# QMI529HT-LV
# Engineering Data Package (v1)

Howard Yun
Henkel Electronics | Jul 2019

# 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 | QMI529HT-LV |
|---|---|---|---|---|
| 1 | Chemistry | | BMI Hybrid | BMI Hybrid |
| 2 | Tg by TMA (°C) | | 3.3 | 36 |
| 3 | Modulus (Mpa) after post mold bake | @25°C | 4,870 | 5,900 |
| | | @150°C | 800 | 910 |
| | | @250°C | 450 | 540 |
| 4 | Weight loss on cure, TGA (%) | | 3.34 | 3.6 |
| 5 | Volume resistivity (ohm-cm) | | 0.00004 | 0.00005 |
| 6 | Thermal Conductivity (W/m.K) | | 6.5 | 8.0 |
| 7 | DSC | Onset Temp (°C) | 123 | 130 |
| | | Peak Temp (°C) | 130 | 138 |
| 8 | Viscosity (5rpm@25°C) | | 18,500 | 16,000 |
| 9 | Thixotropic Index | | 4.8 | 4.0 |
| 10 | Worklife @ RT (Hrs) | | 24 | 24 |
| 11 | CTE (ppm/°C) | Alpha 1 | 53 | 62 |
| | | Alpha 2 | 156 | 162 |

# Formula Design

| 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 | | ✓ |

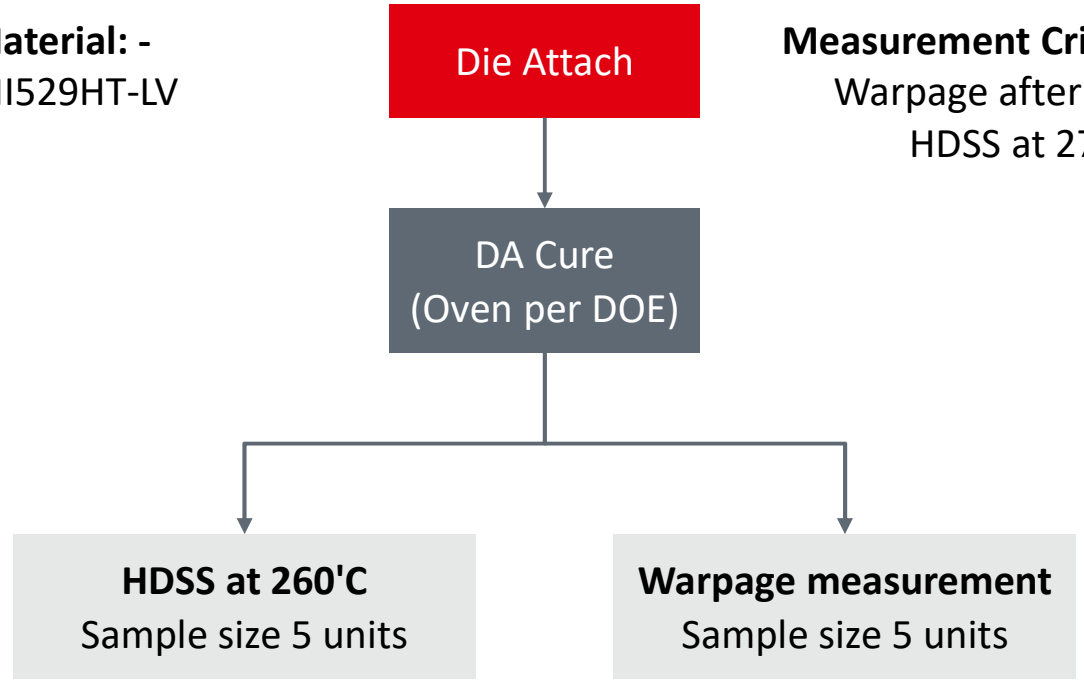
# Outline

1. Cure Study
2. Die Shear Adhesion Study
3. Open Time Evaluation
4. Staging Time Evaluation
5. Dispensability
6. Bleed Performance
7. Electrical and Thermal Characterization
8. Freezing Point and Storage Handling

# QMI529HT-LV
# Cure Study

# Experimental

**Material: -**
QMI529HT-LV




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

# Experimental

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

| | |
|---|---|
| **Die** | Bare Si Backside |
| **Die Size** | 2x2-mm & 5x5-mm |
| **Leadframe** | AgCu. |
| **Target BLT** | 1-Mil. |
| **Die Attach Force** | 2x2-mm = 30g, & 5x5-mm 250g |
| **Die Attach Time** | 2x2-mm = 50mS, 5x5-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: -

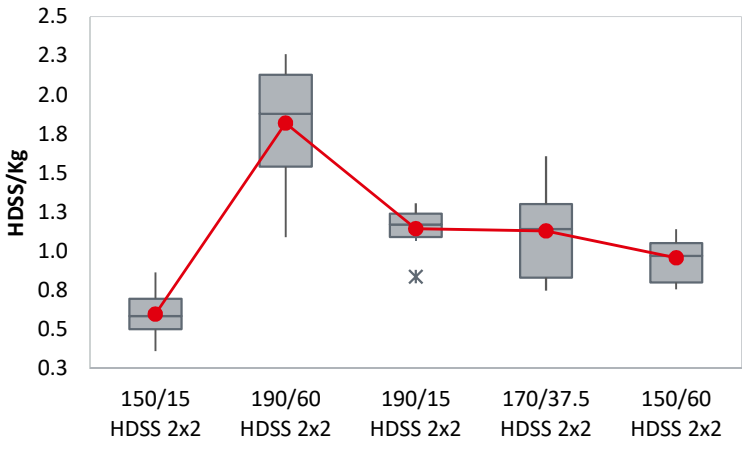
| Variable | Count | Mean | StDev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **HDSS** | | | | | | |
| 150/15 HDSS 5x5 | 8 | 8.243 | 0.614 | 0.377 | 7.373 | 9.241 |
| 190/60 HDSS 5x5 | 8 | 10.919 | 2.415 | 5.834 | 7.997 | 16.254 |
| 190/15 HDSS 5x5 | 8 | 8.807 | 1.183 | 1.401 | 7.355 | 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 |

| Variable | Total Count | Mean | StDev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **Warpage** | | | | | | |
| 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 2x2-mm die size, can be further viewed using the Boxplot and ANOVA analysis: -

**HDSS (270C) for QMI529HT-LV after Different Cure Conditions on AgCu LDF - 2x2-mm Si Die**



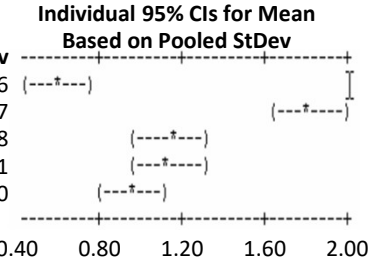

**One-way ANOVA: 150/15 HDSS, 190/60 HDSS, 190/15 HDSS, 170/37.5 HDS, …**

| 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 |

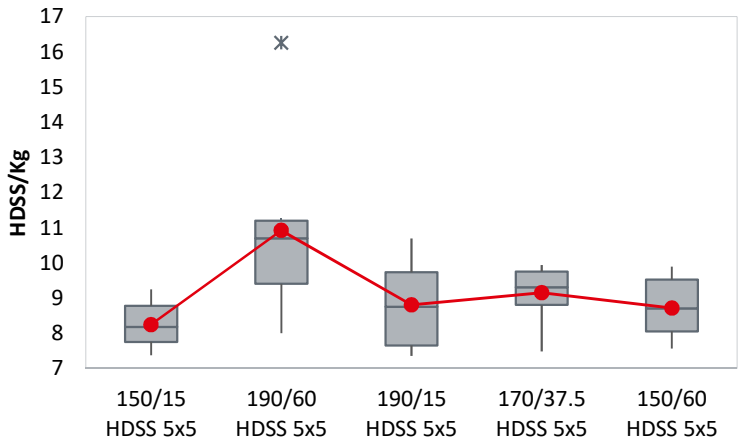



Pooled StDev = 0.2447

# Results

- The results for HDSS 5x5-mm die size, can be further viewed using the Boxplot and ANOVA analysis: -

**HDSS (270C) for QMI529HT-LV after Different Cure Conditions on AgCu LDF - 5x5-mm Si Die**




**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 |

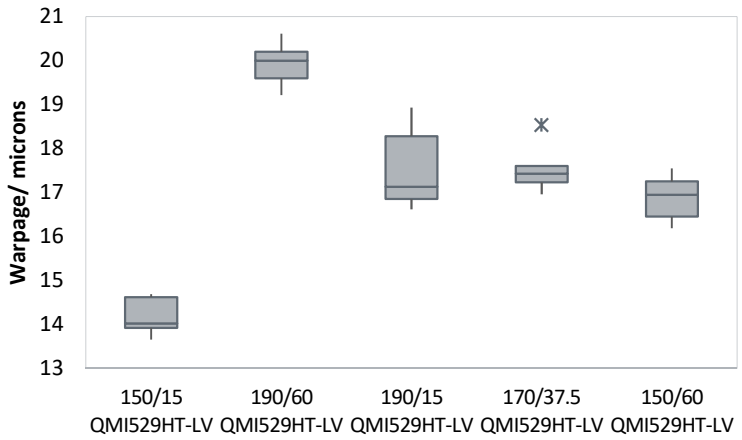
Pooled StDev = 1.331

8.4 9.6 10.8 12.0

# Results

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

**Warpage Data for QMI529HT-LV After Different Cure Conditions**




**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%

Individual 95% CIs for Mean Based on Pooled StDev

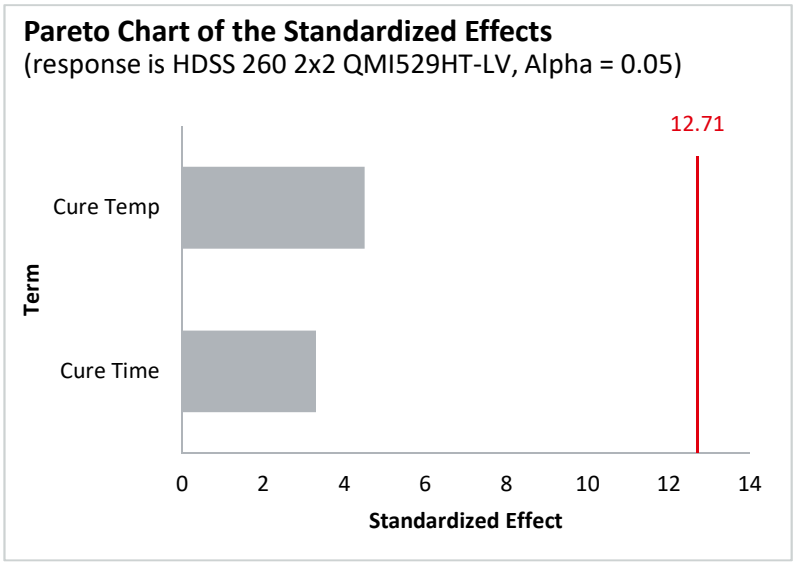
| Level | N | Mean | StDev |
|---|---|---|---|
| 150/15 QMI529HT-LV | 8 | 14.182 | 0.397 |
| 190/60 QMI529HT-LV | 8 | 19.944 | 0.429 |
| 190/15 QMI529HT-LV | 8 | 17.460 | 0.841 |
| 170/37.5 QMI529HT-LV | 8 | 17.512 | 0.471 |
| 150/60 QMI529HT-LV | 8 | 16.906 | 0.451 |

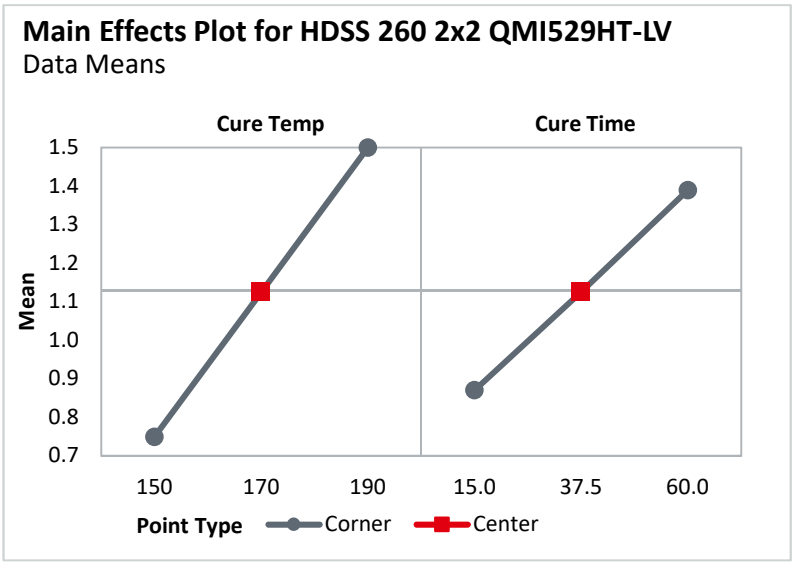
Pooled StDev = 0.543

14.0 16.0 18.0 20.0

# Analysis of DoE – HDSS, 2x2-mm

- The DoE DSS results, 2x2-mm die size, were analysed for statistical significance: -

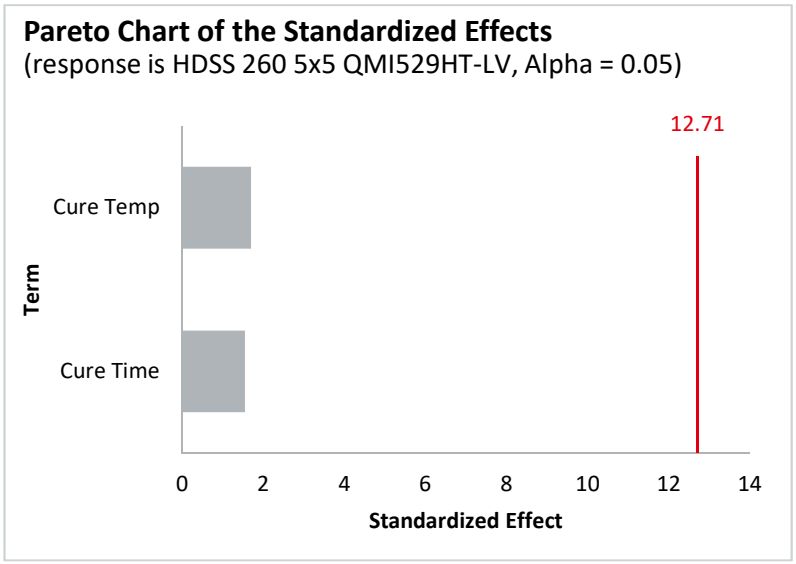


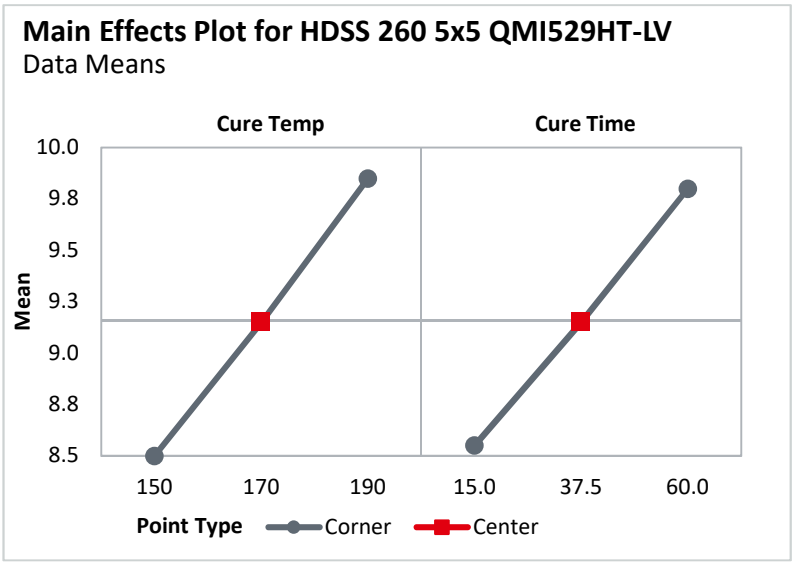




**The trends in the data suggest increased temperature and time do offer increased adhesion however this was not statistically proven at the 95% CI**

# Analysis of DoE – HDSS, 5x5-mm

- The DoE DSS results, 5x5-mm die size, were analysed for statistical significance: -

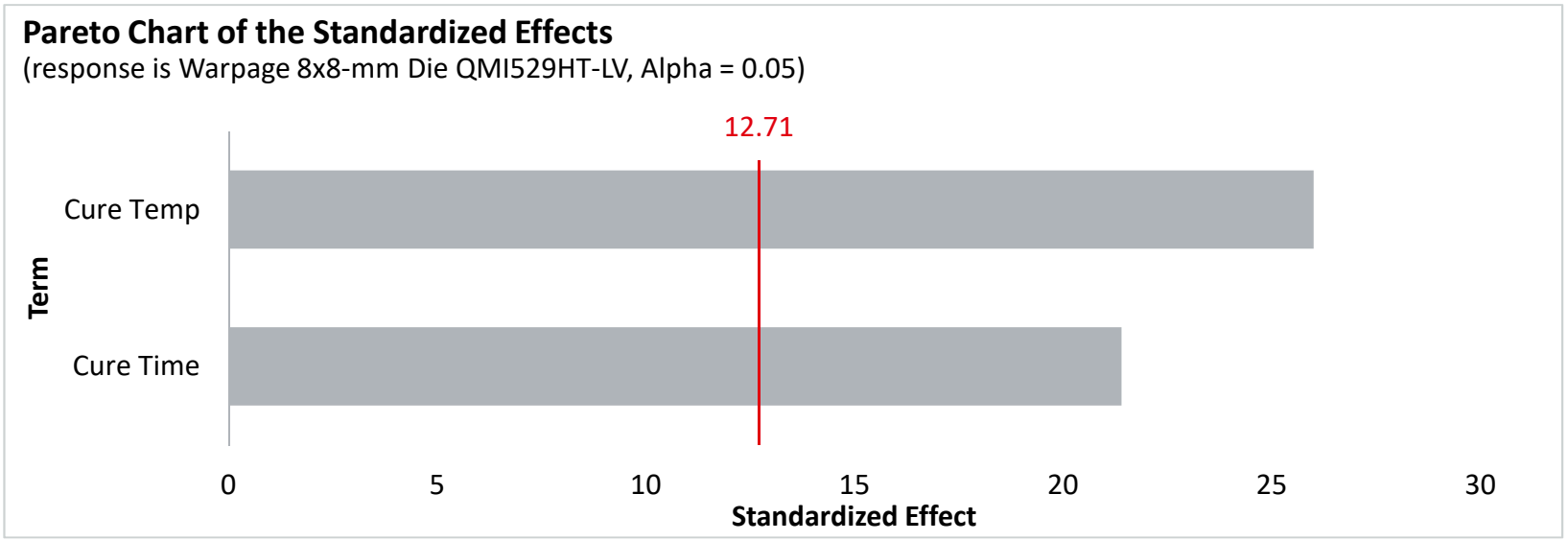



**The trends in the data suggest increased temperature and time do offer increased adhesion however this was not statistically proven at the 95% CI**

# Analysis of DoE – Warpage 8x8-mm

- The DoE warpage results, 8x8-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**

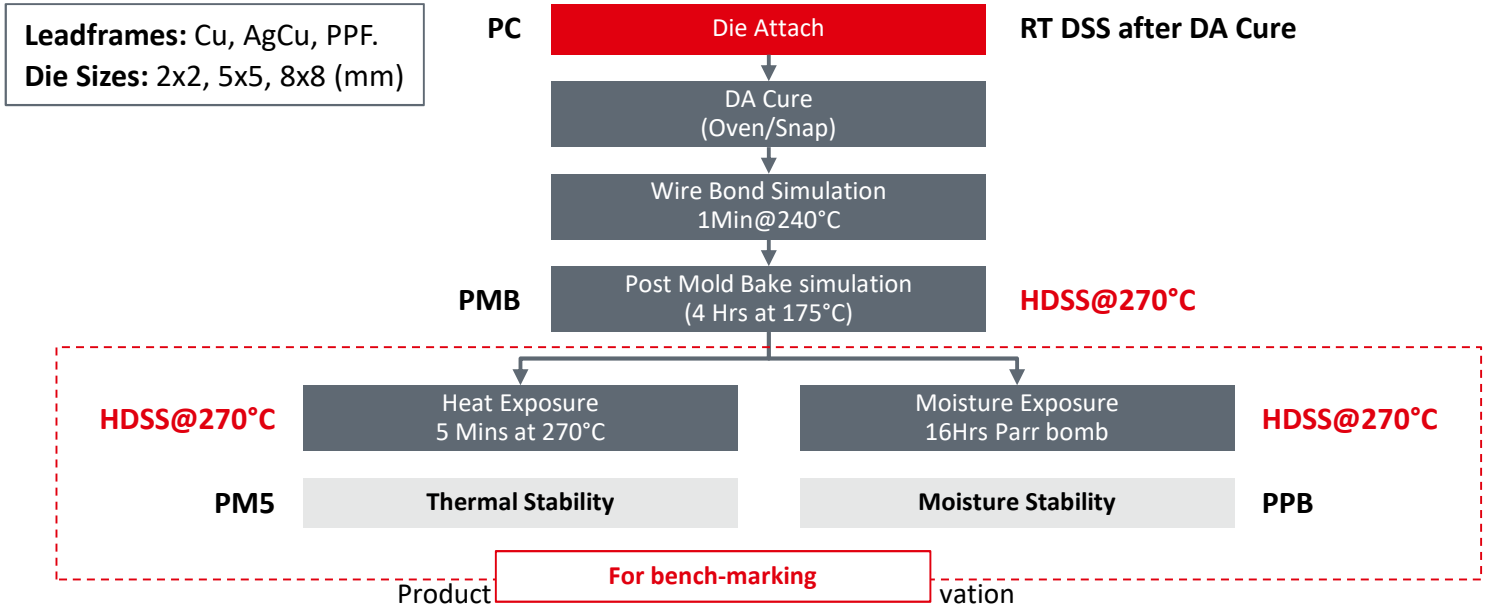
# Conclusions

- 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

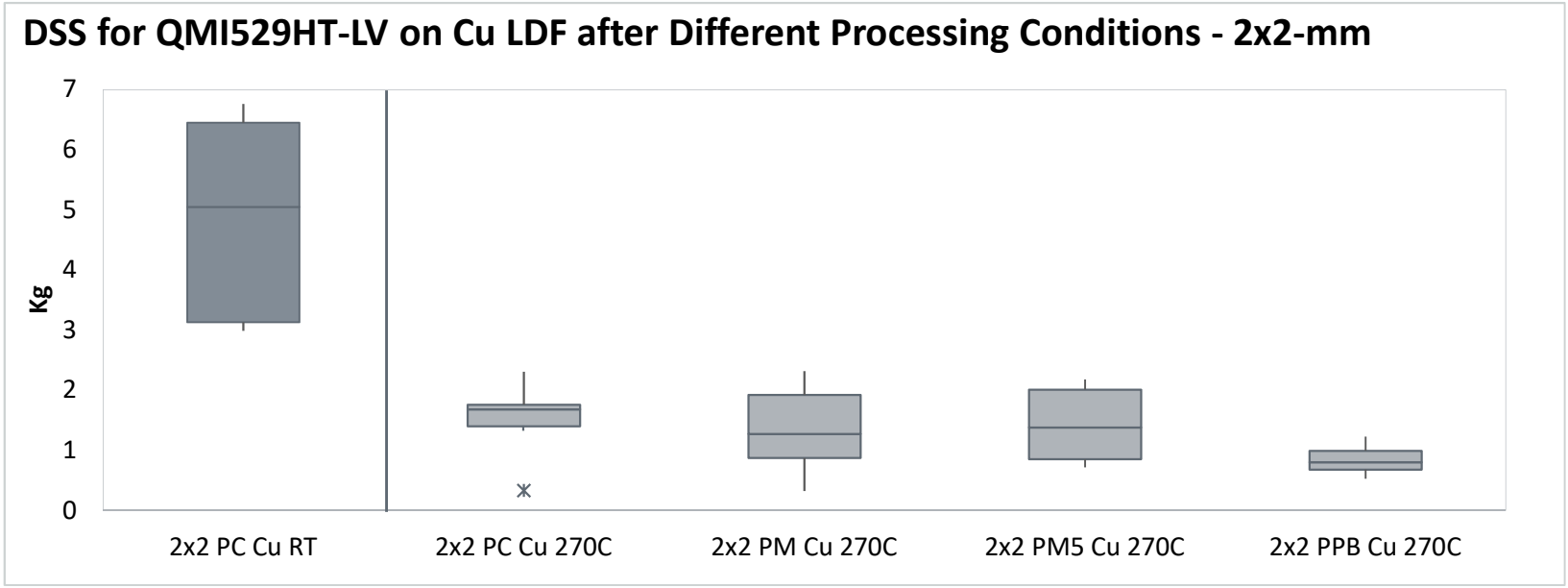
# Test Matrix

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



# Adhesion on Cu, 2x2-mm Die Size

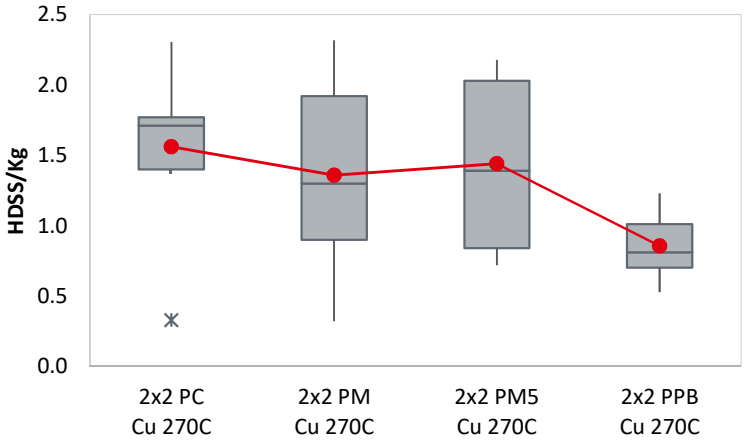
- The adhesion was measured for 2x2-mm die size on Cu LDF in accordance with the test matrix: -



