SIR Intercomparison to Validate the use of a Fine Pitch Pattern

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Abstract
It is well known that structures at fine pitches with flux residues are more susceptible to corrosion issues and electrochemical migration (ECM) problems. Characterization of flux residues in terms of ECM are commonly characterized using SIR testing. A key parameter of the SIR test is the comb pattern used and gap between the electrodes. The current B24 and B25 with their 500 and 318µm gap patterns are not representative of fine pitch. It has been proposed to use a 200µm gap pattern, and this paper describes an intercomparison that validates the introduction of the 200µm gap pattern.

A new test board was used that included the B24 and B25 patterns with an additional 200µm pattern, with each pattern duplicated, giving six in all. This work was motivated by an update to the current IEC 61189-5-501[1]. A protocol for the testing was developed that took a standard test rosin flux and defined the flux loading and thermal conditioning. Seven laboratories took part from five countries. The test boards were prepared centrally and then tested in the seven laboratories, and the results analysed to validate the usage of the 200µm pattern. The paper describes the intercomparison and the data analysis.

Introduction

The pursuit of higher quality and reliability, leads to the requirement of proving that electronic assemblies are not susceptible to electrochemical failure. Such robustness will lead to proven lifetime performance in the field. Electrochemical failure can occur at the surface or sub-surface, and in this paper we focus on surface failure phenomena and its characterisation. Electrochemical failure needs three simultaneous factors to be present for a failure to occur: a continuous water film, an applied electric filed, and soluble ionic material. Under condensing conditions, a macroscopic water film will form and in most instances an uncoated assembly will fail instantly. But for high humidity conditions an invisible sub-micron water film will form that will support low levels of conduction, and certainly no fast dramatic loss of isolation. Applied electric fields can cause electrochemical failure, from 25 V/mm and upwards, by driving ions down an electric field. Ionic material is needed as pure water has very high resistivity; hence dissolved ions increase conductivity and polarization at electrodes resulting in corrosion at the anode. Sources of contamination can appear on the surface of the assembly from the manufacturing process or the environment. If the contamination is water soluble and dissociates to form ionic species, these ions migrate under an electric filed.

It is of course of interest as to what ionic materials are present, but more importantly, the question is what will be the impact of these residues or contamination. The industry many years ago developed the basis of the “Surface Insulation Resistance” test which applies an electrical bias across an interdigitated comb in a damp heat environment at elevated temperatures and measures the resistance stability. This test is a simulation of what will happen in the field, and hence the outcome is relevant to that performance. The IPC TM650 2.6.3.3[2], 2.6.3.6 [3] and 2.6.3.7[4] describe the SIR test for various applications, providing various test geometries and voltage conditions. The B24 has 500µm gap in the comb pattern, and this is typically a lot greater than the minimum distances found on high density circuit assemblies, where the gap can easily be down to 200µm, and below. The B24 was proposed circa 1990 and reflected the needs of those days, and of course since then there has been a move to finer pitches. At finer gaps the electrochemical behaviour can accelerate and is sensitive to the applied electric field [5]. In this work it was shown for certain residues that as the test voltage dropped so did the measured resistance, hence the electrochemical pathway did not behave in a simple ohmic manner. A conclusion of this work was that the gap in the SIR pattern and the applied voltage should be representative of the intended use environment. Hence, within IPC TM650 2.6.3.7[4] there is a recommendation to use a 200µm pattern with a 25 V/mm field strength. No SIR pattern is given in the test method. However, within the IPC-B-52 test coupons there are 200µm SIR patterns used, specifically below the QFP devices.

Therefore, there is a strong interest in using the 200µm SIR pattern but there is not a dedicated test coupon available. This paper sets out to demonstrate the interoperability of using different SIR patterns and hence demonstrate that the 200µm pattern can be used with confidence. Most SIR patterns are approximately 25x25mm^2, and as the pitch of the interdigitated comb decreases the so called number of squares increase. As the number of squares increases the resistance will drop. Hence, if we consider the case where there is a fixed resistance for any square, as the number of squares increase the overall measured resistance of the pattern will decrease, since these squares are in parallel. Any comparison must therefore take into account the number of squares in the SIR pattern.

The electrochemical behaviour in the SIR test is known to be pitch sensitive, and as the pitch reduces the incidence of dendrites increases, even when the field strength is held constant. The potential for this catastrophic failure is the motivation for this intercomparison, but it is not something we wish to occur here. Rather we are attempting to demonstrate that under intermediate SIR values ($10^8\Omega$ and above) the patterns behave in an identical way, allowing for differences in the number of squares. Hence a test regime will be invoked that causes this behaviour and allows a straight forward comparison between the various pitches in this study.

In this study we have taken a 200µm gap pattern in common use, and originally defined in a joint European project. This pattern will be compared with two SIR patterns in common use today, the IPC B24 and a pattern from the B25, with 400/500 and 318/318µm track and gap, respectively. A board was designed that included these three SIR patterns, duplicating each pattern, and named TB144.

To validate the introduction of this new test-pattern an intercomparison exercise was undertaken, with seven laboratories taking part, from Denmark, Germany, Japan, UK, and USA.

Experimental

As mentioned in the introduction a new test vehicle was designed for this project that included the 400/200, 400/500, and 318/318µm track and gap patterns. The 400/200µm is the new pattern, and 400/500, and 318/318µm are the IPC B24 and B25 respectively. This board was designed at our company and given the name TB144, and the design is freely available from our company. The design is shown in Figure 1.

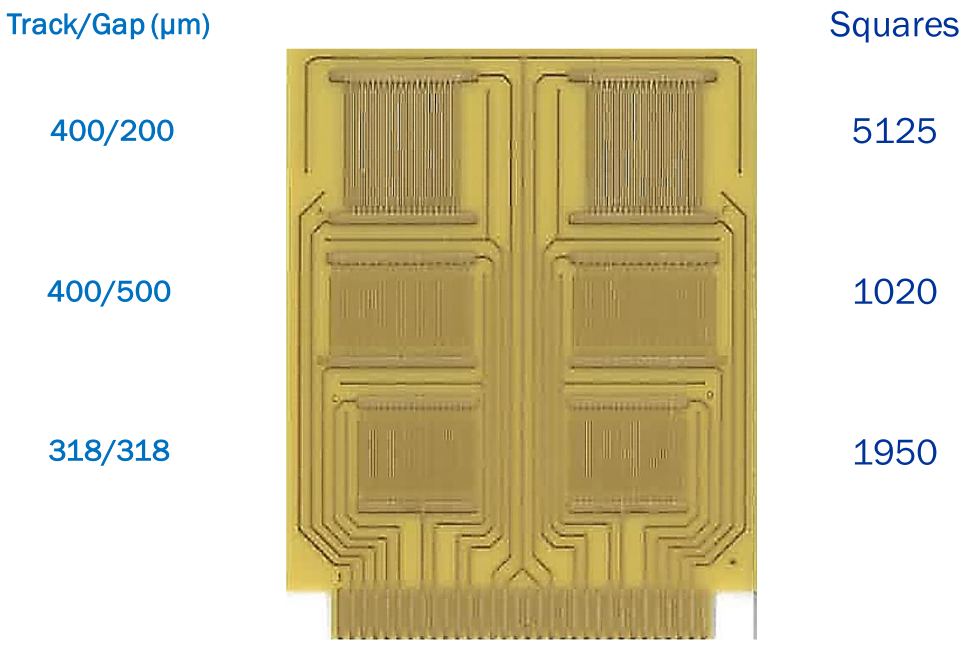


Figure 1: The test PCB, TB144

In Figure 1 the number of squares is also given, and as can be seen the number of squares for the 400/200µm pattern are significantly higher. It can also be seen that there are only small differences in overall size between the patterns. All test patterns have the same applied voltage and in this work was set to 20V. This meant that the electric field strength was different for the three SIR patterns, as occurs on products. The impact of these changes are shown in Table 1.

Table 1: SIR Pattern Information

	B24	B25	New
Track / Gap (µm)	400 / 500	318 / 318	400 / 200
Number of squares	1020	1950	5125
Resistance (Ω)*	1.00E+08	5.23E+07	1.99E+07
Field Strength (V/mm)**	40.0	62.9	100.0

** The $10^8\Omega$ is an example value for the pattern and the two following values assume the same resistance per square, and calculated the drop in resistance caused by the increase in the number of squares.*
*** The field strength is calculated using an applied bias of 20V*

The example resistance and field strength values demonstrate clearly how the Surface Insulation resistance (SIR) of each pattern changes with its design. The new pattern clearly drops the measured pattern resistance significantly and increases the field strength. This intercomparison therefore sets out to establish the relative performance of the new pattern.

All six patterns were dosed with the same density of an activated rosin flux and tested under two climatic conditions, 40ºC/93%RH, and 85ºC/85%RH. The dosing density was refined by a series of experimental iterations to find a level that produced a suitable resistance for all three patterns. An important feature of this intercomparison was that all the test coupon preparation was undertaken at the company, and undertaken for each participant 2 weeks before they were ready to undertake the SIR test. All test boards were cleaned and then fluxed at the company by a single operator.

The test coupons were all supplied were made with 0.5oz Cu and High Tg laminate. The flux used is described in Table 2, and is commonly used in solderability testing.

Table 2 – Flux used for the intercomparison

Constituent[a]	**Composition by mass fraction**
Colophony	25 ± 0,5
Diethylammonium hydrochloride (CAS No. 660-68-4)	0,39 ± 0,01
2-propanol (Isopropyl alcohol) (CAS No. 67-63-0) or ethyl alcohol (CAS No. 64-17-5) as an alternative	74,61 ± 0,5
Mass of chlorine of solids[b]	0,5
[a] See IEC 60068-2-20, Annex B for specification. [b] Expressed as free chlorine based on the colophony content.	

A sample set consisted of three test coupons for each test condition, plus an additional unfluxed control coupon. All coupons were cleaned in an ionic contamination tester containing 75 % propan-2-ol, 25 % deionized water at 45ºC for 15 minutes. All boards were identified by physically scribing the coupon. The coupons were visually inspected for any obvious defects. During the remainder of specimen preparation, the coupons were handled by the edges only, or with the use of non-contaminating polymer gloves. Coupons were stored in contamination-free bags or containers and closed, since the bags were not of the heat sealing variety.

The coupon set for each participant is given in Table 3.

Table 3 – Coupon set for each participant

Sample group	Fluxed	Number of coupons
A = 85°C/85%RH	Yes	3
B = 85°C /85%RH	No	1
C = 40°C /93%RH	Yes	3
D = 40°C /93%RH	No	1

The fluxed coupons were coated using the following procedure. A micro-pipette was used to spread the flux uniformly to coat each of the 6 test patterns on one coupon with 5µl/cm^2 of the liquid flux, avoiding flux spreading beyond the outside of each pattern. Flux coated samples were dried by placing in a heated fan assisted box oven at 100°C ± 1°C for 5 minutes. The boards were placed on an aluminium plate that was at 100ºC, which was already in the oven. The aluminium plate was at least 20mm bigger than the board in both length directions, and was at least 2mm thick. The company prepared all the fluxed coupons for the participants to avoid the variation of flux sample preparation. The participants tested the coupons within 4 weeks of receipt.

The resistance measuring instruments, cabling and connectors were all within their calibration and met the appropriate standards given by either IEC 61189-5-501, or IPC 2.6.3.7, where the required accuracy is: ±5 % up to $10^{10}\Omega$, ±10% between 10^{10} to $10^{11}\Omega$, and ±20 % above $10^{11}\Omega$. In addition to the verification of the system a checker board with, a TB144 board with six $10^{11}\Omega$ resistors soldered on each test pattern, was sent to each participant as an extra validation of their SIR measurement systems and connectors before the intercomparison test. The test apparatus used included the production SIR tester and the integrated production test chamber system using a production electrometer.

The preferred method of connecting to the coupons was to use an edge connector system, and an example arrangement is shown in Figure 2. One participant hand soldered the cable to the coupons, using a low residue no-clean flux.

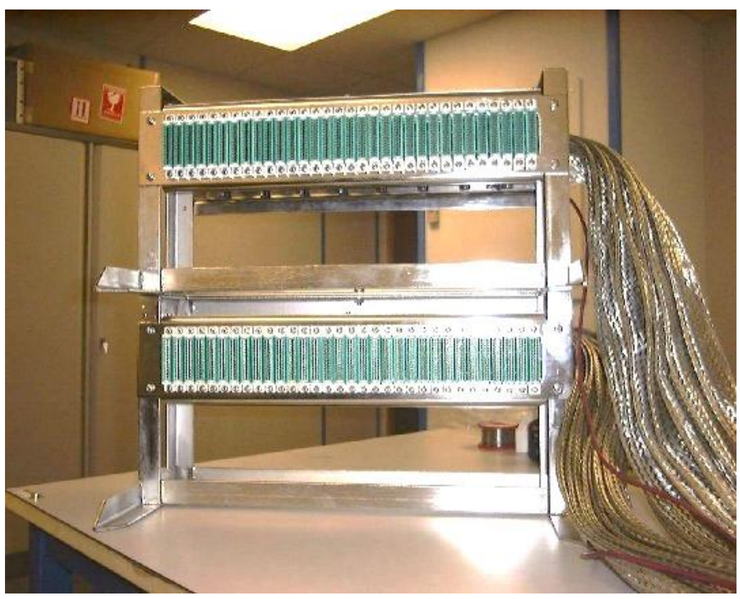


Figure 2: Connector arrangement

Coupons were held vertically and in such a way that the air flow was parallel to the direction of the board in the chamber. Deionised water was used in the chambers. For the A and B conditions in Table 3 the temperature was raised to 85°C ±2°C, or for the C and D condition it was raised to 40ºC ± 2°C, in both instances keeping the humidity at 20 % RH; to allow the chambers to stabilize at this temperature for 3 hours. Then, the humidity was slowly ramped to the target value, either 85 % RH ± 2 % or 93% RH ± 2 % over a minimum period of 15 minutes. The coupons were allowed to come to equilibrium for at least 1 hour before applying the bias voltage to begin the test. The bias voltage was 20 ± 0.1V DC.

The resistance measurements were made under the test conditions of temperature and humidity at 20 min intervals for 168 hours. Resistance measurements were also recorded at ambient condition (~25C/50%RH) before the chamber environmental condition started, to benchmark starting conditions.

Results

The results of testing the $10^{11}\Omega$ checker board for each participant are presented in Figure 3.

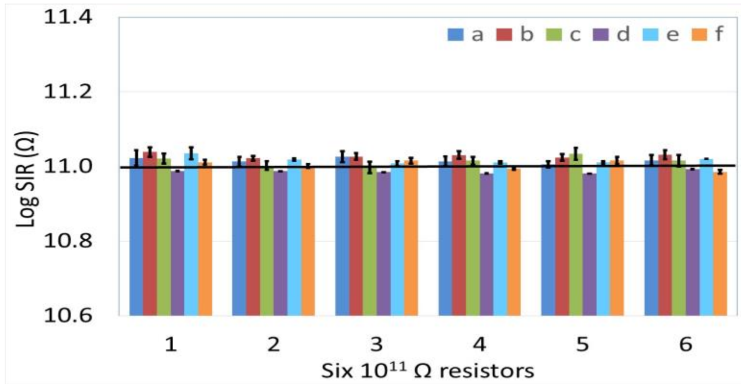


Figure 3: Participants (a to f) resistance measurements for the six resistors on the checker board

For each participant, the average Log SIR value for each resistor is from 5 measurements on 4 different measurement channels (20 measurements in total), shown in Figure 3. The resistance results from all participants are within 0.2% of the nominal value ($10^{11}\Omega$). This shows that for all participants the resistance performance is well within the specification required by the standards.

The seven participant’s results are presented below, starting with participant A. The three results shown in each graph, are an average of results from two identical SIR patterns per PCB and of three PCB test samples, 6 measurements in total for the fluxed coupons.

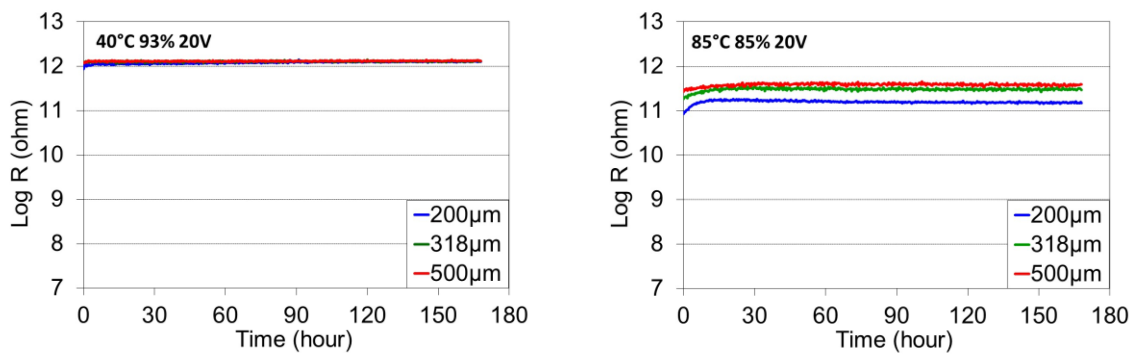


Figure 4: Participant A control boards

Figure 4 shows the measurements for participant A of the control boards.

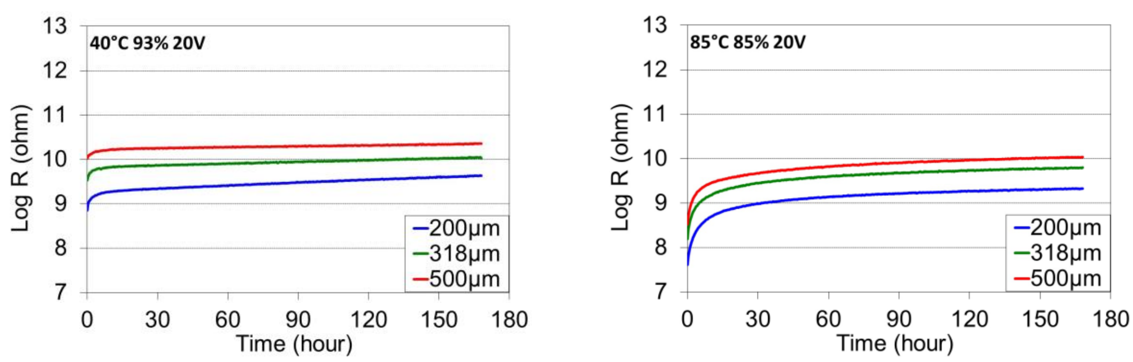


Figure 5: Participant A flux loaded boards

Figure 5 shows the measurements for participant A of the fluxed boards.

