MK2 S5E BiCS5 512Gb iTLC -2/4/8D Micro Package SDSM PQ Report

MPNs:
SDSMGKLK2-128G
SDMMGKLK4-256G
SDSMGKLK8-512G

WDC Packaging
7/1/2022

PQ Full Qual - Matrix

Die Stack	Lots	Substrate vendor	EMI Tool
2D	Lot 1	Y	Tango
2D	Lot 2	Y	Linco
2D	Lot 3	Y	Tango
4D	Lot 1	X	Tango
4D	Lot 2	X	Linco
4D	Lot 3	X	Tango
8D	Lot 1	Y	Tango
8D	Lot 2	Y	Linco
8D	Lot 3	Y	Tango

MK2 S5E BiCS5 512Gb iTLC - 2D
9x13.3x0.87mm
Shielded - 315 BGA

Dimension X-Y-Z, Warpage

2D (shielded)

Item	X(Width)	L(Length)	Package T w/o Bump	Pre-bump Height	Body T w/o Bump	Warpage @ RT
Spec	**9.0+/-0.05mm**	**13.3+/-0.05mm**	**Max. 0.87mm**	**50 +/-20um**	**0.770+/-0.025mm**	**[-30 um,75um]**
Max	8.996	13.299	0.796	53.000	0.766	30.0
Min	8.983	13.279	0.789	44.000	0.758	12.0
Mean	8.990	13.293	0.792	48.000	0.763	23.0
Std Dev	0.004	0.007	0.002	2.0	0.002	3.0

- Data taken from 60 units from 3 PQ lots (20 units/lot) and all dimensions within spec.

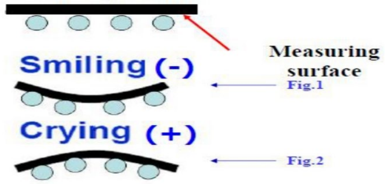
Wire Bond Data (2D)

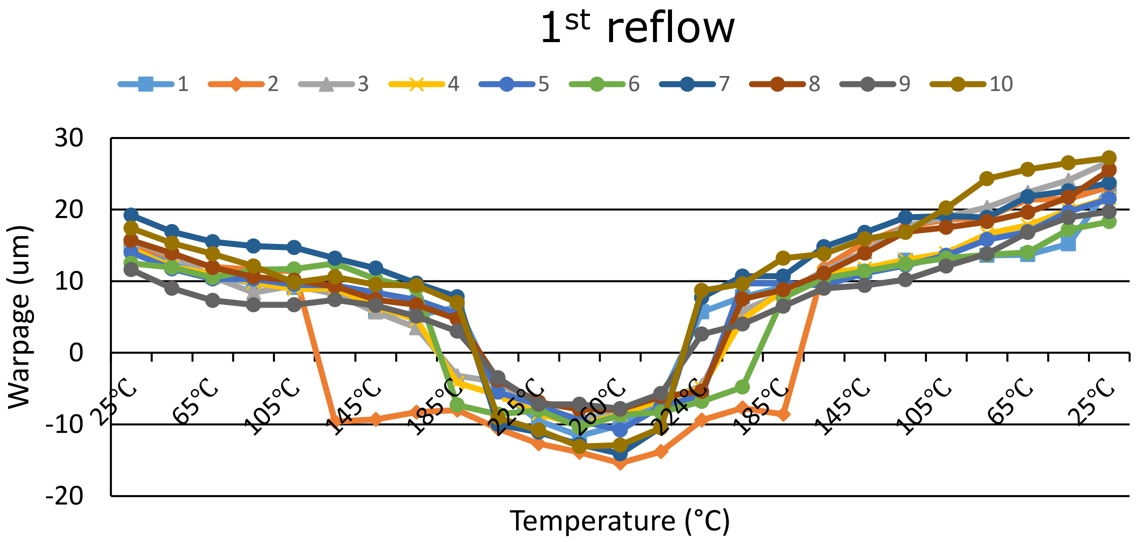
	Lot 1		Lot 2		Lot 3	
	Wire Pull	**Ball Shear**	**Wire Pull**	**Ball Shear**	**Wire Pull**	**Ball Shear**
Spec (gf) – Min.	**1.8**	**10**	**1.8**	**10**	**1.8**	**10**
Max (gf)	9.31	21.0	8.93	22.06	9.04	21.19
Min (gf)	6.10	17.0	6.42	17.86	6.09	17.58
Avg (gf)	7.64	19.17	7.54	19.62	7.47	19.45
Std Dev (gf)	0.66	0.80	0.51	0.95	0.57	0.78

- Data taken from 36 wires (5 units/lot) from 3 PQ lots and passed wire pull and bond shear.

Shadow Moiré (2D)

