QMI529HT-LV

Engineering Data Package (v1)

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General Product Information

- **Background**
  - **QMI529HT, high conductive Die attach Ag filled paste product, has well known excellent performance, such as:**
    - **High conductivity**
    - **Low modulus**
    - **Low moisture absorption**
    - **High reliability**
    - **However, its high viscosity with poor dispensing behavior, limits its application for higher dispensing and UPH requirements.**
  - **QMI529HT-LV**
    - **Was developed based on QMI529HT platform to improve the dispensability without any loss of reliability performance.**
    - **Excellent electrical and thermal performance for use in high power packaging applications using small die.**

Key Material Properties

	QMI529HT-LV
1. Chemistry	Hybrid
2. Tg by TMA (Celsius)	36
3. Modulus (Mpa) after post mold bake @25ºC @150ºC @250ºC	 4910 1010 738
4. Weight loss on cure, TGA (%)	3.9813
5. Volume resistivity (ohm-cm)	0.00005
6. DSC Onset Temp (Celsius) Peak Temp (Celsius)	 138 145
7. Viscosity (5rpm@25ºC)	16,000
8. Thixotropic Index	4.0
9. Worklife @ RT (Hrs)	24
10. CTE (ppm/ºC) Alpha 1 Alpha 2	 62 162

Formula Design

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Design:	QMI529HT	QMI529HT-LV
BMI resin #1	✓	✓
BMI resin #2	✓	✓
Diluent #1	✓	✓
Resin #1	✓	✓
Adhesion promoter	✓	✓
Conductivity promoter	✓	✓
Free radical initiator #1	✓	
Free radical initiator #2		✓
Silver #1	✓	
Silver #2	✓	
Silver #3		✓

Outline

- **Cure Study** *6-13*
- **Die Shear Adhesion Study** *14-43*
- **Open Time Evaluation** *44-59*
- **Staging Time Evaluation** *60-74*
- **Dispensability** *75-84*
- **Bleed Performance** *85-96*
- **Freezing point and storage handling** *97-*
- *Thermal Resistance Data*

QMI529HT-LV Cure Study

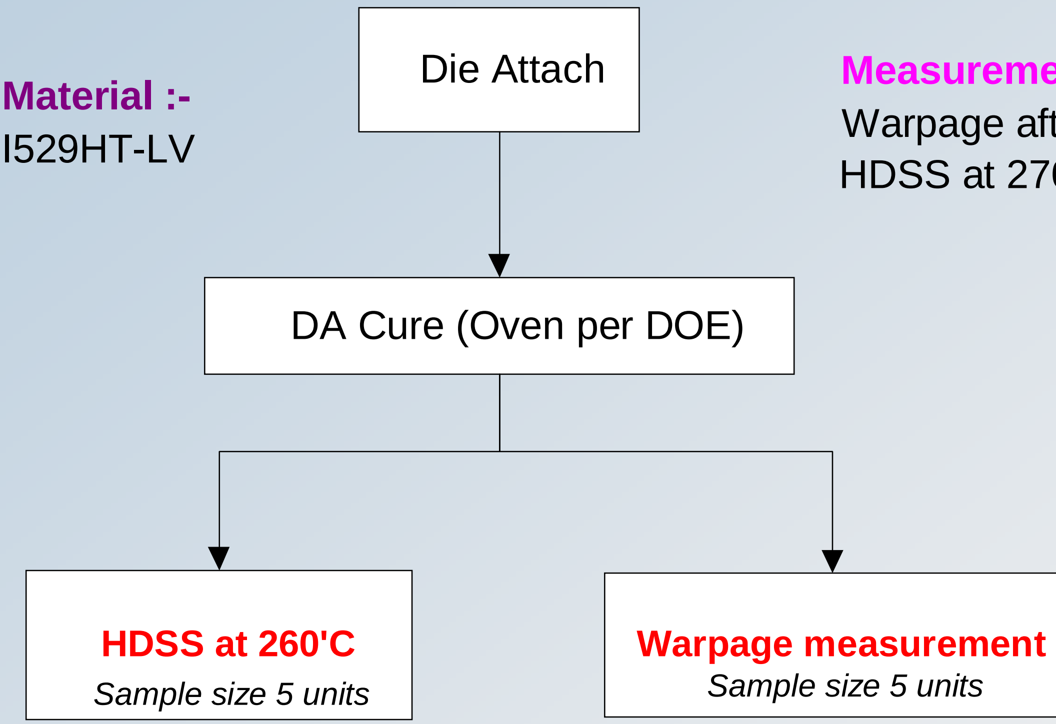
Paul Gleeson/ Jose Venegas

Die Attach Paste TSE

29 March 2010

Experimental

Material :-
QMI529HT-LV



Measurement Criteria (Ys) :-
Warpage after DA cure
HDSS at 270'C

Experimental

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- **The following conditions were used to assemble the test parts: -**

Die:	Bare Si Backside.
Die Size:	2 x 2-mm & 5 x 5-mm
Leadframe:	AgCu.
Target BLT:	1-Mil.
Die Attach Force:	2 x 2-mm = 30g, & 5 x 5-mm 250g.
Die Attach Time:	2 x 2-mm = 50mS, & 5 x 5-mm = 500mS
Needle Diameter:	0.4-m

- **The cure schedule was varied per the DoE.**

DoE

- **The following DoE was produced to study the effect of different cure times and temperatures upon the warpage and adhesion strength of QMI529HT-LV: -**

StdOrder	RunOrder	CenterPt	Blocks	Cure Temp	Cure Time
1	1	1	1	150	15
4	2	1	1	190	60
2	3	1	1	190	15
5	4	0	1	170	37.5
3	5	1	1	150	60

Results

- The following basics statistics were obtained for QMI529HT-LV after the different DoE cure schedules: -

HDSS:

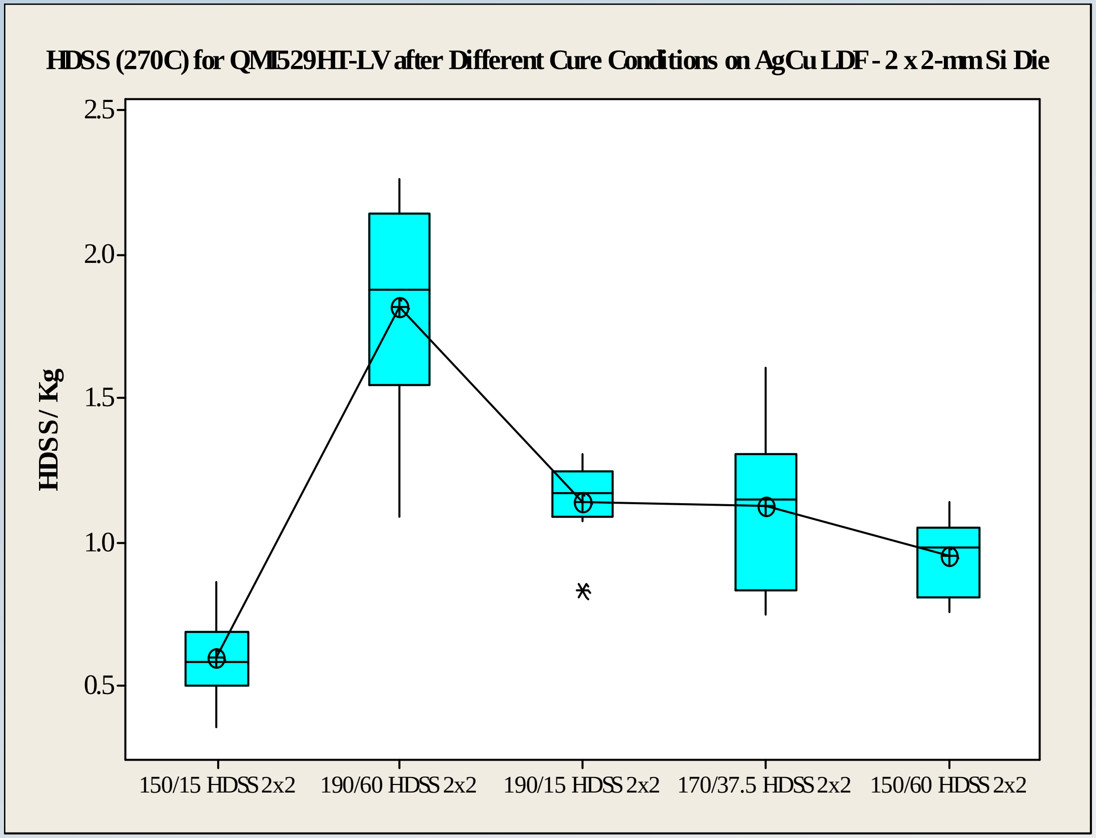
Variable	Count	Mean	StDev	Variance	Minimum	Maximum
150/15 HDSS 5x5	8	8.243	0.614	0.377	7.373	9.241
190/60 HDSS 5x5	8	10.919	2.415	5.834	7.997	16.254
190/15 HDSS 5x5	8	8.807	1.183	1.401	7.355	10.688
170/37.5 HDSS 5x5	8	9.149	0.773	0.598	7.479	9.939
150/60 HDSS 5x5	8	8.716	0.804	0.646	7.561	9.893
150/15 HDSS 2x2	8	0.5964	0.1516	0.0230	0.3601	0.8645
190/60 HDSS 2x2	8	1.819	0.393	0.154	1.088	2.259
190/15 HDSS 2x2	8	1.1431	0.1438	0.0207	0.8350	1.3050
170/37.5 HDSS 2x2	8	1.129	0.288	0.083	0.747	1.607
150/60 HDSS 2x2	8	0.9561	0.1360	0.0185	0.7550	1.14

Warpage:

Variable	Total Count	Mean	StDev	Variance	Minimum	Maximum
150/15 QMI529HT-LV	8	14.182	0.397	0.158	13.650	14.688
190/60 QMI529HT-LV	8	19.944	0.429	0.184	19.213	20.613
190/15 QMI529HT-LV	8	17.460	0.841	0.708	16.613	18.930
170/37.5 QMI529HT-LV	8	17.512	0.471	0.222	16.957	18.528
150/60 QMI529HT-LV	8	16.906	0.451	0.203	16.188	17.550

Results

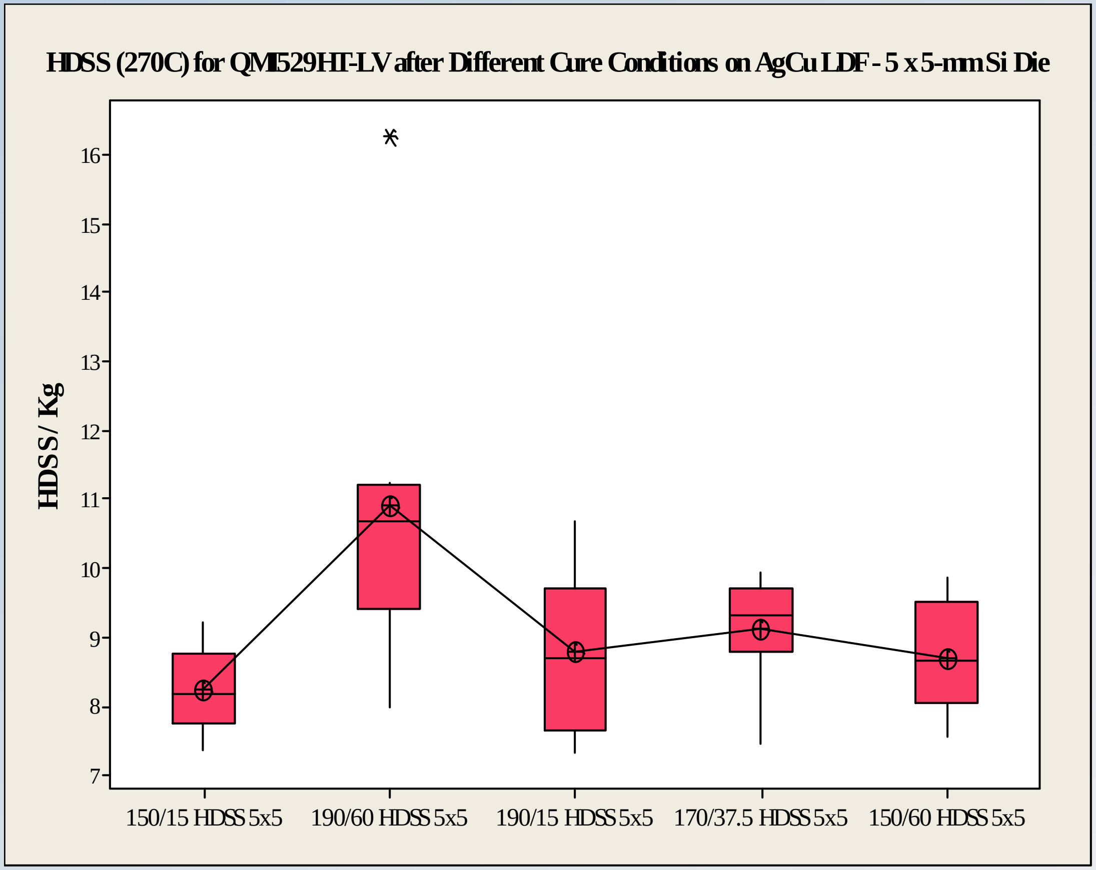
- **The results for HDSS 2 x 2-mm die size, can be further viewed using the Boxplot and ANOVA analysis: -**




```
One-way ANOVA: 150/15 HDSS , 190/60 HDSS , 190/15 HDSS , 170/37.5 HDS, ...

Source  DF      SS      MS      F      P
Factor   4  6.3185  1.5796  26.39  0.000
Error   35  2.0954  0.0599
Total   39  8.4138

S = 0.2447   R-Sq = 75.10%   R-Sq(adj) = 72.25%

                                       Individual 95% CIs For Mean Based on
                                       Pooled StDev
Level             N    Mean   StDev   ---------+---------+---------+---------+
150/15 HDSS 2x2   8  0.5964  0.1516   (---*---)
190/60 HDSS 2x2   8  1.8190  0.3927                                 (---*----)
190/15 HDSS 2x2   8  1.1431  0.1438                 (----*---)
170/37.5 HDSS 2x2 8  1.1290  0.2881                 (---*----)
150/60 HDSS 2x2   8  0.9561  0.1360            (---*---)
                                       ---------+---------+---------+---------+
                                              0.80      1.20      1.60      2.00

Pooled StDev = 0.2447
```

Results

- **The results for HDSS 5 x 5-mm die size, can be further viewed using the Boxplot and ANOVA analysis: -**



One-way ANOVA: 150/15 HDSS , 190/60 HDSS , 190/15 HDSS , 170/37.5 HDS, ...

```
Source  DF     SS    MS     F      P
Factor   4  34.04  8.51  4.80  0.003
Error   35  61.99  1.77
Total   39  96.04

S = 1.331   R-Sq = 35.45%   R-Sq(adj) = 28.07%


                                      Individual 95% CIs For Mean Based on
                                      Pooled StDev
Level               N    Mean  StDev  ---------+---------+---------+---------+
150/15 HDSS 5x5     8   8.243  0.614  (-------*-------)
190/60 HDSS 5x5     8  10.919  2.415                      (-------*-------)
190/15 HDSS 5x5     8   8.807  1.183      (-------*-------)
170/37.5 HDSS 5x5   8   9.149  0.773         (-------*-------)
150/60 HDSS 5x5     8   8.716  0.804      (-------*-------)
                                      ---------+---------+---------+---------+
                                             8.4       9.6      10.8      12.0

Pooled StDev = 1.331
```

Results

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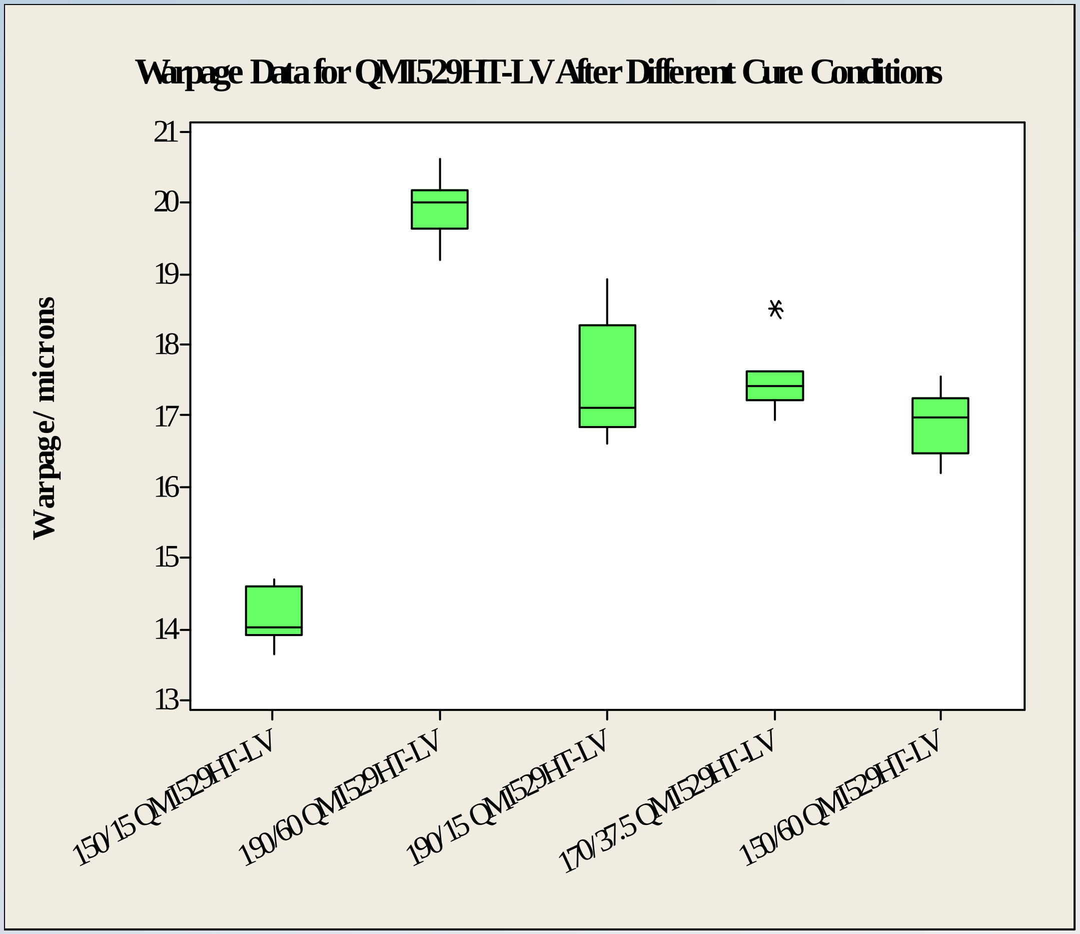
- **The results for warpage can be further viewed using the Boxplot and ANOVA analysis: -**

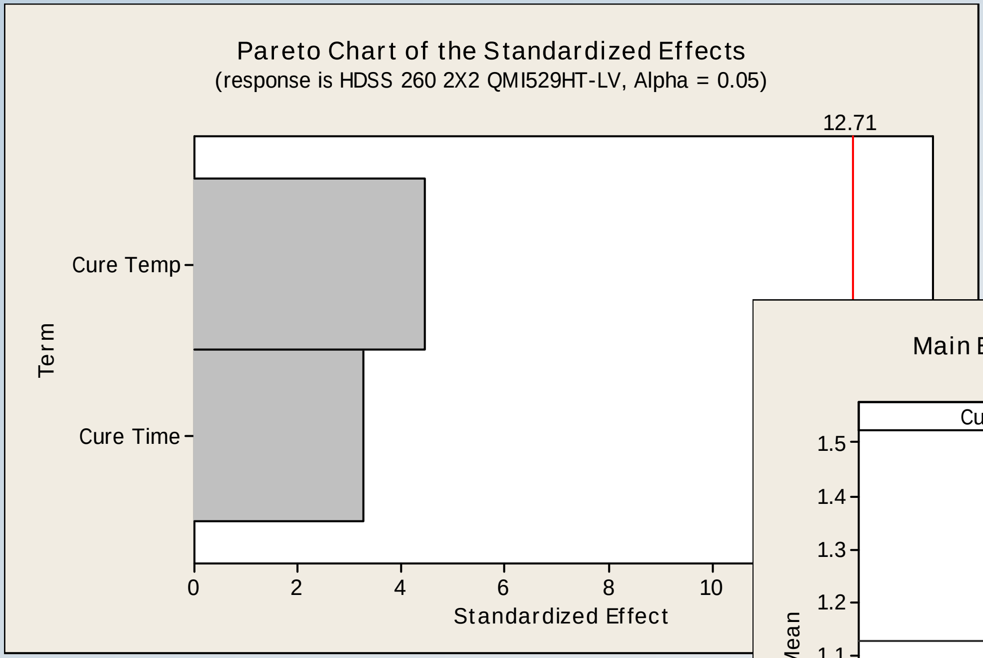


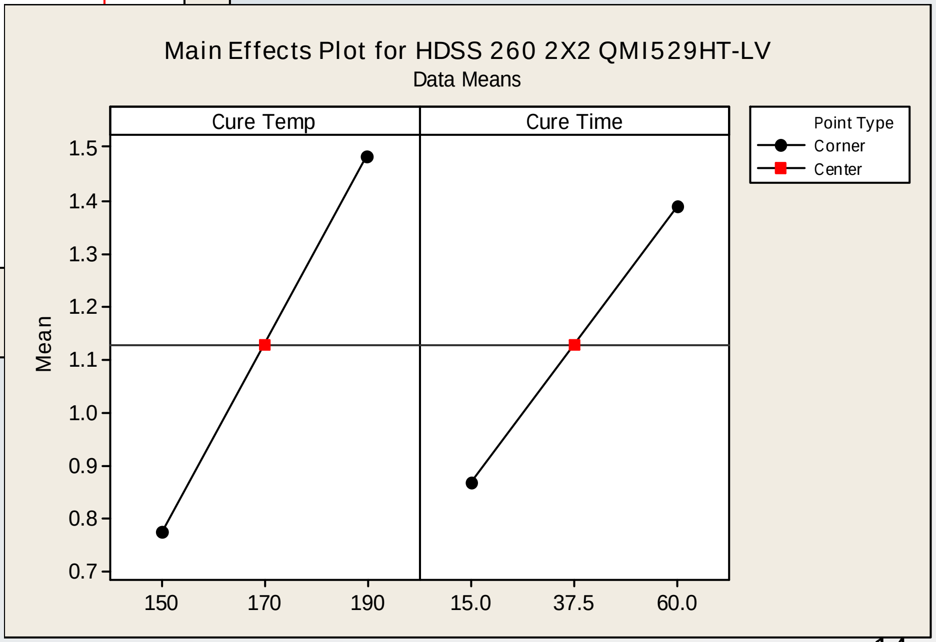
One-way ANOVA: 150/15 QMI52, 190/60 QMI52, 190/15 QMI52, 170/37.5 QMI,

```
Source  DF       SS      MS       F      P
Factor   4  135.140  33.785  114.49  0.000
Error   35   10.328   0.295
Total   39  145.469

S = 0.5432   R-Sq = 92.90%   R-Sq(adj) = 92.09%


Level                N    Mean  StDev
150/15 QMI529HT-LV   8  14.182  0.397
190/60 QMI529HT-LV   8  19.944  0.429
190/15 QMI529HT-LV   8  17.460  0.841
170/37.5 QMI529HT-LV 8  17.512  0.471
150/60 QMI529HT-LV   8  16.906  0.451

                       Individual 95% CIs For Mean Based on Pooled StDev
Level                  --+---------+---------+---------+--------
150/15 QMI529HT-LV       (-*-)
190/60 QMI529HT-LV                                     (-*-)
190/15 QMI529HT-LV                       (-*-)
170/37.5 QMI529HT-LV                      (-*-)
150/60 QMI529HT-LV                     (-*)
                       --+---------+---------+---------+--------
                       14.0      16.0      18.0      20.0

Pooled StDev = 0.543
```

Analysis of DoE – HDSS, 2 x 2-mm

- **The DoE DSS results, 2 x 2-mm die size, were analysed for statistical significance: -**

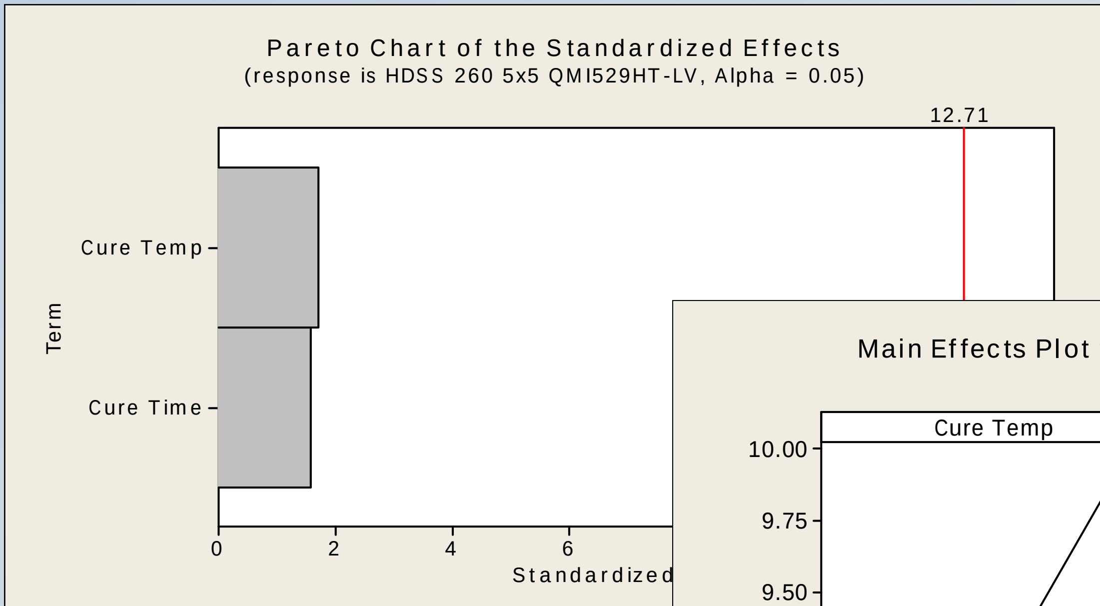


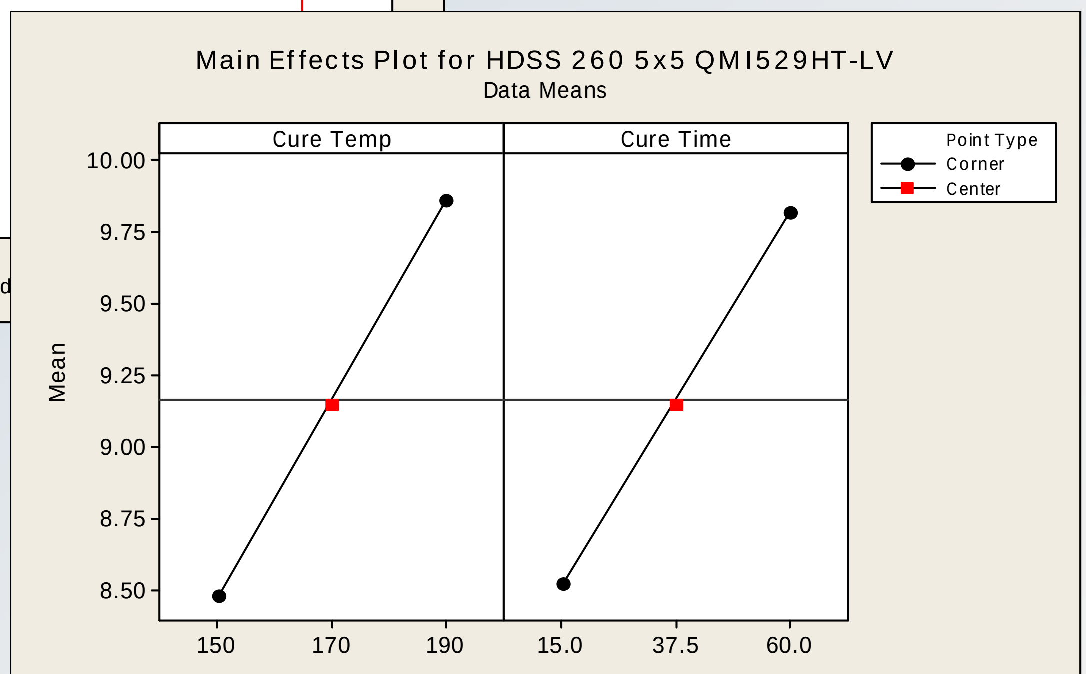


The trends in the data suggest increased temperature and time do offer increased adhesion however this was not statistically proven at the 95% CI.

Analysis of DoE – HDSS, 5 x 5-mm

- **The DoE DSS results, 2 x 2-mm die size, were analysed for statistical significance: -**

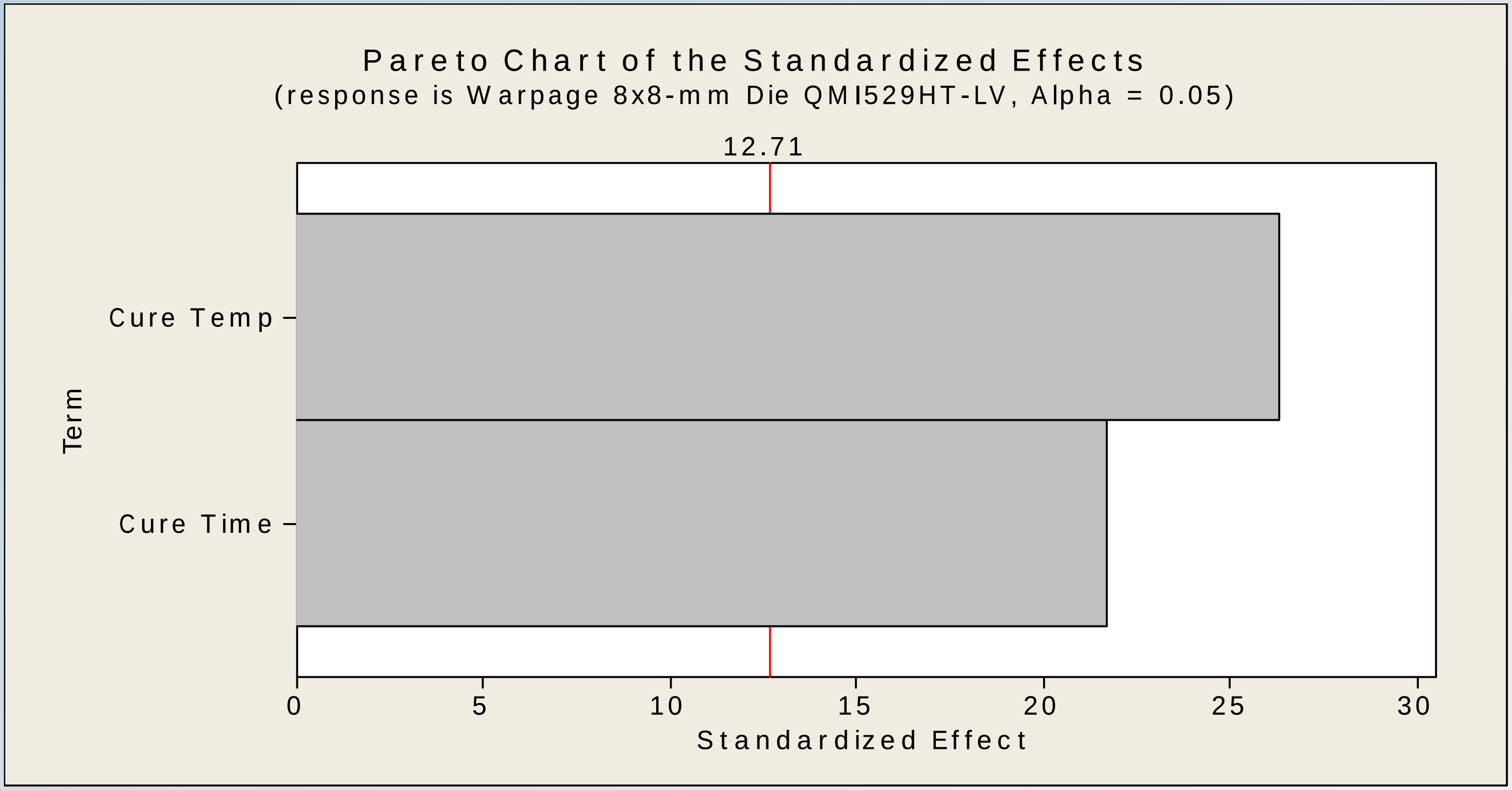




The trends in the data suggest increased temperature and time do offer increased adhesion however this was not statistically proven at the 95% CI.

Analysis of DoE – Warpage 8 x 8-mm

- **The DoE warpage results, 8 x 8-mm die size, were analysed for statistical significance: -**



Both temperature and time are statistically significant factors influencing warpage of QMI529HT-LV at 'large' die sizes.

