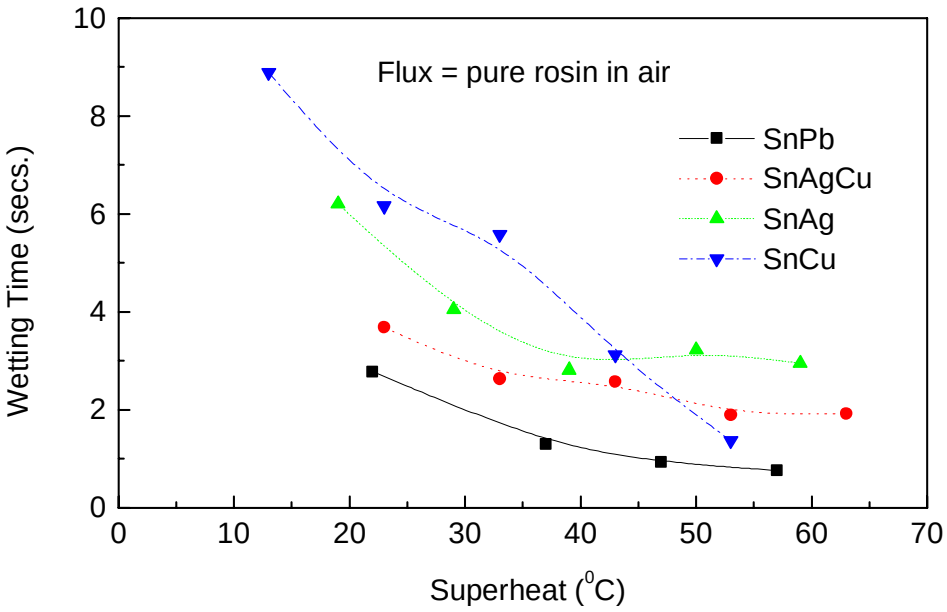


Figure 2: Wetting time with superheat for four alloys using rosin flux in normal atmosphere

Figures 3 and 4 show the wetting times for both flux types respectively, with all three lead-free alloys and SnPb when tested in a nitrogen atmosphere (typically 500ppm of oxygen) for the same range of superheat temperatures.

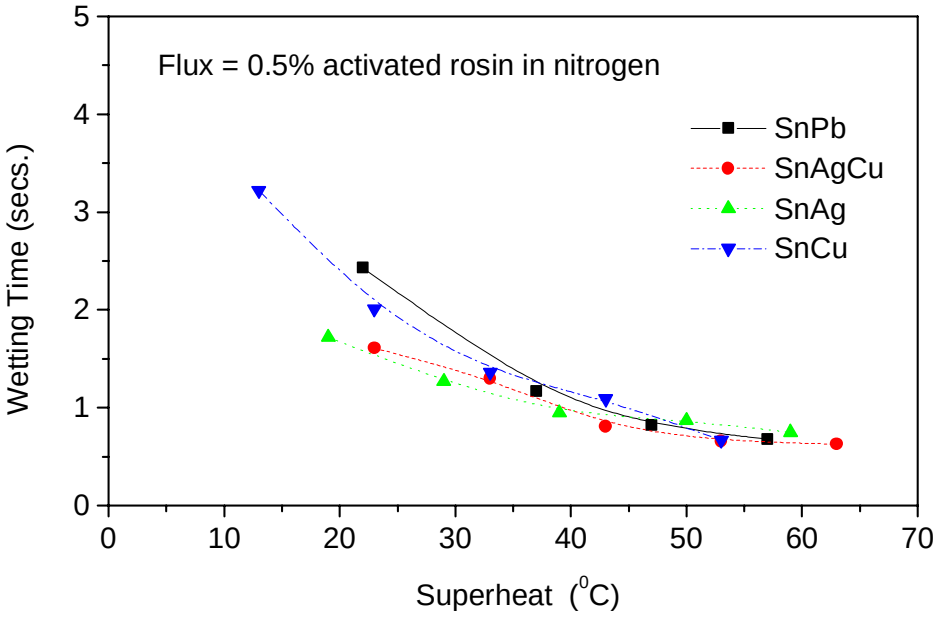


Figure 3: Wetting time with superheat for four alloys using activated rosin flux in nitrogen

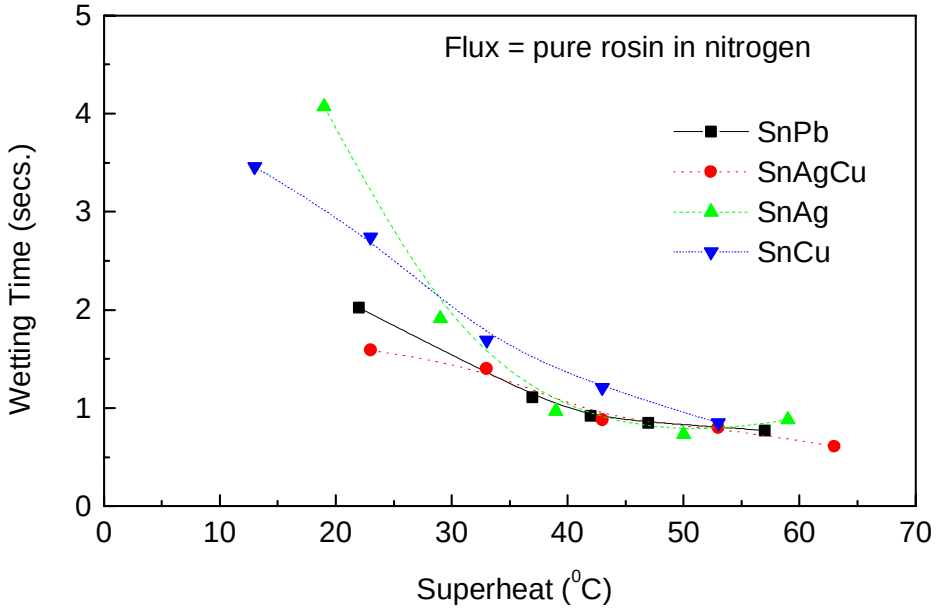


Figure 4: Wetting time with superheat for four alloys using rosin flux in nitrogen

It is noticeable from Figure 3 that the wetting times of all alloys when using an activated rosin flux are similar to those results when tested in air. Nitrogen does not appear to be significantly beneficial to solderability at superheat temperatures above 30 °C when using the activated flux (A). However, there is a small improvement in solderability at superheats below 30°C. Bt

contrast, with the rosin flux there is a significant difference between the nitrogen and normal atmosphere results - see Figure 4 and Figure 2 respectively. The wetting times in nitrogen are significantly enhanced for all the lead-free alloys, and are comparable to those for the SnPb alloy. The effect of nitrogen is to improve the wetting to levels seen with the activated flux. At superheats of 35 ^{0}C and above the solderability of the lead-free alloys is as good as that for SnPb alloy, with only the SnCu being slightly poorer.

3.2 SURFACE MOUNT AND THROUGH HOLE COMPONENTS

The samples and test conditions are given in Tables 3 and 4. The tests that were run are outlined in Table 2. The DoE approach is described in Appendix A. Coefficients from the DoE analysis and wetting force and time values are given in Appendices B and C.

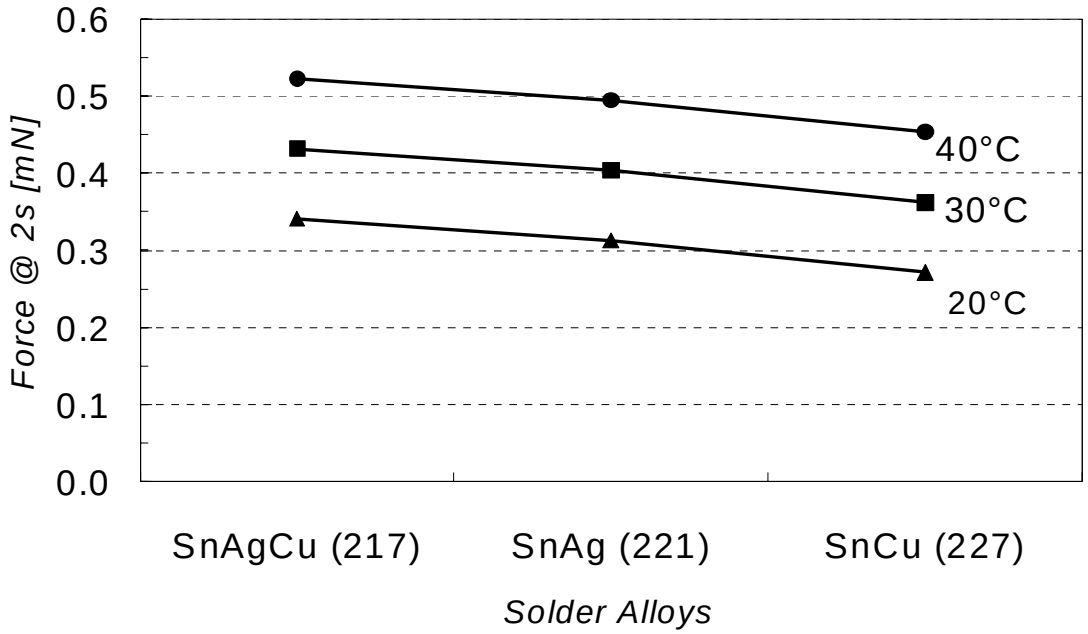


Figure 5: Average wetting force for 19 components with flux A for different superheats

The large data set permits the effect of the alloy to be seen on the wetting force and time when averaged across the component sets. The data are just plotted for flux A for convenience; the other fluxes were similar but with slightly poorer wetting. Using the Flux A data the average wetting force and time are shown in the next two Figures. In Figure 5 the average of predicted wetting forces for all single termination tested components is shown. (19 of the 20 components tested are used; the results from the DIP are excluded since these results are for simultaneously dipping many terminations). It is clear that a higher superheat elevates the wetting force significantly. The effect on wetting time is shown in Figure 6, and a stronger effect of temperature is noted. Only the SnAgCu alloy wets in less than 2 seconds and then only at 40 °C test temperature with flux A. ***It is important to note that in Figure 6 these constant superheat curves show a significant benefit of using the SnAgCu alloy, even compared to the SnAg alloy. This is an important conclusion when applied to wave***

soldering, which currently favours SnCu solder. Significant benefits will come form using the SnAgCu alloy, especially when a wave temperature of 260 °C is implemented.