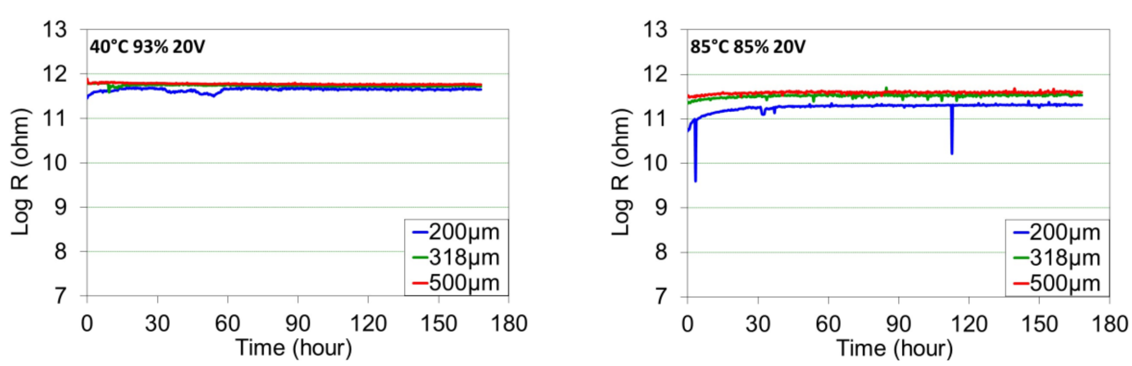


Figure 6: Participant B control boards

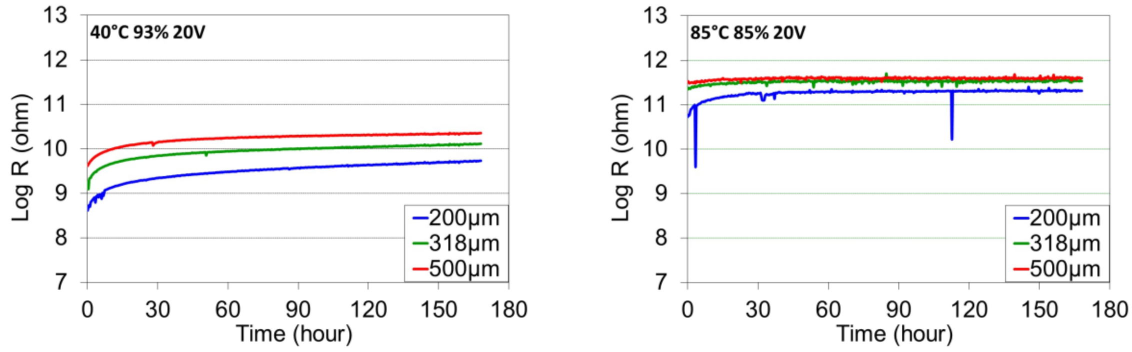


Figure 7: Participant B flux loaded boards

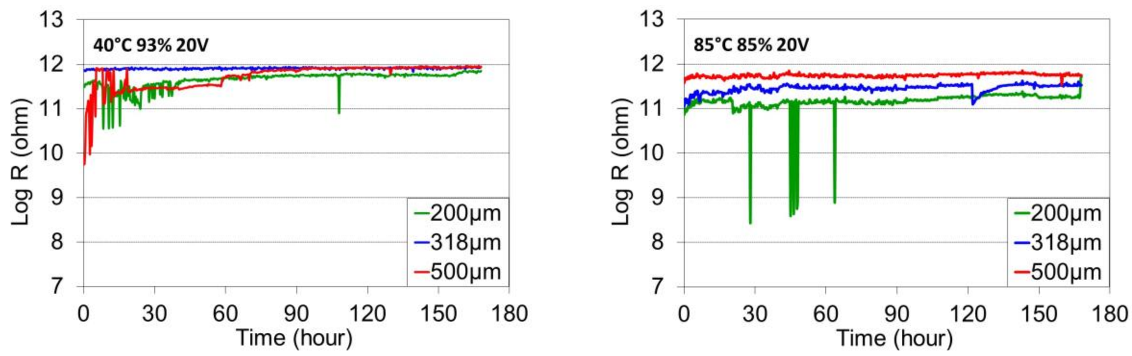


Figure 8: Participant C control boards

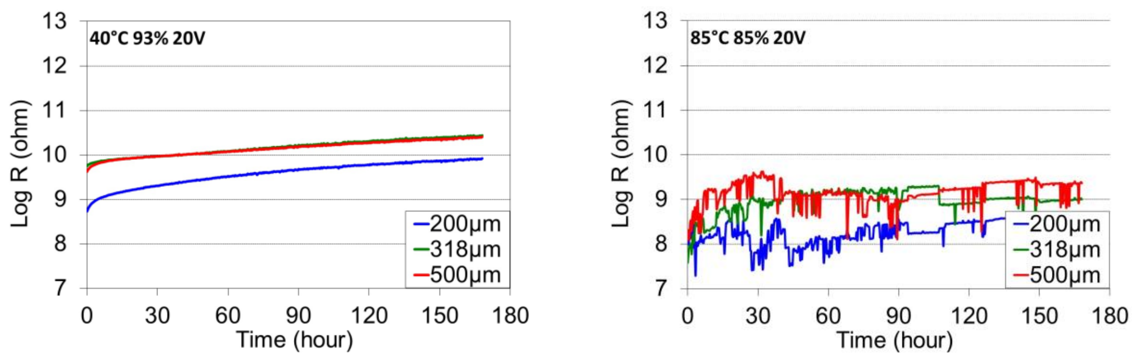


Figure 9: Participant C flux loaded boards

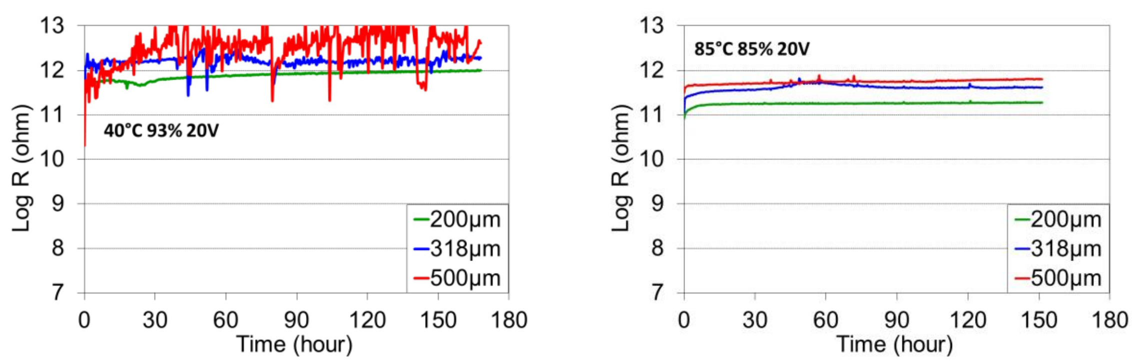


Figure 10: Participant D control boards

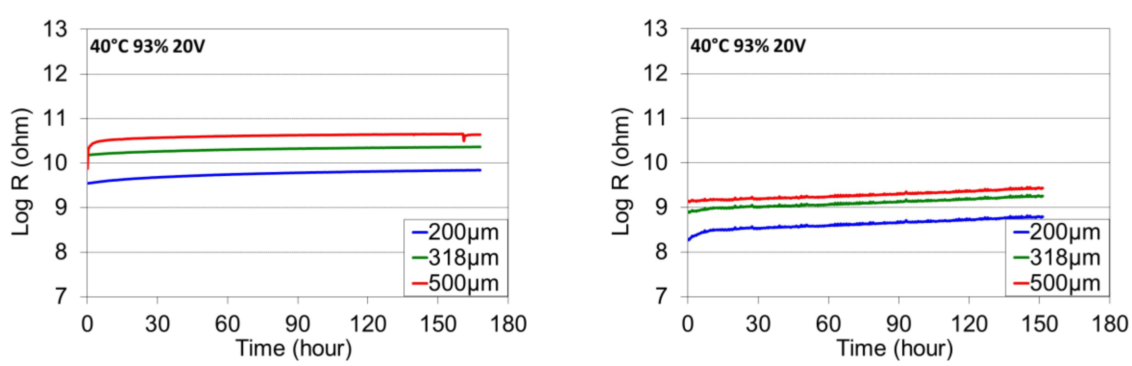


Figure 11: Participant D flux loaded boards

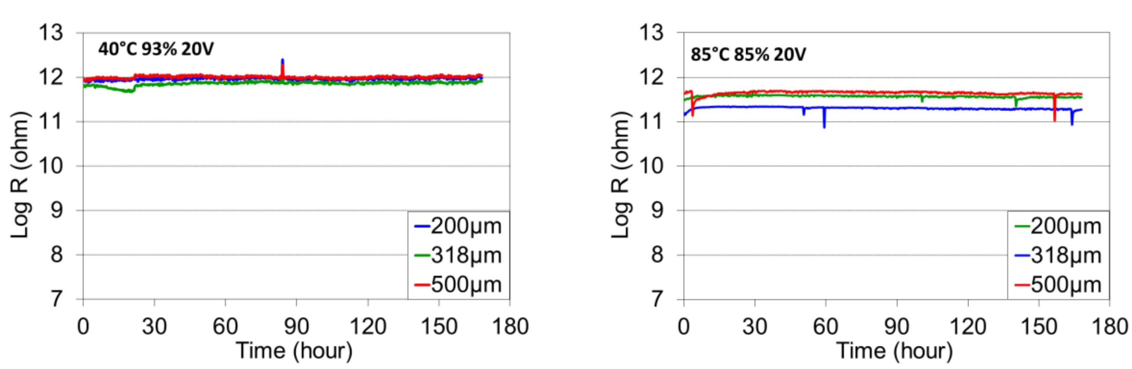


Figure 12: Participant E control boards

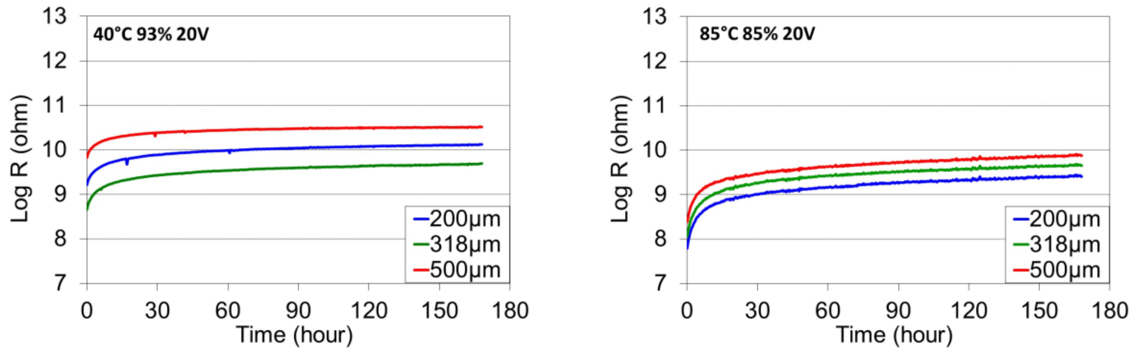


Figure 13: Participant E flux loaded boards

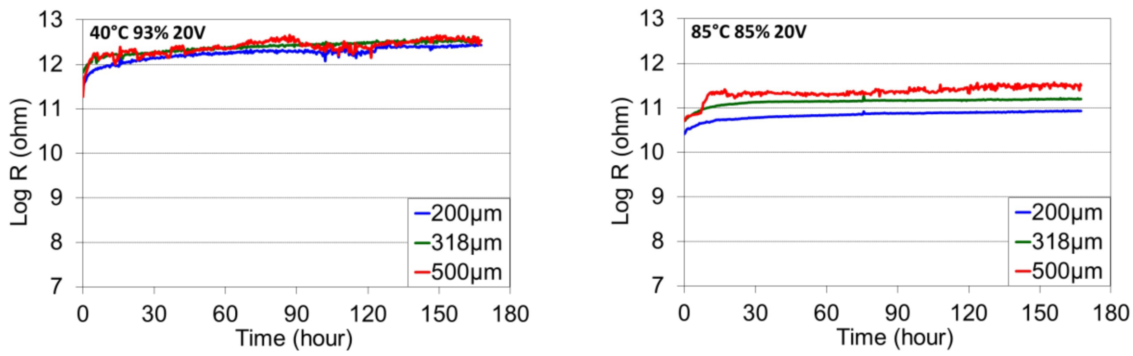


Figure 14: Participant F control boards

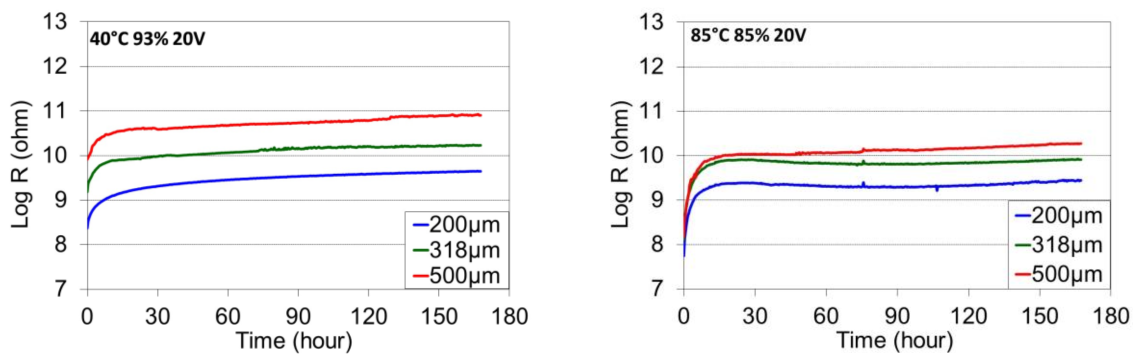


Figure 15: Participant F flux loaded boards

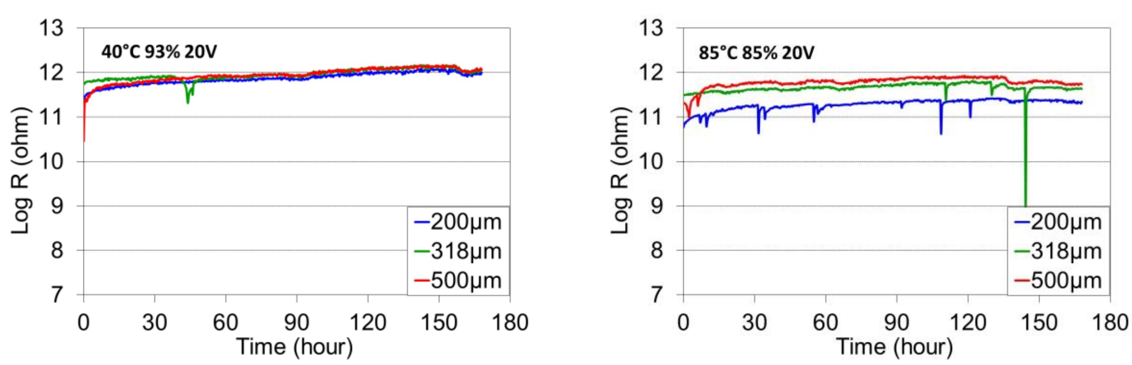


Figure 16: Participant G control boards

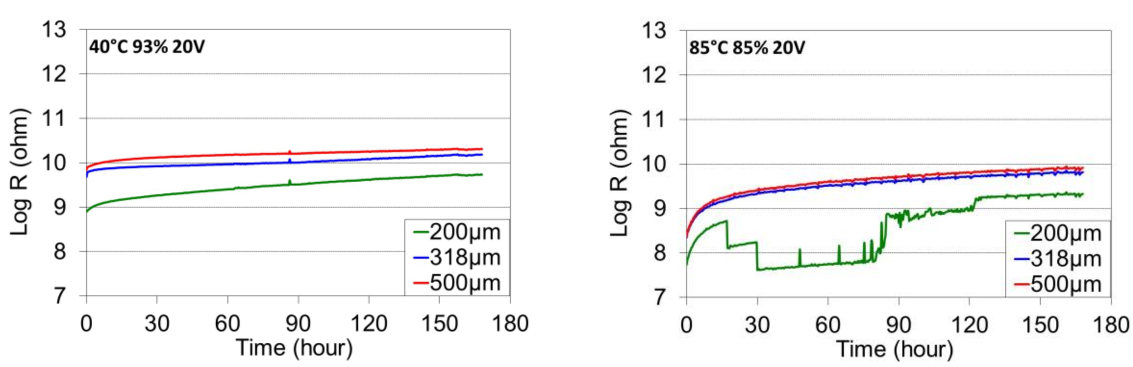


Figure 17: Participant G flux loaded boards

Overall these detailed results show that the quality of these experiments is very high. We can see some issues on some participant's data, and in four specific cases a result from an individual pattern has been removed, and we make a general observation on participant C. Results have been removed because of: fibres, dendrites, water droplets leading to corrosion, and general corrosion. These results are anomalous and not consistent with the flux loading applied at the company. These observations are shown in the results below.

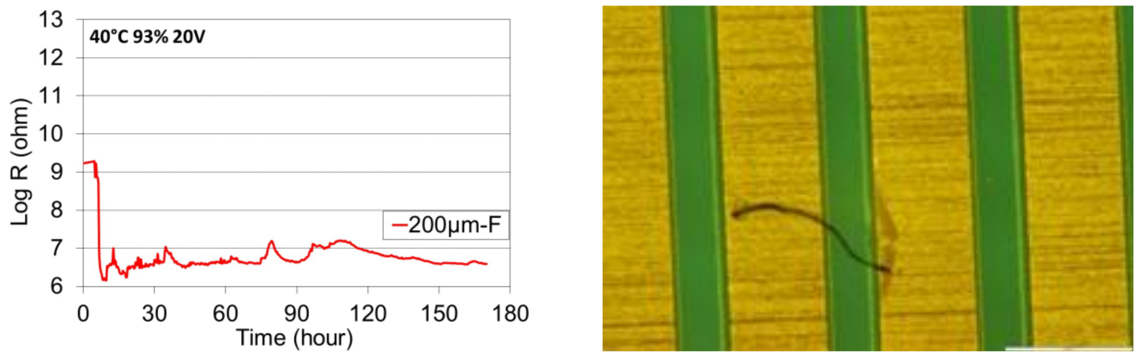


Figure 18: Participant D, and evidence of a fibre and the effect on the SIR

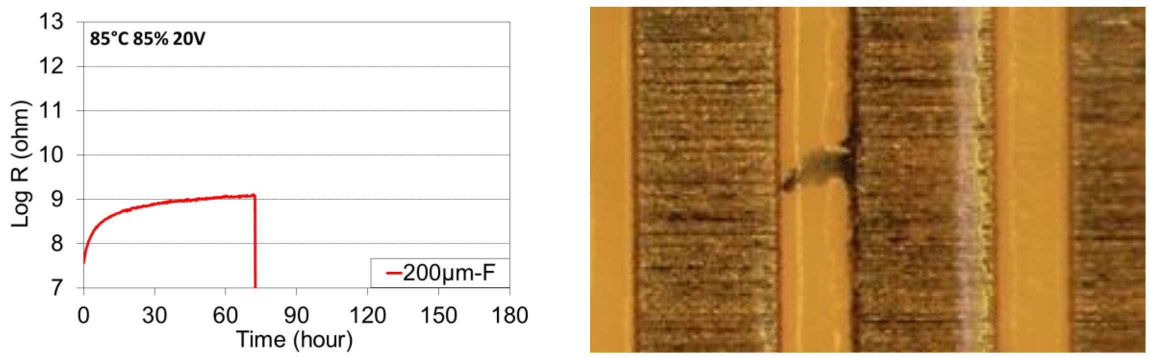


Figure 19: Participant E and evidence of corrosion shorting across the gap

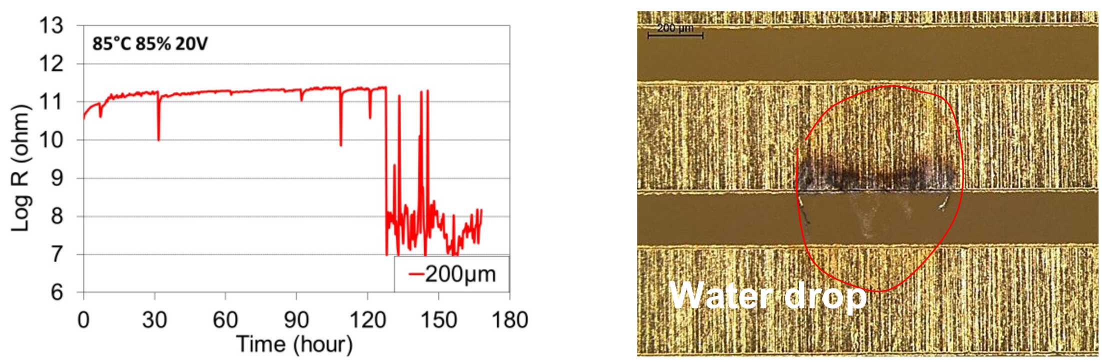


Figure 20: Participant G and evidence of a water droplet and the resulting drop in SIR and dendrite like failure

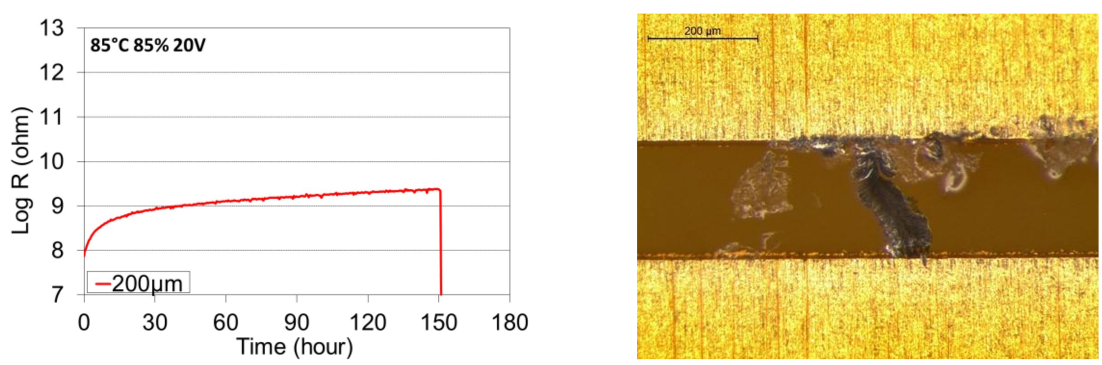


Figure 21: Participant G and a corrosion defect probably from flux residue

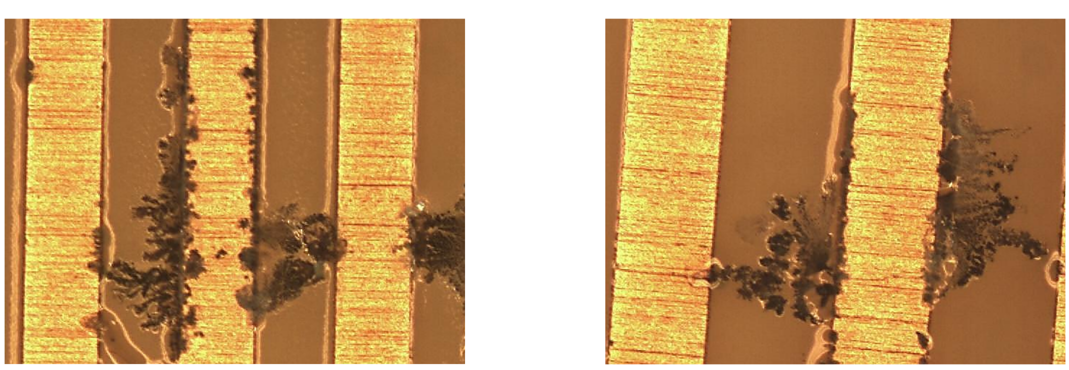
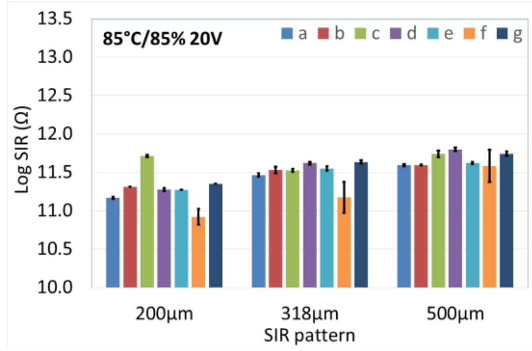


Figure 22: Participant C dendrites and corrosion formed on all SIR patterns of all fluxed samples tested at 85°C/85%RH

Figures 18 to 21 show the defects and the basis for the justification for the removal of specific pattern results. The results from participant C reveal problems with dendrites and general corrosion at 85°C/85%RH (Figure 22), but we have not removed any data from the analysis.

The SIR results in Figures 4 to 17 show that overall there are distinct trends between the different SIR patterns for all participants. There are downwards ticks but this behaviour is independent of the pattern type. Hence, an average of the final 20 data points for each result is calculated and a single resistance value is given for each pattern participant combination. These results are shown in the next two figures (Figures 23 and 24).



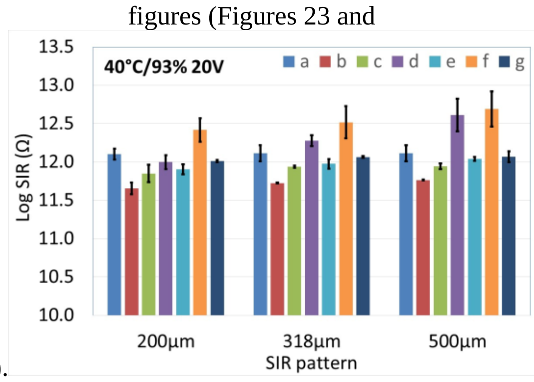


Figure 23: The average final SIR value for the control boards

These results in Figure 23 show more variation than with the resistors in Figure 3. Clearly the measurement repeatability for the resistors is superior. For these results this can be attributed to the variability in the conduction layer, the thin water film. This film thickness is very sensitive to the exact temperature and humidity condition at the coupon surface. Furthermore, small differences in surface energy and surface structure of the coupon will affect the adsorption and conduction in the water film, with further contamination adding to the differences in conduction. This is more evident at 40°C/93%RH, particularly since the current level of ~20pA leads to a greater electrical noise sensitivity, more than for the 85°C /85%RH results. In Figure 24 the fluxed condition shows between the 200, 318 and 500µm gap patterns, following the effect of number of squares. The reproducibility at 40%RH /93%RH is similar to the control results in Figure 23, but the 85/85 results seem more divergent. This cursory observation is strongly influenced by the low results seen for participant C, noted above.

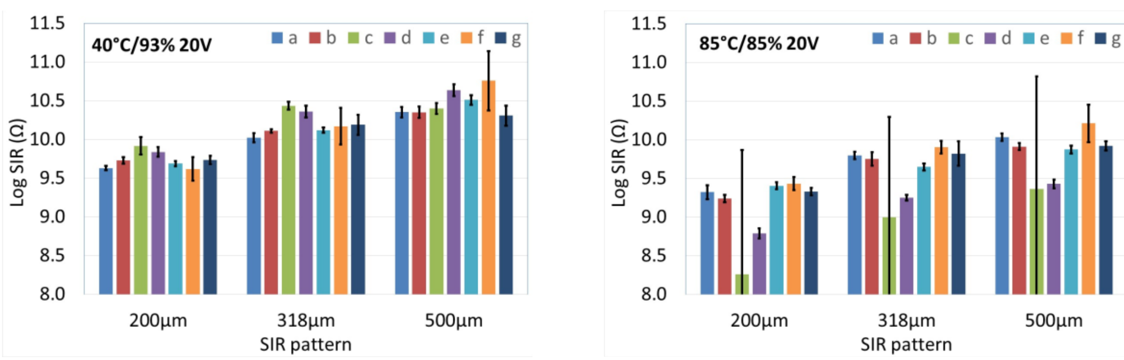


Figure 24: The average final SIR value for the flux loaded boards

The data is rearranged in Figure 25, and plotted by participant, and now the effect of pattern pitch becomes very apparent for each participant. A similar relationship for the patterns is seen for both environmental conditions for each participant.