Dry condition samples - meets Apple spec for all temperature range specified

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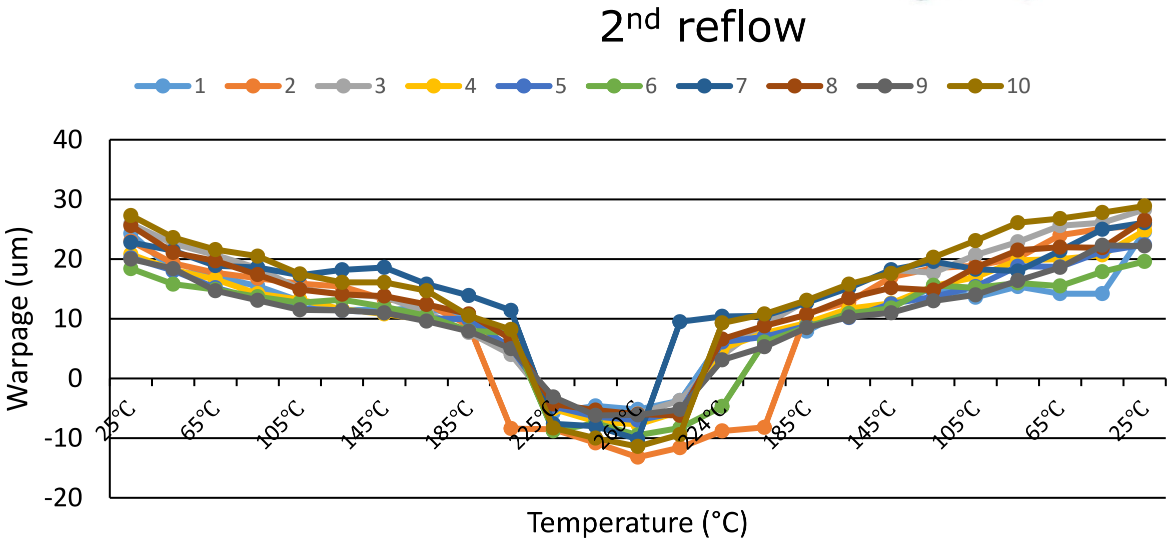
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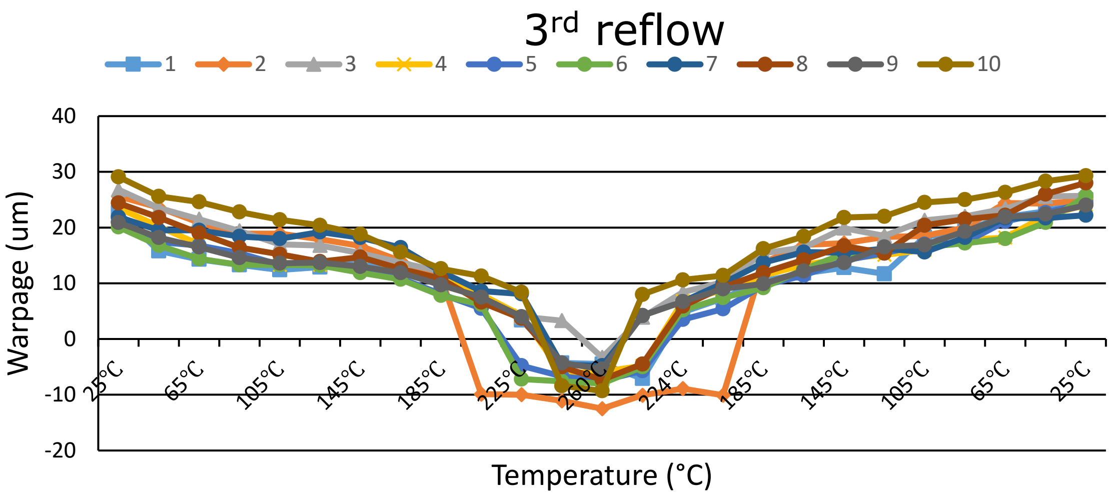
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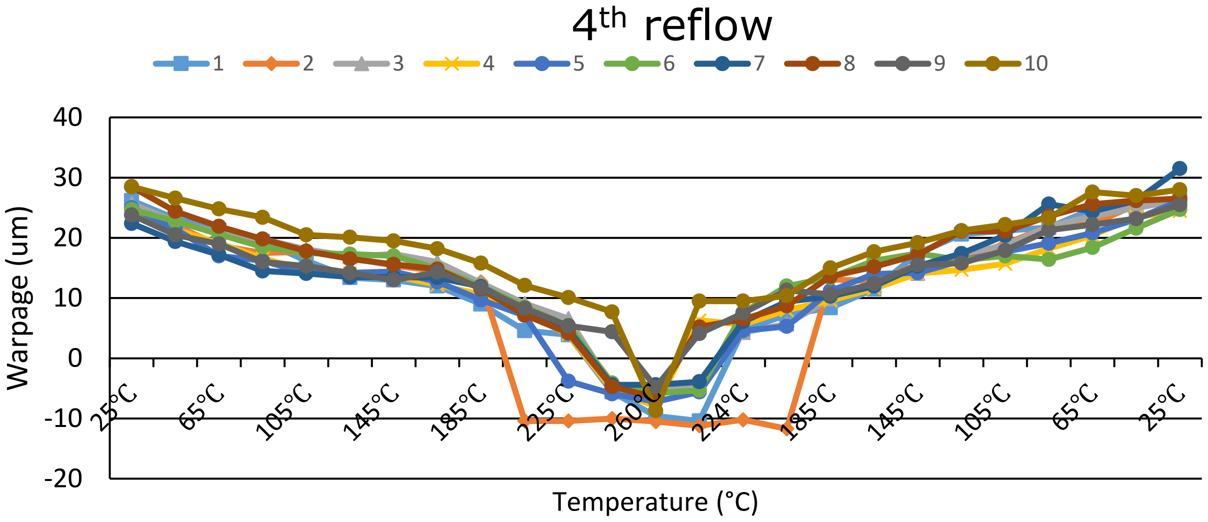
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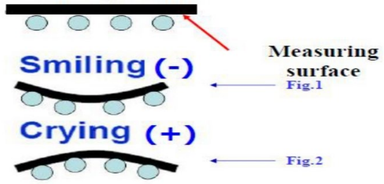
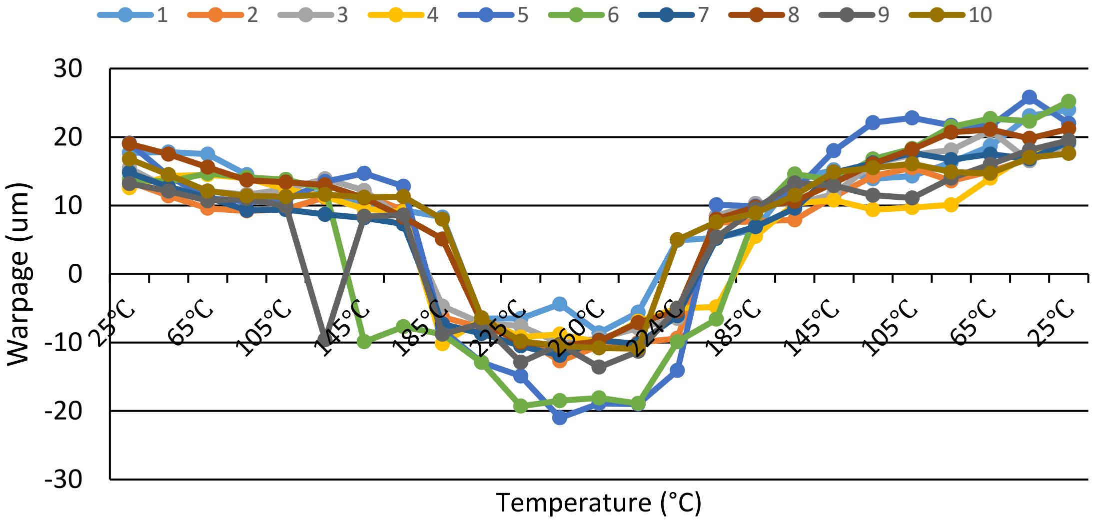
Shadow Moiré (2D)