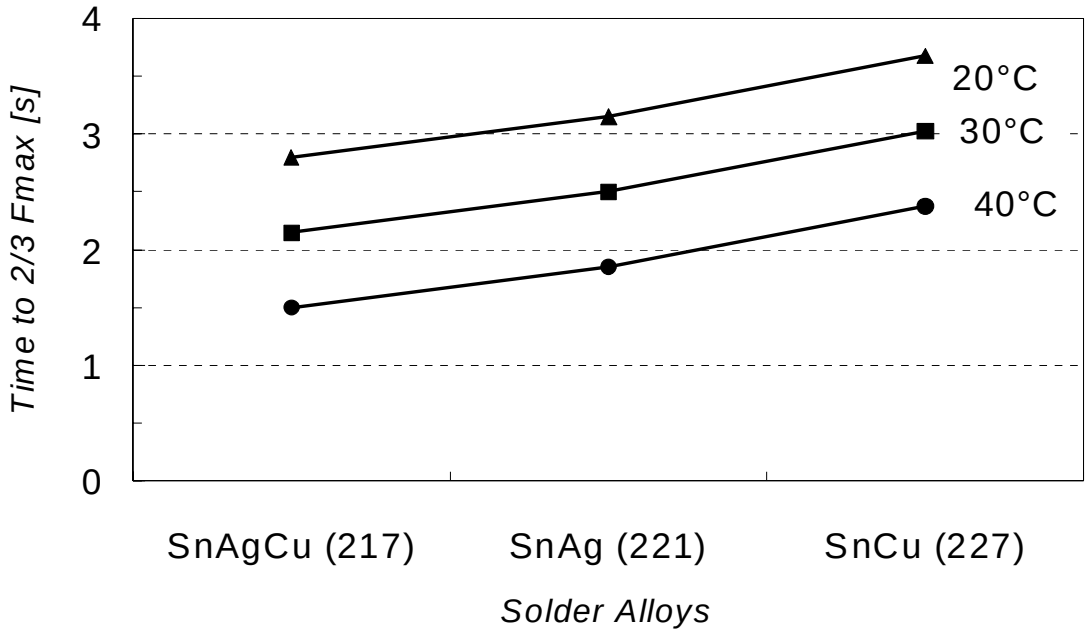


Figure 6: Average wetting time for 19 components with flux A for different superheats

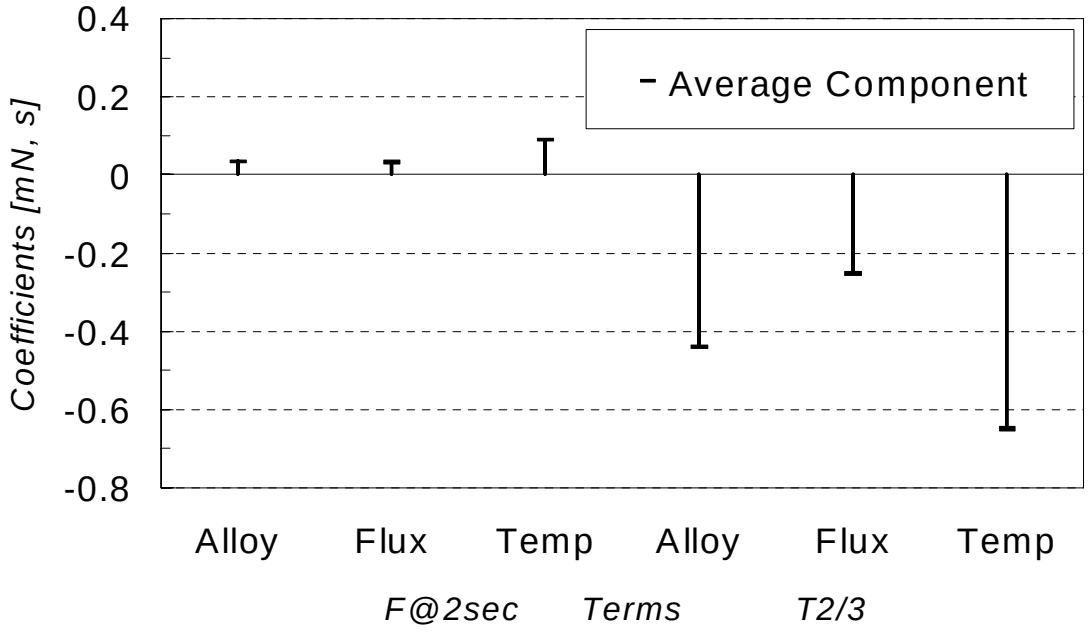


Figure 7: Average coefficients for 19 components (excluding DIP)

Figure 7 is the average for the coefficients for the same 19 components. This shows that the wetting time is far more sensitive to changes in the variables than the wetting force. It is also of interest that the alloy and temperature are more influential than the flux. This indicates that

alloy choice will be key in the future. The relatively small change in melting point from SnAgCu to the SnAg alloy offers real benefits. The other significant factor is that the temperature is key, and anything that can reduce the strength of this coefficient, such as nitrogen will be beneficial. The smaller flux coefficient indicates that temperature is more dominant. So that for a board with a large temperature range during soldering, there will be an effect on the wetting in the cooler areas, which current no-clean fluxes may be unable to compensate. Stronger fluxes would be required to increase the propensity and offset the temperature effect, but this would entail the expensive penalty of cleaning.

4 CONCLUSIONS

- Nitrogen was shown to be very important with lead-free alloys in providing good solderability with a flux typical of current no-clean fluxes. Coupled with the lower superheat that will be used with lead-free alloys this will result in the use of nitrogen becoming more widespread.
- The results show that for the most active flux only SnAgCu (with the highest superheat temperature tested of 40^0C) can achieve wetting times of less than 2 seconds in the wetting test. SnAg was borderline at this temperature.

- SnAgCu also has the lowest liquidus, ultimately giving a lower soldering temperature than SnAg or SnCu. On average, SnCu performed poorly, even at the highest superheat temperature; the wetting time was still unacceptable, being greater than two seconds at 2/3 the maximum wetting force.

- The influence on solderability of each of the factors (flux, temperature and alloy) have been calculated for each of the 20 component types tested, and are presented in Appendix B.

- The wetting force and wetting time has been calculated individually for all 20 components and are given in Appendix C.

- Together these two Appendices comprise an invaluable data set for assessing the solderability of components with lead-free alloys.

- The coefficients given in Appendix B vary considerably across the component range and therefore to optimise solderability it may be possible to calculate the best possible solder/flux/temperature combination for any individual component type.

5. ACKNOWLEDGEMENT

This work was carried out as part of a project in the Measurements for the Processability of Materials (MPM73) Programme of the UK Department of Trade and Industry.

Appendix A

Design of Experiment (DoE)

The design of experiment software used here(DoE JMP 3.2.6 SAS Institute Inc.) is a D-optimal design linear model. The factors (terms) that were considered, as discussed above, were alloy, flux and temperature (superheat). All combinations (triplets) of the terms give 45 combinations (called full factorial). A selection criterion was taken that reduced the number of combinations to 20 triplets (44 %) for the actual experiment runs. The 56 % reduction results in an estimate of standard error of 43.1 % of the measurement. The actual test combinations are given in Table 2. Each of the 20 components was processed independently based on the linear models of Equation 1 and 2. Coefficients were determined by prediction fits of the linear models and reveal not only the strength of each term in influencing the wetting force and time, but also the "polarity" of this influence.

Equation 1 Wetting force linear model

$$F = \frac{\delta F}{\delta Alloy} \cdot Alloy + \frac{\delta F}{\delta Flux} \cdot Flux + \frac{\delta F}{\delta Temperature} \cdot Temperature + F_0$$

Equation 2 Wetting time linear model

$$T = \frac{\delta T}{\delta Alloy} \cdot Alloy + \frac{\delta T}{\delta Flux} \cdot Flux + \frac{\delta T}{\delta Temperature} \cdot Temperature + T_0$$

The various terms are described below:

Independent variables:
F – Predicted wetting force after 2 seconds
T – Predicted time to 2/3 of maximum wetting force

Dependent variables:
Each of the dependent variables have been normalised so their ranges are set between –1 and 1. The intermediate values are set according to their impact on the wetting. For temperature, 30 °C is equidistant between 20 and 40 °C so the variable is 0. Similarly with the alloy, where the variables follow the melting point. The flux was ranked according to the wetting time using SnAgCu at 250 °C.
Alloy = 1 (SnAgCu); = 0.2 (SnAg); = -1 (SnCu)
Flux = 1 (A); = 0.59 (B); = 0.25 (C); = -0.02 (D); = -1 (E)
Temperature = 1 (40°C); = 0 (30°C); = -1 (20°C)

Coefficients:
$\frac{\delta F}{\delta Alloy}$ - coefficient of alloy impact on wetting force
$\frac{\delta F}{\delta Flux}$ - coefficient of flux impact on wetting force

$\frac{\delta F}{\delta Temperature}$ - coefficient of temperature impact on wetting force

F_0 – intercept of the wetting force model

$\frac{\delta T}{\delta Alloy}$ - coefficient of alloy impact on wetting time

$\frac{\delta T}{\delta Flux}$ - coefficient of flux impact on wetting time

$\frac{\delta T}{\delta Temperature}$ - coefficient of temperature impact on wetting time

T_0 – intercept of the wetting time model

The F_o and T_o values are given in the Table A.1, as determined by the fitting.

Table A.1: Tabulated F_o and T_o Values

Component	F_0 [mN]	T_0 [s]
R0603 A	0.091	4.063
R0603 B	0.025	4.848
R0805 A	0.005	3.005
R0805 B	0.028	3.180
R1206	0.018	3.623
Tant A	0.639	1.015
Tant B	1.004	1.691
Tant C	1.152	1.676
Tant D	1.281	2.226
C0603	0.459	0.866
C0805	0.655	0.837
C1206	0.922	1.297
TH Dip	11.954	1.128
TH Res	-0.137	6.598
SOT223	-0.080	8.187
SOT23	0.281	0.469
SOIC14 SnPB	0.091	2.971
SOIC14 PdNi	-0.079	3.638
QFP	0.158	0.931
Minimelf	0.395	2.808

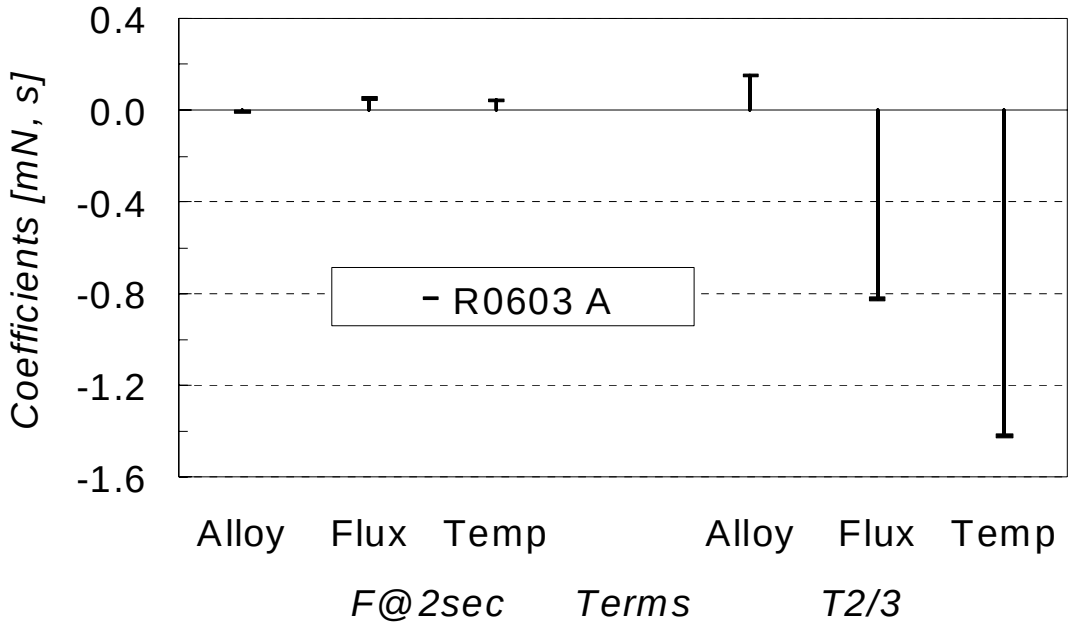
In Appendix B the coefficients for all components are plotted as a function of alloys, fluxes and temperatures for both the wetting force and time. Using the coefficients in Appendix B and the T_o and F_o values in Table A.1, tabulated wetting force and wetting times are given in Appendix B for the 20 component types with the lead-free alloys, the five fluxes, and three temperatures.