Conclusions

- **As expected the trend in adhesion strength is for increased adhesion with increased cure time and cure temperature. However this effect is not drastic and the could not be statistically proven for either die size at 95% CI.**

- **When evaluating the warpage with a large die size both cure time and cure temperature are statistically proven to affect warpage.**
  - **Increased temperature and time = increased warpage.**

QMI529HT-LV Die Shear Adhesion Study

Paul Gleeson/ Jose Venegas
Die Attach Paste TSE

25 March 2010

Test Matrix

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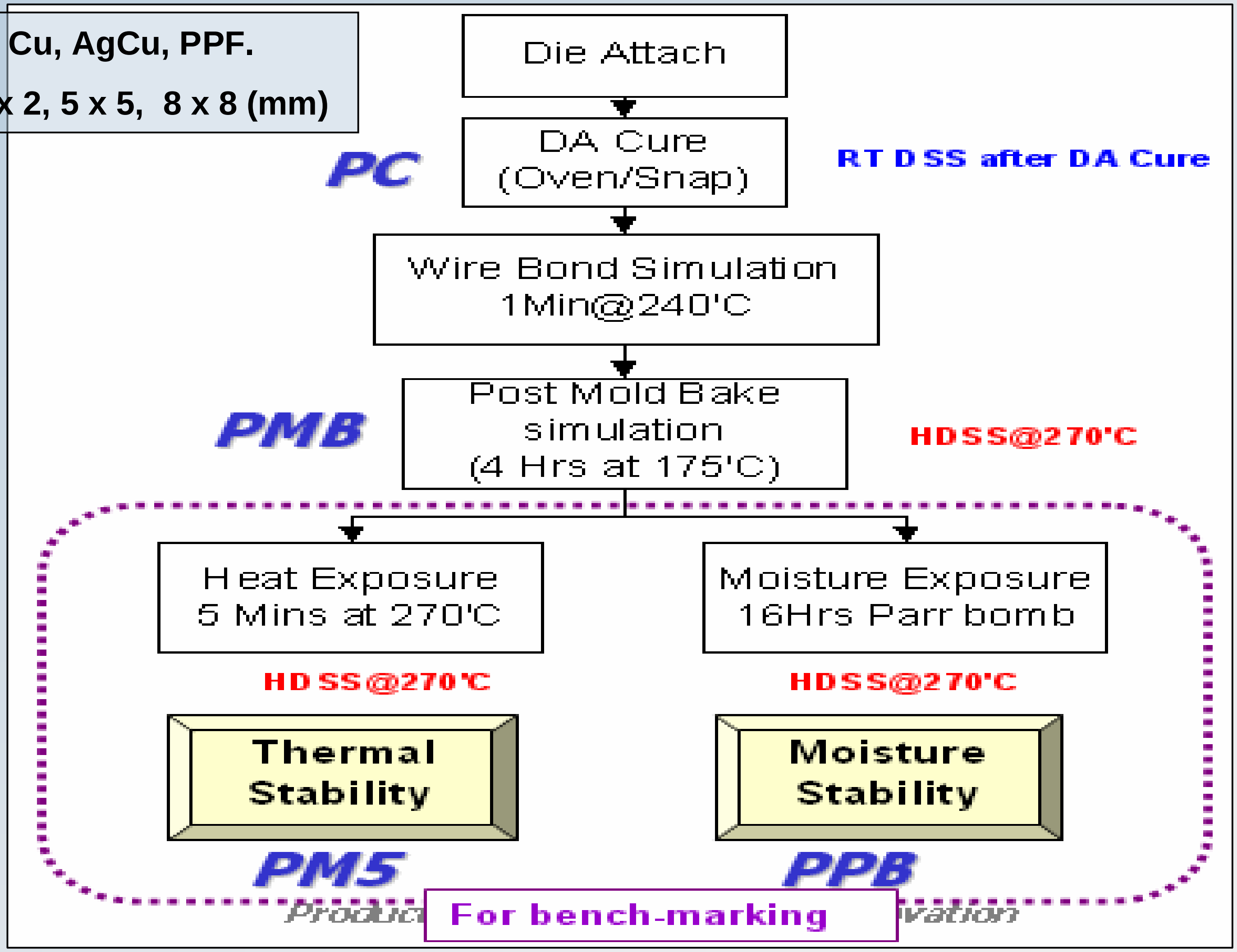
- **Adhesion needs to be verified on all 3 standard substrate surfaces at various different conditioning steps and at three different die sizes.**

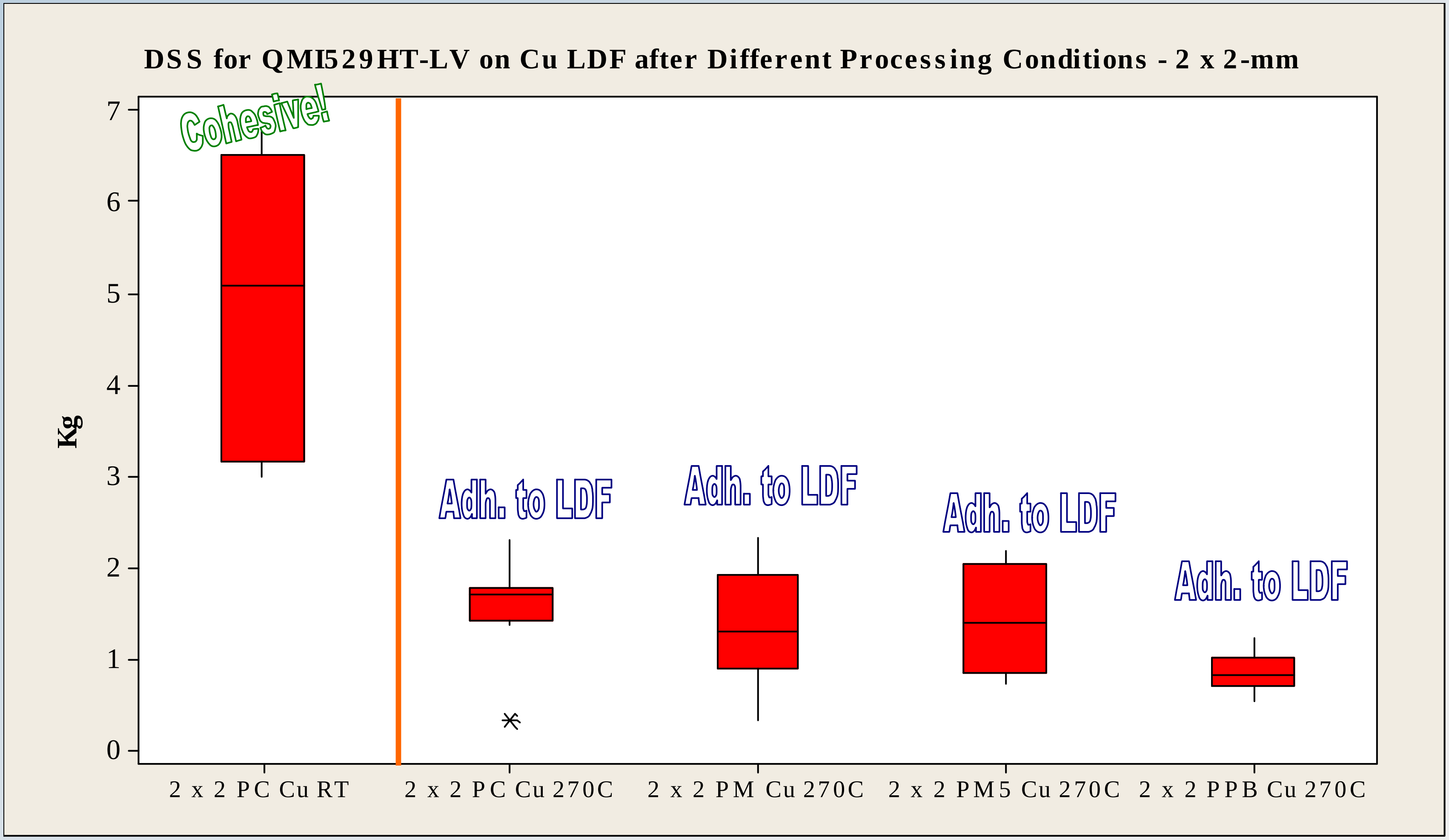
Leadframes: Cu, AgCu, PPF.

Die Sizes: 2 x 2, 5 x 5, 8 x 8 (mm)



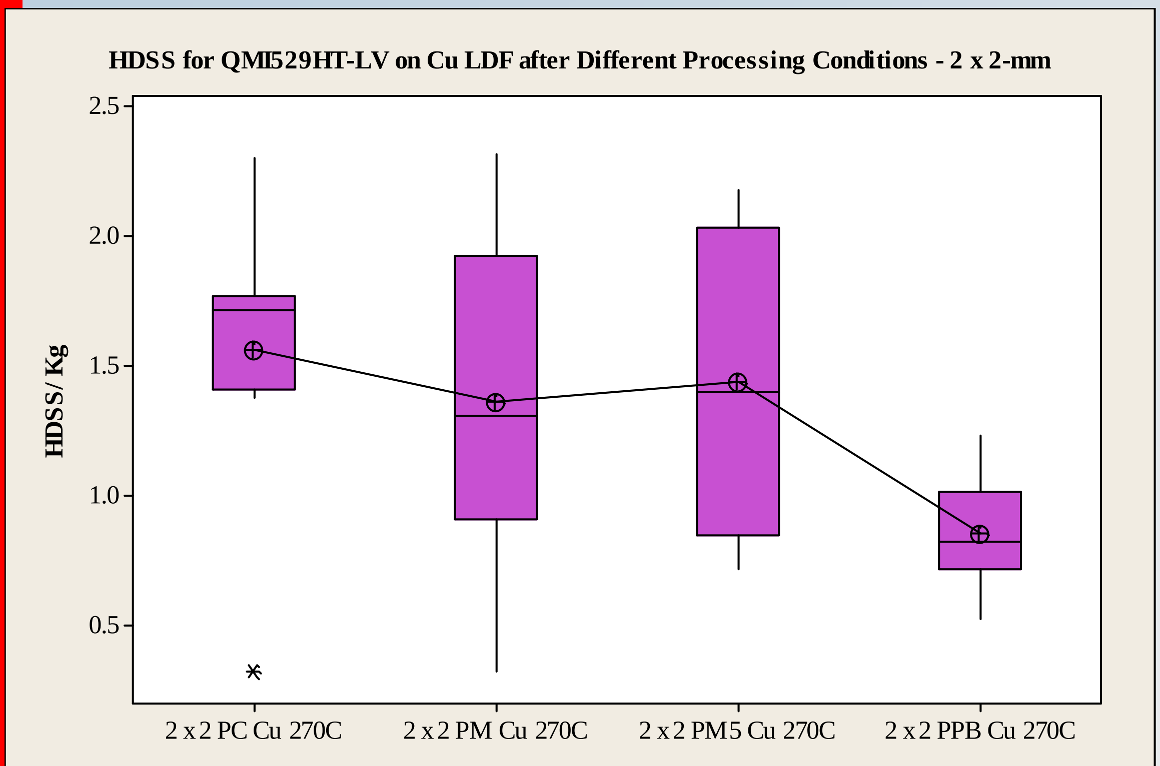
Adhesion on Cu, 2 x 2-mm Die Size

- The adhesion was measured for 2 x 2-mm die size on Cu LDF in accordance with the test matrix: -



HDSS (270°C) on Cu, 2 x 2-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on Cu leadframe at the PMB, PM5 & PPB test intervals: -



One-way ANOVA: 2 x 2 PC Cu , 2 x 2 PM Cu , 2 x 2 PM5 Cu, 2 x 2 PPB Cu

```
Source  DF      SS     MS     F      P
Factor   3   2.311  0.770  2.77  0.060
Error   28   7.793  0.278
Total   31  10.103

S = 0.5275   R-Sq = 22.87%   R-Sq(adj) = 14.61%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level              N    Mean   StDev  --------+---------+---------+---------+-
2 x 2 PC Cu 270C   8  1.5613  0.5669                  (---------*---------)
2 x 2 PM Cu 270C   8  1.3589  0.6478             (---------*---------)
2 x 2 PM5 Cu 270C  8  1.4409  0.5695               (---------*---------)
2 x 2 PPB Cu 270C  8  0.8558  0.2188  (--------*---------)
                                      --------+---------+---------+---------+-
                                            0.80      1.20      1.60      2.00

Pooled StDev = 0.5275
```

HDSS (270°C) on Cu, 5 x 5-mm Die Size

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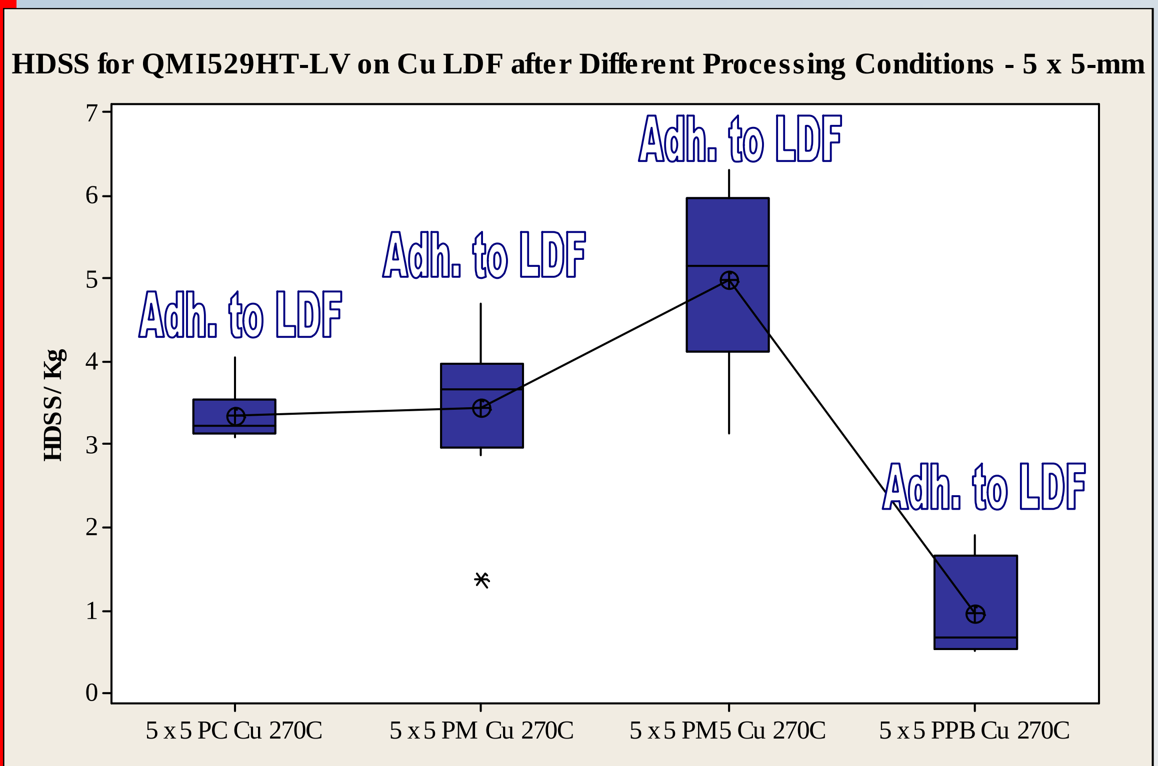
- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on Cu leadframe at the 5 x 5-mm die size at all test intervals: -



One-way ANOVA: 5 x 5 PC Cu , 5 x 5 PM Cu , 5 x 5 PM5 Cu, 5 x 5 PPB Cu

Source	DF	SS	MS	F	P
Factor	3	66.389	22.130	33.93	0.000
Error	28	18.262	0.652		
Total	31	84.651			

S = 0.8076 R-Sq = 78.43% R-Sq(adj) = 76.12%

```
                                       Individual 95% CIs For Mean Based on
                                       Pooled StDev
Level                N   Mean   StDev  --------+---------+---------+---------+-
5 x 5 PC Cu 270C     8  3.3566  0.3251                 (---*---)
5 x 5 PM Cu 270C     8  3.4416  0.9932                  (---*---)
5 x 5 PM5 Cu 270C    8  4.9884  1.0750                            (---*---)
5 x 5 PPB Cu 270C    8  0.9599  0.6009  (---*---)
                                       --------+---------+---------+---------+-
                                              1.5       3.0       4.5       6.0

Pooled StDev = 0.8076
```

HDSS (270°C) on Cu, 8 x 8-mm Die Size

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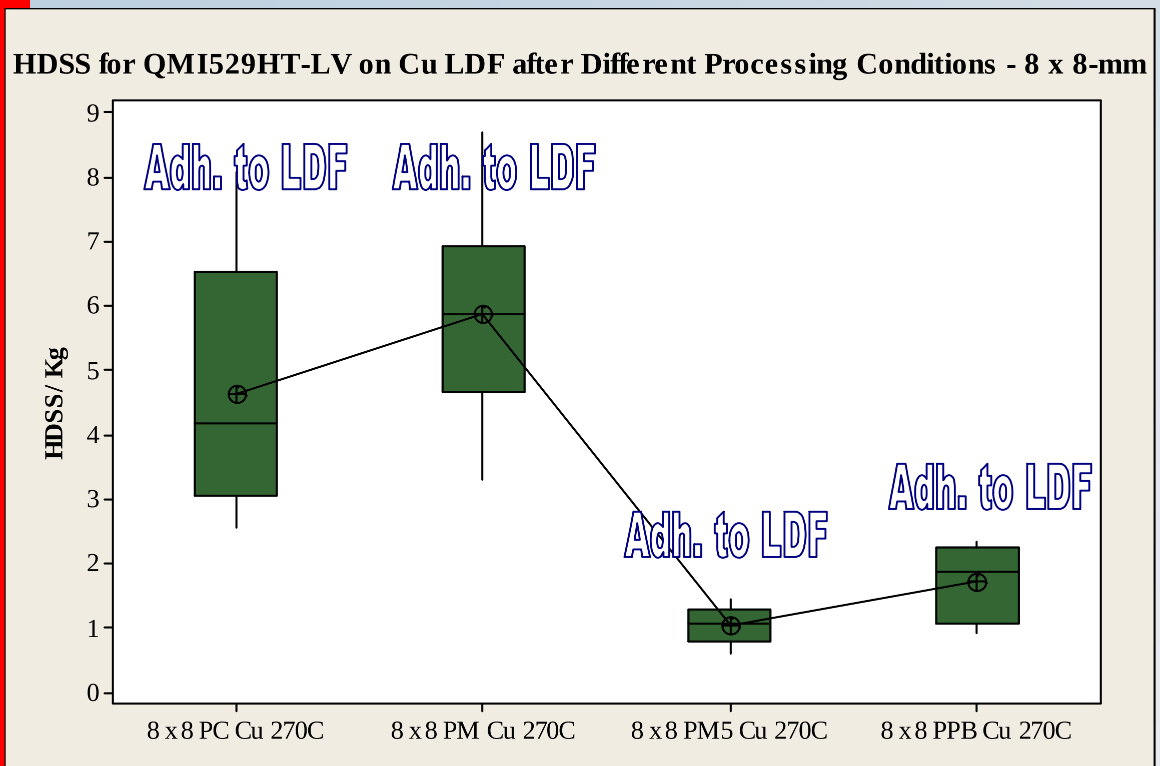
- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on Cu leadframe at the 8 x 8-mm die size at all test intervals: -



One-way ANOVA: 8 x 8 PC Cu , 8 x 8 PM Cu , 8 x 8 PM5 Cu, 8 x 8 PPB Cu

```
Source  DF      SS     MS      F      P
Factor   3  127.20  42.40  23.47  0.000
Error   28   50.59   1.81
Total   31  177.79

S = 1.344   R-Sq = 71.55%   R-Sq(adj) = 68.50%


Level                N   Mean  StDev
8 x 8 PC Cu 270C     8  4.632  1.985
8 x 8 PM Cu 270C     8  5.872  1.698
8 x 8 PM5 Cu 270C    8  1.059  0.284
8 x 8 PPB Cu 270C    8  1.723  0.568

                       Individual 95% CIs For Mean Based on Pooled StDev
Level                  --+---------+---------+---------+-------
8 x 8 PC Cu 270C                          (----*----)
8 x 8 PM Cu 270C                                (----*----)
8 x 8 PM5 Cu 270C       (----*----)
8 x 8 PPB Cu 270C          (----*---)
                       --+---------+---------+---------+-------
                        0.0       2.0       4.0       6.0

Pooled StDev = 1.344
```

Basic Statistics on Cu LDF

- The following Basics Statistics were obtained for QMI529HT-LV on Cu LDF: -

2 x 2-mm Die Size

Variable	Total Count	Mean	StDev	Variance	Minimum	Maximum
2 x 2 PC Cu RT	8	4.900	1.697	2.881	2.987	6.766
2 x 2 PC Cu 270C	8	1.561	0.567	0.321	0.327	2.305
2 x 2 PM Cu 270C	8	1.359	0.648	0.420	0.320	2.318
2 x 2 PM5 Cu 270C	8	1.441	0.570	0.324	0.718	2.178
2 x 2 PPB Cu 270C	8	0.8558	0.2188	0.0479	0.5270	1.2290

5 x 5-mm Die Size

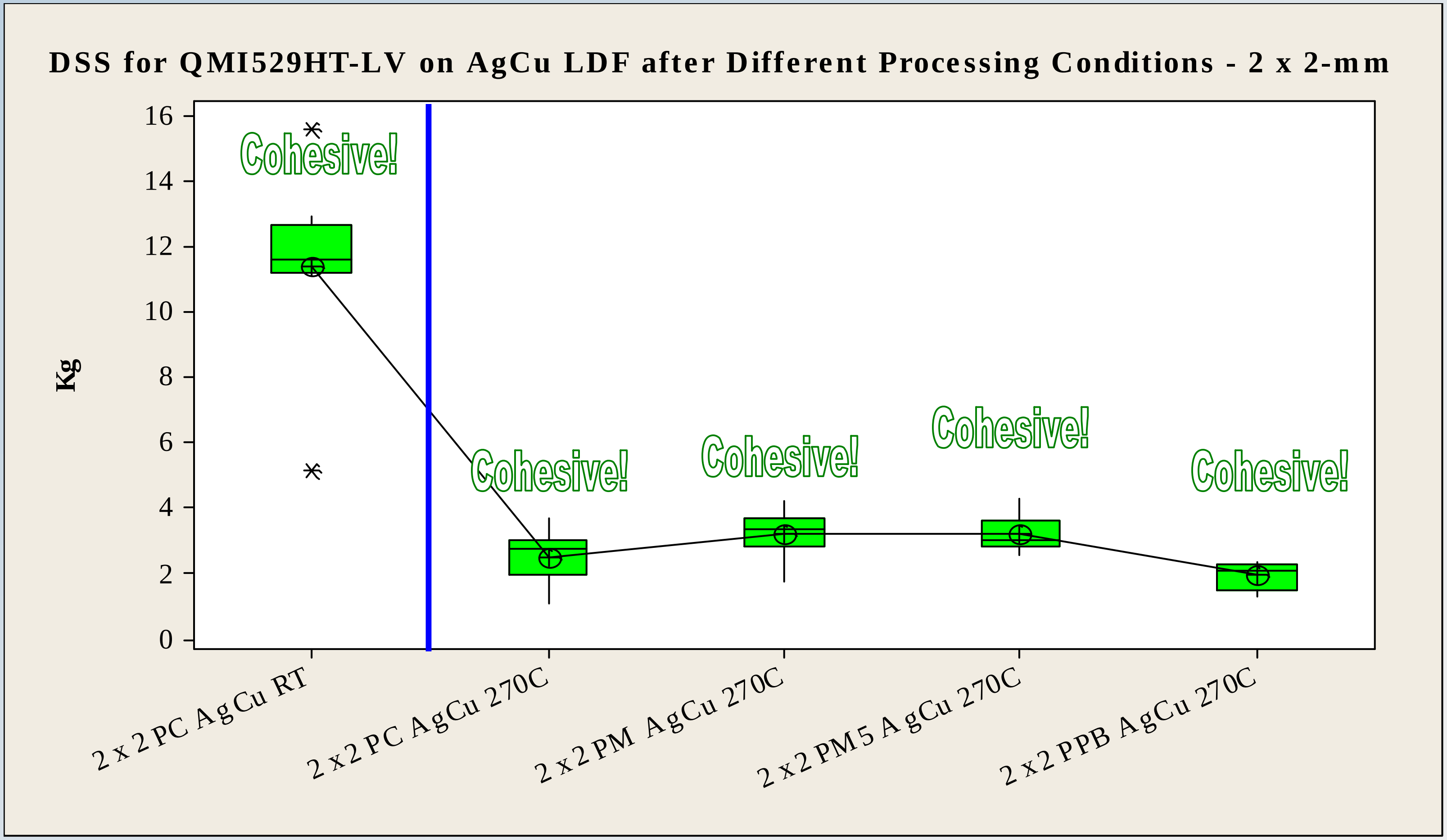
5 x 5 PC Cu 270C	8	3.357	0.325	0.106	3.091	4.050
5 x 5 PM Cu 270C	8	3.442	0.993	0.987	1.369	4.702
5 x 5 PM5 Cu 270C	8	4.988	1.075	1.156	3.148	6.318
5 x 5 PPB Cu 270C	8	0.960	0.601	0.361	0.506	1.913

8 x 8-mm Die Size

8 x 8 PC Cu 270C	8	4.632	1.985	3.941	2.554	8.088
8 x 8 PM Cu 270C	8	5.872	1.698	2.882	3.295	8.707
8 x 8 PM5 Cu 270C	8	1.059	0.284	0.081	0.618	1.449
8 x 8 PPB Cu 270C	8	1.723	0.568	0.323	0.913	2.356

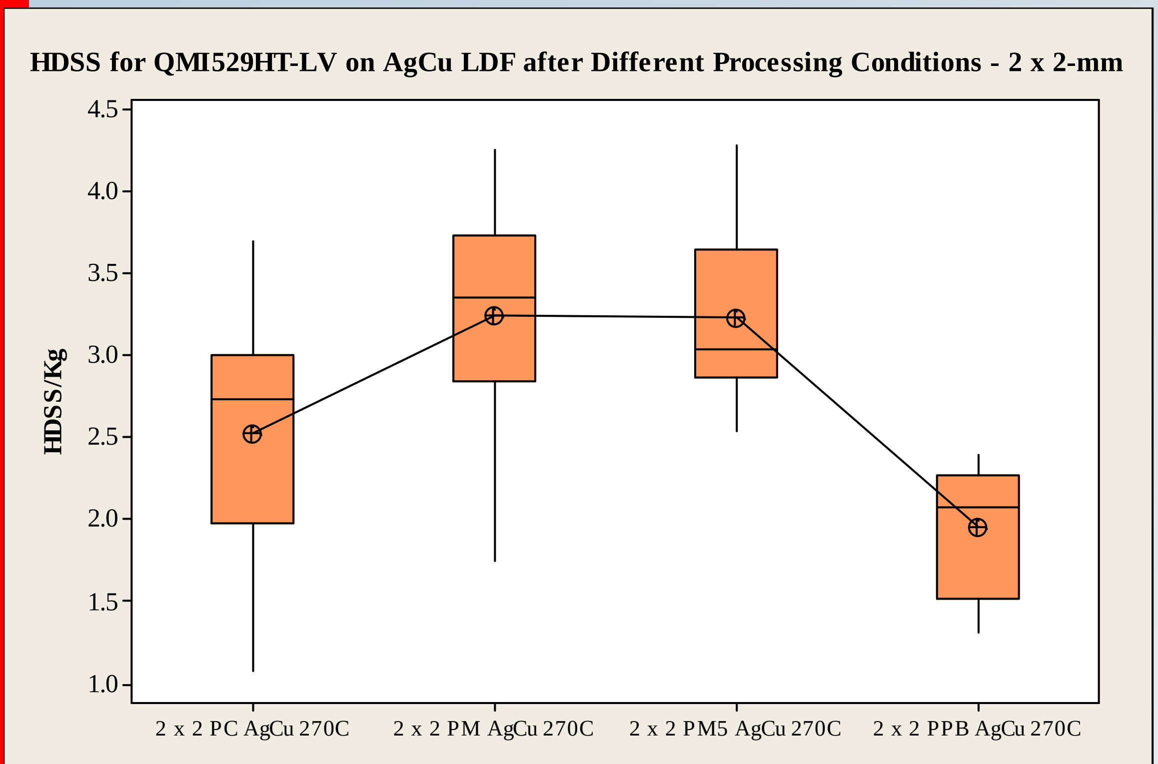
Adhesion on AgCu, 2 x 2-mm Die Size

- The adhesion was measured for 2 x 2-mm die size on AgCu LDF in accordance with the test matrix: -



HDSS (270°C) on AgCu, 2 x 2-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on AgCu leadframe at the PMB, PM5 & PPB test intervals: -

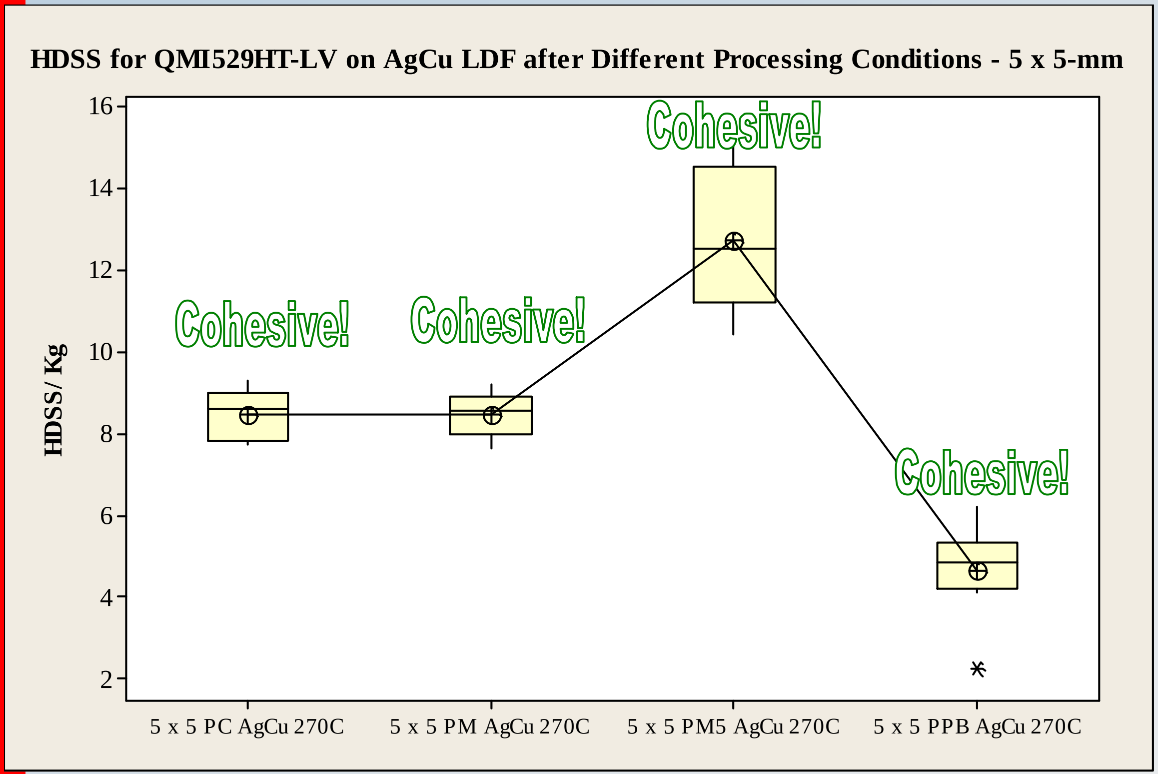


One-way ANOVA: 2 x 2 PC AgC, 2 x 2 PM AgC, 2 x 2 PM5 Ag, 2 x 2 PPB Ag

```
Source  DF      SS     MS     F      P
Factor   3   9.342  3.114  7.27  0.001
Error   28  11.994  0.428
Total   31  21.335

S = 0.6545   R-Sq = 43.78%   R-Sq(adj) = 37.76%


Level                N    Mean   StDev
2 x 2 PC AgCu 270C   8  2.5299  0.8179
2 x 2 PM AgCu 270C   8  3.2524  0.7494
2 x 2 PM5 AgCu 270C  8  3.2424  0.5648
2 x 2 PPB AgCu 270C  8  1.9597  0.4048

                     Individual 95% CIs For Mean Based on
                     Pooled StDev
Level                -----+---------+---------+---------+----
2 x 2 PC AgCu 270C            (-------*-------)
2 x 2 PM AgCu 270C                        (-------*-------)
2 x 2 PM5 AgCu 270C                       (-------*-------)
2 x 2 PPB AgCu 270C  (-------*-------)
                     -----+---------+---------+---------+----
                        1.80      2.40      3.00      3.60

Pooled StDev = 0.6545
```

HDSS (270°C) on AgCu, 5 x 5-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on AgCu leadframe at the 5 x 5-mm die size at all test intervals: -



One-way ANOVA: 5 x 5 PC AgC, 5 x 5 PM AgC, 5 x 5 PM5 Ag, 5 x 5 PPB Ag

```
Source  DF      SS     MS      F      P
Factor   3  260.02  86.67  66.92  0.000
Error   28   36.26   1.30
Total   31  296.28

S = 1.138   R-Sq = 87.76%   R-Sq(adj) = 86.45%

                                     Individual 95% CIs For Mean Based on
                                     Pooled StDev
Level                N    Mean  StDev  -----+---------+---------+---------+----
5 x 5 PC AgCu 270C   8   8.503  0.594                (--*--)
5 x 5 PM AgCu 270C   8   8.496  0.534                (--*--)
5 x 5 PM5 AgCu 270C  8  12.742  1.779                                (--*--)
5 x 5 PPB AgCu 270C  8   4.685  1.175  (---*--)
                                       -----+---------+---------+---------+----
                                          5.0       7.5      10.0      12.5

Pooled StDev = 1.138
```