Wet condition samples - meets Apple spec for all temperature range specified

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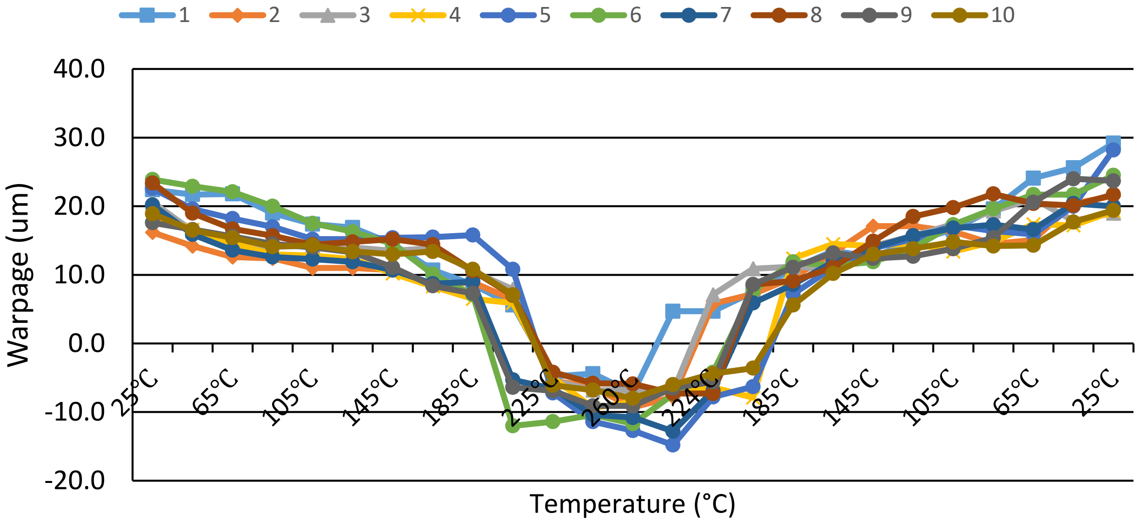
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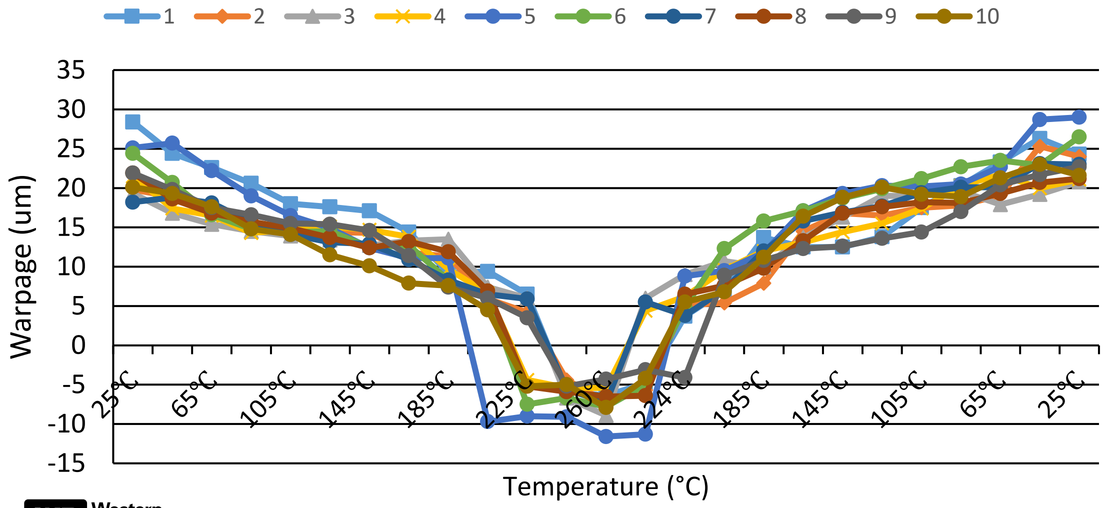
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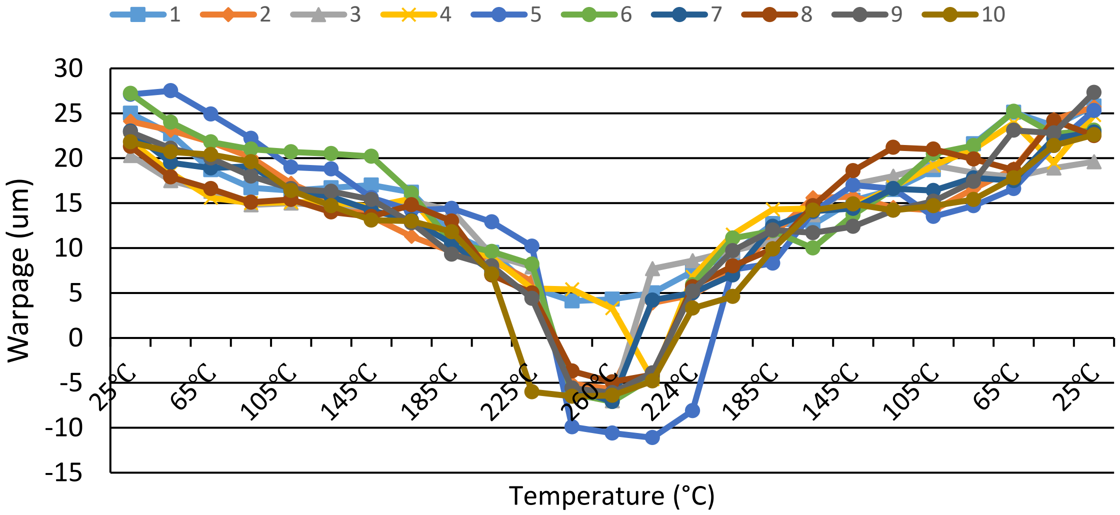

4th reflow

Tape Adhesion test (2D)

20 units from each of 3 PQ lots

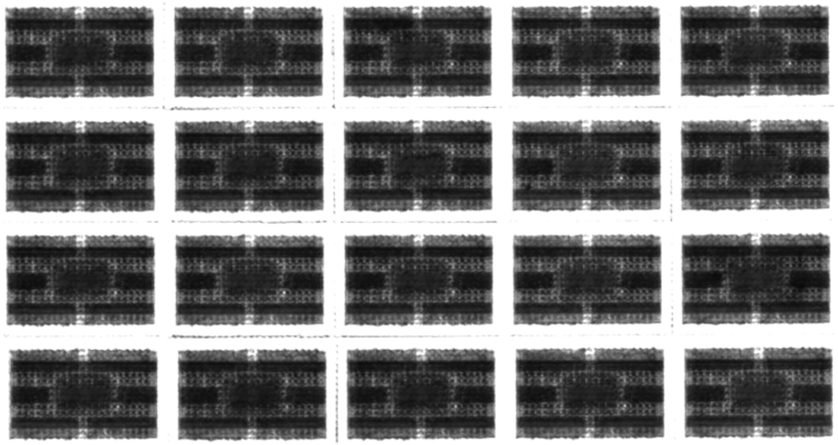
AI No.	Qty	Comment
Lot1	20	Peeling test pass 5B spec
Lot2	20	Peeling test pass 5B spec
Lot3	20	Peeling test pass 5B spec

Tape adhesion test done as per ASTM D-3359 at T_a = 25°C and it meets peeling criterion >=4B

Contact Resistance and Delam check (2D)

Test	Pkg Type	Spec	Test result	Sample size	Remarks
Delamination check by CSAM	Shield	JED22-A113	0 fail / 60ea	60units	Require pre-conditioning with MSL level 3A and measure it after 260C 4x IR reflow
Contact Resistance check	Shield	<0.6Ω	0 fail / 60ea	60 units	

- Data taken from 60 units from 3 PQ lots (20 units/lot)
- CSAM image post MSL3A shows no failures.



Package Reliability Data (2D) – Full Qual

Package Qual Lot #1 (Substrate Vendor Y, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (2D) – Full Qual

Package Qual Lot #2 (Substrate Vendor Y, EMI-Linco)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (2D) – Full Qual

Package Qual Lot #3 (Substrate Vendor Y, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

MK2 S5E BiCS5 512Gb iTLC - 4D
9x13.3x0.87mm
Shielded - 315 BGA

Dimension X-Y-Z, Warpage

4D (shielded)

Item	X(Width)	L(Length)	Package T w/o Bump	Pre-bump Height	Body T w/o Bump	Warpage @ RT
Spec	**9.0+/-0.05mm**	**13.3+/-0.05mm**	**Max. 0.87mm**	**50 +/-20um**	**0.770+/-0.025mm**	**[-30 um,75um]**
Max	8.996	13.298	0.808	52.000	0.764	44.0
Min	8.982	13.276	0.800	47.000	0.758	19.0
Mean	8.991	13.292	0.804	49.000	0.761	34.0
Std Dev	0.003	0.005	2.0	0.001	0.002	4.1

- Data taken from 60 units from 3 PQ lots (20 units/lot) and all dimensions within spec.