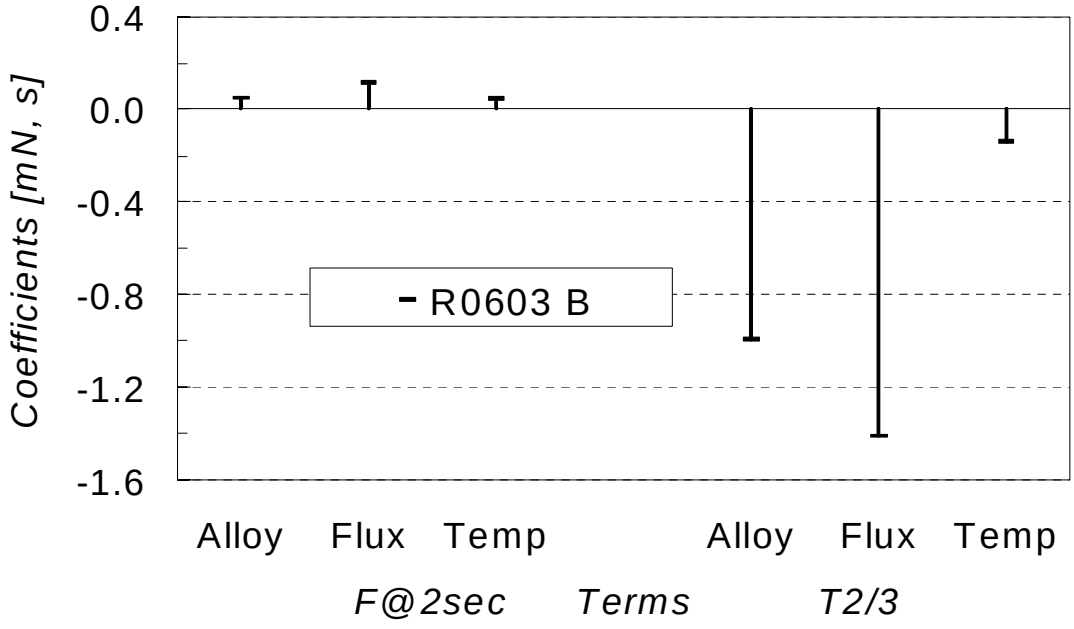
An example of this calculation is given in estimating the wetting force from the prediction model (Equation 1). Coefficients are selected from the component plots in Appendix B. For component Tant B and alloy SnAgCu with Flux A and superheat temperature of 20 °C, equation 1 becomes:

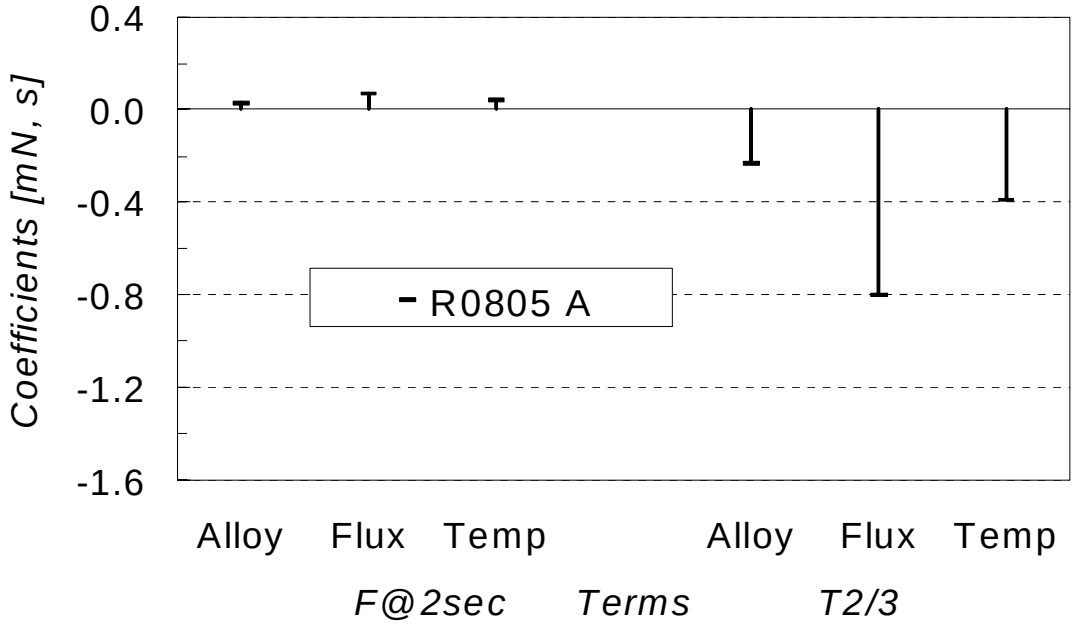
$F_{(@2s)}$= 0.125*1 + 0.068*1 + 0.011*(-1) + 1.004 = 1.19 mN