# HDSS (270°C) on Cu, 2x2-mm Die Size

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

**HDSS for QMI529HT-LV on Cu LDF after Different Processing Conditions - 2x2-mm**




**One-way ANOVA: 2x2 PC Cu, 2x2 PM Cu, 2x2 PM5 Cu, 2x2 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 |
|---|---|---|---|
| 2x2 PC Cu 270C | 8 | 1.5613 | 0.5669 |
| 2x2 PM Cu 270C | 8 | 1.3589 | 0.6478 |
| 2x2 PM5 Cu 270C | 8 | 1.4409 | 0.5695 |
| 2x2 PPB Cu 270C | 8 | 0.8558 | 0.2188 |

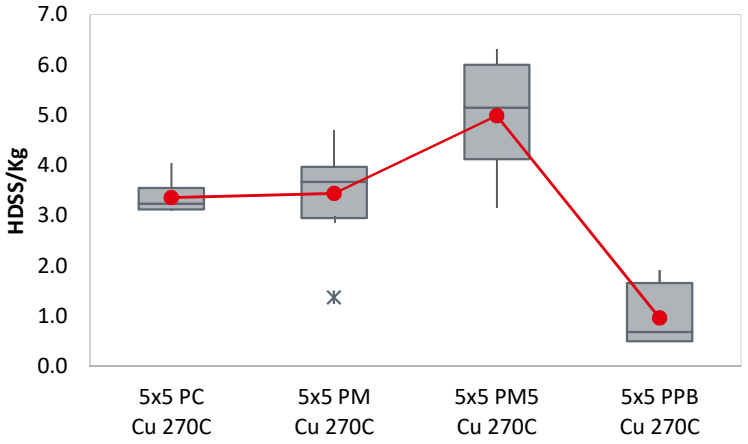
0.80 1.20 1.60 2.00

Pooled StDev 0.5275

# HDSS (270°C) on Cu, 5x5-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (27°C) adhesion on Cu leadframe at the 5x5-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on Cu LDF after Different Processing Conditions - 5x5-mm**




Adh. to LDF

**One-way ANOVA: 5x5 PC Cu, 5x5 PM Cu, 5x5 PM5 Cu, 5x5 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 |
|---|---|---|---|
| 5x5 PC Cu 270C | 8 | 3.3556 | 0.3251 |
| 5x5 PM Cu 270C | 8 | 3.4416 | 0.9932 |
| 5x5 PM5 Cu 270C | 8 | 4.9884 | 1.0750 |
| 5x5 PPB Cu 270C | 8 | 0.9599 | 0.6009 |

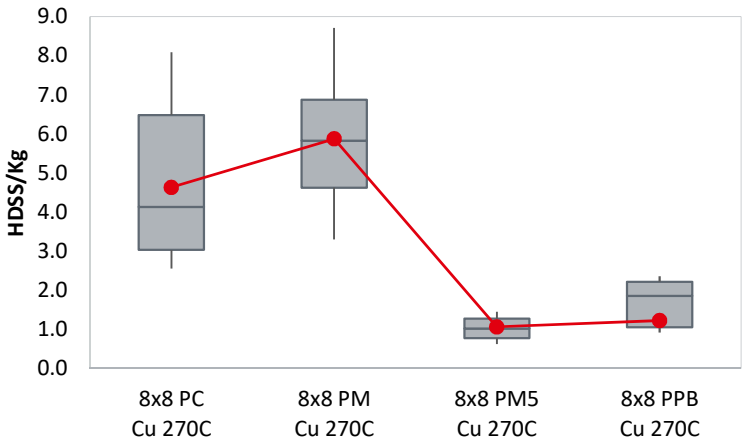
1.5 3.0 4.5 6.0

Pooled StDev 0.8076

# HDSS (270°C) on Cu, 8x8-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on Cu leadframe at the 8x8-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on Cu LDF after Different Processing Conditions - 8x8-mm**




Adh. to LDF

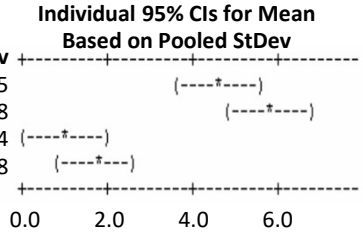
**One-way ANOVA: 8x8 PC Cu, 8x8 PM Cu, 8x8 PM5 Cu, 8x8 PPB Cu**

| 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%

Individual 95% CIs for Mean Based on Pooled StDev

| Level | N | Mean | StDev |
|---|---|---|---|
| 8x8 PC Cu 270C | 8 | 4.632 | 1.985 |
| 8x8 PM Cu 270C | 8 | 5.872 | 1.698 |
| 8x8 PM5 Cu 270C | 8 | 1.059 | 0.284 |
| 8x8 PPB Cu 270C | 8 | 1.723 | 0.568 |




Pooled StDev 1.344

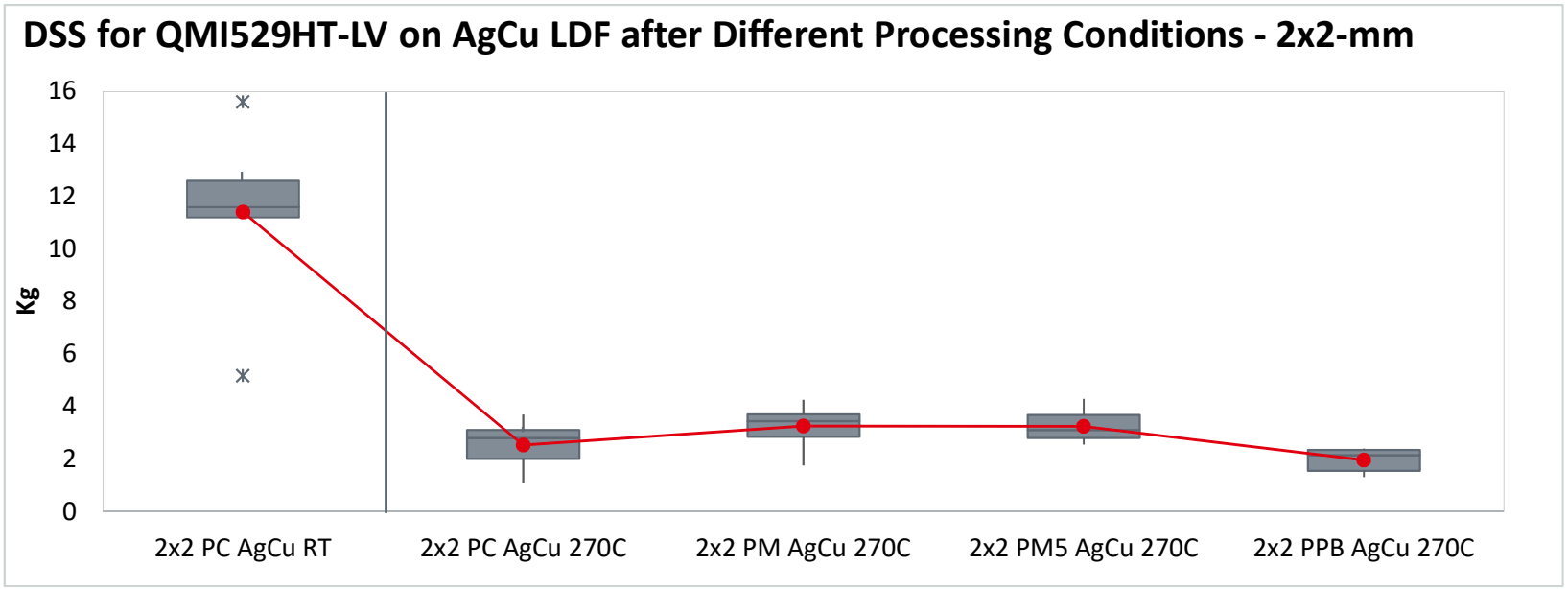
# Basic Statistics on Cu LDF

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

| Variable | Total Count | Mean | StDev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **2x2-mm Die size** | | | | | | |
| 2x2 PC Cu RT | 8 | 4.900 | 1.697 | 2.881 | 2.987 | 6.766 |
| 2x2 PC Cu 270C | 8 | 1.561 | 0.567 | 0.321 | 0.327 | 2.305 |
| 2x2 PM Cu 270C | 8 | 1.359 | 0.648 | 0.420 | 0.320 | 2.318 |
| 2x2 PM5 Cu 270C | 8 | 1.441 | 0.570 | 0.324 | 0.718 | 2.178 |
| 2x2 PPB Cu 270C | 8 | 0.8558 | 0.2188 | 0.0479 | 0.5270 | 1.2290 |
| **5x5-mm Die Size** | | | | | | |
| 5x5 PC Cu 270C | 8 | 3.357 | 0.325 | 0.106 | 3.091 | 4.050 |
| 5x5 PM Cu 270C | 8 | 3.442 | 0.993 | 0.987 | 1.369 | 4.702 |
| 5x5 PM5 Cu 270C | 8 | 4.988 | 1.075 | 1.156 | 3.148 | 6.318 |
| 5x5 PPB Cu 270C | 8 | 0.960 | 0.601 | 0.361 | 0.506 | 1.913 |
| **8x8-mm Die Size** | | | | | | |
| 8x8 PC Cu 270C | 8 | 4.632 | 1.985 | 3.941 | 2.554 | 8.088 |
| 8x8 PM Cu 270C | 8 | 5.872 | 1.698 | 2.882 | 3.295 | 8.707 |
| 8x8 PM5 Cu 270C | 8 | 1.059 | 0.284 | 0.081 | 0.618 | 1.449 |
| 8x8 PPB Cu 270C | 8 | 1.723 | 0.568 | 0.323 | 0.913 | 2.356 |

# Adhesion on AgCu, 2x2-mm Die Size

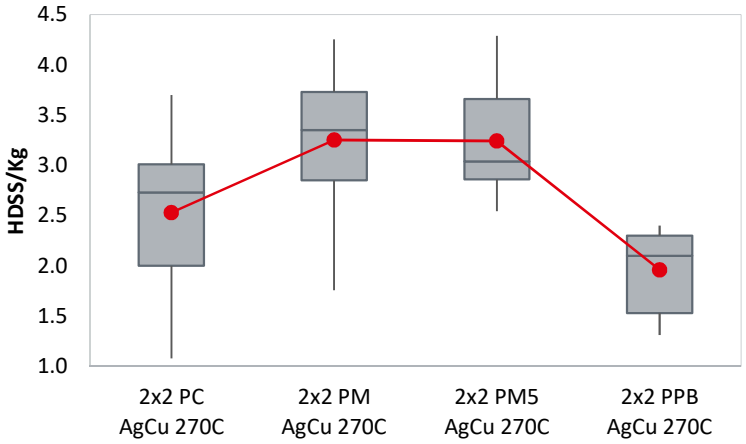
- The adhesion was measured for 2x2-mm die size on AgCu LDF in accordance with the test matrix: -



# HDSS (270°C) on AgCu, 2x2-mm Die Size

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

**HDSS for QMI529HT-LV on AgCu LDF after Different Processing Conditions - 2x2-mm**




**One-way ANOVA: 2x2 PC AgC, 2x2 PM AgC, 2x2 PM5 Ag, 2x2 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 | Individual 95% CIs for Mean Based on Pooled StDev |
|---|---|---|---|---|
| 2x2 PC AgCu 270C | 8 | 2.5299 | 0.8179 | (-------*-------) |
| 2x2 PM AgCu 270C | 8 | 3.2524 | 0.7494 | (-------*-------) |
| 2x2 PM5 AgCu 270C | 8 | 3.2424 | 0.5648 | (-------*-------) |
| 2x2 PPB AgCu 270C | 8 | 1.9597 | 0.4048 | (-------*-------) |

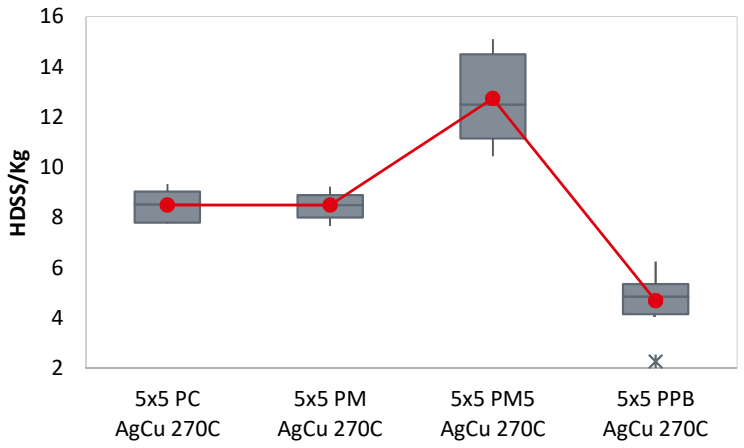
1.8 2.4 3.0 3.6

Pooled StDev 0.6545

# HDSS (270°C) on AgCu, 5x5-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on AgCu leadframe at the 5x5-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on AgCu LDF after Different Processing Conditions - 5x5-mm**



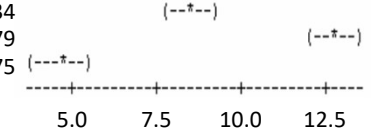

**One-way ANOVA: 5x5 PC AgC, 5x5 PM AgC, 5x5 PM5 Ag, 5x5 PPB Ag**

| 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 |
|---|---|---|---|
| 5x5 PC AgCu 270C | 8 | 8.503 | 0.594 |
| 5x5 PM AgCu 270C | 8 | 8.496 | 0.534 |
| 5x5 PM5 AgCu 270C | 8 | 12.742 | 1.779 |
| 5x5 PPB AgCu 270C | 8 | 4.685 | 1.175 |



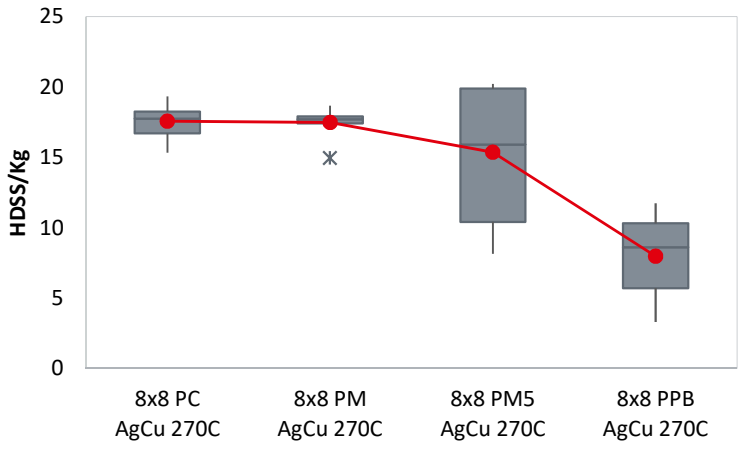

Pooled StDev 1.138

Cohesive!

# HDSS (270°C) on AgCu, 8x8-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on AgCu leadframe at the 8x8-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on AgCu LDF after Different Processing Conditions - 8x8-mm**




**One-way ANOVA: 8x8 PC AgC, 8x8 PM AgC, 8x8 PM5 Ag, 8x8 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 |
|---|---|---|---|
| 8x8 PC AgCu 270C | 8 | 17.568 | 1.201 |
| 8x8 PM AgCu 270C | 8 | 17.473 | 1.097 |
| 8x8 PM5 AgCu 270C | 8 | 15.319 | 4.702 |
| 8x8 PPB AgCu 270C | 8 | 7.974 | 2.830 |

7.0 9.5 12.0 14.5 17.0

Pooled StDev 2.862

Cohesive!

# Basic Statistics on AgCu LDF

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

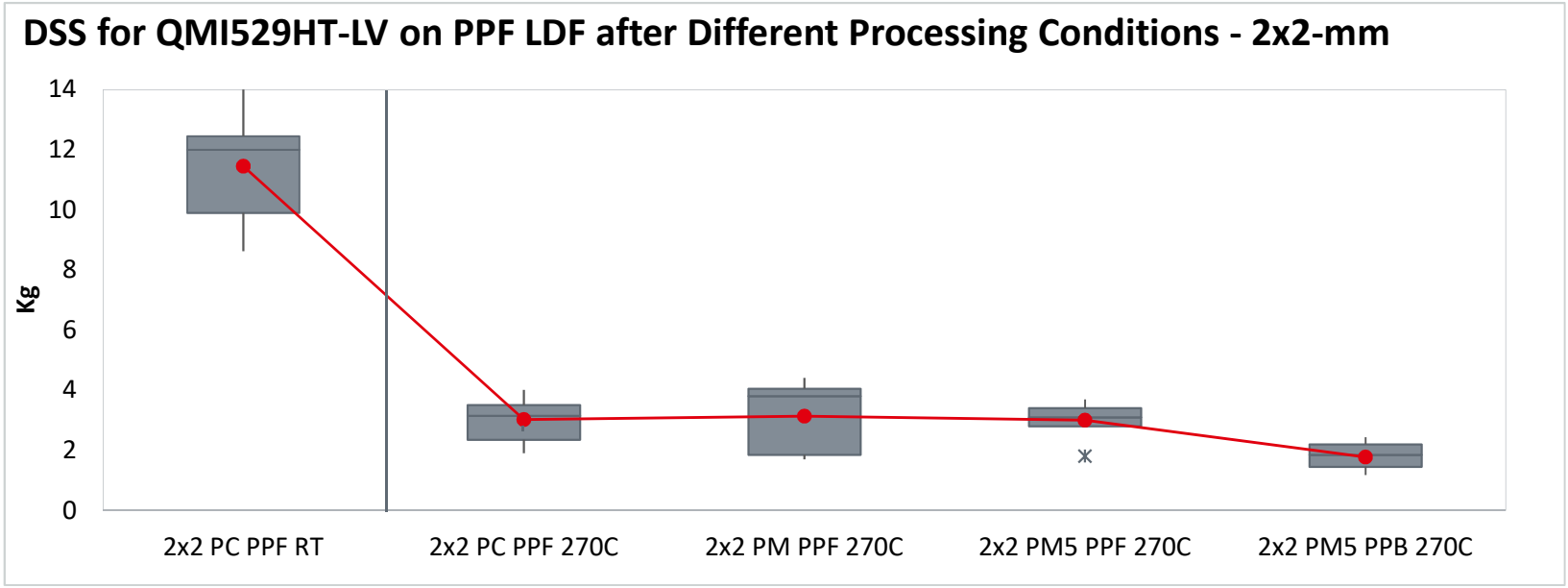
| Variable | Total Count | Mean | StDev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **2x2-mm Die size** | | | | | | |
| 2x2 PC AgCu RT | 8 | 11.41 | 2.91 | 8.46 | 5.17 | 15.60 |
| 2x2 PC AgCu 270C | 8 | 2.530 | 0.818 | 0.669 | 1.079 | 3.700 |
| 2x2 PM AgCu 270C | 8 | 3.252 | 0.749 | 0.562 | 1.757 | 4.255 |
| 2x2 PM5 AgCu 270C | 8 | 3.242 | 0.565 | 0.319 | 2.545 | 4.288 |
| 2x2 PPB AgCu 270C | 8 | 1.960 | 0.405 | 0.164 | 1.310 | 2.401 |
| **5x5-mm Die Size** | | | | | | |
| 5x5 PC AgCu 270C | 8 | 8.503 | 0.594 | 0.352 | 7.770 | 9.328 |
| 5x5 PM AgCu 270C | 8 | 8.496 | 0.534 | 0.285 | 7.669 | 9.225 |
| 5x5 PM5 AgCu 270C | 8 | 12.742 | 1.779 | 3.163 | 10.436 | 15.105 |
| 5x5 PPB AgCu 270C | 8 | 4.685 | 1.175 | 1.380 | 2.262 | 6.256 |
| **8x8-mm Die Size** | | | | | | |
| 8x8 PC AgCu 270C | 8 | 17.568 | 1.201 | 1.443 | 15.335 | 19.332 |
| 8x8 PM AgCu 270C | 8 | 17.473 | 1.097 | 1.203 | 14.939 | 18.665 |
| 8x8 PM5 AgCu 270C | 8 | 15.32 | 4.70 | 22.11 | 8.13 | 20.22 |
| 8x8 PPB AgCu 270C | 8 | 7.97 | 2.83 | 8.01 | 3.28 | 11.73 |



