TEST RESULTS

Inspection intervals

- Doubled cycle count between inspection intervals

- Cycles 0 -250 from Sept-13-2011 to Sept-21-2011
  - First inspection (250 Cycles)

- Cycles 251 -730 from Oct-4-2011 to Nov-1-2011
  - Second inspection (250 + 500 Cycles) (actual count: 250 + 480)

- Cycles 731 - 1797 from Dec-1-2011 to Jan-29-2012
  - Third inspection (250+500+1000 Cycles) (actual count: 250 + 480 + 1067)

Variable summary

Bias Voltage
0 V 5 V

Assembly cleanliness
(microgram/in^2 chloride)
0 10

Rework flux contamination
0 = No 1 = Yes

Part lead material
Cu 42Ni

Part cleanliness
(microgram/in^2 chloride)
0 3

Board contamination nomenclature

0-0 No part contamination-No board contamination

0-1 No part contamination-Board contamination

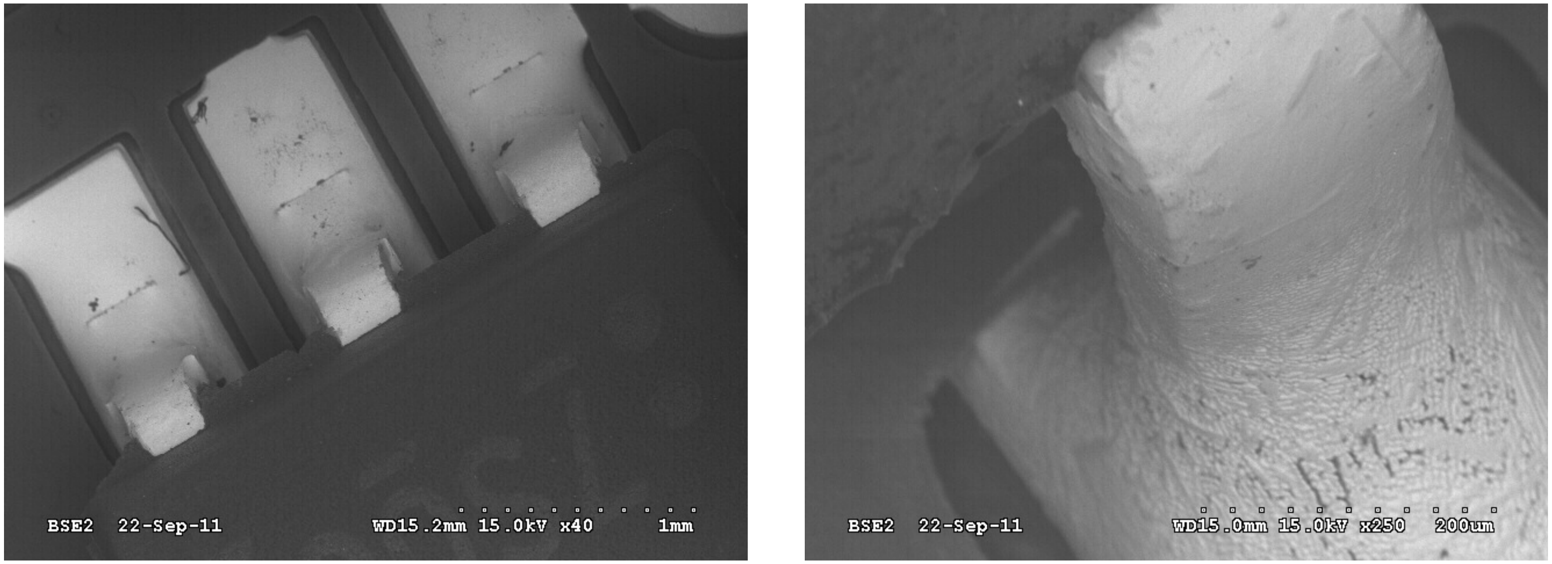
1-0 Part contamination-No board contamination

1-1 Part contamination-Board contamination

Power Cycling, First Inspection after 250 Cycles

- No whiskers or hillocks found

SOT363



Power Cycling, Second Inspection 250 + 500 Cycles

- SOT23-3 and SOT363 with Alloy 42 lead frame material grew some whisker
- SOT23-5 with C194 lead frame material did not grew whiskers; only small hillocks found on 1-1 board

- The Main factor – Alloy 42
  - Alloy 42
    - SOT23-3
      - 42% to 63% components grew whiskers
      - 16% to 27% leads grew whiskers
      - Max whisker length – 9.4µm
    - SOT636
      - 38% to 88% components grew whiskers
      - 8.3% to 17% leads grew whiskers
      - Max whisker length – 10.7µm

- No significant evidence of voltage influence on SOT23-3 and SOT363
  - 0V and 5V
  - Ground and no-connects

SOT3 results

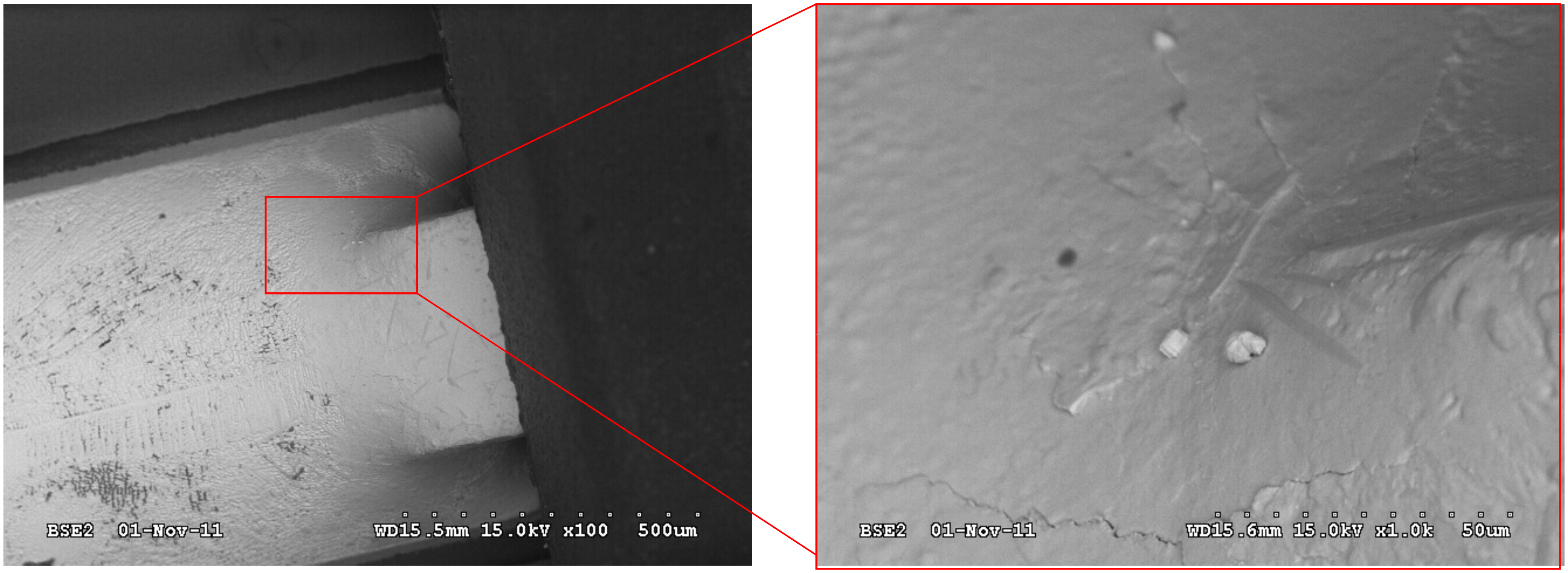
Cleanliness		Parts	Leads	# of Whisk-ers	Max length µm
0-0	# Measured	42	126		
	# With whiskers	26 (61.9%)	31 (24.6%)	57	7.1
0-1	# Measured	28	84		
	# With whiskers	12 (42.9%)	13 (15.5%)	29	7.5
1-0	# Measured	28	84		
	# With whiskers	12 (42.9%)	16 (19%)	30	9.4
1-1	# Measured	26	78		
	# With whiskers	14 (53.8%)	19 (24.4%)	44	9.4

SOT6 results

Cleanliness		Parts	Leads	# of Whisk-ers	Max length µm
0-0	# Measured	8	48		
	# With whiskers	3 (37.5%)	4 (8.3%)	6	10
1-0	# Measured	8	48		
	# With whiskers	4 (50%)	4 (8.3%)	6	10.7
0-1	# Measured	8	48		
	# With whiskers	7 (87.5%)	13 (27.1%)	17	7.4
1-1	# Measured	8	48		
	# With whiskers	4 (50%)	4 (8.3%)	12	10.4

