Tin Whisker Test - Phase II
Passives

Keith Spalding

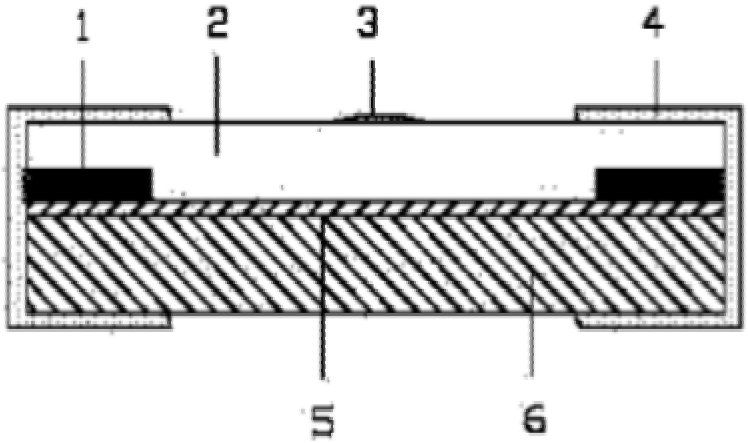
PASSIVE COMPONENT
TIN WHISKERING TEST PLAN - Phase II

Original Plan

- Perform all tests on 1206 size fuses with a Nickel and 100% Matte Tin Plating.
- Vary the plating parameters to produce different lots with different stress levels and surface finishes.
- Minimize the changes to one or two variables per lot.

PASSIVE COMPONENT

General Fuse Construction



1. Termination Pads
2. Ceramic Substrate (Alumina)
3. Printed Glass Amp Mark
4. Silver Thick film Termination (Silver with glass frit.)
   Nickel Plated Barrier
   Tin or Tin/Lead Final Plate
5. Printed Fuse Element
6. Stenciled Glass Layers

PASSIVE COMPONENT

TIN WHISKERING TEST PLAN - Phase II

Plating Lot #	SEM Puck #'s	500 Temp Cycles	SEM Insp	4 wks @ Temp & Humidity	SEM Insp	Fuse Type	Sample Size	Remarks
1	1 - 2	-40 to 90C	X	60C/90% RH	X	1206FA	10 Fuses	Only run Puck 2 at Temp/Humidity
1	3 - 4	None		60C/90% RH	X	1206FA	10 Fuses	
1	5 - 6	None	X	Ambient	X	1206FA	10 Fuses	
2	7 - 8	-40 to 90C	X	60C/90% RH	X	1206FA	10 Fuses	Only run Puck 8 at Temp/Humidity
2	9 - 10	None		60C/90% RH	X	1206FA	10 Fuses	
2	11 - 12	None	X	Ambient	X	1206FA	10 Fuses	
3	13 - 14	-40 to 90C	X	60C/90% RH	X	1206FA	10 Fuses	Only run Puck 14 at Temp/Humidity
3	15 - 16	None		60C/90% RH	X	1206FA	10 Fuses	
3	17 - 18	None	X	Ambient	X	1206FA	10 Fuses	
4	19 - 20	-40 to 90C	X	60C/90% RH	X	1206FA	10 Fuses	Only run Puck 20 at Temp/Humidity
4	21 - 22	None		60C/90% RH	X	1206FA	10 Fuses	
4	23 - 24	None	X	Ambient	X	1206FA	10 Fuses	
5	25 - 26	-40 to 90C	X	60C/90% RH	X	0603FA	10 Fuses	Only run Puck 26 at Temp/Humidity
5	27 - 28	None		60C/90% RH	X	0603FA	10 Fuses	
5	29 - 30	None	X	Ambient	X	0603FA	10 Fuses	

Temp Cycles = 10 min @ Each Temp & 5 sec to shift

PASSIVE COMPONENT

Electrolytic Plating

TIN WHISKERING STUDY PHASE 2 PLATING LOG

Nickel Plating Parameters

Rev. 10/31/02

SEM Puck Number	Part Number	Lot Number	Lot Volume ml	Ball Vol 1/8 or 1/16 ml	Total Volume ml	Ball Size 1/8 / 1/16	Plate Date	Nickel Current	Nickel Voltage	Nickel AmpHr Setting	Actual Plating Time (min)	Nickel Amp-Hrs/Ft^2	Nickel Thickness u in	Nickel pH
1 - 6	1206FA-4A	J189	120	130	250	1/8	7/18/02	25	9	20	48	5.647	263 - 330	4.2
7 - 12	1206FA-1.5A	J184A	137	113	250	3/32	7/17/02	25	9	17	41	4.261	219 - 363	4.1
13 - 18	1206FA-4A	J189	120	130	250	1/16	7/18/02	25	10	12	29	2.428	308 - 415	4.2
19 - 24	1206FA-1.5A	J184A	137	113	250	3/32	7/17/02	25	9	17	41	4.261	229 - 300	4.1
25 - 30	0603FA-2A					None	5/24/02							