Henkel

# Adhesion on PPF, 2x2-mm Die Size

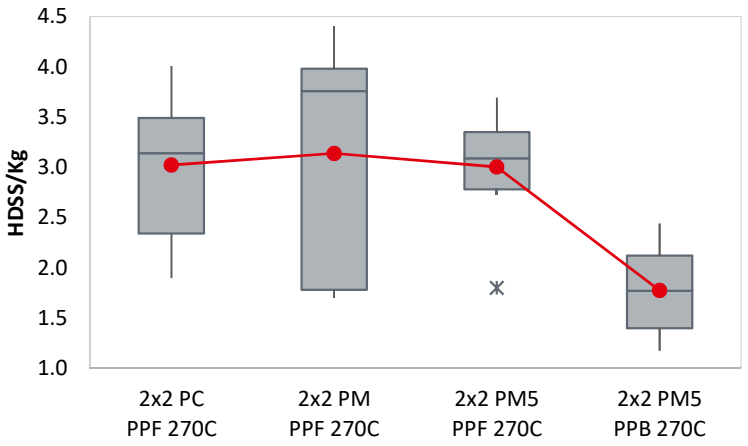
- The adhesion was measured for 2x2-mm die size on PPF LDF in accordance with the test matrix: -



# HDSS (270°C) on PPF, 2x2-mm Die Size

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

**HDSS for QMI529HT-LV on PPF LDF after Different Processing Conditions - 2x2-mm**




**One-way ANOVA: 2x2 PC PPF, 2x2 PM PPF, 2x2 PM5 PP, 2x2 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 |
|---|---|---|---|
| 2x2 PC PPF 270C | 8 | 3.0219 | 0.7061 |
| 2x2 PM PPF 270C | 8 | 3.1384 | 1.1663 |
| 2x2 PM5 PPF 270C | 8 | 3.0033 | 0.5778 |
| 2x2 PM5 PPB 270C | 8 | 1.7745 | 0.496 |

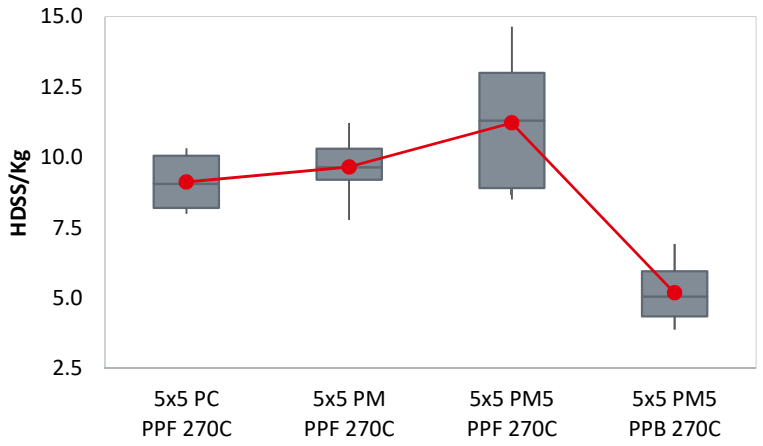
1.4 2.1 2.8 3.5

Pooled StDev 0.7709

# HDSS (270°C) on PPF, 5x5-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on PPF leadframe at the 5x5-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on PPF LDF after Different Processing Conditions - 5x5-mm**




**One-way ANOVA: 5x5 PC PPF, 5x5 PM PPF, 5x5 PM5 PP, 5x5 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 |
|---|---|---|---|
| 5x5 PC PPF 270C | 8 | 9.125 | 0.980 |
| 5x5 PM PPF 270C | 8 | 9.655 | 1.031 |
| 5x5 PM5 PPF 270C | 8 | 11.223 | 2.292 |
| 5x5 PM5 PPB 270C | 8 | 5.182 | 0.987 |

5.0 7.5 10.0 12.5

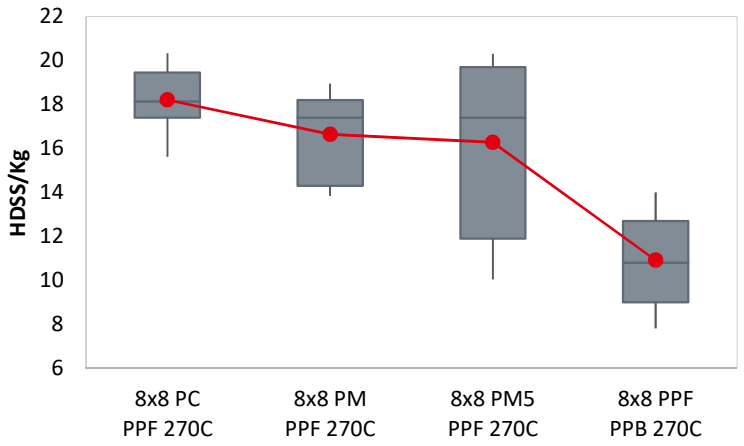
Pooled StDev 1.436

Cohesive!

# HDSS (270°C) on PPF, 8x8-mm Die Size

- The below boxplot and ANOVA analysis compares HDSS (270°C) adhesion on PPF leadframe at the 8x8-mm die size at all test intervals: -

**HDSS for QMI529HT-LV on PPF LDF after Different Processing Conditions - 8x8-mm**




**One-way ANOVA: 8x8 PC PPF, 8x8 PM PPF, 8x8 PM5 PP, 8x8 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%

Individual 95% CIs for Mean Based on Pooled StDev

| Level | N | Mean | StDev |
|---|---|---|---|
| 8x8 PC PPF 270C | 8 | 18.213 | 1.459 |
| 8x8 PM PPF 270C | 8 | 16.651 | 1.999 |
| 8x8 PM5 PPF 270C | 8 | 16.277 | 3.957 |
| 8x8 PPF PPB 270C | 8 | 10.917 | 2.187 |

9.0 12.0 15.0 18.0

Cohesive!

# Basic Statistics on PPF LDF

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

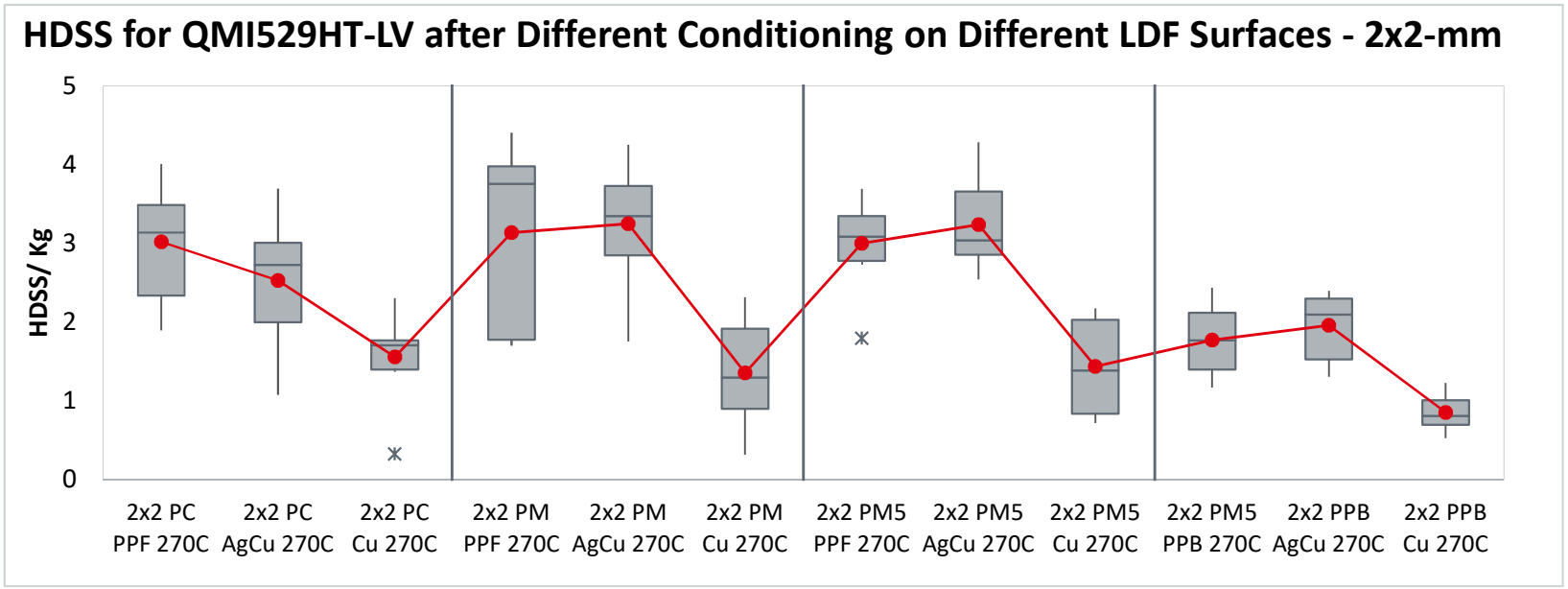
| Variable | Total Count | Mean | StDev | Variance | Minimum | Maximum |
|---|---|---|---|---|---|---|
| **2x2-mm Die size** | | | | | | |
| 2x2 PC PPF RT | 8 | 11.455 | 1.805 | 3.258 | 8.623 | 14.210 |
| 2x2 PC PPF 270C | 8 | 3.022 | 0.706 | 0.499 | 1.898 | 4.010 |
| 2x2 PM PPF 270C | 8 | 3.138 | 1.166 | 1.360 | 1.701 | 4.408 |
| 2x2 PM5 PPF 270C | 8 | 3.003 | 0.578 | 0.334 | 1.797 | 3.694 |
| 2x2 PP5 PPB 270C | 8 | 1.775 | 0.430 | 0.185 | 1.173 | 2.440 |
| **5x5-mm Die Size** | | | | | | |
| 5x5 PC PPF 270C | 8 | 9.125 | 0.980 | 0.960 | 7.989 | 10.317 |
| 5x5 PM PPF 270C | 8 | 9.655 | 1.031 | 1.064 | 7.773 | 11.219 |
| 5x5 PM5 PPF 270C | 8 | 11.223 | 2.292 | 5.253 | 8.499 | 14.640 |
| 5x5 PM5 PPB 270C | 8 | 5.182 | 0.987 | 0.975 | 3.867 | 6.924 |
| **8x8-mm Die Size** | | | | | | |
| 8x8 PC PPF 270C | 8 | 18.213 | 1.459 | 2.129 | 15.621 | 20.332 |
| 8x8 PM PPF 270C | 8 | 16.651 | 1.999 | 3.994 | 13.846 | 18.946 |
| 8x8 PM5 PPF 270C | 8 | 16.28 | 3.96 | 15.66 | 10.04 | 20.31 |
| 8x8 PPF PPB 270C | 8 | 10.917 | 2.187 | 4.782 | 7.813 | 14 |



Henkel

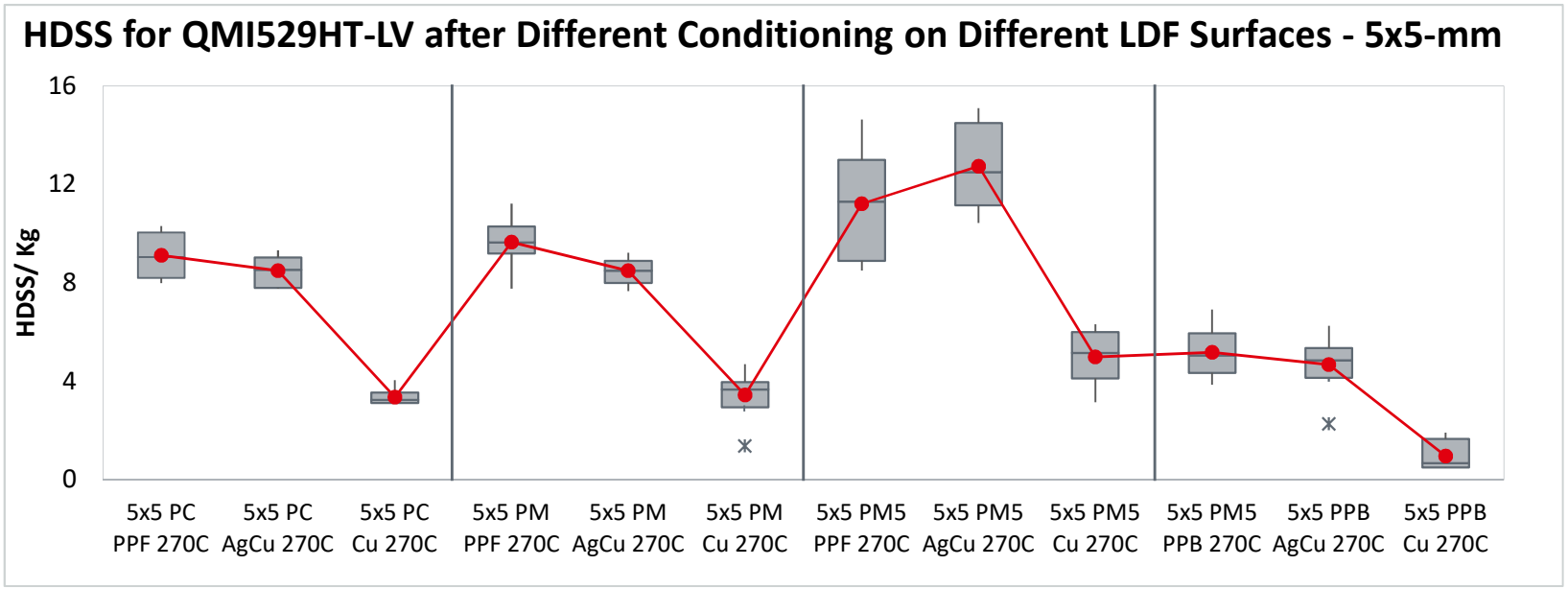
# 2x2-mm Die Size Adhesion Summary

- The below boxplot displays the adhesion for the 2x2-mm die size on all leadframe surfaces and at all test intervals: -



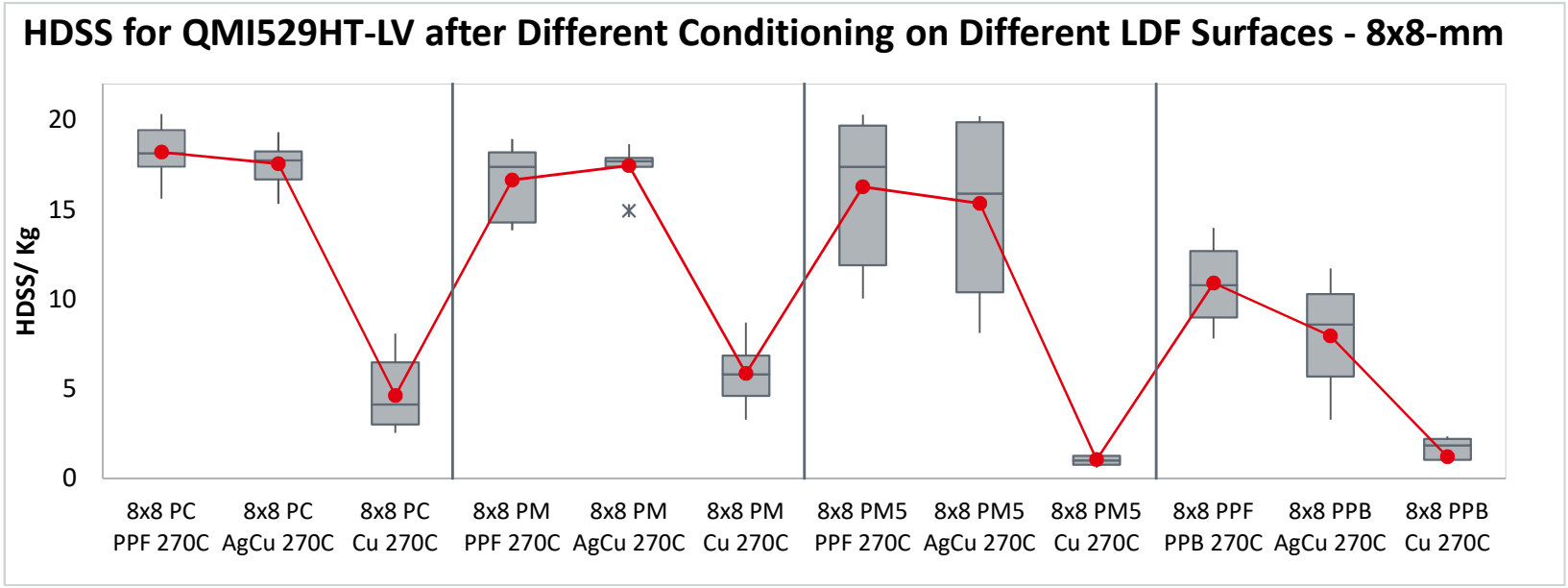
# 5x5-mm Die Size Adhesion Summary

- The below boxplot displays the adhesion for the 5x5-mm die size on all leadframe surfaces and at all test intervals: -



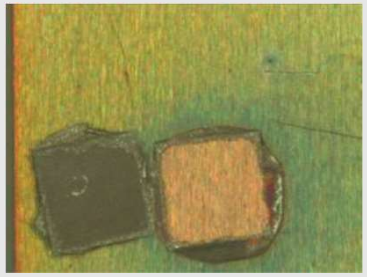
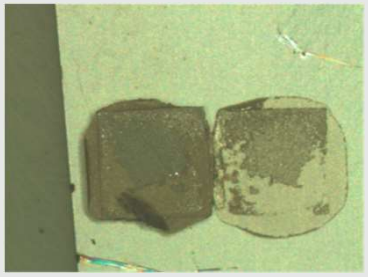
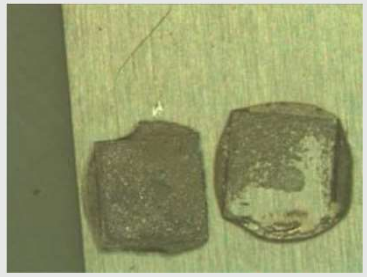
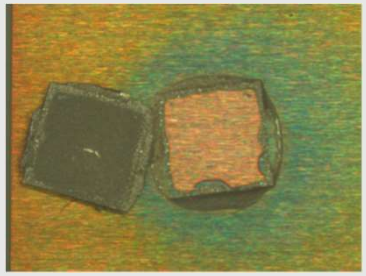
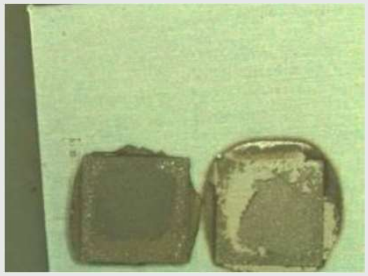
# 8x8-mm Die Size Adhesion Summary

- The below boxplot displays the adhesion for the 8x8-mm die size on all leadframe surfaces and at all test intervals: -



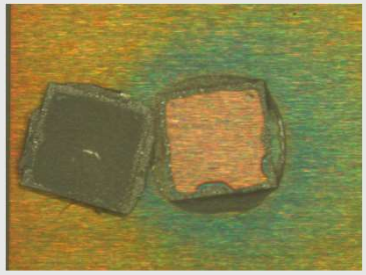
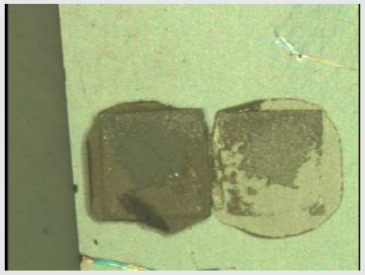
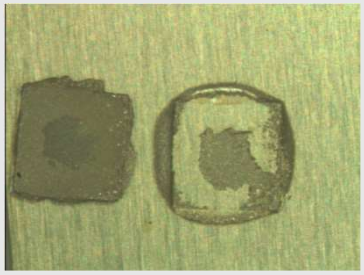
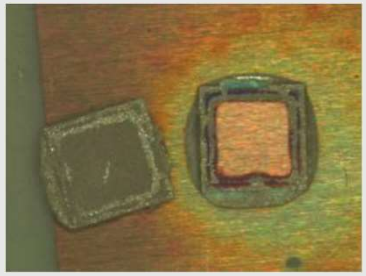
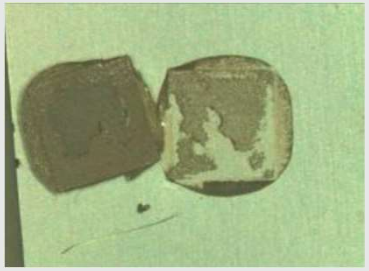
# Die Shear Failure Mode

- The following die shear failures were observed at the 2x2-mm die size after cure and post mold bake: -

| | | | | | |
|---|---|---|---|---|---|
| **Post Cure on Cu**<br>Adh. to LDF |  | **Post Cure on AgCu**<br>Cohesive! |  | **Post Cure on PPF**<br>Cohesive! |  |
| **PMB on Cu**<br>Adh. to LDF |  | **PMB on AgCu**<br>Cohesive! |  | **PMB on PPF**<br>Cohesive! |  |