Second inspection: Short whiskers on Alloy 42

SOT3 1-1 Contamination

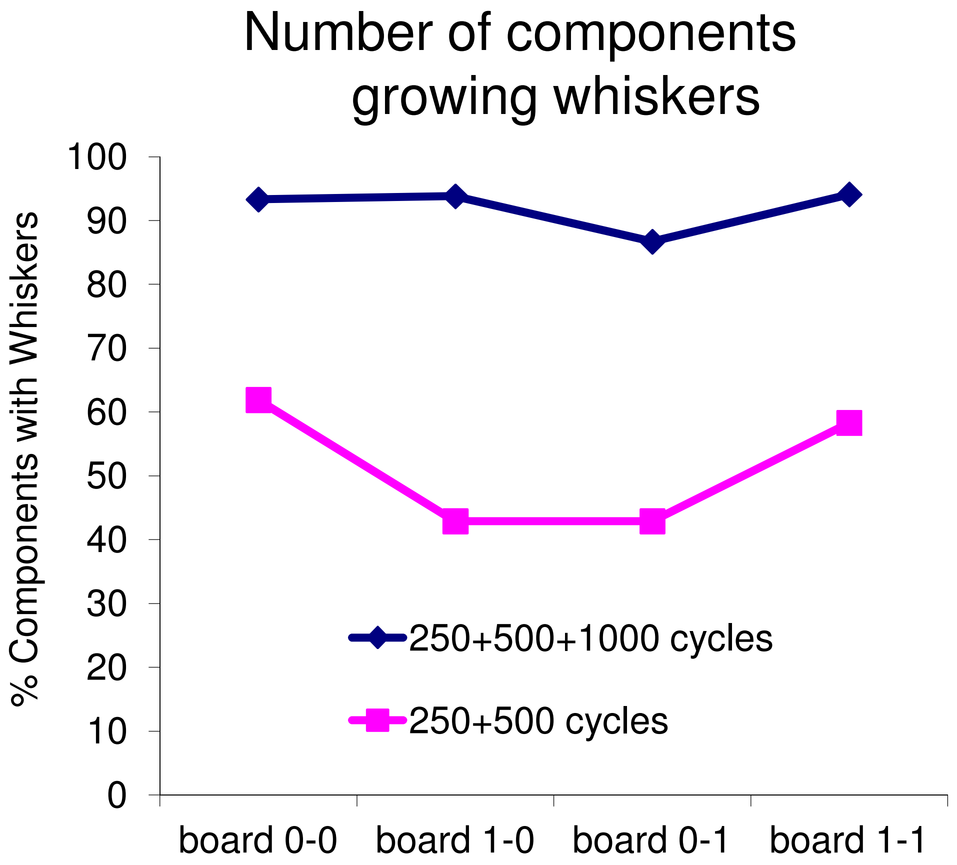


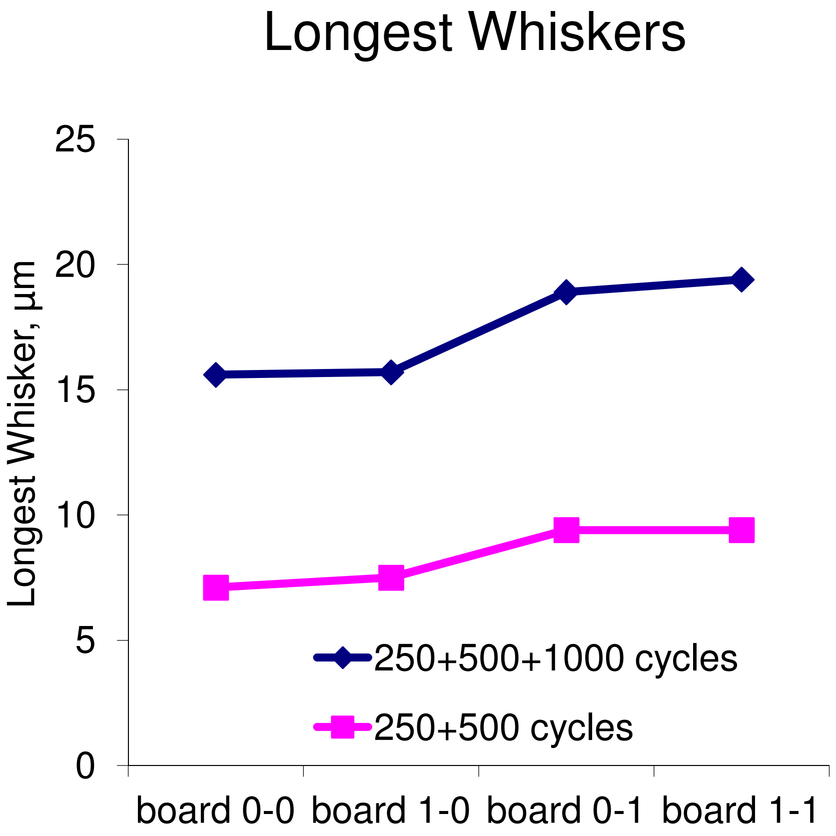
Third Inspection (250+500+1000 Cycles)

- Whiskers were short and density was low
- Decided to continue for 1000 more cycles
  - ☐ Contaminated one board of each eight groups with no clean flux
  - ☐ The following type of boards were place to the chamber for a third Power Cycling Simulation test portion:

0-0	0-0 no conformal coating
0-0 flux	0-0 no conformal coating + flux
1-0	1-0 no conformal coating
1-0 flux	1-0 no conformal coating + flux
0-1	0-1 no conformal coating
0-1 flux	0-1 no conformal coating + flux
1-1	1-1 no conformal coating
1-1 flux	1-1 no conformal coating + flux