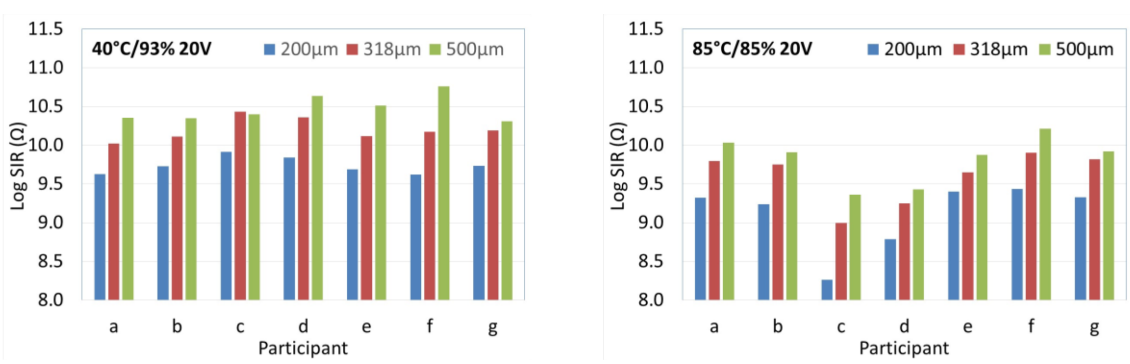


Figure 25: The average final SIR for flux loaded patterns by participant

With this clear dependence on the number of squares shown in Figure 25, the data is corrected for the number squares, by plotting the ohm.square value, and this is shown in Figure 26. Ideally this should show identical results for both of the climatic conditions, and for the 40°C/93%RH condition this is true within the experimental reproducibility. For the 85°C/85%RH condition there is more variability.

This result is very encouraging from an intercomparison perspective, revealing that participants can achieve similar results within the repeatability of the technique, although the 85°/85%RH data does show scatter and we would need to do more work to achieve better agreement on the absolute values. However, the aim of this study was to validate the use of the 200µm pattern, and there is a further data manipulation we can do to further justify the use of this fine pitch pattern. By comparing each participant's data to the B24 pattern, the variations due to implementation issues at each experimental location can be normalised. Hence the impact of adopting the finer 200µm pitch pattern for each participant, can be evaluated and this calculation is shown in Figure 27.

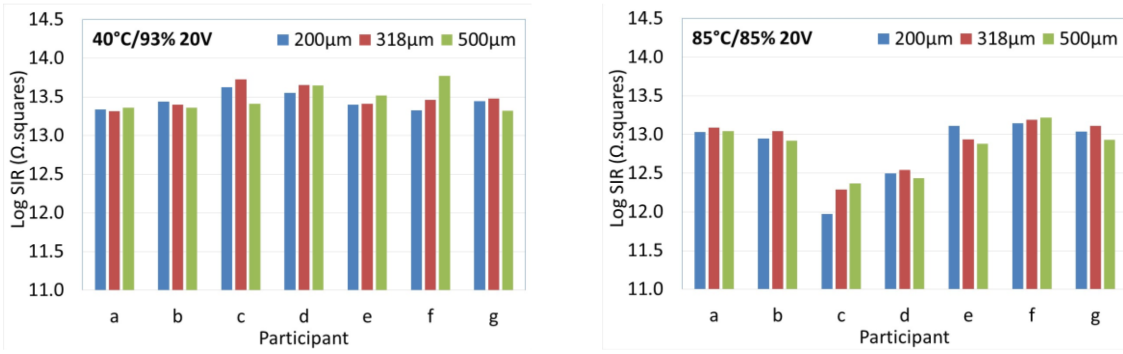


Figure 26: Final SIR plotted as Ohm.Squares

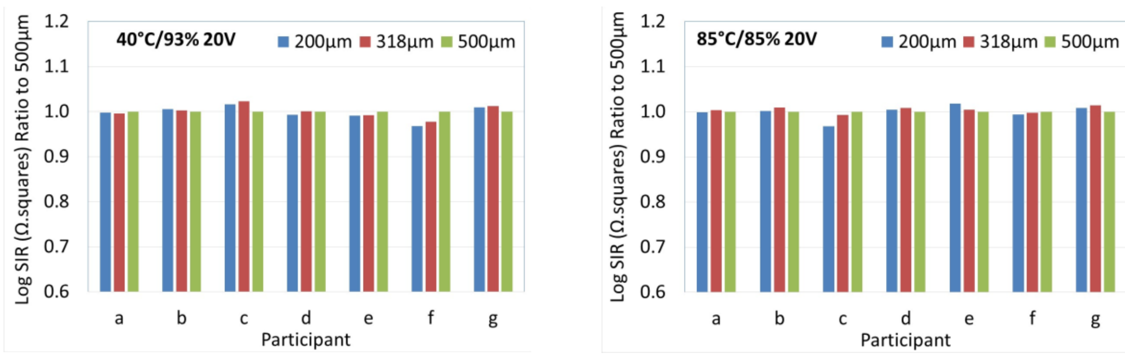


Figure 27: Ratio of the log Ω.square value to the 500µm pattern

The results in Figure 27 clearly show that for each participant the use of the 200µm pattern was identical to the coarser pitch patterns from the B24 and B25. This very positive result completely justifies the use of the 200µm gap pattern in future testing and inclusion in standards.

Participant C connected using hand soldering to the coupon, and with their 85°C/85%RH results can be seen a small trend downwards for the 200µm pattern. Hence hand soldering to the coupon is fraught with flux residue contamination issues, and should be done with extreme care, and fine pitch patterns will be more sensitive to contamination issues.

Conclusions

The aim of this intercomparison was to validate the use of a 200µm gap SIR pattern. The work benchmarked this new pattern against the existing IPC B24 (400/500µm) and B25 (318/318µm) patterns, and demonstrated that the 200µm pattern produces results that are consistent and in line with those from the coarser patterns.

These results have a strong basis, having seven global participants from Denmark, Germany, Japan, UK, and USA. The approach was developed at the company, and the company prepared all the test boards and sent them directly to the participants. This ensured that sample variation was minimised, and was an important factor in achieving good repeatability.

This intercomparison established the relative performance of the new 200µm pattern, and provides a data set for justification and inclusion in any new standard.

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Lothar Henneken of Robert Bosch, Germany
Doug Pauls of Rockwell Collins, USA

We would also like to express our sincere thanks to Dennis Price of Merlin Circuits UK for the provision of the test coupons.

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SIR Intercomparison to Validate the use of a Fine Pitch Pattern

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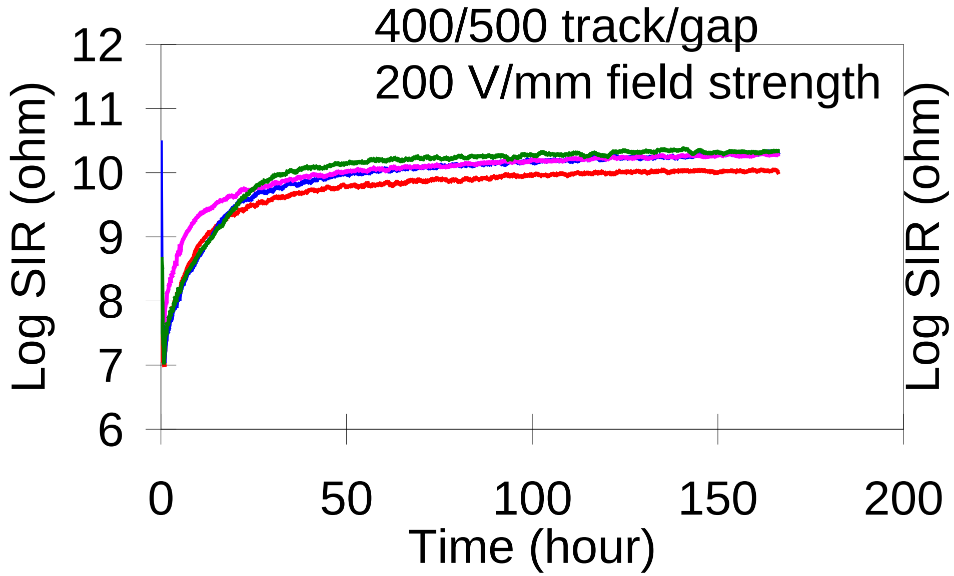
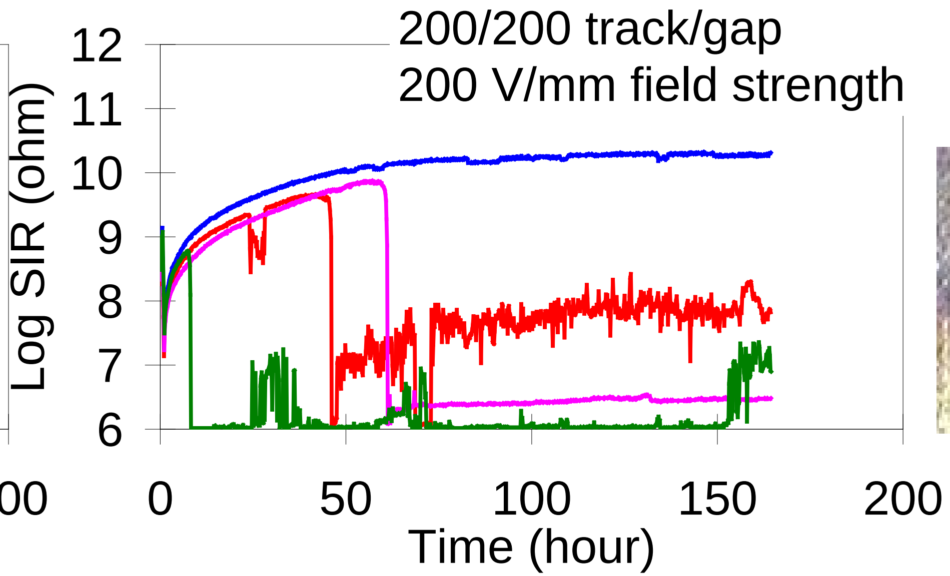
Motivation

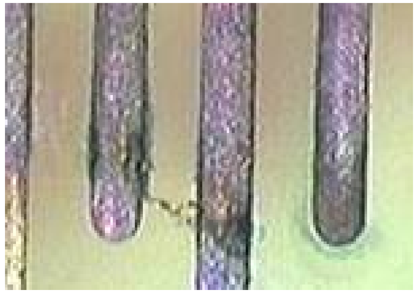
- It is well known that structures at fine pitches with flux residues are more susceptible to corrosion issues and electrochemical migration (ECM) problems.
- Characterization of flux residues in terms of ECM are commonly characterized using SIR testing.
  - *A key parameter of the SIR test is the comb pattern used and the gap between the electrodes.*
  - *The current B24 and B25 with their 500 and 318µm gap patterns are not representative of fine pitch.*
  - *It is proposed to use a 200µm gap pattern*
- This paper describes an intercomparison that validates the introduction of the 200µm gap pattern.

SIR pitch pattern effects

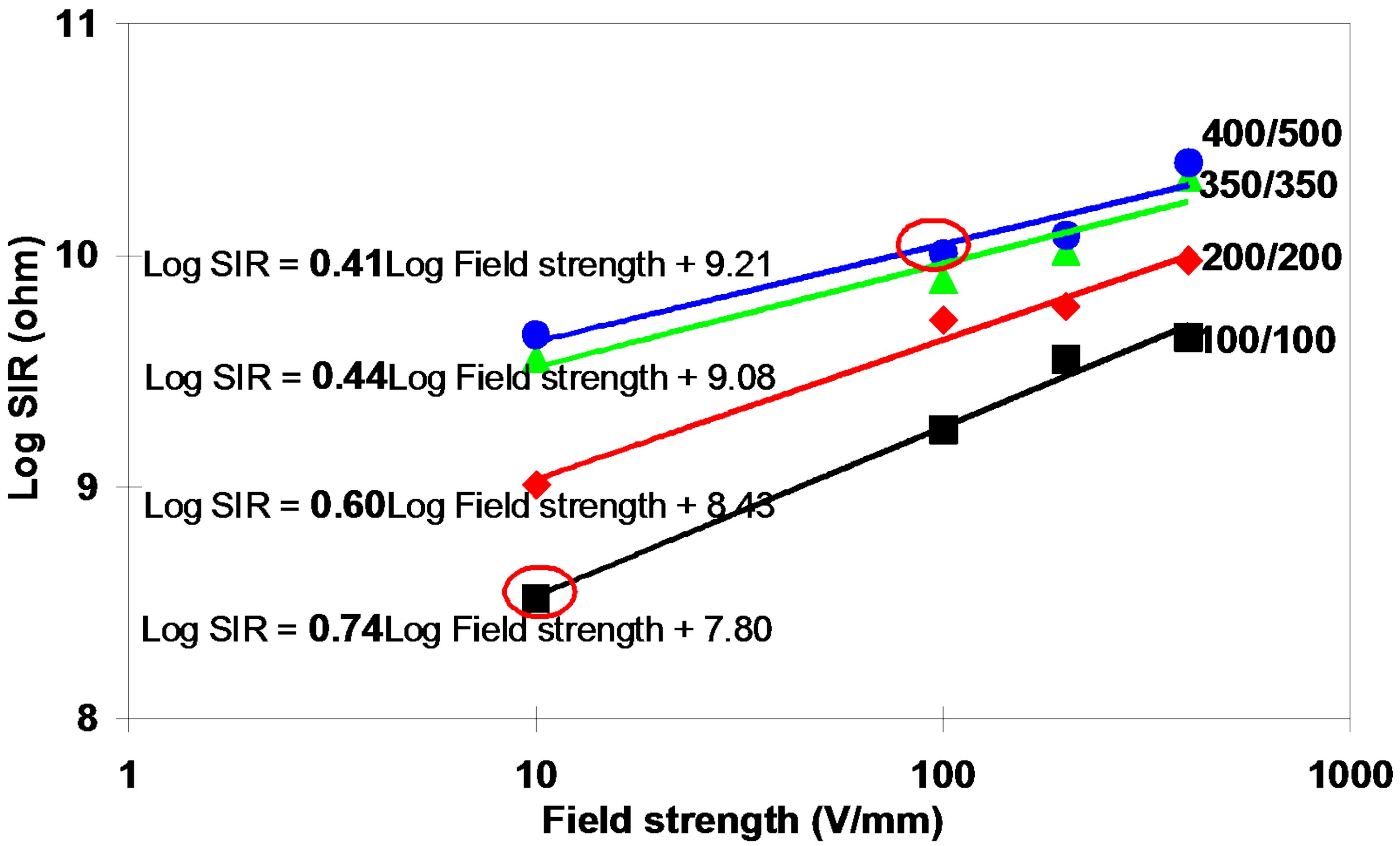
- Test pattern is critical in terms of the SIR response.
- With the same field strength, dendrites can form on fine pitch test board, but not on coarse board.







SIR pitch effects



Approach

- In an update of the standard IEC 61189-5-501: Test methods for printed board assemblies and materials used in manufacturing electronic assemblies. Test 501: Changes of the surface insulation resistance caused by fluxes.
  - *We wish to include a fine pitch pattern with a 200µm gap*
- An intercomparison procedure was agreed with participants
  - *The procedure is outlined in the paper and followed by all participants*
- Seven participants coded as a, b, c, d, e, f and g for this intercomparison testing.
- Participant c directly hand soldered cables to the PCBs, and all others used edge connectors.
- The work here is relevant in IPC and the IPC TM650 2.6.3.3, 2.6.3.6 and 2.6.3.7 can be updated.

Track/Gap (µm)	Squares
400/200	5125
400/500	1020
318/318	1950

0.5oz Cu and high Tg laminate.

Test board

SIR Pattern Information

	B24	B25	New
Track / Gap (µm)	400 / 500	318 / 318	400 / 200
Number of squares	1020	1950	5125
Resistance (Ω)*	1.00E+08	5.23E+07	1.99E+07
Field Strength (V/mm)**	40.0	62.9	100.0

- ** The $10^8\Omega$ is an example value for the pattern and the two following values assume the same resistance per square, and calculated the drop in resistance caused by the increase in the number of squares.*
- *** The field strength is calculated using an applied bias of 20V*

Test sample preparation

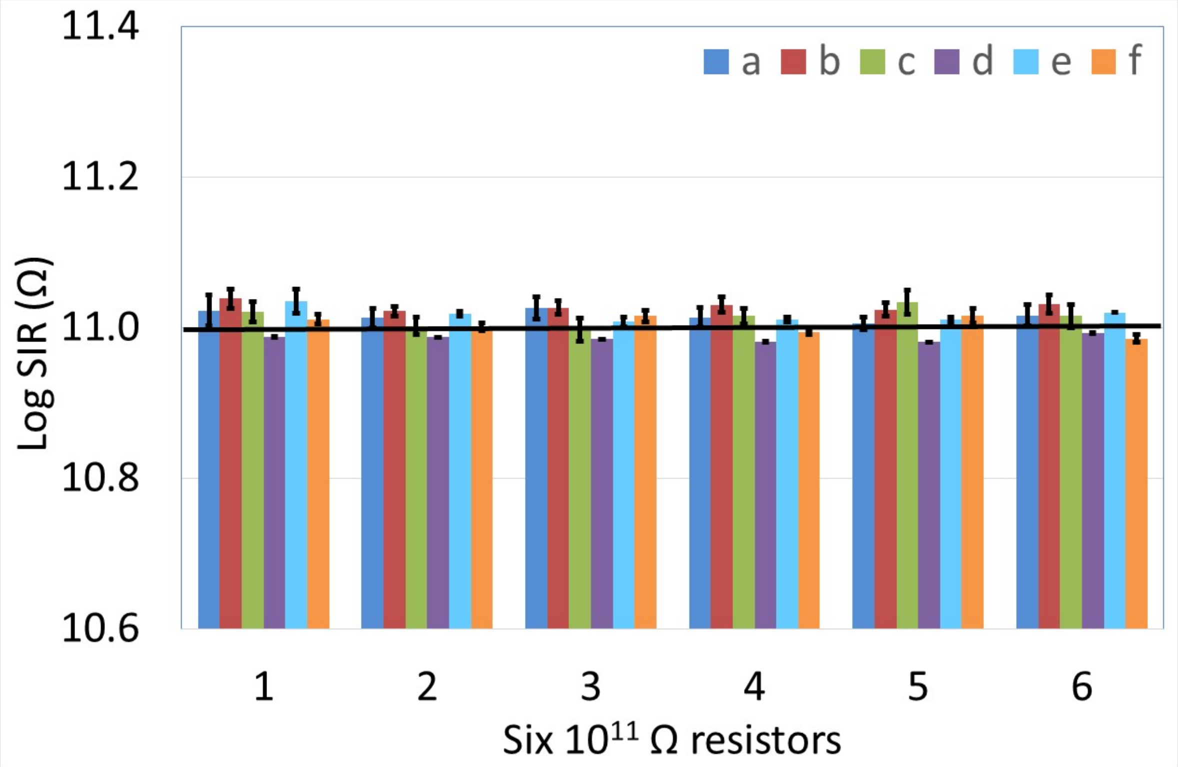
- All test samples were prepared centrally by the company.
- Received PCBs were cleaned in an ionic contamination tester containing 75% IPA + 25% DI water for 15 minutes
- Cleaned PCBs were uniformly coated using the designated flux for each SIR test pattern. Flux volumes were 35, 31 and 27μl for 400/200, 400/500 and 318/318 patterns respectively, to achieve the same flux loading (5μl/cm2). Fluxed samples were dried at 100°C for 5 minutes.
- Two cleaned samples and 6 flux loaded samples were sent to each participant from the company for testing.

Measurement system verification and SIR test conditions

- A checker board, with six $10^{11}\ \Omega$ resistors were soldered to each SIR pattern. This was made to verify their edge connectors and measurement systems. The checker board was measured at ambient condition for 5 measurements with 5 or 6 minutes intervals. Partner c soldered these to the board.
- One clean reference board and 3 flux loaded boards were measured for each test condition for each participant.
- Two test conditions were used for the intercomparison testing: 40°C/93%RH and 85°C/85%RH.

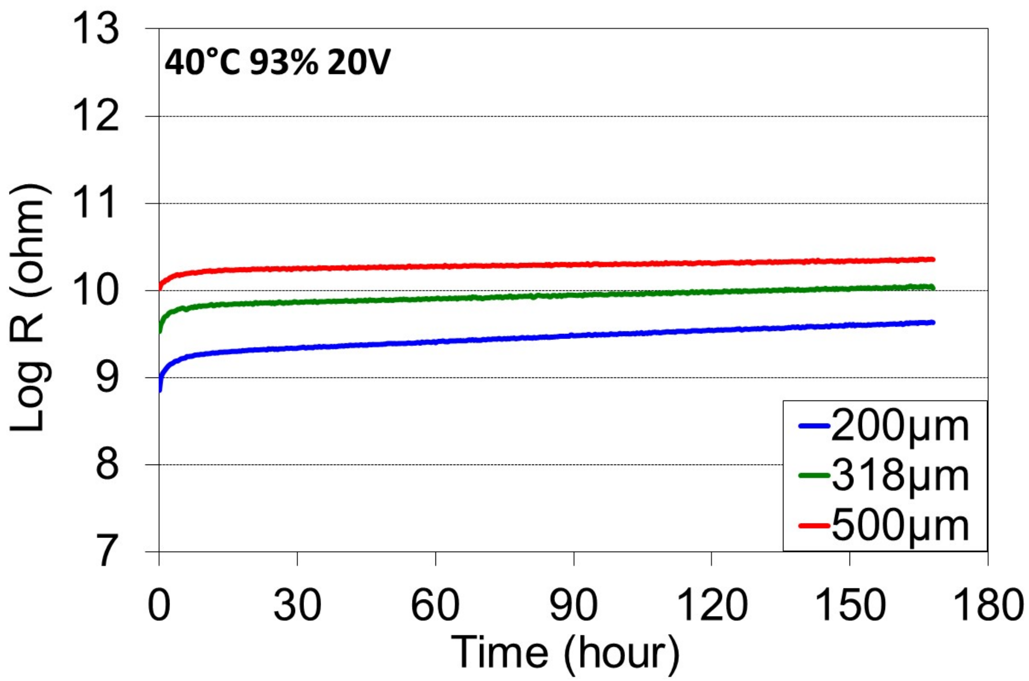
Checker board results from 6 participants

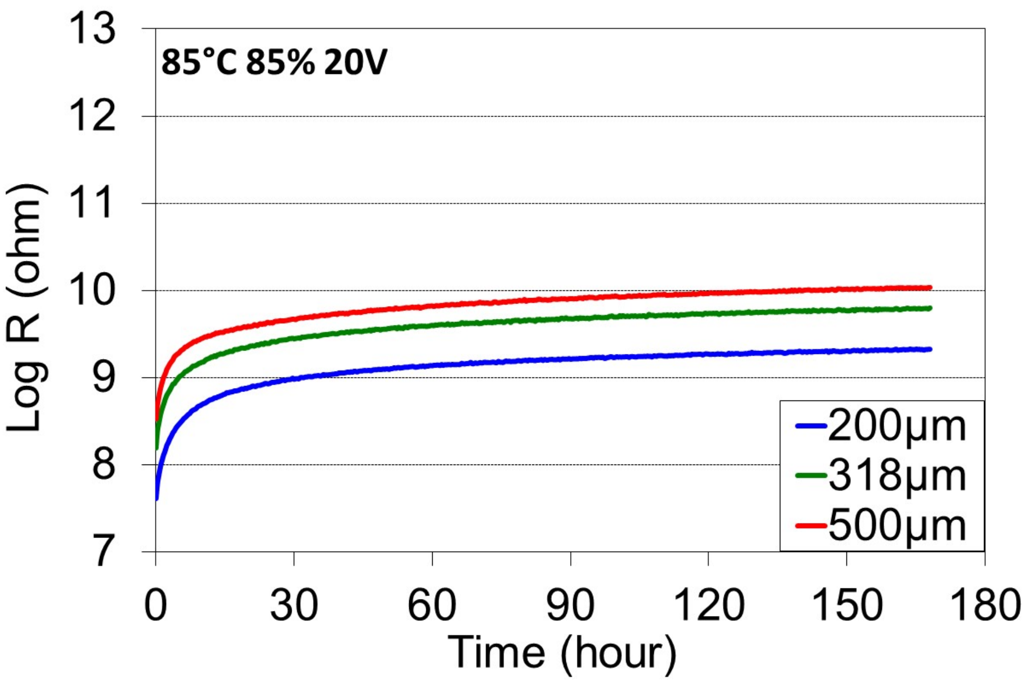
- For each participant, the average Log SIR value for each resistor is from 5 measurements on 4 different measurement channels (20 measurements in total).
- Resistance results from all participants are within 0.2% of the nominal value ($10^{11}\Omega$).