100% Tin Plating Parameters

SEM Puck Number	Part Number	Sn Current	Sn Voltage	Sn AmpHr Setting	Actual Plating Time (min)	Thickness u in	Sn Amp-Hrs/Ft^2	Sn %	Sn pH	Brl. Tilt	Dnglr Immr	Barrel Size Dia x Length	Comments
1 - 6	1206FA-4A	10	5	10	60	420 - 526	2.8235	100%	3.1	0	1	4" dia x 4"	Rod style dangler in barrel #8.
7 - 12	1206FA-1.5A	10	5	8	48	377 - 450	1.9953	100%	3.5	0	1	4" dia x 4"	Rod style dangler in barrel #8.
13 - 18	1206FA-4A	10	5	6	36	418 - 534	1.2054	100%	3.1	0	1	4" dia x 4"	Rod style dangler in barrel #4.
19 - 24	1206FA-1.5A	15	7.5	8	32	302 - 388	1.9953	100%	3.5	0	1	4" dia x 4"	Rod style dangler in barrel #8.
25 - 30	0603FA-2A							100%		N/A	N/A	35mm	Plated on GET machine.

Notes:

1. The first 4 barrel plated groups were burnished for 1 - 2 minutes in the Tin bath. (Tumbled without current.)
2. The last group was plated in an automated plating system from GET Systems without any media.
3. The plating chemicals used in both systems was Nickel Sulfate and Solderon LG.

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PASSIVE COMPONENT

Plating Bath Analysis

Barrel Plating Analysis by Shipley

Tin Solution Contaminants

- Copper - 1 ppm
- Lead - 16 ppm
- Zinc - 1 ppm
- Iron - 3 ppm
- Nickel 70 ppm

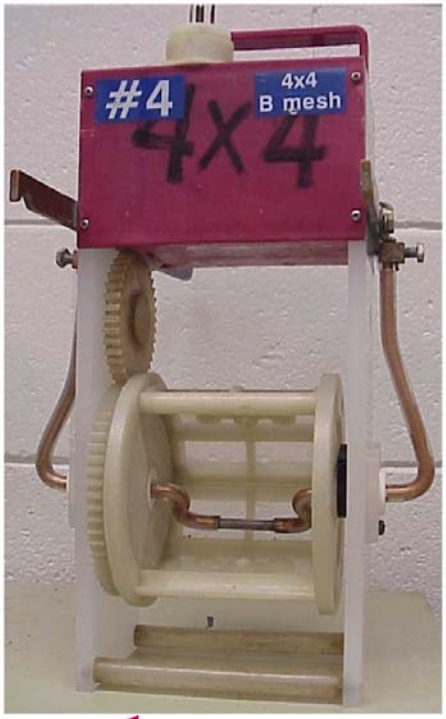
Automated Pulse Plating Machine

- Test was not done.