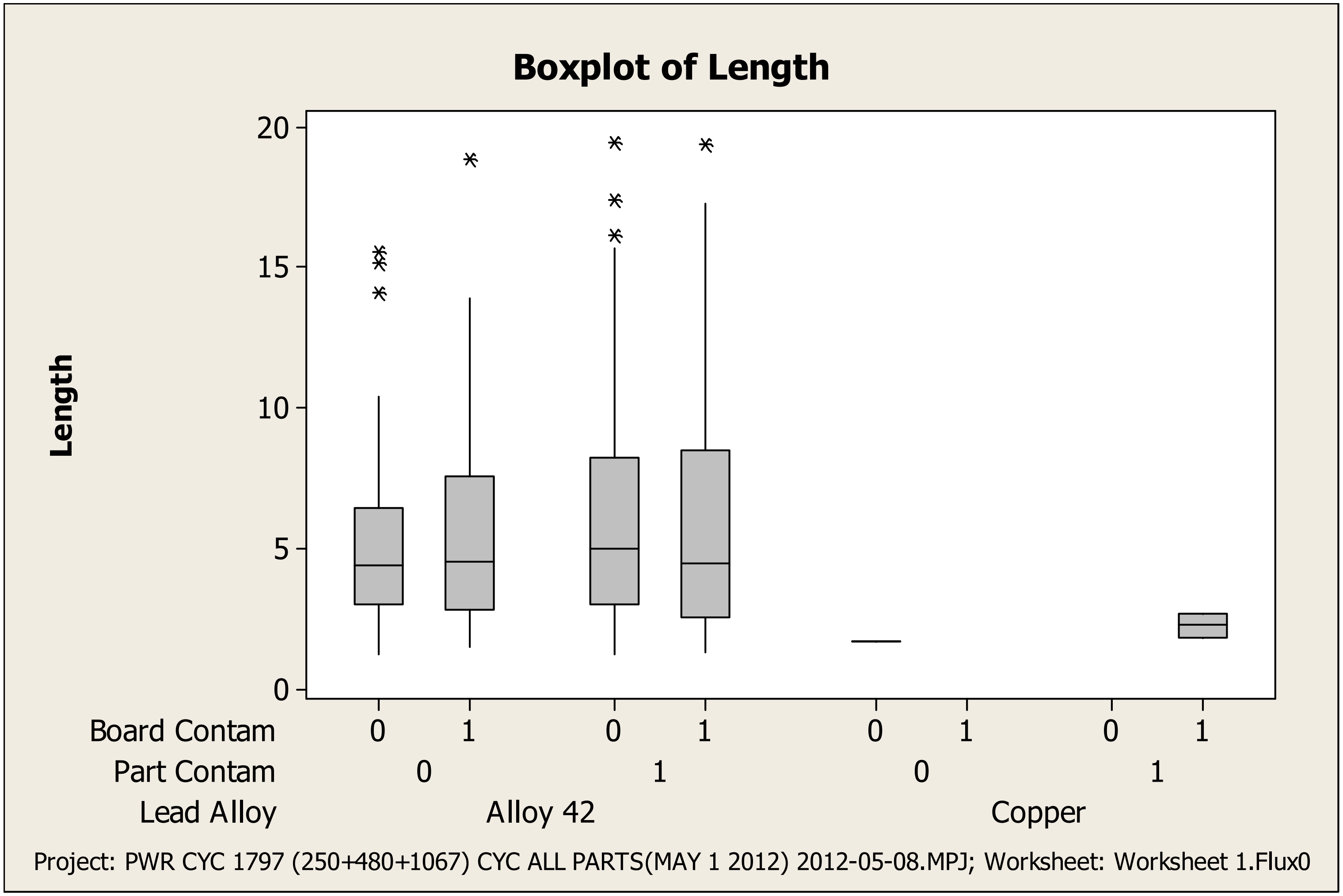
Second and third comparison





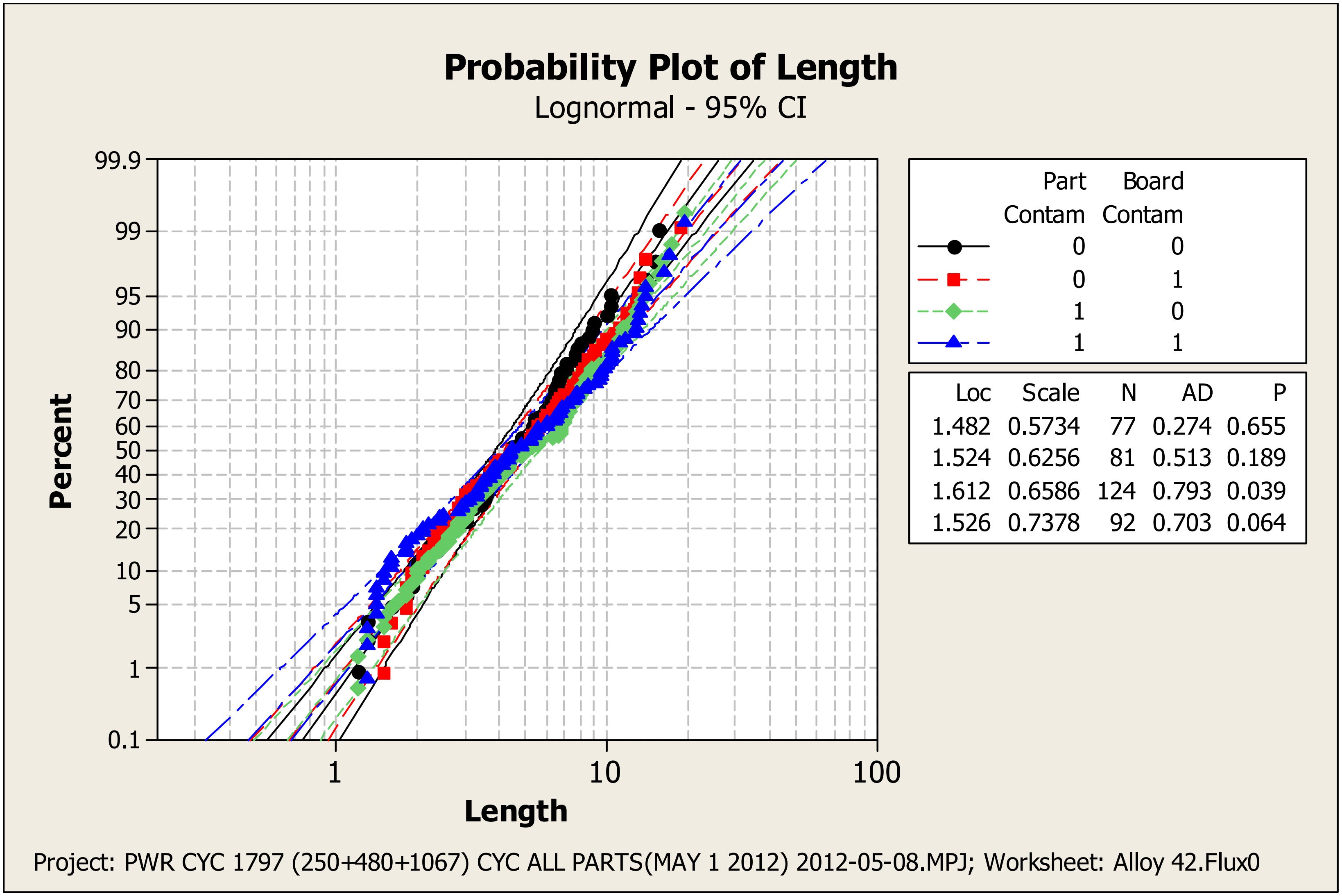
Additional 1000 cycles yielded more and longer whiskers

Third inspection: 250+500+1000 Cycles No Flux



Alloy 42 grew longest whiskers

Alloy 42: 250+500+1000 Cycles No Flux



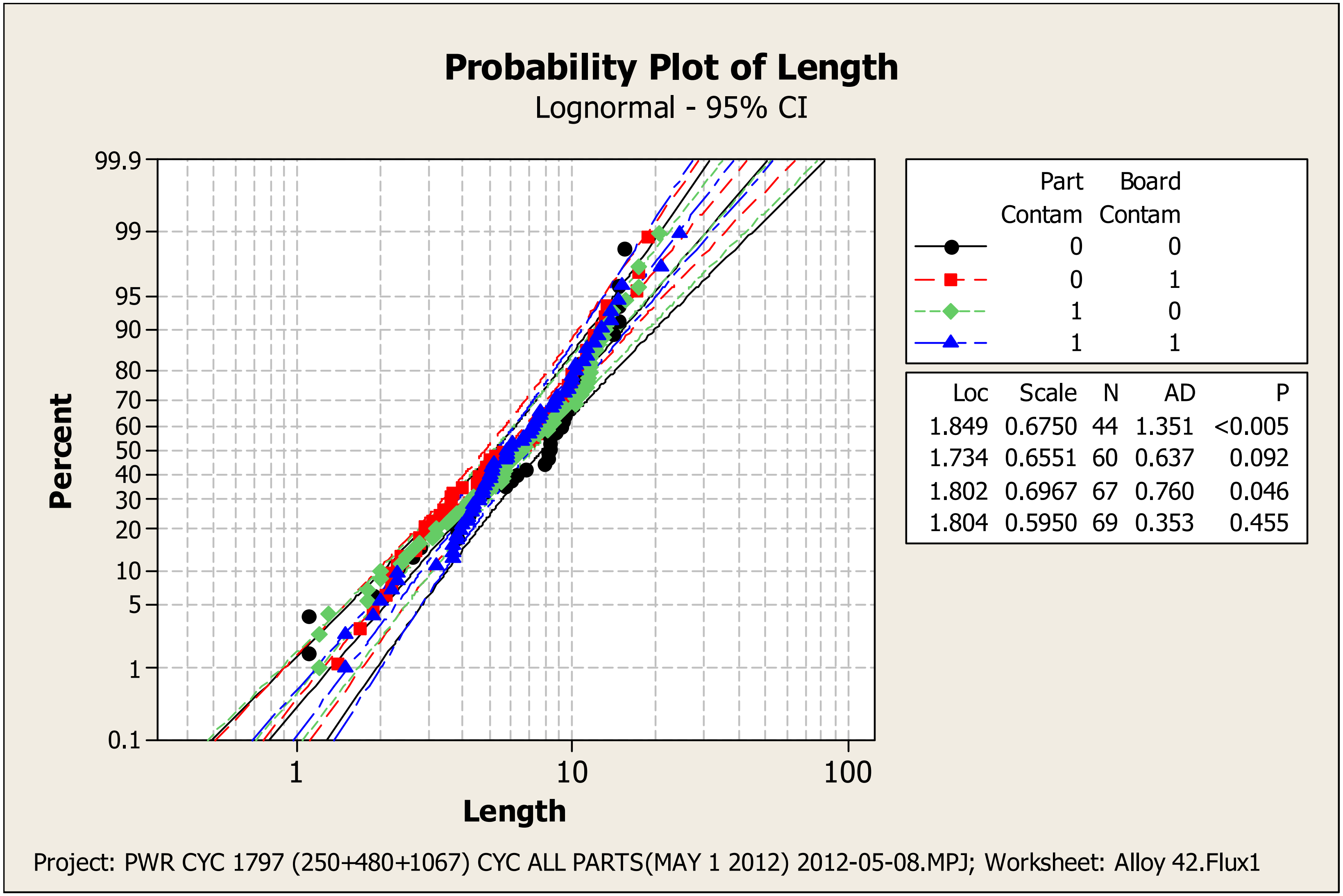
	Part Contam	Board Contam
●	0	0
■	0	1
◆	1	0
▲	1	1

Loc	Scale	N	AD	P
1.482	0.5734	77	0.274	0.655
1.524	0.6256	81	0.513	0.189
1.612	0.6586	124	0.793	0.039
1.526	0.7378	92	0.703	0.064

Project: PWR CYC 1797 (250+480+1067) CYC ALL PARTS(MAY 1 2012) 2012-05-08.MPJ; Worksheet: Alloy 42.Flux0