Appendix B

Coefficients of alloy, flux and temperature for wetting force and time



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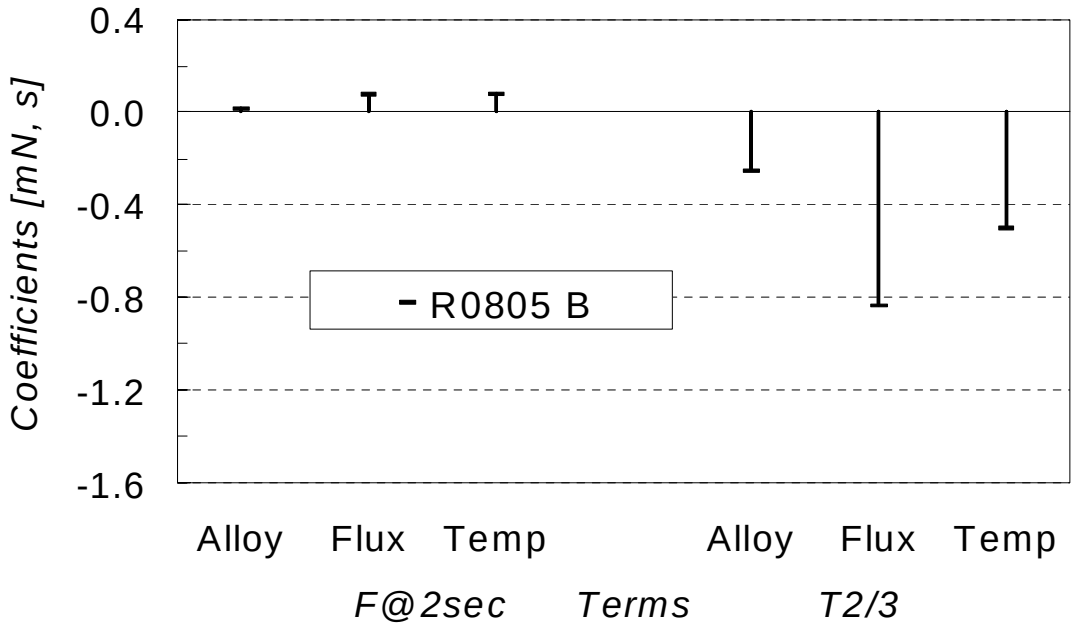
Terms
T2/3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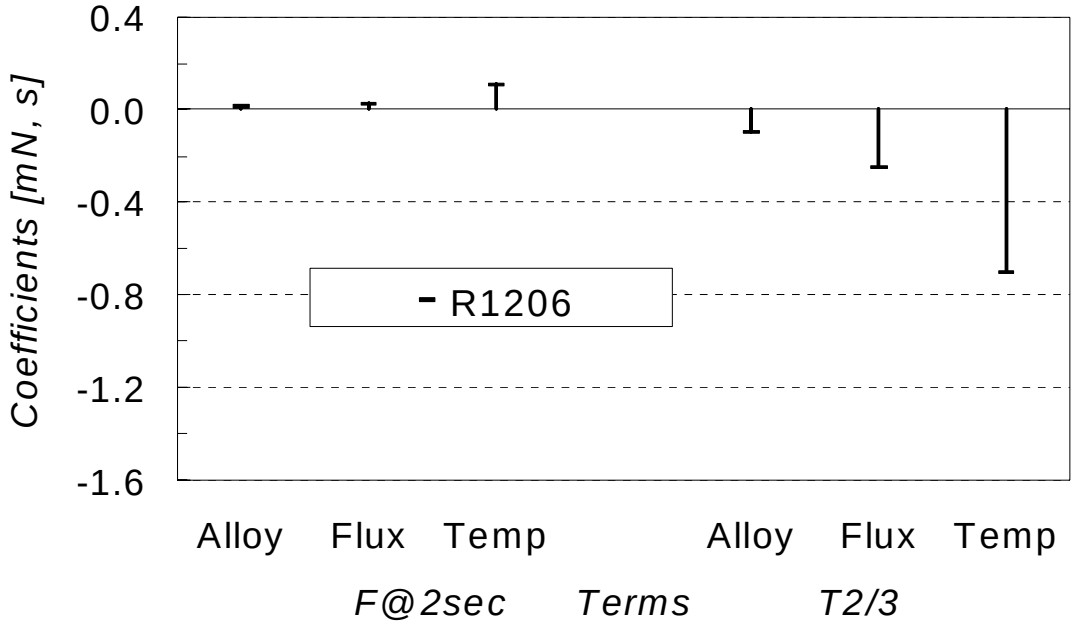
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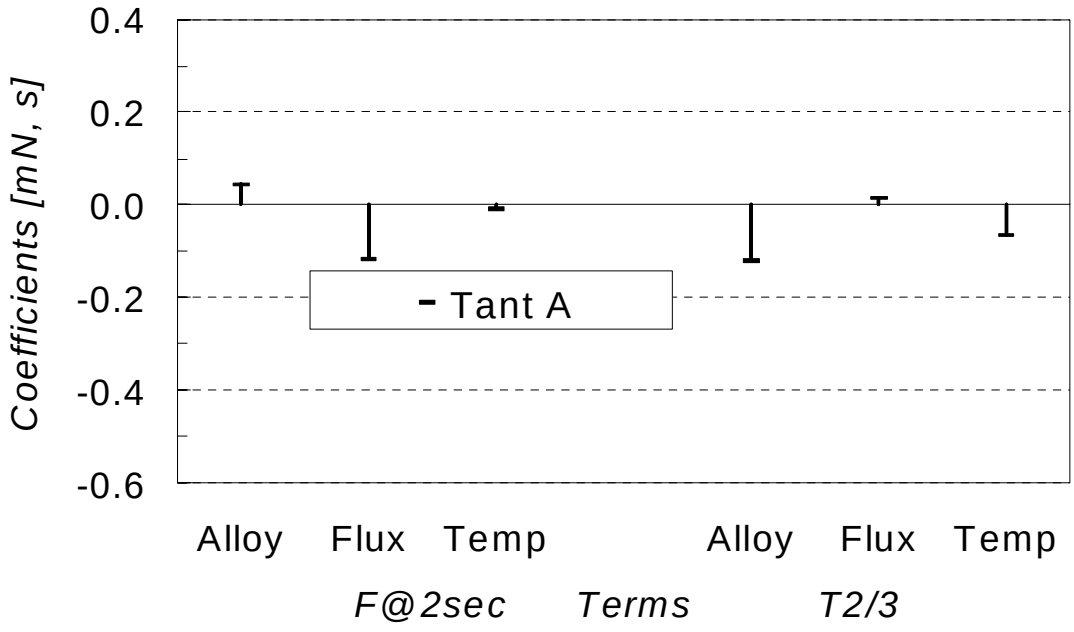
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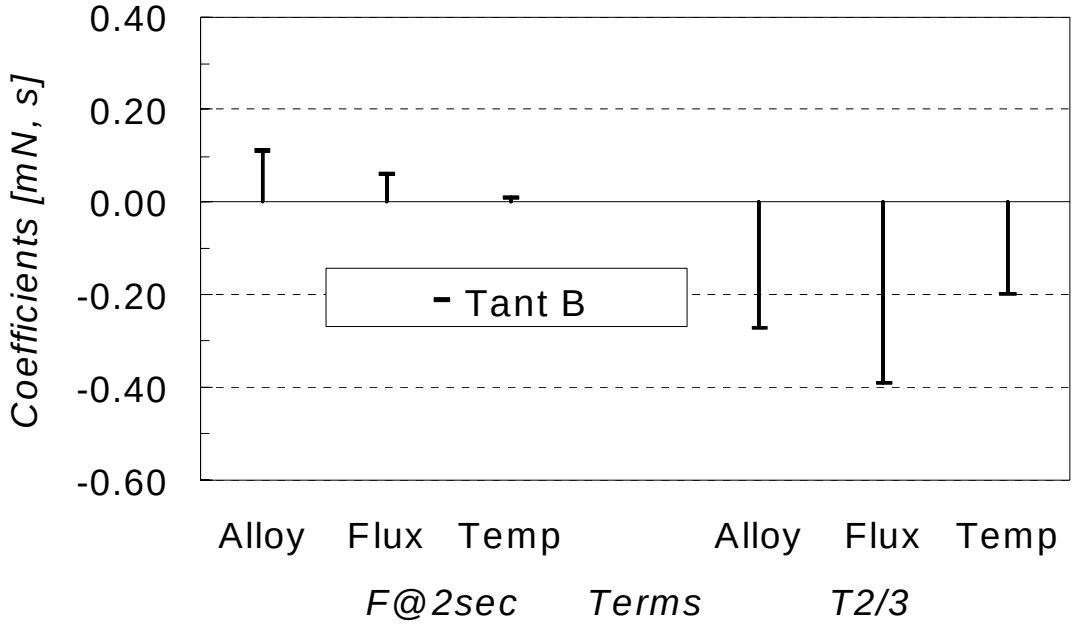
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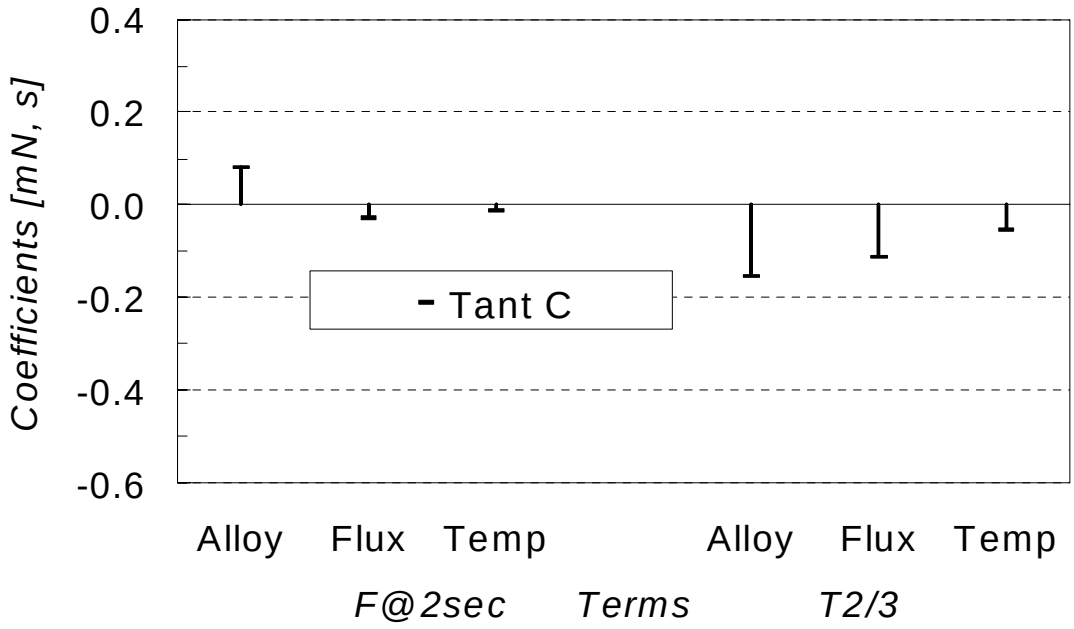
T2/3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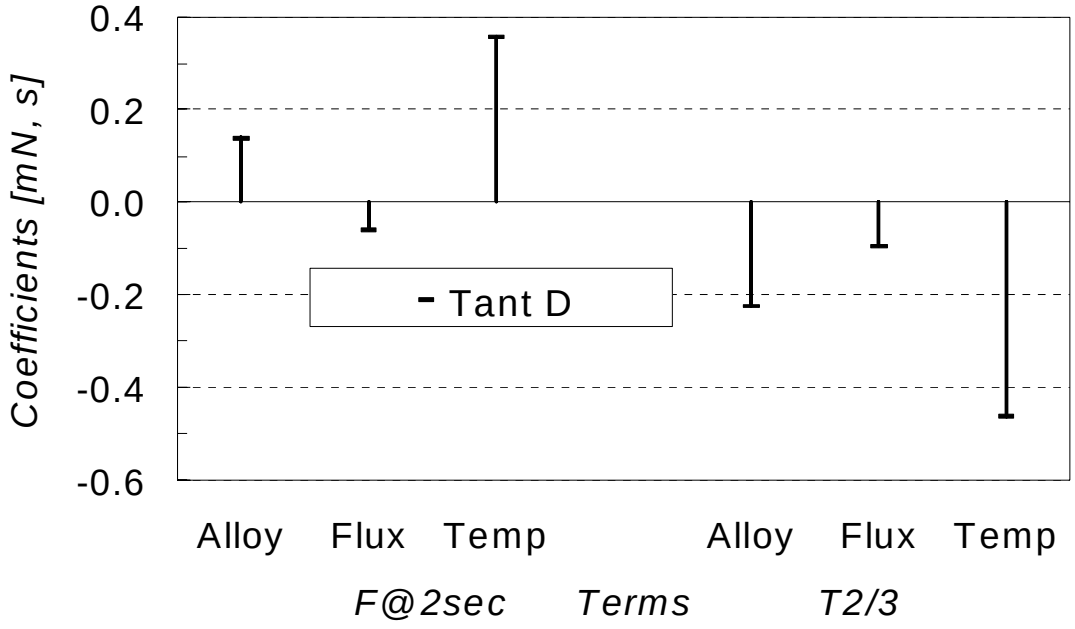
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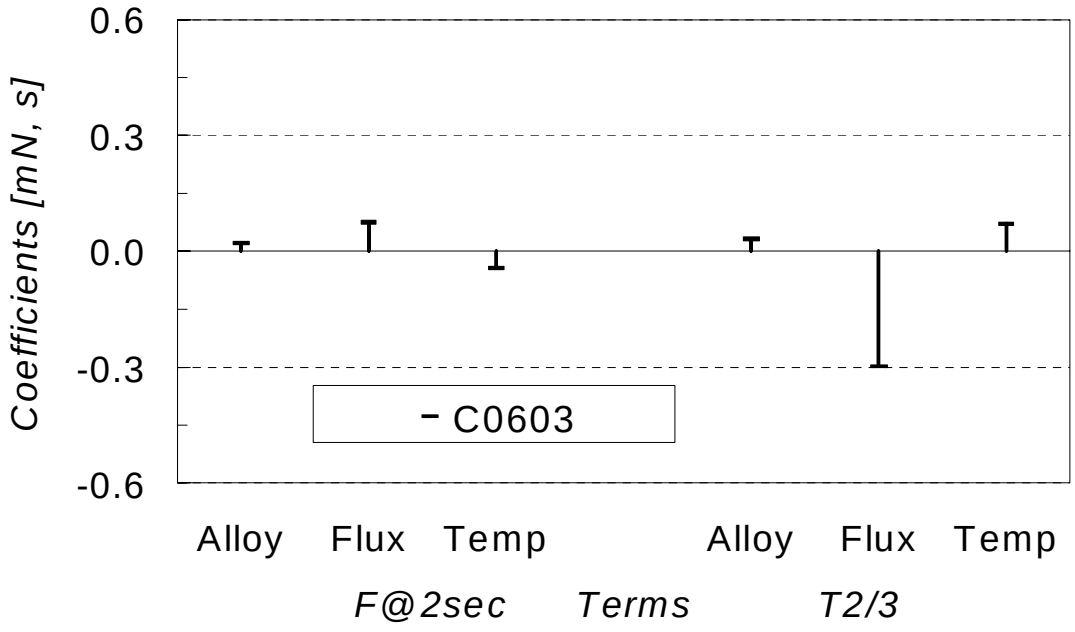
T2/3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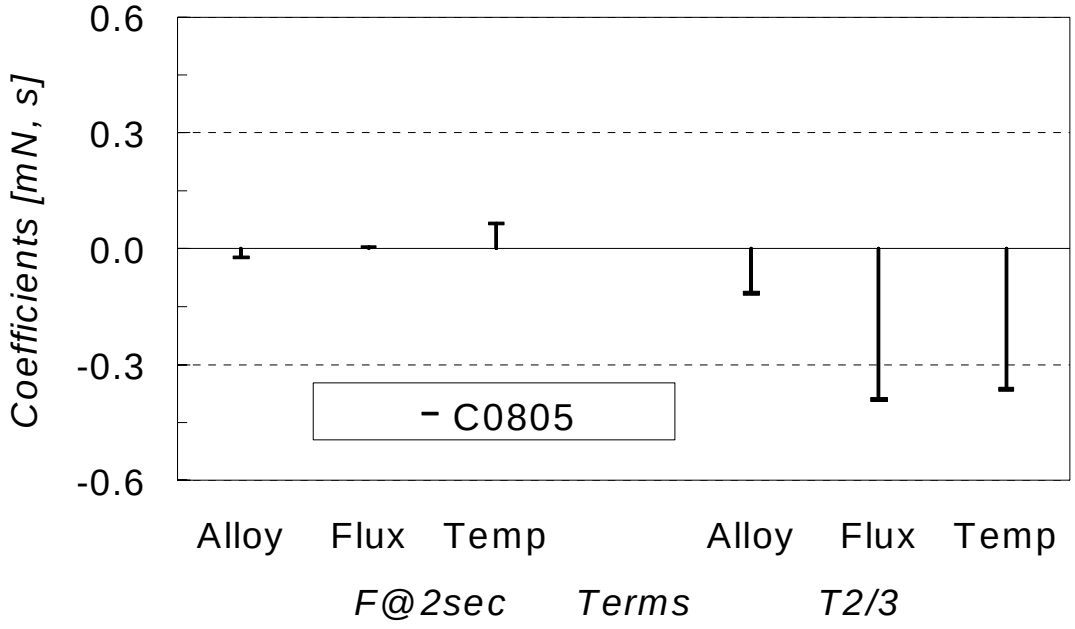
T2/3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Flux
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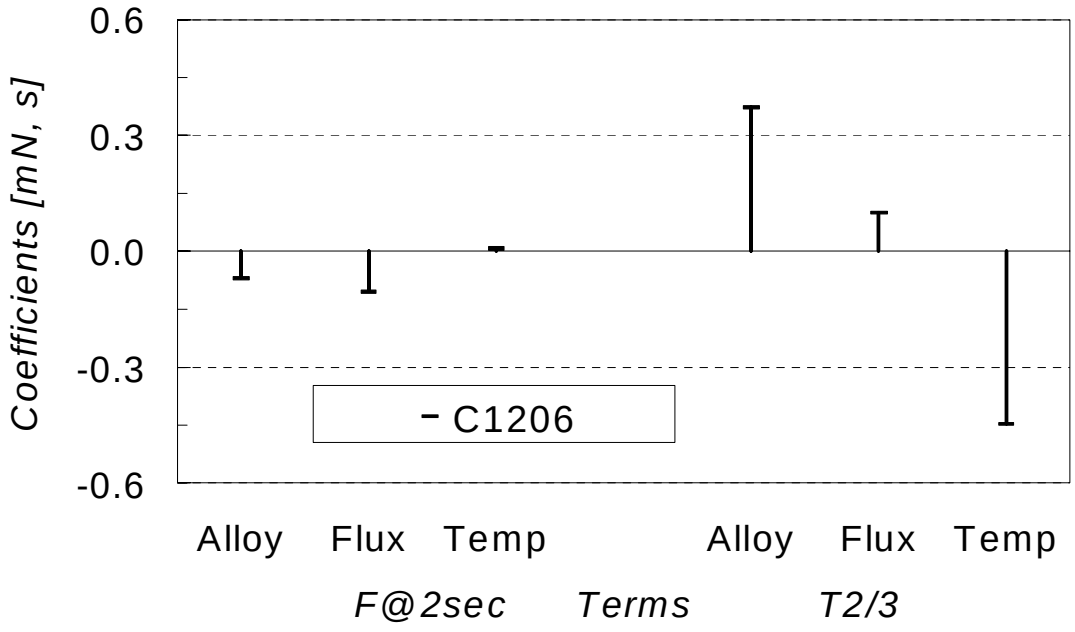