PASSIVE COMPONENT

TIN WHISKERING TEST PLAN - Phase II

Barrel Plating Line



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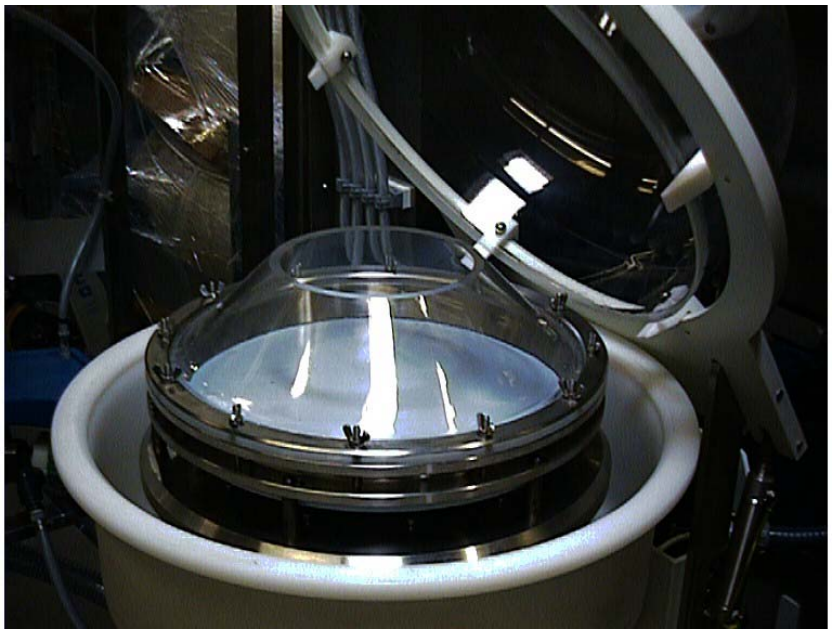
PASSIVE COMPONENT

TIN WHISKERING TEST PLAN - Phase II

Pulse Plating Without Media

GET Systems, Inc.



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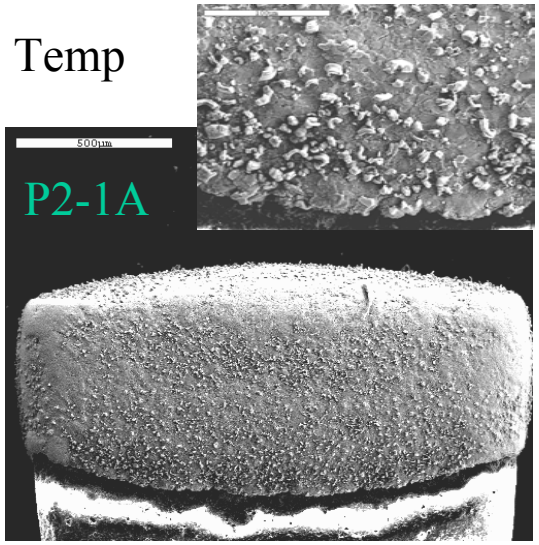
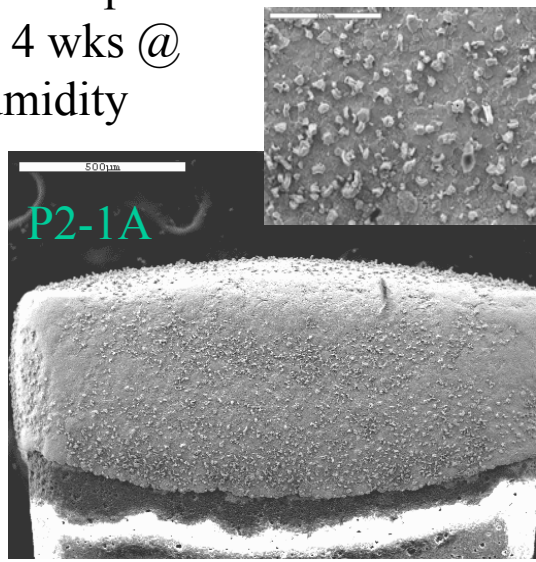
PASSIVE COMPONENT