HDSS (270°C) on AgCu, 8 x 8-mm Die Size

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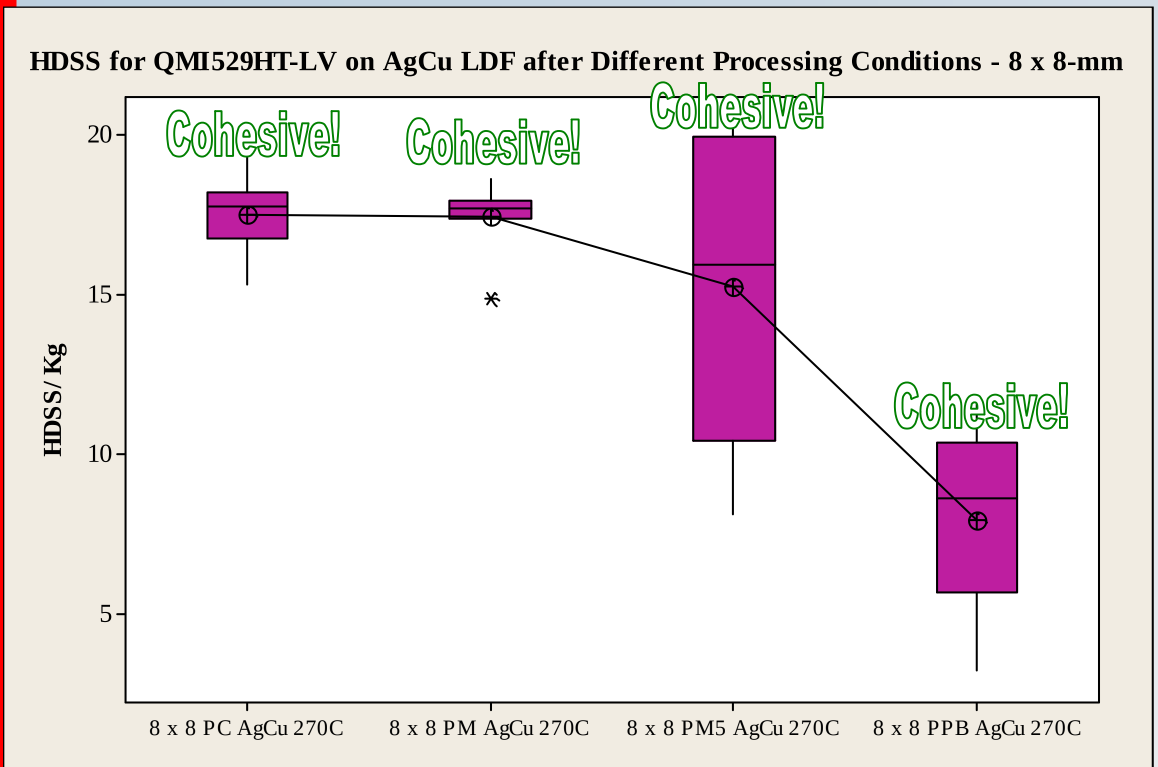
- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on AgCu leadframe at the 8 x 8-mm die size at all test intervals: -



One-way ANOVA: 8 x 8 PC AgC, 8 x 8 PM AgC, 8 x 8 PM5 Ag, 8 x 8 PPB Ag

```
Source  DF      SS      MS      F      P
Factor   3  491.87  163.96  20.02  0.000
Error   28  229.34    8.19
Total   31  721.21

S = 2.862   R-Sq = 68.20%   R-Sq(adj) = 64.79%

                                          Individual 95% CIs For Mean Based on
                                          Pooled StDev
Level                  N    Mean  StDev   ---+---------+---------+---------+------
8 x 8 PC AgCu 270C     8  17.568  1.201                             (-----*-----)
8 x 8 PM AgCu 270C     8  17.473  1.097                             (-----*-----)
8 x 8 PM5 AgCu 270C    8  15.319  4.702                       (-----*-----)
8 x 8 PPB AgCu 270C    8   7.974  2.830   (-----*-----)
                                          ---+---------+---------+---------+------
                                           7.0      10.5      14.0      17.5

Pooled StDev = 2.862
```

Basic Statistics on AgCu LDF

- **The following Basics Statistics were obtained for QMI529HT-LV on AgCu LDF: -**

2 x 2-mm Die Size

Variable	Total Count	Mean	StDev	Variance	Minimum	Maximum
2 x 2 PC AgCu RT	8	11.41	2.91	8.46	5.17	15.60
2 x 2 PC AgCu 270C	8	2.530	0.818	0.669	1.079	3.700
2 x 2 PM AgCu 270C	8	3.252	0.749	0.562	1.757	4.255
2 x 2 PM5 AgCu 270C	8	3.242	0.565	0.319	2.545	4.288
2 x 2 PPB AgCu 270C	8	1.960	0.405	0.164	1.310	2.401

5 x 5-mm Die Size

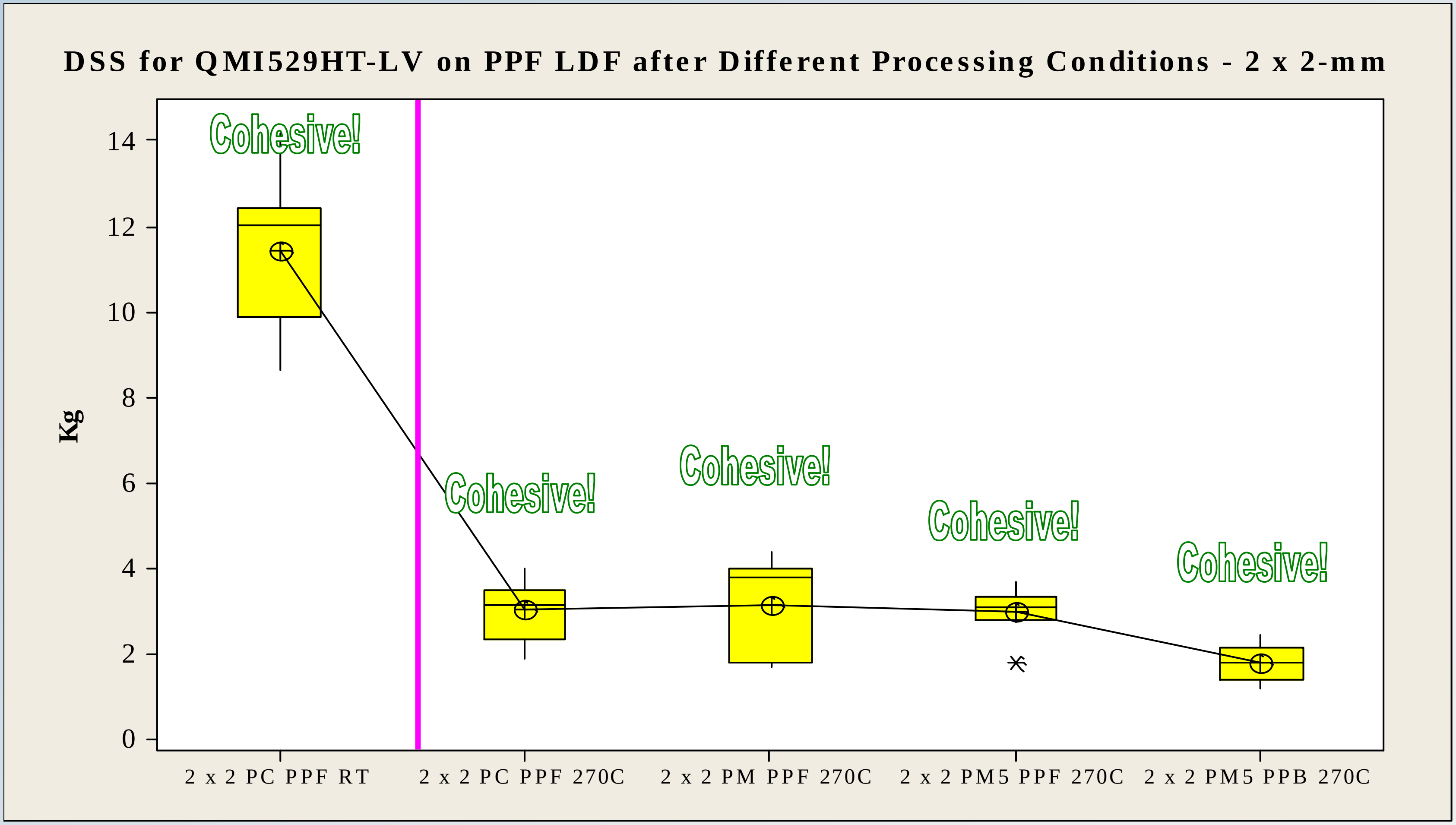
5 x 5 PC AgCu 270C	8	8.503	0.594	0.352	7.770	9.328
5 x 5 PM AgCu 270C	8	8.496	0.534	0.285	7.669	9.225
5 x 5 PM5 AgCu 270C	8	12.742	1.779	3.163	10.436	15.105
5 x 5 PPB AgCu 270C	8	4.685	1.175	1.380	2.262	6.256

8 x 8-mm Die Size

8 x 8 PC AgCu 270C	8	17.568	1.201	1.443	15.335	19.332
8 x 8 PM AgCu 270C	8	17.473	1.097	1.203	14.939	18.665
8 x 8 PM5 AgCu 270C	8	15.32	4.70	22.11	8.13	20.22
8 x 8 PPB AgCu 270C	8	7.97	2.83	8.01	3.28	11.73

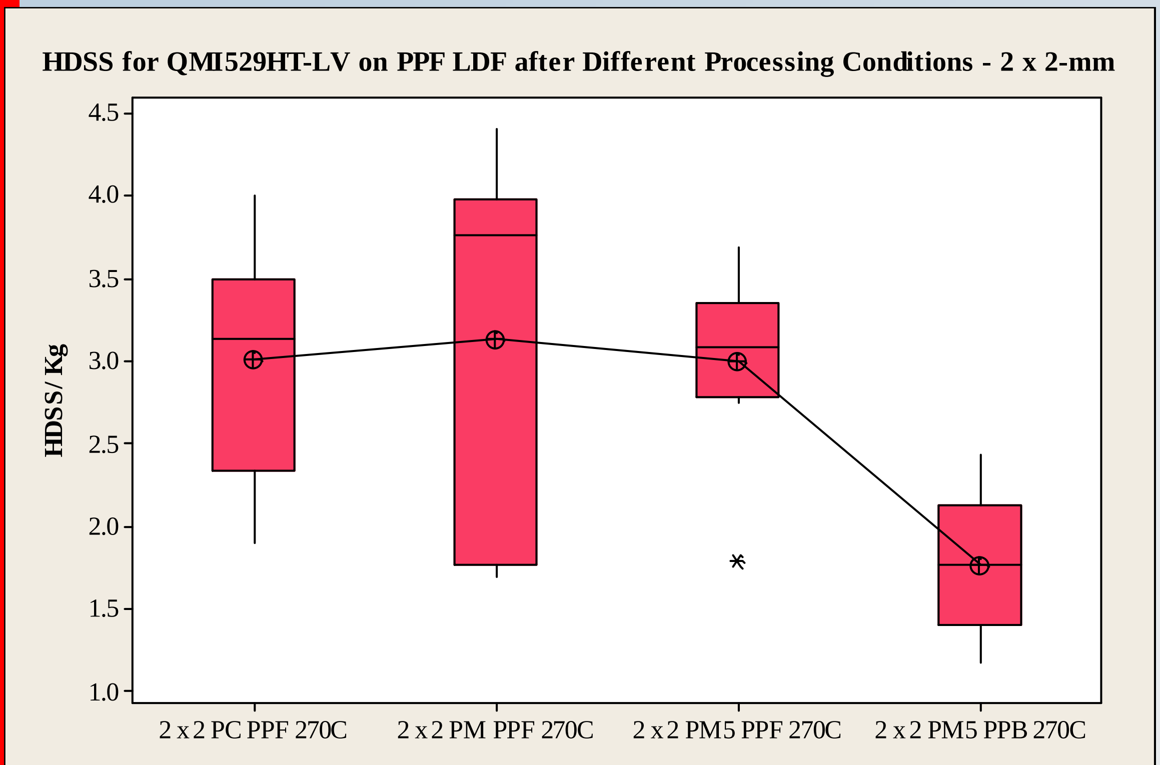
Adhesion on PPF, 2 x 2-mm Die Size

- The adhesion was measured for 2 x 2-mm die size on PPF LDF in accordance with the test matrix: -



HDSS (270°C) on PPF, 2 x 2-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on PPF leadframe at the PMB, PM5 & PPB test intervals: -

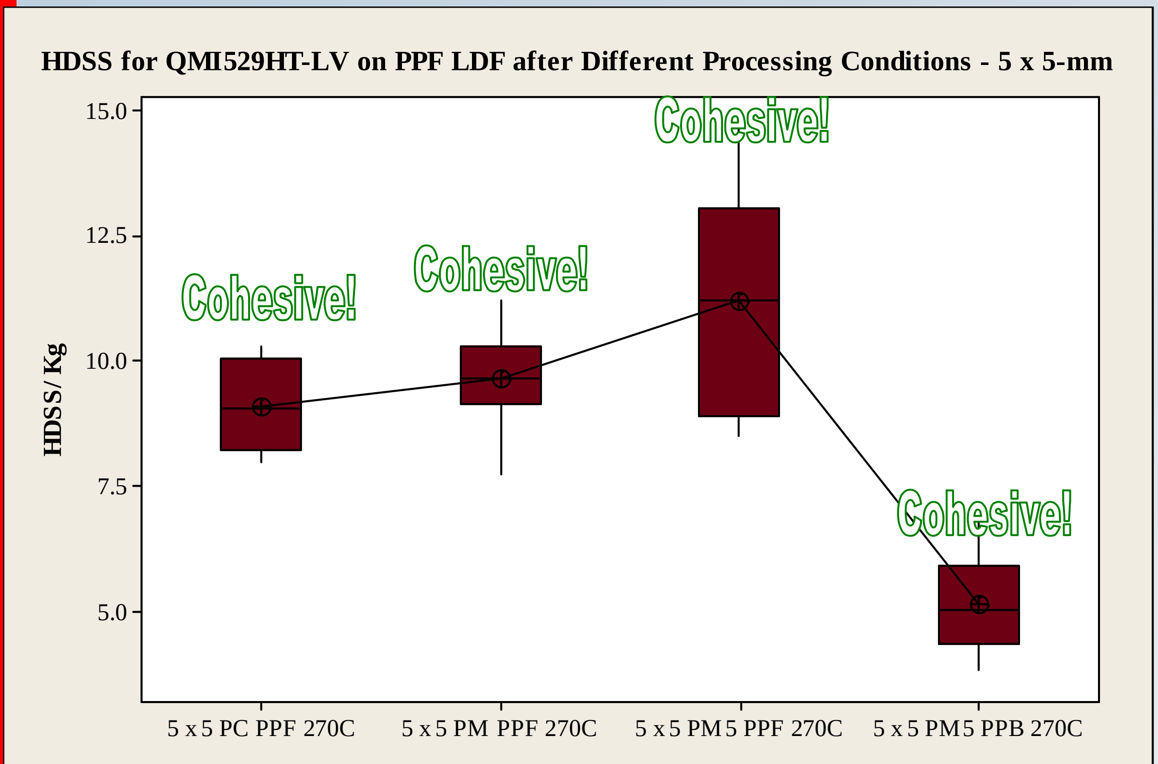



```
One-way ANOVA: 2 x 2 PC PPF, 2 x 2 PM PPF, 2 x 2 PM5 PP, 2 x 2 PM5 PP

Source  DF      SS     MS     F      P
Factor   3   9.916  3.305  5.56  0.004
Error   28  16.642  0.594
Total   31  26.558

S = 0.7709   R-Sq = 37.34%   R-Sq(adj) = 30.62%

                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level             N    Mean   StDev  ---+---------+---------+---------+------
2 x 2 PC PPF 270C  8  3.0219  0.7061                     (-------*-------)
2 x 2 PM PPF 270C  8  3.1384  1.1663                       (-------*-------)
2 x 2 PM5 PPF 270C 8  3.0033  0.5778                     (-------*-------)
2 x 2 PM5 PPB 270C 8  1.7745  0.4296  (-------*-------)
                                     ---+---------+---------+---------+------
                                      1.40      2.10      2.80      3.50

Pooled StDev = 0.7709
```

HDSS (270°C) on PPF, 5 x 5-mm Die Size

Henkel

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on PPF leadframe at the 5 x 5-mm die size at all test intervals: -

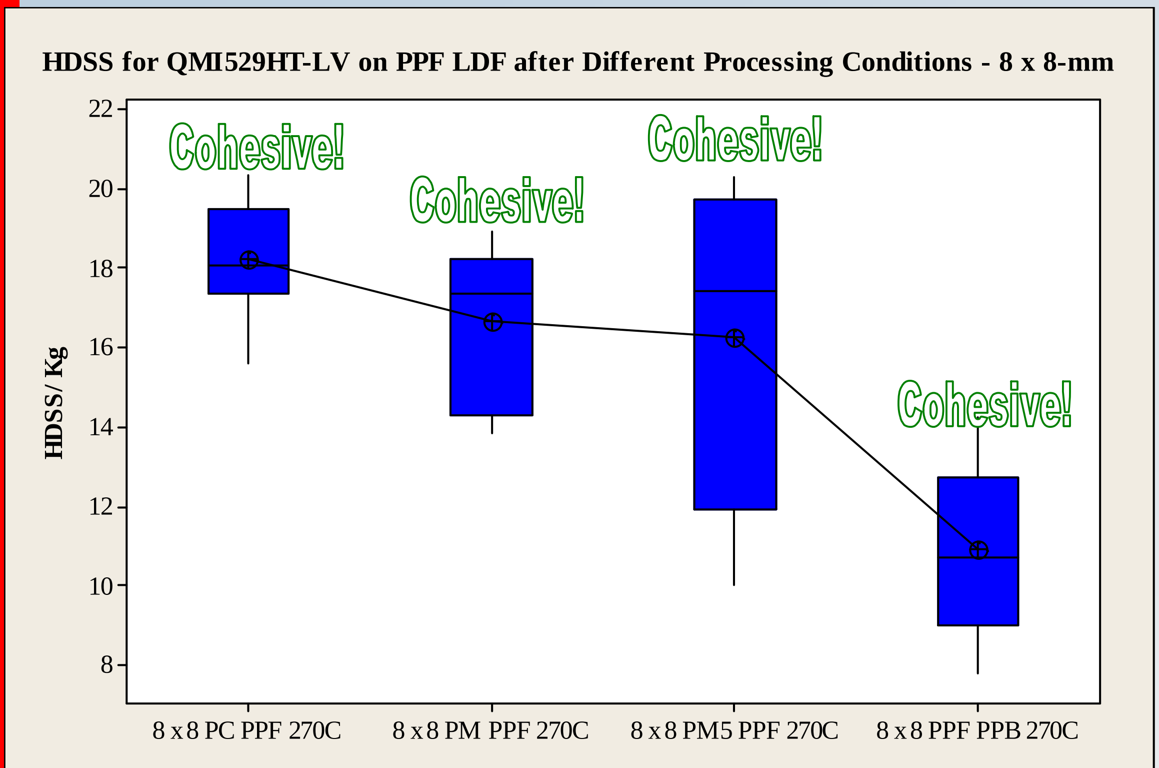


One-way ANOVA: 5 x 5 PC PPF, 5 x 5 PM PPF, 5 x 5 PM5 PP, 5 x 5 PM5 PP

```
Source  DF      SS     MS      F      P
Factor   3  158.35  52.78  25.59  0.000
Error   28   57.76   2.06
Total   31  216.11

S = 1.436   R-Sq = 73.27%   R-Sq(adj) = 70.41%

                                      Individual 95% CIs For Mean Based on
                                      Pooled StDev
Level               N    Mean  StDev  ---+---------+---------+---------+------
5 x 5 PC PPF 270C   8   9.125  0.980                 (---*----)
5 x 5 PM PPF 270C   8   9.655  1.031                   (----*---)
5 x 5 PM5 PPF 270C  8  11.223  2.292                          (---*---)
5 x 5 PM5 PPB 270C  8   5.182  0.987  (---*---)
                                      ---+---------+---------+---------+------
                                        5.0       7.5      10.0      12.5

Pooled StDev = 1.436
```

HDSS (270°C) on PPF, 8 x 8-mm Die Size

- **The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on PPF leadframe at the 8 x 8-mm die size at all test intervals: -**




```
One-way ANOVA: 8 x 8 PC PPF, 8 x 8 PM PPF, 8 x 8 PM5 PP, 8 x 8 PPF PP

Source  DF      SS     MS      F      P
Factor   3  242.35  80.78  12.16  0.000
Error   28  185.96   6.64
Total   31  428.30

S = 2.577   R-Sq = 56.58%   R-Sq(adj) = 51.93%



Level               N    Mean  StDev
8 x 8 PC PPF 270C   8  18.213  1.459
8 x 8 PM PPF 270C   8  16.651  1.999
8 x 8 PM5 PPF 270C  8  16.277  3.957
8 x 8 PPF PPB 270C  8  10.917  2.187

                    Individual 95% CIs For Mean Based on Pooled StDev
Level               +---------+---------+---------+---------
8 x 8 PC PPF 270C                            (------*-----)
8 x 8 PM PPF 270C                       (------*-----)
8 x 8 PM5 PPF 270C                     (-----*-----)
8 x 8 PPF PPB 270C   (-----*------)
                    +---------+---------+---------+---------
                   9.0      12.0      15.0      18.0
```

Basic Statistics on PPF LDF

Henkel

- The following Basics Statistics were obtained for QMI529HT-LV on PPF LDF: -

2 x 2-mm Die Size

Variable	Total Count	Mean	StDev	Variance	Minimum	Maximum
2 x 2 PC PPF RT	8	11.455	1.805	3.258	8.623	14.210
2 x 2 PC PPF 270C	8	3.022	0.706	0.499	1.898	4.010
2 x 2 PM PPF 270C	8	3.138	1.166	1.360	1.701	4.408
2 x 2 PM5 PPF 270C	8	3.003	0.578	0.334	1.797	3.694
2 x 2 PM5 PPB 270C	8	1.775	0.430	0.185	1.173	2.440

5 x 5-mm Die Size

5 x 5 PC PPF 270C	8	9.125	0.980	0.960	7.989	10.317
5 x 5 PM PPF 270C	8	9.655	1.031	1.064	7.773	11.219
5 x 5 PM5 PPF 270C	8	11.223	2.292	5.253	8.499	14.640
5 x 5 PM5 PPB 270C	8	5.182	0.987	0.975	3.867	6.924

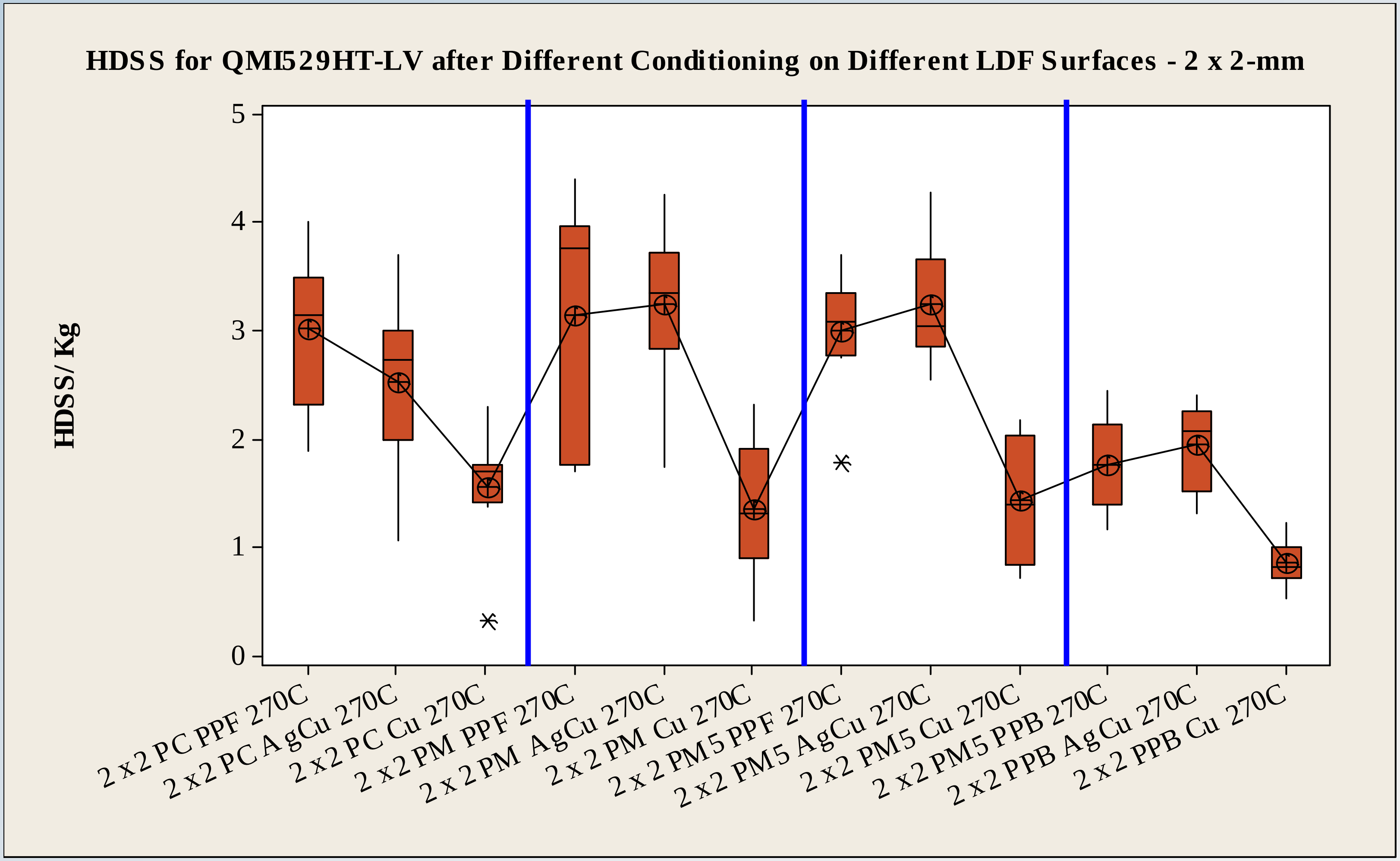
8 x 8-mm Die Size

8 x 8 PC PPF 270C	8	18.213	1.459	2.129	15.621	20.332
8 x 8 PM PPF 270C	8	16.651	1.999	3.994	13.846	18.946
8 x 8 PM5 PPF 270C	8	16.28	3.96	15.66	10.04	20.31
8 x 8 PPF PPB 270C	8	10.917	2.187	4.782	7.813	14.

2 x 2-mm Die Size Adhesion Summary

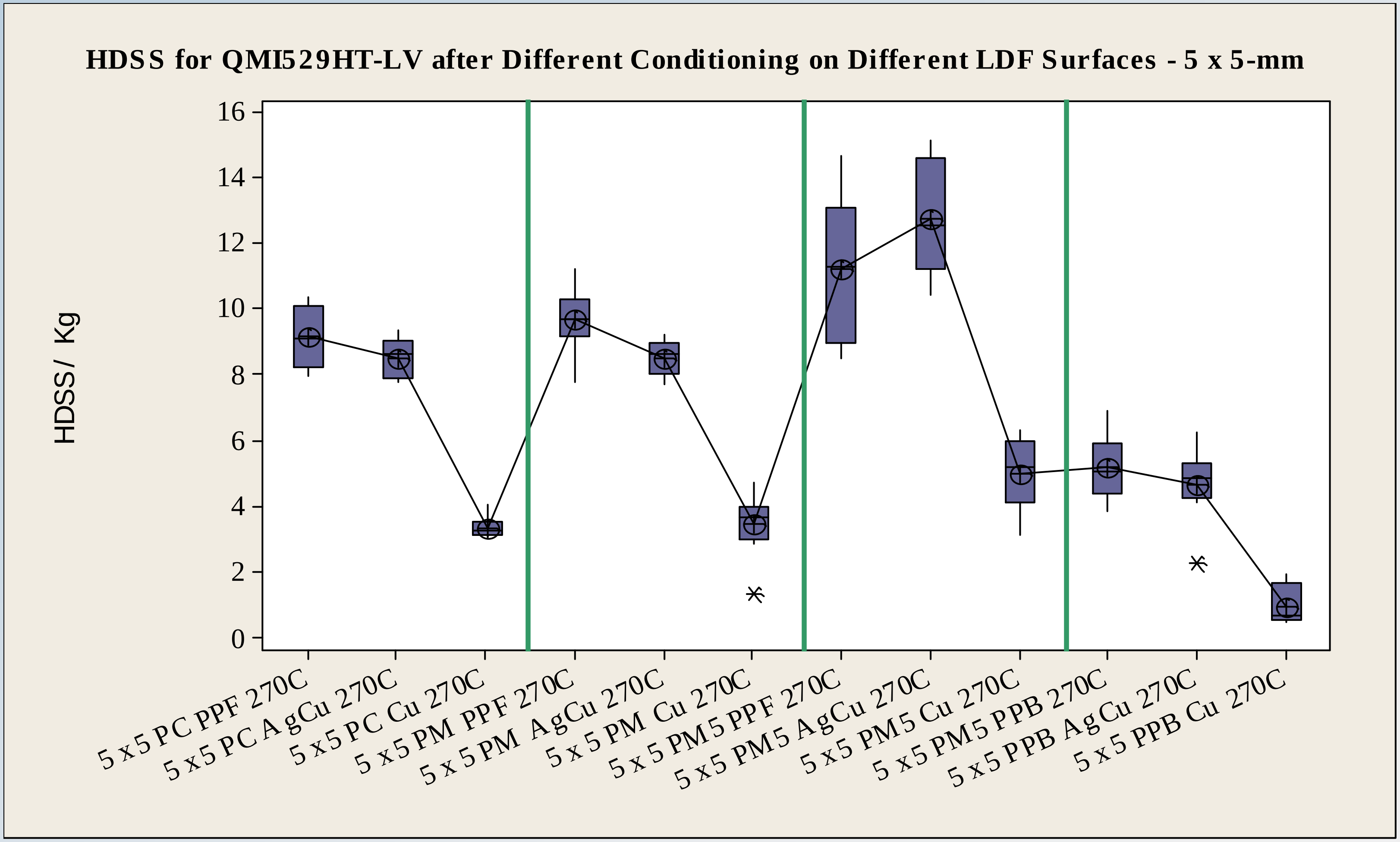
Henkel

- The below boxplot displays the adhesion for the 2 x 2-mm die size on all leadframe surfaces and at all test intervals: -



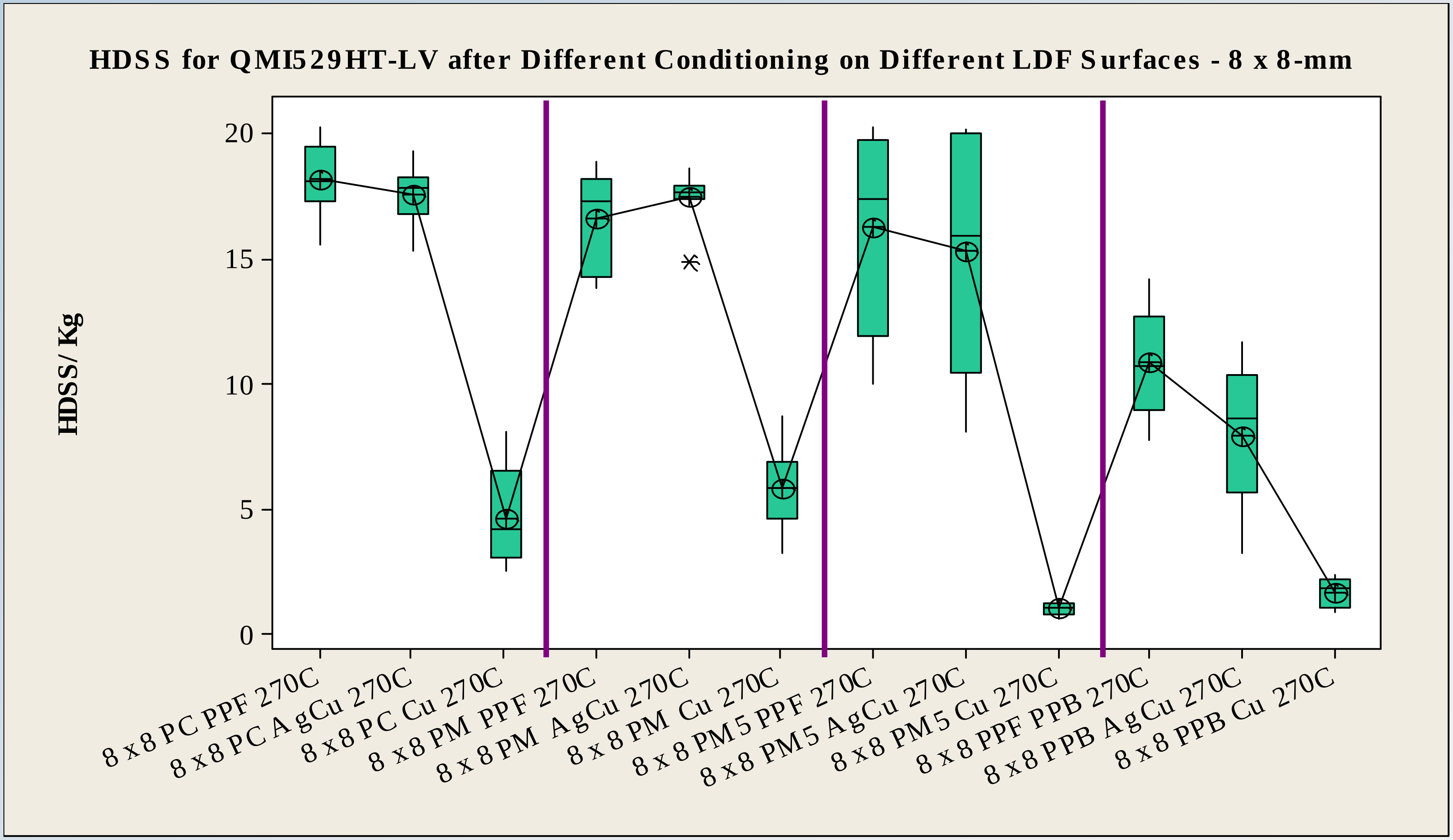
5 x 5-mm Die Size Adhesion Summary

- The below boxplot displays the adhesion for the 5 x 5-mm die size on all leadframe surfaces and at all test intervals: -