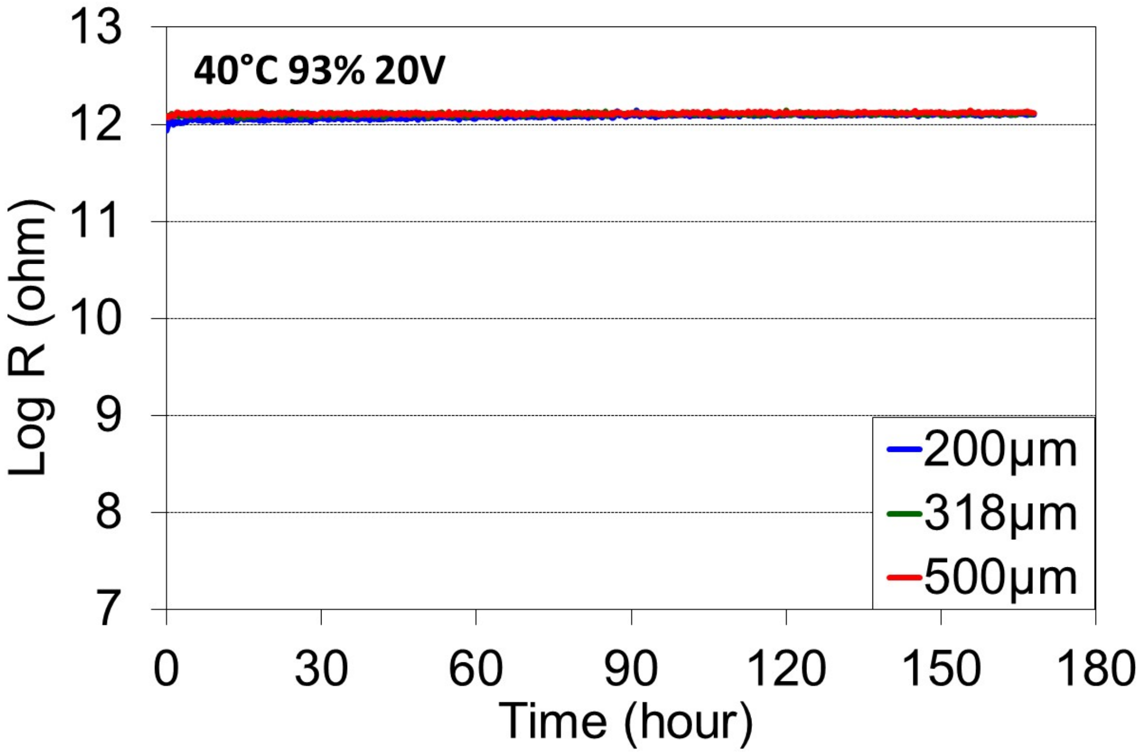
Participant a – flux loaded board

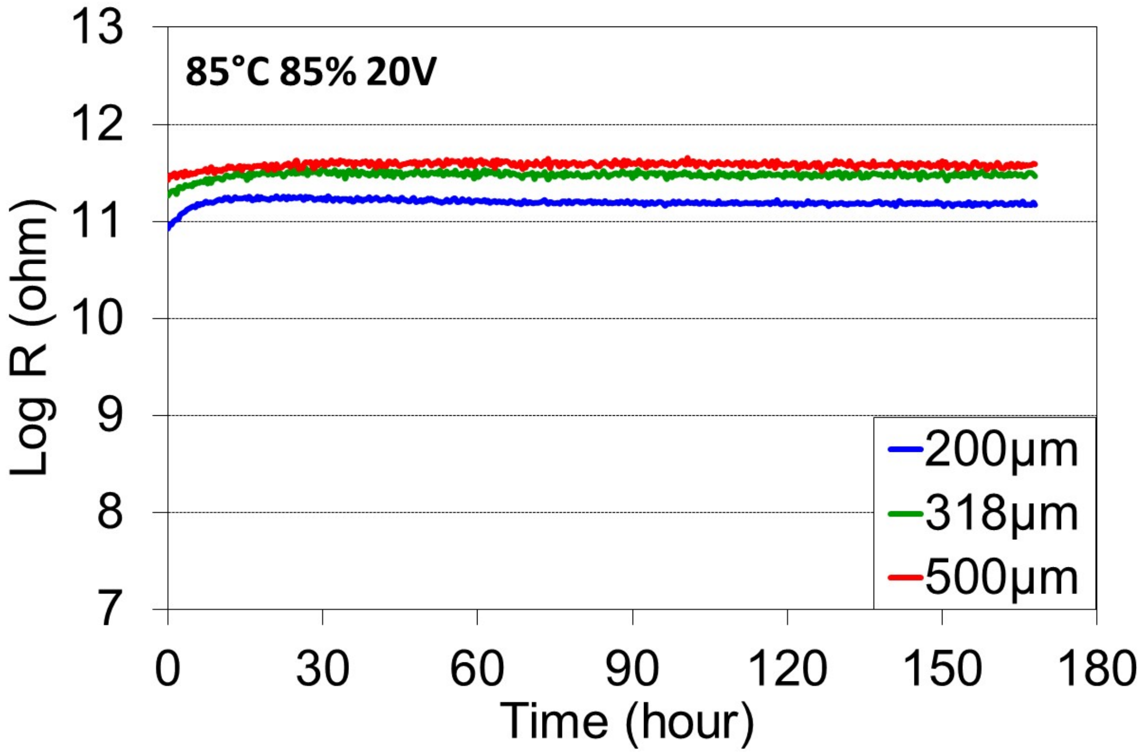
Curves are an average of results from 2 identical SIR patterns per PCB and of 3 PCB test samples.   (6 measurements in total)