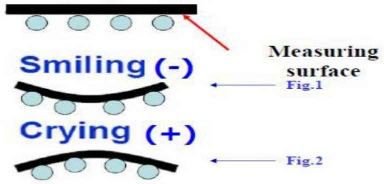
Wire Bond Data (4D)

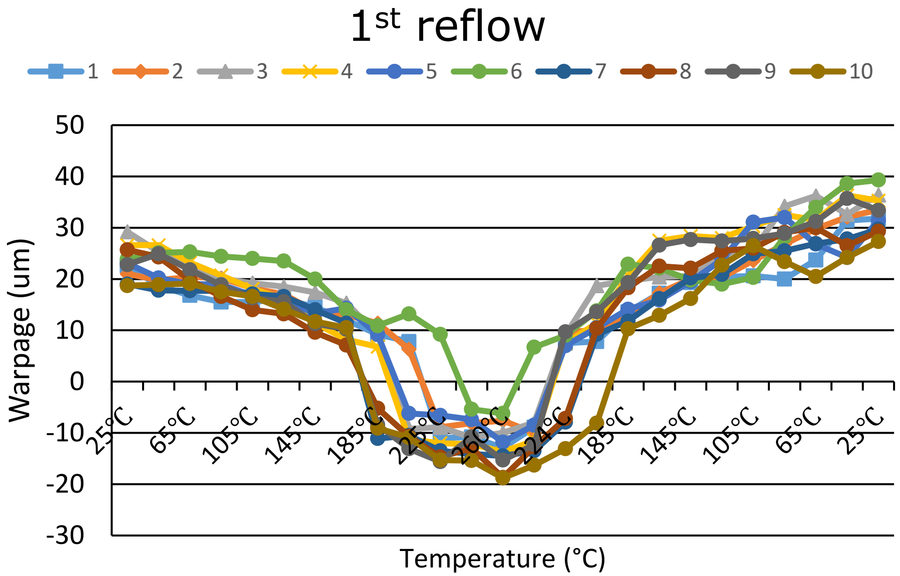
	Lot 1		**Lot 2**		**Lot 3**	
	Wire Pull	**Ball Shear**	**Wire Pull**	**Ball Shear**	**Wire Pull**	**Ball Shear**
Spec (gf) – Min.	**1.8**	**10**	**1.8**	**10**	**1.8**	**10**
Max (gf)	6.54	21.33	6.07	21.19	6.23	21.86
Min (gf)	3.85	17.86	3.75	18.06	3.48	17.35
Avg (gf)	4.89	19.46	4.84	19.64	4.78	19.55
Std Dev (gf)	0.47	0.74	0.44	0.60	0.46	0.76

- Data taken from 36 wires (5 units/lot) from 3 PQ lots and passed wire pull and bond shear.

Shadow Moiré (4D)

Dry condition samples - meets Apple spec for all temperature range specified

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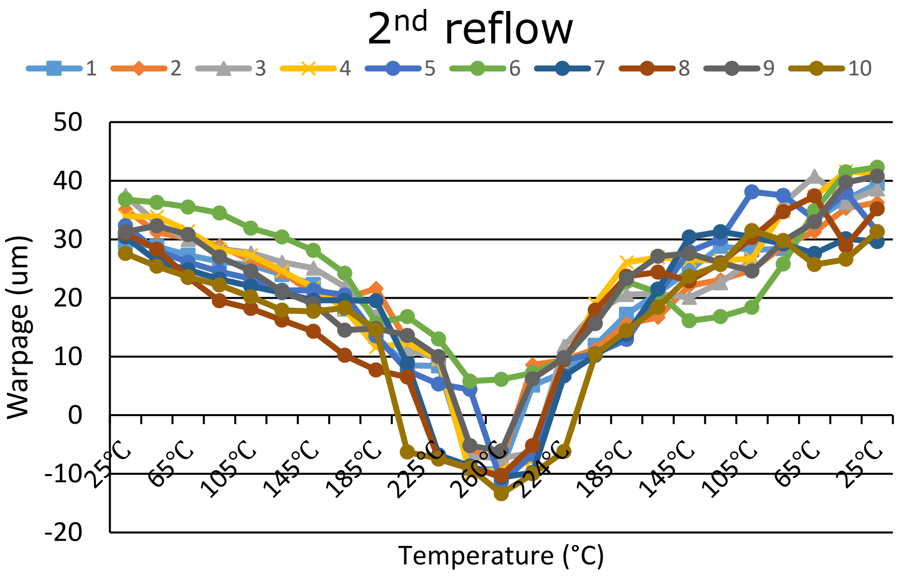
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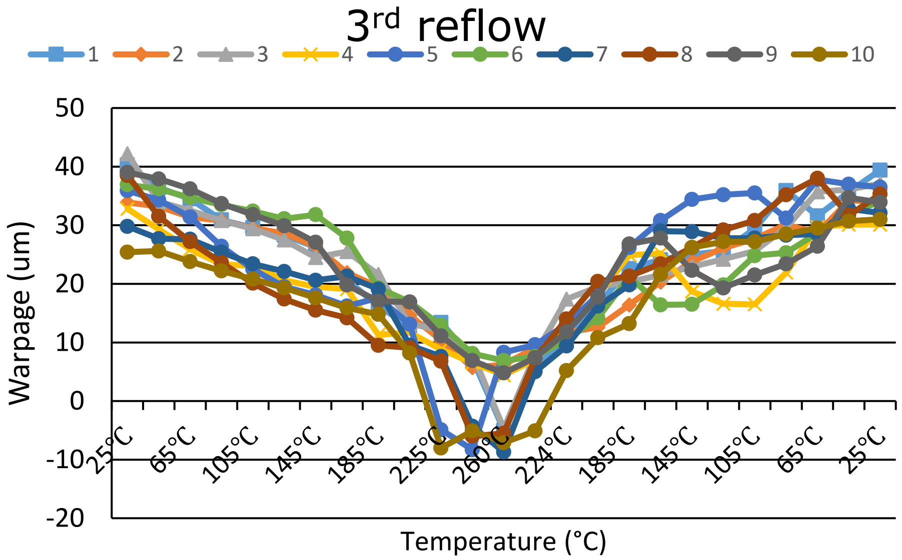
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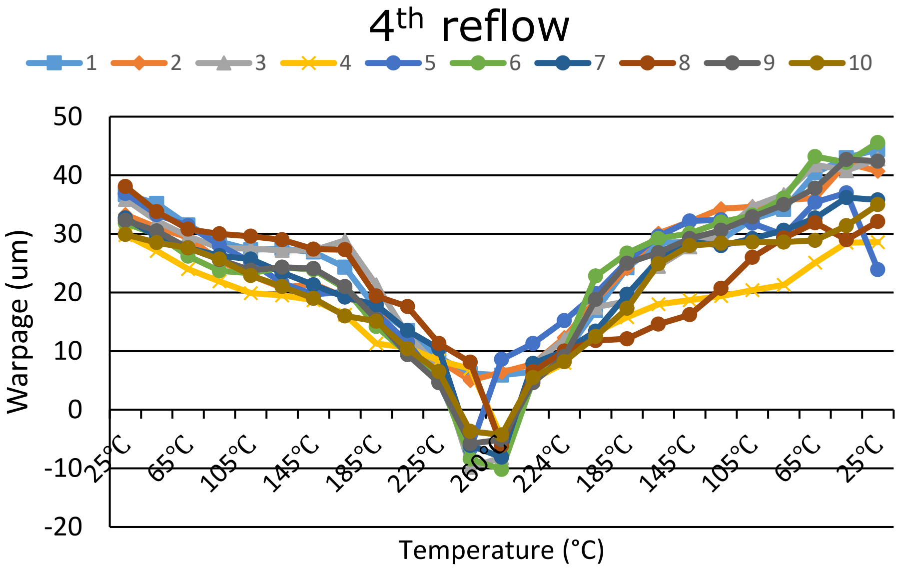
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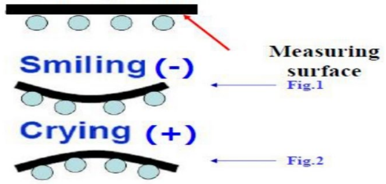
Shadow Moiré (4D)