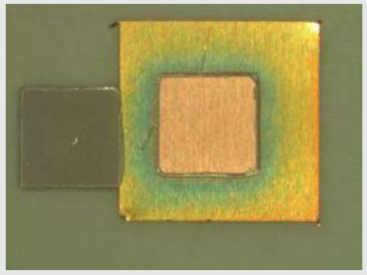
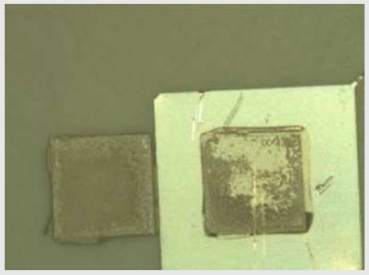
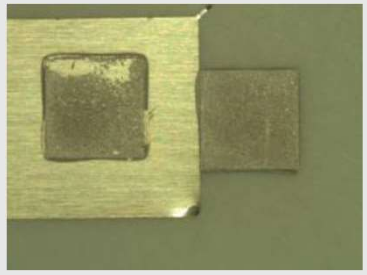
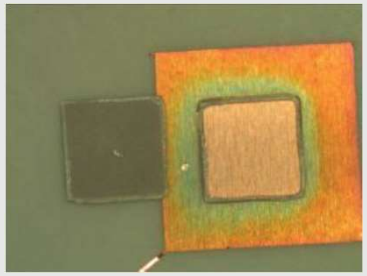
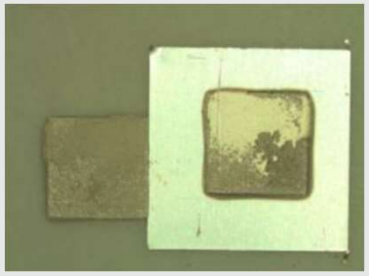
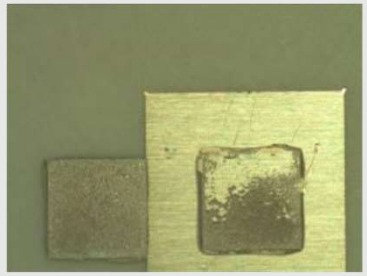
# Die Shear Failure Mode

- The following die shear failures were observed at the 2x2-mm die size after PM5 and PPB bake: -

| | | | | | |
|---|---|---|---|---|---|
| **PM5 on Cu**<br>Adh. to LDF |  | **PM5 on AgCu**<br>Cohesive! |  | **PM5 on PPF**<br>Cohesive! |  |
| **PPB on Cu**<br>Adh. to LDF |  | **PPB on AgCu**<br>Cohesive! |  | **PPB on PPF**<br>Cohesive! |  |

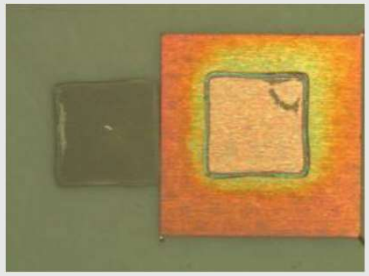
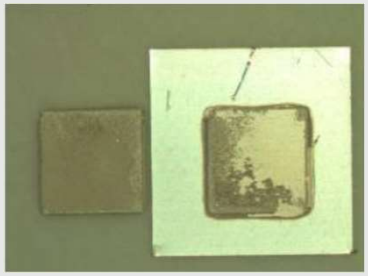
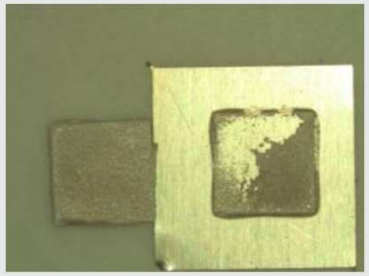
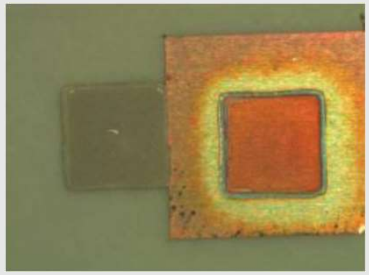
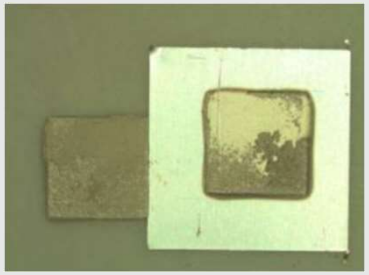
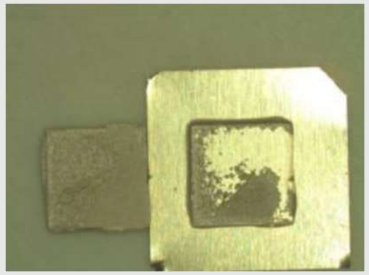
# Die Shear Failure Mode

- The following die shear failures were observed at the 5x5-mm die size after cure and post mold bake: -

| | | | | | |
|---|---|---|---|---|---|
| **Post Cure on Cu**<br>Adh. to LDF |  | **Post Cure on AgCu**<br>Cohesive! |  | **Post Cure on PPF**<br>Cohesive! |  |
| **PMB on Cu**<br>Adh. to LDF |  | **PMB on AgCu**<br>Cohesive! |  | **PMB on PPF**<br>Cohesive! |  |

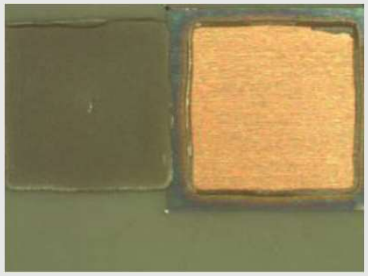
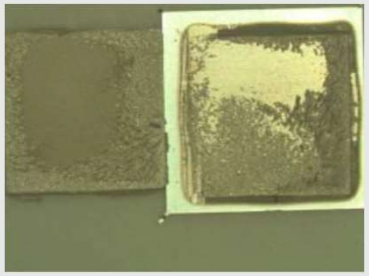
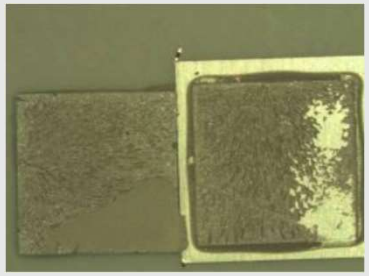
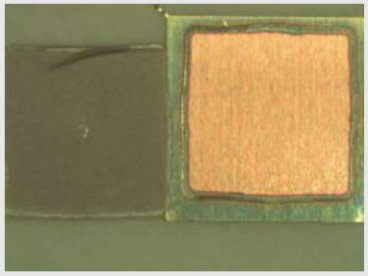
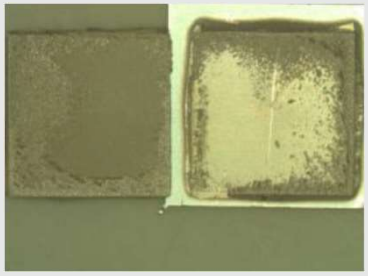
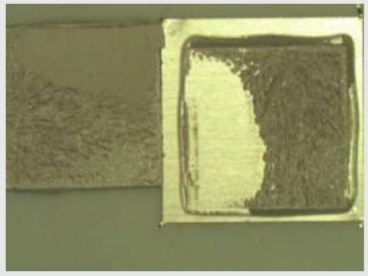
# Die Shear Failure Mode

- The following die shear failures were observed at the 5x5-mm die size after PM5 and PPB bake: -

| | | | | | |
|---|---|---|---|---|---|
| **PM5 on Cu**<br>Adh. to LDF |  | **PM5 on AgCu**<br>Cohesive! |  | **PM5 on PPF**<br>Cohesive! |  |
| **PPB on Cu**<br>Adh. to LDF |  | **PPB on AgCu**<br>Cohesive! |  | **PPB on PPF**<br>Cohesive! |  |

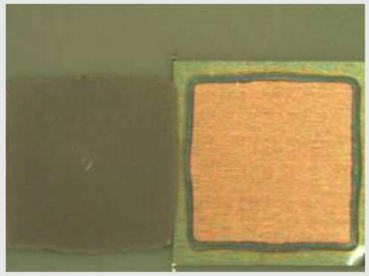
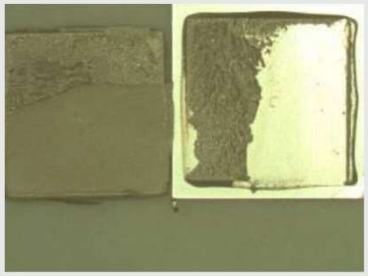
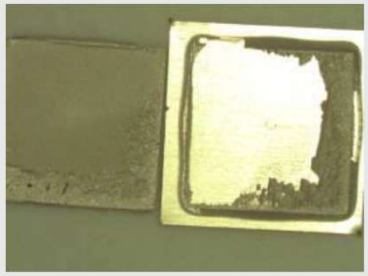
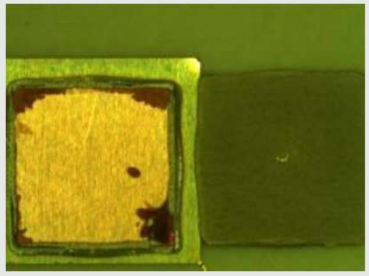
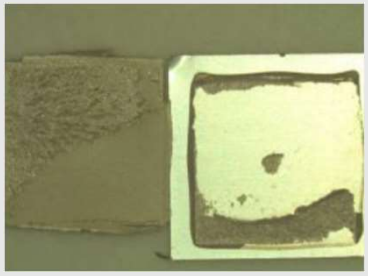
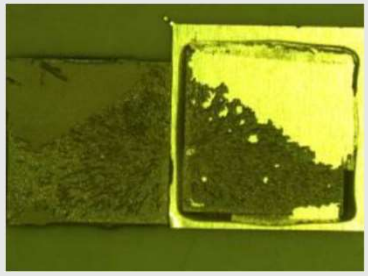
# Die Shear Failure Mode

- The following die shear failures were observed at the 8x8-mm die size after cure and post mold bake: -

| | | | |
|---|---|---|---|
| **Post Cure on Cu**<br>Adh. to LDF |  | **Post Cure on AgCu**<br>Cohesive! |  |
| **Post Cure on PPF**<br>Cohesive! |  | **PMB on Cu**<br>Adh. to LDF |  |
| **PMB on AgCu**<br>Cohesive! |  | **PMB on PPF**<br>Cohesive! |  |

# Die Shear Failure Mode

- The following die shear failures were observed at the 8x8-mm die size after PM5 and PPB bake: -

| | | | | | |
|---|---|---|---|---|---|
| **PM5 on Cu**<br>Adh. to LDF |  | **PM5 on AgCu**<br>Cohesive! |  | **PM5 on PPF**<br>Cohesive! |  |
| **PPB on Cu**<br>Adh. to LDF |  | **PPB on AgCu**<br>Cohesive! |  | **PPB on PPF**<br>Cohesive! |  |

# 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-ILMISR8 and QMI529HT on Cu LDF**

| Die Size (mm) | Conditioning | FS849-TI (g/mm$^2$) | 84-ILMISR8 (g/mm$^2$) | QMI529HT (g/mm$^2$) | QMI529HT-LV (g/mm$^2$) |
|---|---|---|---|---|---|
| 2x2 | 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 |
| 5x5 | 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 |
| 8x8 | 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/mm$^2$ for QMI529HT-LV, FS849-TI, 84-ILMISR8 and QMI529HT on AgCu LDF**

| Die Size (mm) | Conditioning | FS849-TI (g/mm$^2$) | 84-ILMISR8 (g/mm$^2$) | QMI529HT (g/mm$^2$) | QMI529HT-LV (g/mm$^2$) |
|---|---|---|---|---|---|
| 2x2 | Post Mold Bake (270°C) | 66.5 | 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 |
| 5x5 | 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 |
| 8x8 | 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/mm$^2$ for QMI529HT-LV, FS849-TI, 84-ILMISR8 and QMI529HT on PPF LDF**

| Die Size (mm) | Conditioning | FS849-TI (g/mm$^2$) | 84-ILMISR8 (g/mm$^2$) | QMI529HT (g/mm$^2$) | QMI529HT-LV (g/mm$^2$) |
|---|---|---|---|---|---|
| 2x2 | 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 |
| 5x5 | 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 |
| 8x8 | 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

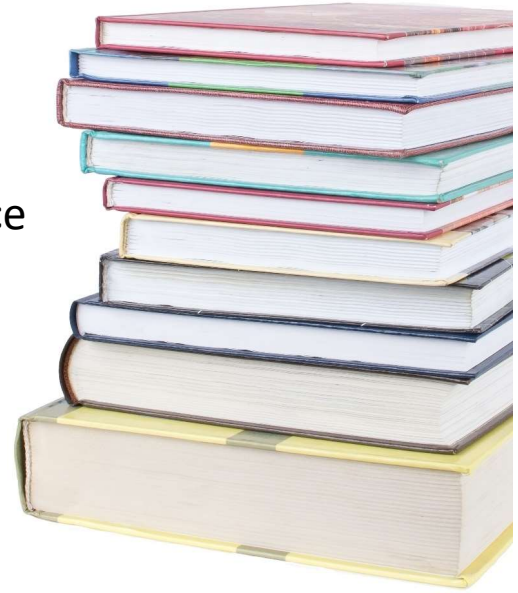
- QMI529HT-LV has excellent adhesion to AgCu and PPF leadframes surfaces
- The QMI529HT-LV exhibits very high adhesion performance on AgCu and PPF surfaces when the die size is small e.g. 2x2-mm
- QMI529HT-LV does not exhibit high adhesion strength on the Cu LDF surface used in this trial
- HDSS failure 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.**

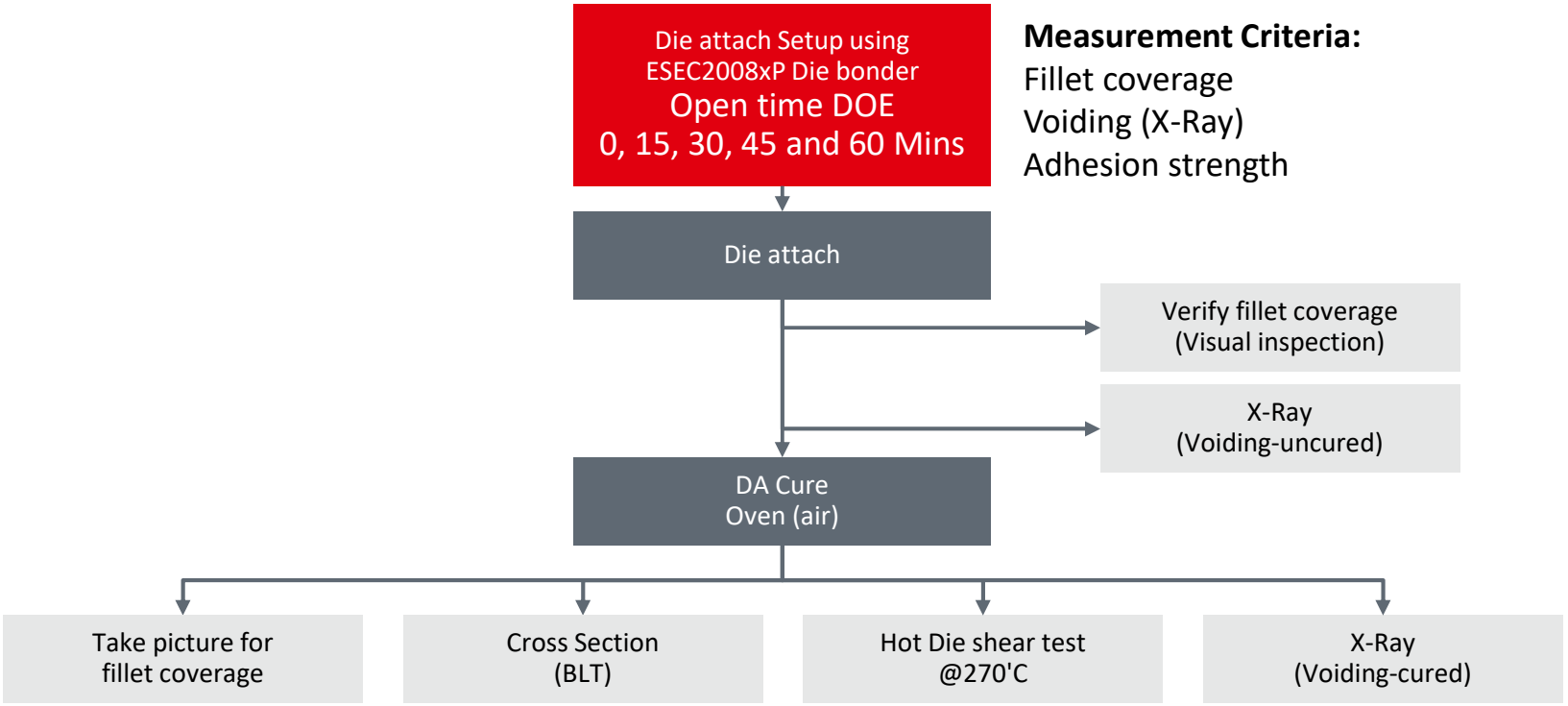
# QMI529HT-LV
# Open Time Evaluation

# 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



# Experimental Set Up

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

- Die size: 2x2, 5x5 & 8x8-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.

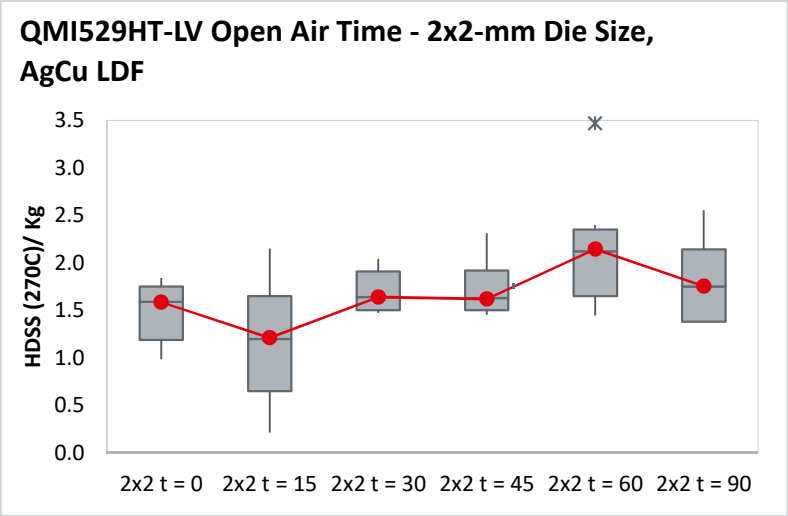
# Hot Die Shear Strength (270°C) Comparison versus Open Time

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

| Variable | Total Count | Mean | StDev | Variance | Min. | Median | Max. |
|---|---|---|---|---|---|---|---|
| 2x2 t = 0 | 8 | 1.477 | 0.310 | 0.096 | 0.985 | 1.584 | 1.841 |
| 2x2 t = 15 | 8 | 1.196 | 0.632 | 0.399 | 0.214 | 1.211 | 2.151 |
| 2x2 t = 30 | 8 | 1.6988 | 0.2173 | 0.0472 | 1.4740 | 1.6395 | 2.0400 |
| 2x2 t = 45 | 8 | 1.733 | 0.290 | 0.084 | 1.453 | 1.619 | 2.310 |
| 2x2 t = 60 | 8 | 2.156 | 0.626 | 0.392 | 1.447 | 2.144 | 3.466 |
| 2x2 t = 90 | 8 | 1.809 | 0.441 | 0.194 | 1.371 | 1.753 | 2.552 |
| 5x5 t =0 | 8 | 9.106 | 0.920 | 0.846 | 7.236 | 9.405 | 10.098 |
| 5x5 t = 15 | 8 | 7.951 | 0.872 | 0.761 | 6.961 | 7.786 | 9.785 |
| 5x5 t = 30 | 8 | 8.167 | 0.964 | 0.929 | 6.864 | 8.035 | 9.650 |
| 5x5 t = 45 | 8 | 6.388 | 1.119 | 1.253 | 4.847 | 6.271 | 8.050 |
| 5x5 t = 60 | 8 | 6.384 | 1.409 | 1.985 | 4.828 | 5.928 | 9.250 |
| 5x5 t = 90 | 8 | 6.186 | 0.874 | 0.764 | 4.833 | 6.190 | 7.832 |
| 8x8 t =0 | 8 | 13.185 | 1.391 | 1.935 | 11.419 | 12.967 | 15.071 |
| 8x8 t = 15 | 8 | 14.723 | 1.875 | 3.516 | 12.494 | 14.361 | 17.620 |
| 8x8 t = 30 | 8 | 15.146 | 1.204 | 1.449 | 13.021 | 15.378 | 16.695 |
| 8x8 t = 45 | 8 | 16.946 | 1.483 | 2.201 | 14.314 | 17.203 | 19.449 |
| 8x8 t = 60 | 8 | 15.840 | 1.223 | 1.496 | 13.964 | 15.900 | 17.545 |
| 8x8 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 2x2-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 |
|---|---|---|---|
| 2x2 t = 0 | 8 | 1.4773 | 0.3097 |
| 2x2 t = 15 | 8 | 1.1964 | 0.6315 |
| 2x2 t = 30 | 8 | 1.6988 | 0.2173 |
| 2x2 t = 45 | 8 | 1.7326 | 0.2903 |
| 2x2 t = 60 | 8 | 2.1555 | 0.6258 |
| 2x2 t = 90 | 8 | 1.8095 | 0.4409 |

Pooled StDev 0.4495

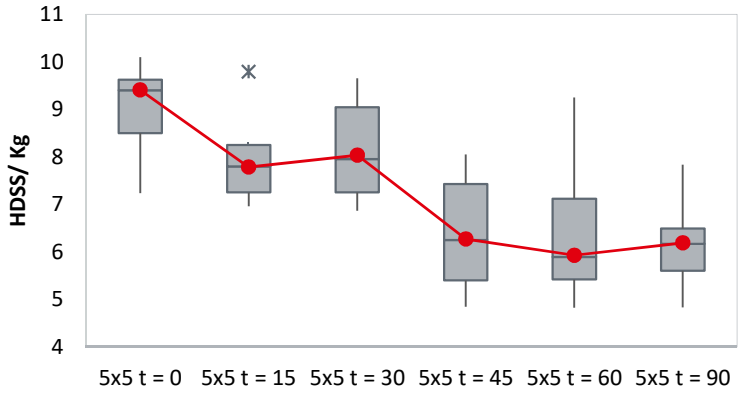
1.0 1.5 2.0 2.5

**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 5x5-mm die size (270°C): -

**QMI529HT-LV Open Air Time - 5x5-mm Die Size, AgCu LDF**

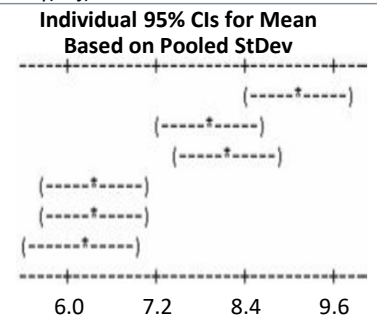



| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Factor | 5 | 58.62 | 11.72 | 10.76 | 0.000 |
| Error | 42 | 45.77 | 1.09 | | |
| Total | 47 | 104.38 | | | |

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

| Level | N | Mean | StDev |
|---|---|---|---|
| 5x5 t =0 | 8 | 9.106 | 0.920 |
| 5x5 t = 15 | 8 | 7.951 | 0.872 |
| 5x5 t = 30 | 8 | 8.167 | 0.964 |
| 5x5 t = 45 | 8 | 6.388 | 1.119 |
| 5x5 t = 60 | 8 | 6.384 | 1.409 |
| 5x5 t = 90 | 8 | 6.186 | 0.874 |