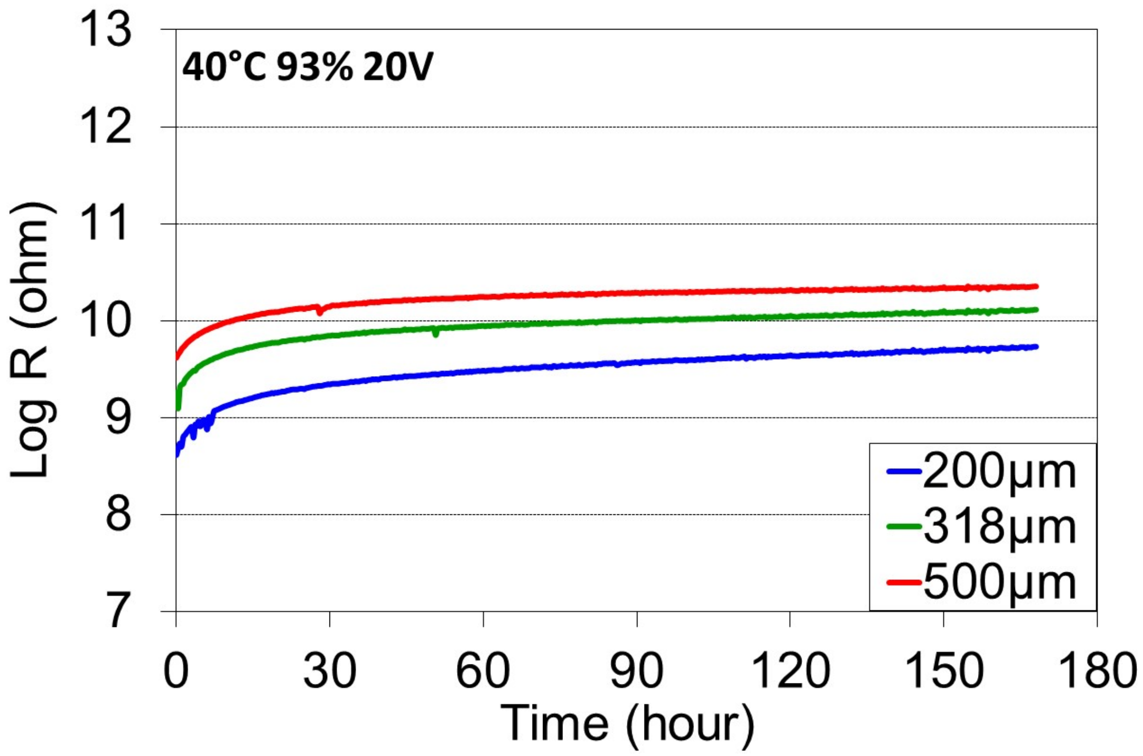


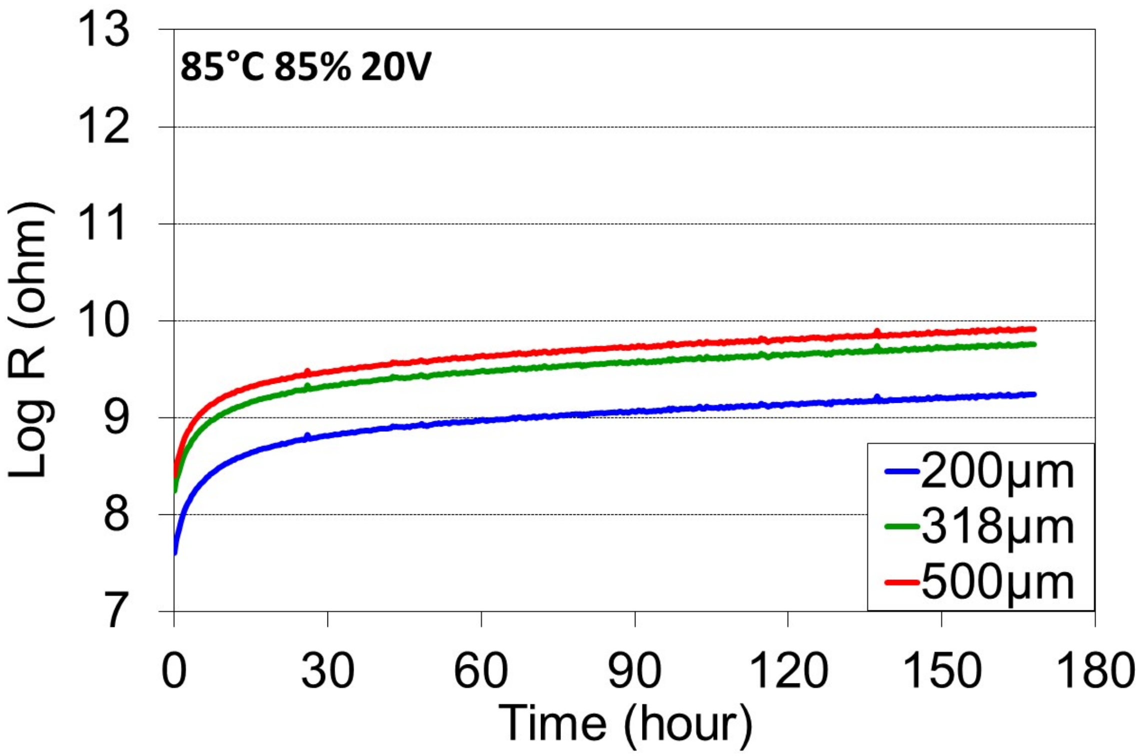
Participant a – reference board



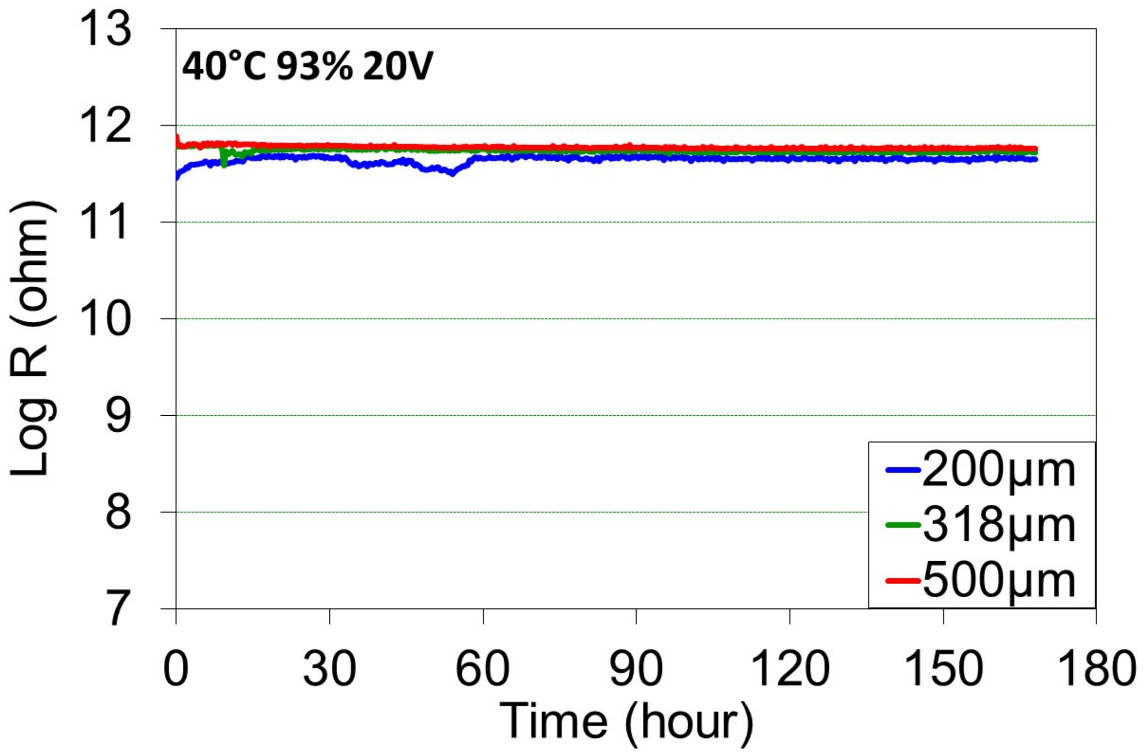


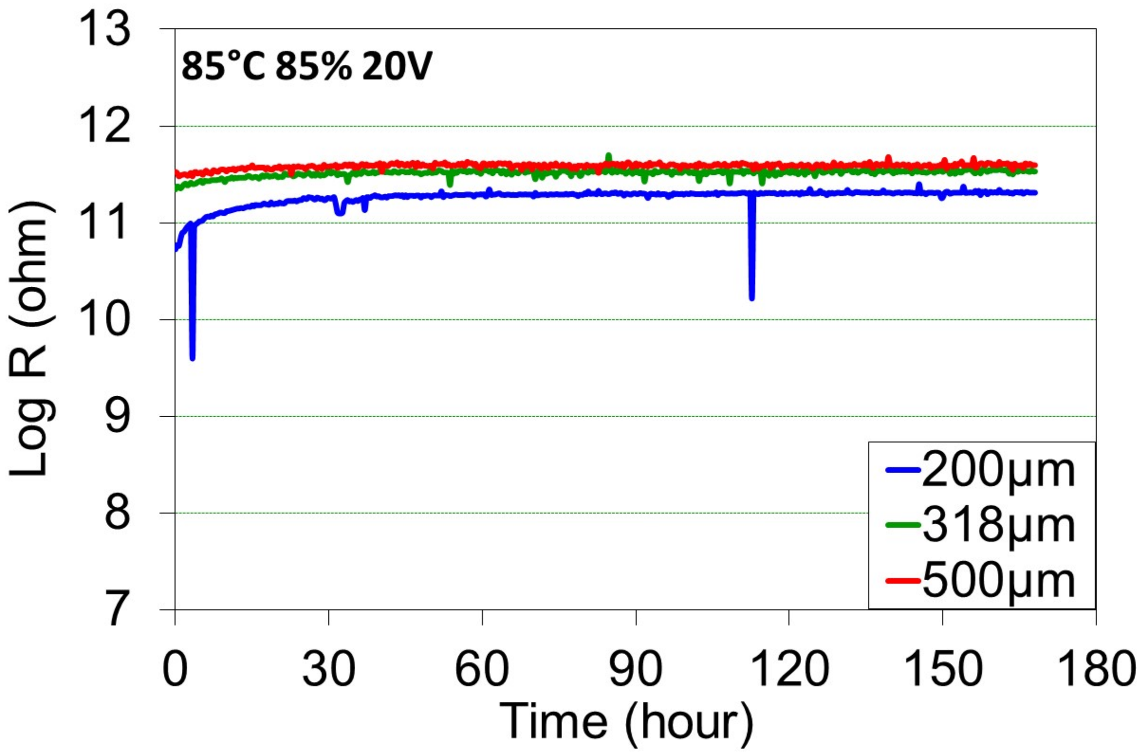
Participant b – flux loaded board



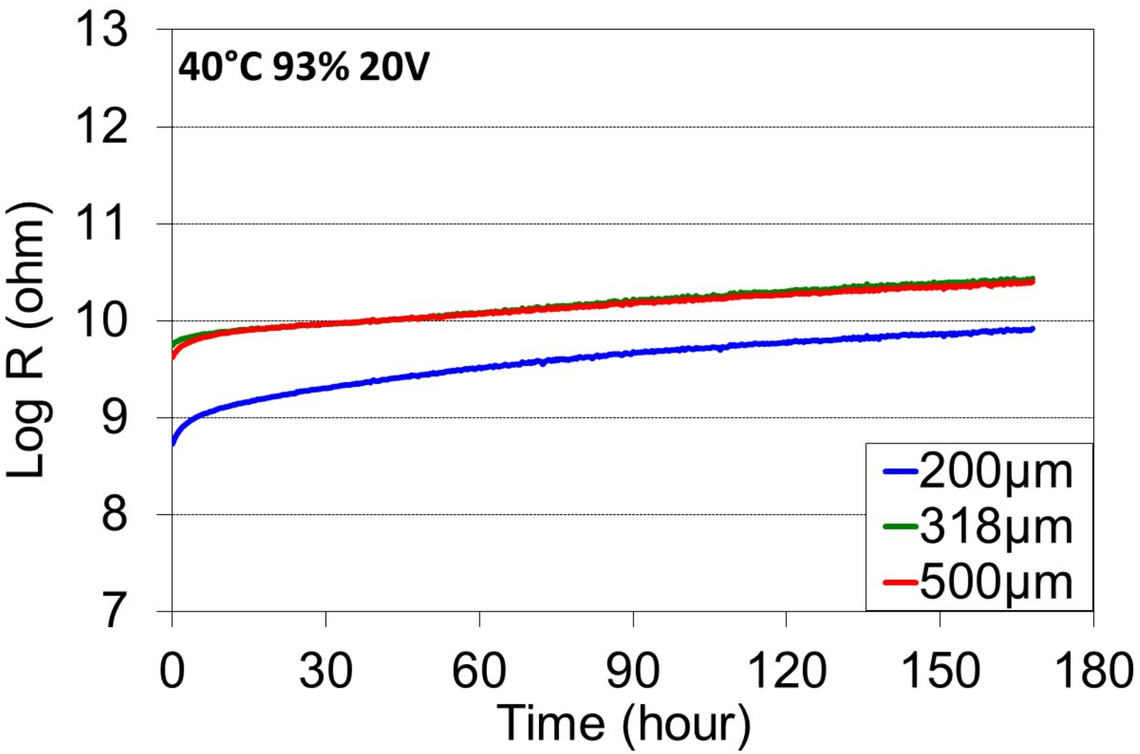


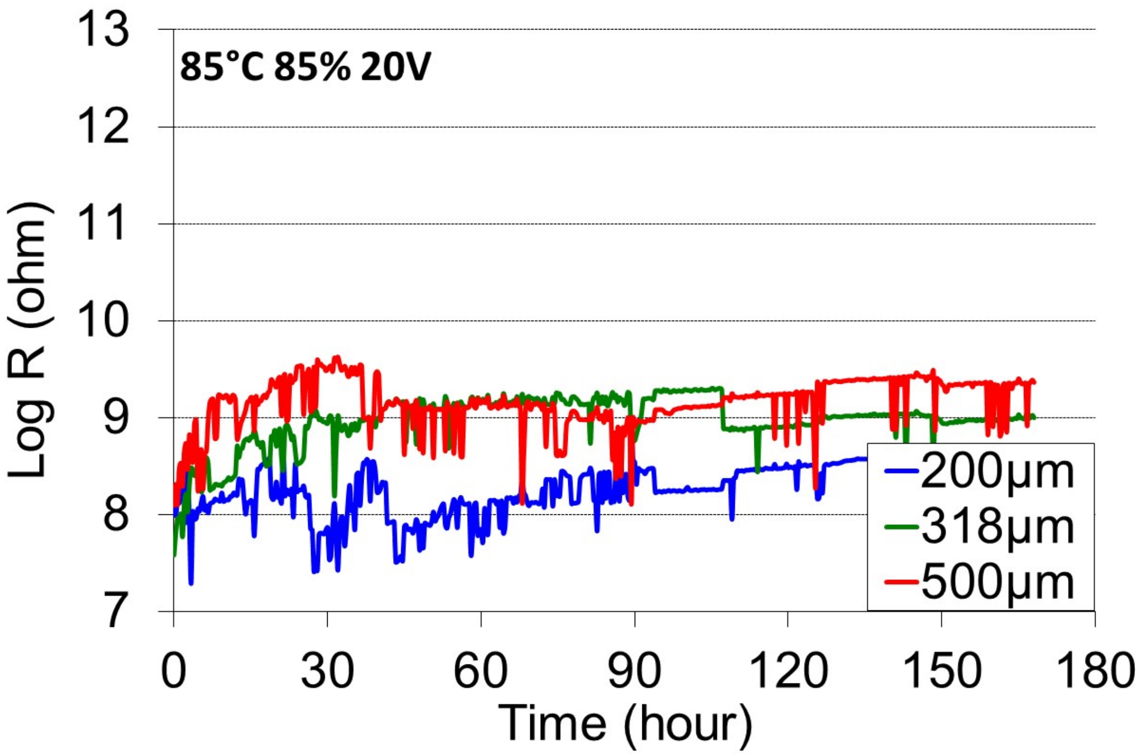
Participant b – reference board



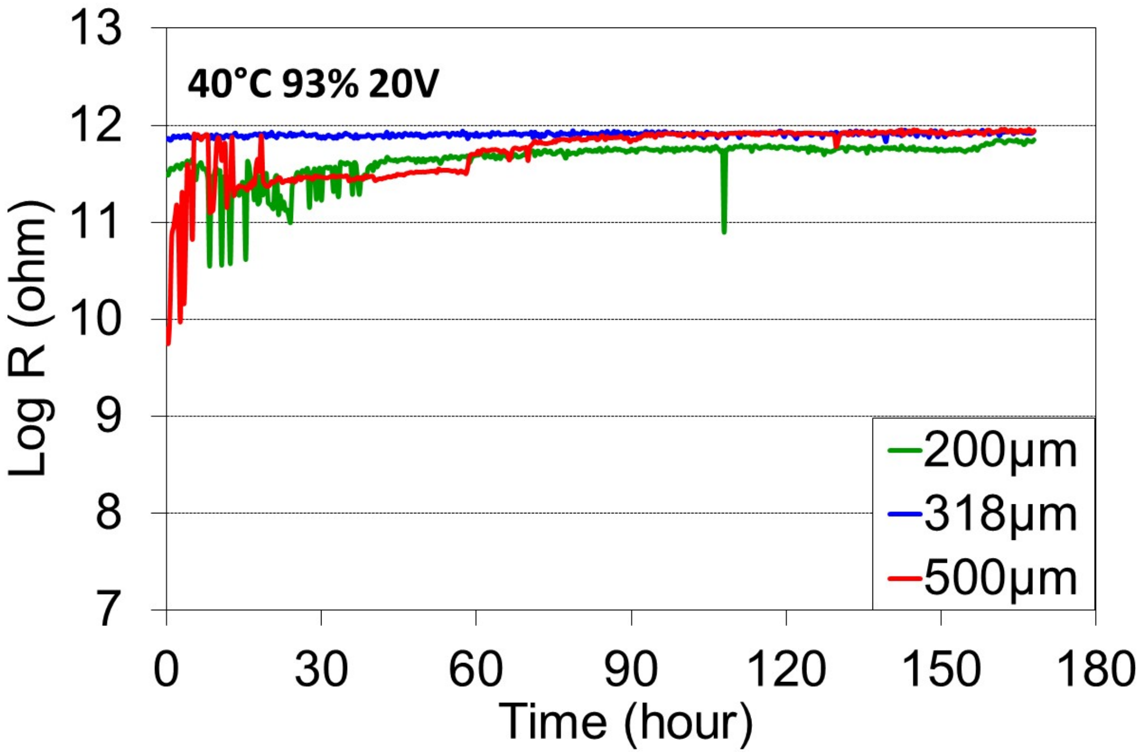


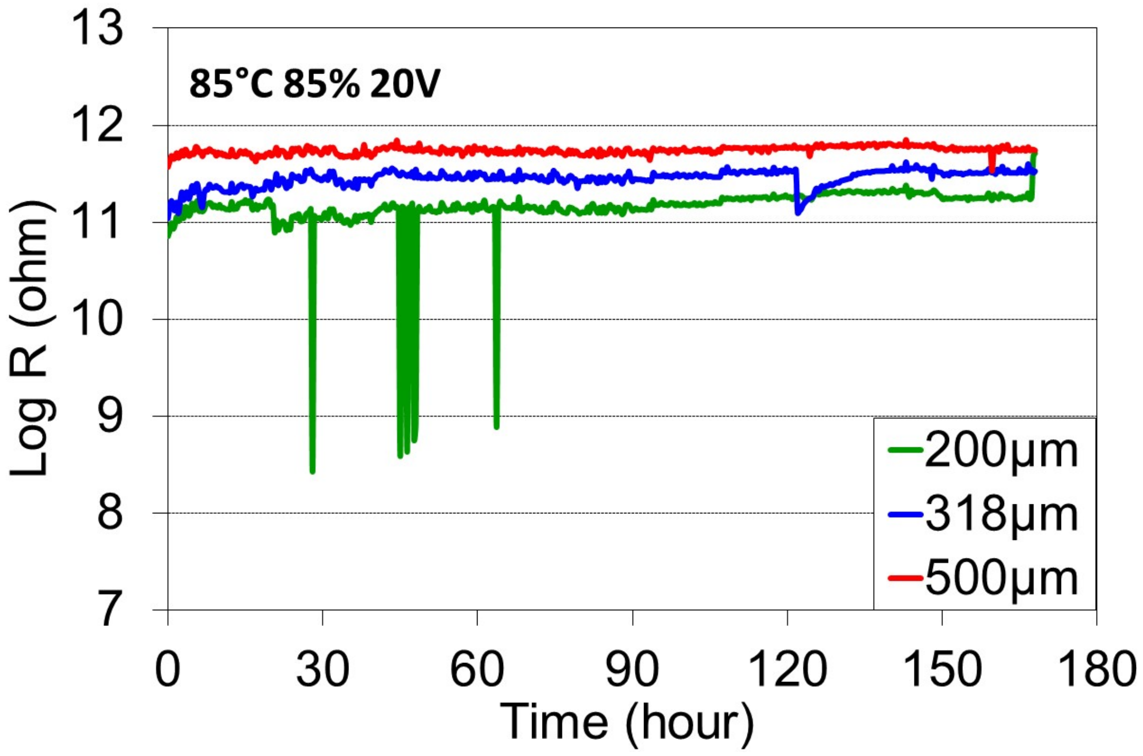
Participant c – flux loaded board



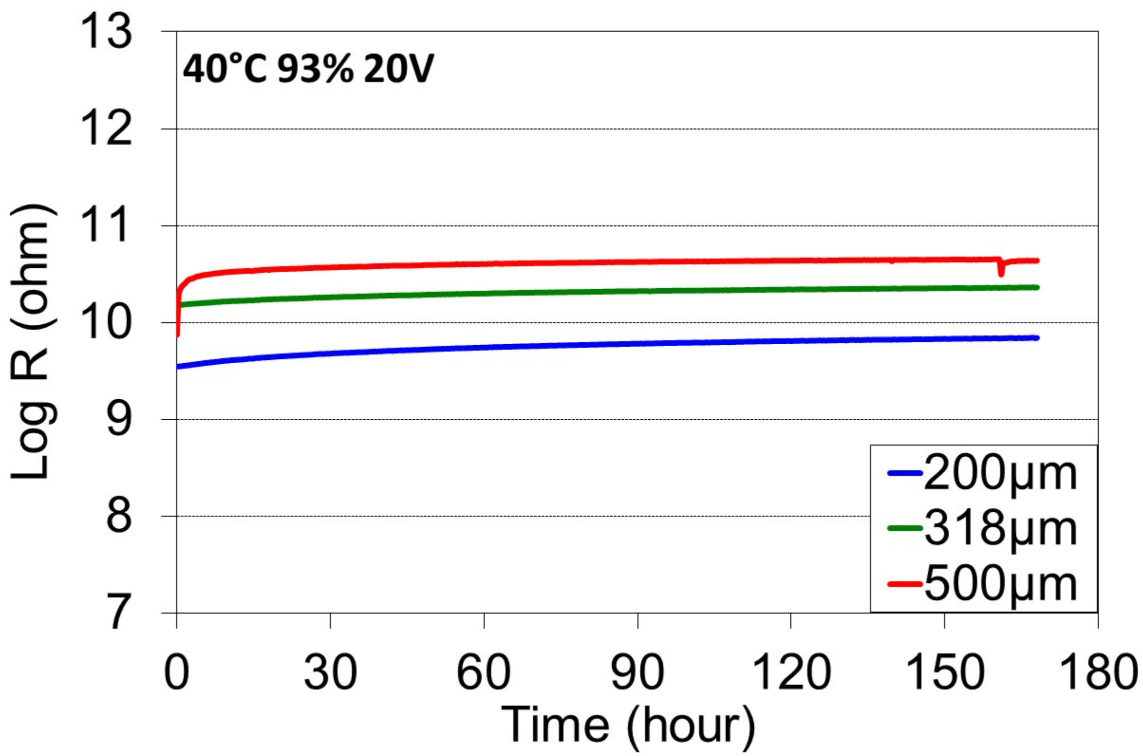


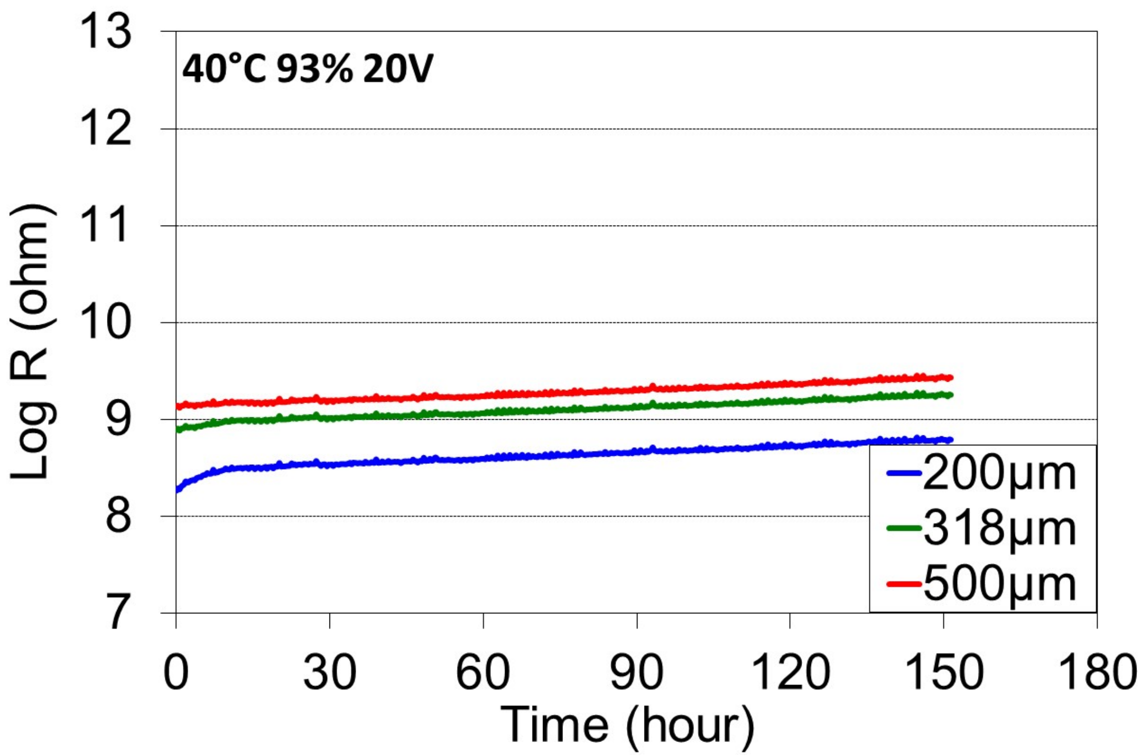
Participant c – reference board



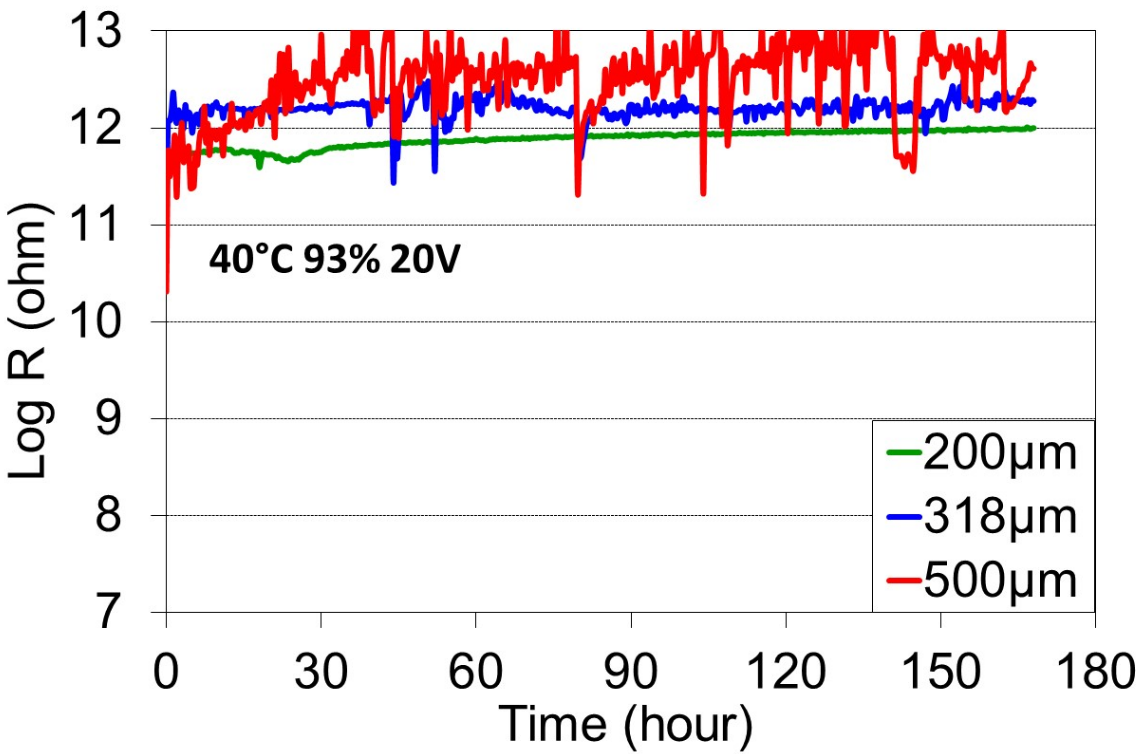


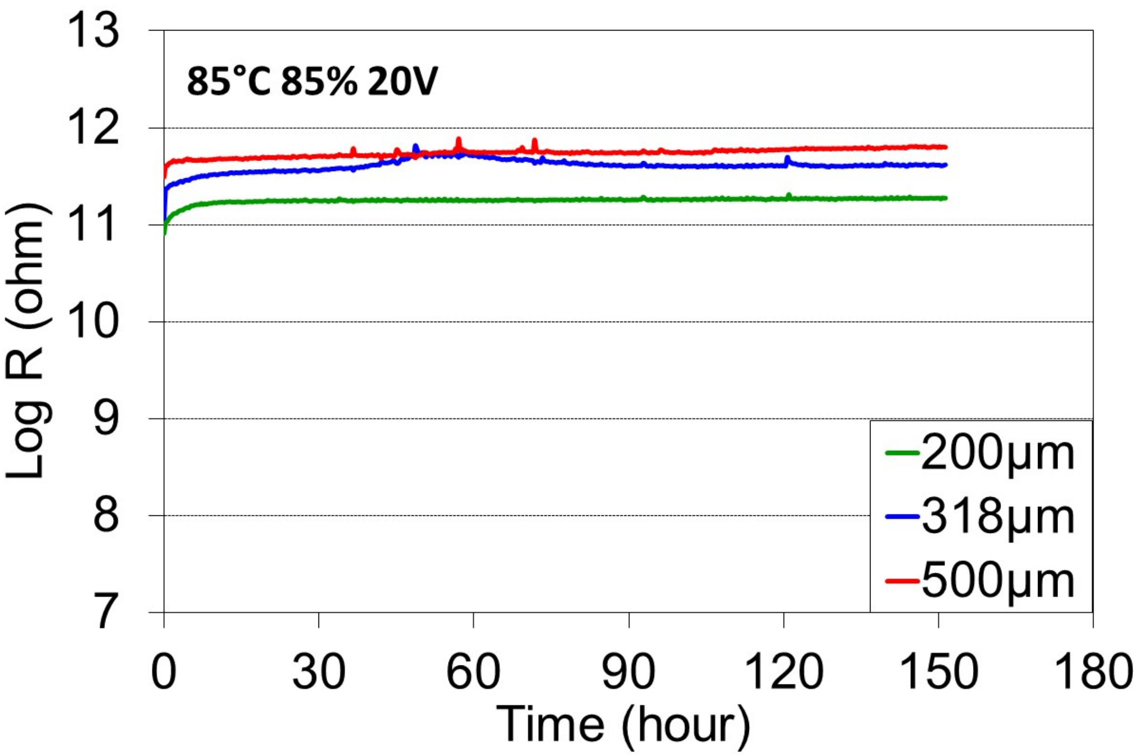
Participant d – flux loaded board



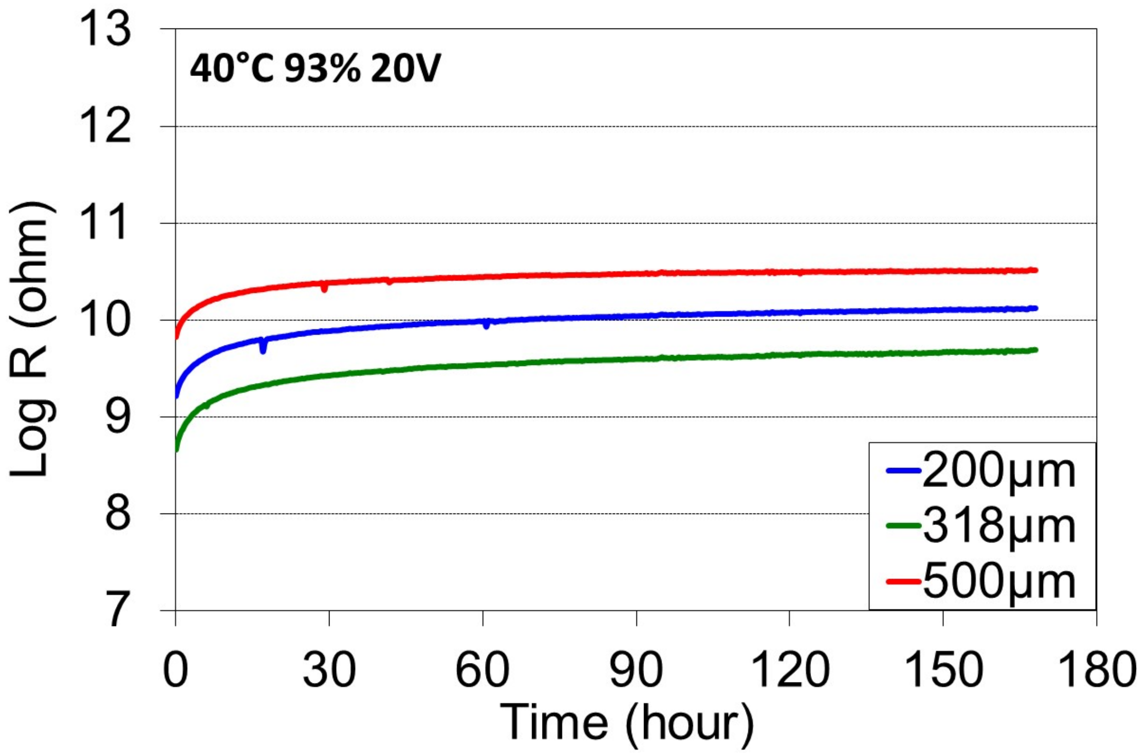


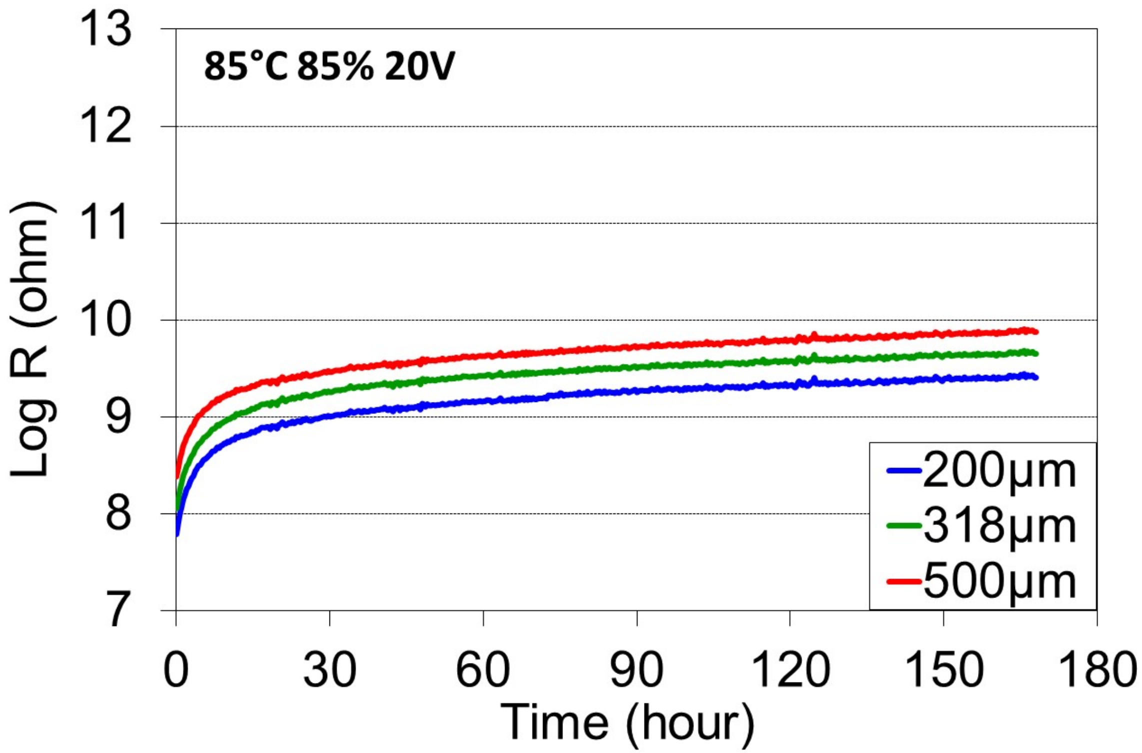