Contamination resulted in slightly longer whisker growth

Alloy 42: 250+500+1000 Cycles Flux



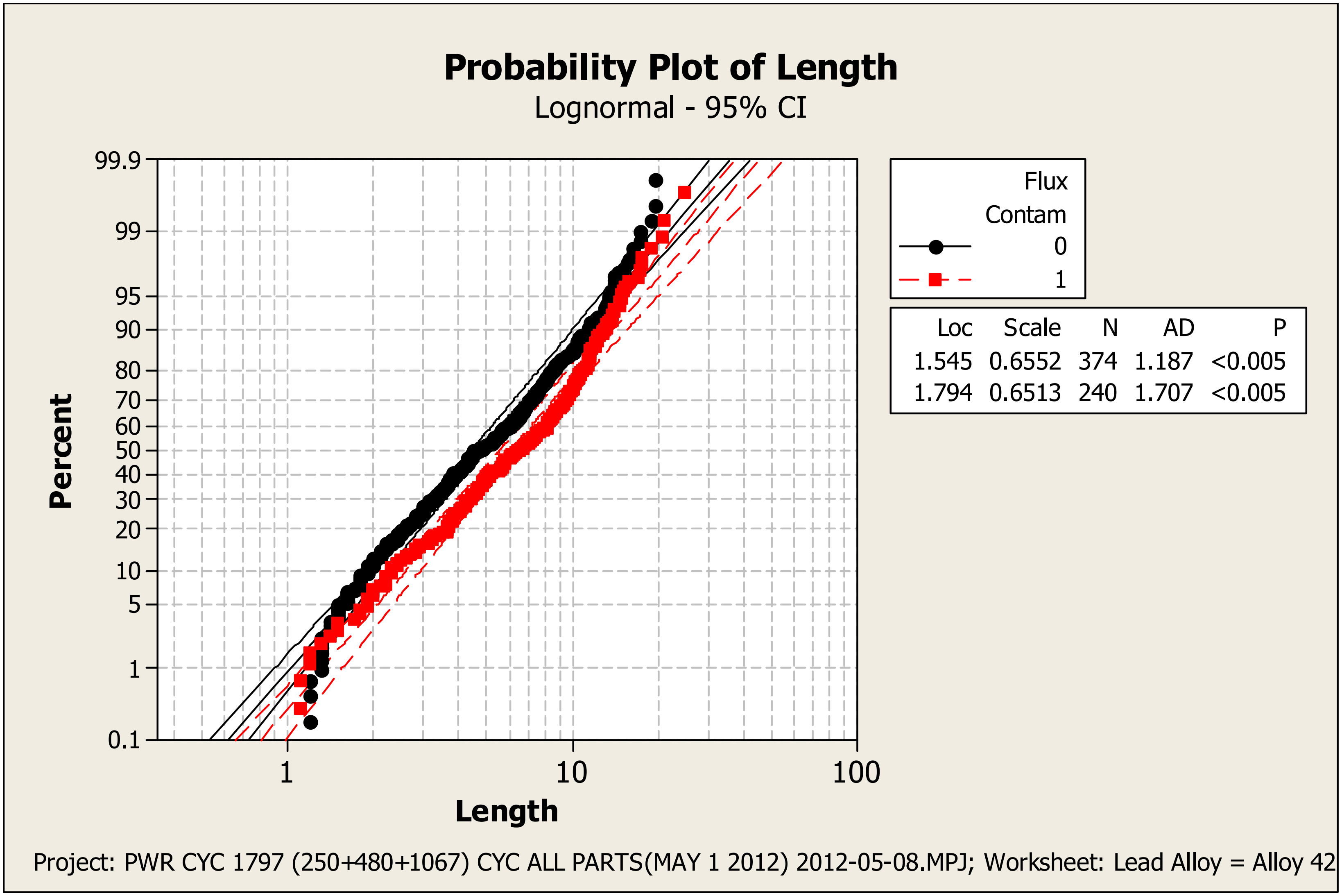
Part Contam	Board Contam
0	0
0	1
1	0
1	1

Loc	Scale	N	AD	P
1.849	0.6750	44	1.351	<0.005
1.734	0.6551	60	0.637	0.092
1.802	0.6967	67	0.760	0.046
1.804	0.5950	69	0.353	0.455

Project: PWR CYC 1797 (250+480+1067) CYC ALL PARTS(MAY 1 2012) 2012-05-08.MPJ; Worksheet: Alloy 42.Flux1

Contamination resulted in slightly longer whisker growth

Alloy 42: 250+500+1000 Cycles No-flux and flux

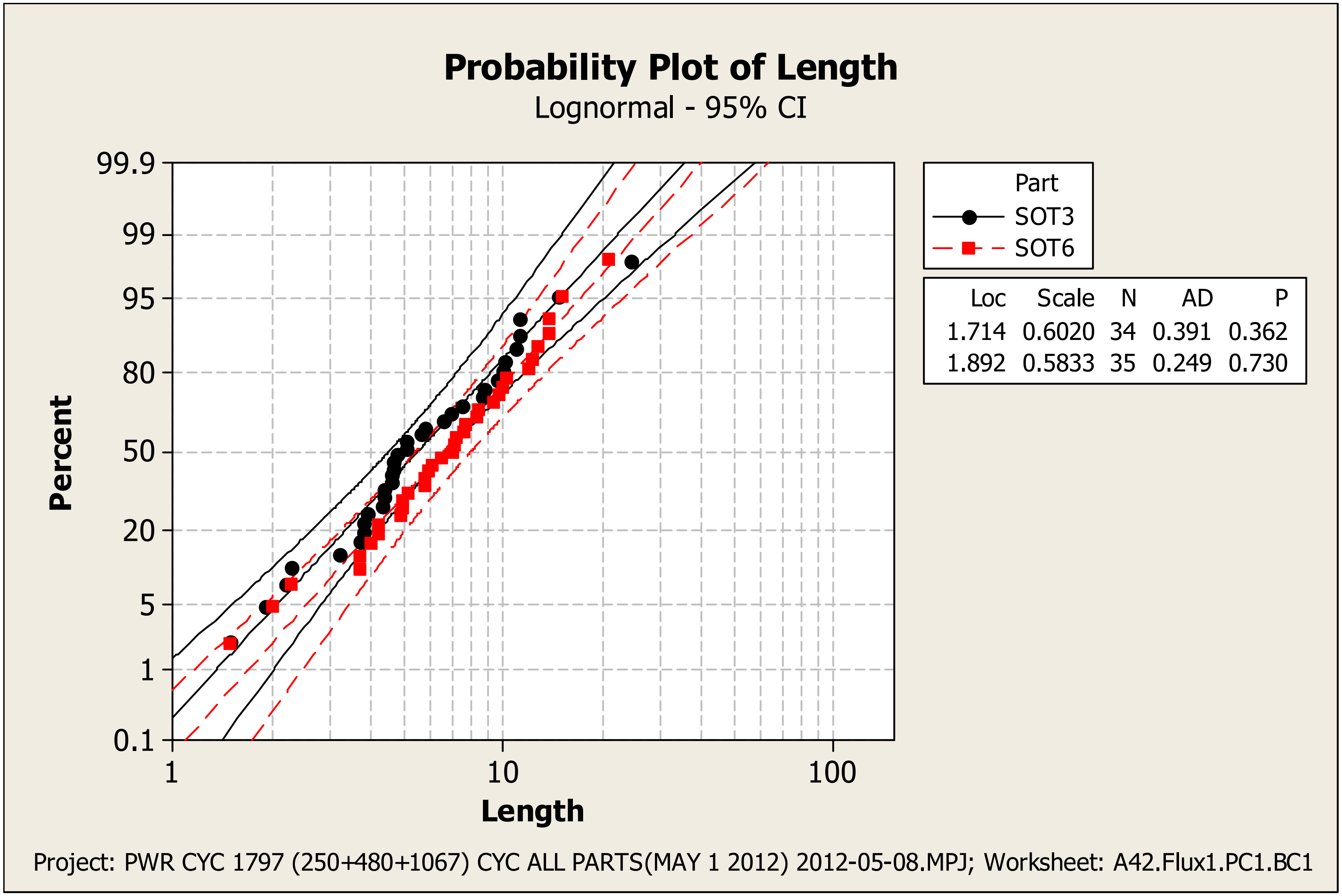


Loc	Scale	N	AD	P
1.545	0.6552	374	1.187	<0.005
1.794	0.6513	240	1.707	<0.005

Project: PWR CYC 1797 (250+480+1067) CYC ALL PARTS(MAY 1 2012) 2012-05-08.MPJ; Worksheet: Lead Alloy = Alloy 42

Flux yielded slightly longer whisker growth

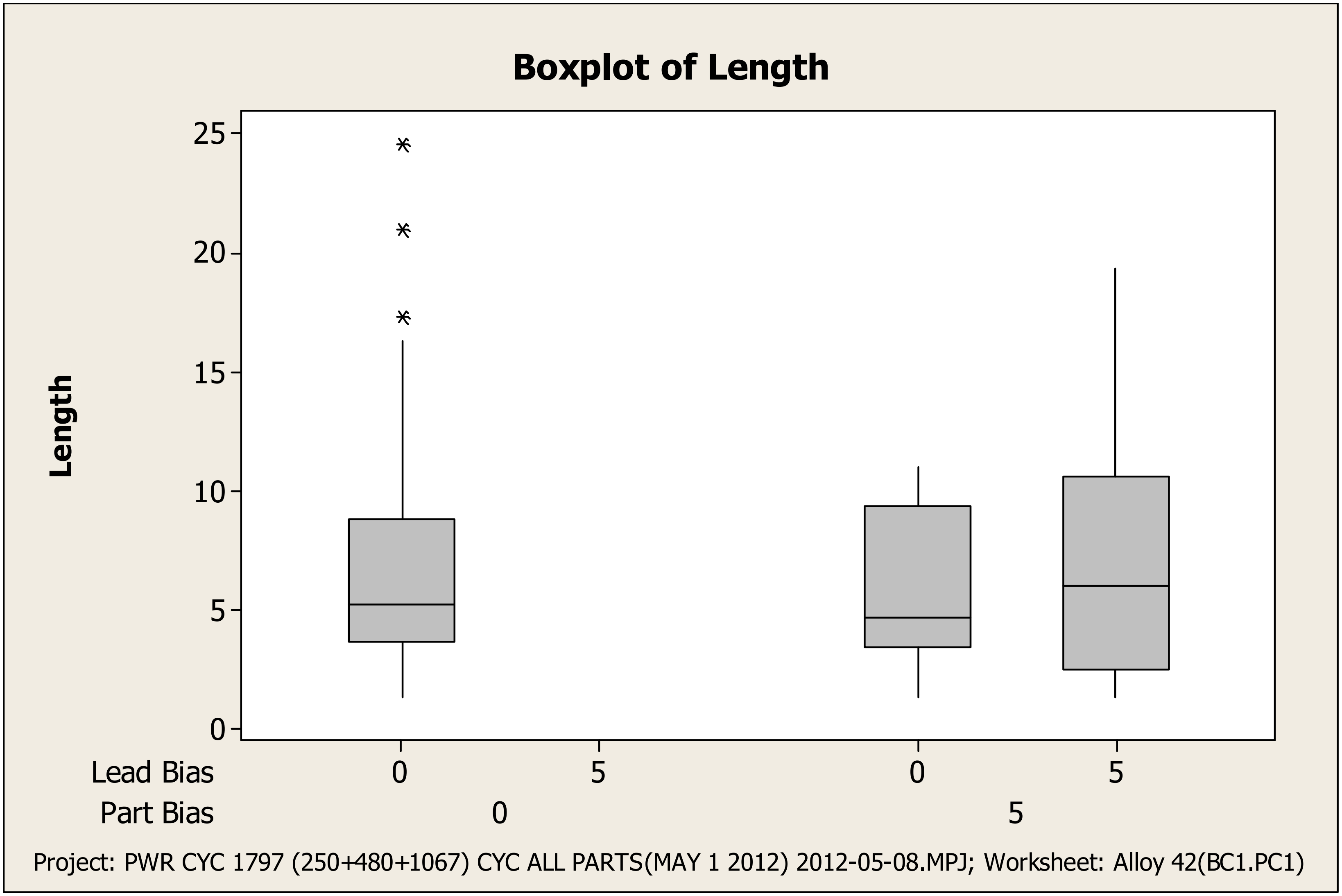
Alloy 42: 250+500+1000 Cyc. 1-1 contam with flux