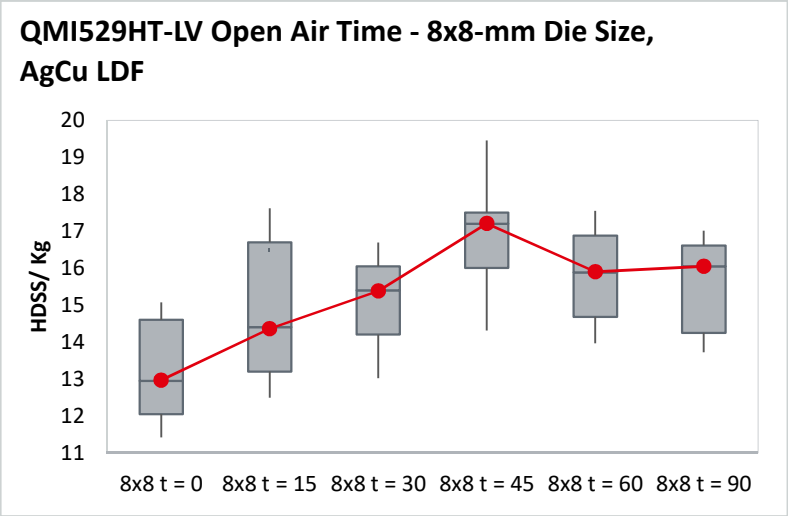
Pooled StDev 1.044




**HDSS data start after 45 minutes open time is statistically lower than 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 8x8-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 |
|---|---|---|---|
| 8x8 t =0 | 8 | 13.185 | 1.391 |
| 8x8 t = 15 | 8 | 14.723 | 1.875 |
| 8x8 t = 30 | 8 | 15.146 | 1.204 |
| 8x8 t = 45 | 8 | 16.946 | 1.483 |
| 8x8 t = 60 | 8 | 15.840 | 1.223 |
| 8x8 t = 90 | 8 | 15.644 | 1.234 |

Pooled StDev 1.421

13.5 15.0 16.5 18.0

**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

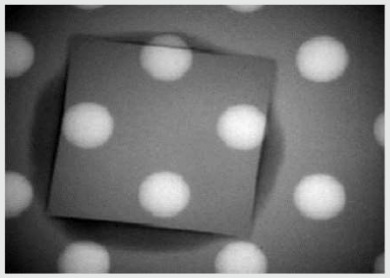


**Figure 2**

T = 30 mins,
2 x 2-mm Die

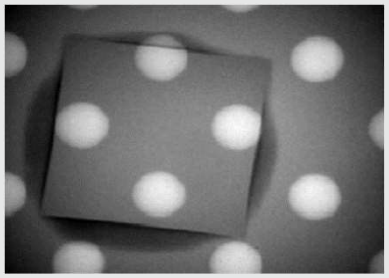


**Figure 3**

T = 60 mins,
2 x 2-mm Die

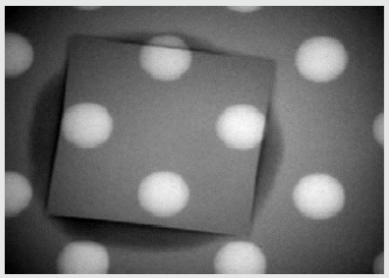
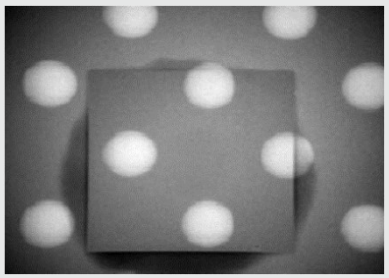


**Figure 4**

T = 90 mins,
2 x 2-mm Die



**No voiding as a function of open time test interval!**

# Assessment of Voiding versus Open Time

- Voiding was checked at various open time intervals: -

**Figure 5**

T = 0 mins,
5 x 5-mm Die

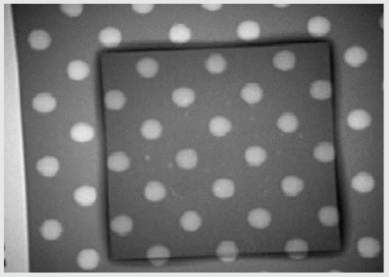


**Figure 6**

T = 30 mins,
5 x 5-mm Die

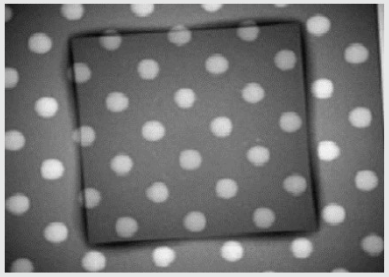


**Figure 7**

T = 60 mins,
5 x 5-mm Die

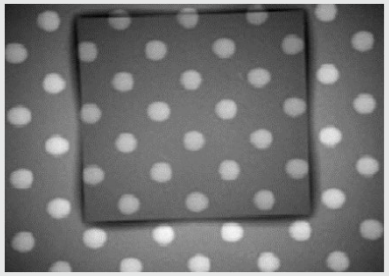
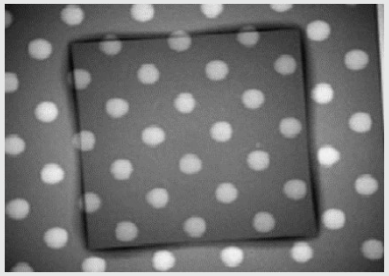


**Figure 8**

T = 90 mins,
5 x 5-mm Die



**No voiding as a function of open time test interval!**

# Assessment of Voiding versus Open Time

- Voiding was checked at various open time intervals: -

**Figure 9**

T = 0 mins,
8 x 8-mm Die

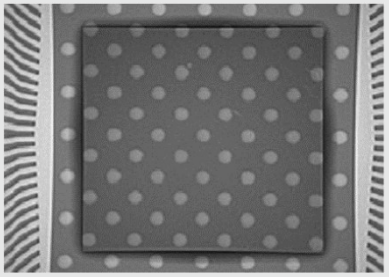


**Figure 10**

T = 30 mins,
8 x 8-mm Die

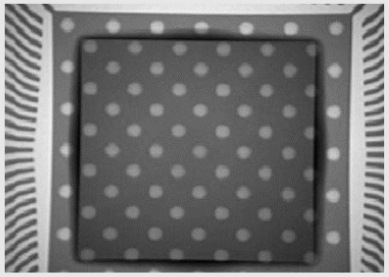


**Figure 11**

T = 60 mins,
8 x 8-mm Die

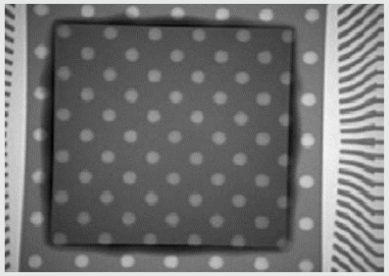
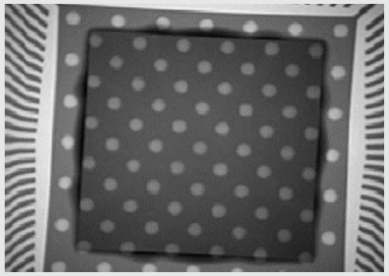


**Figure 12**

T = 90 mins,
8 x 8-mm Die



**No voiding as a function of open time test interval!**

# 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

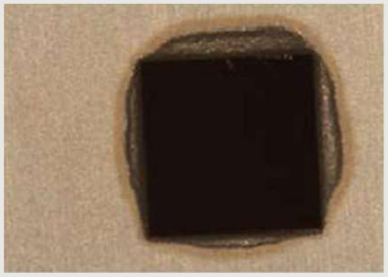


**Figure 16**

T = 30 mins,
2 x 2-mm Die

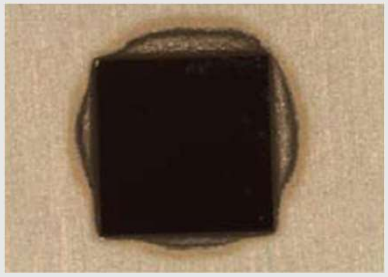


**Figure 17**

T = 60 mins,
2 x 2-mm Die

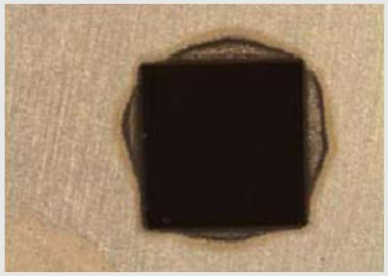
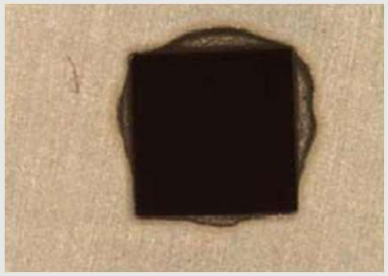


**Figure 18**

T = 90 mins,
2 x 2-mm Die



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

# 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

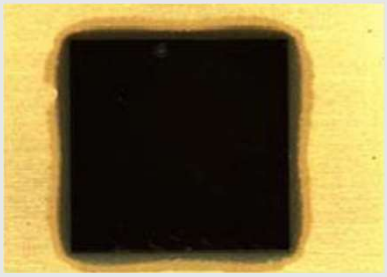


**Figure 20**

T = 30 mins,
5 x 5-mm Die

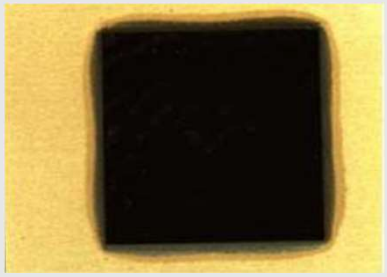


**Figure 21**

T = 60 mins,
5 x 5-mm Die

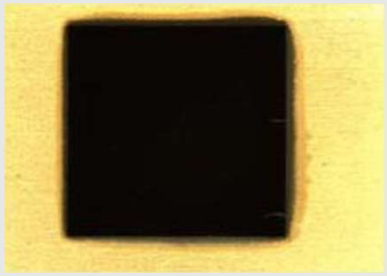
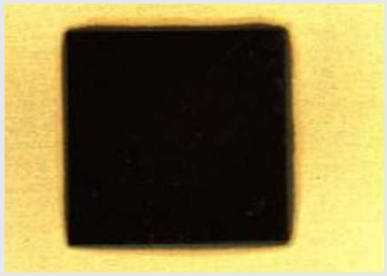


**Figure 22**

T = 90 mins,
5 x 5-mm Die



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

# 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

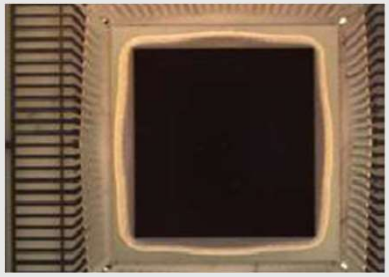


**Figure 24**

T = 30 mins,
8 x 8-mm Die

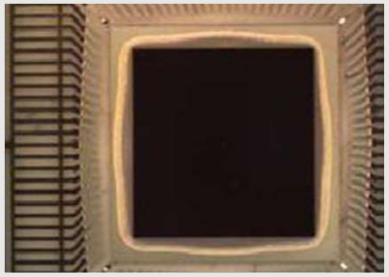


**Figure 25**

T = 60 mins,
8 x 8-mm Die

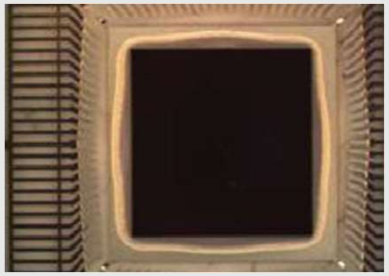
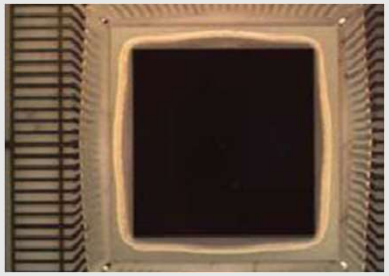


**Figure 26**

T = 90 mins,
8 x 8-mm Die



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

# 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

**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 dependent). Bleed was not a function of open time.

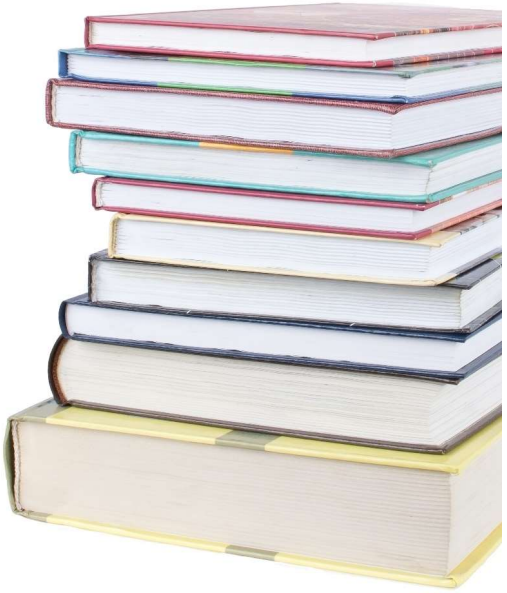
**Comments**

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

# QMI529HT-LV
# Stage Time Evaluation

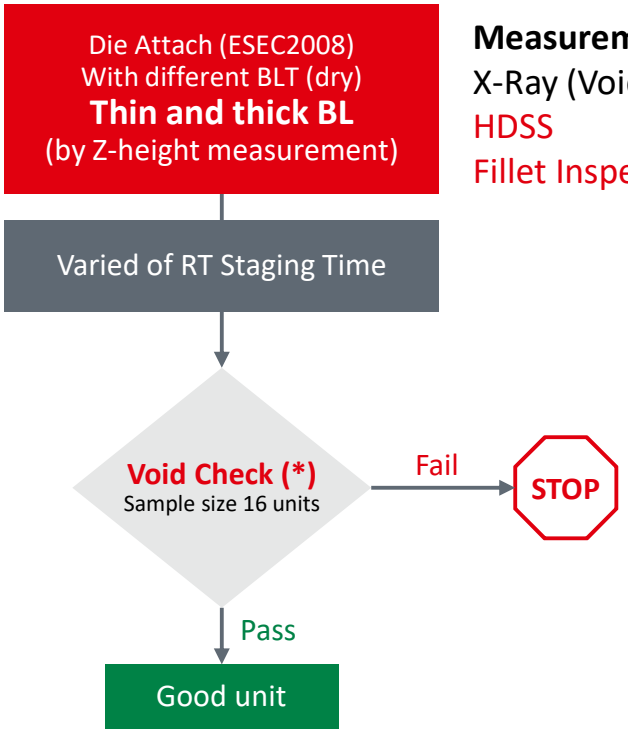
# Background

- 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

**Material:**
**QMI529HT-LV**




**Measurement Criteria:**
X-Ray (Voiding)
HDSS
Fillet Inspection (Bleed)

# Experimental Set Up

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

- Die size: 2x2, 5x5 & 8x8-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.

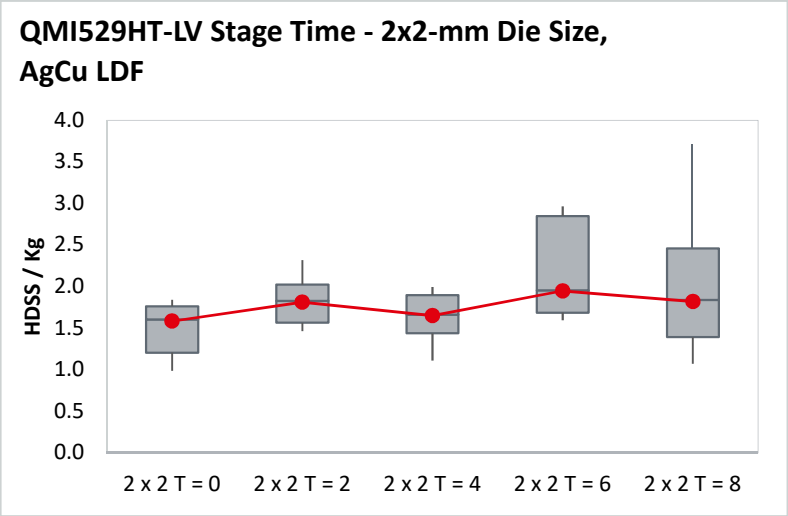
# Hot Die Shear Strength (270°C) Comparison versus Stage Time

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

| Variable | Total Count | Mean | StDev | Variance | Minimum | Median | Maximum |
|---|---|---|---|---|---|---|---|
| 2x2 T = 0 | 8 | 1.477 | 0.310 | 0.096 | 0.985 | 1.584 | 1.841 |
| 2x2 T = 2 | 8 | 1.808 | 0.284 | 0.081 | 1.465 | 1.811 | 2.316 |
| 2x2 T = 4 | 8 | 1.631 | 0.288 | 0.083 | 1.111 | 1.652 | 1.996 |
| 2x2 T = 6 | 8 | 2.184 | 0.567 | 0.321 | 1.595 | 1.947 | 2.966 |
| 2x2 T = 8 | 8 | 1.983 | 0.827 | 0.684 | 1.070 | 1.821 | 3.662 |
| 5x5 T = 0 | 8 | 9.106 | 0.920 | 0.846 | 7.236 | 9.405 | 10.098 |
| 5x5 T = 2 | 8 | 8.277 | 0.978 | 0.956 | 6.870 | 8.271 | 9.445 |
| 5x5 T = 4 | 8 | 7.960 | 1.991 | 3.966 | 3.188 | 8.573 | 9.498 |
| 5x5 T = 6 | 8 | 7.374 | 2.281 | 5.204 | 2.004 | 7.960 | 9.134 |
| 5x5 T = 8 | 8 | 7.894 | 0.458 | 0.210 | 7.239 | 7.993 | 8.399 |
| 8x8 T = 0 | 8 | 13.185 | 1.391 | 1.935 | 11.419 | 12.967 | 15.071 |
| 8x8 T = 2 | 8 | 15.75 | 3.03 | 9.19 | 12.77 | 14.89 | 20.28 |
| 8x8 T = 4 | 8 | 18.10 | 2.88 | 8.29 | 12.97 | 19.66 | 20.31 |
| 8x8 T = 6 | 8 | 15.84 | 3.23 | 10.42 | 12.00 | 14.34 | 20.30 |
| 8x8 T = 8 | 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 2x2-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 |
|---|---|---|---|
| 2x2 T = 0 Hr | 8 | 1.4773 | 0.3097 |
| 2x2 T = 2 Hr | 8 | 1.8081 | 0.2843 |
| 2x2 T = 4 Hr | 8 | 1.6308 | 0.2882 |
| 2x2 T = 6 Hr | 8 | 2.1836 | 0.5667 |
| 2x2 T = 8 Hr | 8 | 1.9829 | 0.8272 |

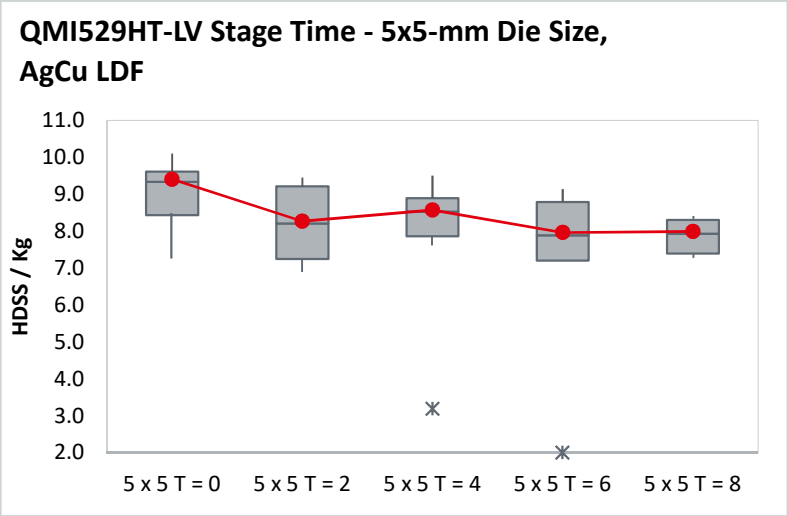
1.20 1.60 2.00 2.40

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

- The below boxplot and ANOVA further display results for HDSS at the 5x5-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 |
|---|---|---|---|
| 2x2 T = 0 Hr | 8 | 9.106 | 0.920 |
| 2x2 T = 2 Hr | 8 | 8.277 | 0.978 |
| 2x2 T = 4 Hr | 8 | 7.960 | 1.991 |
| 2x2 T = 6 Hr | 8 | 7.374 | 2.281 |
| 2x2 T = 8 Hr | 8 | 7.894 | 0.458 |

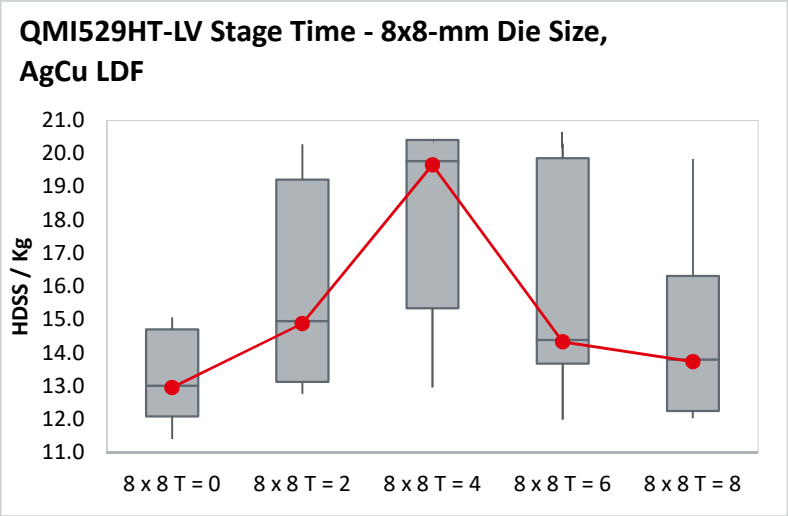
7.0 8.0 9.0 10.0

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 8x8-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 |
|---|---|---|---|
| 2x2 T = 0 Hr | 8 | 13.185 | 1.391 |
| 2x2 T = 2 Hr | 8 | 15.751 | 3.032 |
| 2x2 T = 4 Hr | 8 | 18.104 | 2.880 |
| 2x2 T = 6 Hr | 8 | 15.836 | 3.228 |
| 2x2 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