Participant d – Reference board



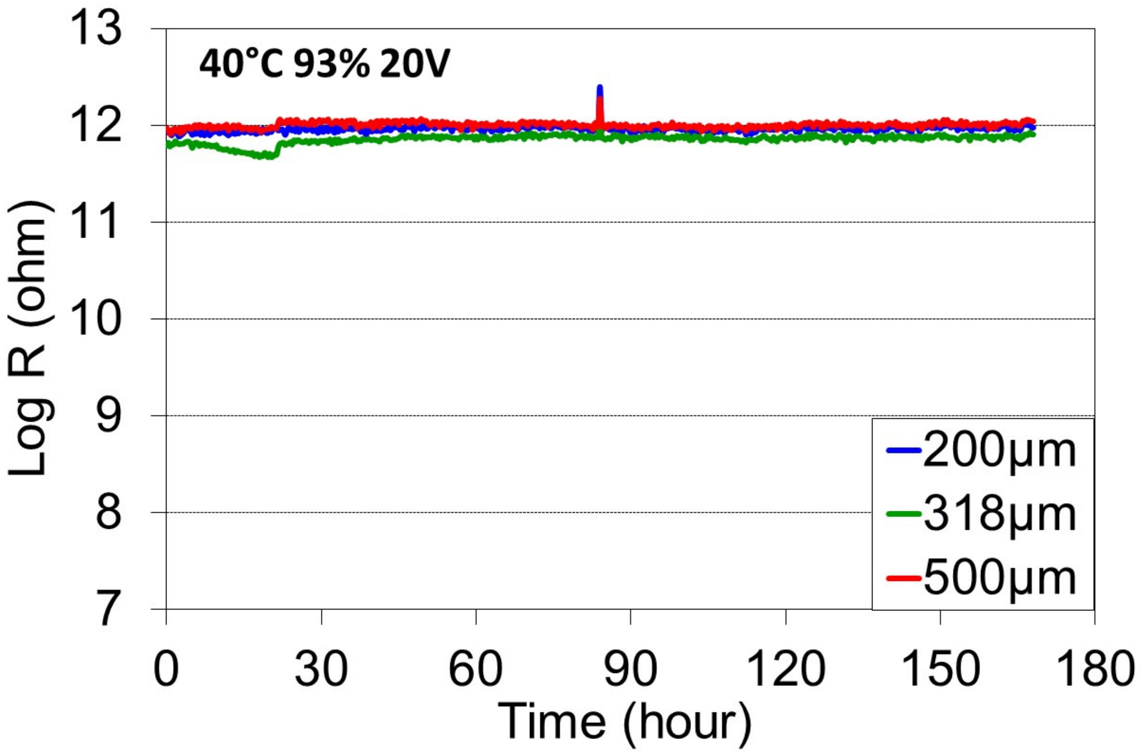


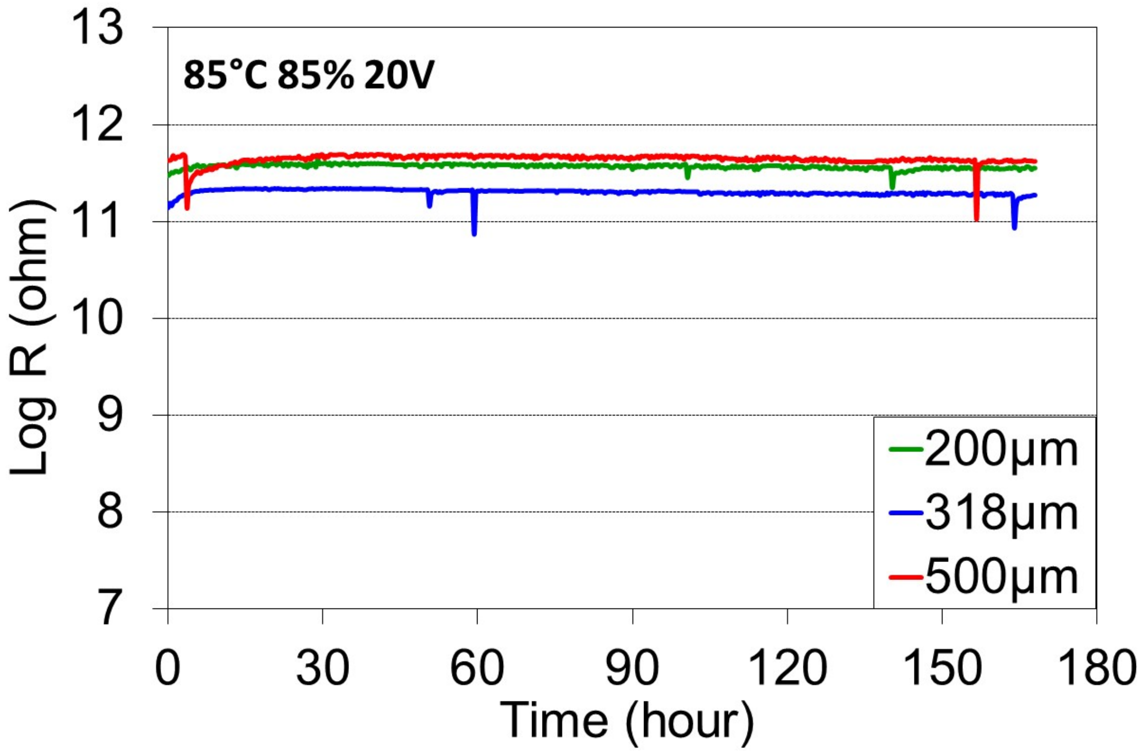
Participant e – flux loaded board



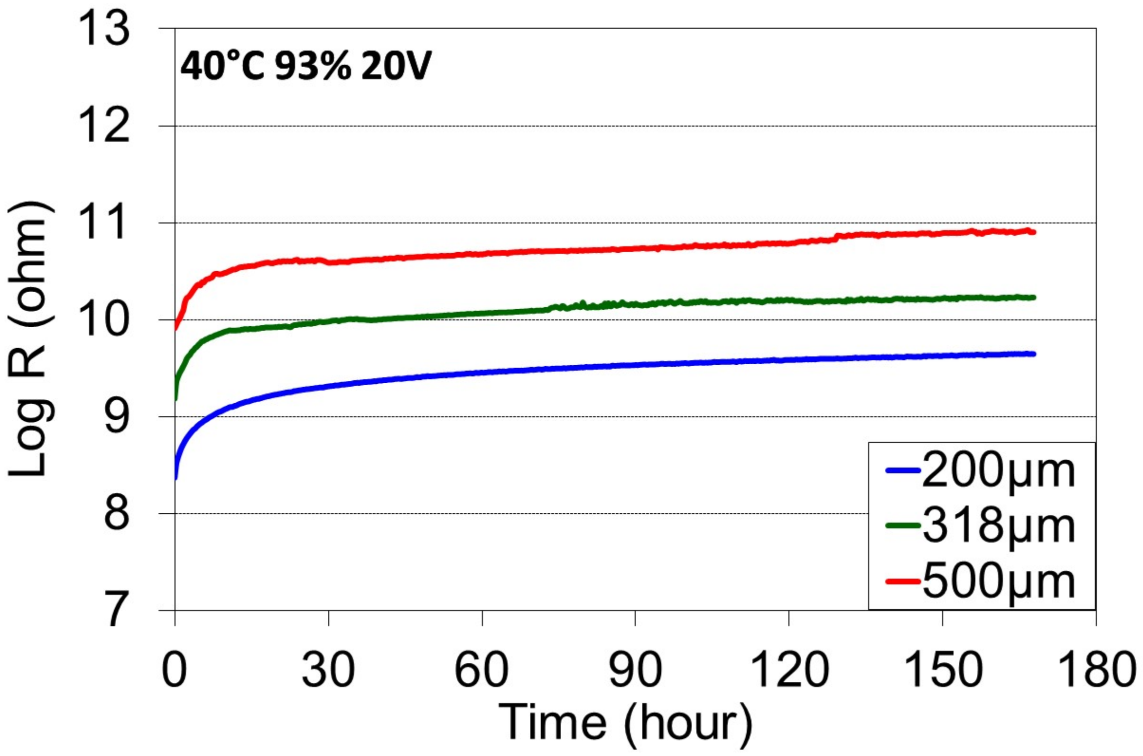


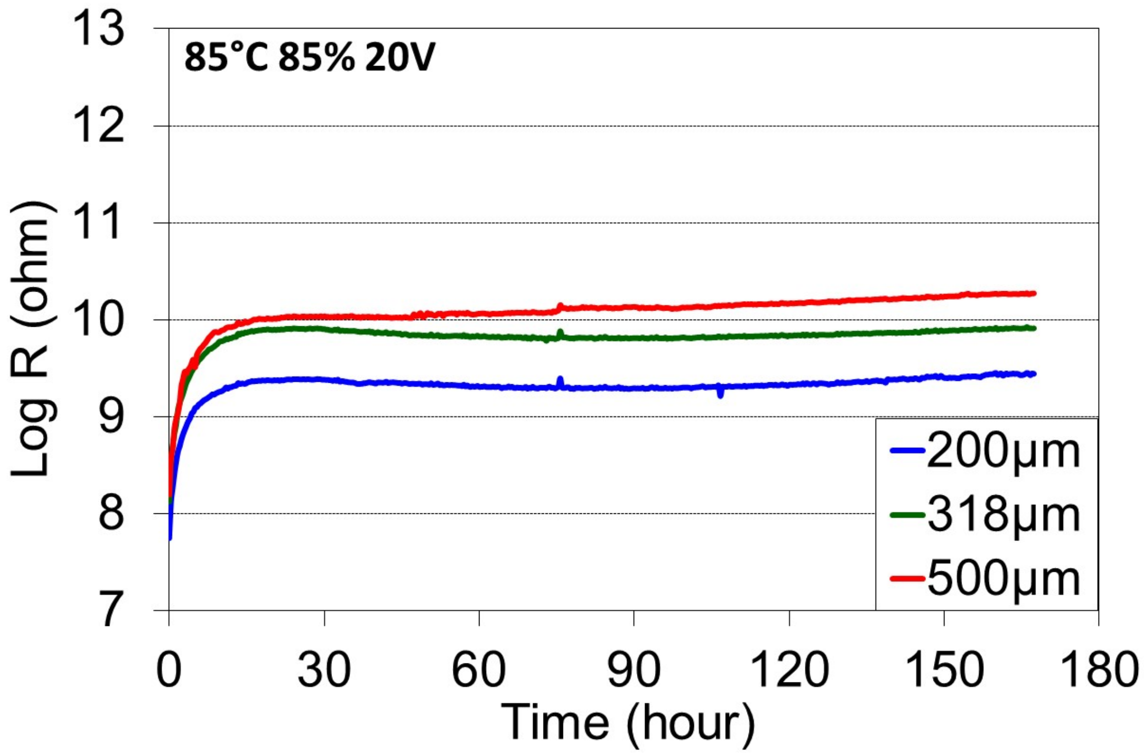
Participant e – reference board



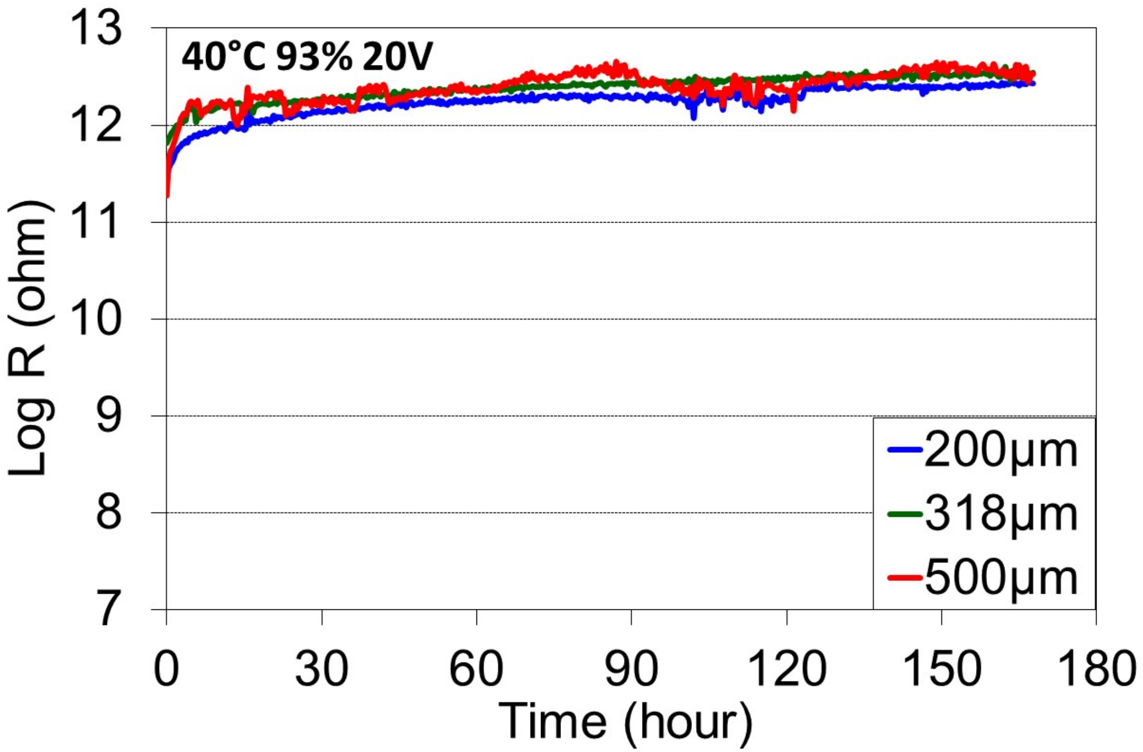


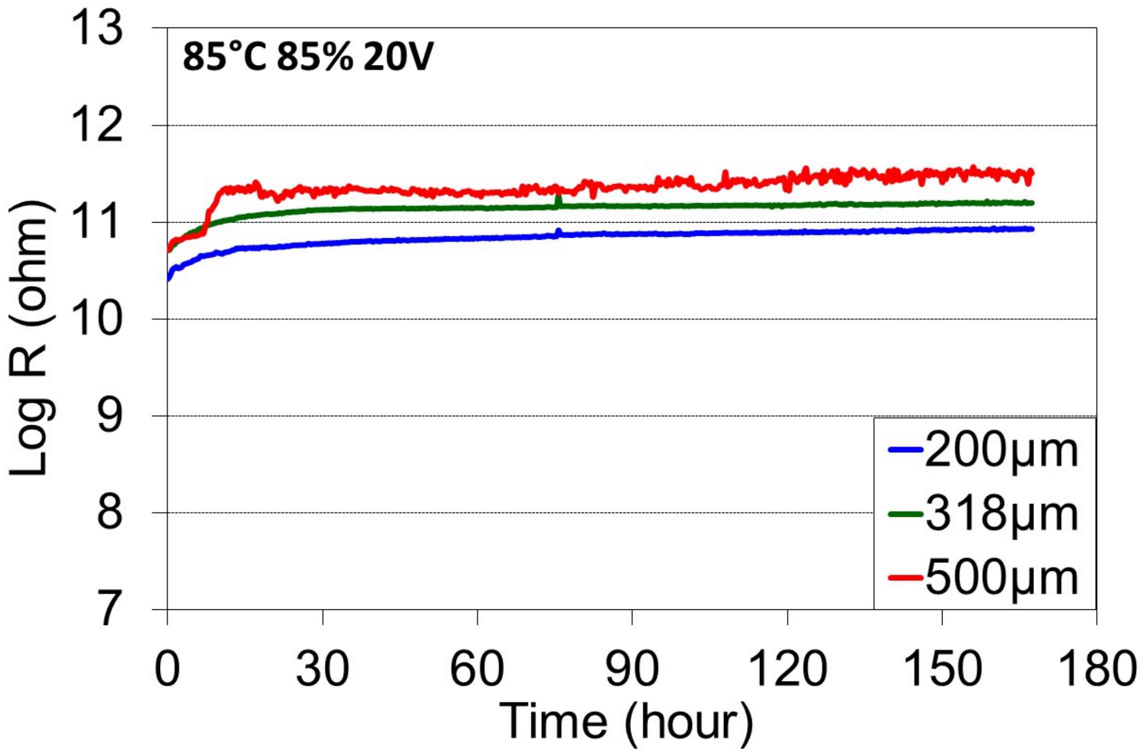
Participant f – flux loaded board



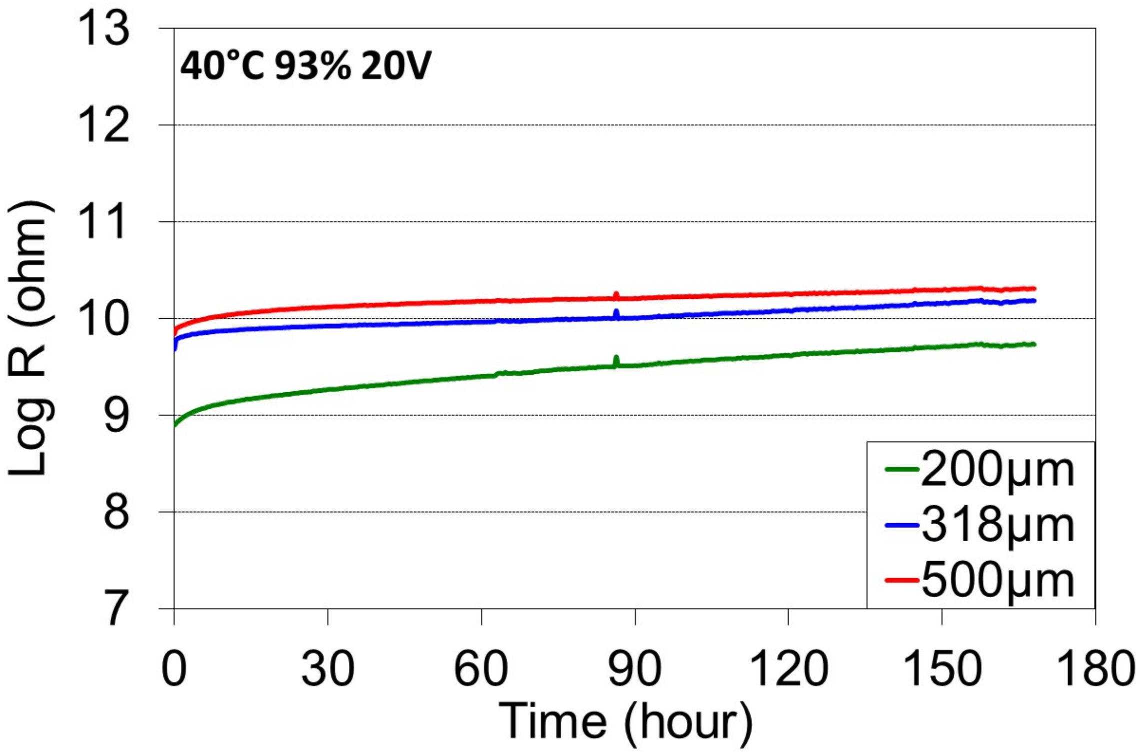


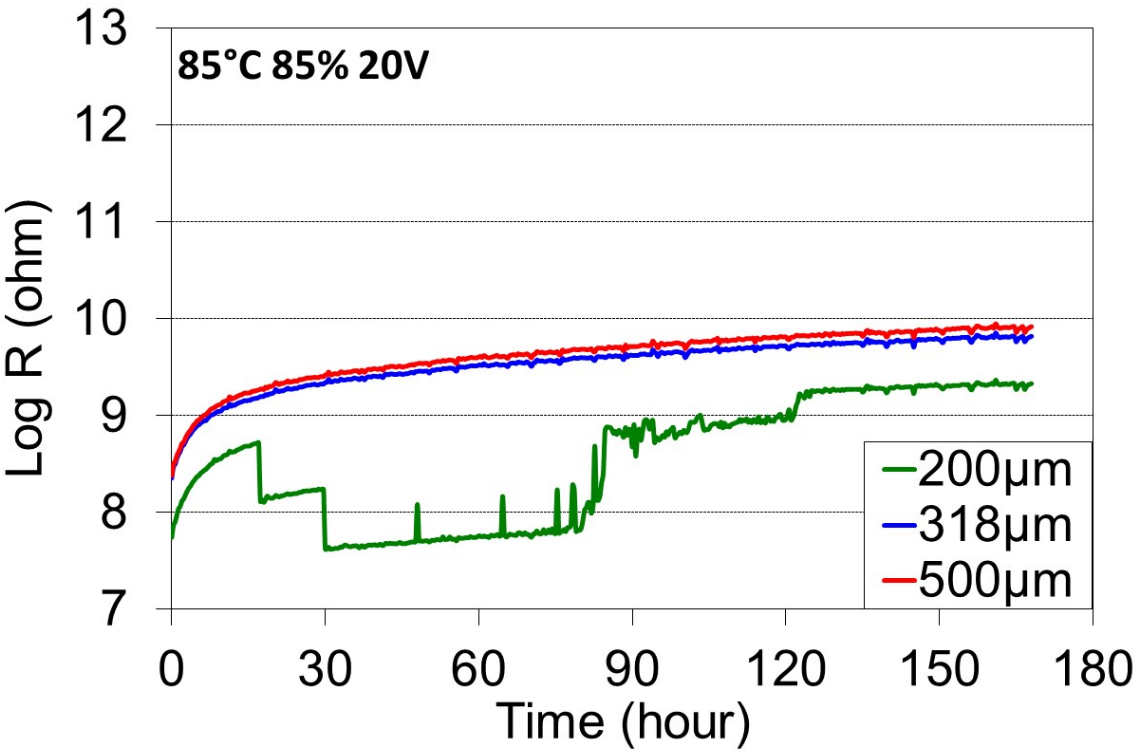
Participant f – reference board



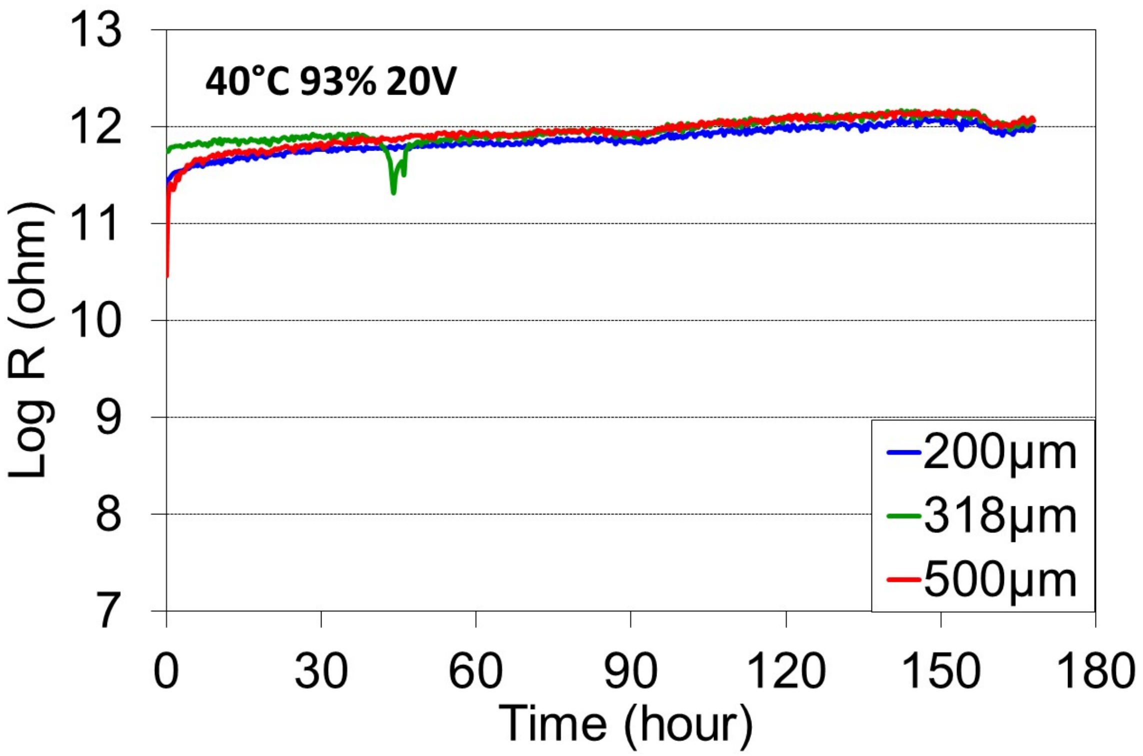


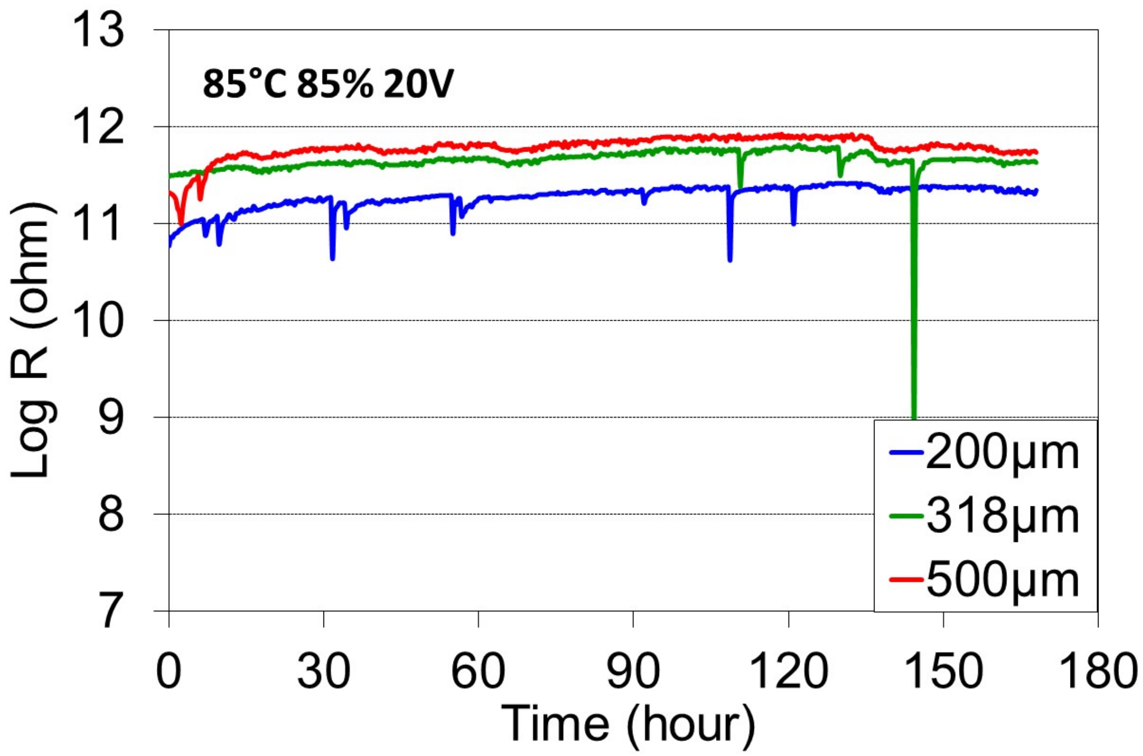
Participant g – flux loaded board





Participant g – reference board



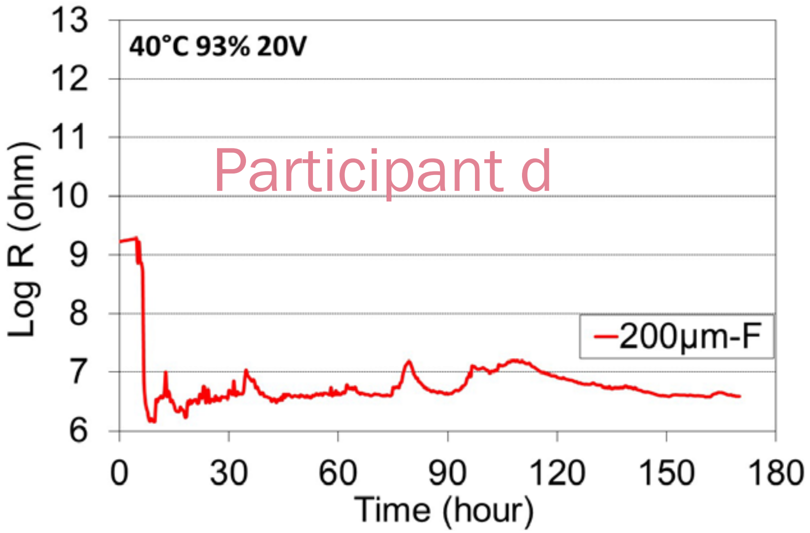


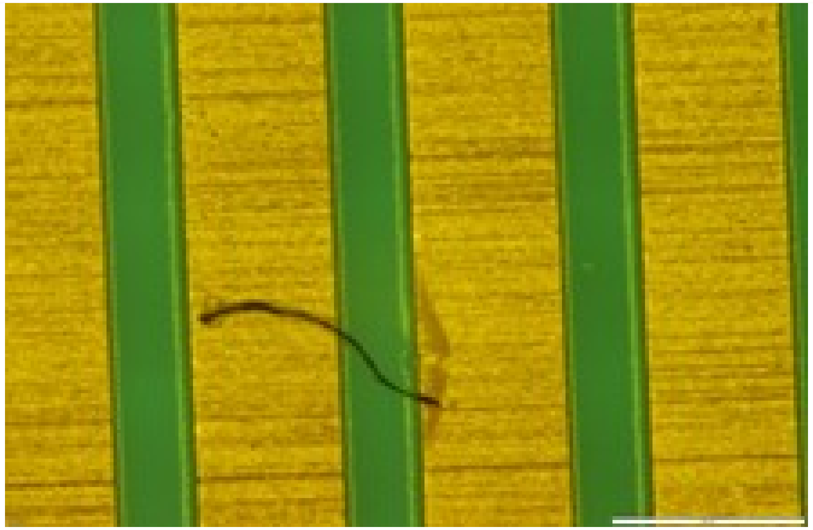
Some results have been removed from the analysis