Wet condition samples - meets Apple spec for all temperature range specified



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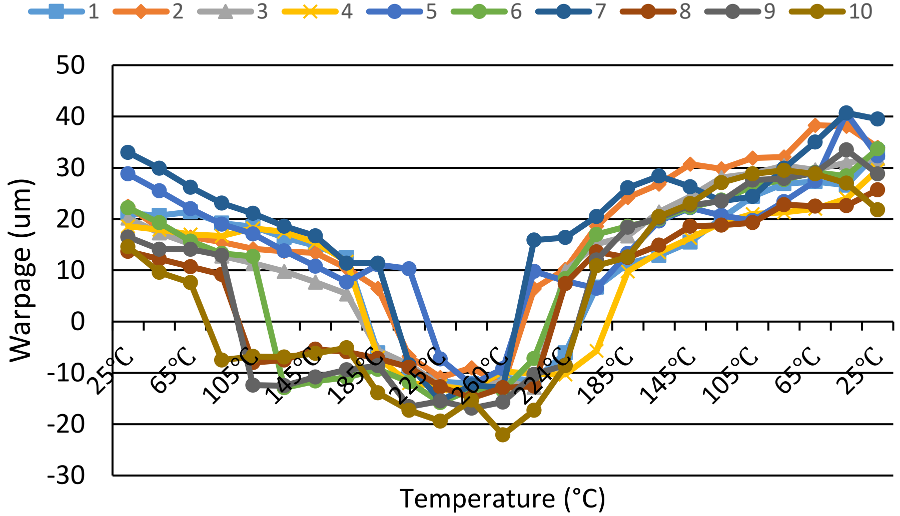

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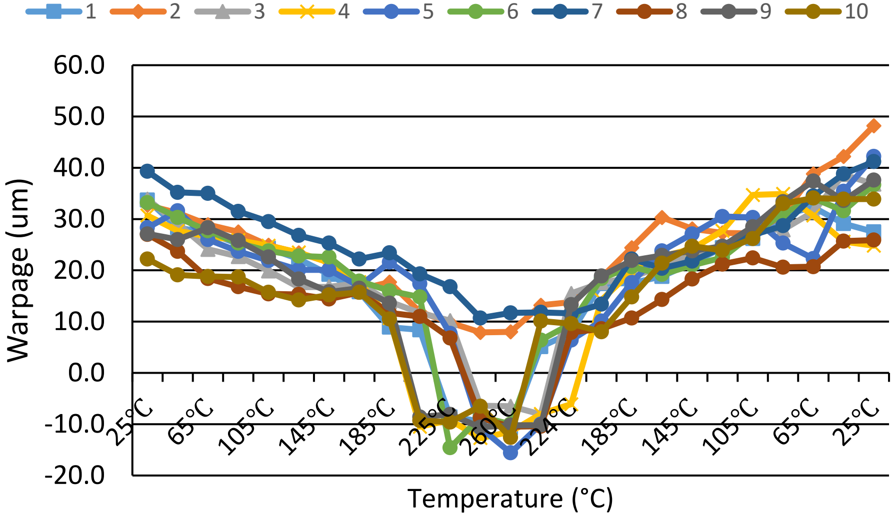

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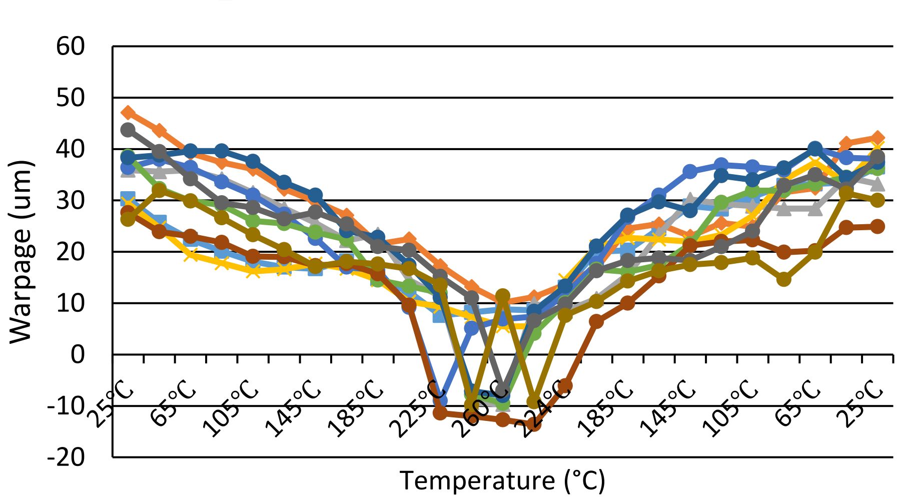

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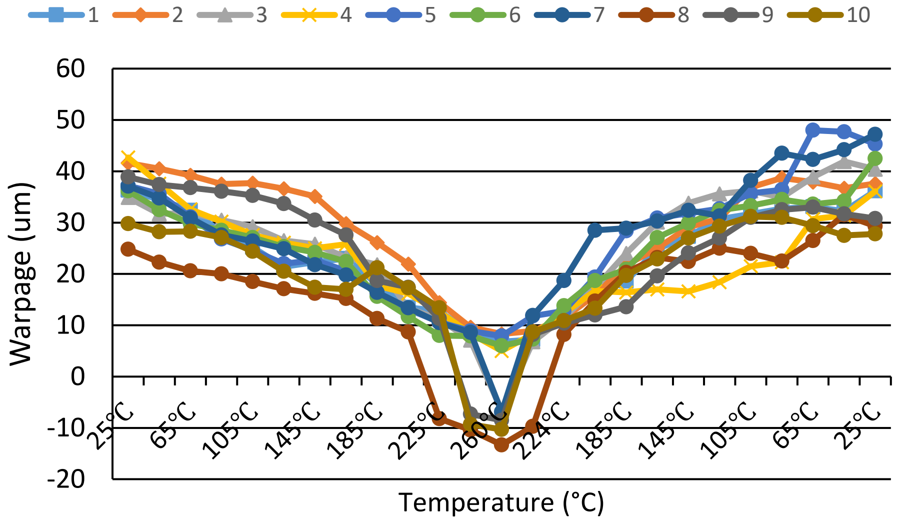


Tape Adhesion test (4D)