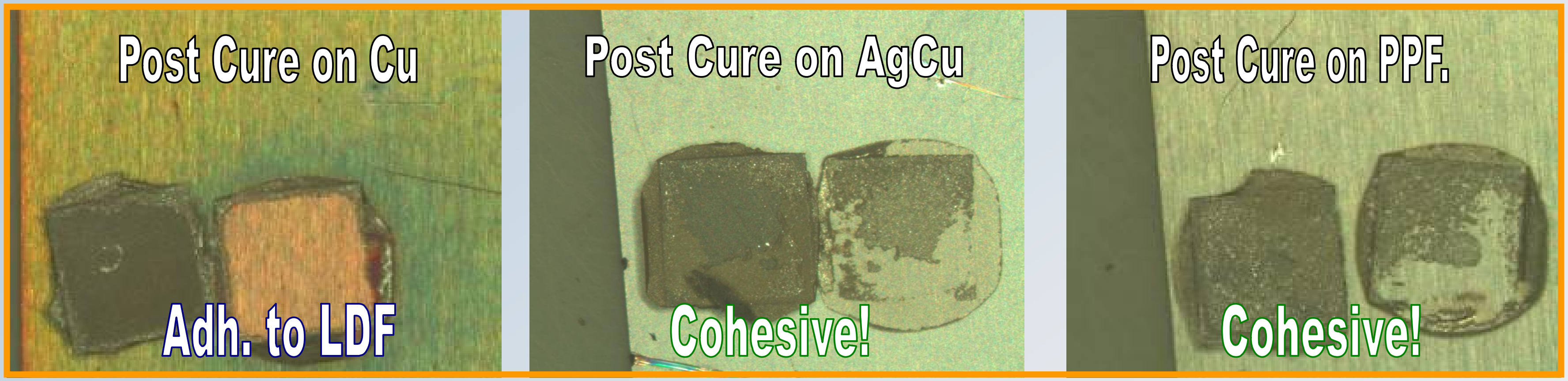
8 x 8-mm Die Size Adhesion Summary

- The below boxplot displays the adhesion for the 8 x 8-mm die size on all leadframe surfaces and at all test intervals: -



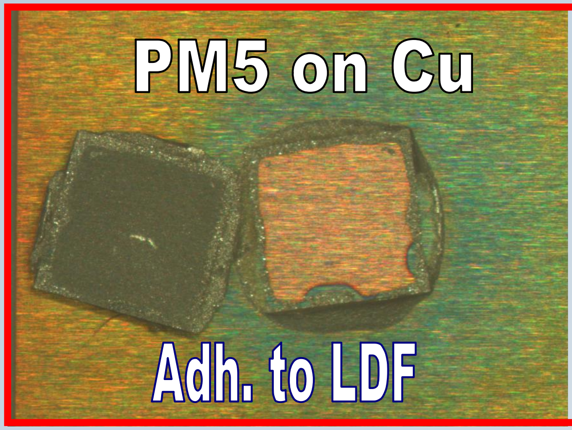
Die Shear Failure Mode

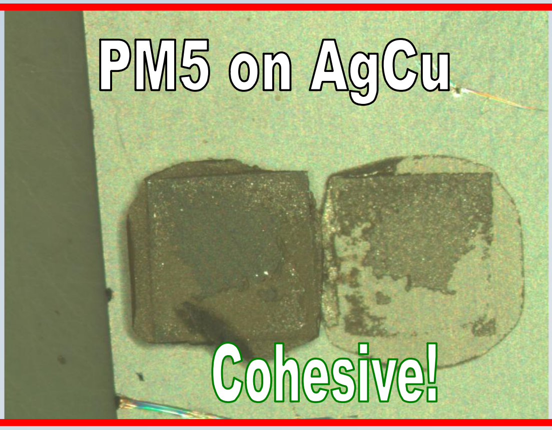
- The following die shear failures were observed at the 2 x 2-mm die size after cure and post mold bake: -

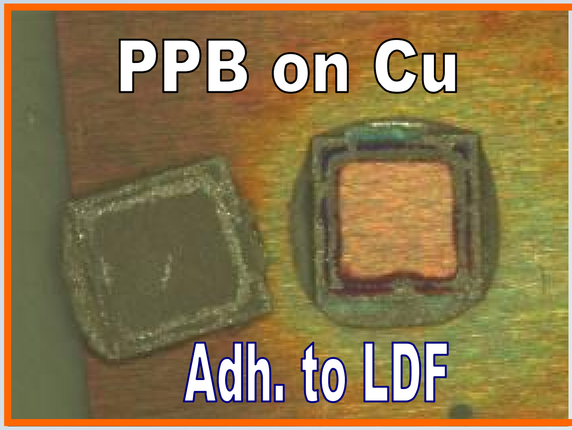


Die Shear Failure Mode

- The following die shear failures were observed at the 2 x 2-mm die size after PM5 and PPB bake: -

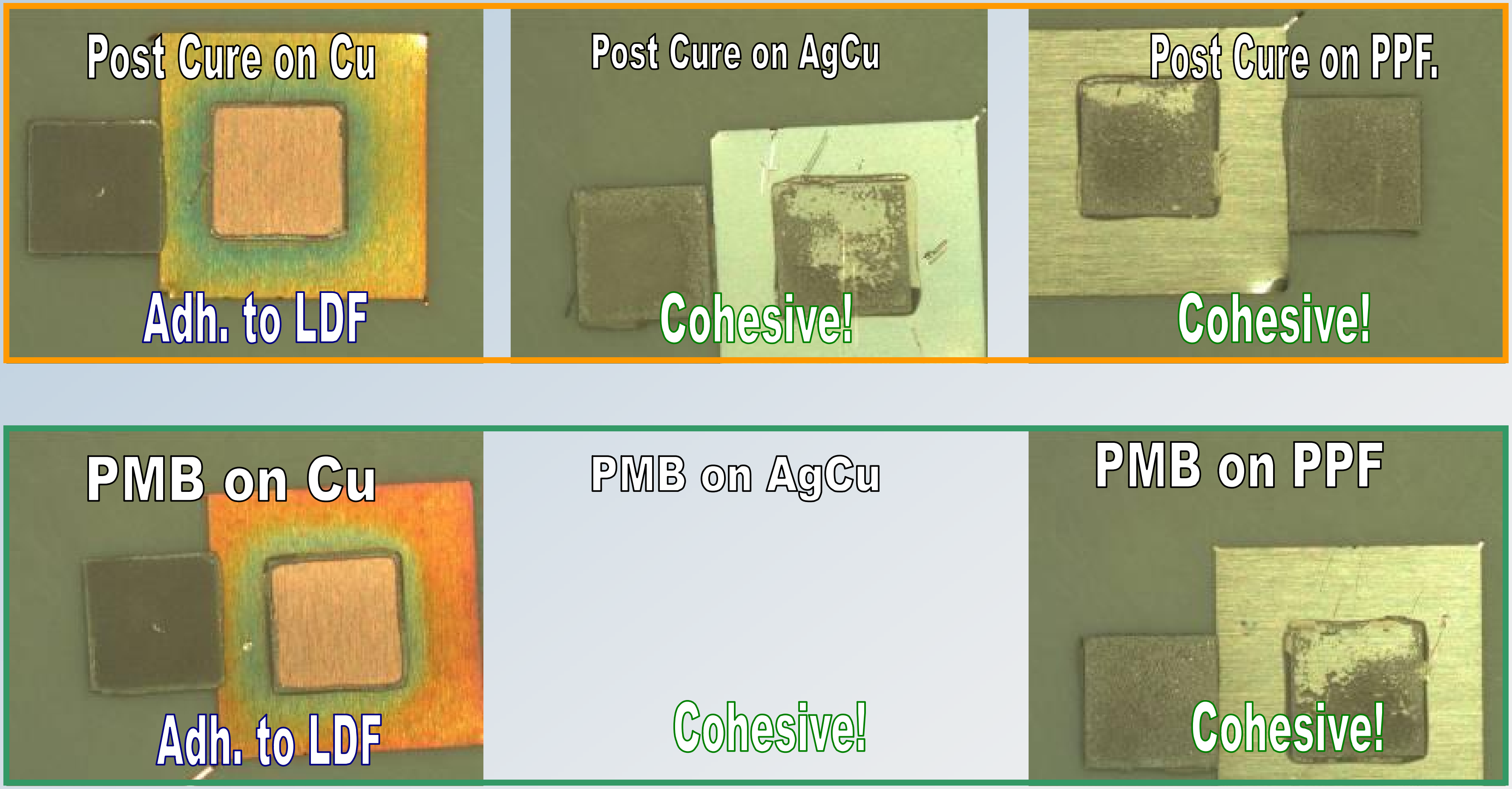






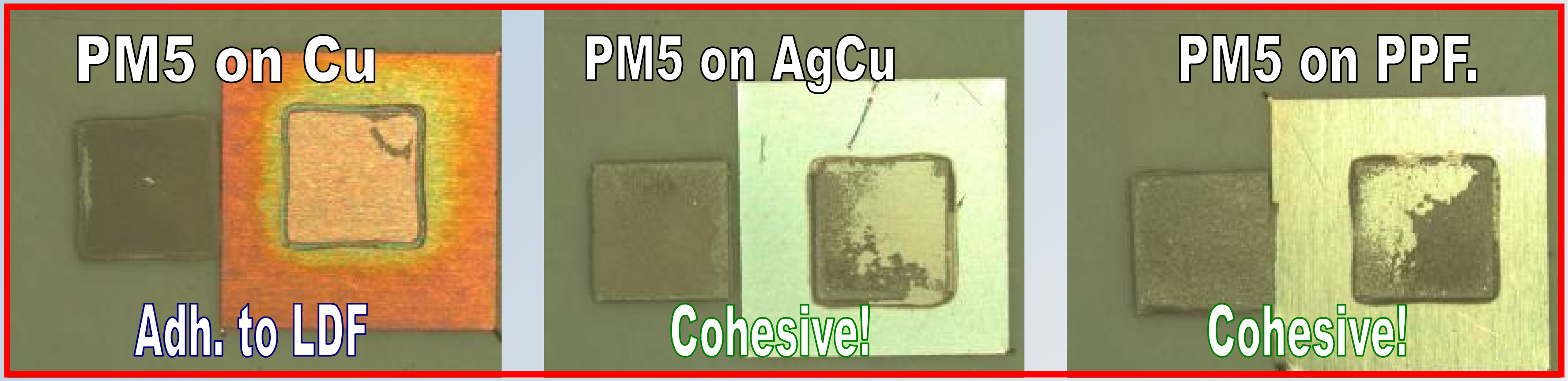
Die Shear Failure Mode

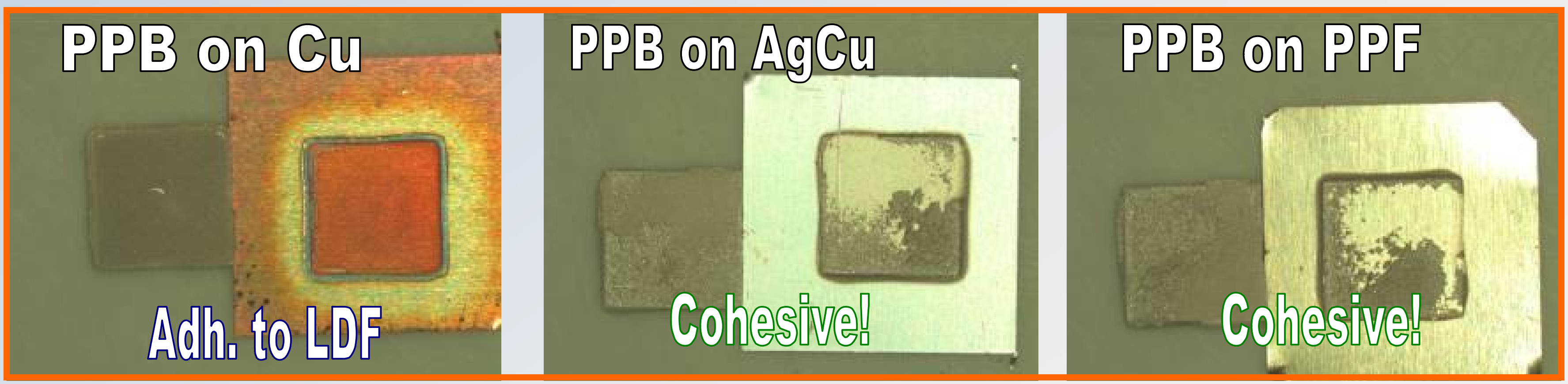
- The following die shear failures were observed at the 5 x 5-mm die size after cure and post mold bake: -



Die Shear Failure Mode

- The following die shear failures were observed at the 5 x 5-mm die size after PM5 and PPB bake: -





Die Shear Failure Mode

Henkel

- The following die shear failures were observed at the 8 x 8-mm die size after cure and post mold bake: -

Die Shear Failure Mode

- The following die shear failures were observed at the 8 x 8-mm die size after PM5 and PPB bake: -

Adhesion Comparison

- **The HDSS adhesion was compared for QMI529HT-LV versus other products targeting high power applications.**
- **The following data details the adhesion strength on Cu LDF: -**

Mean Adhesion Strength Data in g/mm^2 For QMI529HT-LV, FS849-TI, 84-1LMISR8 and QMI529HT on Cu LDF					
Die Size (mm)	Conditioning	FS849-TI (g/mm^2)	84-1LMISR8 (g/mm^2)	QMI529HT (g/mm^2)	QMI529HT-LV (g/mm^2)
2 x 2	Post Mold Bake (270°C)	390.7	341.7	152.0	339.7
	PM5 (270°C)	353.5	324.2	98	360.2
	PPB (270°C)	345.2	277.2	72	213.7
5 x 5	Post Mold Bake (270°C)	26.6	208.4	66	137.7
	PM5 (270°C)	59.8	142.2	36	125.9
	PPB (270°C)	37.0	131.4	27	38.4
8 x 8	Post Mold Bake (270°C)	26.4	179.6	52	91.7
	PM5 (270°C)	12.8	102.6	10	16.5
	PPB (270°C)	18.5	80.5	8	26.9

Adhesion Comparison

- The HDSS adhesion was compared for QMI529HT-LV versus other products targeting high power applications.
- The following data details the adhesion strength on AgCu LDF: -

Mean Adhesion Strength Data in g/mm² For QMI529HT-LV, FS849-TI, 84-1LMISR8 and QMI529HT on AgCu LDF					
Die Size (mm)	Conditioning	FS849-TI (g/mm²)	84-1LMISR8 (g/mm²)	QMI529HT (g/mm²)	QMI529HT-LV (g/mm²)
2 x 2	Post Mold Bake (270°C)	661.5	368.7	465.0	813
	PM5 (270°C)	587.7	214.2	639.2	810.5
	PPB (270°C)	433.2	220.2	303.8	490
5 x 5	Post Mold Bake (270°C)	268.3	191.0	399.3	339.8
	PM5 (270°C)	104.9	124.8	323.9	509.7
	PPB (270°C)	112.7	84.7	94.8	187.4
8 x 8	Post Mold Bake (270°C)	116.1	93.5	450.7	273.0
	PM5 (270°C)	48.3	60.8	339.2	239.4
	PPB (270°C)	20.7	55.5	147.1	124.5

Adhesion Comparison

- **The HDSS adhesion was compared for QMI529HT-LV versus other products targeting high power applications.**
- **The following data details the adhesion strength on PPF LDF: -**

Mean Adhesion Strength Data in g/mm² For QMI529HT-LV, FS849-TI, 84-1LMISR8 and QMI529HT on PPF LDF					
Die Size (mm)	Conditioning	FS849-TI (g/mm²)	84-1LMISR8 (g/mm²)	QMI529HT (g/mm²)	QMI529HT-LV (g/mm²)
2 x 2	Post Mold Bake (270°C)	406	251.7	344.7	784.5
	PM5 (270°C)	454.5	282.2	451.5	750.7
	PPB (270°C)	411.2	211.5	170.9	443.7
5 x 5	Post Mold Bake (270°C)	350.4	116.1	230.2	386.2
	PM5 (270°C)	231.1	114.4	118.0	448.9
	PPB (270°C)	214.2	71.6	44.6	207.3
8 x 8	Post Mold Bake (270°C)	284.3	54.8	395.7	260.2
	PM5 (270°C)	23.14	59.7	263.8	254.4
	PPB (270°C)	53.37	44.0	185.8	170.6

Summary/ Conclusions

- QMI529HT-LV has excellent adhesion to AgCu and PPF leadframes surfaces.
- The QMI529HT-LV exhibits very high adhesion performance on AgCu and PPF surfaces when the die size is small e.g. 2 x 2-mm.
- QMI529HT-LV does not exhibit high adhesion strength on the Cu LDF surface used in this trial.
- HDSS failure mode on Cu LDF is typically adhesive to the leadframe Cu surface at all test intervals.
- HDSS failure mode on both AgCu and PPF leadframe is typically Cohesive. The degree of cohesive failure does vary depending on pre-conditioning however some level of Cohesive failure is retained.

Recommendation:

QMI529HT-LV is an excellent choice for high power packages utilising AgCu or PPF leadframe surfaces and small die sizes.

QMI529HT- LV Open Time Evaluation.

Paul Gleeson/ Jose Venegas

Die Attach Paste TSE

17 March 2010

Background

- **Open time is the time that a die attach adhesive is left after dispense before die placement.**

- **Some adhesives lose low molecular weight components from the bulk when exposed to the atmosphere at ambient conditions. This loss of low molecular weight material can result in reduced wet out at die attach, impact final BLT, reduce fillet formation and cause die attach voiding. Therefore open time is a critical die attach adhesive property.**

- **The following adhesive needs to be evaluated for open time: -**
  - **QMI529HT-LV**

Experimental Test Flow

Henkel

Die attach Setup using ESEC2008xP Die bonder
Open time DOE
0, 15, 30, 45 and 60 Mins

Measurement Criteria:

Fillet coverage
Voiding (X-Ray)
Adhesion strength

- Die attach
  - Verify fillet coverage (Visual inspection)
  - X-Ray (Voiding-uncured)
- DA Cure Oven (air)
  - Take picture for fillet coverage
  - Cross Section (BLT)
  - Hot Die shear test @270'C
  - X-Ray (Voiding-cured)

Experimental Set Up

Henkel

- The following set up and equipment was used for the test build and subsequent analysis.

Die size :	2 x 2, 5 x 5 & 8 x 8-mm
DA Machine :	ESEC 2008xP.
Dispense method :	Writing with Pneumatic pump.
Die Attach Force:	Varied per die size - 50g, 200g & 250g.
Die Attach Bond Time:	Varied per die size - 200, 500, & 1500 ms.
Fillet height :	75%
Leadframe :	In-house AgCu
Void X-Ray :	Phoenix (parameters : 140 kV & 30uA)
Mat'l :	QMI529HT-LV
Open time :	0, 15, 30, 45, 60, 90 mins.

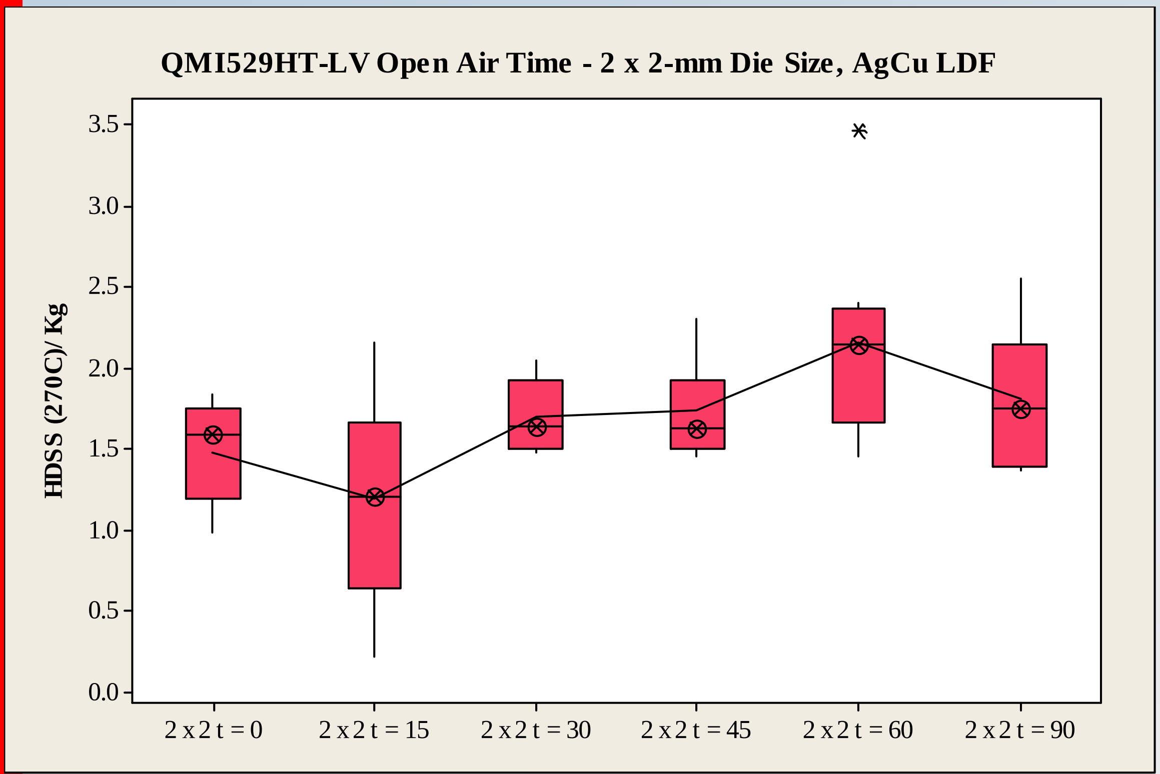
Hot Die Shear Strength (270°C) Comparison versus Open Time

- **The following basic statistics were obtained for HDSS (270°C): -**

Variable	Total Count	Mean	StDev	Variance	Min.	Median	Max.
2 x 2 t = 0	8	1.477	0.310	0.096	0.985	1.584	1.841
2 x 2 t = 15	8	1.196	0.632	0.399	0.214	1.211	2.151
2 x 2 t = 30	8	1.6988	0.2173	0.0472	1.4740	1.6395	2.0400
2 x 2 t = 45	8	1.733	0.290	0.084	1.453	1.619	2.310
2 x 2 t = 60	8	2.156	0.626	0.392	1.447	2.144	3.466
2 x 2 t = 90	8	1.809	0.441	0.194	1.371	1.753	2.552
5 x 5 t =0	8	9.106	0.920	0.846	7.236	9.405	10.098
5 x 5 t = 15	8	7.951	0.872	0.761	6.961	7.786	9.785
5 x 5 t = 30	8	8.167	0.964	0.929	6.864	8.035	9.650
5 x 5 t = 45	8	6.388	1.119	1.253	4.847	6.271	8.050
5 x 5 t = 60	8	6.384	1.409	1.985	4.828	5.928	9.250
5 x 5 t = 90	8	6.186	0.874	0.764	4.833	6.190	7.832
8 x 8 t =0	8	13.185	1.391	1.935	11.419	12.967	15.071
8 x 8 t = 15	8	14.723	1.875	3.516	12.494	14.361	17.620
8 x 8 t = 30	8	15.146	1.204	1.449	13.021	15.378	16.695
8 x 8 t = 45	8	16.946	1.483	2.201	14.314	17.203	19.449
8 x 8 t = 60	8	15.840	1.223	1.496	13.964	15.900	17.545
8 x 8 t = 90	8	15.644	1.234	1.522	13.726	16.043	17.013

Hot Die Shear Strength (270°C) Comparison versus Open Time

- **The below boxplot and ANOVA further display results for HDSS at the 2 x 2-mm die size (270°C): -**

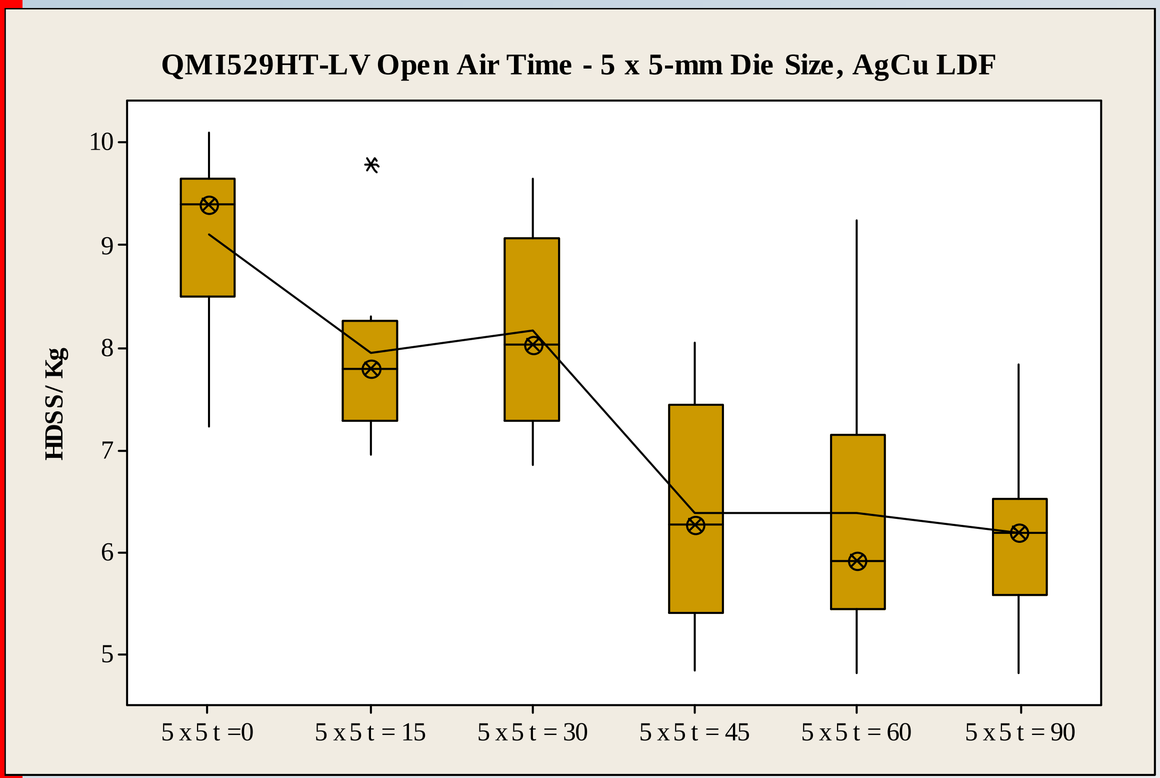



```
Source  DF      SS     MS     F      P
Factor   5   4.168  0.834  4.13  0.004
Error   42   8.487  0.202
Total   47  12.654

S = 0.4495   R-Sq = 32.93%   R-Sq(adj) = 24.95%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level         N    Mean   StDev  --+---------+---------+---------+----
2 x 2 t = 0   8  1.4773  0.3097      (------*-----)
2 x 2 t = 15  8  1.1964  0.6315  (-----*-----)
2 x 2 t = 30  8  1.6988  0.2173           (-----*-----)
2 x 2 t = 45  8  1.7326  0.2903           (------*-----)
2 x 2 t = 60  8  2.1555  0.6258                    (-----*------)
2 x 2 t = 90  8  1.8095  0.4409             (-----*------)
                                 --+---------+---------+---------+----
                                 1.00      1.50      2.00      2.50

Pooled StDev = 0.4495
```

HDSS statistically equivalent, irrespective of open time interval

Hot Die Shear Strength (270°C) Comparison versus Open Time

- **The below boxplot and ANOVA further display results for HDSS at the 5 x 5-mm die size (270°C): -**

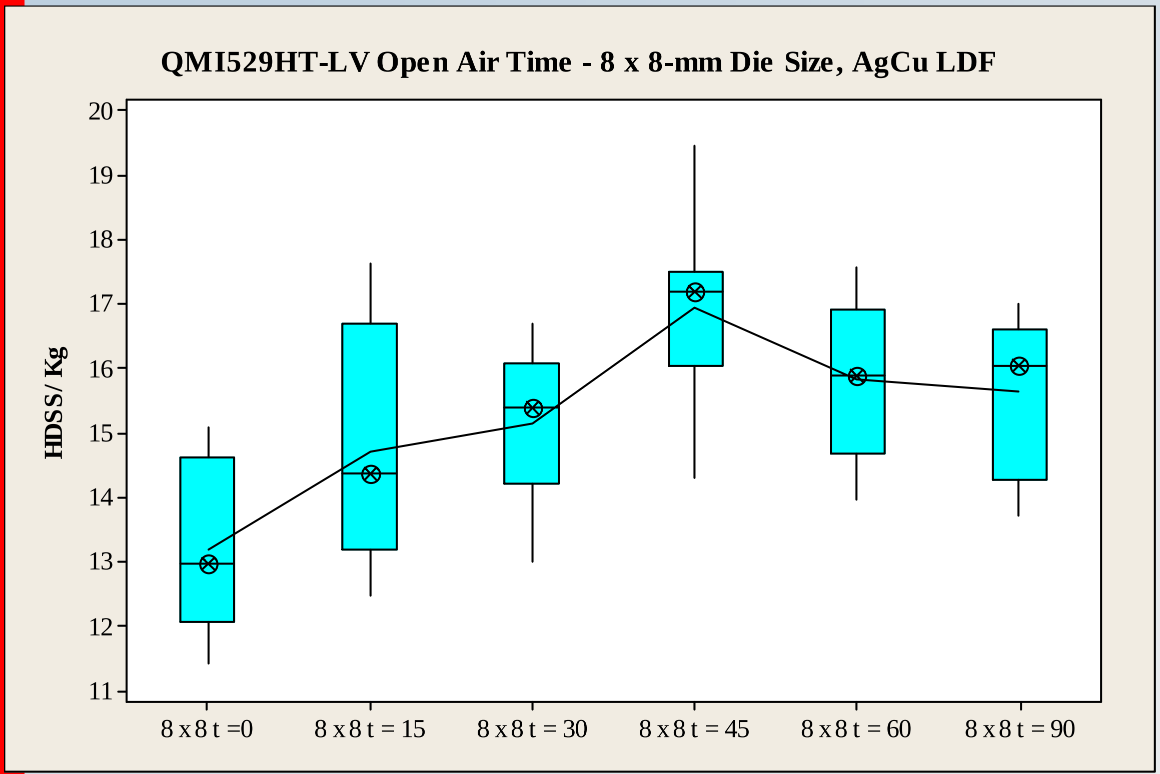



```
Source  DF      SS     MS      F      P
Factor   5   58.62  11.72  10.76  0.000
Error   42   45.77   1.09
Total   47  104.38

S = 1.044   R-Sq = 56.16%   R-Sq(adj) = 50.94%

                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N   Mean  StDev  -----+---------+---------+---------+---
5 x 5 t =0    8  9.106  0.920                           (-----*-----)
5 x 5 t = 15  8  7.951  0.872                  (-----*-----)
5 x 5 t = 30  8  8.167  0.964                    (-----*-----)
5 x 5 t = 45  8  6.388  1.119    (-----*-----)
5 x 5 t = 60  8  6.384  1.409    (-----*-----)
5 x 5 t = 90  8  6.186  0.874  (-----*-----)
                               -----+---------+---------+---------+---
                                  6.0       7.2       8.4       9.6

Pooled StDev = 1.044
```

HDSS data after 45 minutes open time is statistically lower than previous time test intervals

Hot Die Shear Strength (270°C) Comparison versus Open Time

- **The below boxplot and ANOVA further display results for HDSS at the 8 x 8-mm die size (270°C): -**




```
Source  DF      SS     MS     F      P
Factor   5   63.46  12.69  6.28  0.000
Error   42   84.83   2.02
Total   47  148.29

S = 1.421   R-Sq = 42.79%   R-Sq(adj) = 35.98%

                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  ---------+---------+---------+---------+
8 x 8 t =0    8  13.185  1.391  (------*------)
8 x 8 t = 15  8  14.723  1.875            (------*------)
8 x 8 t = 30  8  15.146  1.204               (------*------)
8 x 8 t = 45  8  16.946  1.483                           (------*------)
8 x 8 t = 60  8  15.840  1.223                    (------*-----)
8 x 8 t = 90  8  15.644  1.234                   (-----*------)
                                ---------+---------+---------+---------+
                                      13.5      15.0      16.5      18.0

Pooled StDev = 1.421
```

No statistically significant reduction in HDSS as a function of open time!

Assessment of Voiding versus Open Time

- **Voiding was checked at various open time intervals: -**

Figure 1. T = 0 mins, 2 x 2-mm Die.

Figure 2. T = 30 mins, 2 x 2-mm Die.

No voiding as a function of open time test interval!

Figure 3. T = 60 mins, 2 x 2-mm Die.

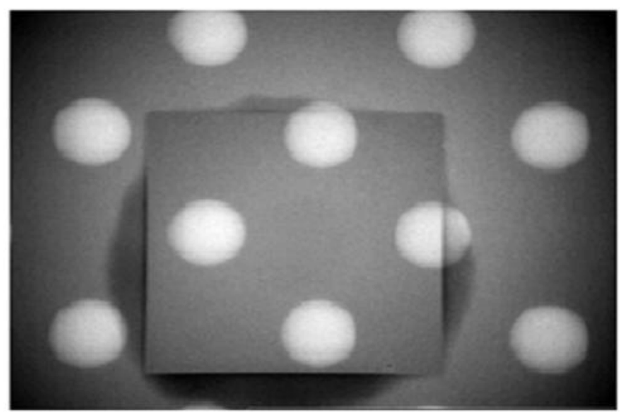


Figure 4. T = 90 mins, 2 x 2-mm Die.