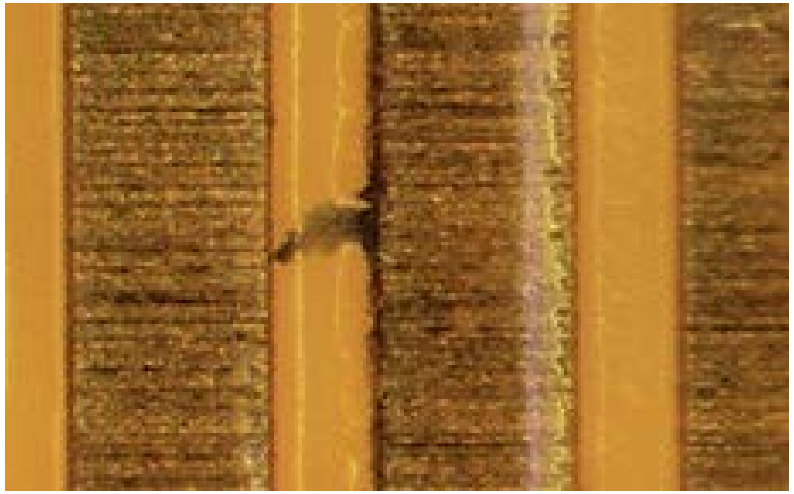
- Results have been removed because of :
  - *Fibres*
  - *Dendrites*
  - *Water drop corrosion*
  - *General corrosion*

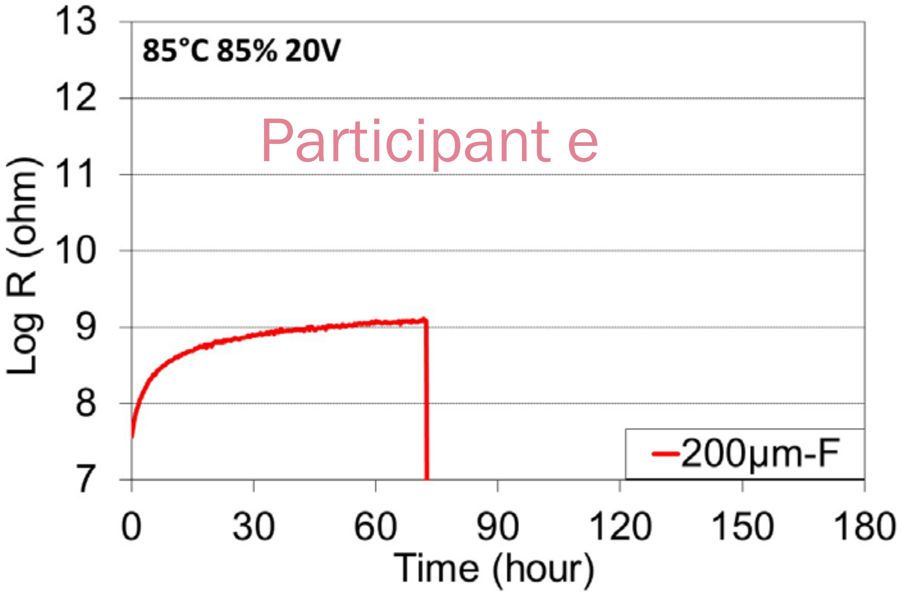
- These are shown on the next three slides
- These results are anomalous and not consistent with the flux loading applied at the company.

Failures not included in the analysis results

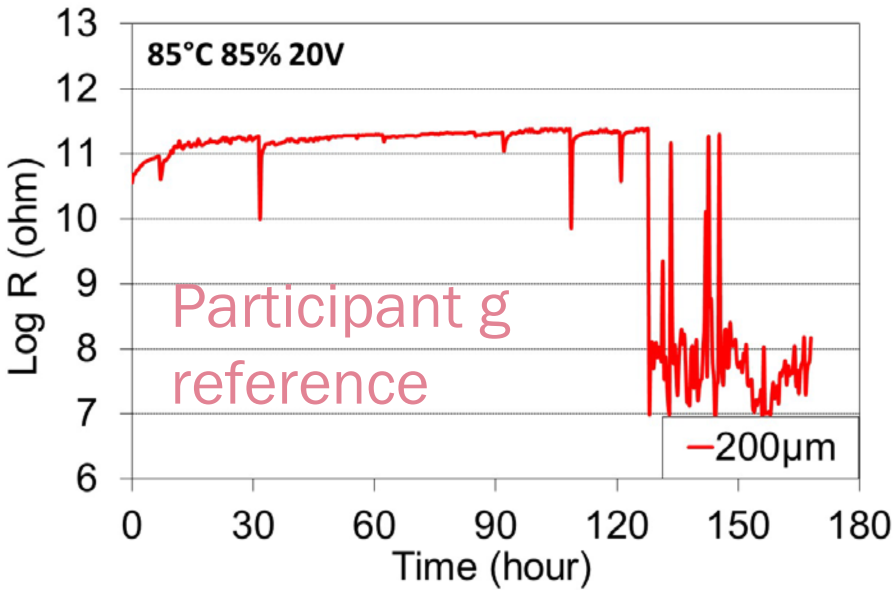


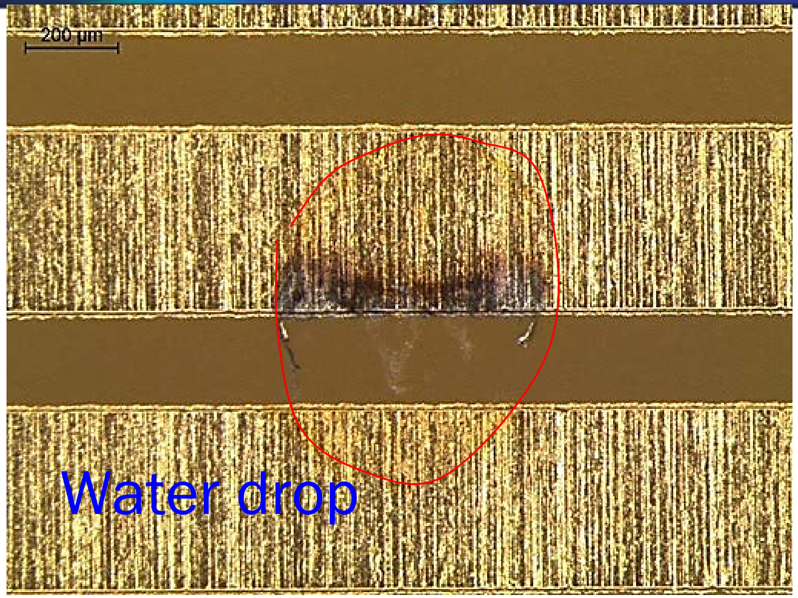


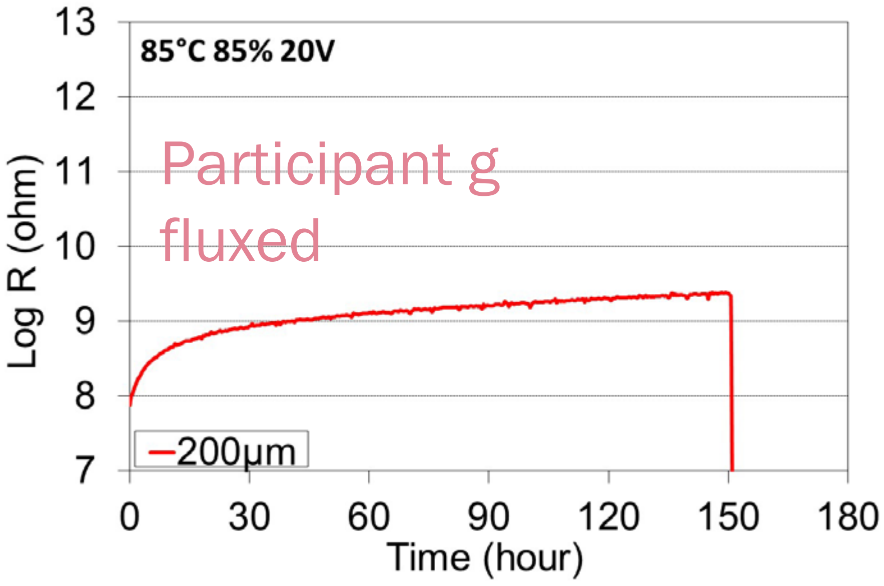


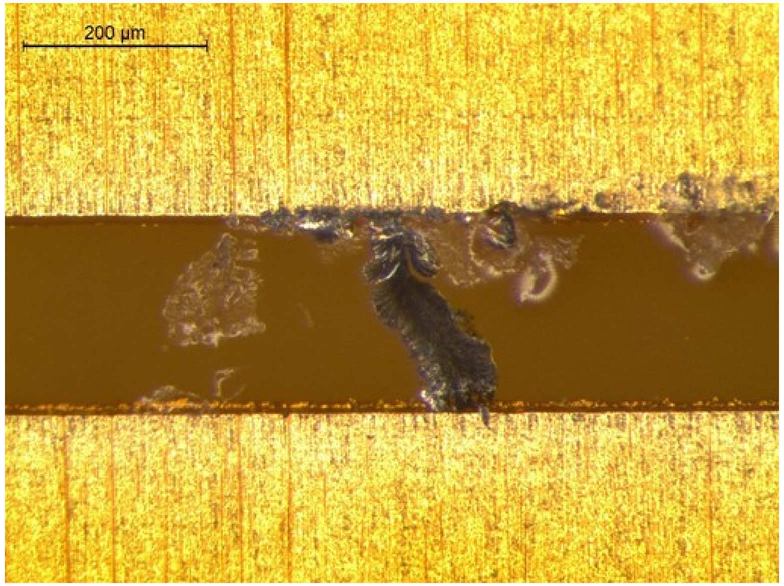


Failures not included in the analysis results



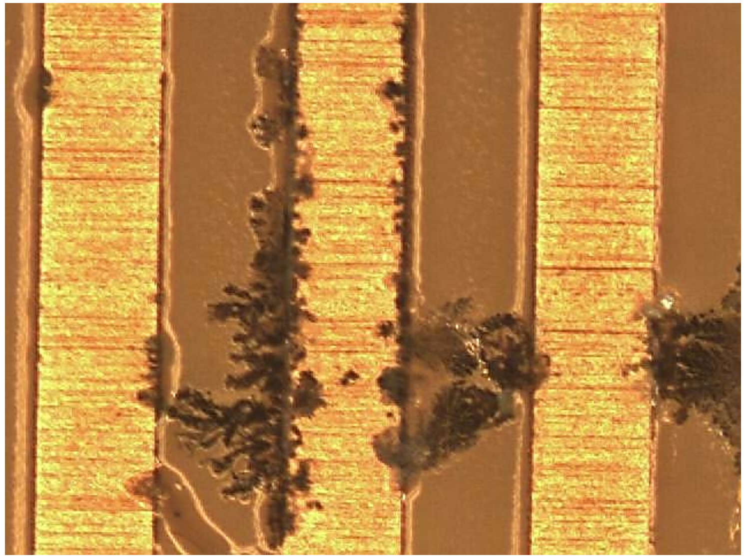


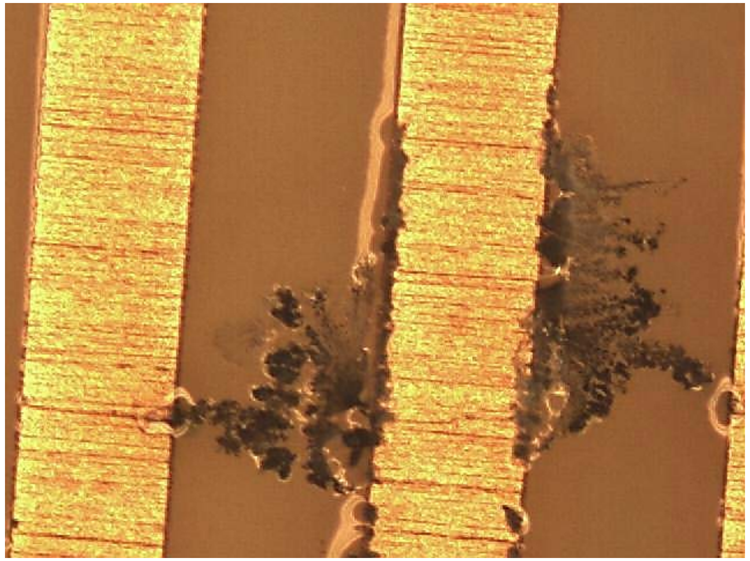




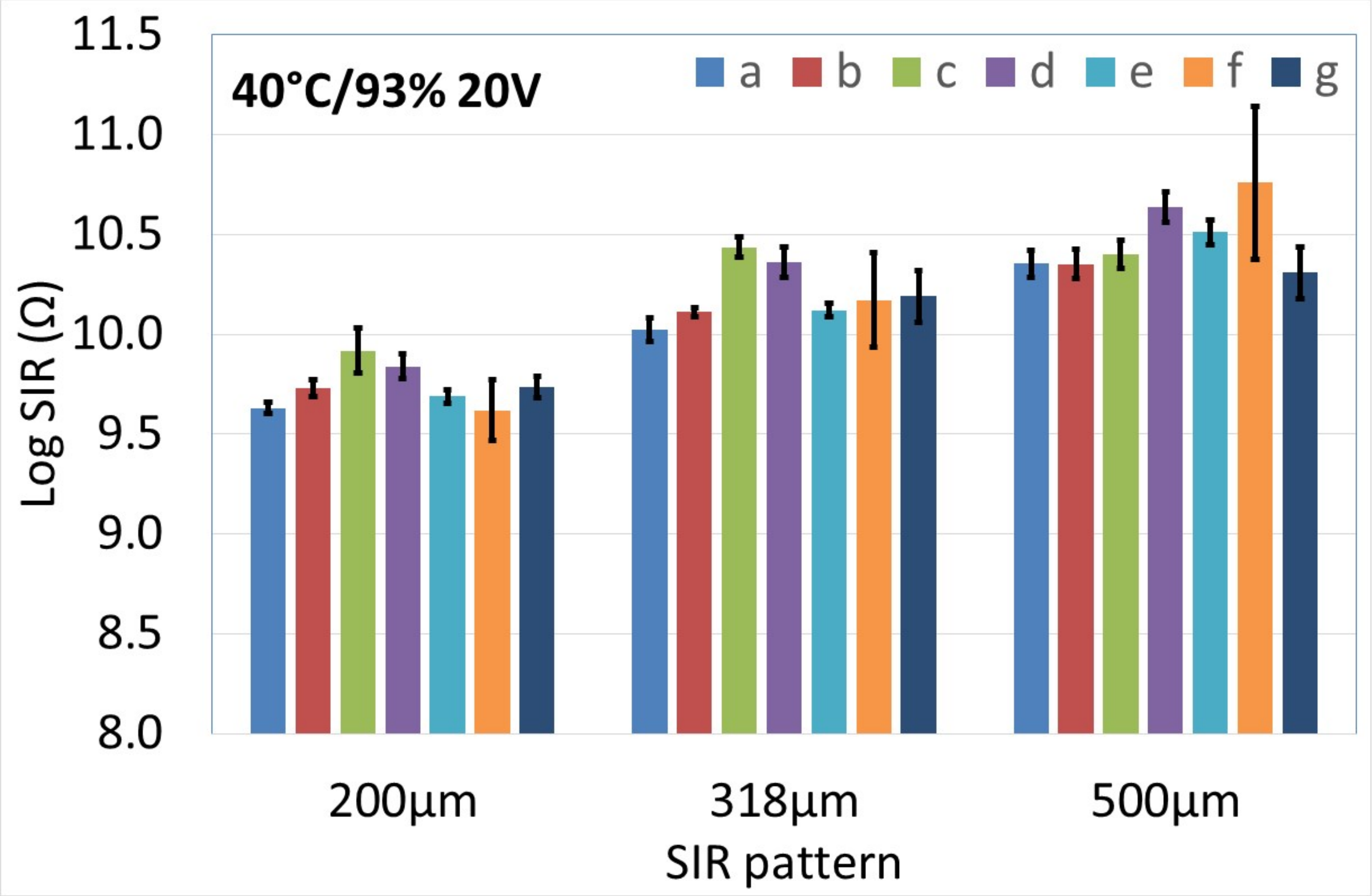
Participant c – Direct soldering

- Dendrites and corrosion formed on all SIR patterns of all fluxed samples tested at 85°C/85%RH.