20 units from each of 3 PQ lots

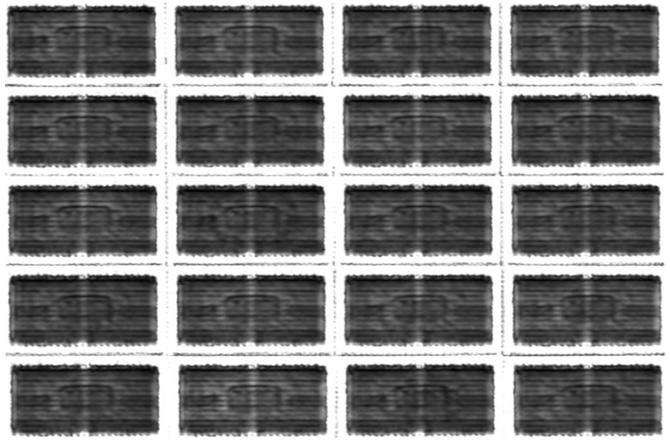
AI No.	Qty	Comment
Lot1	20	Peeling test pass 5B spec
Lot2	20	Peeling test pass 5B spec
Lot3	20	Peeling test pass 5B spec

Tape adhesion test done as per ASTM D-3359 at T_a = 25°C and it meets peeling criterion >=4B

Contact Resistance and Delam check (4D)

Test	Pkg Type	Spec	Test result	Sample size	Remarks
Delamination check by CSAM	Shield	JED22-A113	0 fail / 60ea	60units	Require pre-conditioning with MSL level 3A and measure it after 260C 4x IR reflow
Contact Resistance check	Shield	<0.6Ω	0 fail / 60ea	60 units	

- Data taken from 60 units from 3 PQ lots (20 units/lot)
- CSAM image post MSL3A shows no failures



Package Reliability Data (4D) – Full Qual

Package Qual Lot #1 (Substrate Vendor X, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (4D) – Full Qual

Package Qual Lot #2 (Substrate Vendor X, EMI-Linco)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (4D) – Full Qual

Package Qual Lot #3 (Substrate Vendor X, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

MK2 S5E BiCS5 512Gb iTLC - 8D
9x13.3x0.9mm
Shielded - 315 BGA

Dimension X-Y-Z, Warpage

8D (shielded)

Item	X(Width)	L(Length)	Package T w/o Bump	Pre-bump Height	Body T w/o Bump	Warpage @ RT
Spec	**9.0+/-0.05mm**	**13.3+/-0.05mm**	**Max. 0.90mm**	**50 +/-20um**	**0.800+/-0.025mm**	**[-30 um,75um]**
Max	8.993	13.283	0.838	56.000	0.796	41.000
Min	8.980	13.263	0.828	48.000	0.791	23.000
Mean	8.987	13.278	0.833	53.000	0.793	36.000
Std Dev	0.003	0.005	0.005	2.0	0.002	3.0

- Data taken from 60 units from 3 PQ lots (20 units/lot) and all dimensions within spec.

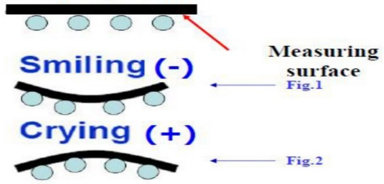
Wire Bond Data (8D)

	Lot 1		Lot 2		Lot 3	
	Wire Pull	**Ball Shear**	**Wire Pull**	**Ball Shear**	**Wire Pull**	**Ball Shear**
Spec (gf) – Min.	**1.8**	**10**	**1.8**	**10**	**1.8**	**10**
Max (gf)	6.79	20.35	6.93	20.39	6.53	20.34
Min (gf)	4.42	17.40	4.30	17.35	3.81	16.69
Avg (gf)	5.50	18.90	5.62	18.92	5.45	18.86
Std Dev (gf)	0.46	0.53	0.50	0.54	0.53	0.58

- Data taken from 36 wires (5 units/lot) from 3 PQ lots and passed wire pull and bond shear.

Shadow Moiré (8D)

Dry condition samples - meets Apple spec for all temperature range specified



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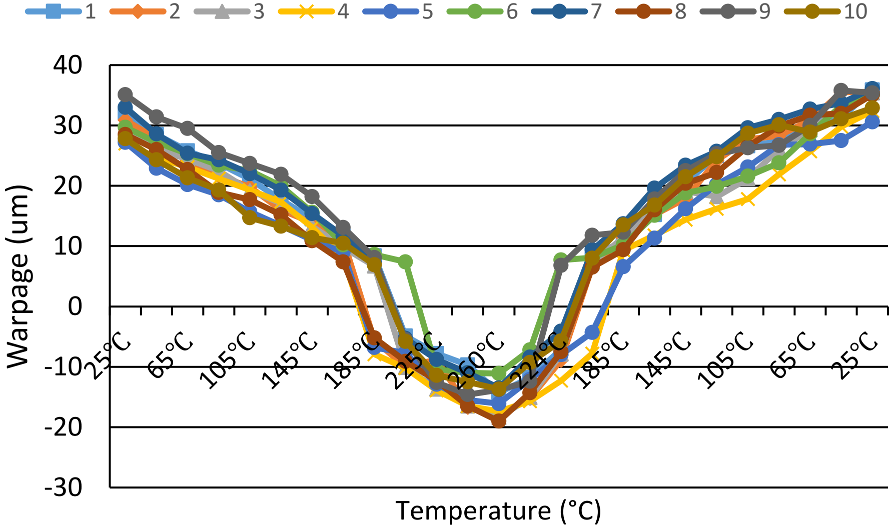

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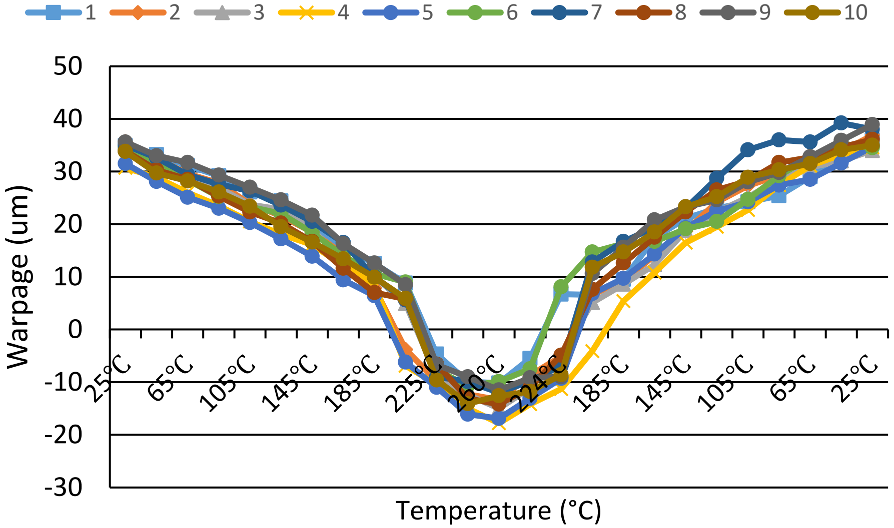