Assessment of Voiding versus Open Time

- **Voiding was checked at various open time intervals: -**

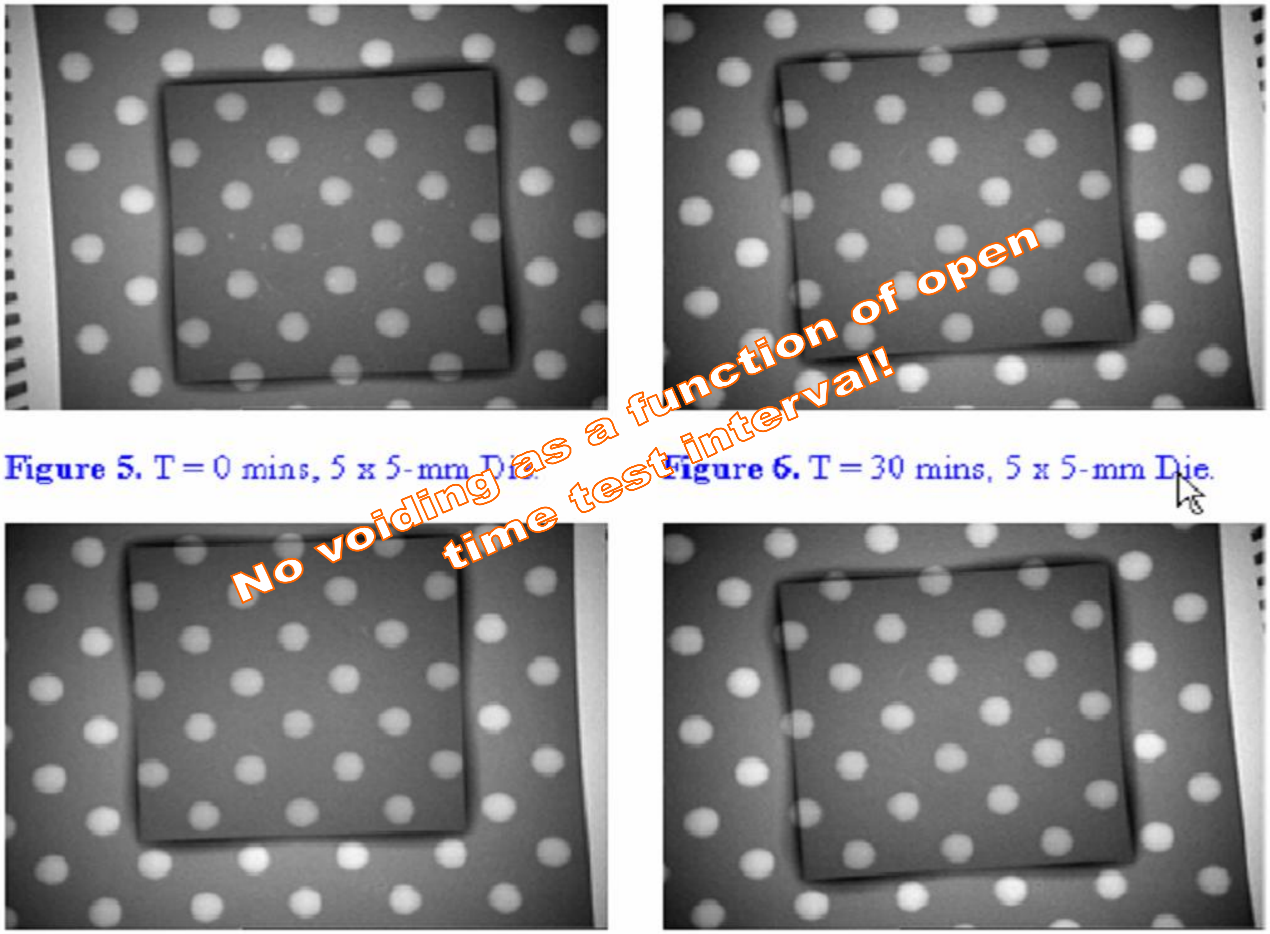


Figure 5. T = 0 mins, 5 x 5-mm Die.

Figure 6. T = 30 mins, 5 x 5-mm Die.

Figure 7. T = 60 mins, 5 x 5-mm Die.

Figure 8. T = 90 mins, 5 x 5-mm Die.

Assessment of Voiding versus Open Time

- **Voiding was checked at various open time intervals: -**

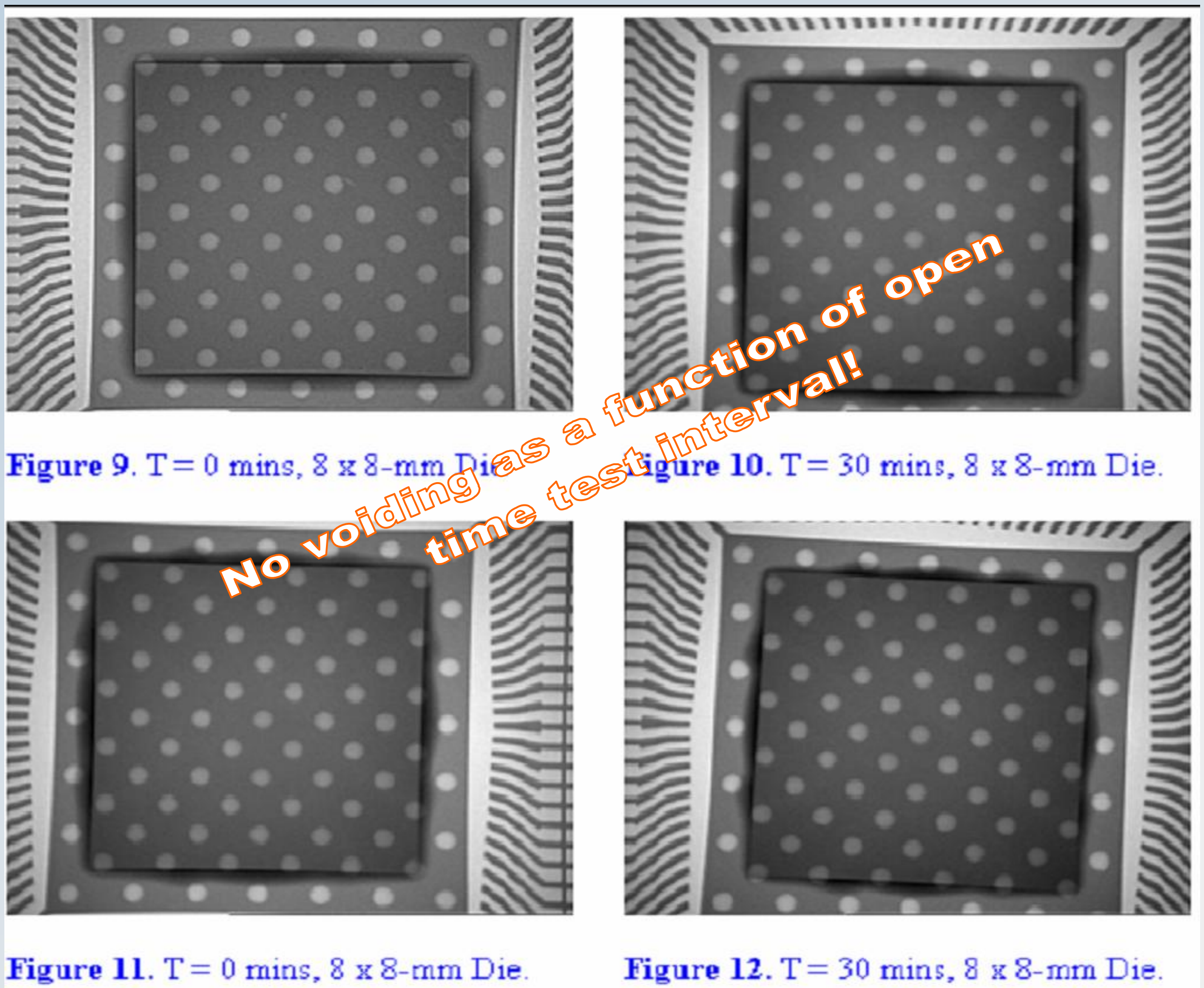


Figure 9. T = 0 mins, 8 x 8-mm Die.

Figure 10. T = 30 mins, 8 x 8-mm Die.

Figure 11. T = 0 mins, 8 x 8-mm Die.

Figure 12. T = 30 mins, 8 x 8-mm Die.

Fillet Coverage versus Open Time

- **Fillet coverage was compared at the various different open time intervals, 2 x 2-mm die size: -**

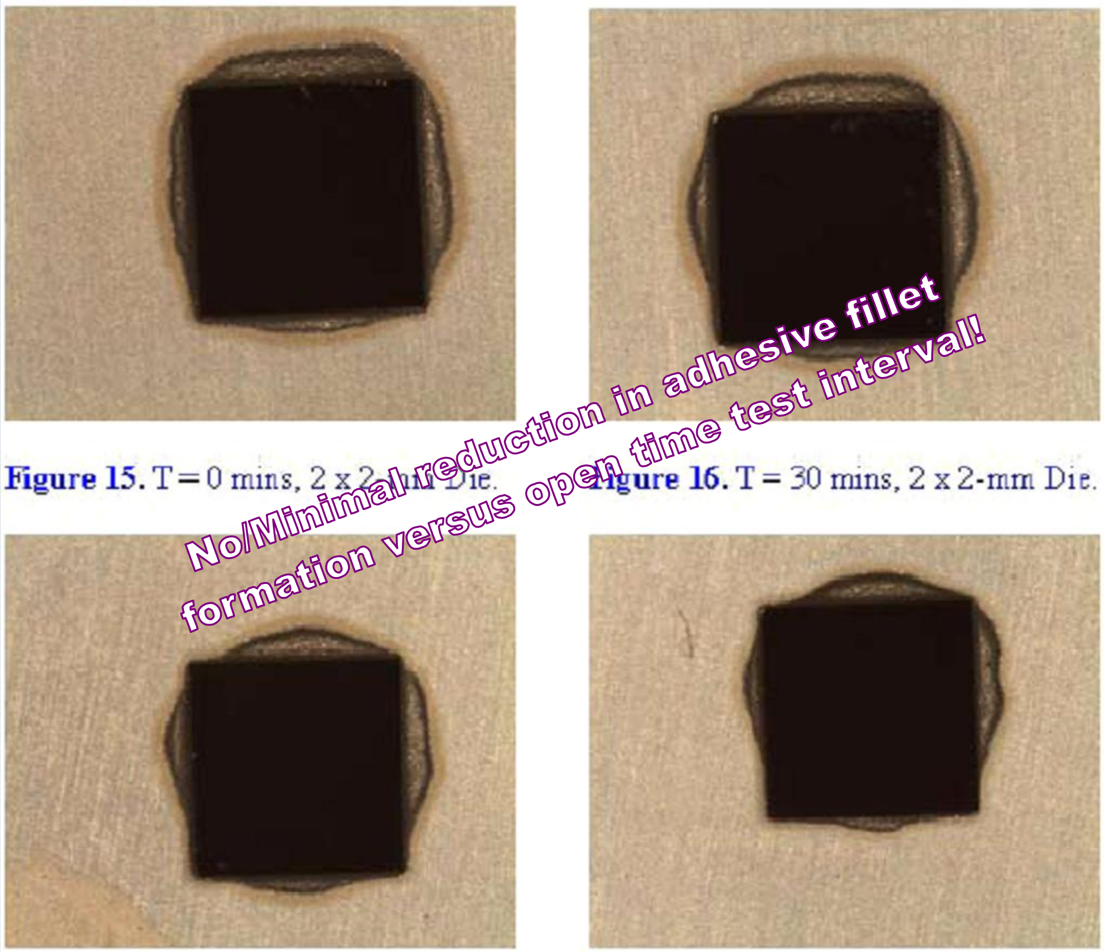


Figure 15. T = 0 mins, 2 x 2-mm Die.

Figure 16. T = 30 mins, 2 x 2-mm Die.

Figure 17. T = 60 mins, 2 x 2-mm Die.

Figure 18. T = 90 mins, 2 x 2-mm Die.

Fillet Coverage versus Open Time

- **Fillet coverage was compared at the various different open time intervals, 5 x 5-mm die size: -**

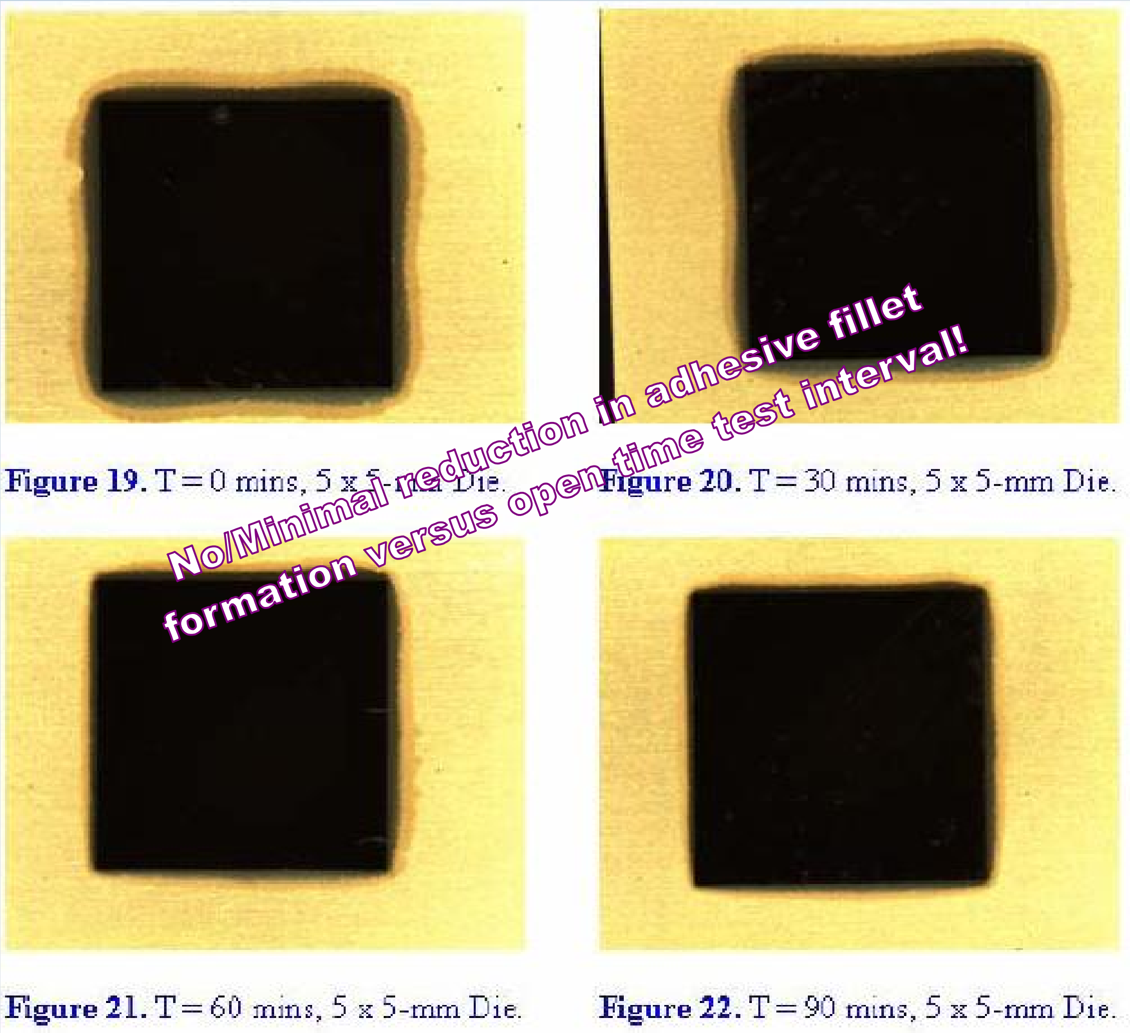


Figure 19. T = 0 mins, 5 x 5-mm Die.

Figure 20. T = 30 mins, 5 x 5-mm Die.

Figure 21. T = 60 mins, 5 x 5-mm Die.

Figure 22. T = 90 mins, 5 x 5-mm Die.

Fillet Coverage versus Open Time

- **Fillet coverage was compared at the various different open time intervals, 8 x 8-mm die size: -**

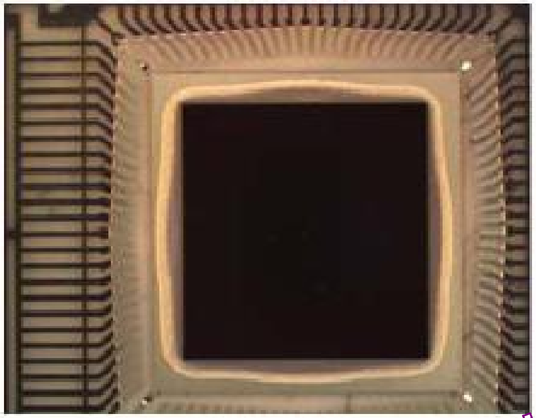


Figure 23. T = 0 mins, 8 x 8-mm Die.

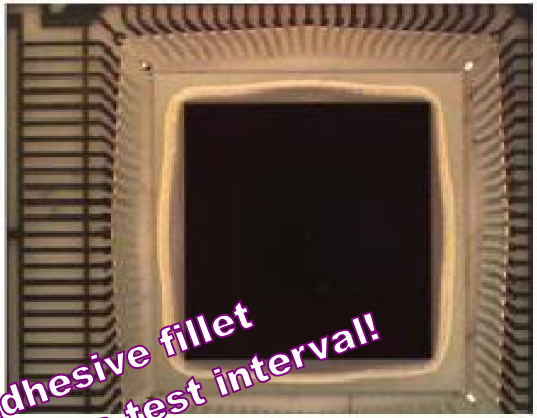


Figure 24. T = 30 mins, 8 x 8-mm Die.

No reduction in adhesive fillet formation versus open time test interval!

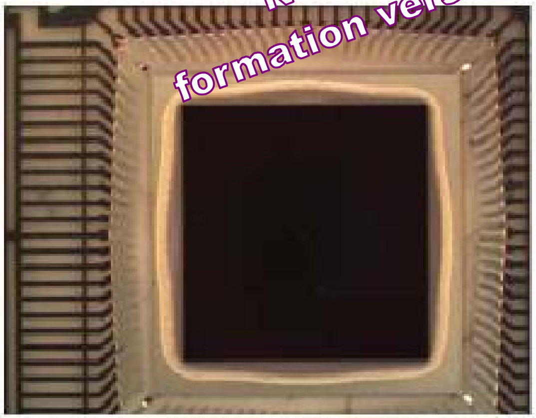


Figure 25. T = 60 mins, 8 x 8-mm Die.

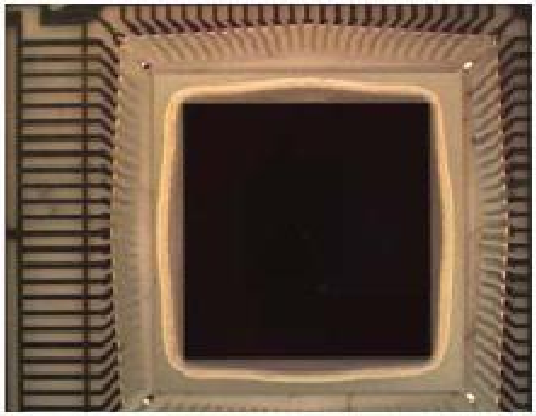


Figure 26. T = 90 mins, 8 x 8-mm Die.

Conclusions

- **HDSS**
  - **Is largely independent of open time. The 5 x 5-mm die shear condition did show a reduction in adhesion after 45 minute test interval however this trend was not observed with either 2 x 2-mm or 8 x 8-mm die sizes and should be treated with caution.**
  - **HDSS failure mode for all test parts at all die sizes was predominantly cohesive.**
- **Voiding**
  - **No voids were detected as a function of adhesive open time at any of the test intervals for any die size.**

Conclusions

Henkel

- **Fillet formation**
  - **Fillet formation appears to be marginally less at 90 minute open time interval, however differences are subtle rather then dramatic.**

- **Further Observations**
  - **QMI529HT-LV did display resin bleed out on the Henkel in-house leadframe used in this test (Resin bleed is surface dependant). Bleed was not a function of open time.**

- **Comments**
  - **QMI529HT-LV is a robust product in terms of adhesive open time, up to a period of 90 minutes.**

QMI529HT-LV Stage Time Evaluation.

Paul Gleeson/ Jose Venegas
Die Attach Paste TSE

18 March 2010

Background

- Stage time is the time that a die attach adhesive joint is left before entering the curing oven after the attach process.
- Some adhesives lose low molecular weight components from the bulk when exposed to the atmosphere at ambient conditions. This loss of low molecular weight material can impact final BLT and cause die attach voiding. Therefore stage time is a critical die attach adhesive property.
- The following adhesive needs to be evaluated for adhesive stage time: -
  - QMI529HT-LV

Experimental Test Flow

Henkel

Material :

QMI529HT-LV

Die Attach (ESEC2008)
With different BLT (dry)
Thin and thick BL
(by Z-height measurement)

Measurement Criteria :

X-Ray (Voiding)
HDSS
Fillet Inspection (Bleed)

Varied of RT Staging Time

Void Check (*)
Sample size 16 units

Fail

Stop

Pass

Good unit

Experimental Set Up

Henkel

- The following set up and equipment was used for the test build and subsequent analysis.

  - Die size : 2 x 2, 5 x 5 & 8 x 8-mm
  - DA Machine : ESEC 2008xP.
  - Dispense method : Writing with Pneumatic pump.
  - Die Attach Force: Varied per die size - 50g, 200g & 250g.
  - Die Attach Bond Time: Varied per die size - 200, 500, & 1500 ms.
  - Fillet height : 75%
  - Leadframe : In-house AgCu
  - Void X-Ray : Phoenix (parameters : 140 kV & 30uA)
  - Mat'l : QMI529HT-LV
  - Open time : 0, 2, 4, 6, 8 Hours.

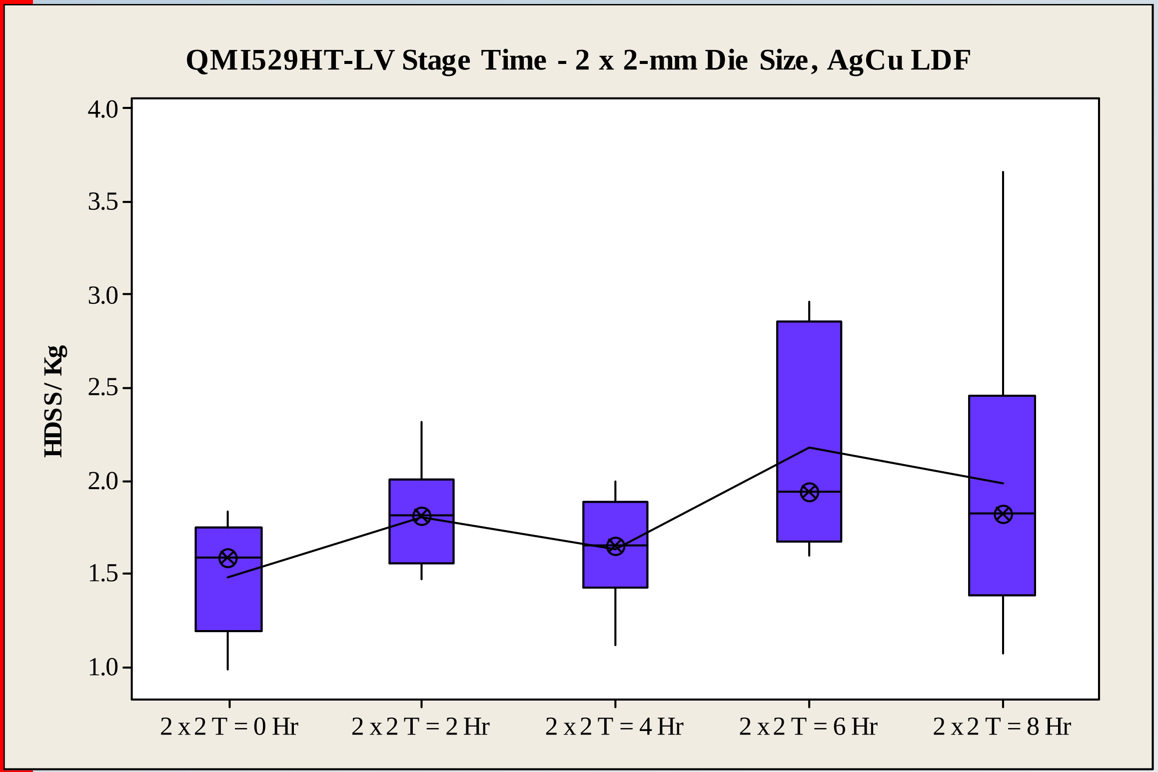
Hot Die Shear Strength (270°C) Comparison versus Stage Time

- **The following basic statistics were obtained for HDSS (270°C): -**

Variable	Total Count	Mean	StDev	Variance	Minimum	Median	Maximum
2 x 2 T = 0 Hr	8	1.477	0.310	0.096	0.985	1.584	1.841
2 x 2 T = 2 Hr	8	1.808	0.284	0.081	1.465	1.811	2.316
2 x 2 T = 4 Hr	8	1.631	0.288	0.083	1.111	1.652	1.996
2 x 2 T = 6 Hr	8	2.184	0.567	0.321	1.595	1.947	2.966
2 x 2 T = 8 Hr	8	1.983	0.827	0.684	1.070	1.821	3.662
5 x 5 T = 0 Hr	8	9.106	0.920	0.846	7.236	9.405	10.098
5 x 5 T = 2 Hr	8	8.277	0.978	0.956	6.870	8.271	9.445
5 x 5 T = 4 Hr	8	7.960	1.991	3.966	3.188	8.573	9.498
5 x 5 T = 6 Hr	8	7.374	2.281	5.204	2.004	7.960	9.134
5 x 5 T = 8 Hr	8	7.894	0.458	0.210	7.239	7.993	8.399
8 x 8 T = 0 Hr	8	13.185	1.391	1.935	11.419	12.967	15.071
8 x 8 T = 2 Hr	8	15.75	3.03	9.19	12.77	14.89	20.28
8 x 8 T = 4 Hr	8	18.10	2.88	8.29	12.97	19.66	20.31
8 x 8 T = 6 Hr	8	15.84	3.23	10.42	12.00	14.34	20.30
8 x 8 T = 8 Hr	8	14.510	2.715	7.370	12.042	13.743	19.756

Hot Die Shear Strength (270°C) Comparison versus Stage Time

- **The below boxplot and ANOVA further display results for HDSS at the 2 x 2-mm die size (270°C): -**



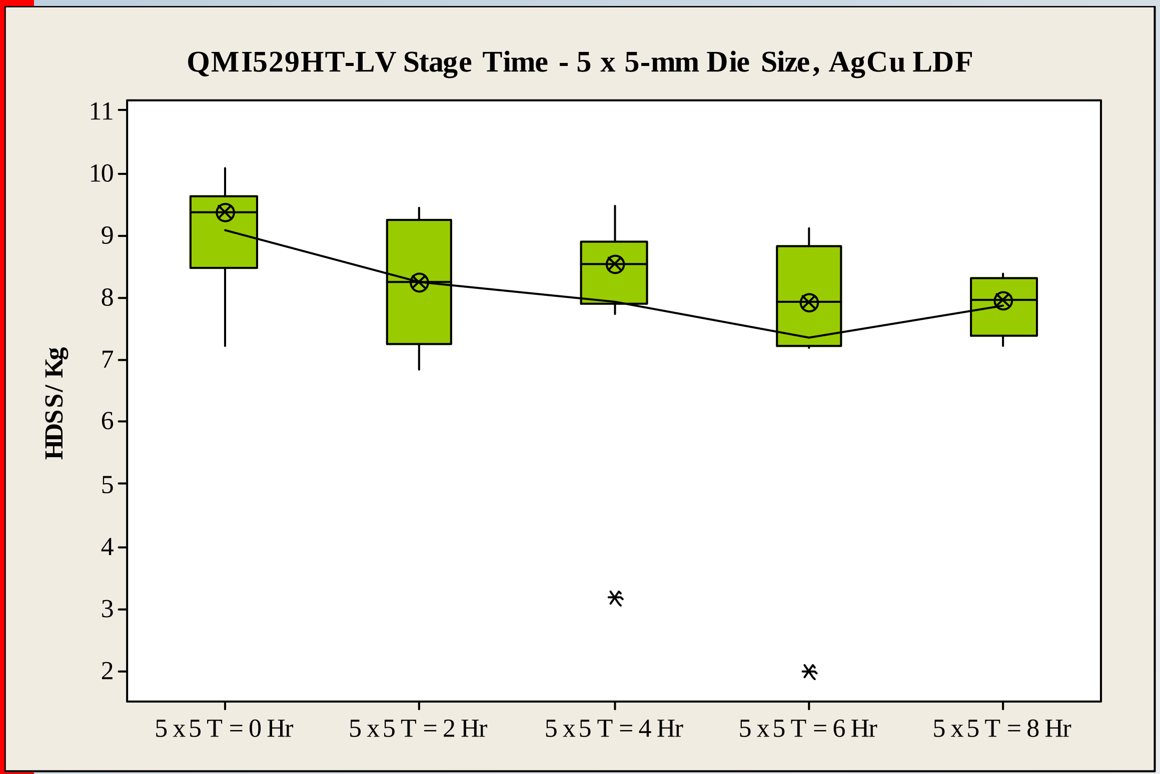

```
Source  DF      SS     MS     F      P
Factor   4   2.497  0.624  2.47  0.063
Error   35   8.856  0.253
Total   39  11.353

S = 0.5030   R-Sq = 21.99%   R-Sq(adj) = 13.08%

                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level          N    Mean   StDev  --+---------+---------+---------+-------
2 x 2 T = 0 Hr  8  1.4773  0.3097  (--------*--------)
2 x 2 T = 2 Hr  8  1.8081  0.2843          (--------*--------)
2 x 2 T = 4 Hr  8  1.6308  0.2882      (--------*--------)
2 x 2 T = 6 Hr  8  2.1836  0.5667                    (--------*--------)
2 x 2 T = 8 Hr  8  1.9829  0.8272              (--------*--------)
                                  --+---------+---------+---------+-------
                                  1.20      1.60      2.00      2.40

Pooled StDev = 0.5030
```

Some statistical differences in the data but the trend is not consistent with stage time interval!

Hot Die Shear Strength (270°C) Comparison versus Stage Time

Henkel

- **The below boxplot and ANOVA further display results for HDSS at the 5 x 5-mm die size (270°C): -**

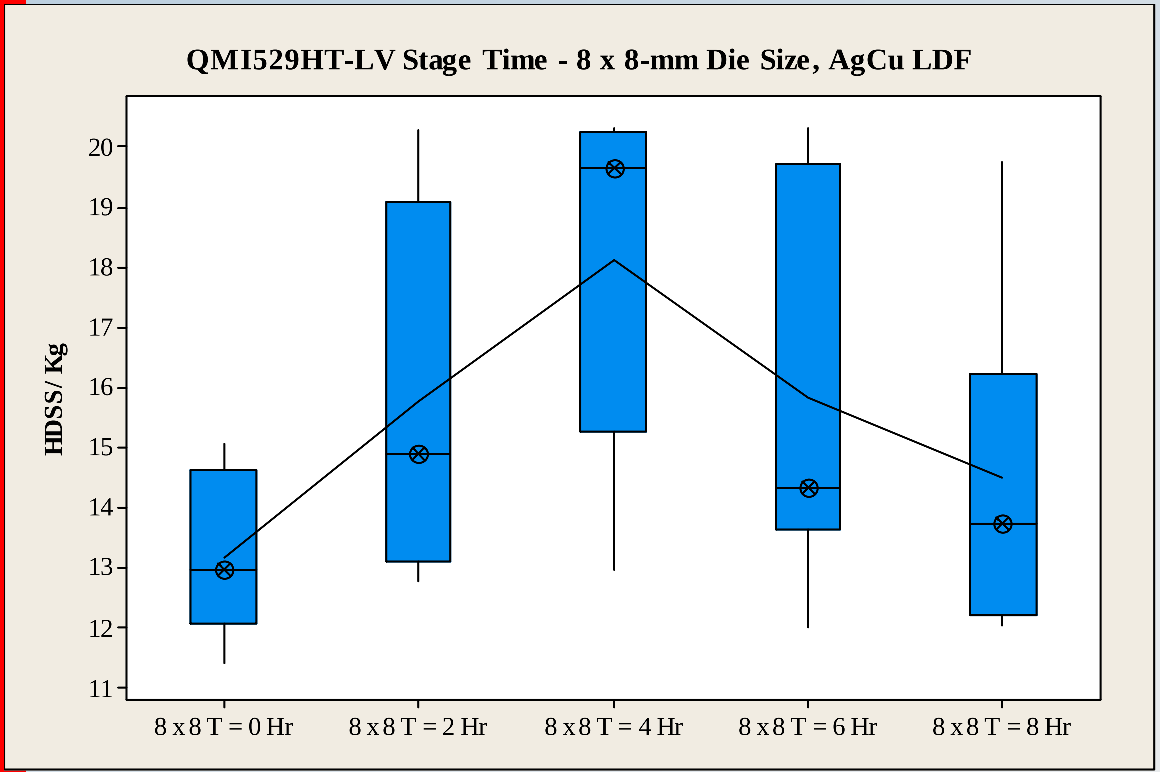



```
Source  DF     SS     MS     F      P
Factor   4  13.05   3.26  1.46  0.236
Error   35  78.28   2.24
Total   39  91.32

S = 1.495   R-Sq = 14.29%   R-Sq(adj) = 4.49%

                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level           N   Mean  StDev  -------+---------+---------+---------+--
5 x 5 T = 0 Hr  8  9.106  0.920                   (----------*----------)
5 x 5 T = 2 Hr  8  8.277  0.978           (----------*----------)
5 x 5 T = 4 Hr  8  7.960  1.991        (----------*---------)
5 x 5 T = 6 Hr  8  7.374  2.281  (----------*---------)
5 x 5 T = 8 Hr  8  7.894  0.458       (----------*----------)
                                 -------+---------+---------+---------+--
                                      7.0       8.0       9.0      10.0

Pooled StDev = 1.495
```

High degree of statistical equivalence!