F@2sec
Terms
T2/3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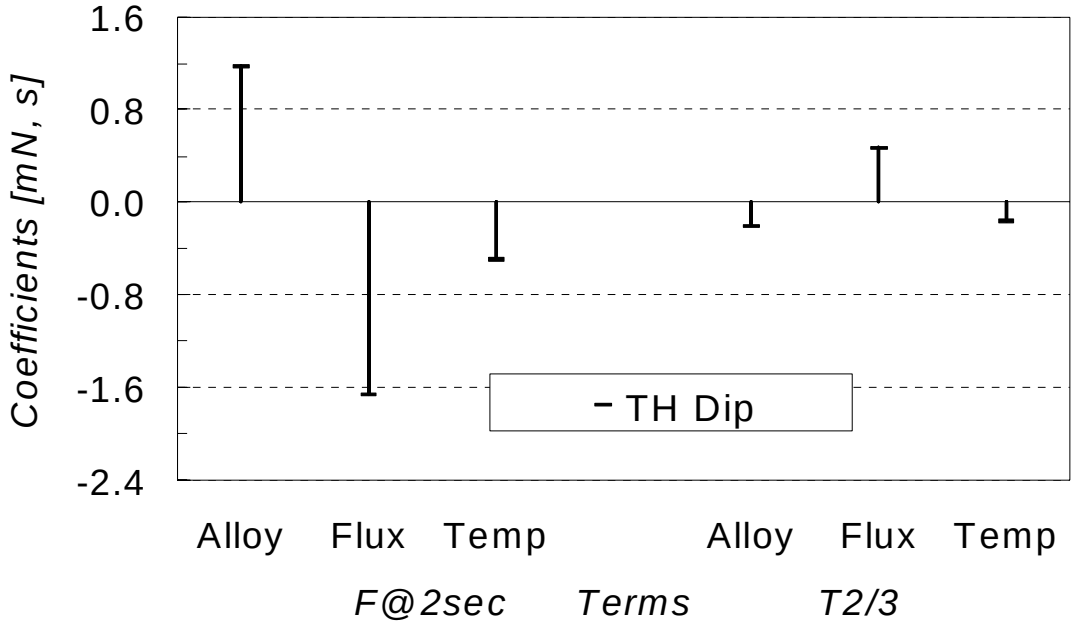
T2/3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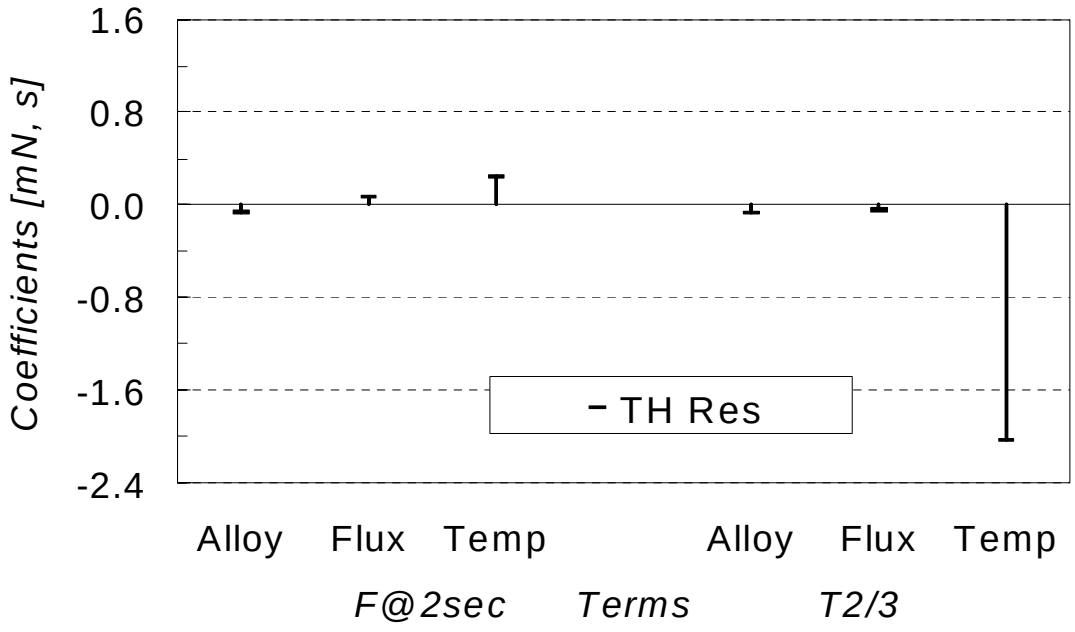
T2/3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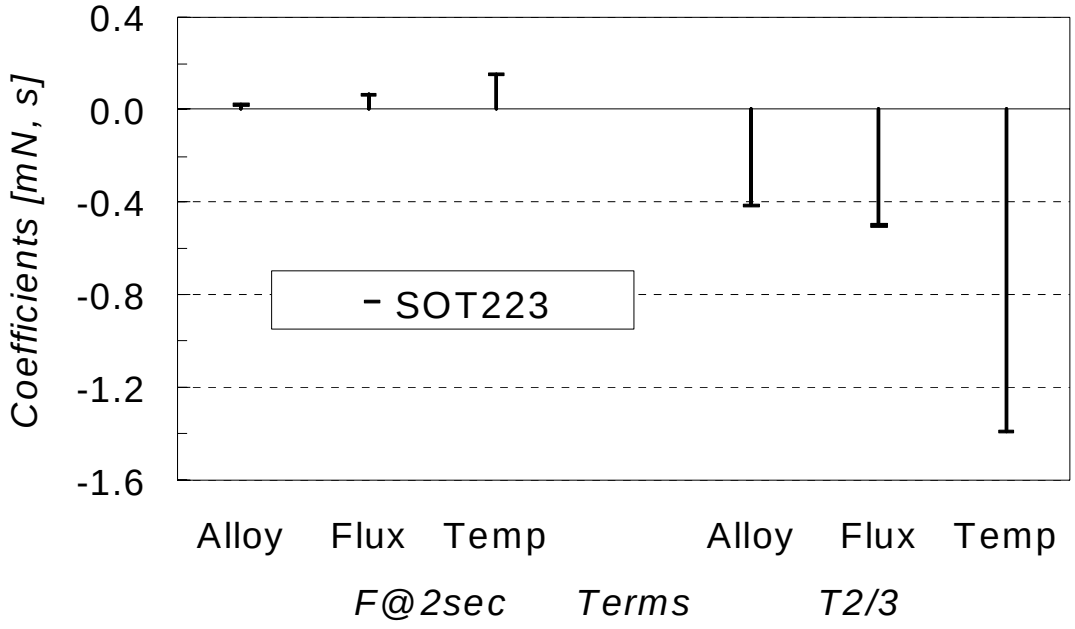
T2/3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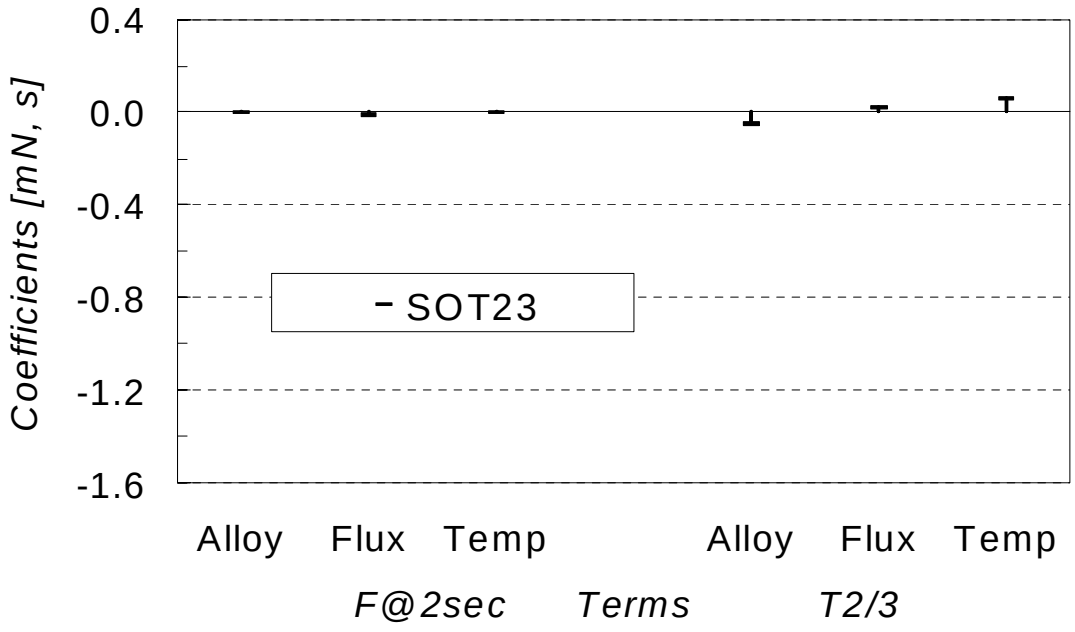
T2/3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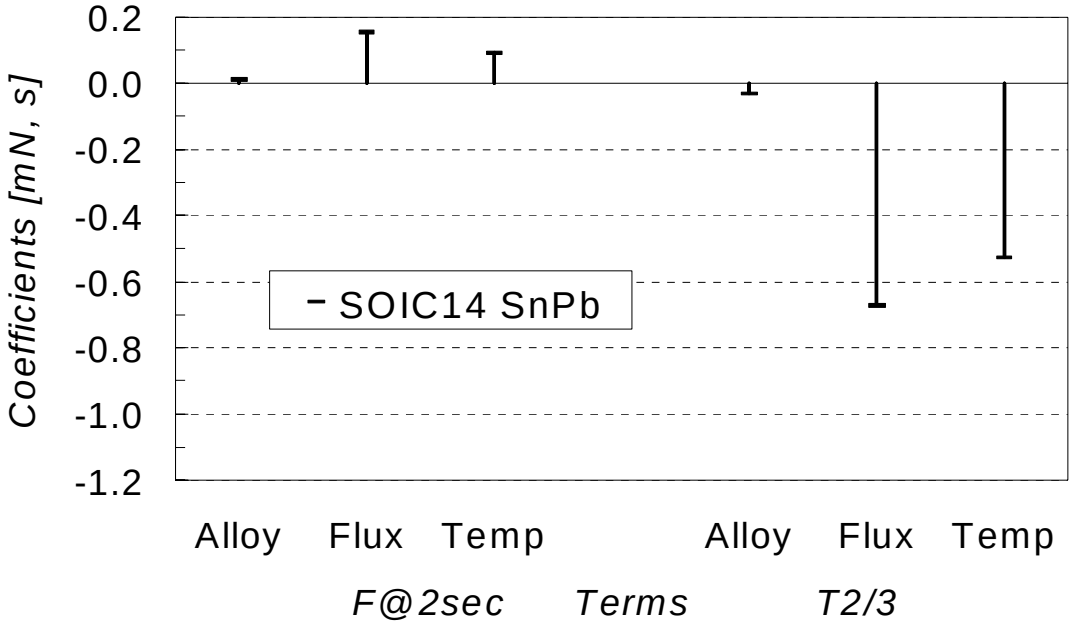
Terms
T2/3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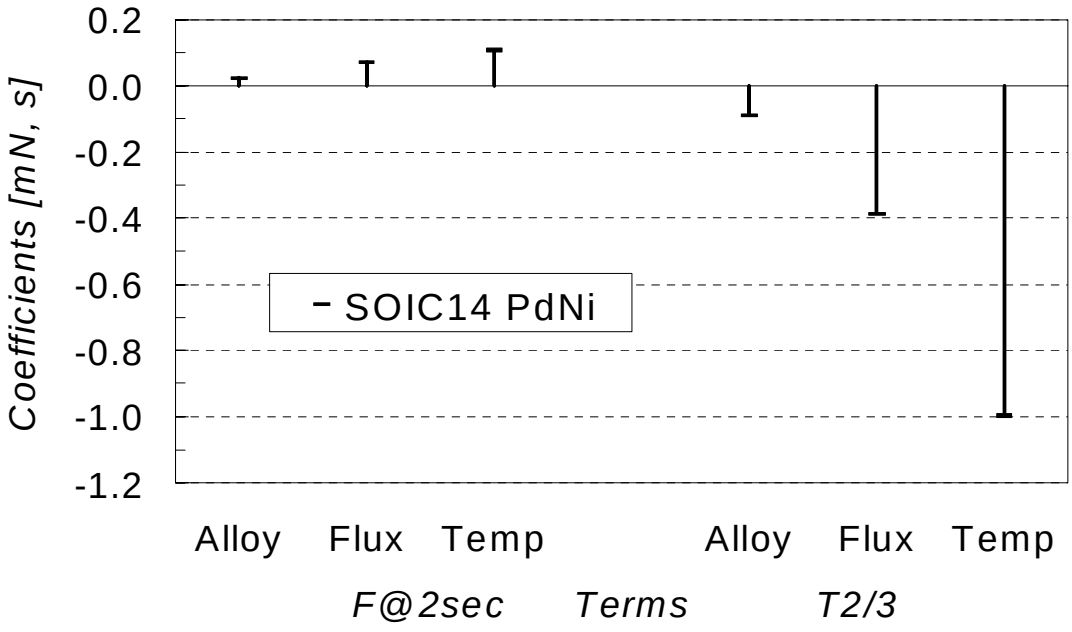
T2/3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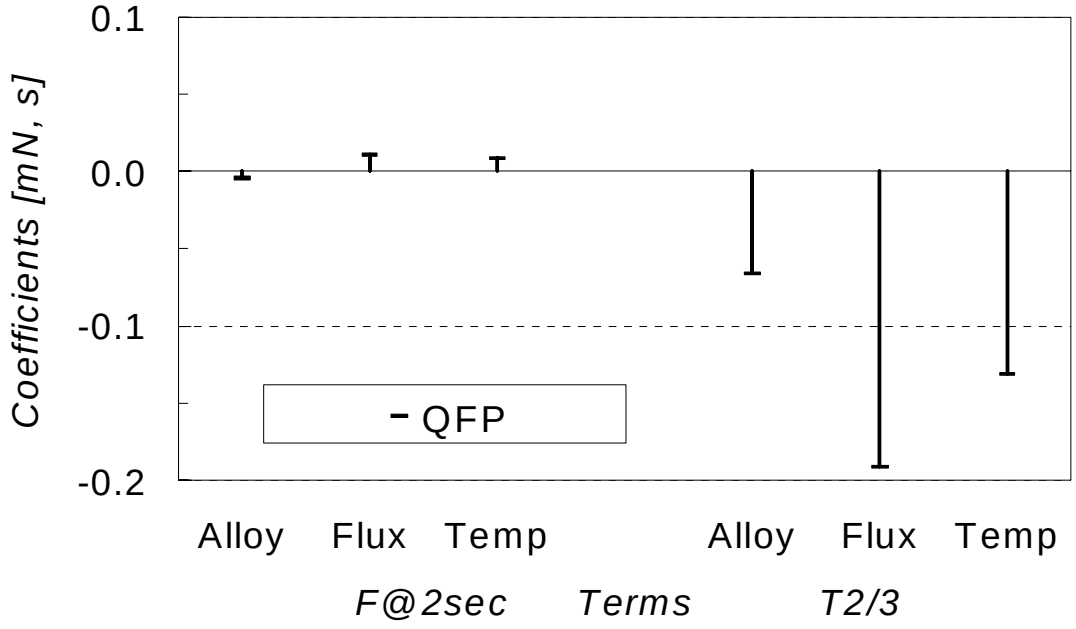
T2/3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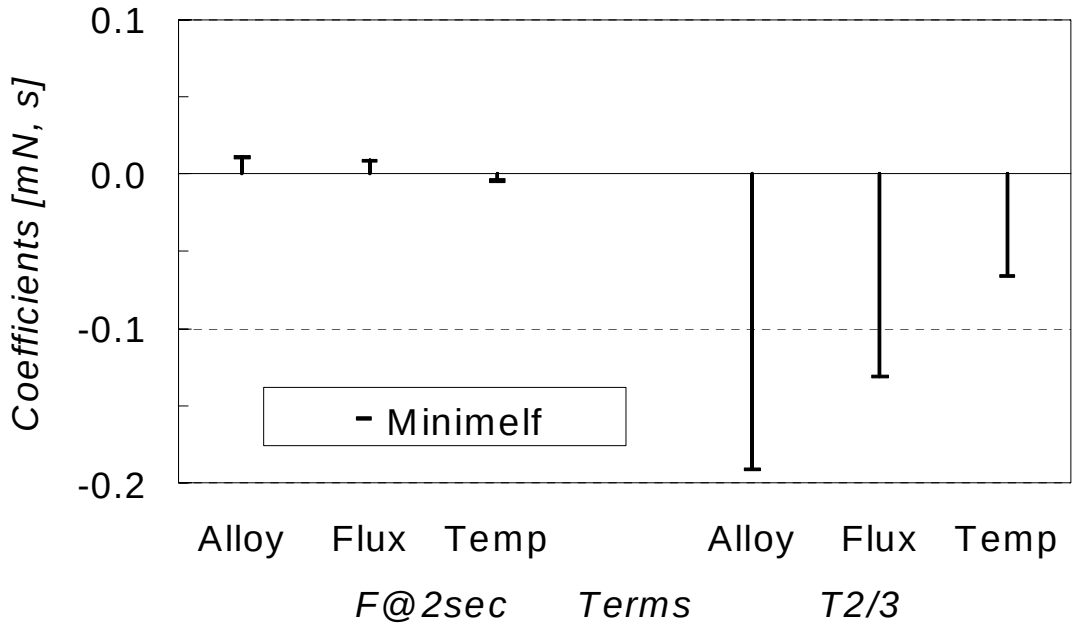
Terms
T2/3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Flux
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Flux
Temp
F@2sec
Terms
T2/3