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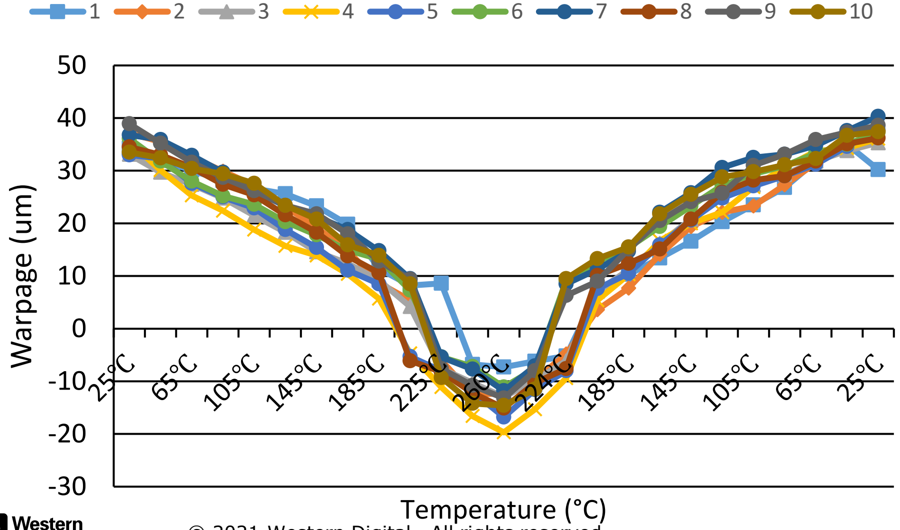
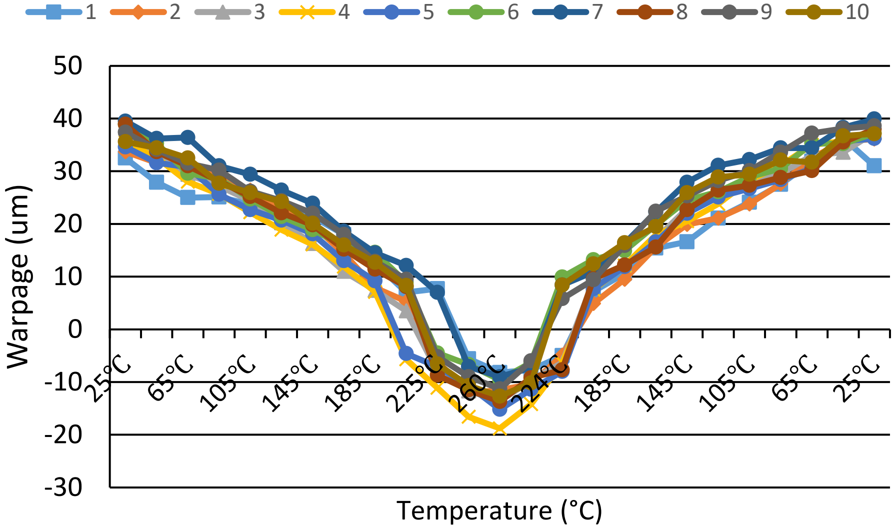
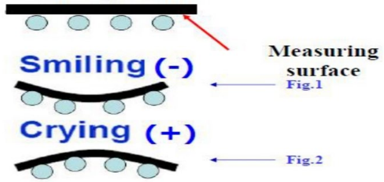


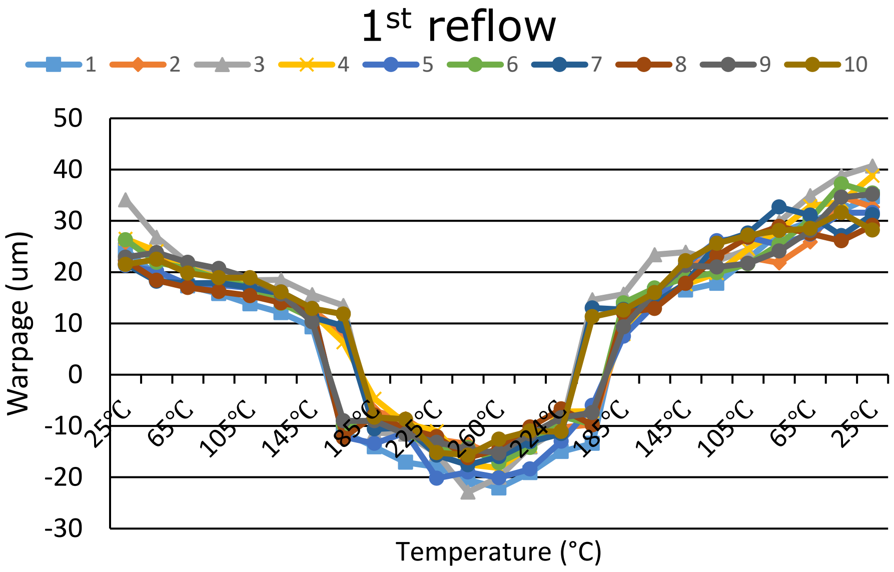
4th reflow

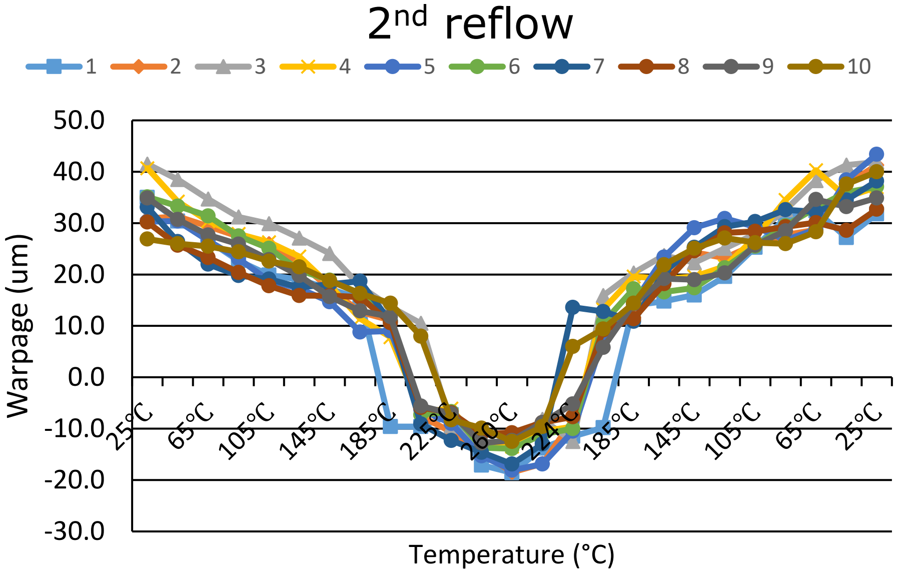


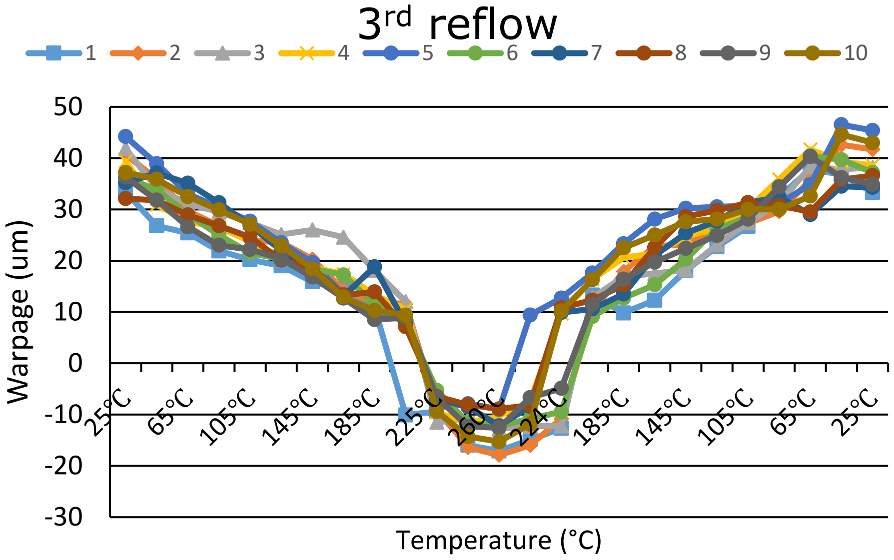
Shadow Moiré (8D)