Hot Die Shear Strength (270°C) Comparison versus Stage Time

- **The below boxplot and ANOVA further display results for HDSS at the 8 x 8-mm die size (270°C): -**




```
Source  DF      SS     MS     F      P
Factor   4  106.33  26.58  3.57  0.015
Error   35  260.48   7.44
Total   39  366.81

S = 2.728   R-Sq = 28.99%   R-Sq(adj) = 20.87%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N    Mean  StDev  -----+---------+---------+---------+----
8 x 8 T = 0 Hr  8  13.185  1.391  (-------*-------)
8 x 8 T = 2 Hr  8  15.751  3.032            (-------*-------)
8 x 8 T = 4 Hr  8  18.104  2.880                      (------*-------)
8 x 8 T = 6 Hr  8  15.836  3.228             (------*-------)
8 x 8 T = 8 Hr  8  14.510  2.715       (-------*-------)
                                  -----+---------+---------+---------+----
                                     12.5      15.0      17.5      20.0

Pooled StDev = 2.728
```

Some statistical differences in the data but the trend is not consistent with stage time interval!

Assessment of Voiding versus Stage Time

- **Voiding was checked at various stage time intervals using 2 x 2-mm Si Die: -**

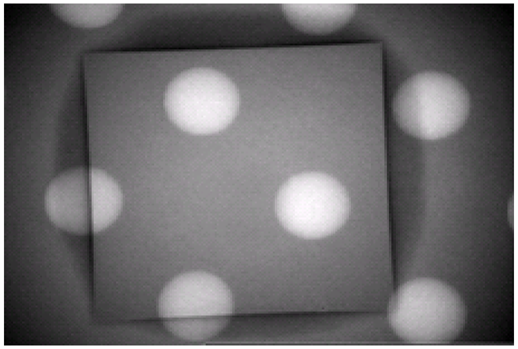


Figure 1. Stage Time, T = 0 Hrs.

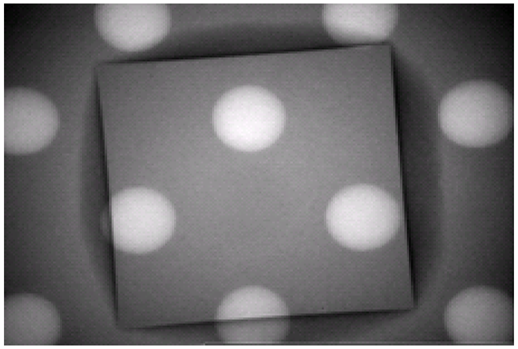


Figure 2. Stage Time, T = 2 Hrs.

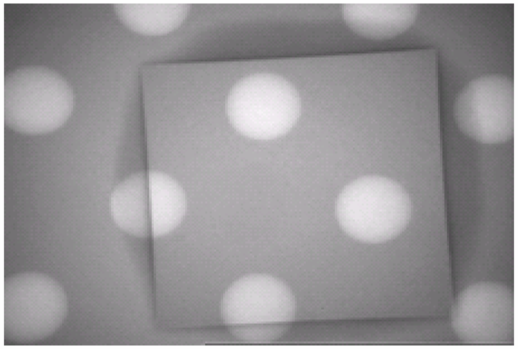


Figure 3. Stage Time, T = 4 Hrs.

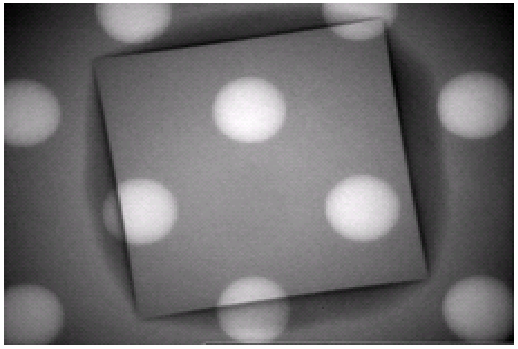


Figure 4. Stage Time, T = 6 Hrs.

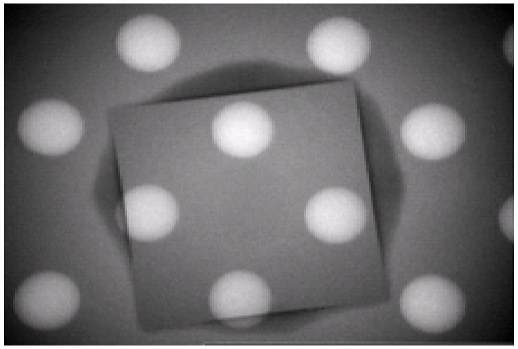


Figure 5. Stage Time, T = 8 Hrs.

No voiding as a function of stage time for the 2 x 2-mm die size.

Assessment of Voiding versus Stage Time

- **Voiding was checked at various stage time intervals using 5 x 5-mm die: -**

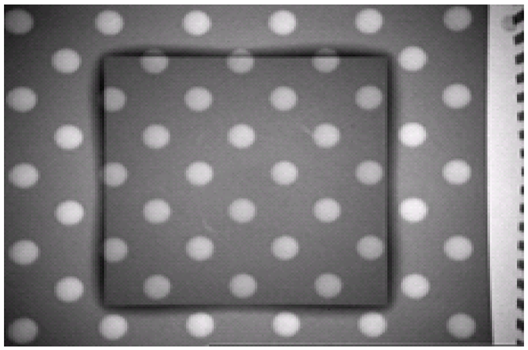


Figure 6. Stage Time, T = 0 Hrs.

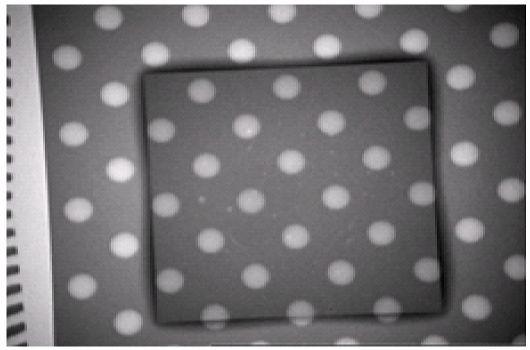


Figure 7. Stage Time, T = 2 Hrs.

Figure 8. Stage Time, T = 4 Hrs.

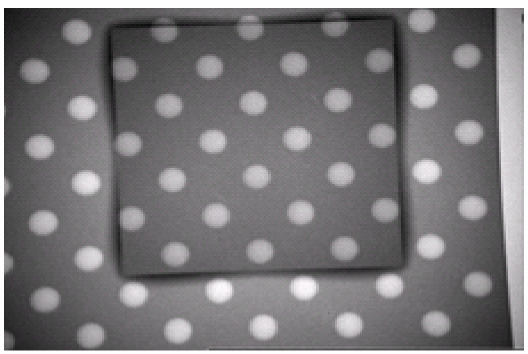


Figure 9. Stage Time, T = 6 Hrs.

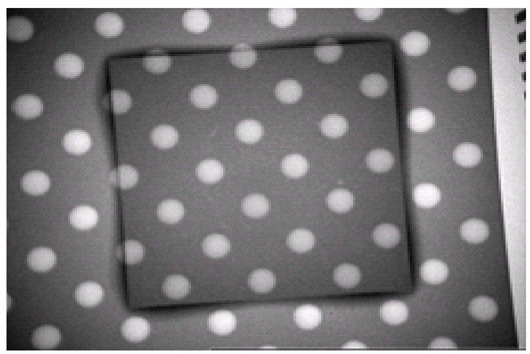


Figure 10. Stage Time, T = 8 Hrs.

No voiding as a function of stage time for the 5 x 5-mm die size.

Assessment of Voiding versus Stage Time

- **Voiding was checked at various stage time intervals using 8 x 8-mm die: -**

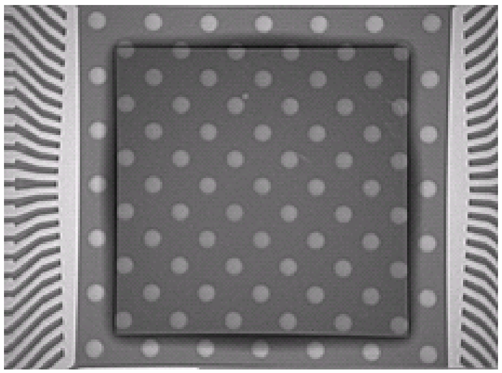


Figure 11. Stage Time, T = 0 Hrs.

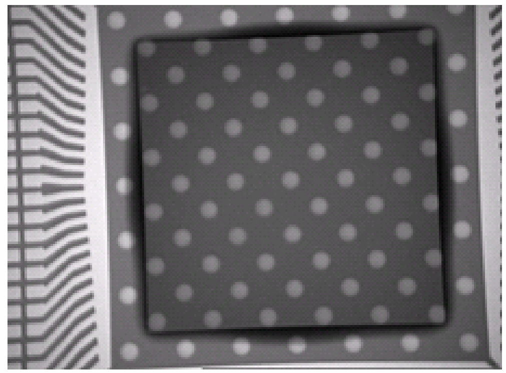


Figure 12. Stage Time, T = 2 Hrs.

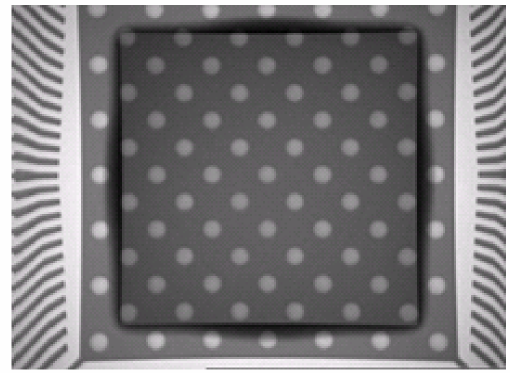


Figure 13. Stage Time, T = 4 Hrs.

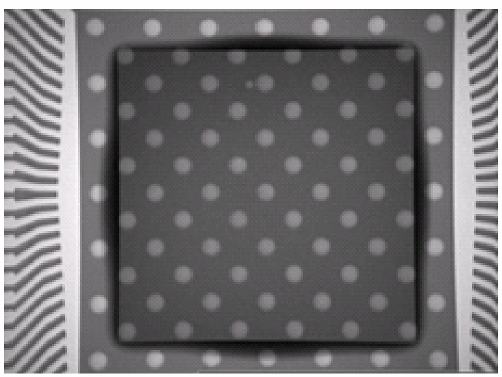


Figure 14. Stage Time, T = 2 Hrs.

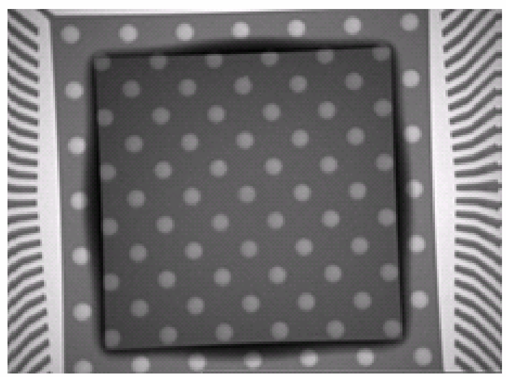


Figure 15. Stage Time, T = 4 Hrs.

No voiding as a function of stage time for the 8 x 8-mm die size.

Fillet Inspection (Bleed) versus Stage Time

- **Fillets were inspected for increased adhesive flow and resin bleed at the various different stage time intervals, 2 x 2-mm die size: -**

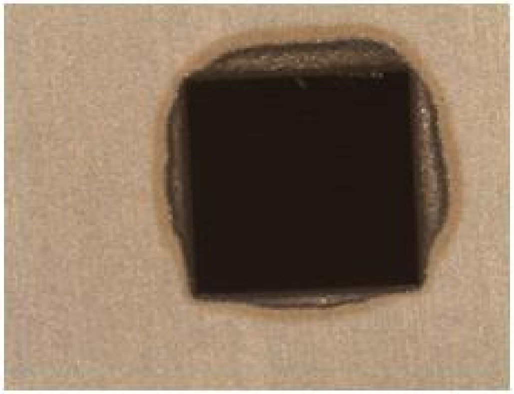


Figure 16. Fillet coverage, T = 0 Hrs.

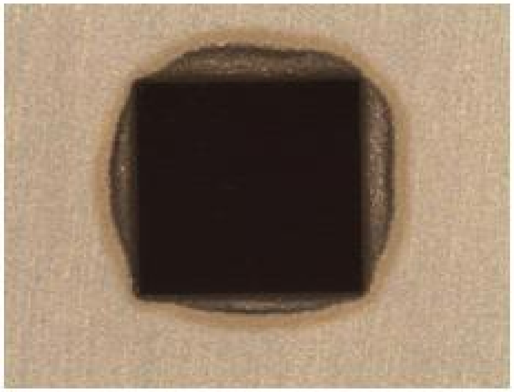


Figure 17. Fillet Coverage, T = 2 Hrs.

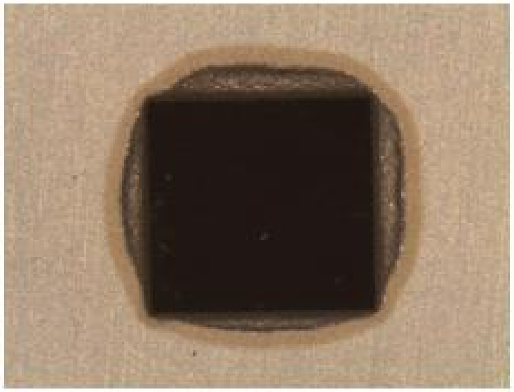


Figure 18. Fillet Coverage, T = 4 Hrs.

Figure 19. Fillet Coverage, T = 6 Hrs.

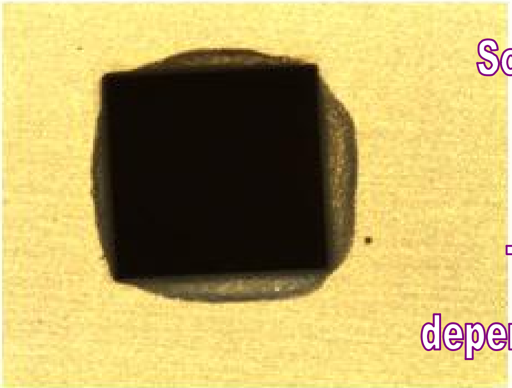


Figure 20. Fillet Coverage, T = 8 Hrs.

Some resin bleed can be seen on the surface of the AgCu leadframe.
The bleed is not stage time dependant, but substrate dependant!

Fillet Inspection (Bleed) versus Stage Time

- **Fillets were inspected for increased adhesive flow and resin bleed at the various different stage time intervals, 5 x 5-mm die size: -**

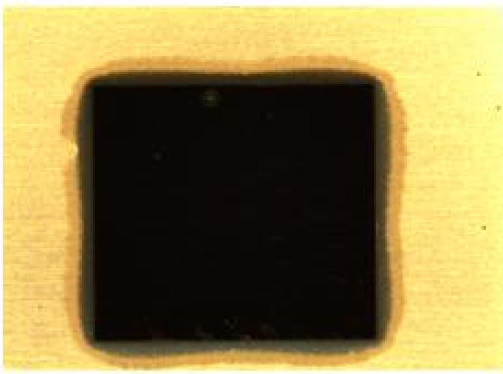


Figure 21. Fillet coverage, T = 0 Hrs.

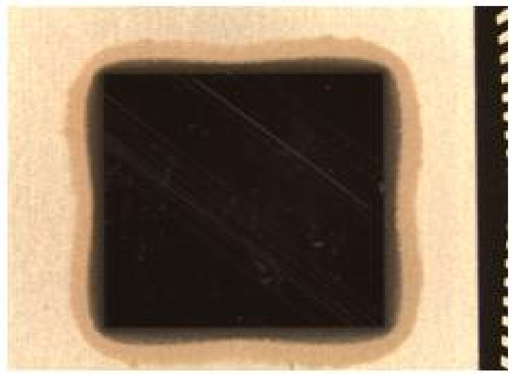


Figure 22. Fillet Coverage, T = 2 Hrs.

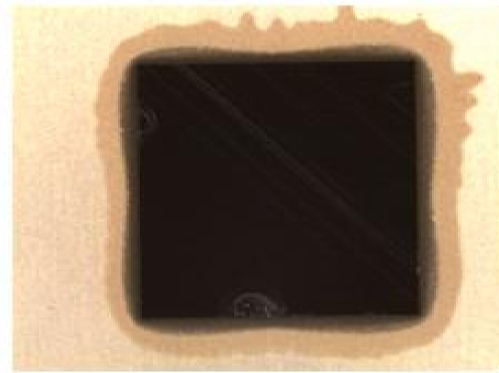


Figure 23. Fillet Coverage, T = 4 Hrs.

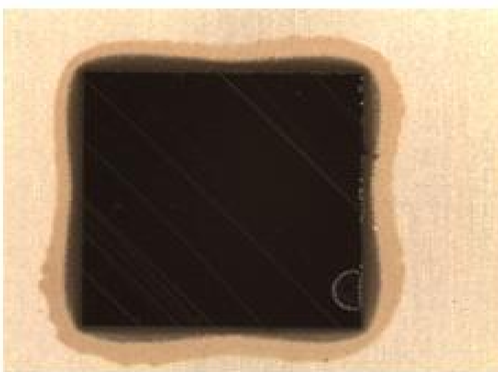


Figure 24. Fillet coverage, T = 6 Hrs.

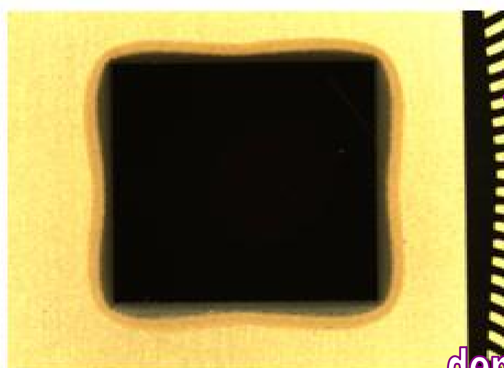


Figure 25. Fillet Coverage, T = 8 Hrs.

Some resin bleed can be seen
on the surface of
the AgCu leadframe.
The bleed is not stage time
dependant, but substrate dependant!

Fillet Inspection (Bleed) versus Stage Time

- **Fillets were inspected for increased adhesive flow and resin bleed at the various different stage time intervals, 8 x 8-mm die size: -**

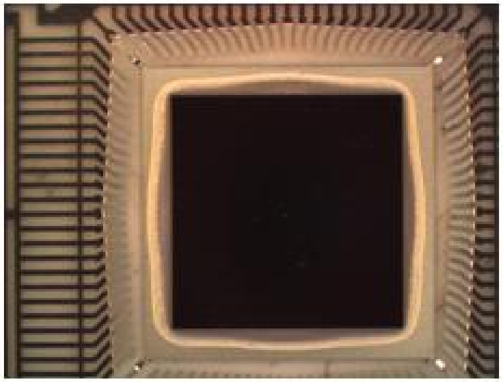


Figure 26. Fillet coverage, T = 0 Hrs.

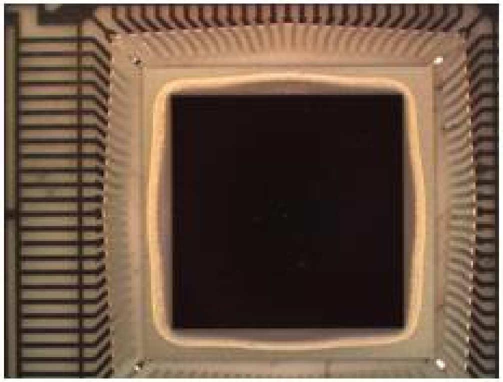


Figure 27. Fillet Coverage, T = 2 Hrs.

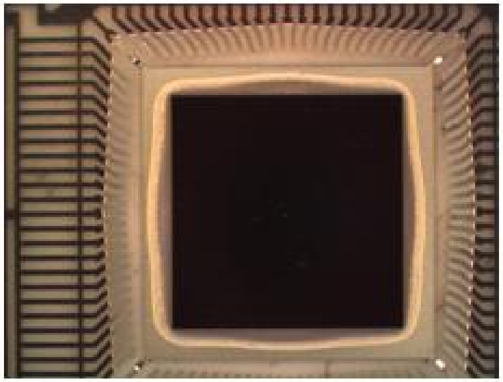


Figure 28. Fillet Coverage, T = 4 Hrs.

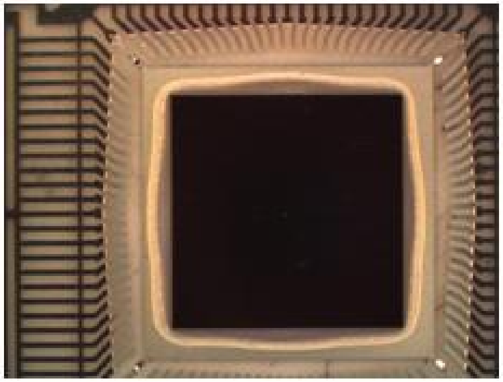


Figure 29. Fillet Coverage, T = 2 Hrs.

Figure 30. Fillet Coverage, T = 4 Hrs.

Some resin bleed can be seen
on the surface of
the AgCu leadframe.
The bleed is not stage time
dependant, but substrate dependant!

Conclusion

- HDSS is not adversely affected as a function of stage time at all die size test intervals.
- Voiding beneath the die is not observed as a function of adhesive stage time. In this trial the QMI529HT-LV showed no tendency to void beneath the attached die at any of the die size test intervals.
- Resin bleed is observed for QMI529HT-LV when using the Henkel internal AgCu test leadframe surface. The level of resin bleed does not relate to stage time test interval.
- Fillet flow versus stage time does not appear to be a issue with this product.

QMI529HT-LV Tailing Evaluation By Dot Dispense.

Paul Gleeson/ Javier Gutierrez

Die Attach Paste TSE

30 March 2010

Background

- QMI529HT-LV has been formulated to offer lower viscosity dispensing and improved electrical and thermal performance compared with standard QMI529HT.
- QMI529HT and Ablebond 84-1LMISR4 are widely used conductive die attach adhesives. QMI529HT is a similar formulation to the QMI529HT-LV, whilst Ablebond 84-1LMISR4 is considered the industry standard material in terms of needle dispense performance.
- It is necessary to characterise the dot dispense (tailing performance) of QMI529HT-LV performance versus the two control adhesives.

Experimental

Dot Dispense

- A standard dot dispense trial was performed to try and assess if there is any deterioration in the product dispense performance.

- After selecting the appropriate shot size the dispense test method is performed by dispensing adjacent dots in three consecutive rows using defined dispense conditions, before moving to next set of three dots using another condition: -

  - Dispense Needle: 0.4-mm diameter (EFD Blue 16”).
  - Dispense Pressure: 30 psi.
  - Dispense Time: 125 m/sec.
  - Dispense Height: 0.25-mm.
  - Dispense ‘Move Up’ Height: Varied – 350, 300, 250, 200, 150, 100 & 50 (mil).

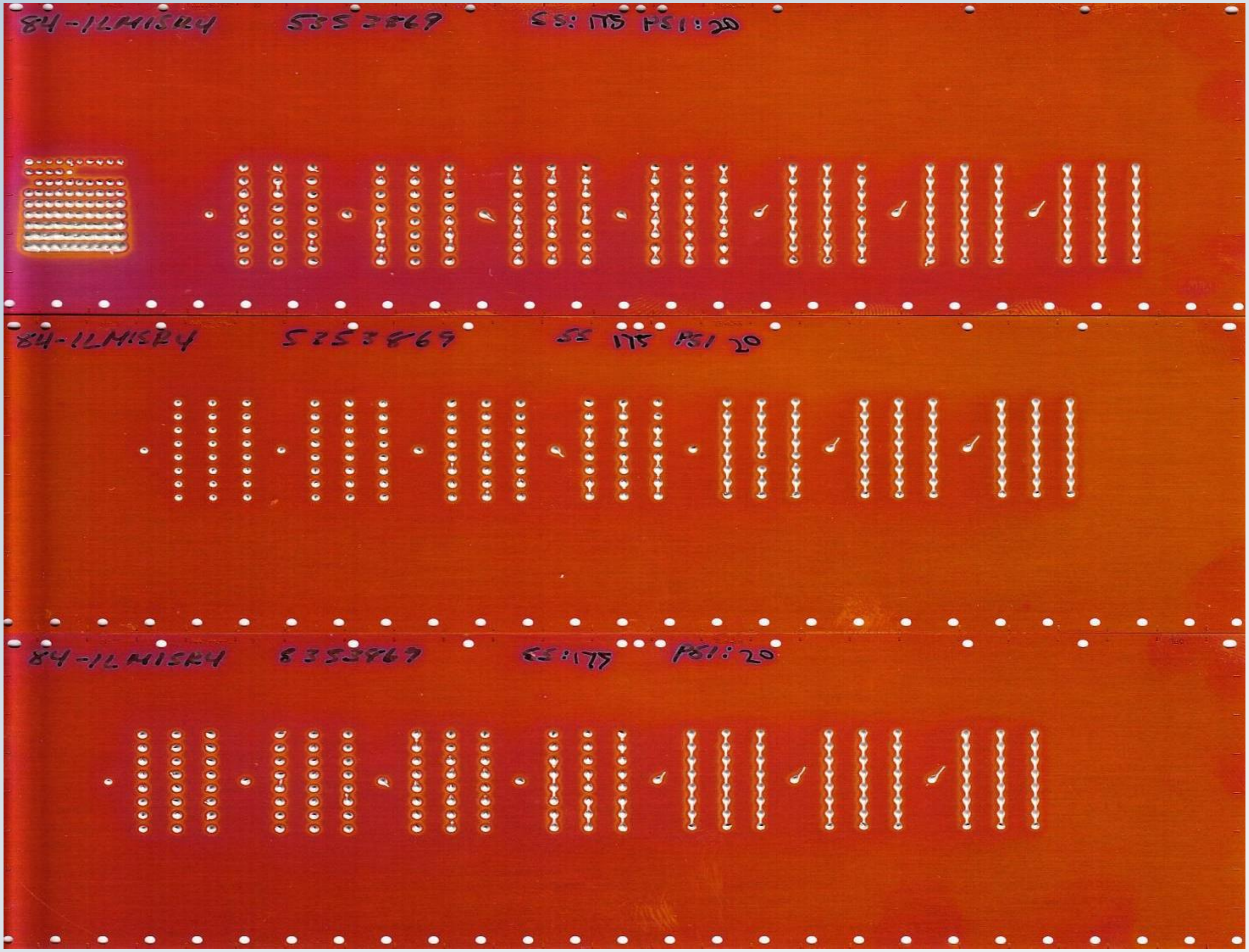
- Three test frames were produced per adhesive and dispense defects counted.

- The final comparative analysis was done using a ‘Two Proportions Test’ of the adhesive in question versus the control.

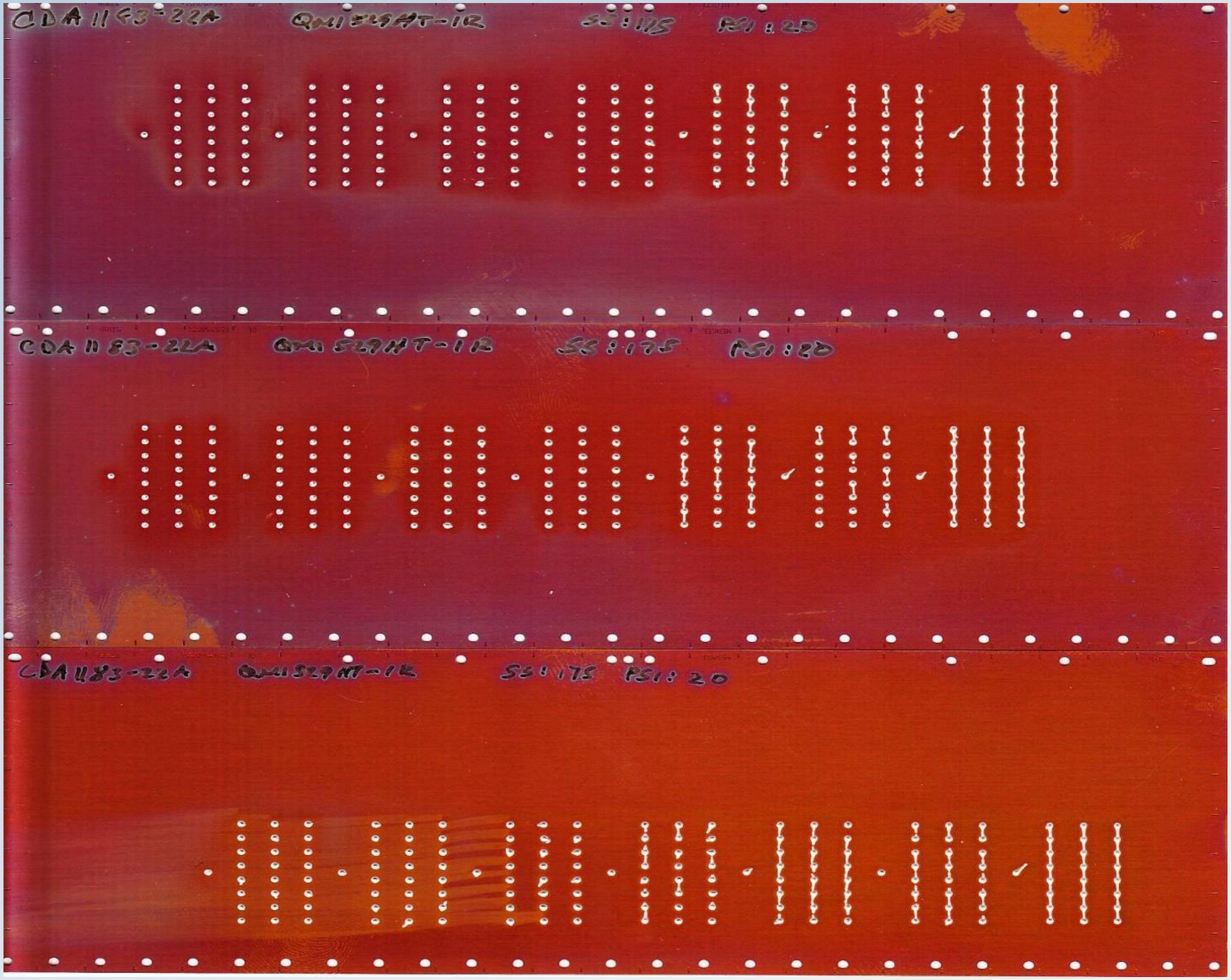
Equipment

- **Dispenser:** **Camelot - Time /Pressure.**
- **Substrate:** **Cu**
- **Needle Size:** **Blue 22 gauge**
- **Air Pressure:** **20 psi**
- **Cure profile:** **30 min. ramp to 175°C; Hold for 30 min.**
- **Selected Shot Size:** **175**

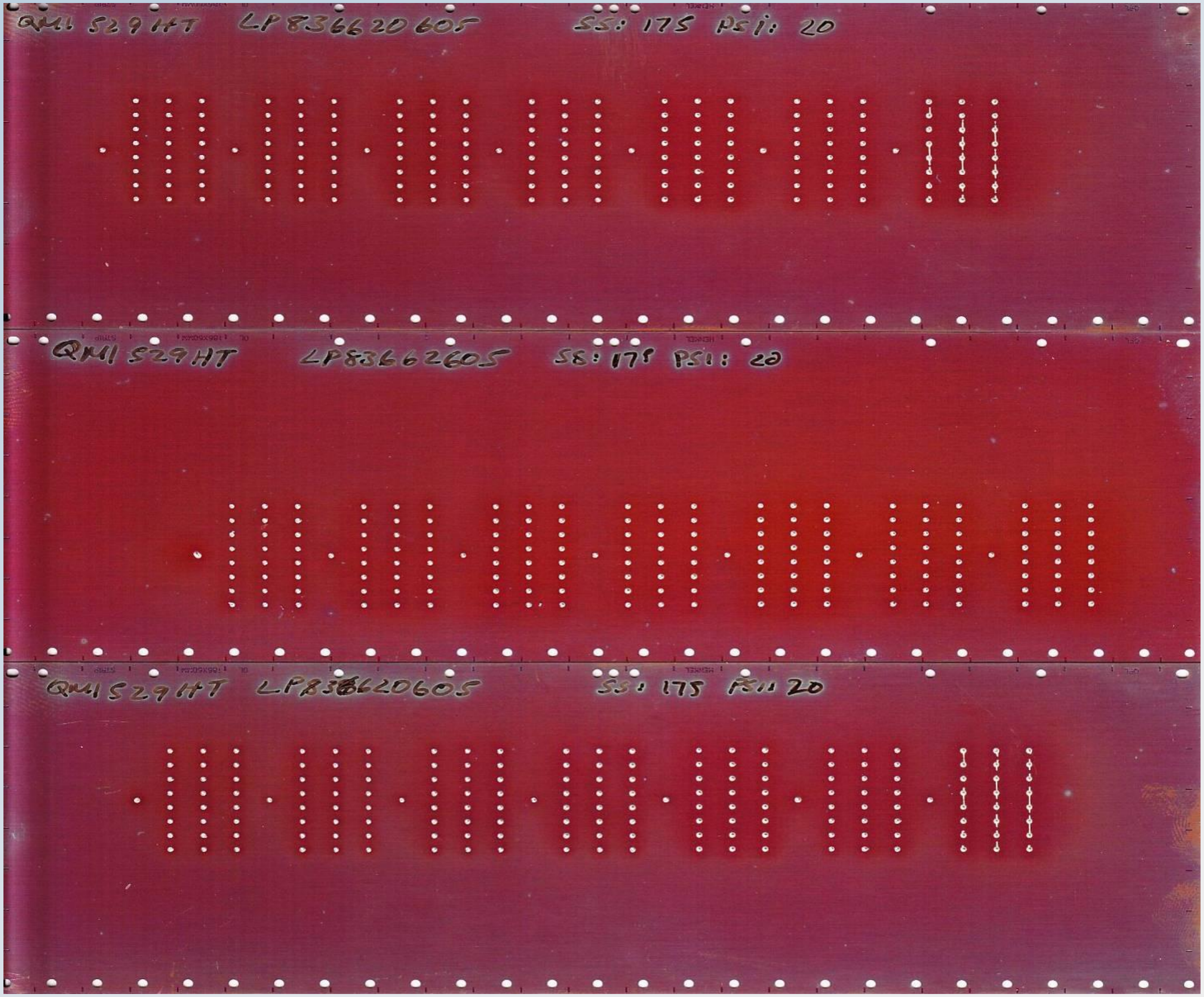
Dispensability – Dot Dispense of 84-LMISR4



Dispensability – Dot Dispense of QMI529HT-LV



Dispensability – Dot Dispense of QMI529HT



Results

- **The following number of defects were counted for each test adhesive: -**

Dot Dispense Results QMI529HT-LV, QMI529HT & Ablebond 84-1LMISR4			
Product	**Number of Tailed Dots**	**Number of Missed Dots**	**Total Defects**
QMI529HT-LV	174	0	174
QMI529HT	13*	0	13*
84-1LMISR4	280	0	280

Number of total dot dispensed per test = 504

*** QMI529HT typically had fewer 'defects' than both QMI529HT-LV and 84-1LMISR4, however the quantity of adhesive dispensed was typically much lower. Therefore comparison of QMI529HT-LV versus QMI529HT should not be considered for this study.**

Statistical 2-Proportions Test – SR4 versus QMI529HT-LV

- **A two proportions test was performed on the two test materials: -**

Test and CI for Two Proportions

Sample	X	N	Sample p
1	174	504	0.345238
2	280	504	0.555556

```
Difference = p (1) - p (2)
Estimate for difference:  -0.210317
95% CI for difference:  (-0.270358, -0.150277)
Test for difference = 0 (vs not = 0):  Z = -6.87  P-Value = 0.000

Fisher's exact test: P-Value = 0.000
```

QMI529HT-LV has statistically better tailing performance by dot dispense testing than Ablebond 84-1LMISR4

Conclusions

- QMI529HT-LV out performed Ablebond 84-1LMISR4 in terms of tailing performance by dot dispense in this trial.