Appendix C

Wetting Force and Wetting Time

R0603 A Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.10	0.16	0.21
SnAg (221)	0.11	0.16	0.21
SnCu (227)	0.11	0.16	0.22
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.08	0.13	0.18
SnAg (221)	0.08	0.13	0.19
SnCu (227)	0.08	0.13	0.19
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.05	0.11	0.16
SnAg (221)	0.05	0.11	0.16
SnCu (227)	0.06	0.11	0.17
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.03	0.09	0.14
SnAg (221)	0.04	0.09	0.14
SnCu (227)	0.04	0.09	0.15
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.03	0.02	0.07
SnAg (221)	-0.03	0.02	0.08
SnCu (227)	-0.03	0.02	0.08

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.65	2.95	1.24
SnAg (221)	4.57	2.87	1.16
SnCu (227)	4.45	2.75	1.05
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	5.15	3.45	1.74
SnAg (221)	5.07	3.37	1.66
SnCu (227)	4.95	3.25	1.54
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	5.89	4.19	2.48
SnAg (221)	5.81	4.11	2.40
SnCu (227)	5.69	3.99	2.28
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	5.89	4.19	2.48
SnAg (221)	5.81	4.11	2.40
SnCu (227)	5.69	3.99	2.28
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	7.08	5.38	3.67
SnAg (221)	7.00	5.30	3.59
SnCu (227)	6.88	5.18	3.48

R0603 B Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.17	0.23	0.29
SnAg (221)	0.05	0.11	0.17
SnCu (227)	-0.13	-0.07	-0.01
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.15	0.21	0.27
SnAg (221)	0.03	0.09	0.15
SnCu (227)	-0.15	-0.09	-0.03
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.13	0.19	0.25
SnAg (221)	0.01	0.07	0.13
SnCu (227)	-0.17	-0.11	-0.05
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.11	0.17	0.23
SnAg (221)	-0.01	0.05	0.11
SnCu (227)	-0.18	-0.13	-0.07
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.06	0.12	0.17
SnAg (221)	-0.06	0.00	0.06
SnCu (227)	-0.24	-0.18	-0.12

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.21	2.04	1.88
SnAg (221)	3.56	3.39	3.23
SnCu (227)	5.59	5.42	5.26
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.66	2.50	2.34
SnAg (221)	4.02	3.85	3.69
SnCu (227)	6.05	5.88	5.72
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.34	3.18	3.01
SnAg (221)	4.70	4.53	4.37
SnCu (227)	6.72	6.56	6.39
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.34	3.18	3.01
SnAg (221)	4.70	4.53	4.37
SnCu (227)	6.72	6.56	6.39
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.44	4.27	4.11
SnAg (221)	5.79	5.62	5.46
SnCu (227)	7.82	7.65	7.49

R0805 A Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.08	0.13	0.19
SnAg (221)	0.01	0.06	0.11
SnCu (227)	-0.11	-0.05	0.00
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.07	0.12	0.17
SnAg (221)	-0.01	0.04	0.10
SnCu (227)	-0.12	-0.07	-0.01
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.05	0.11	0.16
SnAg (221)	-0.02	0.03	0.09
SnCu (227)	-0.13	-0.08	-0.03
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.04	0.10	0.15
SnAg (221)	-0.03	0.02	0.08
SnCu (227)	-0.14	-0.09	-0.04
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.01	0.06	0.12
SnAg (221)	-0.07	-0.01	0.04
SnCu (227)	-0.18	-0.12	-0.07