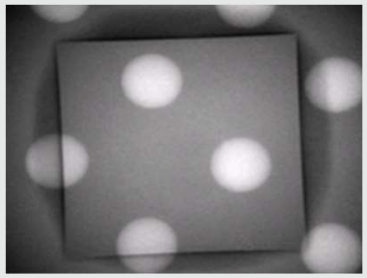


**Figure 2**

Stage Time, T = 2 Hrs

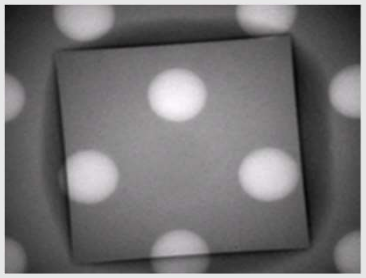


**Figure 3**

Stage Time, T = 4 Hrs

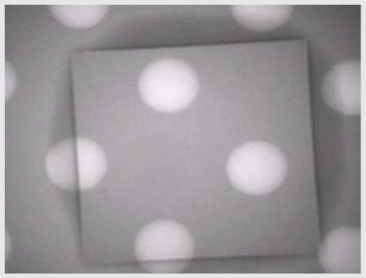


**Figure 4**

Stage Time, T = 6 Hrs

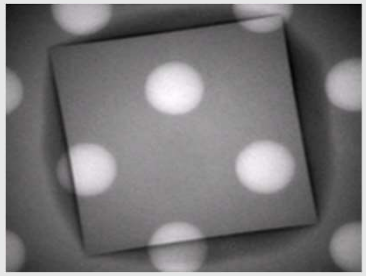
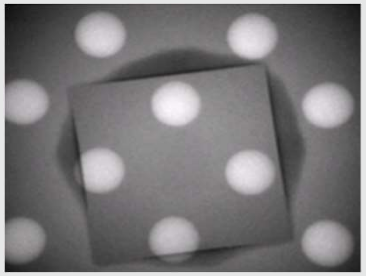


**Figure 5**

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

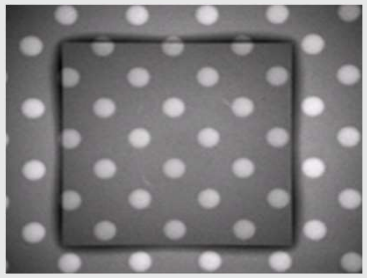


**Figure 7**

Stage Time, T = 2 Hrs

**Figure 8**

Stage Time, T = 4 Hrs

**Figure 9**

Stage Time, T = 6 Hrs

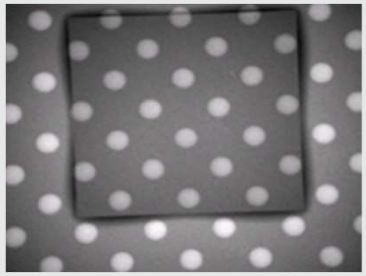


**Figure 10**

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

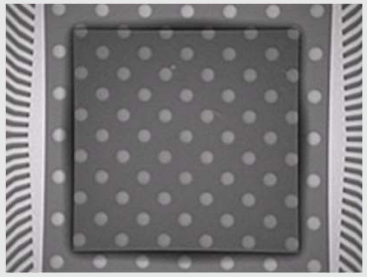


**Figure 12**

Stage Time, T = 2 Hrs

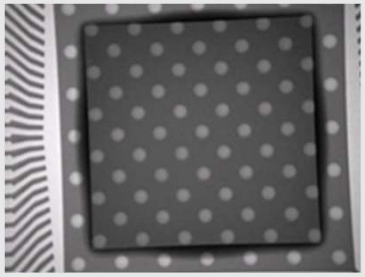


**Figure 13**

Stage Time, T = 4 Hrs

**Figure 14**

Stage Time, T = 6 Hrs

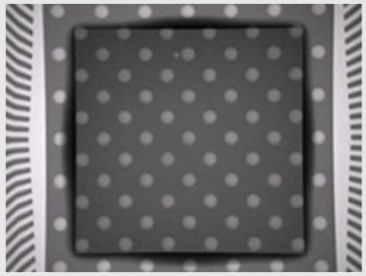
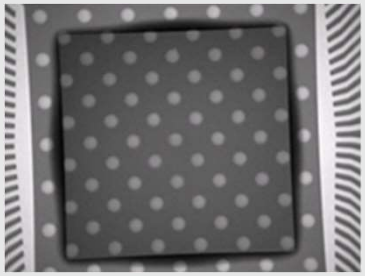


**Figure 15**

Stage Time, T = 8 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

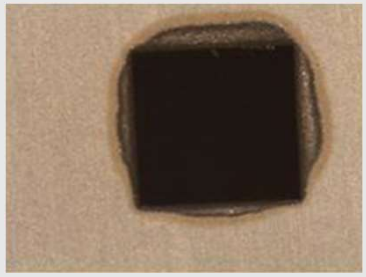


**Figure 17**

Fillet Coverage, T = 2 Hrs

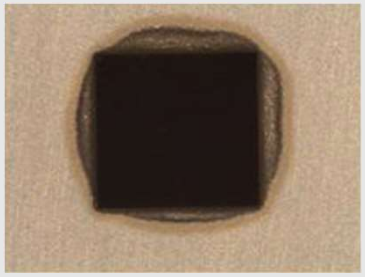


**Figure 18**

Fillet Coverage, T = 4 Hrs

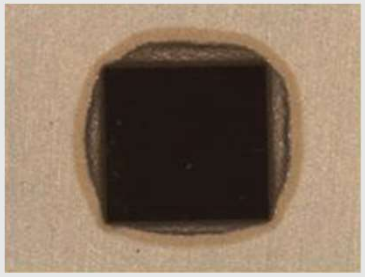
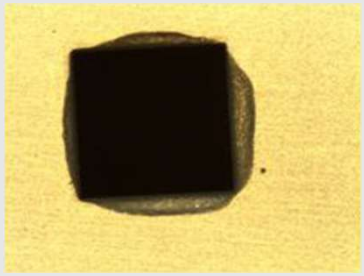


**Figure 19**

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 dependent, but substrate dependent!**

# 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

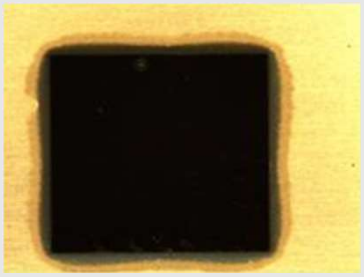


**Figure 22**

Fillet Coverage, T = 2 Hrs

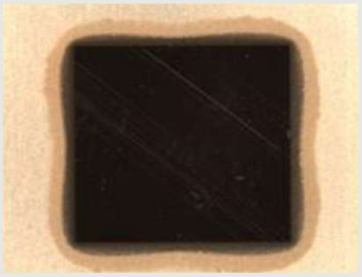


**Figure 23**

Fillet Coverage, T = 4 Hrs

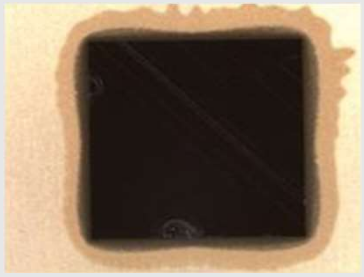


**Figure 24**

Fillet Coverage, T = 6 Hrs

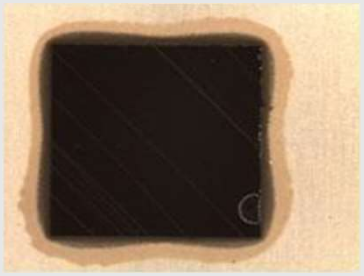
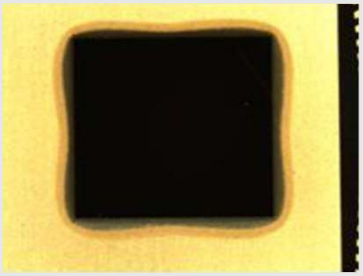


**Figure 25**

Fillet Coverage, T = 8 Hrs



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

# 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

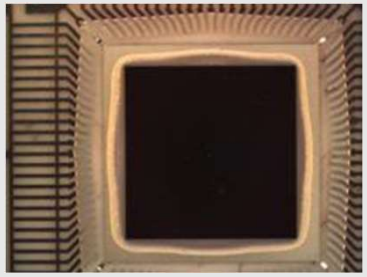


**Figure 27**

Fillet Coverage, T = 2 Hrs

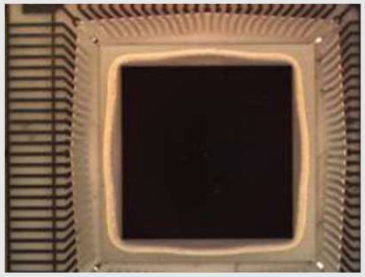


**Figure 28**

Fillet Coverage, T = 4 Hrs

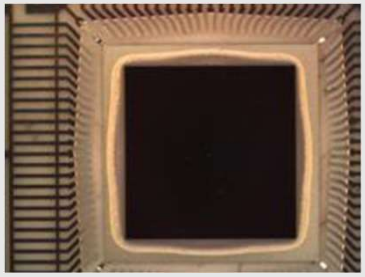


**Figure 29**

Fillet Coverage, T = 6 Hrs

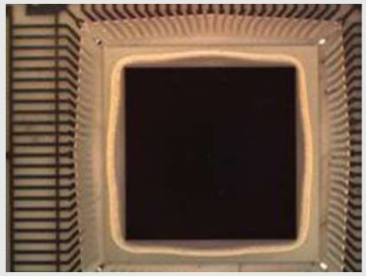
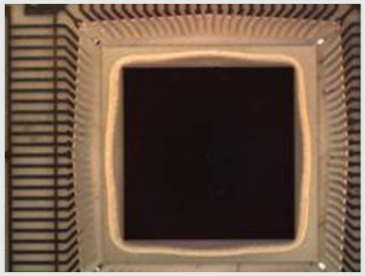


**Figure 30**

Fillet Coverage, T = 8 Hrs



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

# Conclusions

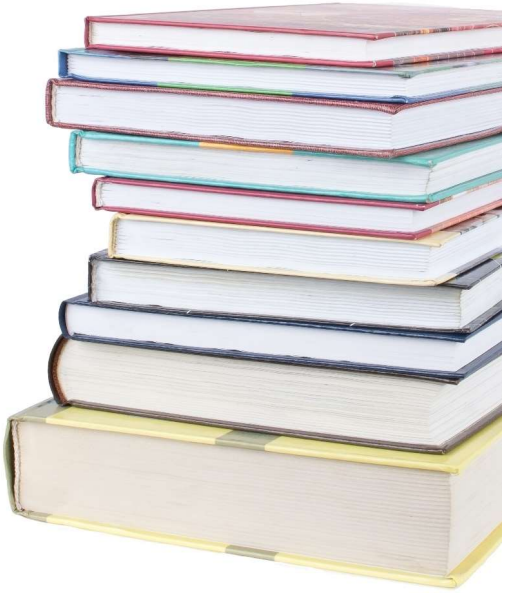
- HDSS is not adversely affected as a function of stage time at all die size test intervals.
- Voiding beneath the die is not observed as a function of adhesive stage time. In this trial the QMI529HT-LV showed no tendency to void beneath the attached die at any of the die size test intervals.
- Resin 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

# 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.



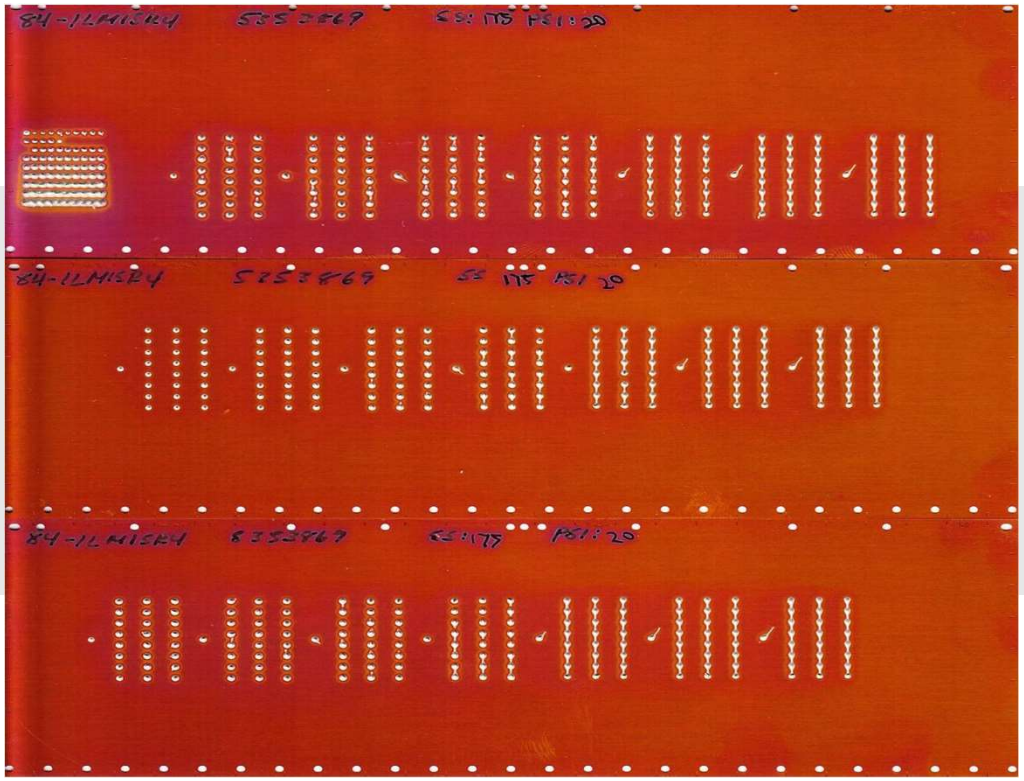
# Experimental
## Dot Dispense

- 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.

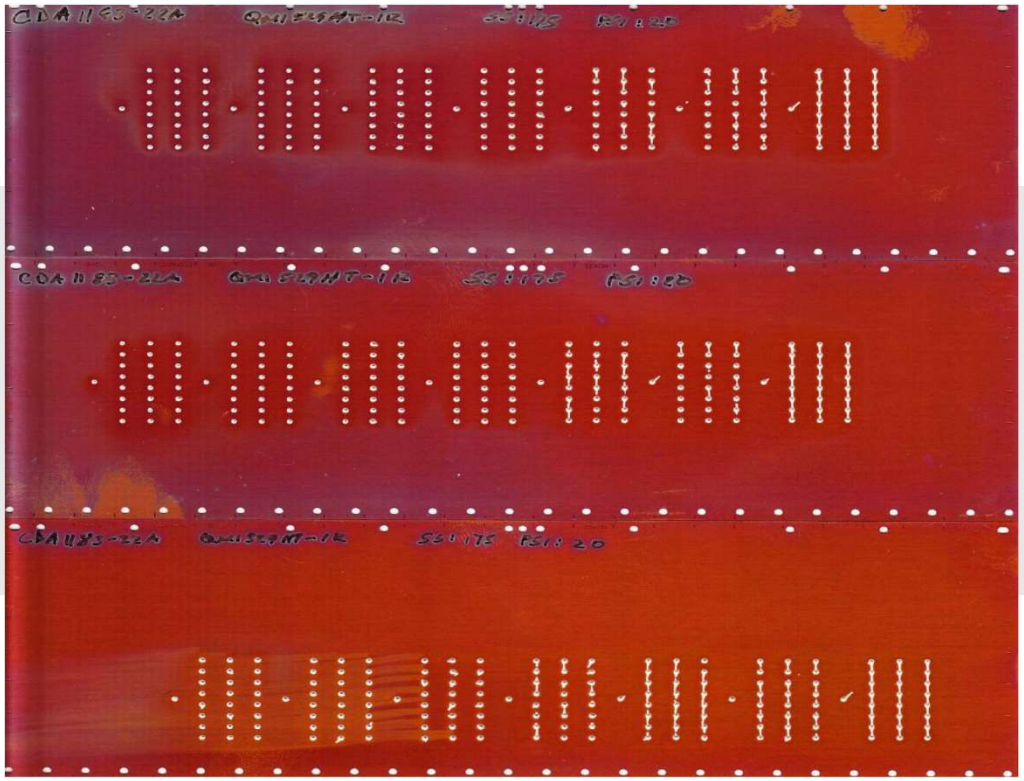
# Equipment

- 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

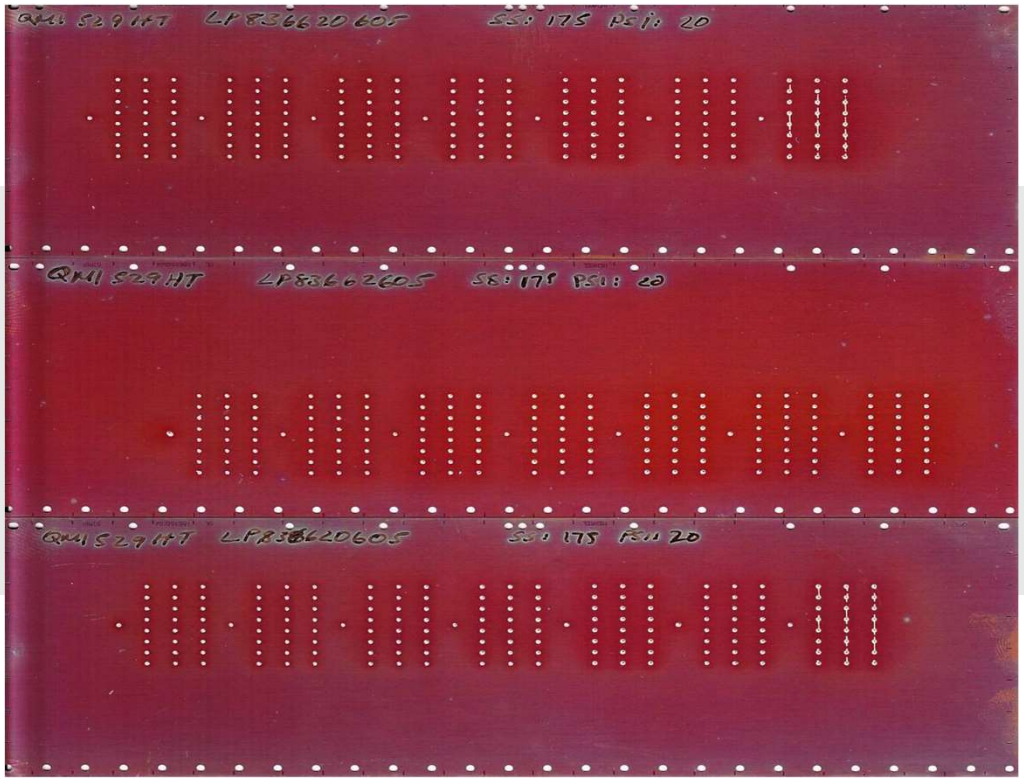
# Dispensability – Dot Dispense of 84-LMISR4



# 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

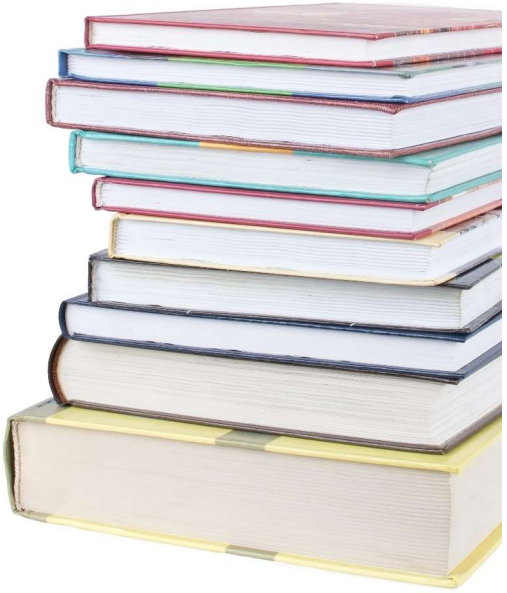
- QMI529HT-LV out performed Ablebond 84-1LMISR4 in terms of tailing performance by dot dispense in this trial.
- Subtle differences in the volume of adhesive dispensed may have skewed the result in favour of QMI529HT-LV however the adhesive can be considered to dispense well and shows little tendency to tail under ‘normal’ dispense conditions.