Loc	Scale	N	AD	P
1.714	0.6020	34	0.391	0.362
1.892	0.5833	35	0.249	0.730

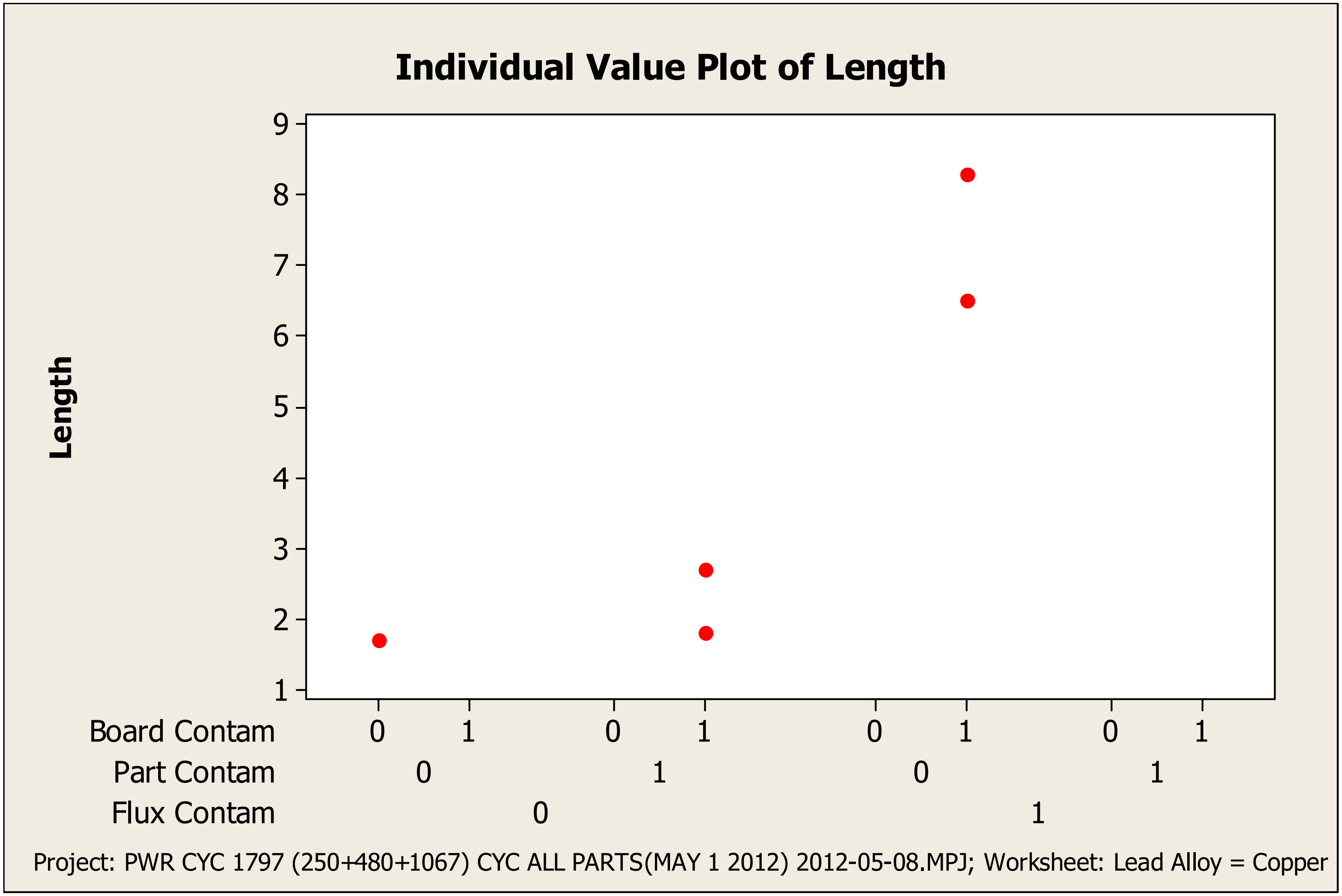
Longest whiskers obtained with 1-1 contamination level with flux