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.17	1.70	1.23
SnAg (221)	2.99	2.52	2.06
SnCu (227)	4.23	3.76	3.29
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.28	1.81	1.35
SnAg (221)	3.10	2.64	2.17
SnCu (227)	4.34	3.87	3.40
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.45	1.98	1.51
SnAg (221)	3.27	2.80	2.34
SnCu (227)	4.51	4.04	3.57
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.45	1.98	1.51
SnAg (221)	3.27	2.80	2.34
SnCu (227)	4.51	4.04	3.57
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.72	2.25	1.78
SnAg (221)	3.54	3.07	2.61
SnCu (227)	4.78	4.31	3.84

R0805 B Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.06	0.15	0.25
SnAg (221)	-0.02	0.07	0.17
SnCu (227)	-0.15	-0.05	0.04
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.05	0.15	0.24
SnAg (221)	-0.03	0.06	0.16
SnCu (227)	-0.16	-0.06	0.03
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.04	0.14	0.23
SnAg (221)	-0.04	0.05	0.15
SnCu (227)	-0.16	-0.07	0.02
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.04	0.13	0.23
SnAg (221)	-0.05	0.05	0.14
SnCu (227)	-0.17	-0.08	0.02
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.02	0.11	0.20
SnAg (221)	-0.07	0.03	0.12
SnCu (227)	-0.19	-0.10	0.00

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.39	1.79	1.19
SnAg (221)	3.26	2.66	2.06
SnCu (227)	4.56	3.96	3.36
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.52	1.92	1.32
SnAg (221)	3.38	2.78	2.18
SnCu (227)	4.68	4.08	3.48
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.70	2.10	1.50
SnAg (221)	3.57	2.97	2.37
SnCu (227)	4.87	4.27	3.67
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.70	2.10	1.50
SnAg (221)	3.57	2.97	2.37
SnCu (227)	4.87	4.27	3.67
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.00	2.40	1.80
SnAg (221)	3.87	3.27	2.67
SnCu (227)	5.17	4.57	3.97

R1206 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.05	0.08	0.21
SnAg (221)	-0.08	0.05	0.18
SnCu (227)	-0.14	-0.01	0.12
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.06	0.07	0.20
SnAg (221)	-0.09	0.04	0.17
SnCu (227)	-0.14	-0.01	0.12
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.06	0.07	0.20
SnAg (221)	-0.10	0.03	0.16
SnCu (227)	-0.15	-0.02	0.11
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.07	0.06	0.19
SnAg (221)	-0.10	0.03	0.16
SnCu (227)	-0.16	-0.03	0.10
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.09	0.04	0.17
SnAg (221)	-0.12	0.01	0.14
SnCu (227)	-0.18	-0.05	0.08

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.94	3.10	2.26
SnAg (221)	4.25	3.41	2.56
SnCu (227)	4.71	3.86	3.02
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.00	3.16	2.32
SnAg (221)	4.31	3.46	2.62
SnCu (227)	4.77	3.92	3.08
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.09	3.24	2.40
SnAg (221)	4.39	3.55	2.71
SnCu (227)	4.85	4.01	3.16
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.09	3.24	2.40
SnAg (221)	4.39	3.55	2.71
SnCu (227)	4.85	4.01	3.16
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.23	3.38	2.54
SnAg (221)	4.53	3.69	2.84
SnCu (227)	4.99	4.15	3.30

Tant A Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.55	0.54	0.53
SnAg (221)	0.67	0.66	0.65
SnCu (227)	0.85	0.84	0.83
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.53	0.52	0.51
SnAg (221)	0.65	0.64	0.63
SnCu (227)	0.83	0.82	0.81
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.51	0.50	0.49
SnAg (221)	0.63	0.62	0.61
SnCu (227)	0.81	0.80	0.79
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.50	0.49	0.48
SnAg (221)	0.62	0.61	0.60
SnCu (227)	0.80	0.79	0.78
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.45	0.44	0.43
SnAg (221)	0.57	0.56	0.55
SnCu (227)	0.75	0.74	0.73

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.98	0.90	0.82
SnAg (221)	0.96	0.88	0.80
SnCu (227)	0.93	0.85	0.77
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.04	0.96	0.88
SnAg (221)	1.02	0.94	0.86
SnCu (227)	0.99	0.91	0.83
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.12	1.04	0.96
SnAg (221)	1.10	1.02	0.94
SnCu (227)	1.07	0.99	0.91
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.12	1.04	0.96
SnAg (221)	1.10	1.02	0.94
SnCu (227)	1.07	0.99	0.91
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.26	1.18	1.10
SnAg (221)	1.24	1.16	1.08
SnCu (227)	1.21	1.13	1.05

Tant B Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.19	1.20	1.21
SnAg (221)	1.13	1.14	1.15
SnCu (227)	1.05	1.06	1.07
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.13	1.15	1.16
SnAg (221)	1.08	1.09	1.10
SnCu (227)	1.00	1.01	1.02
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.09	1.10	1.12
SnAg (221)	1.04	1.05	1.06
SnCu (227)	0.96	0.97	0.98
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.06	1.07	1.08
SnAg (221)	1.00	1.02	1.03
SnCu (227)	0.92	0.93	0.95
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.93	0.95	0.96
SnAg (221)	0.88	0.89	0.90
SnCu (227)	0.80	0.81	0.82

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.13	0.89	0.66
SnAg (221)	1.52	1.28	1.04
SnCu (227)	2.10	1.87	1.63
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.26	1.02	0.78
SnAg (221)	1.65	1.41	1.17
SnCu (227)	2.23	1.99	1.76
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.45	1.21	0.97
SnAg (221)	1.84	1.60	1.36
SnCu (227)	2.42	2.18	1.95
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.45	1.21	0.97
SnAg (221)	1.84	1.60	1.36
SnCu (227)	2.42	2.18	1.95
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.75	1.52	1.28
SnAg (221)	2.14	1.91	1.67
SnCu (227)	2.73	2.49	2.25

Tant C Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.21	1.20	1.18
SnAg (221)	1.25	1.23	1.22
SnCu (227)	1.30	1.29	1.27
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.18	1.16	1.15
SnAg (221)	1.21	1.20	1.18
SnCu (227)	1.26	1.25	1.23
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.14	1.13	1.12
SnAg (221)	1.18	1.17	1.15
SnCu (227)	1.23	1.22	1.20
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.12	1.11	1.09
SnAg (221)	1.16	1.14	1.13
SnCu (227)	1.21	1.19	1.18
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.03	1.02	1.00
SnAg (221)	1.07	1.05	1.04
SnCu (227)	1.12	1.11	1.09

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.44	1.37	1.31
SnAg (221)	1.54	1.48	1.41
SnCu (227)	1.70	1.63	1.57
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.51	1.44	1.38
SnAg (221)	1.61	1.55	1.48
SnCu (227)	1.77	1.70	1.64
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.61	1.55	1.49
SnAg (221)	1.72	1.65	1.59
SnCu (227)	1.87	1.81	1.75
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.61	1.55	1.49
SnAg (221)	1.72	1.65	1.59
SnCu (227)	1.87	1.81	1.75
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.78	1.72	1.66
SnAg (221)	1.89	1.82	1.76
SnCu (227)	2.04	1.98	1.92

Tant D Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.98	1.41	1.84
SnAg (221)	1.02	1.45	1.87
SnCu (227)	1.08	1.50	1.93
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.91	1.34	1.76
SnAg (221)	0.95	1.37	1.80
SnCu (227)	1.00	1.43	1.86
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.85	1.28	1.71
SnAg (221)	0.89	1.32	1.74
SnCu (227)	0.95	1.37	1.80
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.80	1.23	1.66
SnAg (221)	0.84	1.27	1.70
SnCu (227)	0.90	1.33	1.75
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.63	1.06	1.49
SnAg (221)	0.67	1.10	1.53
SnCu (227)	0.73	1.16	1.58

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.36	1.80	1.25
SnAg (221)	2.48	1.92	1.37
SnCu (227)	2.66	2.10	1.55
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.47	1.92	1.36
SnAg (221)	2.59	2.04	1.48
SnCu (227)	2.77	2.21	1.66
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.64	2.08	1.53
SnAg (221)	2.76	2.20	1.65
SnCu (227)	2.94	2.38	1.83
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.64	2.08	1.53
SnAg (221)	2.76	2.20	1.65
SnCu (227)	2.94	2.38	1.83
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.91	2.35	1.80
SnAg (221)	3.03	2.47	1.91
SnCu (227)	3.20	2.65	2.09

C0603 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.62	0.57	0.51
SnAg (221)	0.55	0.50	0.45
SnCu (227)	0.44	0.39	0.34
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.61	0.56	0.51
SnAg (221)	0.54	0.49	0.44
SnCu (227)	0.44	0.38	0.33
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.60	0.55	0.50
SnAg (221)	0.53	0.48	0.43
SnCu (227)	0.43	0.38	0.33
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.60	0.55	0.49
SnAg (221)	0.53	0.48	0.42
SnCu (227)	0.42	0.37	0.32
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.58	0.52	0.47
SnAg (221)	0.51	0.46	0.40
SnCu (227)	0.40	0.35	0.30

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.45	0.53	0.62
SnAg (221)	0.74	0.83	0.92
SnCu (227)	1.19	1.27	1.36
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.43	0.52	0.60
SnAg (221)	0.73	0.81	0.90
SnCu (227)	1.17	1.26	1.35
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.41	0.49	0.58
SnAg (221)	0.70	0.79	0.88
SnCu (227)	1.15	1.24	1.32
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.41	0.49	0.58
SnAg (221)	0.70	0.79	0.88
SnCu (227)	1.15	1.24	1.32
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.37	0.46	0.54
SnAg (221)	0.67	0.75	0.84
SnCu (227)	1.11	1.20	1.29

C0805 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.57	0.65	0.72
SnAg (221)	0.56	0.64	0.71
SnCu (227)	0.54	0.62	0.70
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.58	0.65	0.73
SnAg (221)	0.57	0.64	0.72
SnCu (227)	0.55	0.63	0.71
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.58	0.66	0.74
SnAg (221)	0.57	0.65	0.73
SnCu (227)	0.56	0.64	0.71
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.59	0.67	0.75
SnAg (221)	0.58	0.66	0.74
SnCu (227)	0.56	0.64	0.72
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.61	0.69	0.77
SnAg (221)	0.60	0.68	0.76
SnCu (227)	0.59	0.66	0.74

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-1.11	-1.11	-1.11
SnAg (221)	-0.99	-0.99	-0.99
SnCu (227)	-0.81	-0.81	-0.81
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.93	-0.93	-0.93
SnAg (221)	-0.81	-0.81	-0.81
SnCu (227)	-0.63	-0.63	-0.63
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.66	-0.66	-0.66
SnAg (221)	-0.54	-0.54	-0.54
SnCu (227)	-0.37	-0.37	-0.37
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.66	-0.66	-0.66
SnAg (221)	-0.54	-0.54	-0.54
SnCu (227)	-0.37	-0.37	-0.37
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.23	-0.23	-0.23
SnAg (221)	-0.11	-0.11	-0.11
SnCu (227)	0.06	0.06	0.06

C1206 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.71	0.72	0.73
SnAg (221)	0.81	0.82	0.83
SnCu (227)	0.96	0.97	0.98
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.74	0.75	0.76
SnAg (221)	0.84	0.85	0.86
SnCu (227)	0.99	1.00	1.01
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.77	0.78	0.79
SnAg (221)	0.87	0.88	0.89
SnCu (227)	1.02	1.03	1.04
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.79	0.80	0.81
SnAg (221)	0.89	0.90	0.91
SnCu (227)	1.04	1.05	1.06
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.87	0.87	0.88
SnAg (221)	0.96	0.97	0.98
SnCu (227)	1.11	1.12	1.13