- Subtle differences in the volume of adhesive dispensed may have skewed the result in favour of QMI529HT-LV however the adhesive can be considered to dispense well and shows little tendency to tail under ‘normal’ dispense conditions.

QMI529HT-LV Bleed Study on AgCu Leadframe.

Paul Gleeson/ Jose Venegas
Die Attach Paste TSE

30 March 2010

Background

- **The product QMI529HT-LV is an improved version of QMI529HT and has been developed to give improved: -**
  - **Dispense Performance.**
  - **Electrical Performance.**
  - **Thermal Performance.**

- **The bleed of QMI529HT-LV needs to be characterised and compared against other Henkel adhesives on AgCu target leadframe surface.**

- **The other test adhesives for comparison are: -**
  - **84-1LMISR4.**
  - **QMI529HT.**

Experimental

- **Resin Bleed:**
  - **The thawed adhesive was dot dispensed onto the test leadframes surface(s), Cu, AgCu, NiPdAu.**
  - **The diameter of the dots was measured. Subsequently the adhesive dot size, including any bleed, was re-measured after defined time intervals at ambient conditions (T = 0, 2, 4 hrs and post cure).**
  - **The adhesive dots were cured using the recommended cure profile and the adhesive dot size re-measured.**
  - **The mean % average bleed was calculated and the batches compared.**

Results

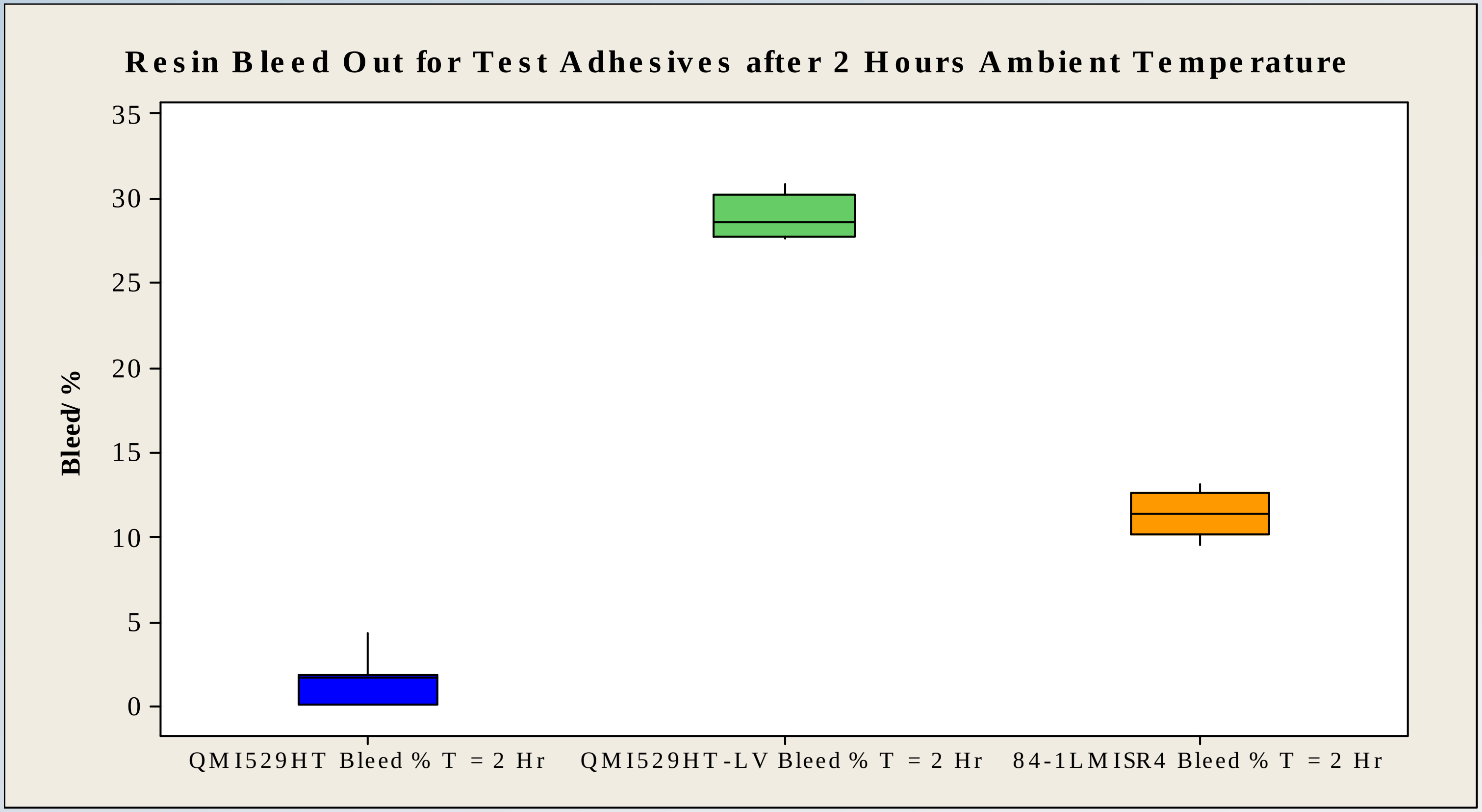
- **The following resin bleed basic statistics data was obtained for QMI529HT-LV and the comparative control adhesives: -**

Variable	Total Count	Mean	StDev	Variance	Minimum	Maximum
QMI529HT Bleed % T = 2 Hrs	8	1.551	1.396	1.950	0.160	4.390
QMI529HT Bleed % T = 4 Hrs	8	15.56	9.45	89.36	4.28	27.97
QMI529HT Bleed % T = PC	8	22.28	11.95	142.82	5.77	35.71
QMI529HT-LV Bleed % T= 2 Hrs	8	29.012	1.326	1.758	27.720	30.940
QMI529HT-LV Bleed % T= 4 Hrs	8	36.59	3.19	10.18	31.87	42.95
QMI529HT-LV Bleed % T= PC	8	38.130	2.341	5.482	35.010	41.680
84-1LMISR4 Bleed % T= 2 Hrs	8	11.442	1.315	1.729	9.540	13.210
84-1LMISR4 Bleed % T= 4 Hrs	8	19.259	1.877	3.524	16.920	22.140
84-1LMISR4 Bleed % T = PC	8	22.814	1.671	2.792	19.950	24.600

Both control materials exhibit less bleed than QMI529HT-LV on the AgCu LDF used

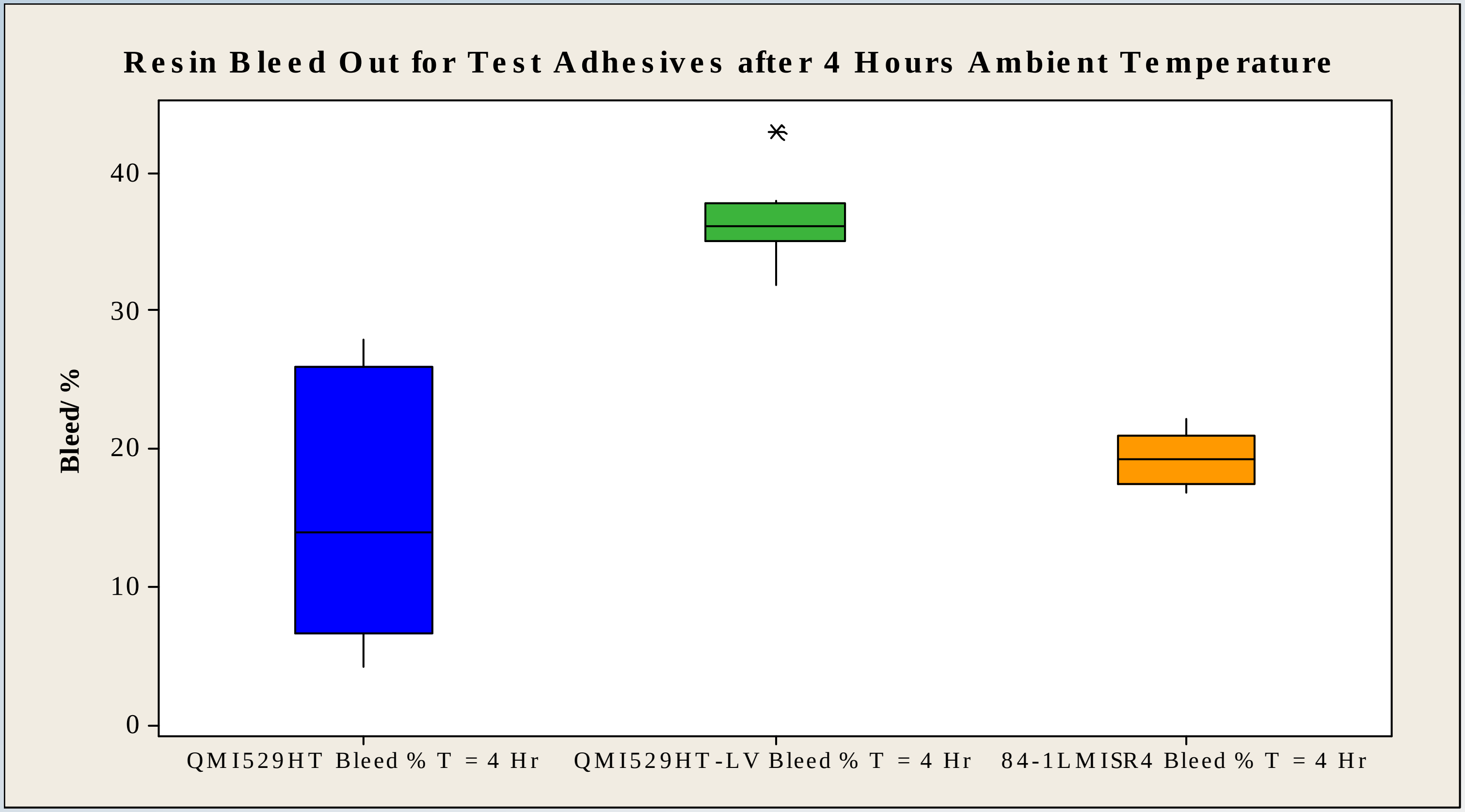
Results

- **The results obtained at the T= 2 Hrs ambient temperature can also be viewed graphically using the below box plot: -**



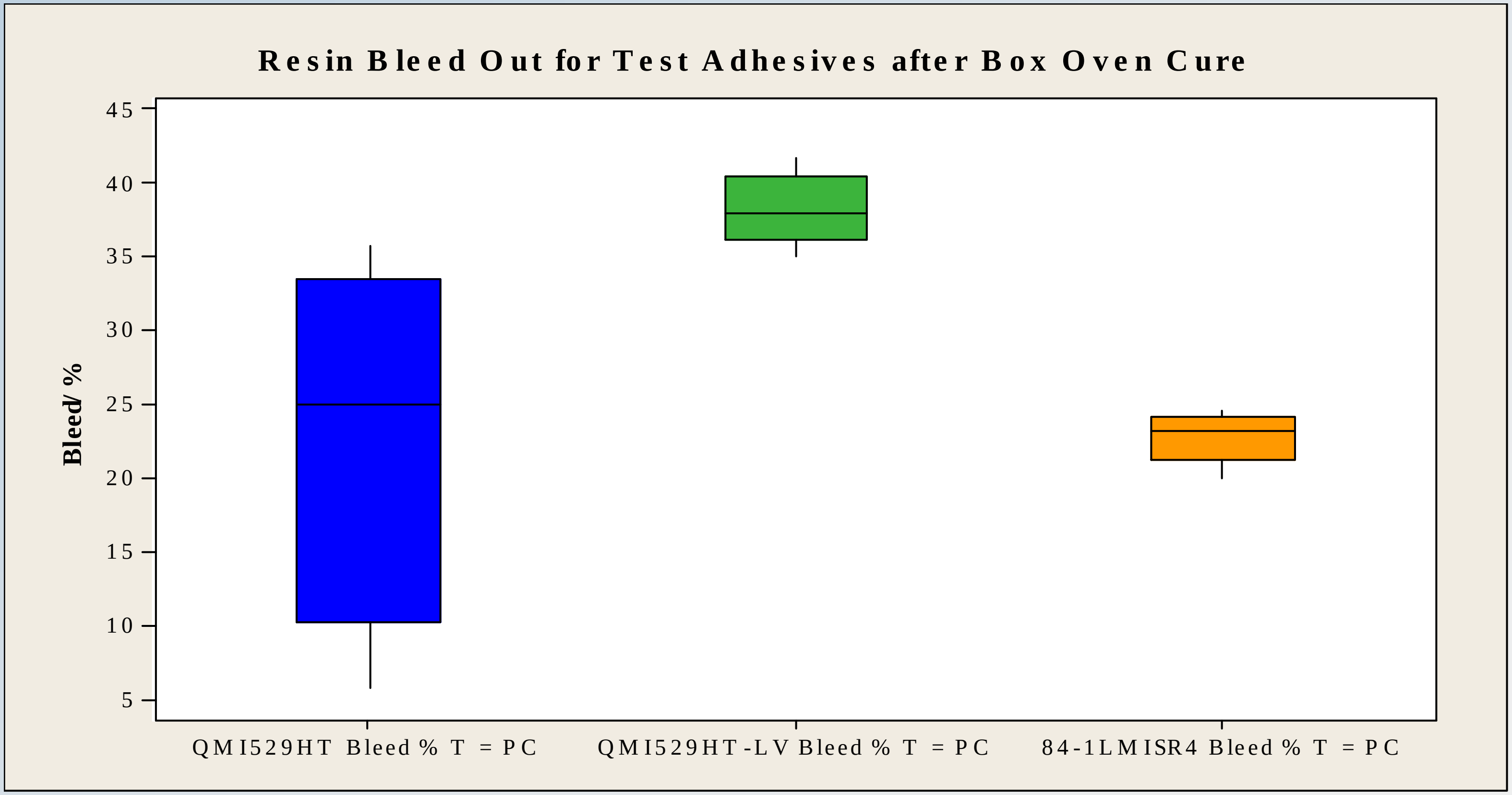
Results

- **The results obtained at the T= 4 Hrs ambient temperature can also be viewed graphically using the below box plot: -**



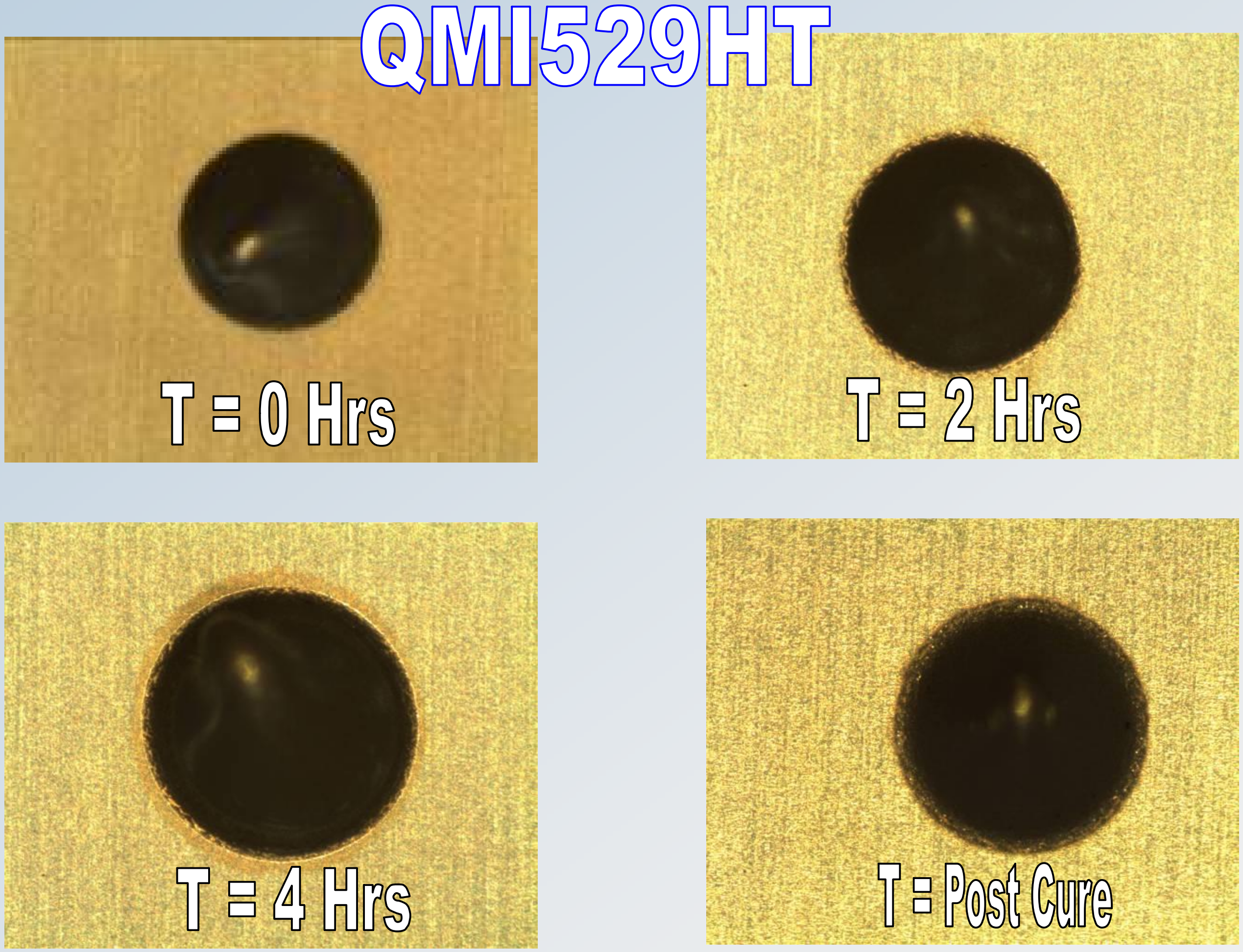
Results

- The results obtained at the T= post cure can also be viewed graphically using the below box plot: -



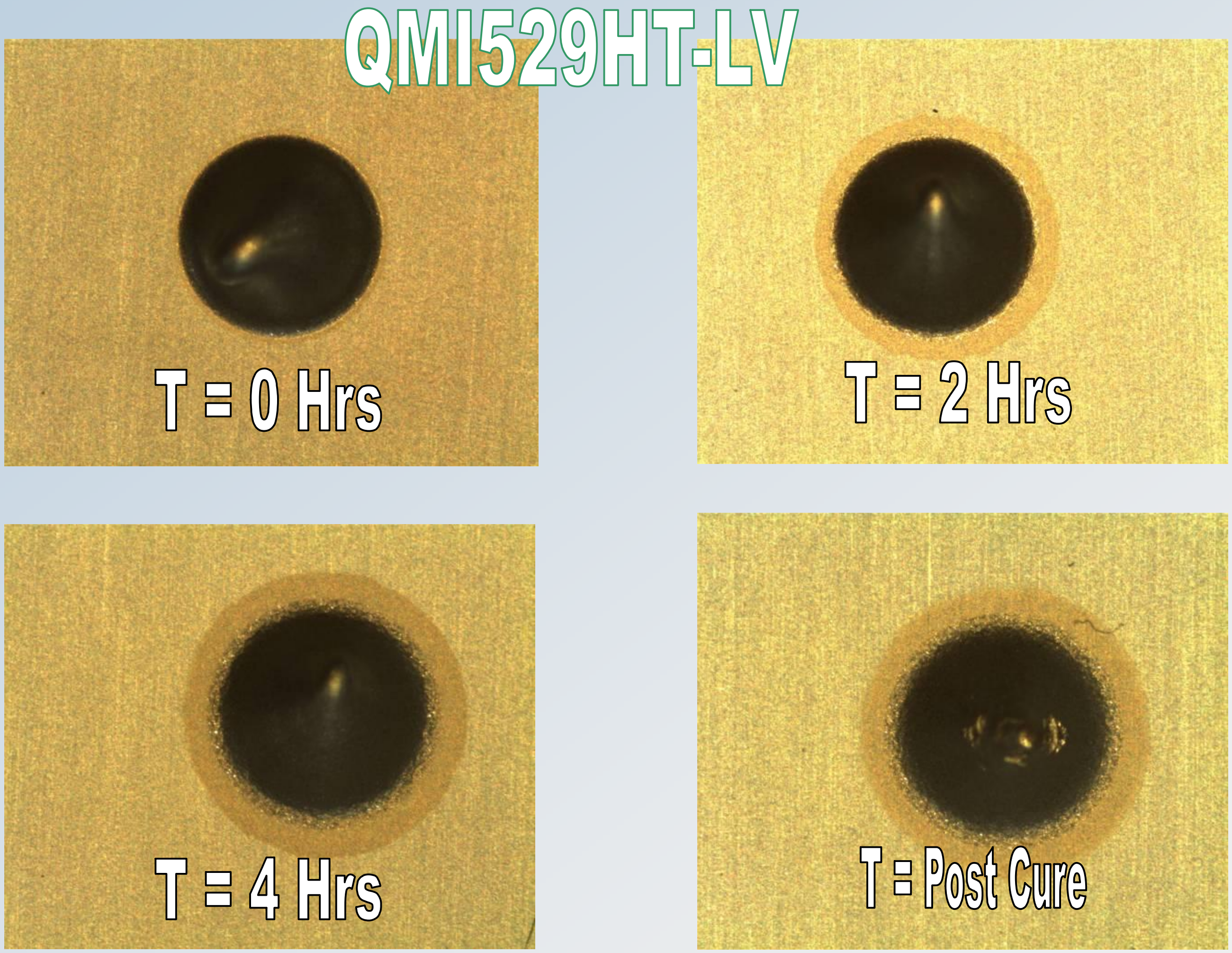
Results

- **The below pictures show the typical resin bleed observed for QMI529HT: -**



Results

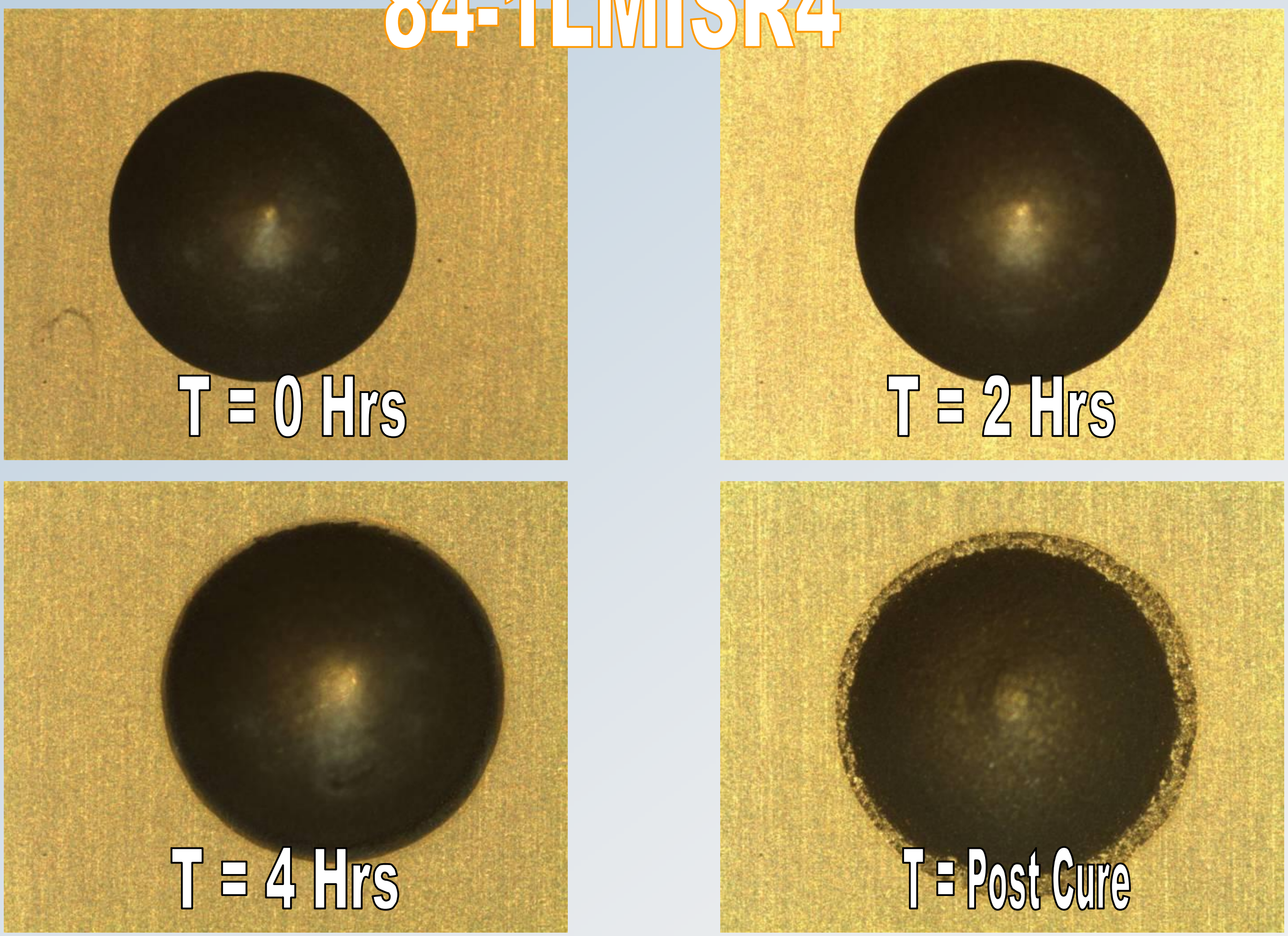
- **The below pictures show the typical resin bleed observed for QMI529HT-LV: -**



Results

- **The below pictures show the typical resin bleed observed for Ablebond 84-1LMISR4: -**

84-1LMISR4



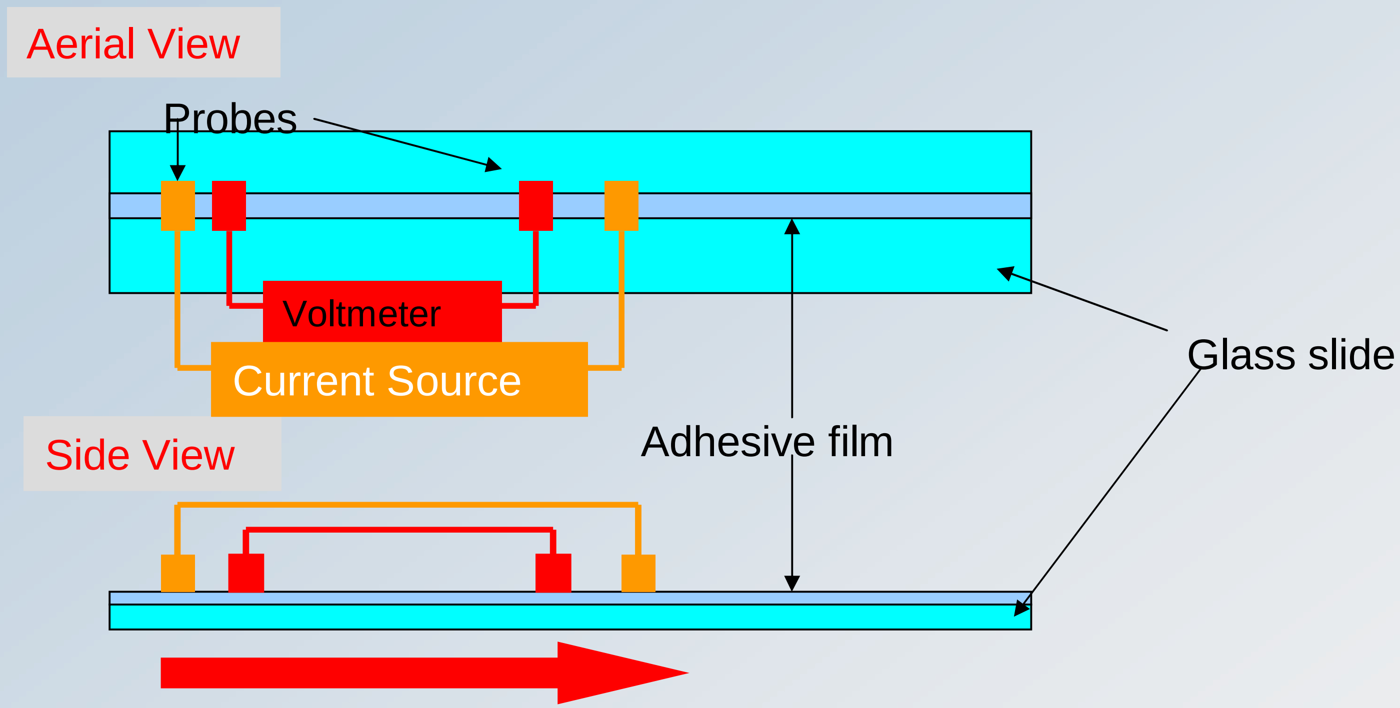
Conclusions

- QMI529HT-LV has statistically higher resin bleed out on the internal AgCu leadframe used in this trial.
- Ablebond 84-1LMISR4 and QMI529HT have statistically equivalent bleed performance on internal AgCu leadframe.
- Resin bleed is as much a function of test surface as it is the tendency of the product. Products will display different RBO behaviour depending on the following factors:-
  - Surface energy of the substrate.
  - Roughness of substrate.
  - Cleanliness of substrate.
- **Resin bleed should also be checked using the target substrate to fully quantify the expected performance of any given substrate for any given product.**