Alloy 42: 250+500+1000 Cycles voltage comparison



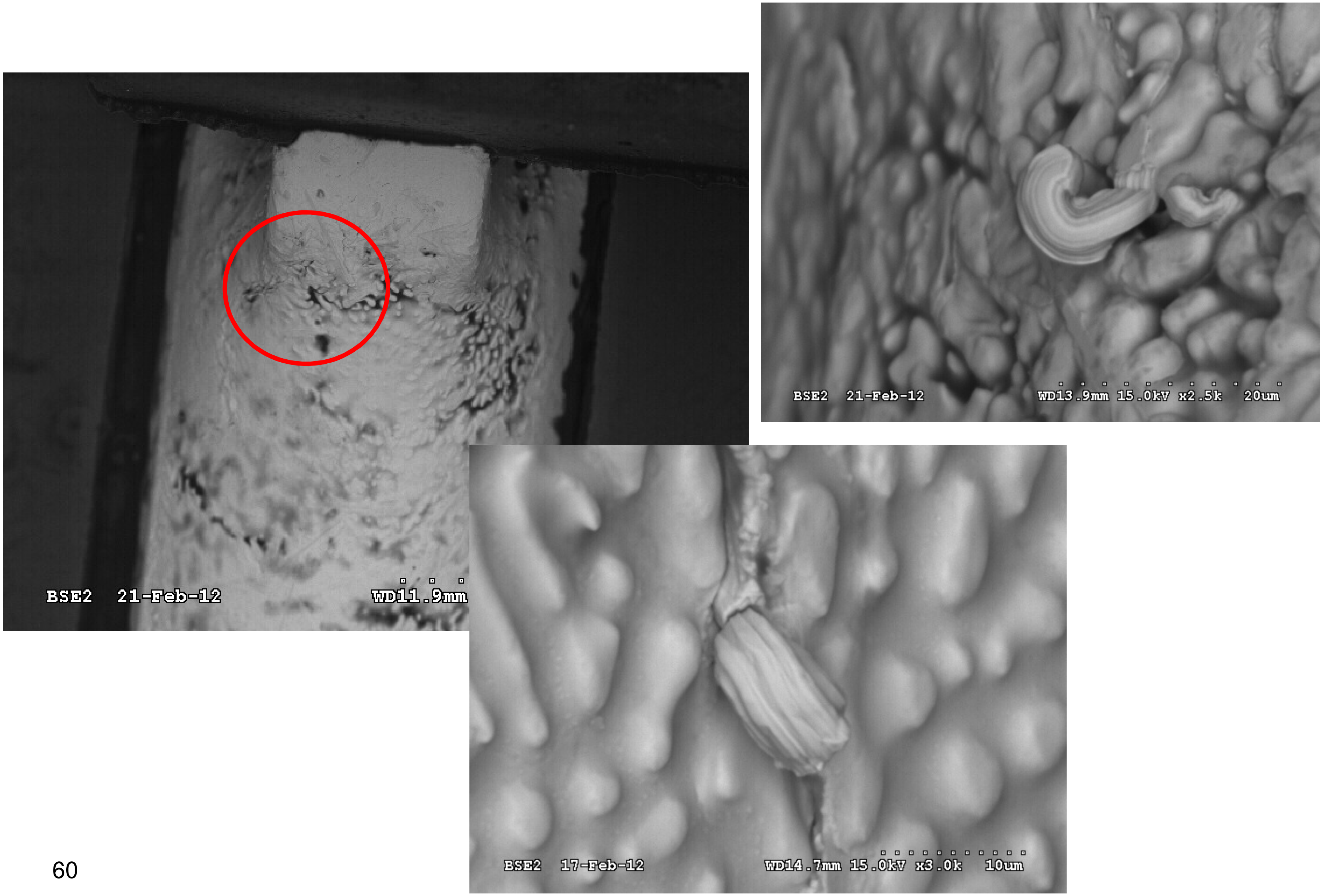
No strong influence of bias voltage

Copper: 250+500+1000 Cycles short whiskers

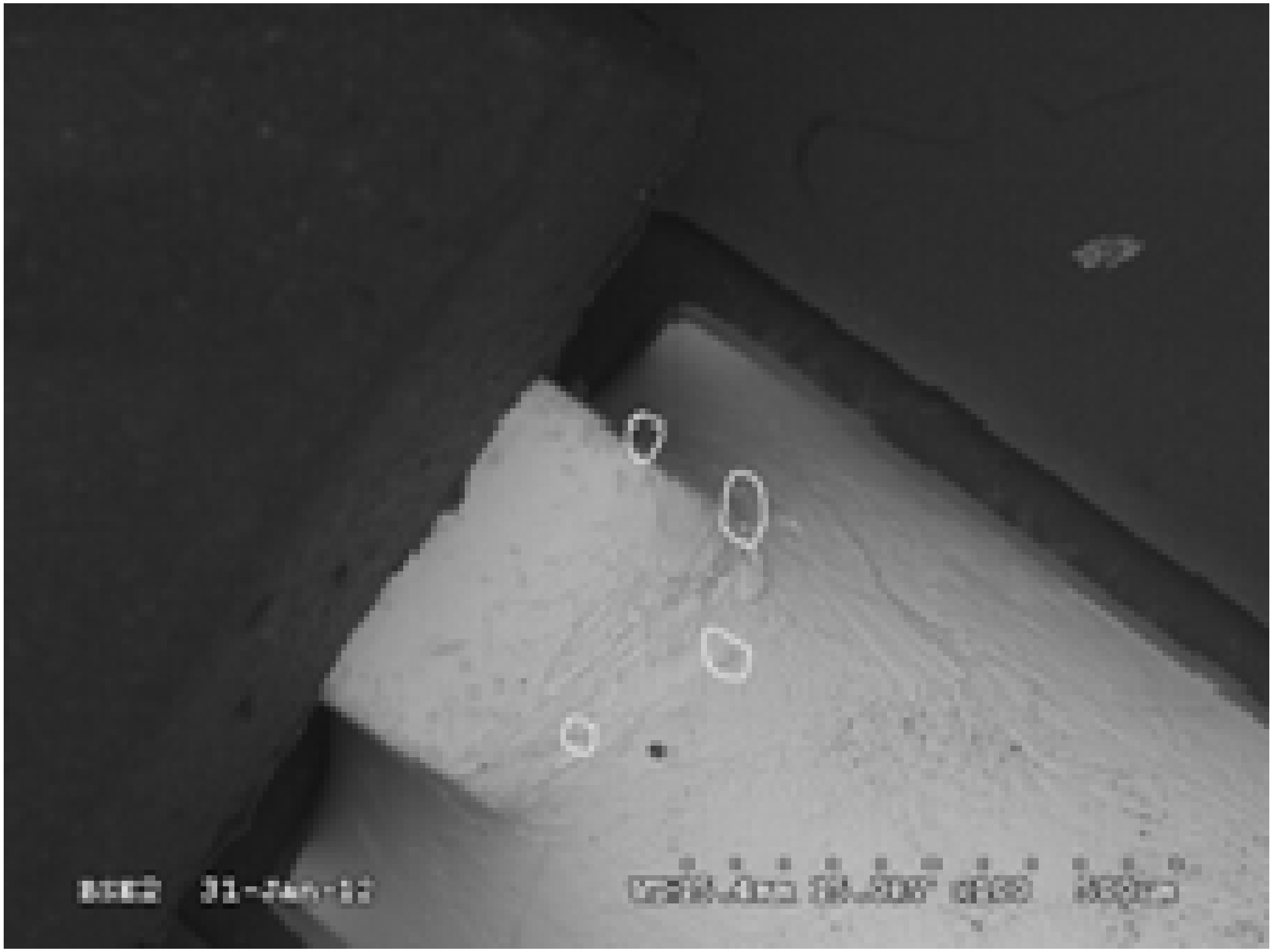


Few measured whiskers - Cannot draw trends

Alloy 42: 250+500+1000 Cycles

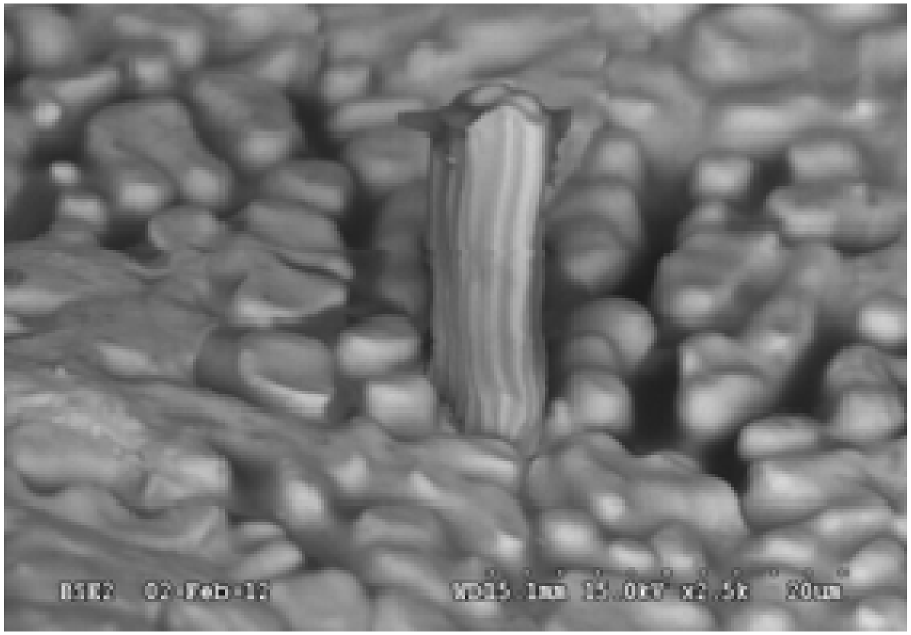


Alloy 42: 250+500+1000 Cycles

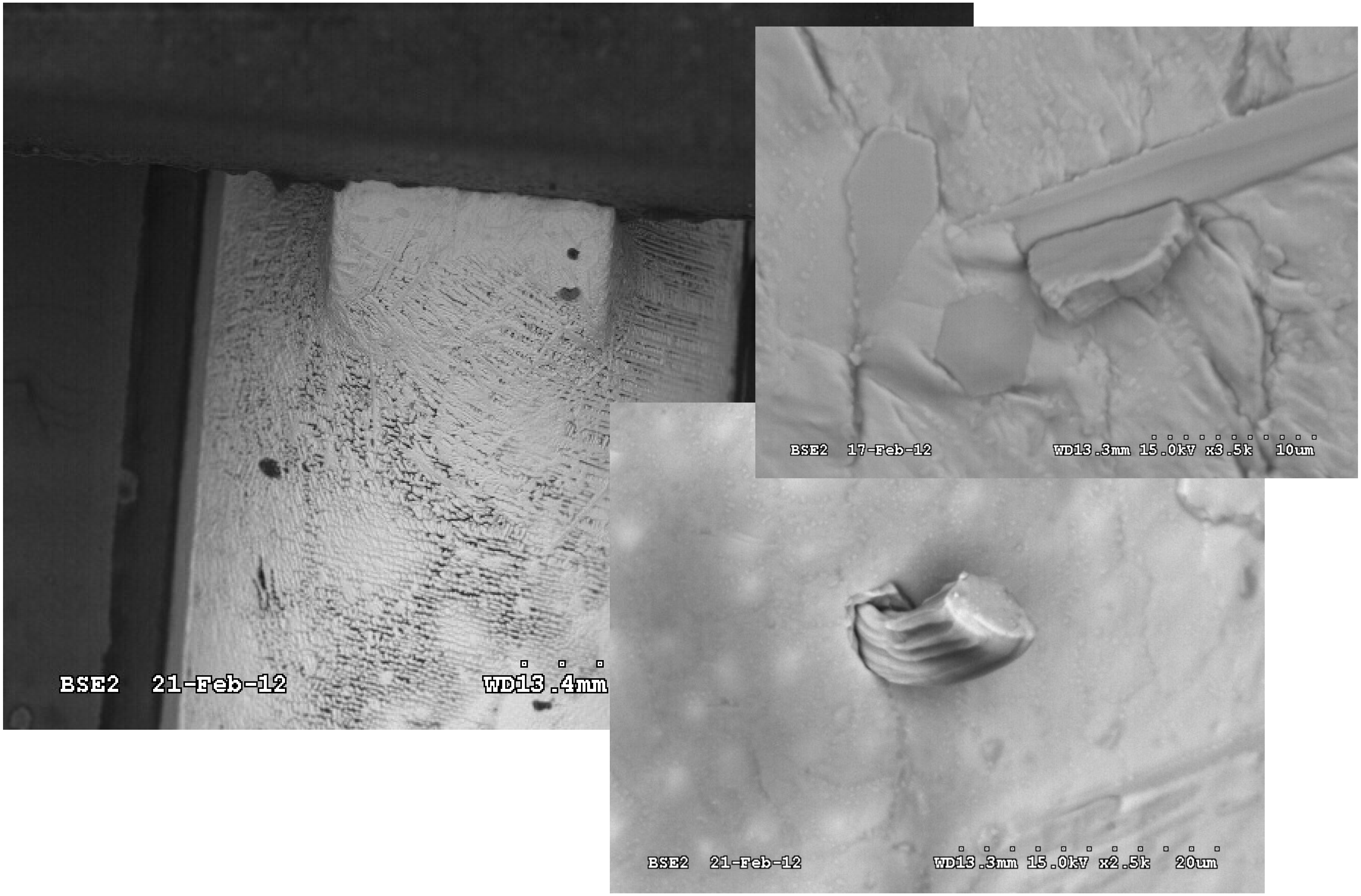


Whiskers grow from solder where lead exits the main fillet

Alloy 42: Whiskers after 250+500+1000 Cycles SOT6 with 1-1 contamination with flux