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.27	1.73	1.19
SnAg (221)	2.24	1.70	1.16
SnCu (227)	2.19	1.65	1.12
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.10	1.57	1.03
SnAg (221)	2.07	1.54	1.00
SnCu (227)	2.03	1.49	0.95
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.86	1.33	0.79
SnAg (221)	1.83	1.30	0.76
SnCu (227)	1.79	1.25	0.71
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.86	1.33	0.79
SnAg (221)	1.83	1.30	0.76
SnCu (227)	1.79	1.25	0.71
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.48	0.94	0.40
SnAg (221)	1.45	0.91	0.37
SnCu (227)	1.40	0.87	0.33

TH Dip Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	11.56	10.97	10.38
SnAg (221)	13.38	12.79	12.20
SnCu (227)	16.10	15.51	14.92
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	11.04	10.45	9.85
SnAg (221)	12.85	12.26	11.67
SnCu (227)	15.57	14.98	14.39
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	10.60	10.01	9.42
SnAg (221)	12.42	11.83	11.24
SnCu (227)	15.14	14.55	13.96
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	10.25	9.66	9.07
SnAg (221)	12.07	11.48	10.89
SnCu (227)	14.79	14.20	13.61
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.99	8.40	7.81
SnAg (221)	10.80	10.21	9.62
SnCu (227)	13.52	12.93	12.34

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.68	1.49	1.30
SnAg (221)	1.20	1.01	0.82
SnCu (227)	0.49	0.30	0.11
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.78	1.59	1.40
SnAg (221)	1.30	1.11	0.92
SnCu (227)	0.58	0.39	0.20
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.92	1.73	1.54
SnAg (221)	1.44	1.25	1.06
SnCu (227)	0.73	0.54	0.35
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	1.92	1.73	1.54
SnAg (221)	1.44	1.25	1.06
SnCu (227)	0.73	0.54	0.35
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.15	1.96	1.77
SnAg (221)	1.67	1.48	1.29
SnCu (227)	0.95	0.76	0.58

TH Res. Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.37	-0.07	0.23
SnAg (221)	-0.47	-0.17	0.13
SnCu (227)	-0.61	-0.32	-0.02
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.34	-0.05	0.25
SnAg (221)	-0.44	-0.14	0.15
SnCu (227)	-0.59	-0.29	0.00
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.32	-0.03	0.27
SnAg (221)	-0.42	-0.13	0.17
SnCu (227)	-0.57	-0.27	0.02
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.31	-0.01	0.29
SnAg (221)	-0.41	-0.11	0.19
SnCu (227)	-0.56	-0.26	0.04
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.26	0.04	0.34
SnAg (221)	-0.35	-0.06	0.24
SnCu (227)	-0.50	-0.21	0.09

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.58	6.14	3.71
SnAg (221)	8.80	6.37	3.93
SnCu (227)	9.14	6.70	4.26
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.65	6.22	3.78
SnAg (221)	8.88	6.44	4.00
SnCu (227)	9.21	6.77	4.34
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.76	6.32	3.89
SnAg (221)	8.98	6.55	4.11
SnCu (227)	9.32	6.88	4.44
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.76	6.32	3.89
SnAg (221)	8.98	6.55	4.11
SnCu (227)	9.32	6.88	4.44
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.93	6.50	4.06
SnAg (221)	9.16	6.72	4.28
SnCu (227)	9.49	7.05	4.62

SOT223 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.13	0.05	0.24
SnAg (221)	-0.21	-0.03	0.16
SnCu (227)	-0.33	-0.15	0.04
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.15	0.04	0.22
SnAg (221)	-0.23	-0.04	0.14
SnCu (227)	-0.34	-0.16	0.03
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.16	0.03	0.21
SnAg (221)	-0.24	-0.05	0.13
SnCu (227)	-0.35	-0.17	0.01
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.17	0.02	0.20
SnAg (221)	-0.25	-0.06	0.12
SnCu (227)	-0.36	-0.18	0.00
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.20	-0.01	0.17
SnAg (221)	-0.28	-0.09	0.09
SnCu (227)	-0.40	-0.21	-0.03

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.58	6.91	5.24
SnAg (221)	9.18	7.51	5.83
SnCu (227)	10.07	8.40	6.73
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	8.80	7.13	5.46
SnAg (221)	9.39	7.72	6.05
SnCu (227)	10.29	8.62	6.95
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	9.12	7.45	5.78
SnAg (221)	9.72	8.05	6.38
SnCu (227)	10.61	8.94	7.27
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	9.12	7.45	5.78
SnAg (221)	9.72	8.05	6.38
SnCu (227)	10.61	8.94	7.27
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	9.64	7.97	6.30
SnAg (221)	10.24	8.57	6.90
SnCu (227)	11.14	9.47	7.79

SOT23 Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.26	0.27	0.27
SnAg (221)	0.28	0.28	0.28
SnCu (227)	0.29	0.30	0.30
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.26	0.27	0.27
SnAg (221)	0.28	0.28	0.28
SnCu (227)	0.29	0.30	0.30
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.26	0.27	0.27
SnAg (221)	0.28	0.28	0.28
SnCu (227)	0.29	0.30	0.30
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.26	0.27	0.27
SnAg (221)	0.28	0.28	0.28
SnCu (227)	0.29	0.30	0.30
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.26	0.27	0.27
SnAg (221)	0.27	0.28	0.28
SnCu (227)	0.29	0.29	0.30

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.39	0.46	0.53
SnAg (221)	0.35	0.43	0.50
SnCu (227)	0.30	0.38	0.45
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.41	0.48	0.55
SnAg (221)	0.37	0.45	0.52
SnCu (227)	0.32	0.40	0.47
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.44	0.51	0.59
SnAg (221)	0.41	0.48	0.55
SnCu (227)	0.36	0.43	0.50
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.44	0.51	0.59
SnAg (221)	0.41	0.48	0.55
SnCu (227)	0.36	0.43	0.50
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.49	0.56	0.64
SnAg (221)	0.46	0.53	0.60
SnCu (227)	0.41	0.48	0.55

SOIC14 SnPb Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.20	0.31	0.42
SnAg (221)	0.04	0.15	0.26
SnCu (227)	-0.21	-0.10	0.02
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.19	0.31	0.42
SnAg (221)	0.03	0.14	0.25
SnCu (227)	-0.22	-0.10	0.01
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.19	0.30	0.41
SnAg (221)	0.02	0.14	0.25
SnCu (227)	-0.22	-0.11	0.00
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.18	0.30	0.41
SnAg (221)	0.02	0.13	0.24
SnCu (227)	-0.23	-0.11	0.00
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.17	0.28	0.39
SnAg (221)	0.00	0.11	0.23
SnCu (227)	-0.24	-0.13	-0.02

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.64	2.01	1.38
SnAg (221)	3.36	2.73	2.10
SnCu (227)	4.45	3.81	3.18
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.66	2.03	1.40
SnAg (221)	3.39	2.75	2.12
SnCu (227)	4.47	3.84	3.21
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.70	2.07	1.44
SnAg (221)	3.42	2.79	2.16
SnCu (227)	4.51	3.87	3.24
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.70	2.07	1.44
SnAg (221)	3.42	2.79	2.16
SnCu (227)	4.51	3.87	3.24
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	2.76	2.13	1.50
SnAg (221)	3.48	2.85	2.22
SnCu (227)	4.57	3.93	3.30

SOIC14 PdNi Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.08	0.05	0.18
SnAg (221)	-0.15	-0.03	0.10
SnCu (227)	-0.27	-0.15	-0.02
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.09	0.04	0.17
SnAg (221)	-0.17	-0.04	0.09
SnCu (227)	-0.29	-0.16	-0.03
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.10	0.03	0.16
SnAg (221)	-0.18	-0.05	0.08
SnCu (227)	-0.30	-0.17	-0.04
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.11	0.02	0.15
SnAg (221)	-0.19	-0.06	0.07
SnCu (227)	-0.31	-0.18	-0.05
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	-0.14	-0.01	0.12
SnAg (221)	-0.22	-0.09	0.04
SnCu (227)	-0.34	-0.21	-0.08

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.09	2.89	1.69
SnAg (221)	4.57	3.37	2.17
SnCu (227)	5.28	4.08	2.88
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.15	2.96	1.76
SnAg (221)	4.63	3.43	2.23
SnCu (227)	5.34	4.14	2.94
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.25	3.05	1.85
SnAg (221)	4.72	3.52	2.32
SnCu (227)	5.43	4.23	3.04
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.25	3.05	1.85
SnAg (221)	4.72	3.52	2.32
SnCu (227)	5.43	4.23	3.04
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	4.40	3.20	2.00
SnAg (221)	4.87	3.67	2.47
SnCu (227)	5.58	4.38	3.18

QFP Wetting Force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.16	0.17	0.18
SnAg (221)	0.15	0.16	0.17
SnCu (227)	0.13	0.14	0.15
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.16	0.17	0.18
SnAg (221)	0.15	0.16	0.17
SnCu (227)	0.13	0.14	0.15
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.16	0.17	0.18
SnAg (221)	0.15	0.16	0.17
SnCu (227)	0.13	0.14	0.15
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.16	0.17	0.18
SnAg (221)	0.15	0.16	0.17
SnCu (227)	0.13	0.14	0.15
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.17	0.18	0.19
SnAg (221)	0.15	0.17	0.18
SnCu (227)	0.14	0.15	0.16

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.76	0.60	0.44
SnAg (221)	0.96	0.80	0.64
SnCu (227)	1.26	1.10	0.94
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.79	0.63	0.48
SnAg (221)	0.99	0.83	0.68
SnCu (227)	1.29	1.13	0.98
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.84	0.68	0.53
SnAg (221)	1.04	0.88	0.73
SnCu (227)	1.34	1.18	1.02
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.84	0.68	0.53
SnAg (221)	1.04	0.88	0.73
SnCu (227)	1.34	1.18	1.02
Flux E	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.92	0.76	0.60
SnAg (221)	1.12	0.96	0.80
SnCu (227)	1.42	1.26	1.10

Minimelf Wetting force F2 [mN]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.23	0.38	0.53
SnAg (221)	0.28	0.43	0.58
SnCu (227)	0.34	0.49	0.64
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.22	0.37	0.52
SnAg (221)	0.26	0.41	0.56
SnCu (227)	0.32	0.47	0.62
Flux SLS 65	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.20	0.35	0.50
SnAg (221)	0.24	0.39	0.55
SnCu (227)	0.31	0.46	0.61
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.19	0.34	0.49
SnAg (221)	0.23	0.38	0.53
SnCu (227)	0.30	0.45	0.60
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	0.15	0.30	0.45
SnAg (221)	0.19	0.34	0.49
SnCu (227)	0.26	0.41	0.56

Time to 2/3Fmax [s]

Flux A	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.53	2.82	2.11
SnAg (221)	3.47	2.76	2.04
SnCu (227)	3.37	2.66	1.95
Flux B	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.56	2.85	2.14
SnAg (221)	3.50	2.78	2.07
SnCu (227)	3.40	2.69	1.98
Flux SLS 65	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.60	2.89	2.18
SnAg (221)	3.54	2.83	2.11
SnCu (227)	3.44	2.73	2.02
Flux C	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.60	2.89	2.18
SnAg (221)	3.54	2.83	2.11
SnCu (227)	3.44	2.73	2.02
Flux D	Superheat [°C]		
Solder	20	30	40
SnAgCu (217)	3.67	2.96	2.24
SnAg (221)	3.61	2.89	2.18
SnCu (227)	3.51	2.80	2.08