Plating Group 1 - Barrel, 1/8” balls, Tin Plated @ 5V & 10A, 2.82 amp-hrs/ft^2

After 500 Temp Cycles



After 500 Temp Cycles & 4 wks @ Temp/Humidity



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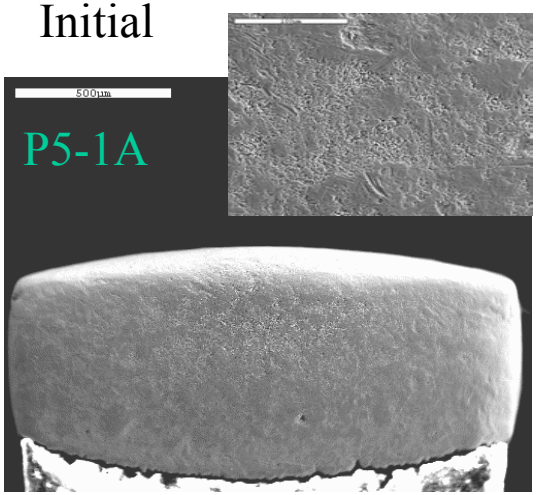
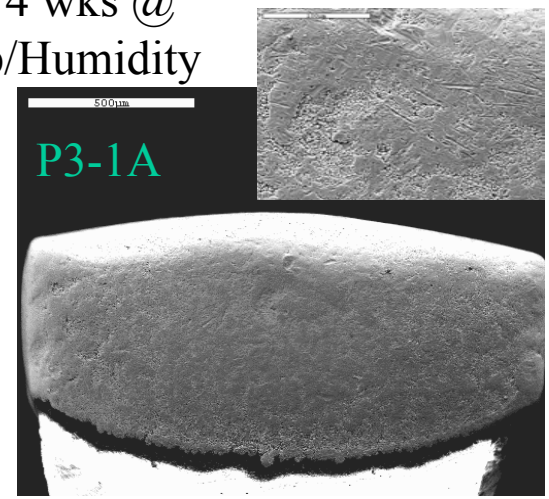


After 4 wks @ Temp/Humidity



Scale:

Large Picture - 500 µm

Inset Picture - 100 µm

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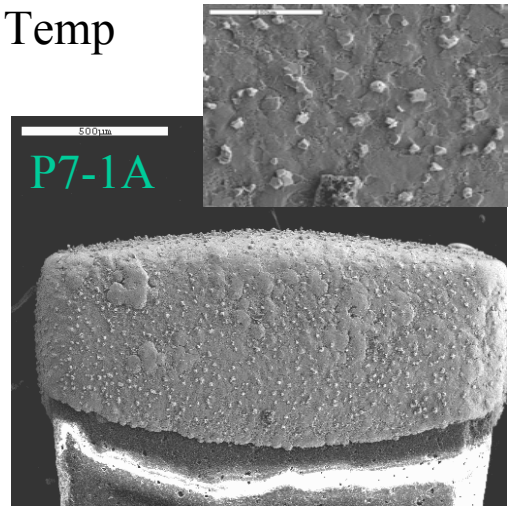
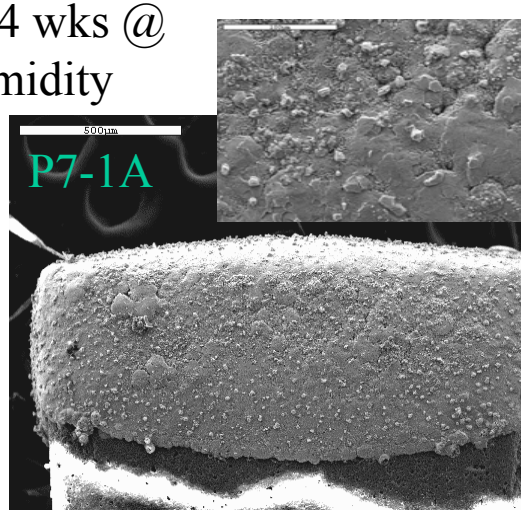
PASSIVE COMPONENT

Plating Group 2 - Barrel, 3/32” balls, Tin Plated @ 5V & 10A, 1.99 amp-hrs/ft^2

After 500 Temp Cycles



After 500 Temp Cycles & 4 wks @ Temp/Humidity



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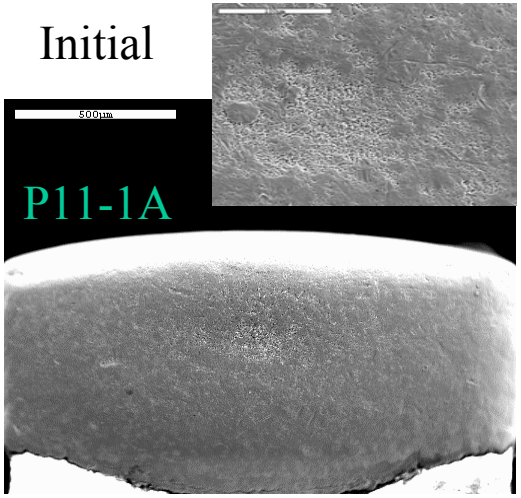
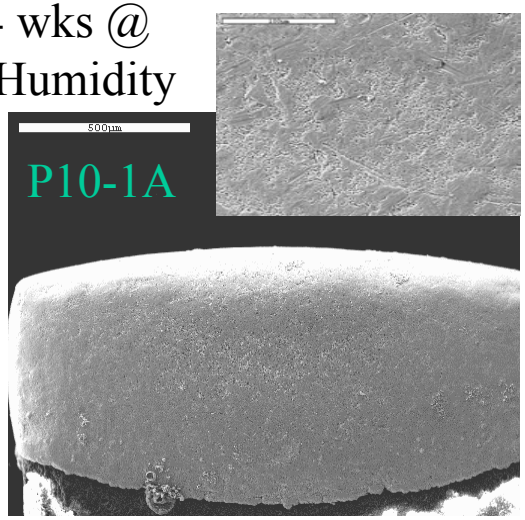