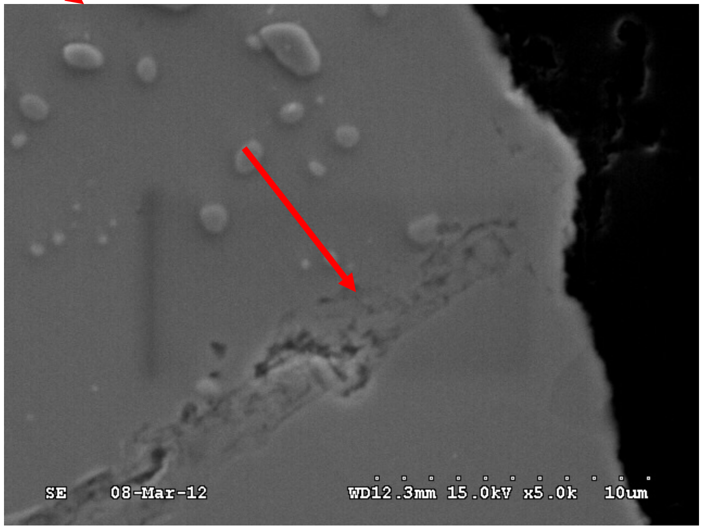


Alloy 42: Whiskers after 250+500+1000 Cycles

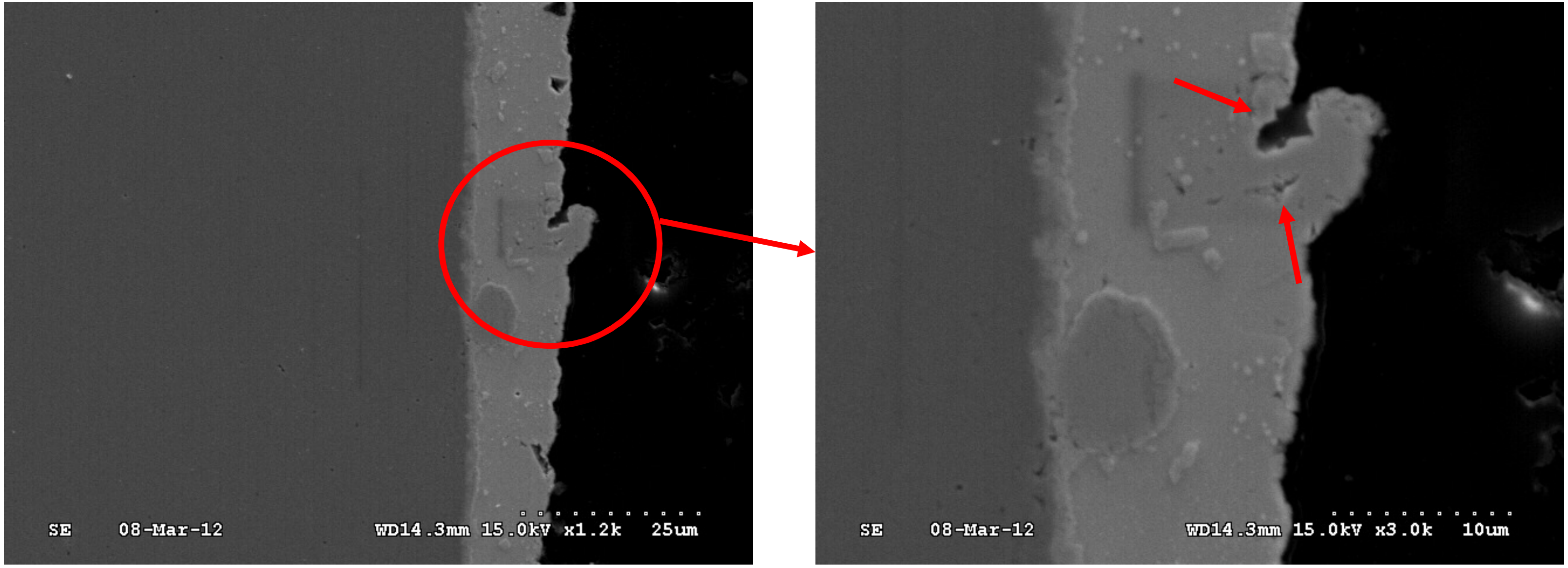


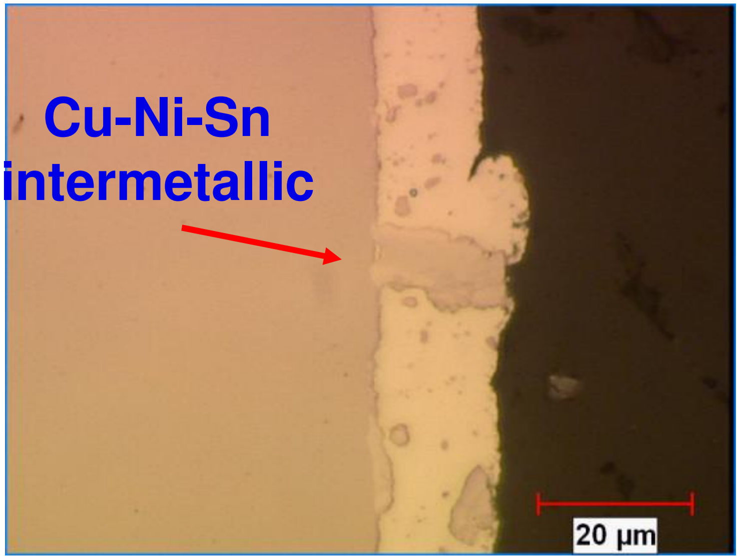
SOT6, 250+500+1000 Cycles, Cross-Sections

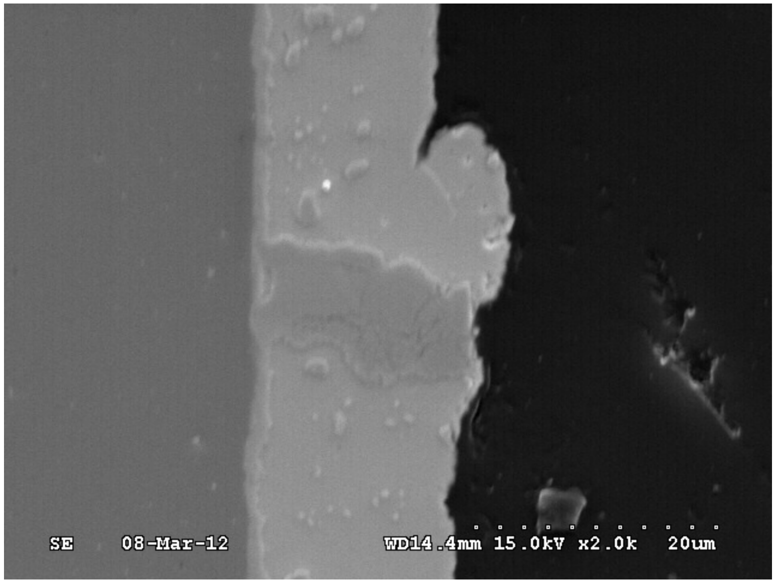
Corrosion



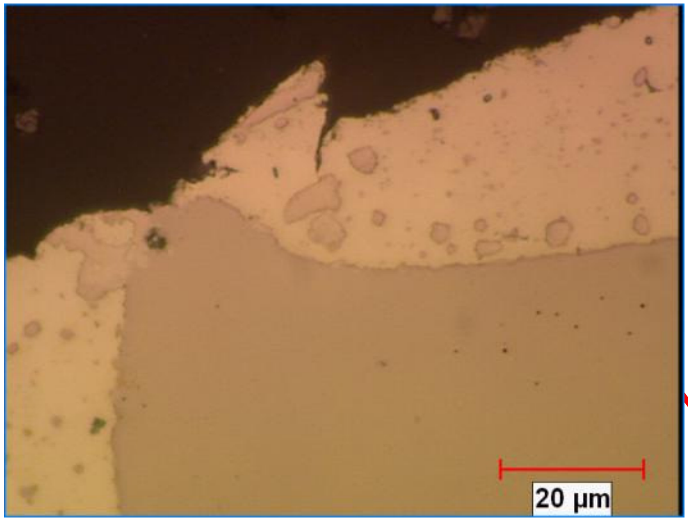
SOT6 250+500+1000 Cycles, Whisker Cross-sections







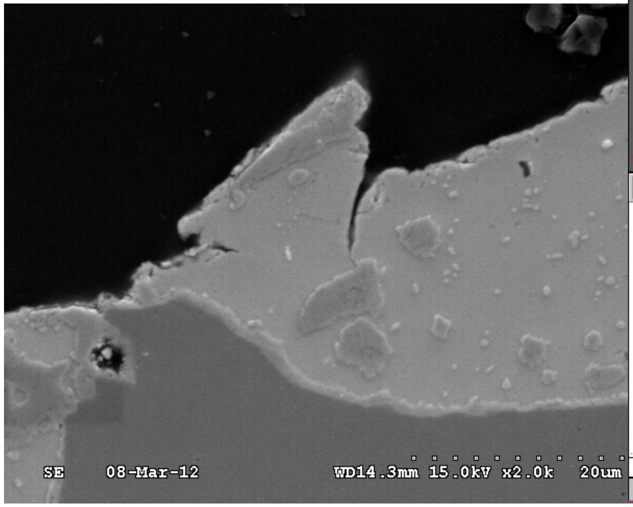
SOT363 250+500+1000 Cycles, Whisker Cross-sections