# QMI529HT-LV

# Bleed Study on AgCu Leadframe

# 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

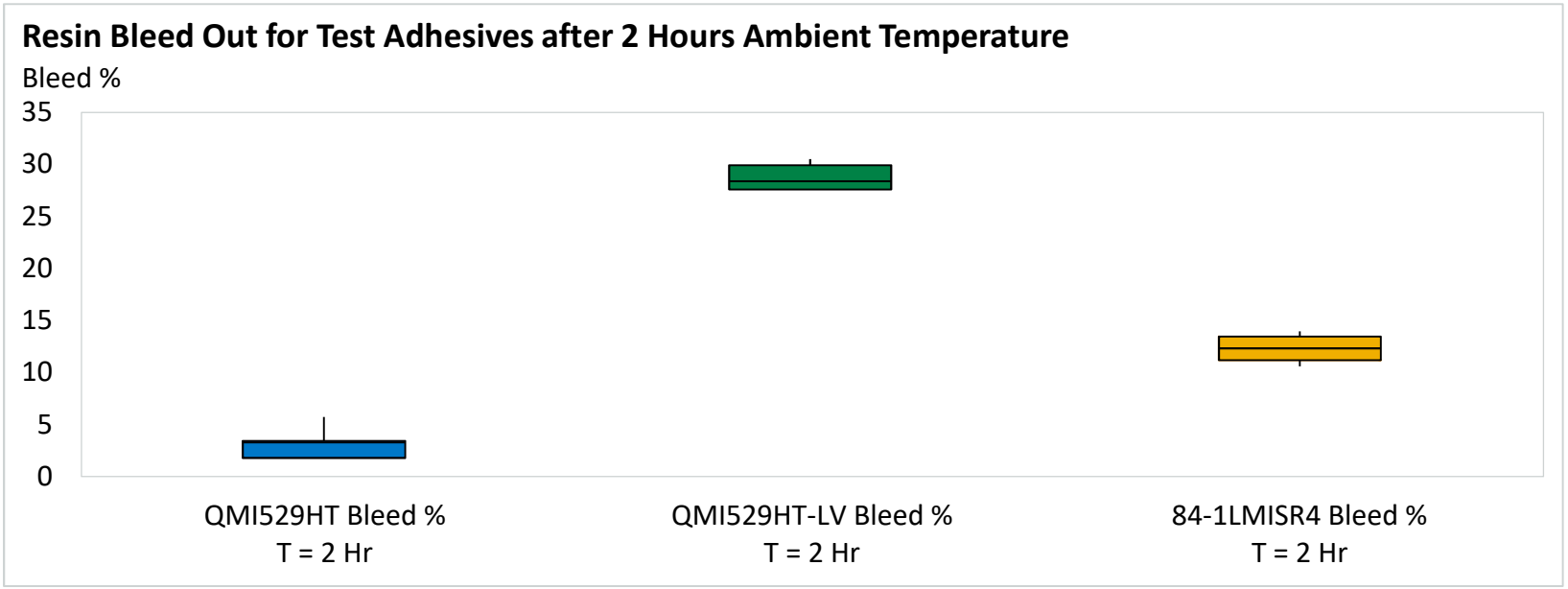
- The following resin bleed basic statistics data was obtained for QMI529HT-LV and the comparative control adhesives: -

| Variable | Total Count | Mean | StDev | Variance | Min. | Max. |
|---|---|---|---|---|---|---|
| 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**

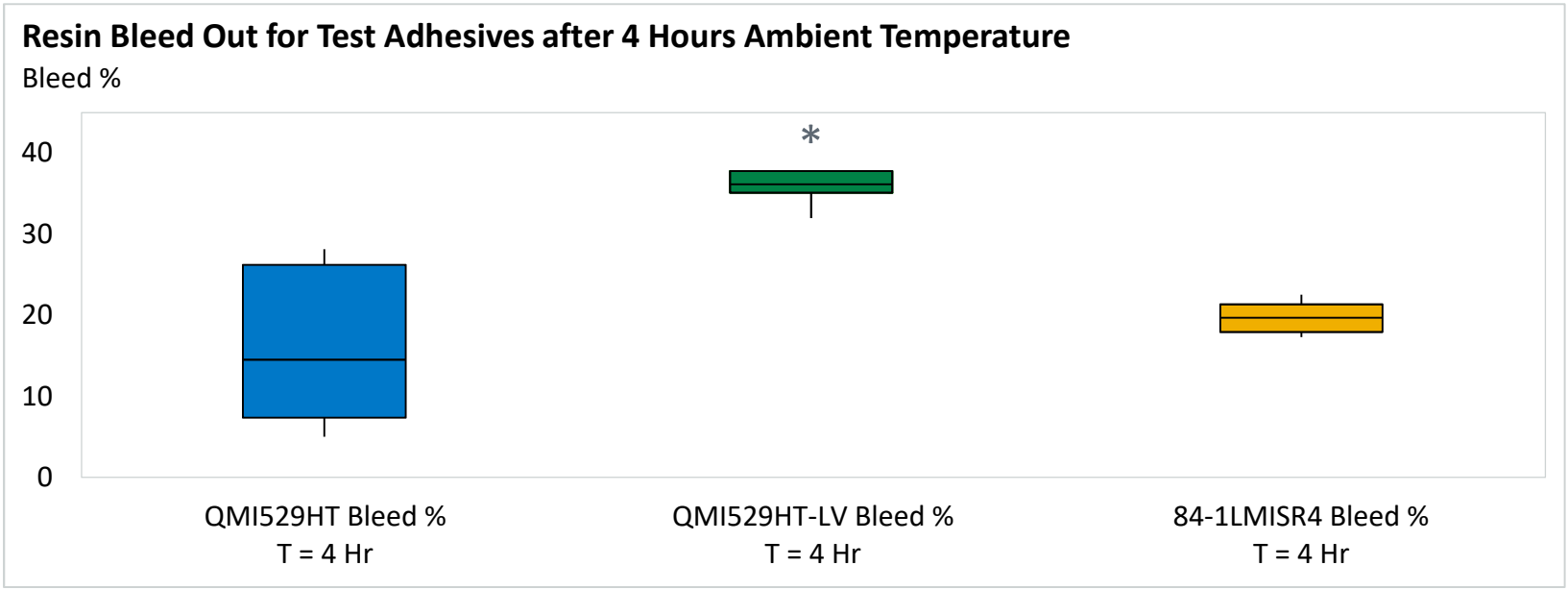
# Results

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



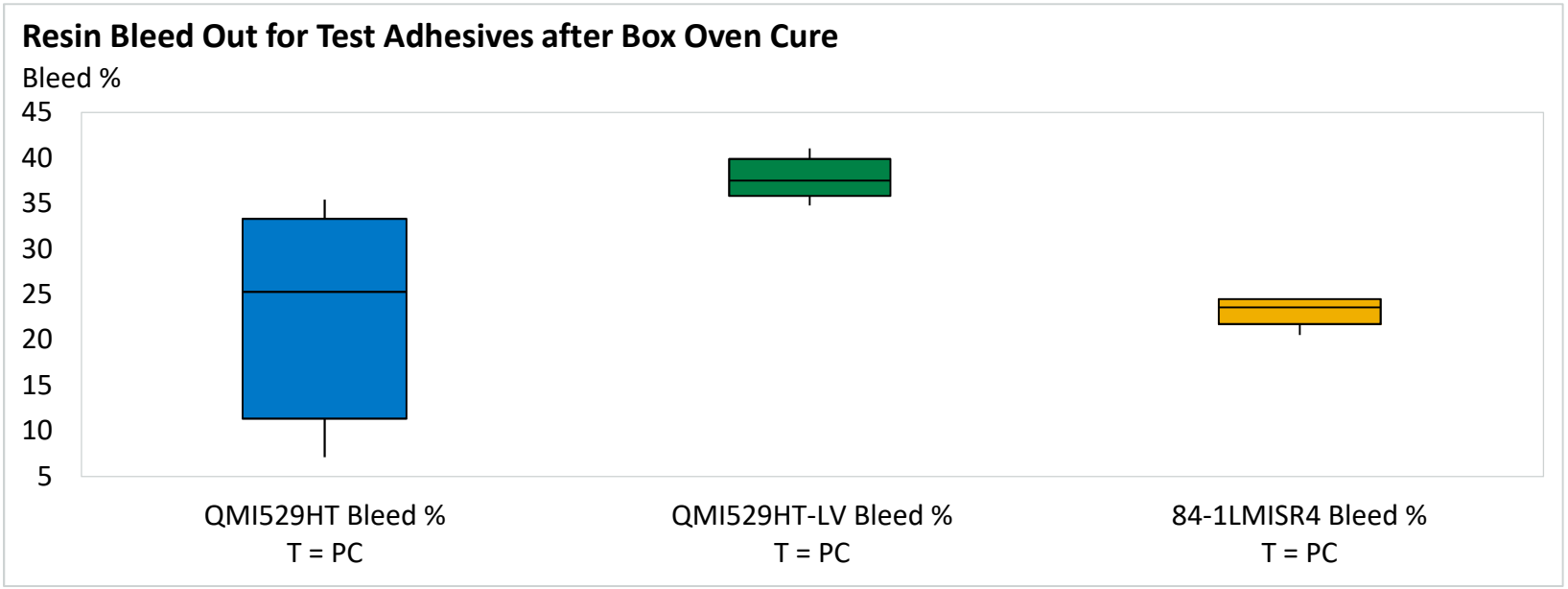
# Results

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



# Results

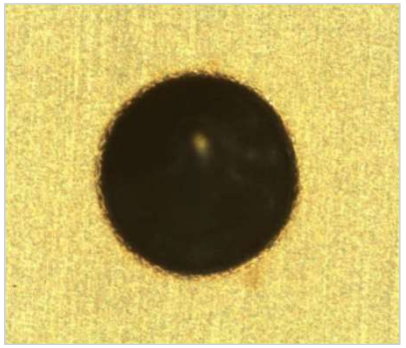
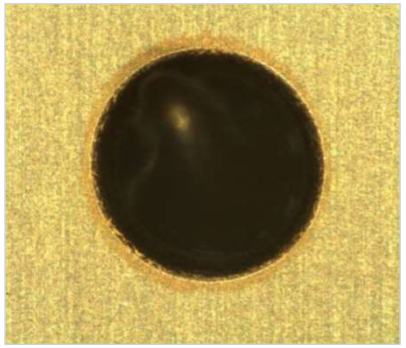
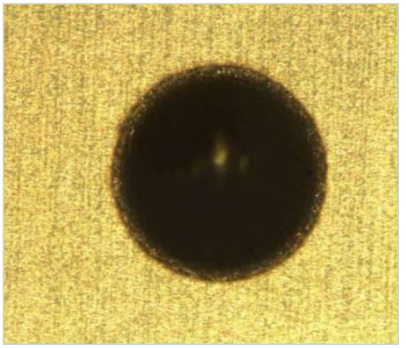
- The results obtained at the T= post cure can also be viewed graphically using the below box plot: -



# Results

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

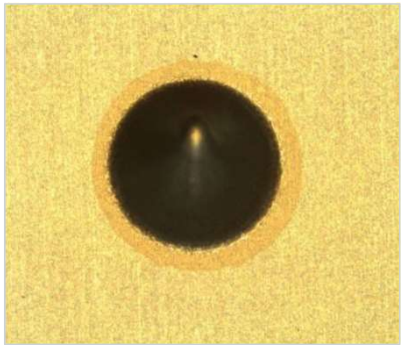
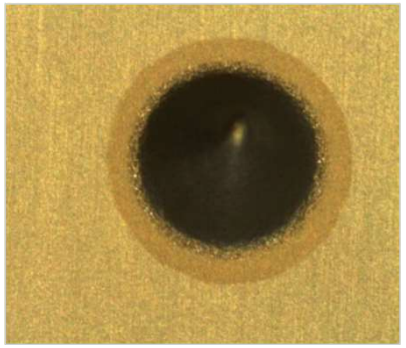
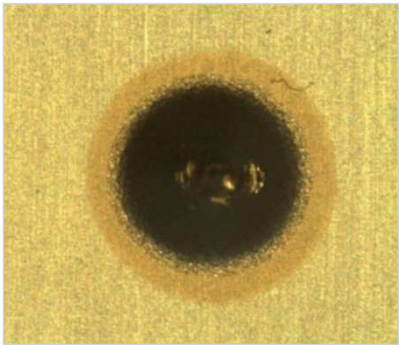
**QMI529HT**

| T = 0 Hrs | T = 2 Hrs | T = 4 Hrs | T = Post Cure |
|---|---|---|---|
|  |  |  |  |

# Results

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

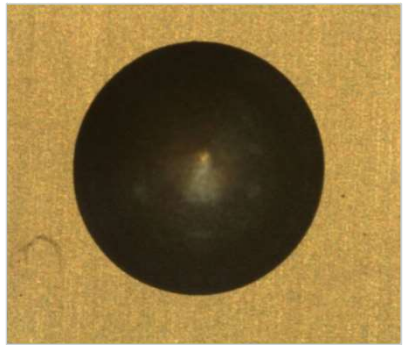
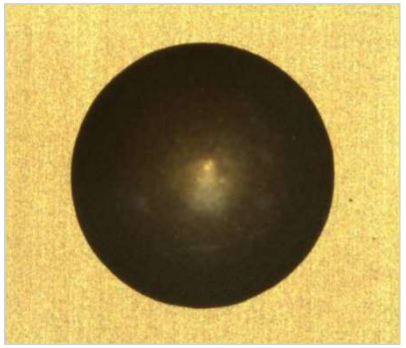
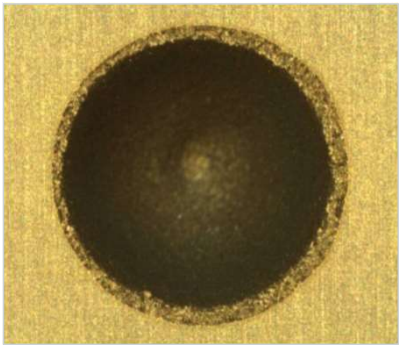
**QMI529HT-LV**

| T = 0 Hrs | T = 2 Hrs | T = 4 Hrs | T = Post Cure |
|---|---|---|---|
|  |  |  |  |

# Results

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

**84-1LMISR4**

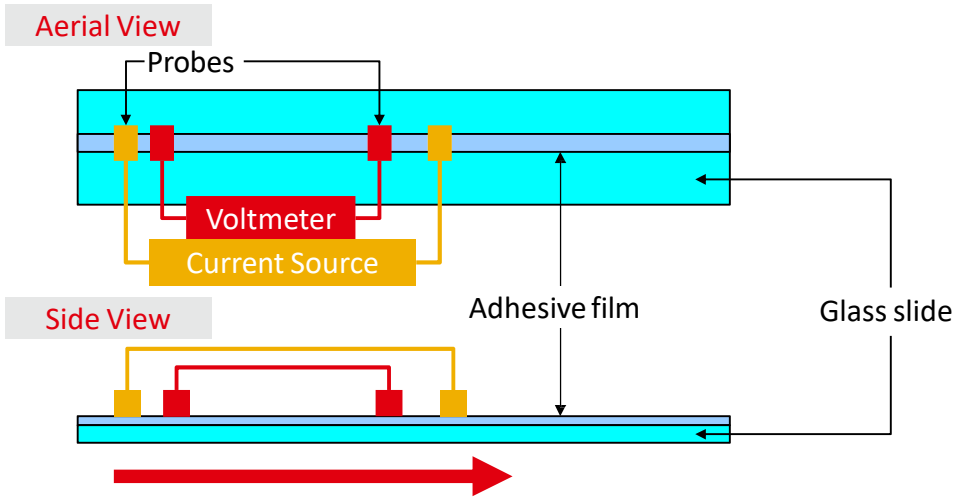
| T = 0 Hrs | T = 2 Hrs | T = 4 Hrs | T = Post Cure |
|---|---|---|---|
|  |  |  |  |

# 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

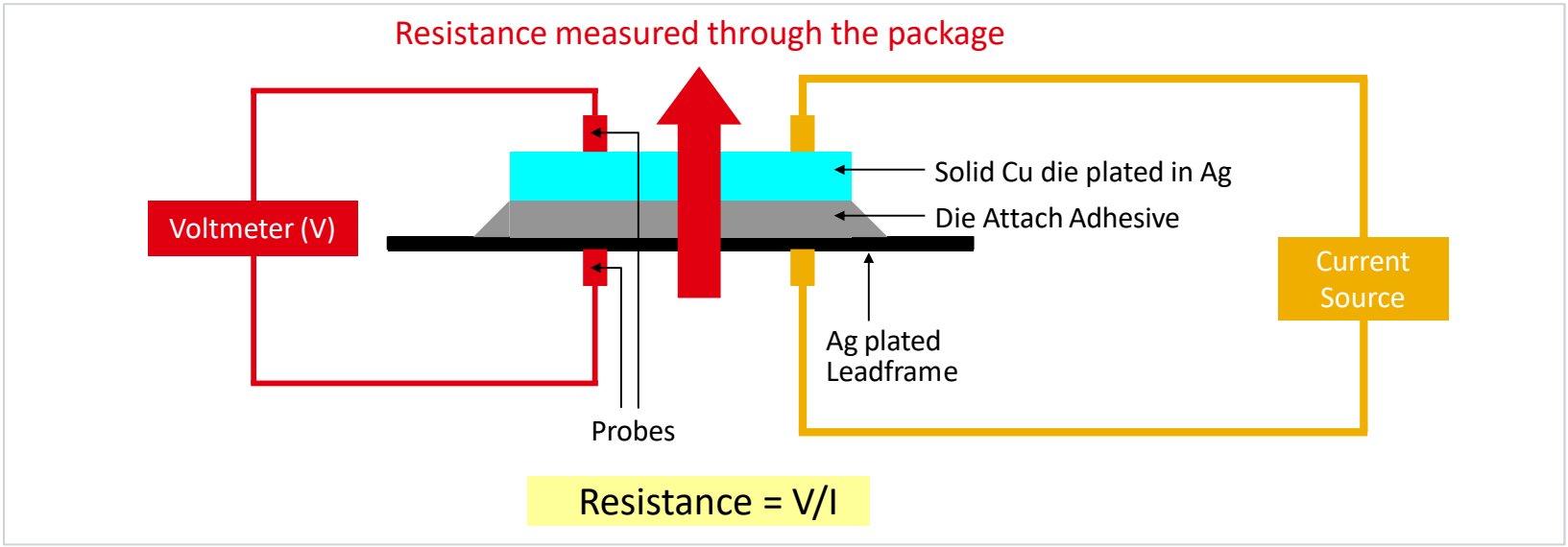
# Electrical and Thermal Conductivity Test Results for QMI529HT-LV

# Electrical Testing
## Volume Resistivity



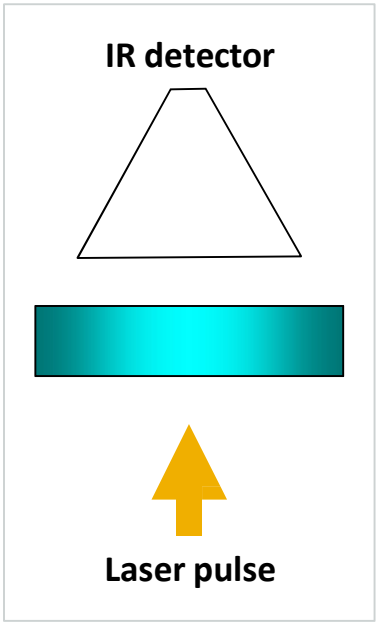

| | VR/Ω.mm | | | Average |
|---|---|---|---|---|
| **QMI529HT-LV** | 0.000067 | 0.000298 | 0.000139 | 0.000168 |
| **SR4** | 0.000055 | 0.000081 | 0.000065 | 0.000067 |

# Electrical Testing
## Bond Joint Resistance (BJR)




| | 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

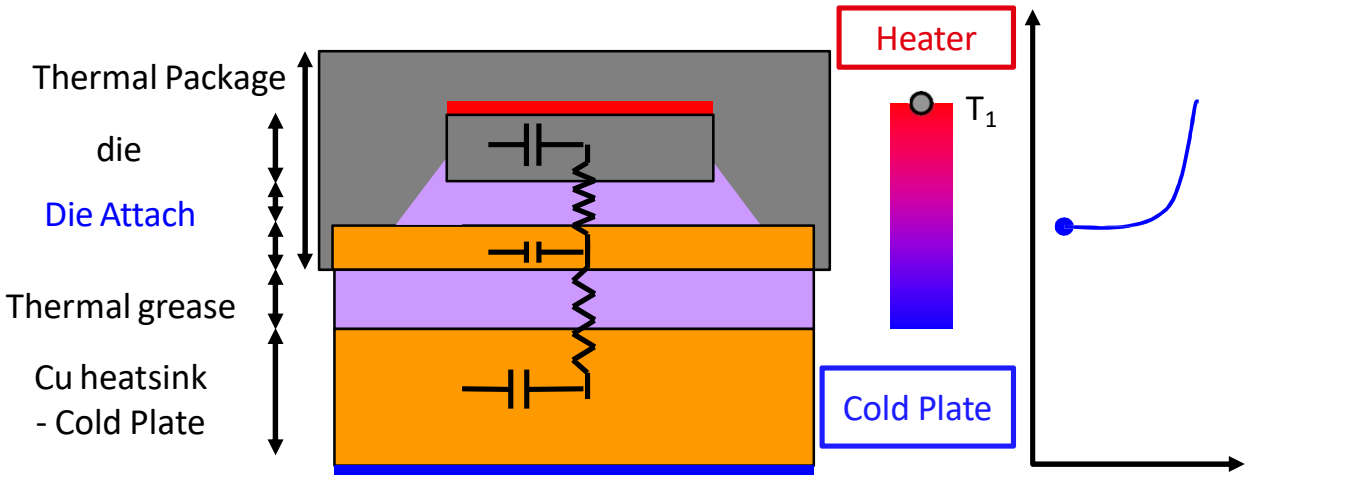



- Laser adds known quantity of heat
- Diffusivity calculated from heating rate
- Sample heat capacity calculated from temperature rise: -
  TC = (diffusivity) x (heat capacity) x (density)

| | 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)




| | In-package Thermal Resistance(K/W) | |
|---|---|---|
| **QMI529HT-LV** | 0.67 | TiNiAg die onto PPF leadframe |
| **Soft Solder** | 0.43 | |

# Electrical and Thermal Performance Summary

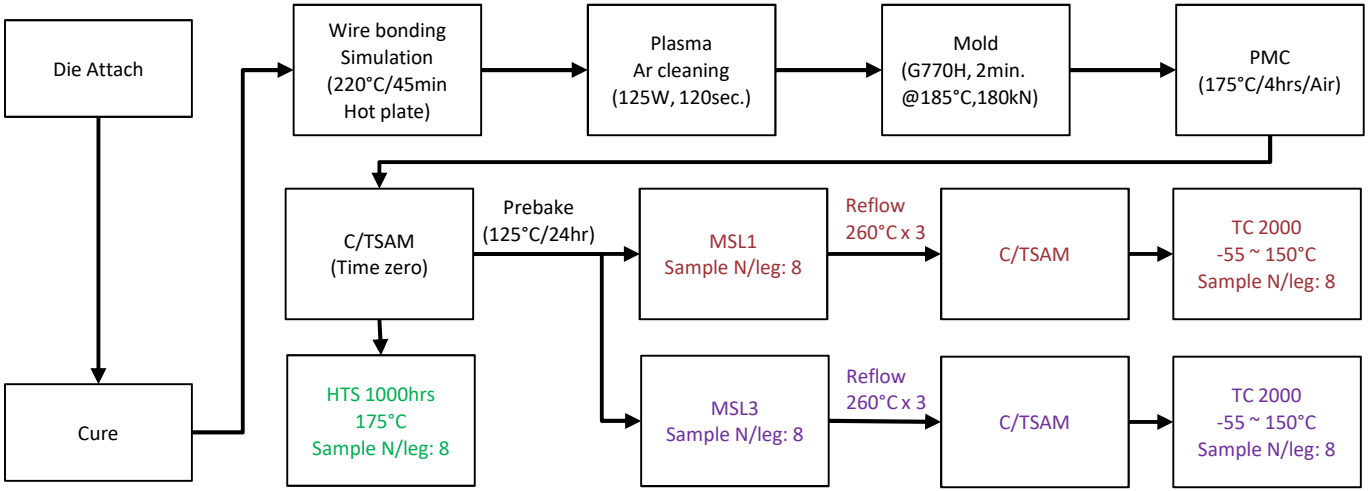
- QMI529HT-LV has excellent bulk electrical and Thermal properties.
- QMI529HT-LV offers Excellent in-package thermal performance and is considered to be at the leading edge in thermal performance for commercially available organic adhesives.