After 4 wks @ Temp/Humidity



Scale:

Large Picture - 500 µm

Inset Picture - 100 µm

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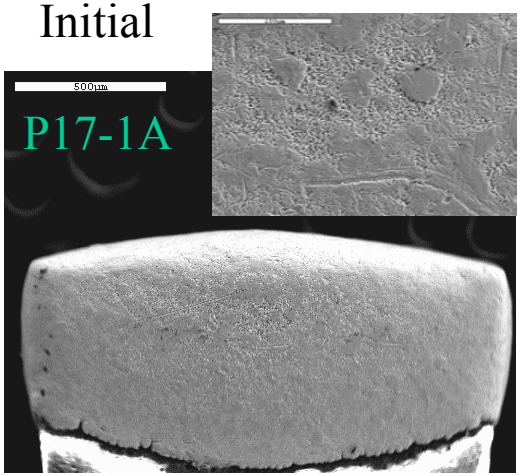
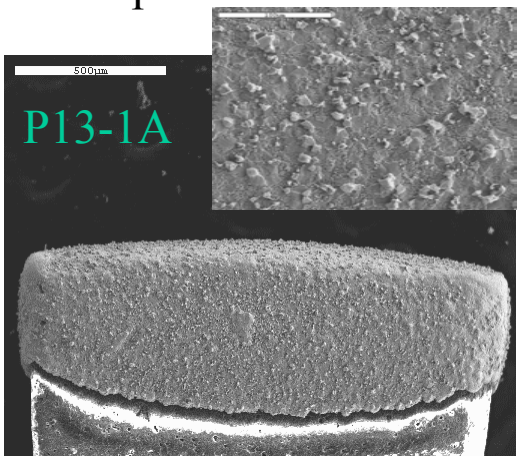
PASSIVE COMPONENT

Plating Group 3 - Barrel, 1/16” balls, Tin Plated @ 5V & 10A, 1.20 amp-hrs/ft^2

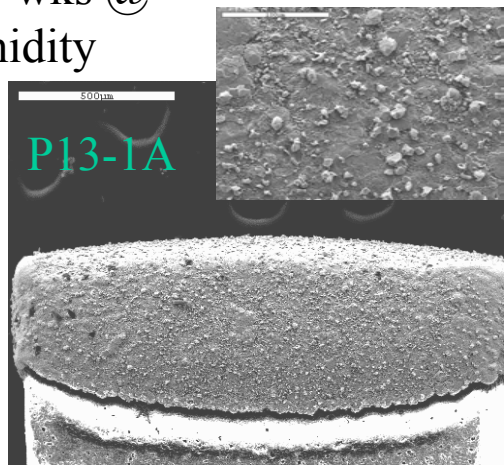
Initial



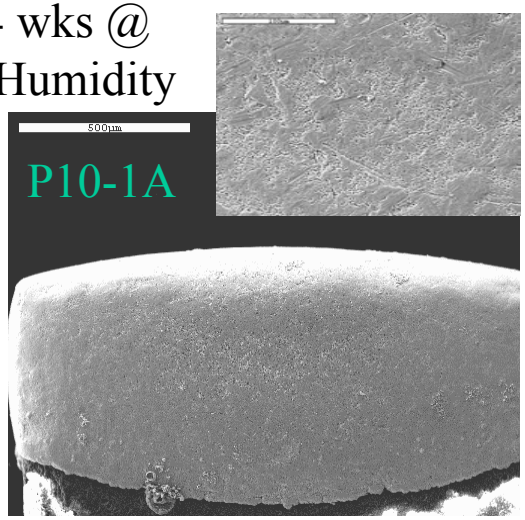
After 500 Temp Cycles



After 500 Temp Cycles & 4 wks @ Temp/Humidity



After 4 wks @ Temp/Humidity



Scale:

Large Picture - 500 µm

Inset Picture - 100 µm

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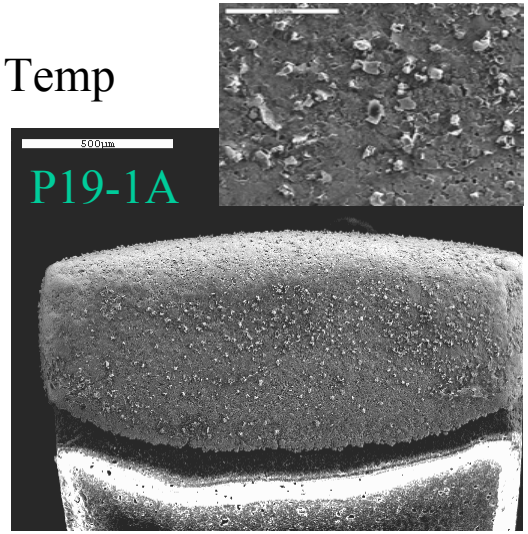
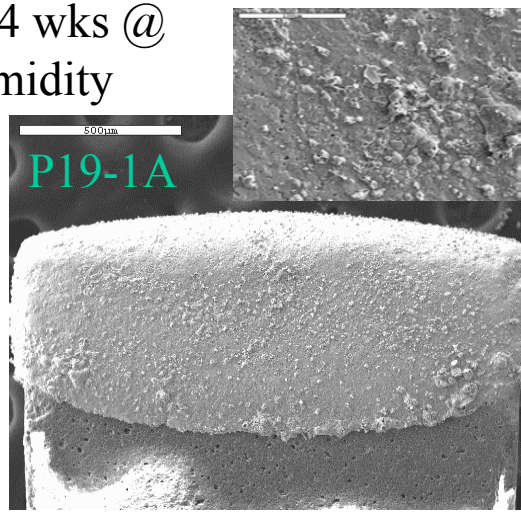
PASSIVE COMPONENT

Plating Group 4 - Barrel, 3/32” balls, Tin Plated @ 7.5V & 15A, 1.99 amp-hrs/ft^2

After 500 Temp Cycles



After 500 Temp Cycles & 4 wks @ Temp/Humidity



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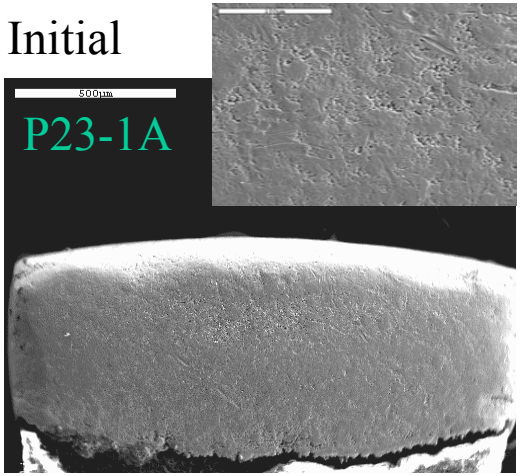
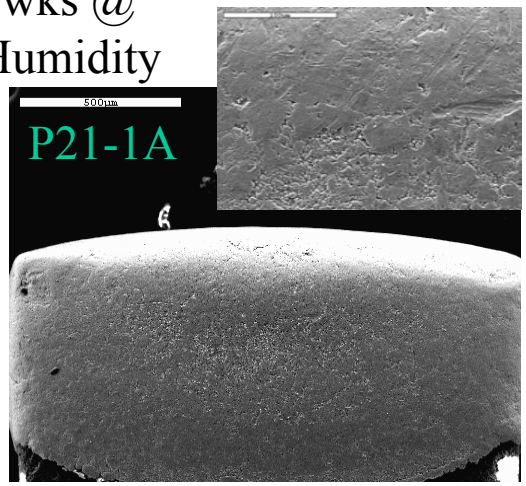


After 4 wks @ Temp/Humidity



Scale:

Large Picture - 500 µm

Inset Picture - 100 µm

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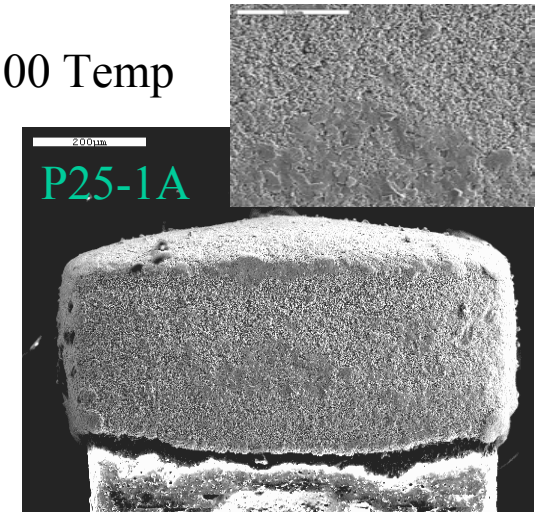
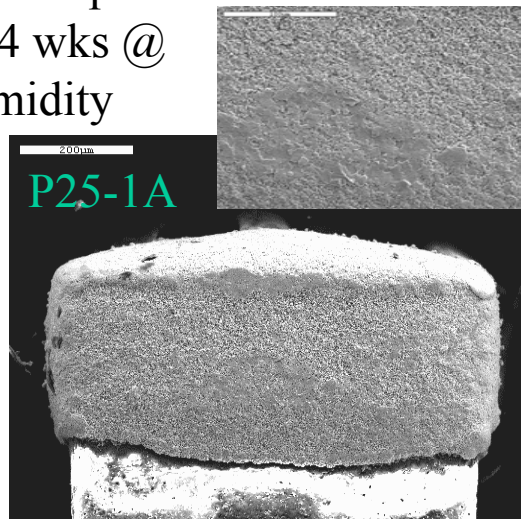
PASSIVE COMPONENT

Plating Group 5 - GET Systems, No Media, Pulse Plated, Minimal Tumbling

After 500 Temp Cycles



After 500 Temp Cycles & 4 wks @ Temp/Humidity



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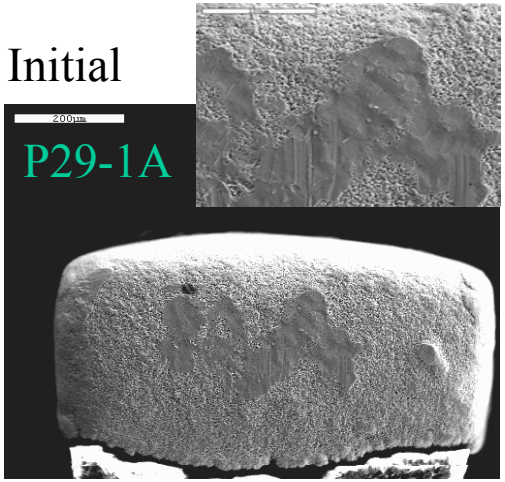
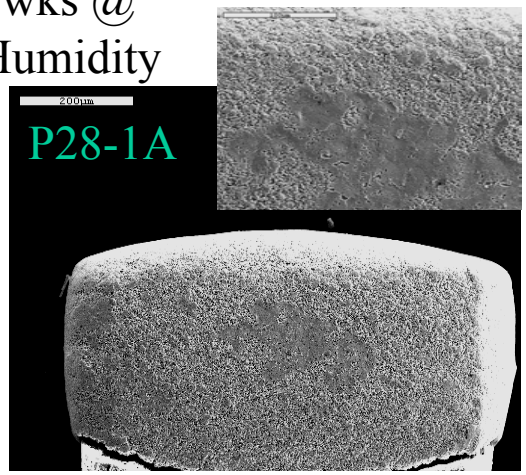


After 4 wks @ Temp/Humidity



Scale:

Large Picture - 500 µm

Inset Picture - 100 µm

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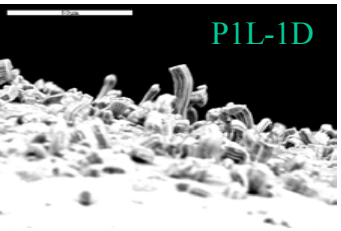
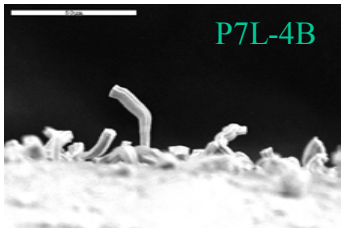
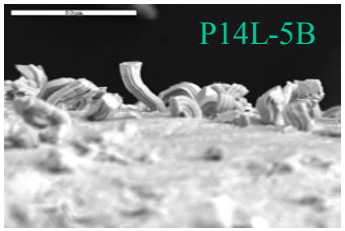
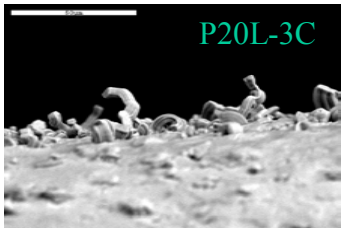
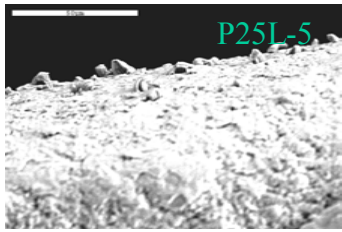
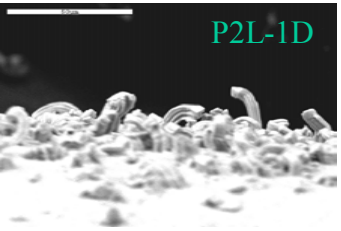
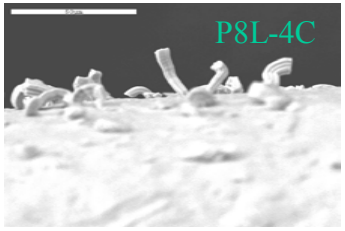
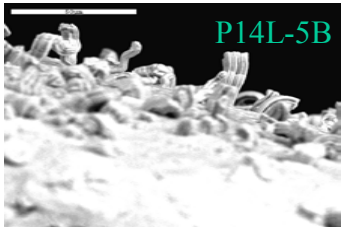
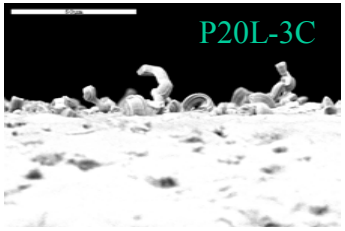
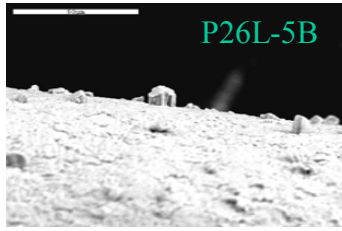
PASSIVE COMPONENT

Plating Groups vs Max Whisker Length

After 500 Temp Cycles

Group 1	Group 2	Group 3	Group 4	Group 5
				
31 µm	44 µm	28 µm	34 µm	9 µm

After 500 Temp Cycles & 4 wks of Temp/Humidity

Group 1	Group 2	Group 3	Group 4	Group 5
				
22 µm	25 µm	38 µm	34 µm	9 µm

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Scale: Each bar length is 50 µm

PASSIVE COMPONENT

Summary - Whisker Count & Size

	After 500 Temp Cycles @ -40C to 90C		After 500 Temp Cycles @ -40C to 90C & 4 wks @ 60C/90% RH	
Plating Group #	Whisker Frequency 200μm x 260μm Area	Max Size μm	Whisker Frequency 200μm x 260μm Area	Max Size μm
1	223	31	159	22
2	54	44	66	25
3	137	28	144	38
4	66	34	93	34
5	6	9	3	9

PASSIVE COMPONENT

Summary Conclusions

- The automated pulse plating system imparted less surface stresses to the tin plating, which resulted in fewer whiskers and shorter whisker lengths. The system does not use media and uses a mild agitation versus the heavy impact the parts see from the tumbling action in the barrel plating process. (More studies are required for verification.)

- The 3/32” dia media, 1.99 Amp-Hrs/Ft^2 current density and 3.5 pH level produced less whiskers than the other barrel plated groups. The whisker lengths were similar in all four barrel plating groups.

- Ambient or Temp/Humidity exposure alone over a 4 wk period does not grow whiskers on this type of device.

- 500 Temp Cycles easily generates whiskers on this type of device. The addition of Temp/Humidity exposure did not add to the whisker length or frequency.

PASSIVE COMPONENT

Acknowledgments

All SEM pictures provided by Kemet

Rudy Wagner - Kemet Mgr, Microscopy and Failure Analysis