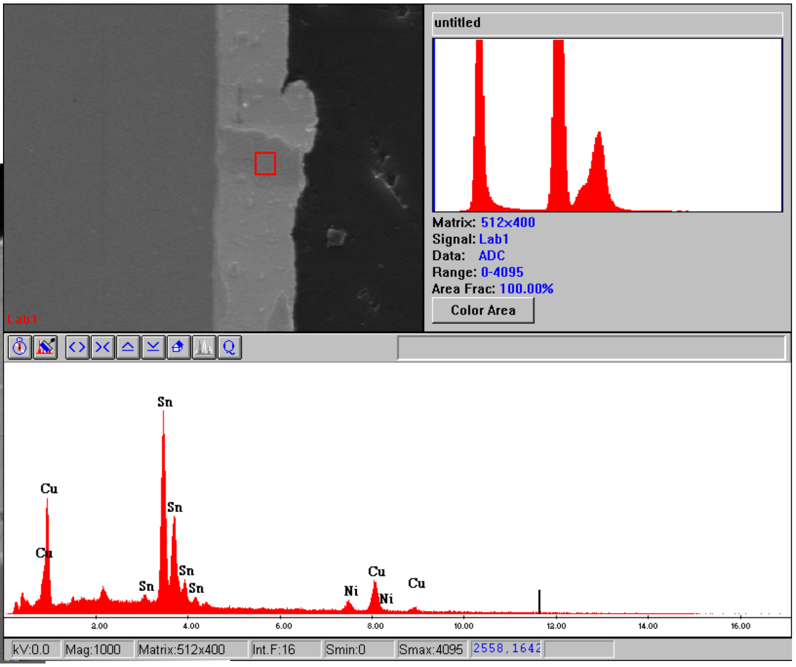


Interesting observation:

IMC on boards before cycling - 2.6µm and after cycling - 3.0µm

IMC on lead before cycling - 0.3µm and after cycling – 1.6µm – grow more that 5X





Matrix: 512x400
Signal: Lab1
Data: ADC
Range: 0-4095
Area Frac: 100.00%

kV:0.0 Mag:1000 Matrix:512x400 Int.F:16 Smin:0 Smax:4095 2558,1642

Significant growth of Cu-Ni-Sn intermetallic on Alloy 42 lead

SOT363 250+500+1000 Cycles, Whisker Cross-sections

Interesting observation:
- IMC on component contains Cu after cycling:
  - Enhance diffusion
    - Cu - from pad to component
    - Sn – to whisker?

Conclusions

- The simulated power cycle thermal cycling in the present work is considerably lower than the JESD201 piece part tests, but it was sufficient to promote whisker incubation and growth.
- Whisker growth from SAC305 was observed on all configurations except for some of the copper lead configurations.
- The most significant factor was the lead material and the next most significant factor was the contamination level.
  - ☐ Alloy 42 – grew most and longest whiskers
  - ☐ Copper alloy – grew few short whiskers
  - ☐ The difference in whisker growth between Alloy 42 and copper indicates that the source of the whisker formation stress is due to the thermal expansion mismatch between the Alloy 42 and the SAC305 solder.
- The increase in whisker growth due to the presence of contamination was a little more surprising because the low humidity in the 50 to 85 °C thermal cycle.
- It is not necessarily a high stress condition, but combination of factors which combine in an optimal way which promotes whisker growth.

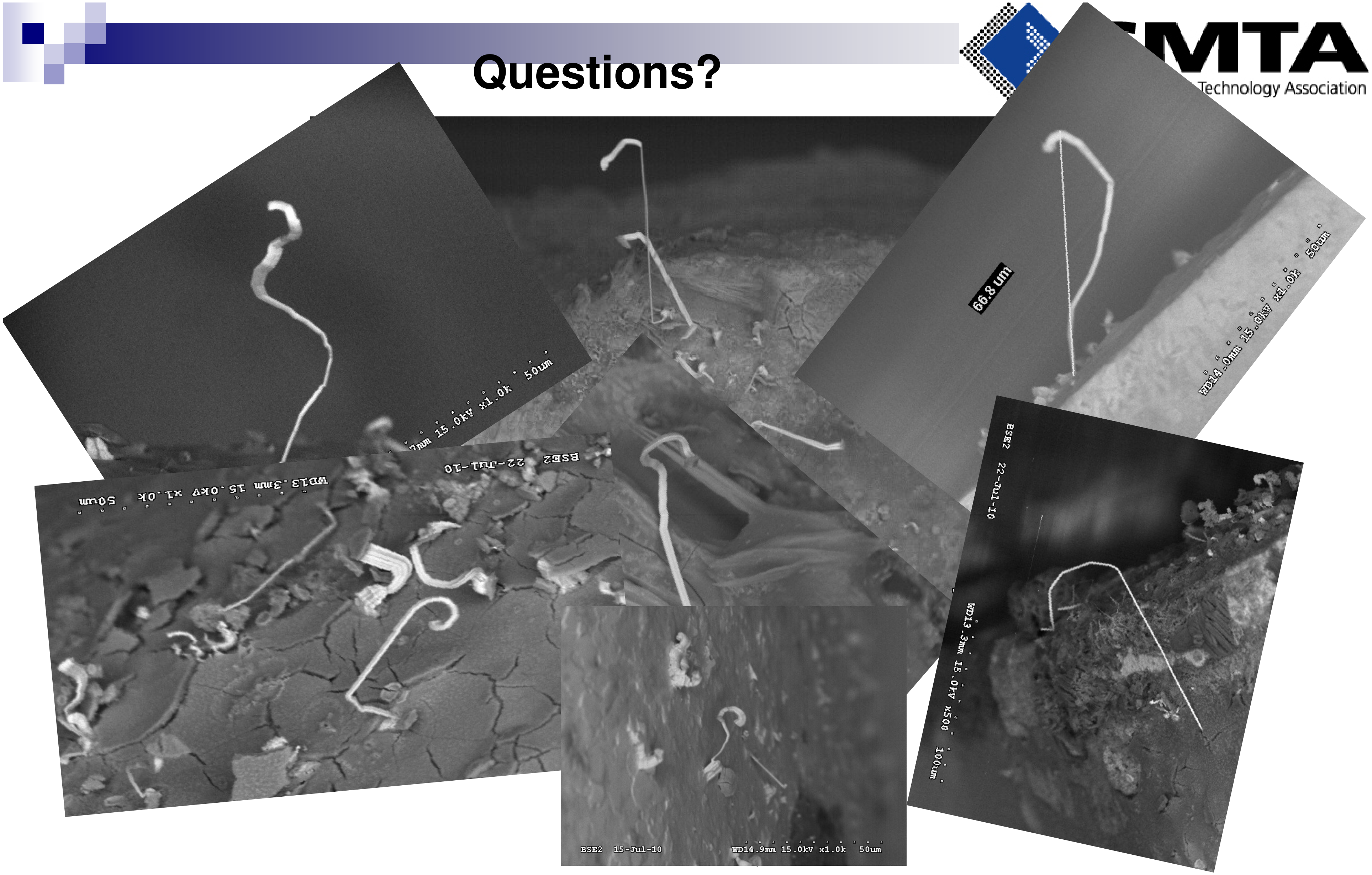
Acknowledgments

- **Acknowledgements**
  - Work supported by the Strategic Environmental Research and Development Program, U.S. Department of Defense, Project 2010 WP1753
  - Andre Delhaise for help with the data analysis
  - Jie Qian for sample preparation and contamination

Publications

- **Publications**
  - P. Snugovsky, S. Meschter, Z. Bagheri, E. Kosiba, M. Romansky, J. Kennedy, ”Tin Whisker Mitigation in Assembly,” IPC Tin Whisker Conference, IPC Tin Whiskers Conference, Fort Worth, Texas April 17-19, 2012
  - P. Snugovsky, S. Meschter, P. Kapadia, M. Romansky, J. Kennedy and E. Kosiba, “Influence of Board and Component Cleanliness on Whisker Formation” the IPC/SMTA High performance Cleaning and Contamination Conference, November 17-18, 2010
  - Meschter and Snugovsky, “Tin-Whisker Testing and Modeling (SERDP WP-1753) Overview,” “Influence of Board and Component Cleanliness on Whisker Formation” and “Whisker growth from solder joints,” Aerospace Industries Association Lead(Pb)-Free Electronics Risk Management (AIA-PERM) Consortium Meeting Number 7, Coral Gables, FL, January 11-13, 2010.
  - Meschter and Snugovsky, “Tin-Whisker Testing and Modeling (SERDP-1753)” Partners in Environmental Technology Technical Symposium and Workshop, Washington, D.C., November 30-December 2, 2010.
  - *Whisker Formation Induced by Component and Assembly Ionic Contamination*, TMS2011, February 27 -March 3, 2011
  - *Microstructure Formation and Whisker Growth in SAC105 Solder Joints with Rare Earth Elements,* TMS2011, February 27 -March 3, 2011
  - Development of a Test Vehicle for the Study of Tin Whiskers SMTA ICRS Toronto, May 2011
  - Microstructure and Whisker Growth of SAC Solder Alloys with Rear Earth Additions in Different Environments SMTA ICRS Toronto, May 2011

Questions?



WD14.0mm 15.0kV x1.0k 50um
66.8 um
BSE2 22-Jul-10
WD13.3mm 15.0kV x1.0k 50um
BSE2 15-Jul-10
WD14.9mm 15.0kV x1.0k 50um
BSE2 22-Jul-10
WD13.3mm 15.0kV x500 100um

Thank you

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