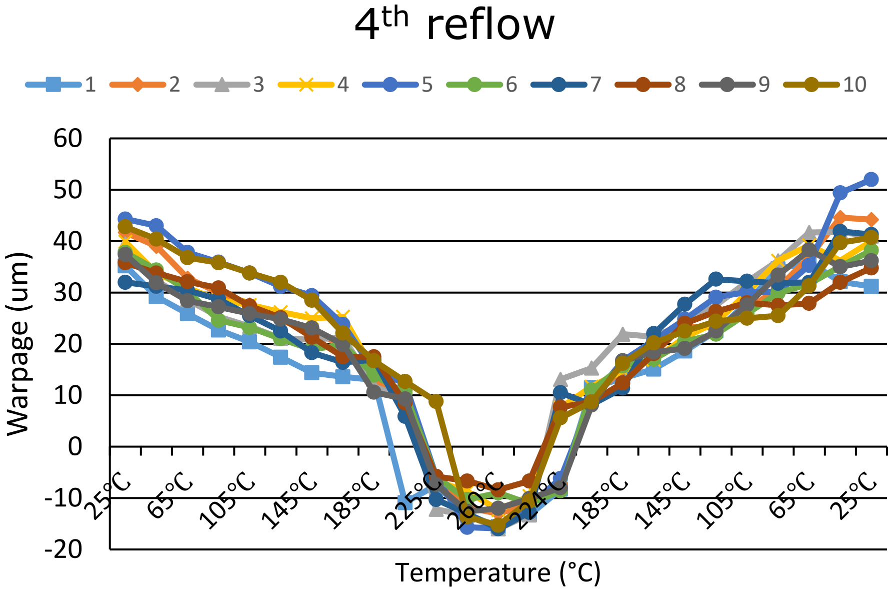
Wet condition samples - meets Apple spec for all temperature range specified




1st reflow


2nd reflow


3rd reflow


4th reflow

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Tape Adhesion test (8D)

20 units from each of 3 PQ lots

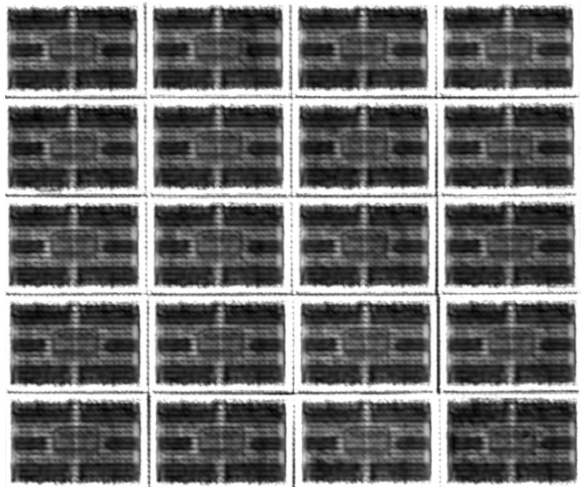
AI No.	Qty	Comment
Lot1	20	Peeling test pass 5B spec
Lot2	20	Peeling test pass 5B spec
Lot3	20	Peeling test pass 5B spec

Tape adhesion test done as per ASTM D-3359 at $T_a = 25°C$ and it meets peeling criterion >=4B

Contact Resistance and Delam check (8D)

Test	Pkg Type	Spec	Test result	Sample size	Remarks
Delamination check by CSAM	Shield	JED22-A113	0 fail / 60ea	60units	Require pre-conditioning with MSL level 3A and measure it after 260C 4x IR reflow
Contact Resistance check	Shield	<0.6Ω	0 fail / 60ea	60 units	

- Data taken from 60 units from 3 PQ lots. (20 units/lot)
- CSAM image post MSL3A shows no failures.



Package Reliability Data (8D) – Full Qual

Package Qual Lot #1 (Substrate Vendor X, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (8D) – Full Qual

Package Qual Lot #2 (Substrate Vendor X, EMI-Linco)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55°C to 125°C; 300cycles	No Failure	After 300cys	0/77
		-55°C to 125°C; 500cycles	No Failure	After 500cys	0/77
		-55°C to 125°C; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110°C, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110°C, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150°C; 300hours	No Failure	After 300hrs	0/45
		150°C; 500hours	No Failure	After 500hrs	0/45

Package Reliability Data (8D) – Full Qual

Package Qual Lot #3 (Substrate Vendor X, EMI-Tango)

Test Items	Sample Size (ea)	Test Condition	Criteria	Intermediate read-point	Result
Pre-condition: MSL3A +4xIR	280	60° C; 60% RH; 40hours 4xIR.	No Failure	SAT result	0/280
				Test result	0/280
TMCL for embedded components after pre-con (Temperature Cycling Test)	77	-55ºC to 125ºC; 300cycles	No Failure	After 300cys	0/77
		-55ºC to 125ºC; 500cycles	No Failure	After 500cys	0/77
		-55ºC to 125ºC; 700cycles	No Failure	After 700cys	0/77
Biased-HAST after pre-con (Biased Highly Accelerated Stress Test)	77	110ºC, 85%RH; 3.6V/1.95V/0.99V for 96hours.	No Failure	After 96hrs	0/77
		110ºC, 85% RH; 3.6V/1.95V/0.99V for 264hours.	No Failure	After 264hrs	0/77
Un-Biased-HAST after pre-con (Un-Biased Highly Accelerated Stress Test)	77	110ºC, 85%RH; 96hours.	No Failure	After 96hrs	0/77
		110ºC, 85% RH; 264hours.	No Failure	After 264hrs	0/77
HTST after pre-con (High Temperature Storage Test)	45	150ºC; 300hours	No Failure	After 300hrs	0/45
		150ºC; 500hours	No Failure	After 500hrs	0/45

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MCP ESD CDM (500V, 400V, 250V) Results

BiCS5 512Gb iTLC S5E – 2D	Sample size (ea)	Results
500V CDM	10	0F/10T
400V CDM	10	0F/10T
250V CDM	10	0F/10T
BiCS5 512Gb iTLC S5E – 4D	**Sample size (ea)**	**Results**
500V CDM	10	0F/10T
400V CDM	10	0F/10T
250V CDM	10	0F/10T
BiCS5 512Gb iTLC S5E – 8D	**Sample size (ea)**	**Results**
500V CDM	10	0F/10T
400V CDM	10	0F/10T
250V CDM	10	0F/10T

- All die stacks passed ESD min. spec >= 250V.

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