# Reliability Performance for QMI529HT-LV

# Reliability Performance Test Flow

- Henkel in-house roughened Cu, roughened PPF,
- 6x6mm, nBSM Si, 300um-t Die
- 25±10um BLT
- 100% fillet coverage
- 50-90% fillet height

- 30min ramp up to 175°C Dwell@175°C for 1hr. $N_2$ (Competitors: Follow TDS)



# Reliability Performance
## Roughened Cu Leadframe

Die size; 6x6 mm with no BSM
Automotive Grade 0 Testing
(*) Temp Cycling; -55C to +150C

| Material | Test | TSAM |
|---|---|---|
| Roughened Cu | Initial |  |
| | Post MSL1 |  |
| | Post MSL3 |  |
| | HTS 1,000 hrs at 175C |  |
| | MSL1 + Temp Cycling(*) 1,000 cyc |  |
| | MSL1 + Temp Cycling(*) 2,000 cyc |  |

**QMI529HT-LV passed MSL1, HTS 1,000 hrs and temp cycling 2,000 cyc on roughened Cu.**



Henkel

# Reliability Performance
## Roughened PPF Leadframe

Die size; 6x6 mm with no BSM
Automotive Grade 0 Testing
(*) Temp Cycling; -55C to +150C

| Material | Test | TSAM |
|---|---|---|
| Roughened PPF | Initial |  |
| | Post MSL1 |  |
| | Post MSL3 |  |
| | HTS 1,000 hrs at 175C |  |
| | MSL1 + Temp Cycling(*) 1,000 cyc |  |
| | MSL1 + Temp Cycling(*) 2,000 cyc |  |

**QMI529HT-LV passed MSL1, HTS 1,000 hrs and temp cycling 2,000 cyc on roughened PPF.**

# Reliability Performance Summary

- QMI529HT-LV is capable to meet grade 0 requirements for automotive applications.

# Freezing Point & Storage Handling of QMI529HT-LV

# Outline

1. Introduction – how the freezing point Affects FTV formation.
2. Freezing point data of Ablebond QMI529HT-LV and recommended storage temperature
3. Appendix A : Other factors effecting on FTV
4. Appendix B : Handling recommendations
5. 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

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?

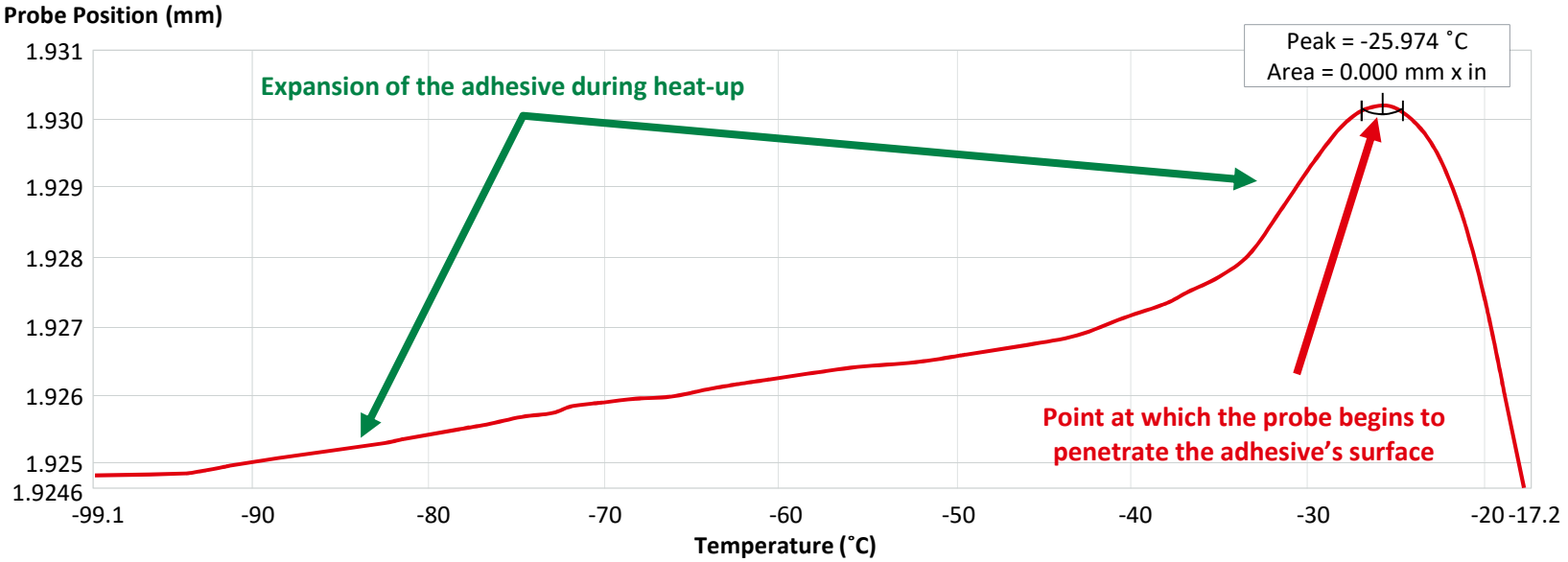
- By Definition, the freezing point of a liquid is:

*"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

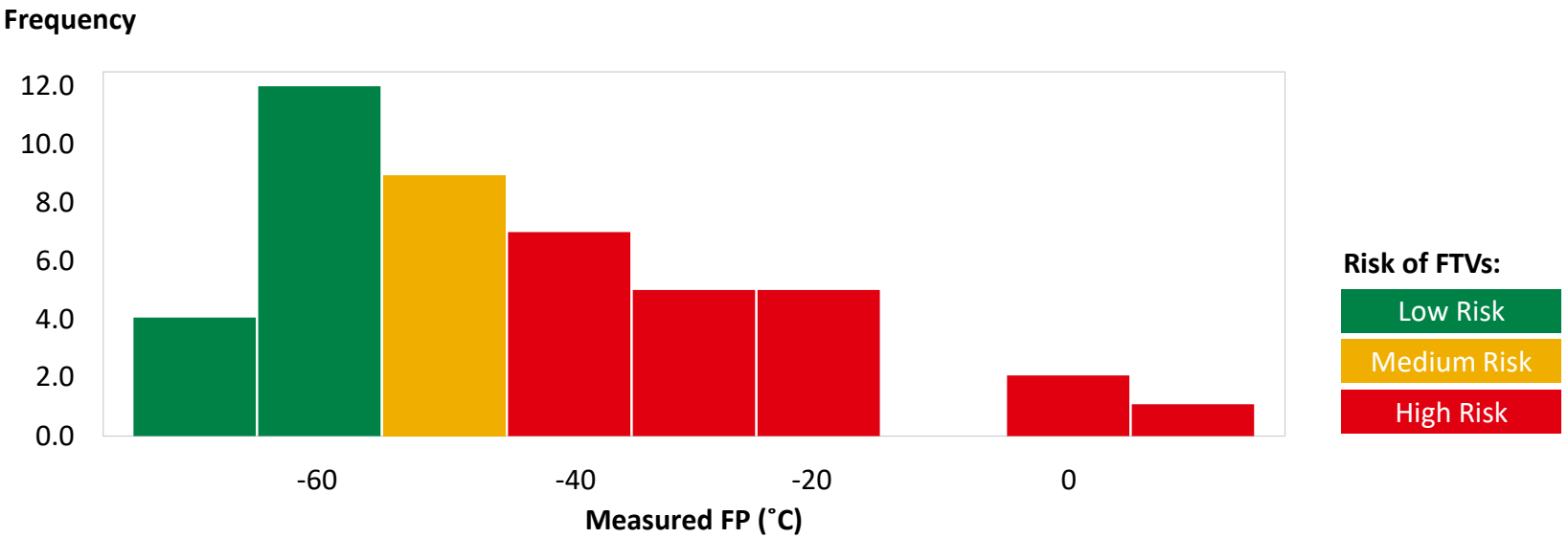
# How Is The Freezing Point Measured?




- 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.

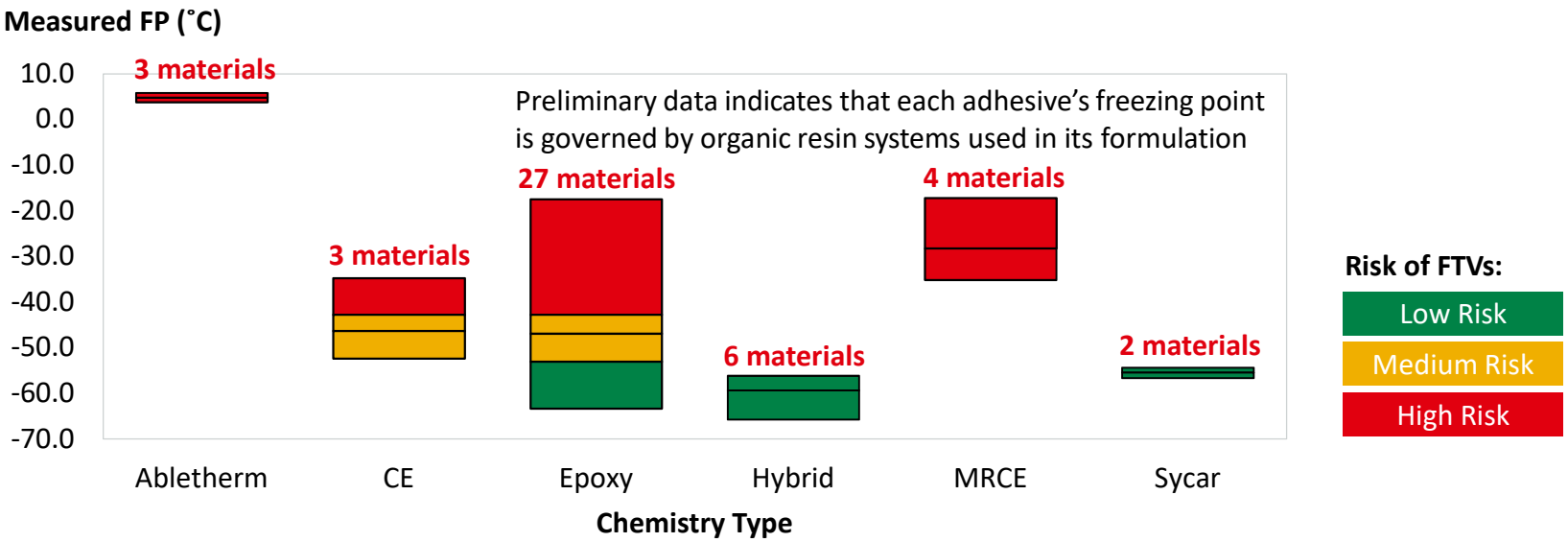
# Freezing Point Characterization




**45 materials tested:**

- Different Chemistries
- Different Fillers

# Freezing Point By Chemistry




**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

# Other Factors Effecting FTV Occurrences

**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**

# Handling Recommendations

# 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

**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**

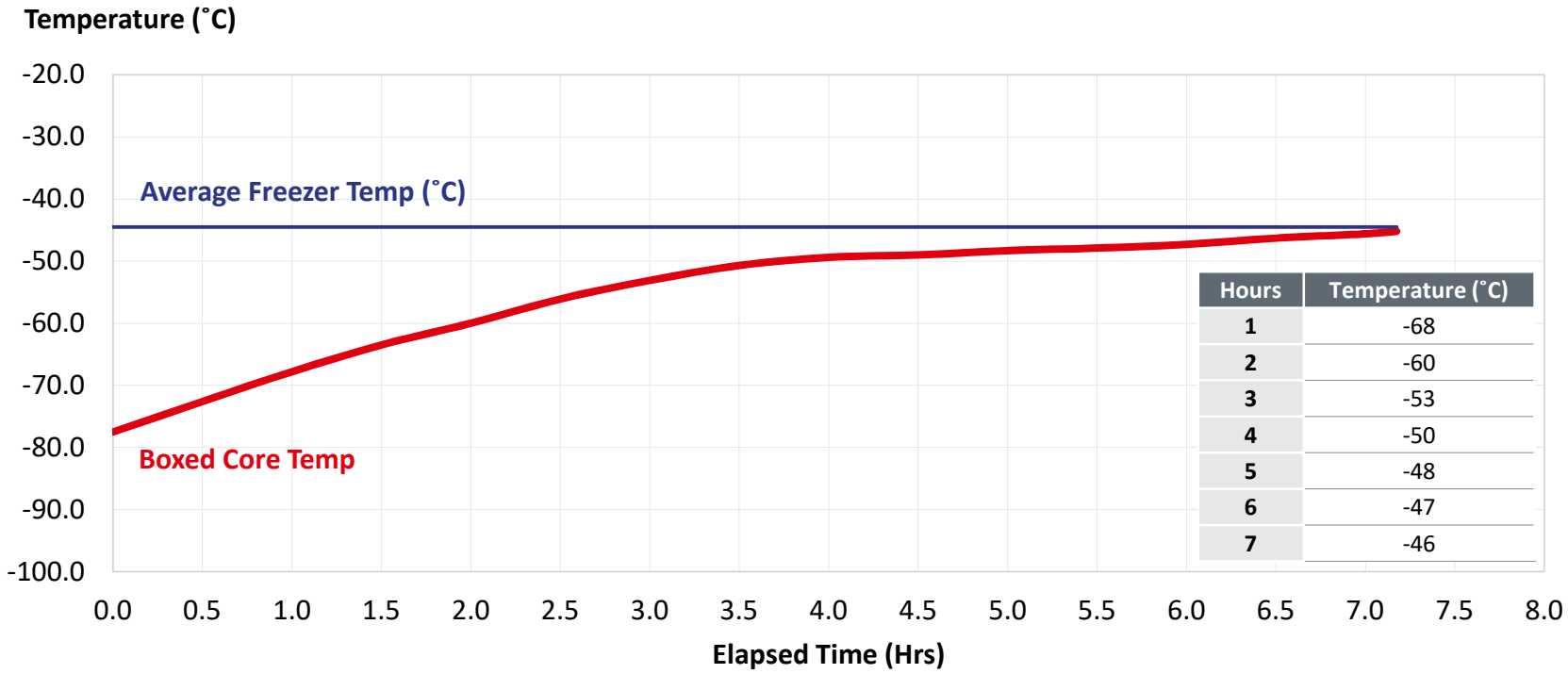
- Open shipping box as close to the storage freezer as possible. Only open one shipping box at a time and transfer contents to the storage freezer before moving on to the next shipping box
- While wearing thermal gloves, transfer the white syringe boxes a quickly a possible to the storage freezer and 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

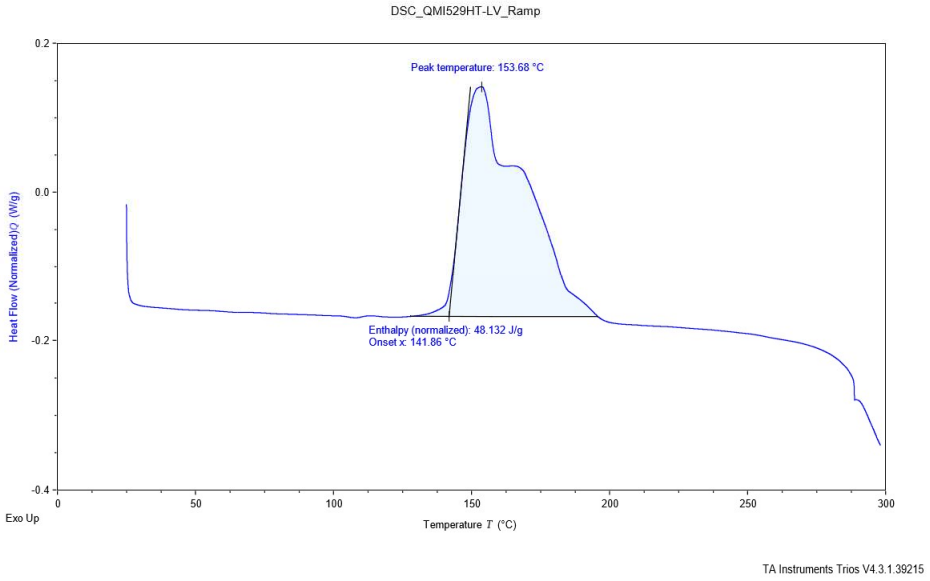
# Thaw Time For A 33cm X 33cm Syringe Box



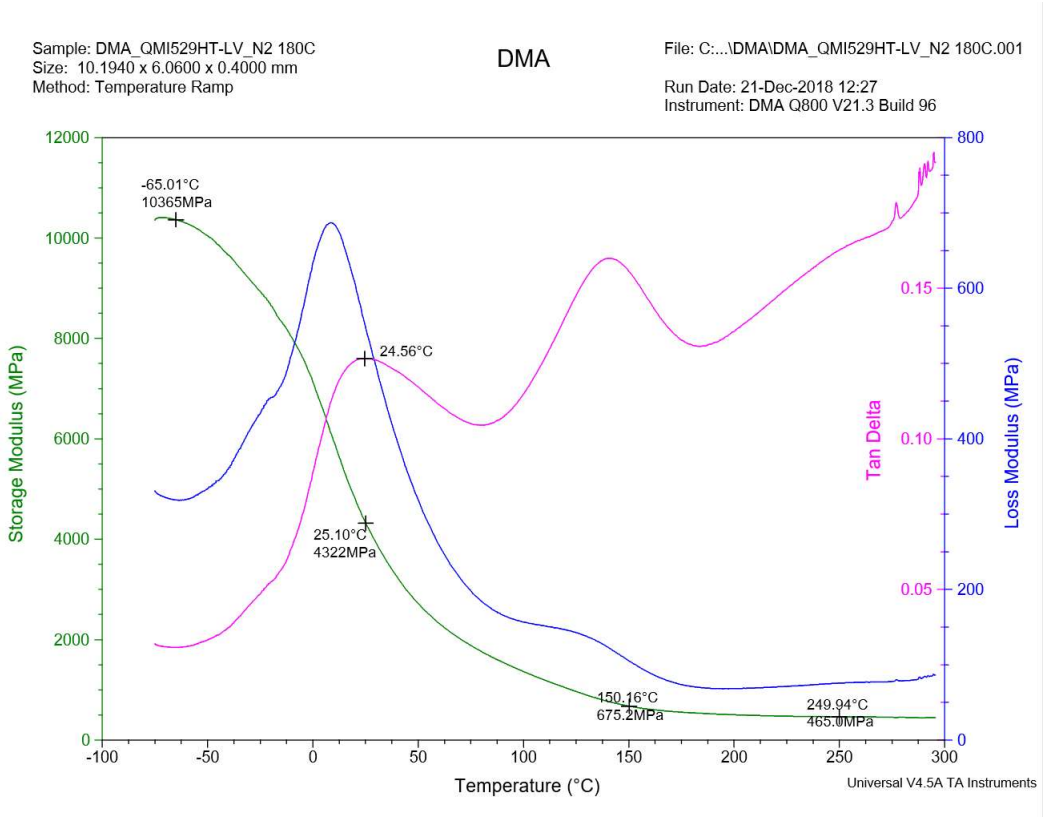

| Hours | Temperature (˚C) |
|---|---|
| 1 | -68 |
| 2 | -60 |
| 3 | -53 |
| 4 | -50 |
| 5 | -48 |
| 6 | -47 |
| 7 | -46 |

# Thermal Analysis Data

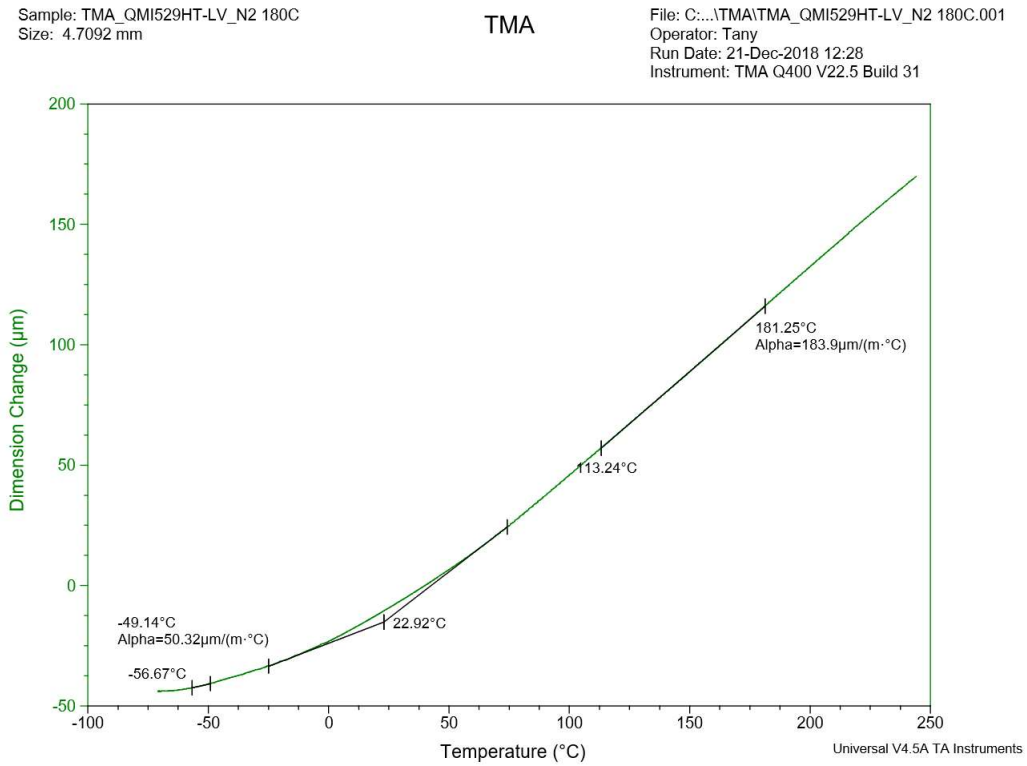
# DSC for QMI529HT-LV



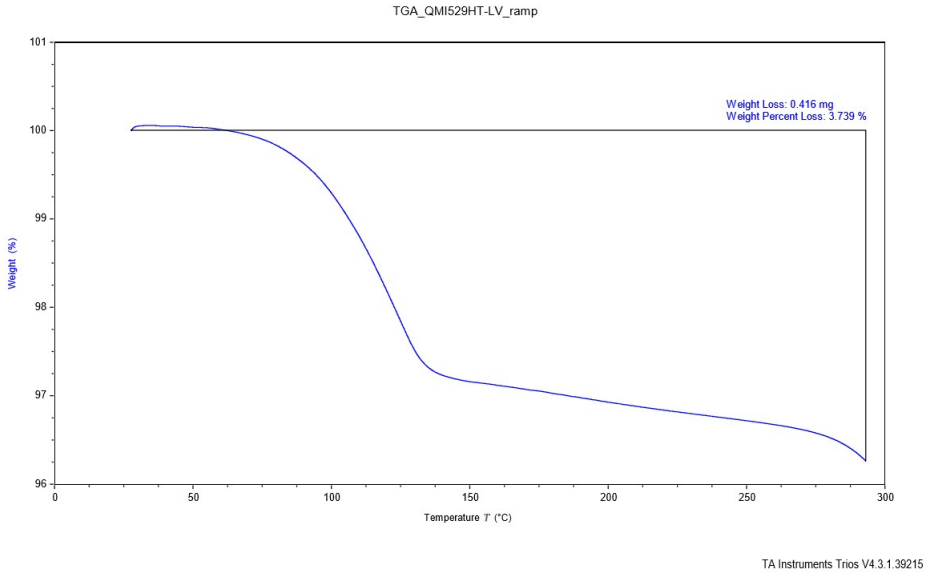
# DMA for QMI529HT-LV



# TMA for QMI529HT-LV



# TGA for Uncured QMI529HT-LV



# 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