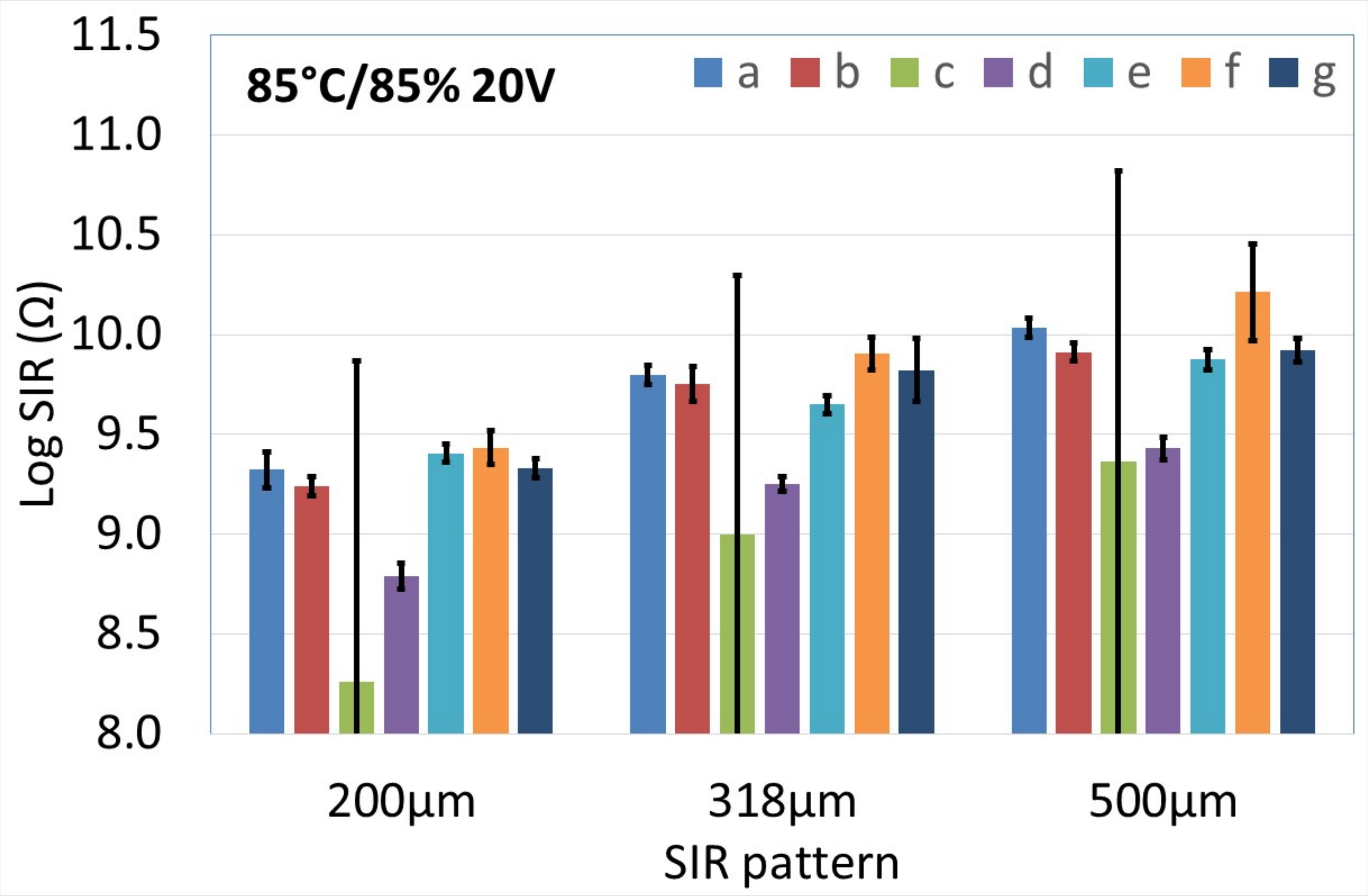




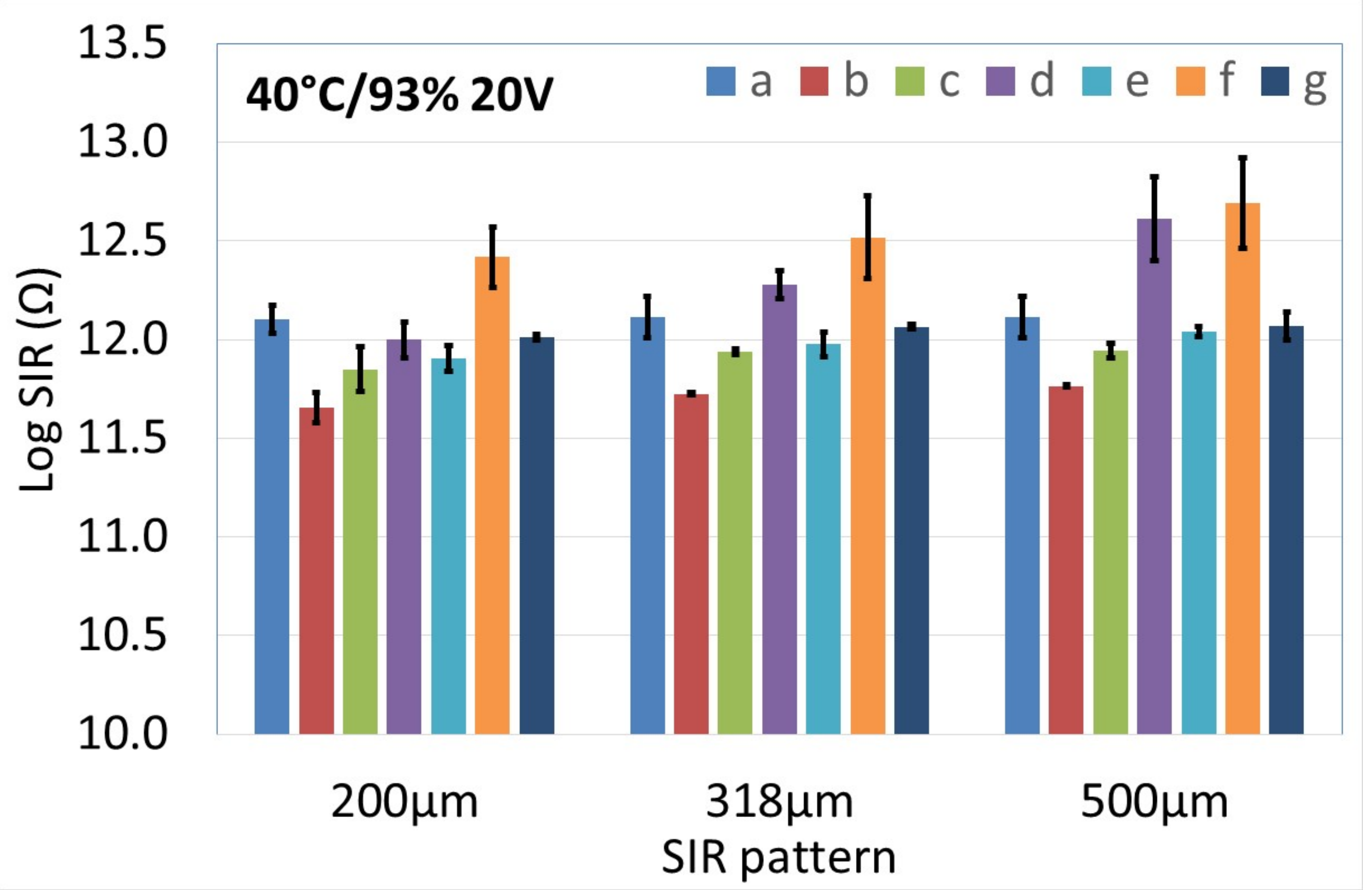
Average final SIR value - flux loaded - 40°C/93%RH



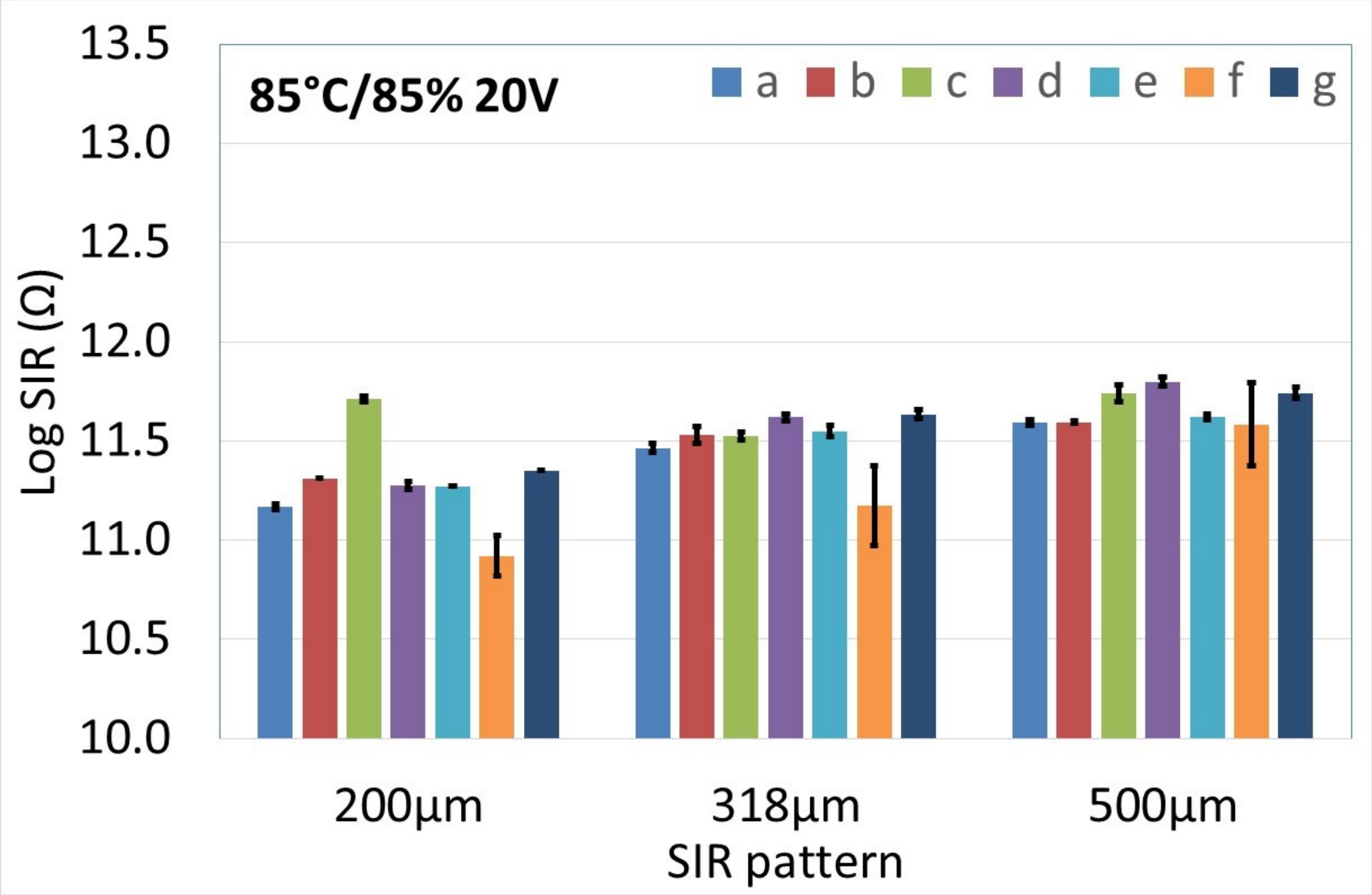
Average final SIR value – flux loaded - 85°C/85%RH



Average final SIR value - reference - 40°C/93%RH

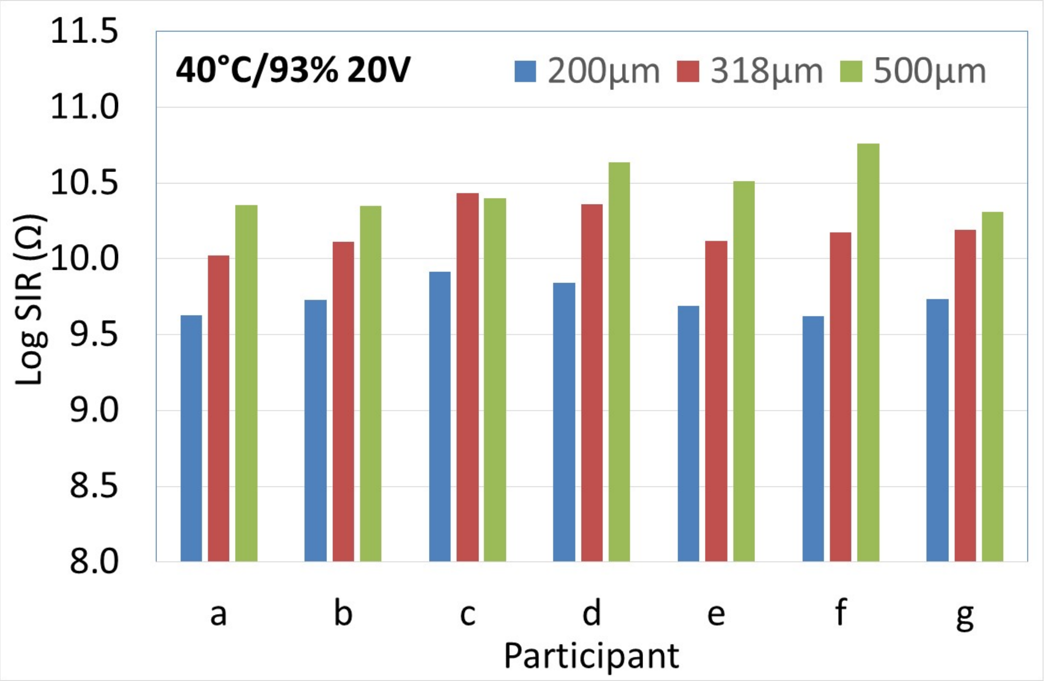


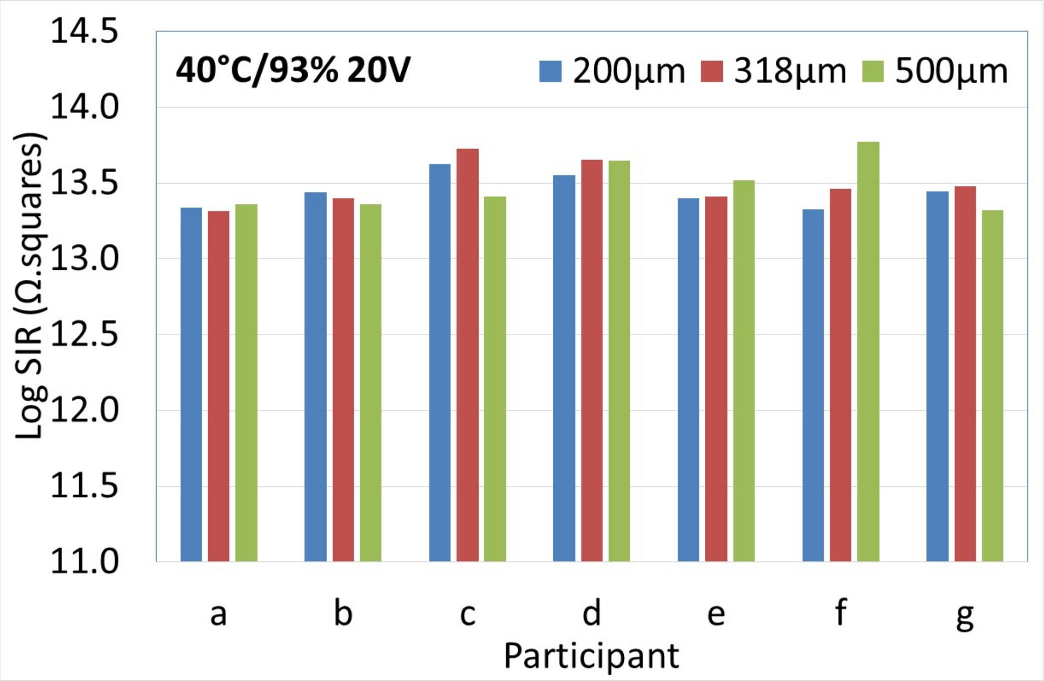
Average final SIR value - reference - 85°C/85%RH



SIR & Ω.square SIR - flux loaded - 40°C/93%RH - different patterns

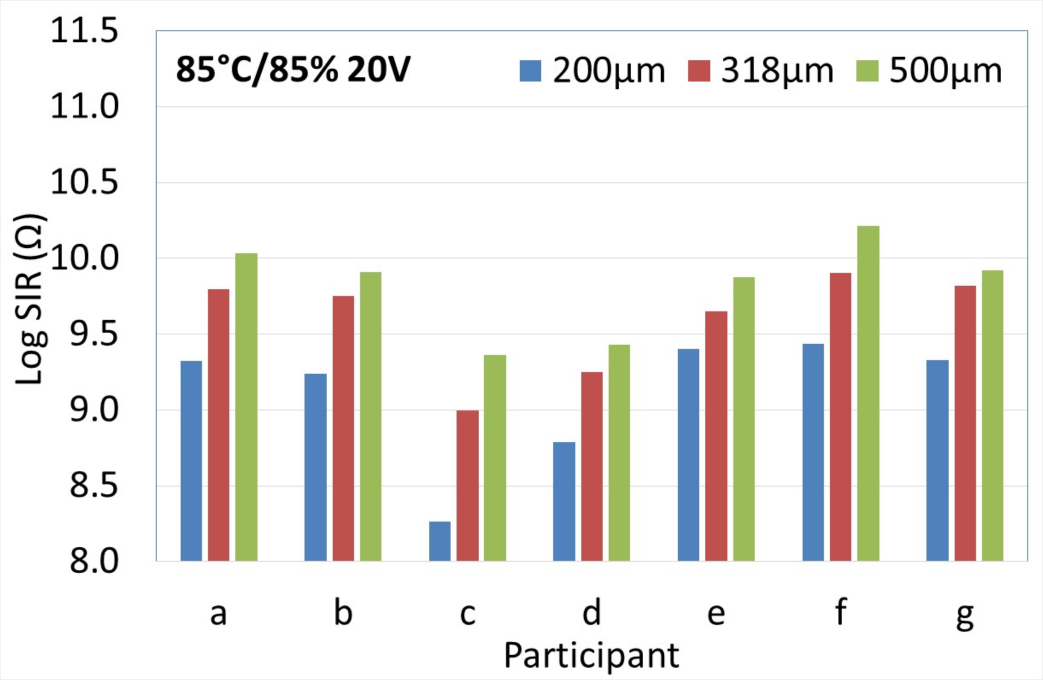
- Ω.squares role was followed by most of participants

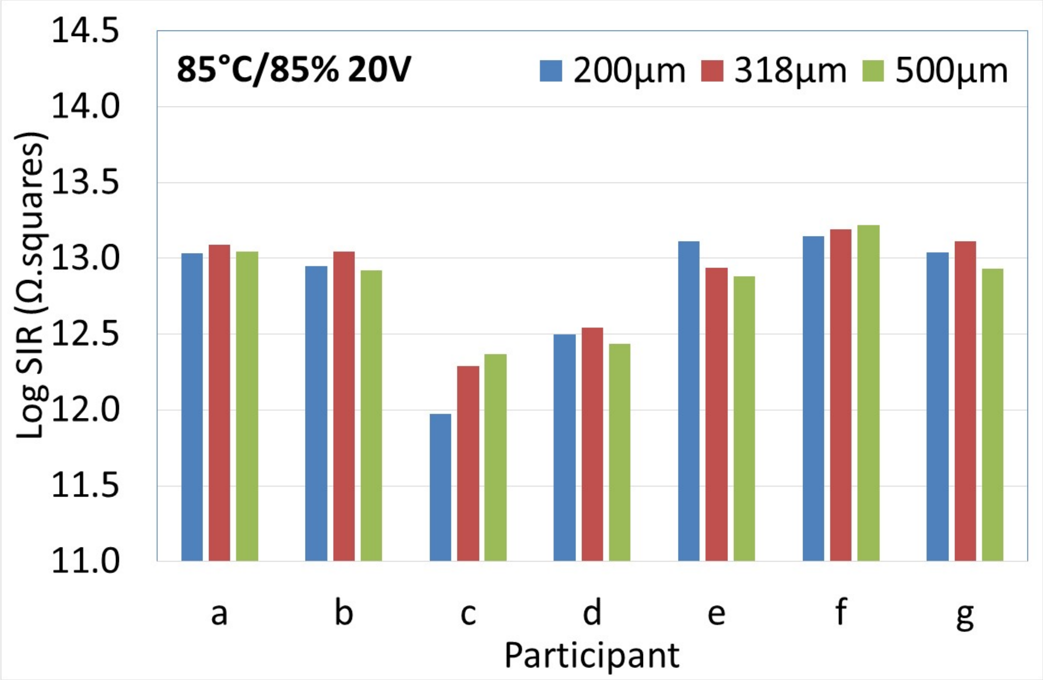




SIR, Ω.square SIR, - flux loaded - 85°C/85%RH - different patterns

- Ω.squares role was followed by most of participants



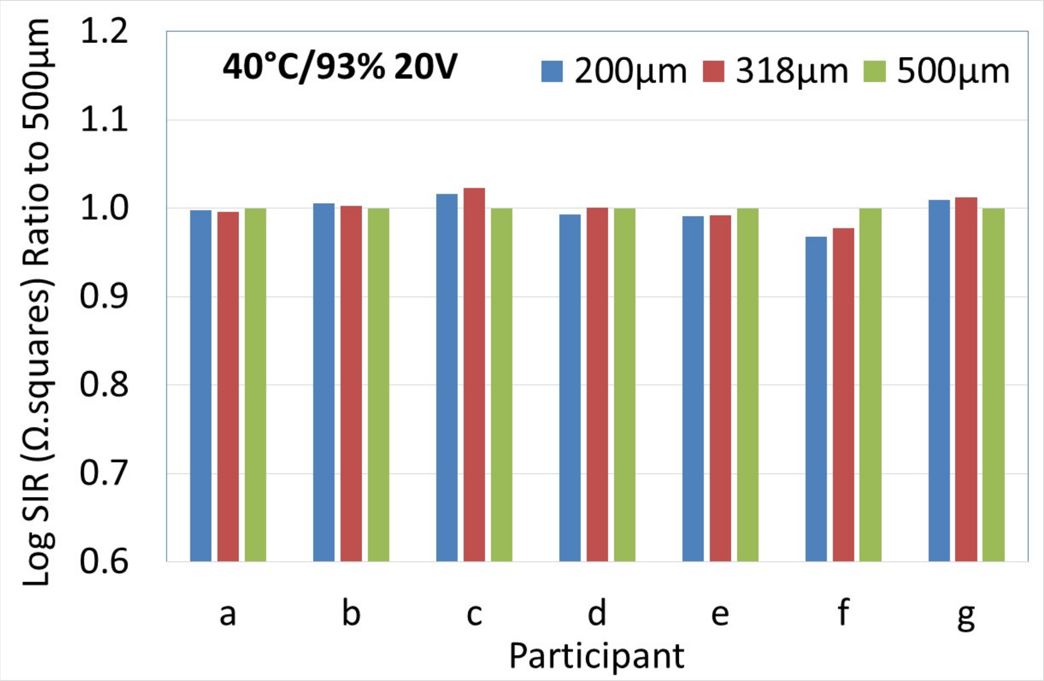


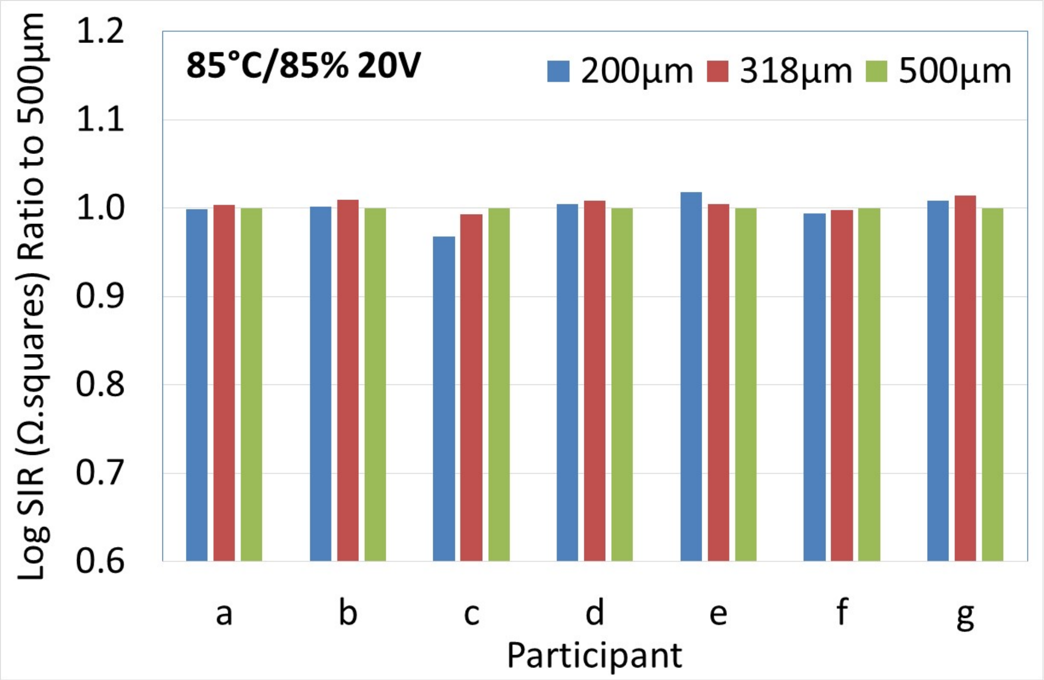
Final normalisation

- Ω.squares role was followed by most of participants
- We now normalise the Ω.square value to the 500µm pattern results.
- The rationale that we have adopted here is:
  - *There is a correction for the geometric effect of the different patterns, i.e. the finer pitch patterns having more squares.*
  - *Then we normalise to one pattern, i.e. the 500µm pattern*
  - *Therefore, we can now see the impact of adopting the finer 200µm pitch pattern for each participant, as shown on the following slide*

Ratio to 500µm- Log SIR (Ω.square)

- This analysis shows that the SIR values are constant as the pattern pitch reduces.





Summary

- The aim of this intercomparison was to validate the use of a 200µm SIR pattern.
  - *The intercomparison benchmarked this new pattern against the existing 400/500 and 318/318 patterns*
- 7 participants were involved in the intercomparison
  - *From Denmark, Germany, Japan, UK, USA*
- The approach was developed at the company, and the company prepared all the test boards and sent them directly to the participants.
- The intercomparison showed that the new pattern behaves in line with the existing patterns.
- The new 200/400 pattern will be incorporated into IEC 61189-5-501

Acknowledgements

We wish to acknowledge the participating laboratories:

- Alpha Assembly Solutions, USA
- Gen 3 Systems, UK
- Hytek, Denmark
- Nihon Genma MFG. CO. Ltd, Japan
- Robert Bosch, Germany
- Rockwell Collins, USA (plus maker of the checker boards)

- We would also like to express our sincere thanks to Merlin Circuits UK for the provision of the test coupons.

Any questions ?