Electrical and Thermal Conductivity Test Results for QMI529HT-LV

Electrical Testing

- **Volume Resistivity**

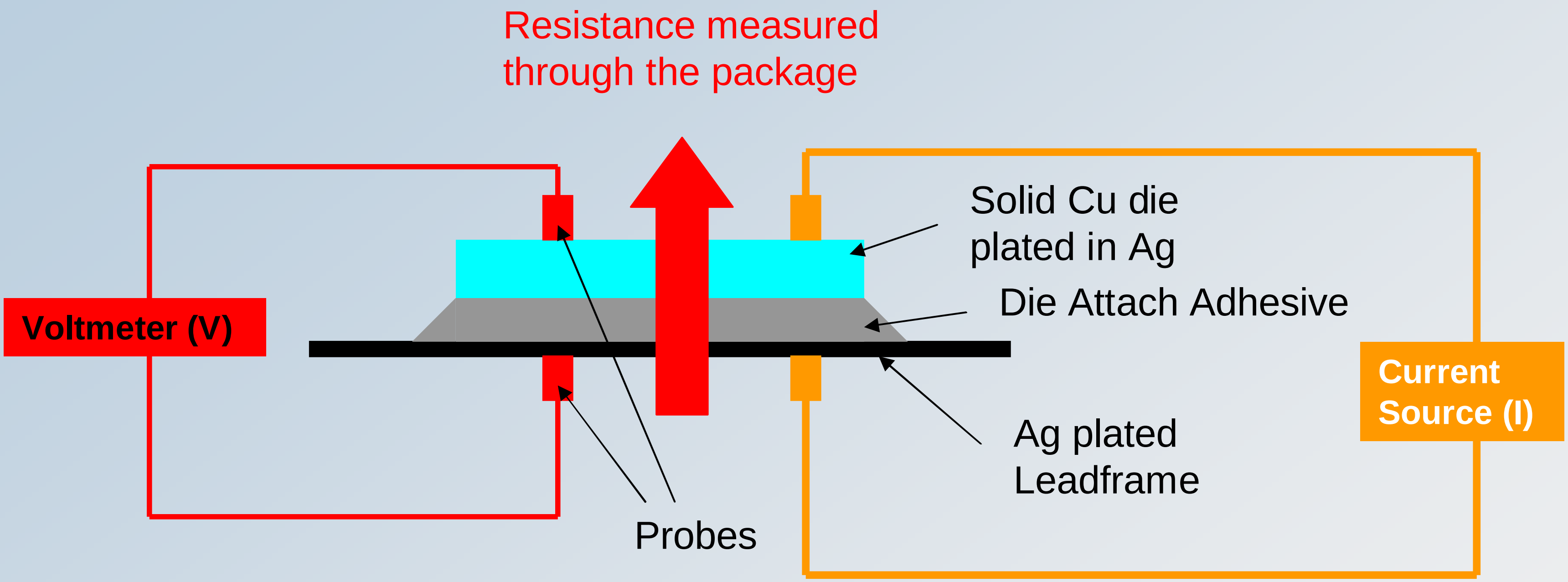


Resistance measured through the Adhesive

	VR/Ω.mm			Average
QMI529HT-LV	0.000067	0.000298	0.000139	0.000168
SR4	0.000055	0.000081	0.000065	0.000067

Electrical Testing

- **Bond Joint Resistance (BJR)**

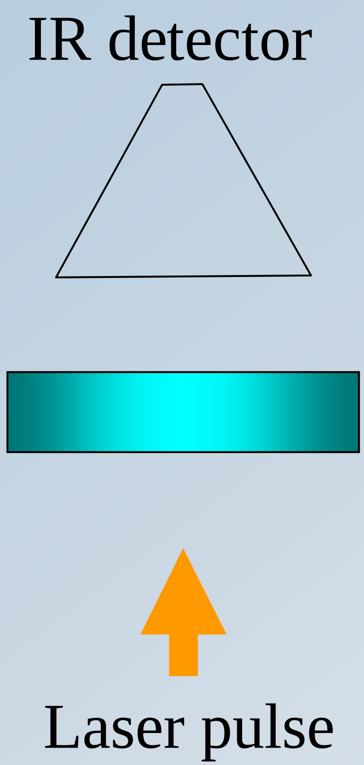


Resistance = V/I

	BJR/Ω						**Average**
QMI529HT-LV	0.00083	0.00084	0.00084	0.00084	0.00084	0.00084	0.00084
SR4	0.00081	0.00082	0.00081	0.00081	0.00079	0.00079	0.00081

Thermal Conductivity (Bulk) – Laser Flash

Henkel



Laser adds known quantity of heat

Diffusivity calculated from heating rate

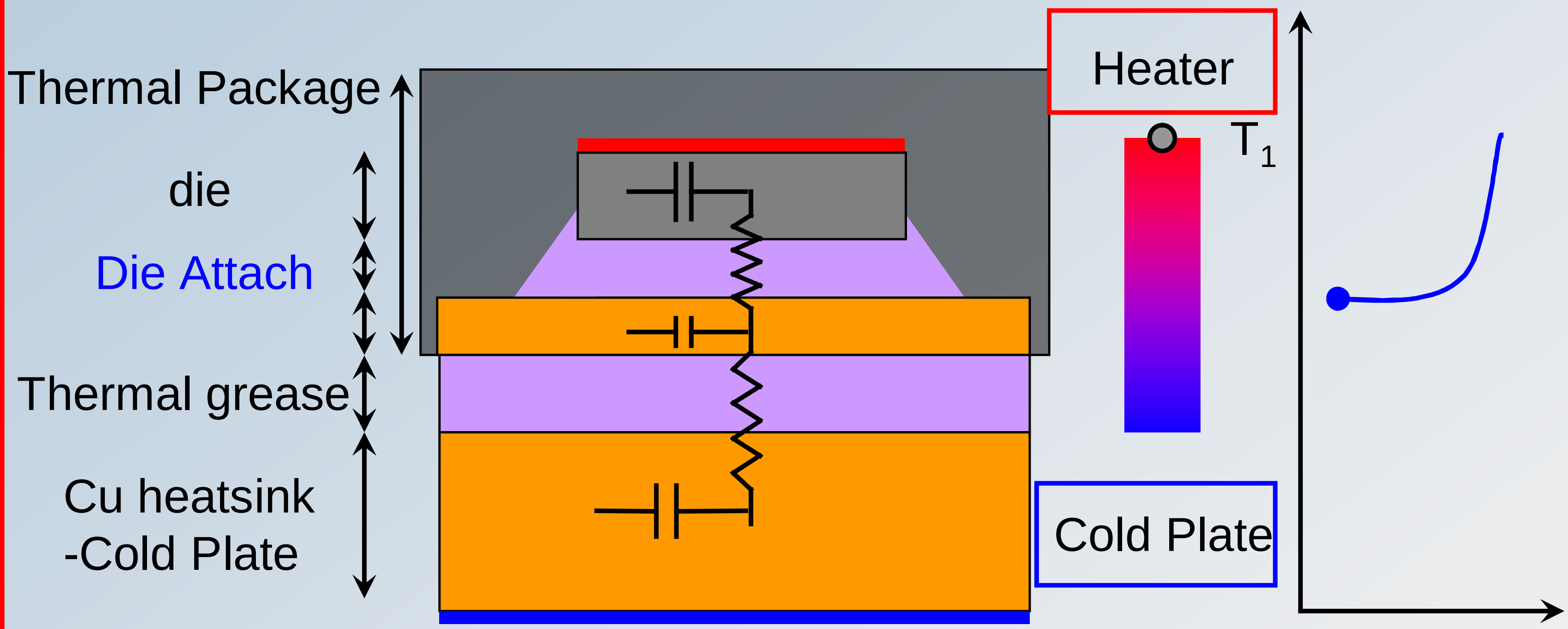
Sample heat capacity calculated from temperature rise: -

TC = (diffusivity) x (heat capacity) x (density)

	Thermal Conductivity/W.mk				Average
QMI529HT-LV	8.960	10.264	9.346	9.028	9.400
SR4	1.439	1.607	1.540	1.679	1.566

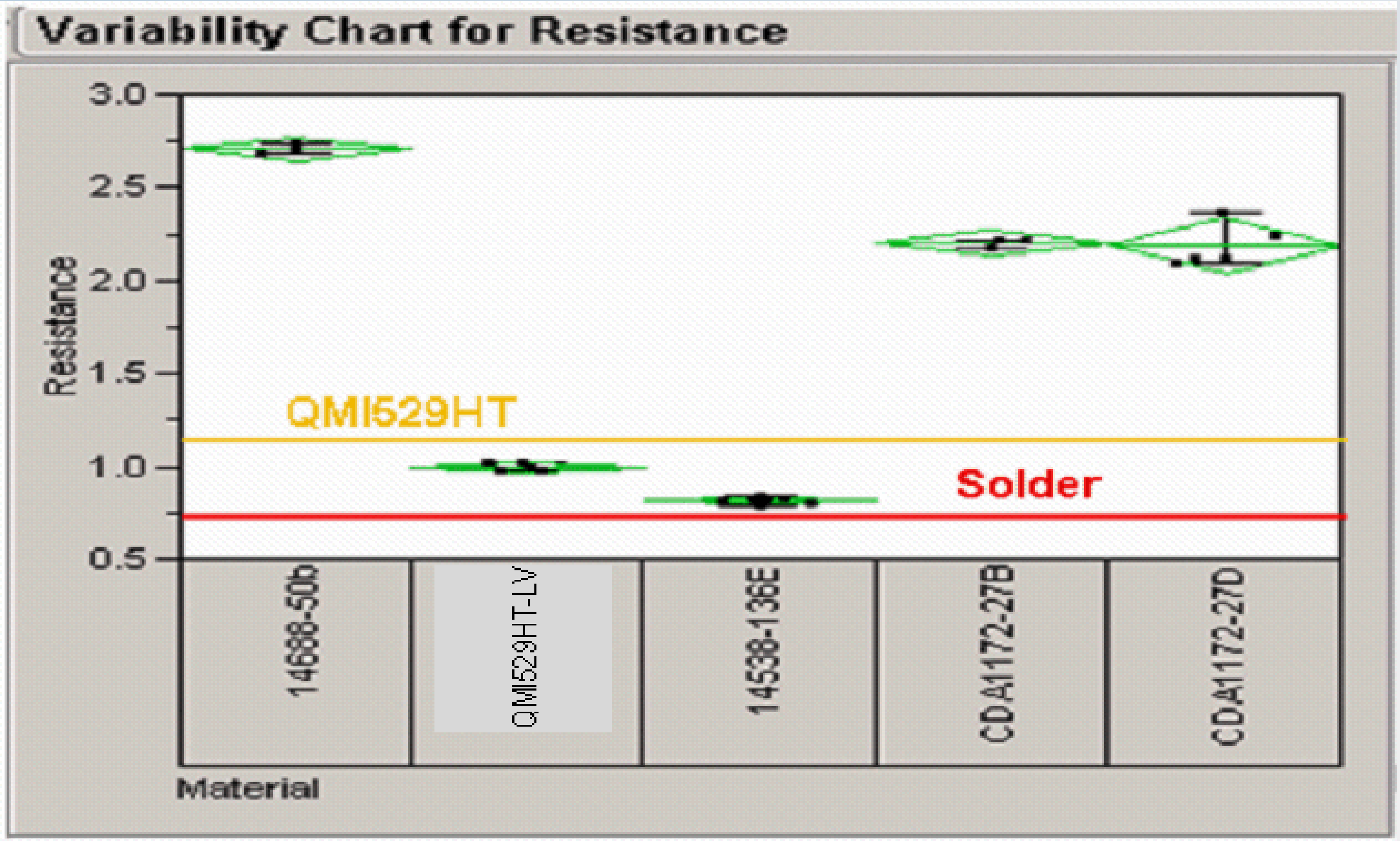
NB. Bulk Thermal properties do not take into account the key driver to ‘in-package’ thermal performance e.g. Interfacial Resistance

Transient Thermal Package Test Measurement – (Including Interfacial Effects).



- All power applied goes through column
- Starting point in equilibrium

In Package Thermal Resistance Comparison



Electrical and Thermal Performance Summary

- **QMI529HT-LV has excellent bulk electrical and Thermal properties.**
- **QMI529HT-LV offers Excellent in-package thermal performance and is considered to be at the leading edge in thermal performance for commercially available organic adhesives.**

Freezing Point & Storage Handling of QMI529HT-LV.

Outline

- Introduction – how the freezing point Affects FTV formation.
- Freezing point data of Ablebond QMI529HT-LV and recommended storage temperature
- Appendix A : Other factors effecting on FTV
- Appendix B : Handling recommendations
- Appendix C : Freezing point curves

Introduction

- **The FTV potential of an adhesive is significantly affected by its freezing point, storage temperature and shipping temperature. Testing has shown that an adhesive must be frozen in order for delamination to occur (between the frozen adhesive and syringe wall) and cause FTVs**
- **A frozen adhesive is incapable of absorbing stresses resulting from differential shrinkage/expansion of the adhesive, syringe and piston. As the syringe temperature is reduced farther below its freezing point, more and more stress is created to the point where delamination occurs during thaw (thermal shock) which will ultimately lead to FTVs**
- **Since the freezing point of each adhesive is unique, specific storage/handling/shipping recommendations may need to be made for high freezing point adhesives.**

Source: ***FTV Presentation by Derek Wyatt (Tech Serv Dept-Version 1.5)***

Factors Effecting FTVs

Henkel

A) Adhesive Freezing Point

Main objective

for this study

B) Piston Effects

- Proximity to adhesive
- Design Geometry

C) Syringe Size

D) Handling (Covered later)

What Is A Freezing Point?

By Definition, the freezing point of a liquid is:

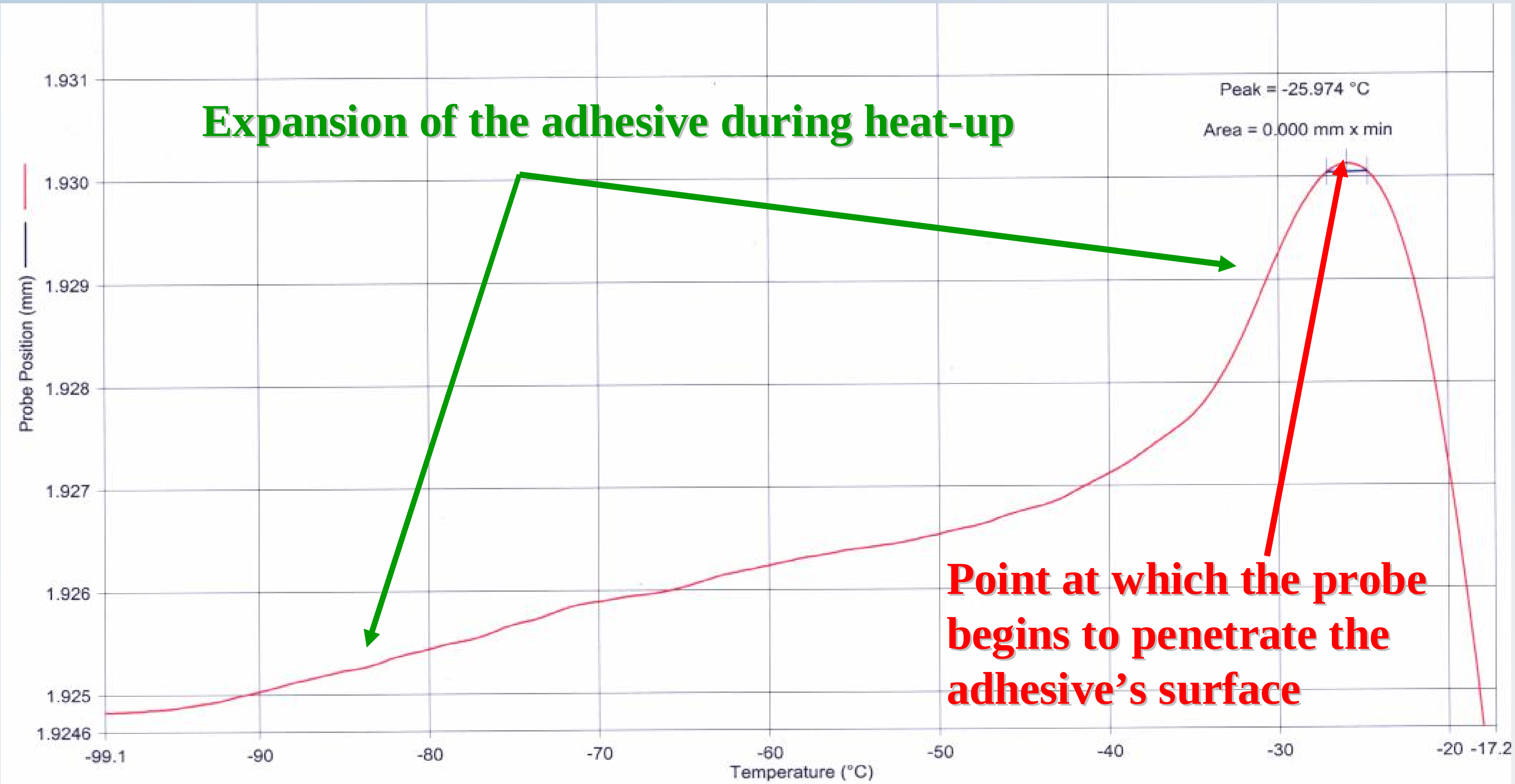
“The temperature at which the liquid and solid phases of a substance of specified composition are in equilibrium at atmospheric pressure”.

Since most of Henkel’s adhesives are complex mixtures and that it is highly unlikely that they would have a true freezing point (by definition), the freezing point will be considered to be the temperature at which the adhesive takes on similar characteristics of a solid and has a tack-free surface.

Source: *The American Heritage® Dictionary of the English Language, Fourth Edition*

How Is The Freezing Point Measured?

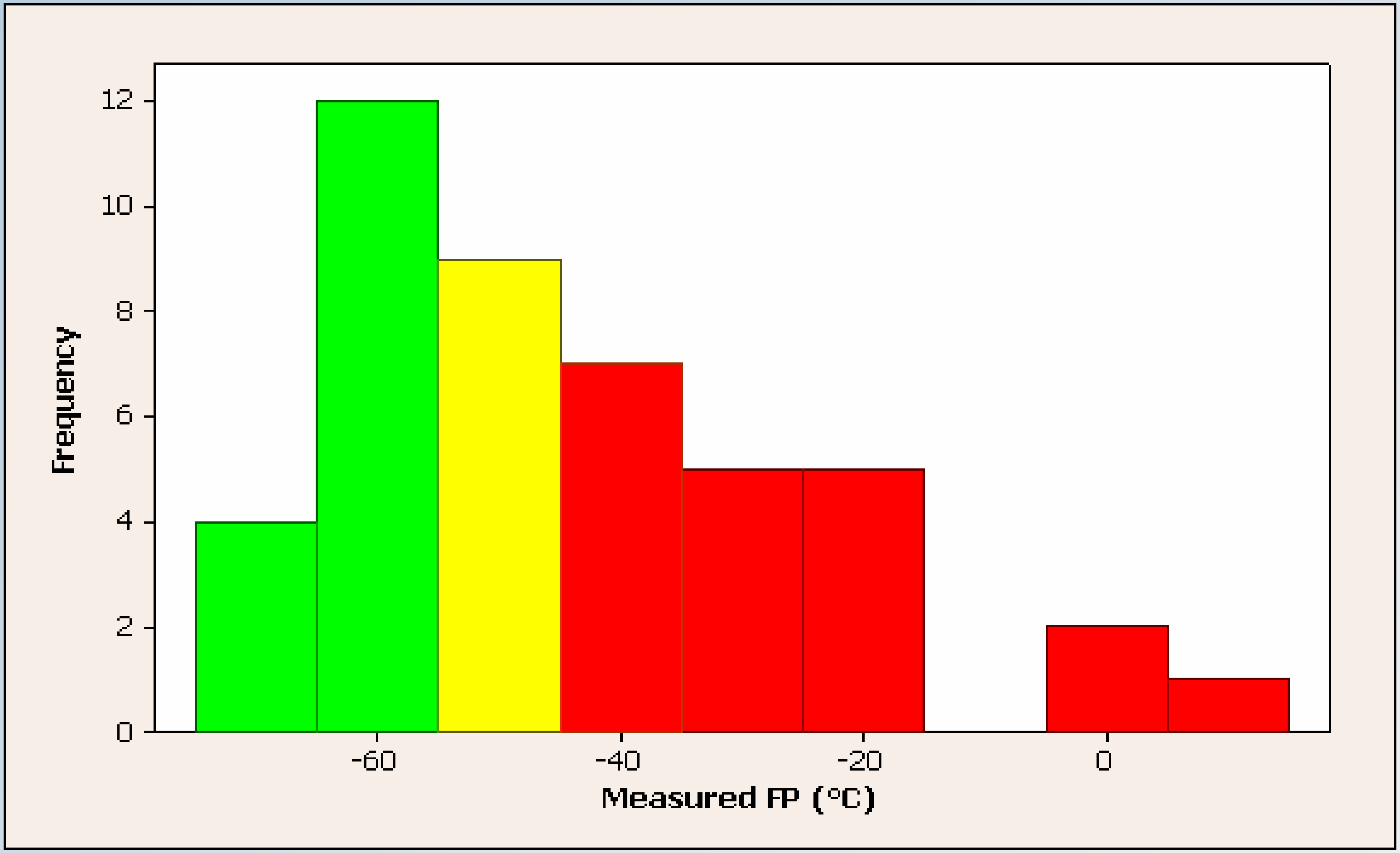
Henkel



Using TMA (fitted with an expansion probe), the probe position is monitored while increasing the sample temperature. The point at which the probe begins to penetrate the sample is considered the freezing point of the adhesive.

Note: TMA used instead of DSC due to complexity of an adhesive and its affects on the measured endotherms.

Freezing Point Characterization



Risk of FTVs

Low Risk

Medium Risk

High Risk

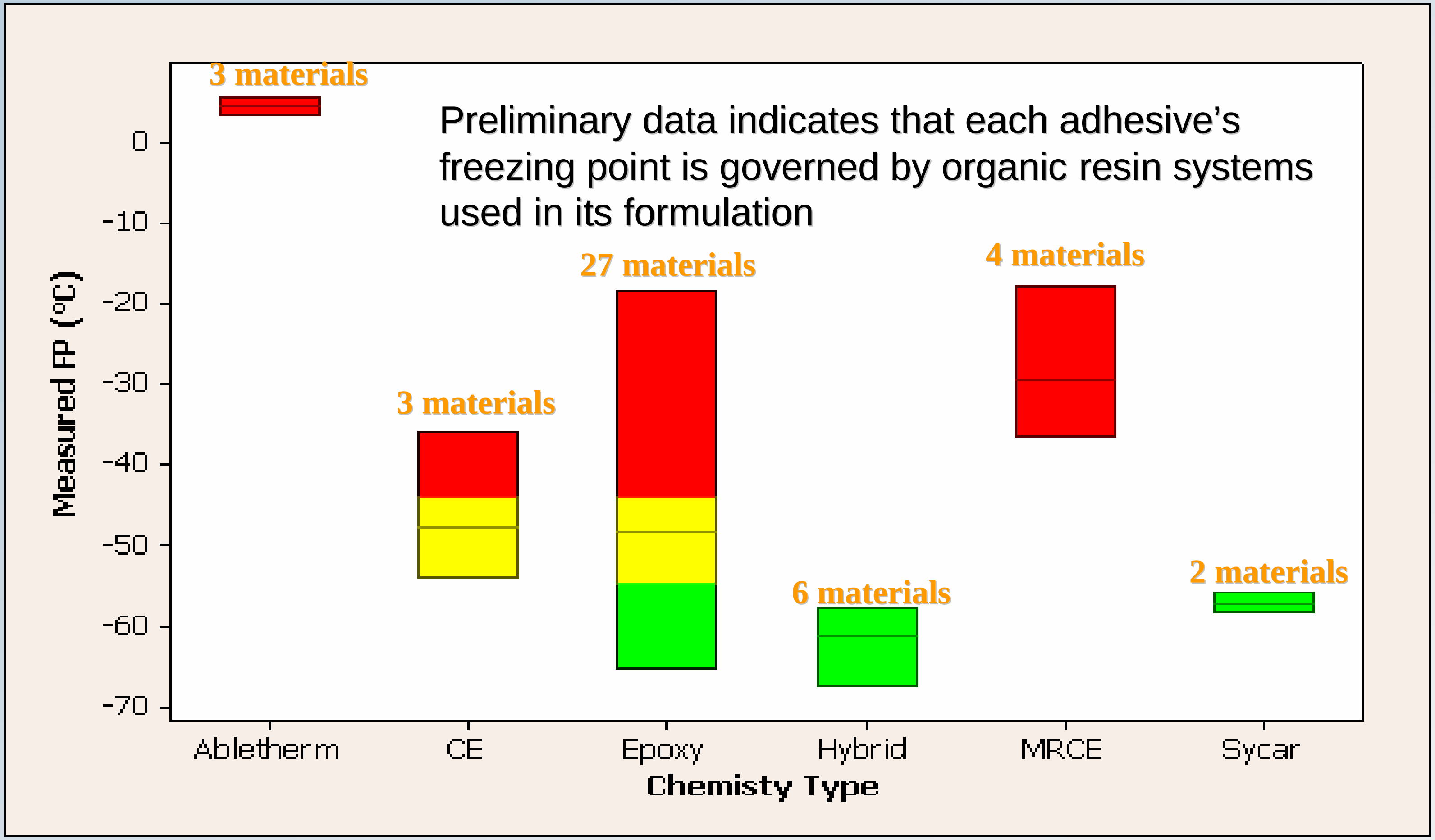
45 materials tested:

-Different Chemistries

-Different Fillers

Freezing Point By Chemistry

Henkel



Risk of FTVs

Low Risk Medium Risk High Risk

Note: Based on testing:

- Abletherm, MRCE, CE and some epoxy systems pose the highest risk of FTVs
- BMI & Sycar systems pose the lowest risk of FTVs

Freezing Point Comparison

- The freezing point for QMI529HT-LV was compared versus other standard conductive die attach adhesives: -

Freezing Point Comparison For QMI529HT-LV versus Selected Leadframe Die Attach Conductive Adhesives					
Material	Chemistry Type	Batch #	Run No.	Freezing Point (°C)	Mean Freezing Point (°C)
FS849-TI	Hybrid	5227987	1	-71.28	-71.945
			2	-72.61	
8200TI	Hybrid	020906	1	-76.90	-75.30
			2	-73.70	
8600	Hybrid	5163850	1	-68.40	-70.30
			2	-72.20	
QMI529HT-LV	BMI		1	-74.02	-74.01
			2	-75.73	
			3	-72.28	

- QMI529HT-LV has low risk potential for the formation of FTV in Henkel’s standard shipping method (dry ice) and storage recommendation (–40°C freezer).

Other Factors Effecting on FTV

Source: ***FTV Presentation by Derek Wyatt***

(Tech Serv Dept-Version 1.5)

Other Factors Effecting FTV Occurrences

Henkel

- Freezing point of the adhesive
  - Adhesive freezing points range from +5°C to -70°C
    - Lower freezing point adhesives generally perform worse than higher freezing point adhesives
    - Lower storage temperatures will increase the risk of FTVs.
- Storage temperature
  - Delta between ambient and actual syringe temperature when pulled for thaw
    - Larger deltas between storage temperature and freezing point of the adhesive will increase the likelihood of FTVs.
- Freezer Variability
  - A freezer is just like an oven. Its temperature will vary based on loading and usage.
  - Some freezers have been observed to have a 30°C variation from top to bottom which would results in sporadic FTV performance.
- Piston gap
  - A piston gap can work is some cases but its effectiveness will be governed by
    - Actual storage temperature of the adhesive (not set temperature)
    - Ambient temperatures (delta T)
    - Adhesive type
    - Syringe handling while frozen

Other Factors Effecting FTV Occurrences

- **Piston design**
  - **Loose fitting pistons (no flanges) can decrease FTV performance.**
- **Syringe ID/length**
  - **Longer dimensions will increase stress as differential shrinkage takes place between the adhesive and syringe**
- **CTE differences between syringe and piston.**
- **Shrinkage rate of uncured adhesive**
  - **May differ between chemistries.**
- **Adhesion of adhesive to syringe wall.**
- **Adhesive volume relative to syringe length.**
- **Syringe handling by the customer**

Appendix B
Handling Recommendations

Source: ***FTV Presentation by Derek Wyatt (Tech Serv Dept-Version 1.5)***

Handling Recommendations

- **Precautions**
  - **All frozen shipments are shipped using dry ice**
  - **The dry ice temperature used to ship frozen adhesives is approximately –80°C.**
  - **Handling of this material requires protective gloves designed to withstand these extremely cold temperatures**
  - **Protective gloves should be used during the handling of the syringe box and frozen syringes**

Handling Recommendations

Henkel

- Incoming inspection
  - It is not recommended that individual syringes go through an incoming inspection
  - The practice of removing the syringes from the syringe box and handling to visually inspect them has been linked to an increase in freeze thaw voiding frequency
  - If incoming inspection or quantity verification is deemed necessary, it is recommended that the syringe box be immediately placed into a –40°C freezer and allowed to equilibrate for at least 6 hours.
  - Inspections can then be done in a manner that keeps the syringes as close to the recommended storage temperature (-40°C) as possible
  - Avoid prolonged handling of the syringes since it will increase the risk of FTVs.

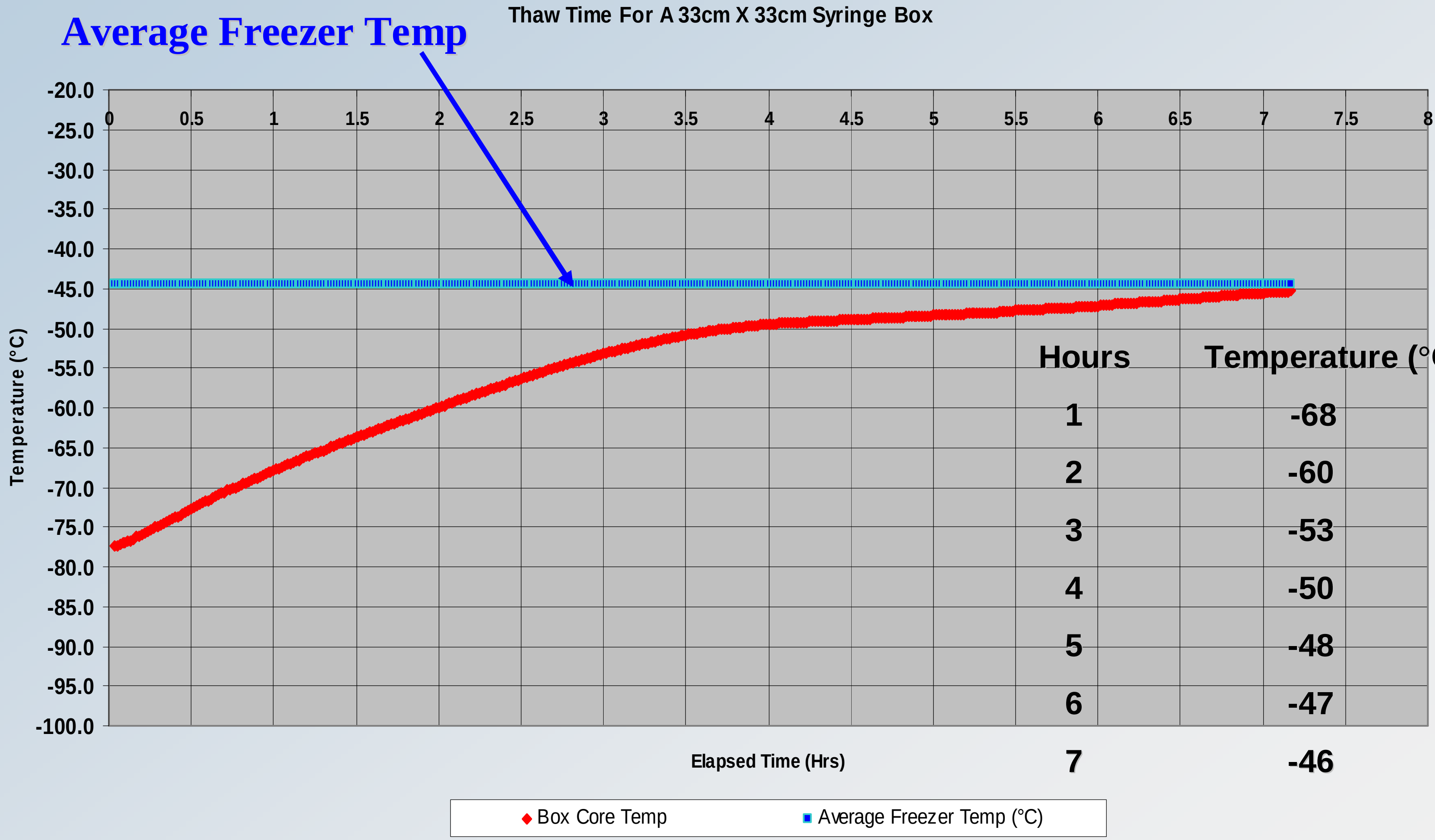
Handling Recommendations

- Unpacking
  - Open shipping box as close to the storage freezer as possible. Only open one shipping box at a time and transfer contents to the storage freezer before moving on to the next shipping box
  - While wearing thermal gloves, transfer the white syringe boxes a quickly a possible to the storage freezer and allow the contents to warm to the storage temperature for at least 6 hours
    - Temperatures in an unopened syringe box can rise enough to cause freeze thaw voiding in as little as 5 minutes if left out in ambient temperatures

Handling Technique

- Syringe thaw technique
  - **When ready to use the adhesive, transfer the needed syringes from the syringe box to a designated thaw area using thermal gloves. While frozen, only handle the syringe by the flanges located at the top end of the syringe. This will minimize thermal shock and reduce the likelihood of FTVs from forming**
  - **Caution, syringes are extremely brittle at temperatures around –40°C and below. Dropping the syringe could fracture the syringe wall or syringe tip**
- **During thaw, the syringes should be stored in the vertical position (if possible, use a test tube holder). Thaw times vary depending on syringe size.**
  - **10 cc syringe thaw time: ~30 minutes**
  - **30 cc syringe thaw time: ~60 minutes**
- **Before use, wipe off any residual condensation**

Thaw Time For A 33cm X 33cm Syringe Box



Hours	Temperature (°C)
1	-68
2	-60
3	-53
4	-50
5	-48
6	-47
7	-46

Thank you

- These application guidelines are intended to provide the basic understanding for QMI529HT-LV process window and key material characteristics
- Refer to the technical data sheet (TDS) for specific product information, which may be available on www.henkel.com or by contact Technical Service Department
- Please contact Henkel Technical Service Department for recommendations concerning a specific application for recommendation