

# Reliability Qualification Report

**with Pb/Halogen Free**

**for**

**ASFC20G31P5-51BIN**

**ASFC64G31T5B-51BIN**

**ASFC64G31T5B-51BAN**

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## 1 Qualification

### 1.1 Definition of Operating Temperature Grade

|            |                |
|------------|----------------|
| Industrial | -40°C to 85°C  |
| Automotive | -40°C to 105°C |

### 1.2 Device under Test (DUT) definition

| eMMC<br>Serie | BGA<br>type                | Capacity | Config. | Flash |                     |          |         | HW               | FW                  | Temp<br>Grade | Qual<br>Level |
|---------------|----------------------------|----------|---------|-------|---------------------|----------|---------|------------------|---------------------|---------------|---------------|
|               |                            |          |         | Type  | Vendor              | Capacity | Stack   | Qual Tested      |                     |               |               |
| ASFC          | 153 ball<br>(11,5x13x1 mm) | 64GB     | 3D TLC  | BiCS5 | KIO/SD <sup>2</sup> | 512Gbit  | 1 Stack | Ref <sup>1</sup> | Tested <sup>3</sup> | A/I           | A             |
|               |                            |          |         |       |                     |          |         |                  |                     |               |               |
| ASFC          | 153 ball<br>(11,5x13x1 mm) | 20GB     | pSLC    | BiCS5 | KIO/SD <sup>2</sup> | 512Gbit  | 1 Stack | Ref <sup>1</sup> | Tested <sup>3</sup> | I             | A             |

<sup>1</sup> Passed by Reference to other capacity

<sup>2</sup> The Raw wafers of Kioxia and Sandisk are identical

<sup>3</sup> Results in DVT Report (on request)

## 1.3 Form

| # | Test      | Standard           | Condition | Test result |
|---|-----------|--------------------|-----------|-------------|
| 1 | Dimension | Data sheet / JEDEC | ambient   | Pass        |

Lot 1 (60211056):

| BGA Component SPC |         |         |         |     |     |     |        |      |  |
|-------------------|---------|---------|---------|-----|-----|-----|--------|------|--|
| . BGA             |         |         |         |     |     |     |        |      |  |
| Item              | Reject- | Nominal | Reject+ | Min | Avg | Max | 3sigma | Cpk  |  |
| >bx               | -100    | 11500   | 100     | -7  | 5   | 24  | 9.49   | 9.96 |  |
| >by               | -100    | 13000   | 100     | -62 | 2   | 13  | 18.32  | 5.10 |  |

Lot 2 (60217721):

| BGA Component SPC |         |         |         |     |     |     |        |       |  |
|-------------------|---------|---------|---------|-----|-----|-----|--------|-------|--|
| . BGA             |         |         |         |     |     |     |        |       |  |
| Item              | Reject- | Nominal | Reject+ | Min | Avg | Max | 3sigma | Cpk   |  |
| >bx               | -100    | 11500   | 100     | -11 | -1  | 25  | 8.82   | 10.76 |  |
| >by               | -100    | 13000   | 100     | -10 | -3  | 12  | 6.59   | 14.37 |  |

Lot 3 (60222443):

| BGA Component SPC |         |         |         |       |       |       |        |      |  |
|-------------------|---------|---------|---------|-------|-------|-------|--------|------|--|
| . BGA             |         |         |         |       |       |       |        |      |  |
| Item              | Reject- | Nominal | Reject+ | Min   | Avg   | Max   | 3sigma | Cpk  |  |
| bx                | -100    | 11500   | 100     | 11490 | 11501 | 11517 | 10.31  | 9.59 |  |
| by                | -100    | 13000   | 100     | 12985 | 13003 | 13020 | 11.33  | 8.60 |  |

## 1.4 Electrical Verification Tests

| # | ID | Test                           | Standard    | Condition                                                                                             | Test result |
|---|----|--------------------------------|-------------|-------------------------------------------------------------------------------------------------------|-------------|
| 1 | E2 | ESD - Human Body Model HBM     | MIL-STD-883 | all test pins $\geq \pm 2\text{kV}$<br>Test @RT                                                       | Pass        |
| 2 | E3 | ESD - Charged Device Model CDM | JESD22-C101 | all test pins $\geq \pm 500\text{V}$<br>Test @RT                                                      | Pass        |
| 3 | E4 | Latch Up                       | JESD78      | Trigger Current $\pm 200\text{mA}$ ;<br>Over Voltage test $1.5 \times \text{VCC}$ ;<br>Class I and II | Pass        |

## 1.5 Accelerated Environment Stress Test (Hardware Based Tests)

| # | ID | Test                          | Standard                           | Condition                              | Test result                                                          |                      |                          |
|---|----|-------------------------------|------------------------------------|----------------------------------------|----------------------------------------------------------------------|----------------------|--------------------------|
|   |    |                               |                                    |                                        | 64GB<br>Bics3                                                        | 64GB<br>Bics5<br>KIO | 64GB<br>Bics5<br>Sandisk |
| 1 | A1 | Preconditioning               | JESD22-A113                        | internal                               | Pass                                                                 | Pass                 | Pass*                    |
| 2 | A6 | High Temperature Storage Life | JESD22-A103                        | B +150°C 1000h                         | Lot 1: 45 / 45<br>Lot 2: 45 / 45<br>90 / 90 Pass                     | 45 / 45 Pass         | Pass*                    |
| 3 | A2 | Temperature Humidity Bias     | AEC-Q100<br>JESD22-A101            | 85°C / 85%<br>1000h                    | Lot 1: 77 / 77<br>Lot 2: 77 / 77<br>Lot 3: 77 / 77<br>231 / 231 Pass | 77 / 77 Pass         | Pass*                    |
|   |    | SAM after THB                 | internal                           | internal                               | Pass                                                                 | Pass                 | Pass*                    |
| 4 | A4 | Temperature Cycling           | AEC-Q100<br>JESD22-A104            | -55°C to 125°C<br>500 Cycles           | Lot 1: 77 / 77<br>Lot 2: 77 / 77<br>Lot 3: 77 / 77<br>231 / 231 Pass | 77 / 77 Pass         | Pass*                    |
|   |    | SAM after Temperature Cycling | internal                           | Internal                               | Pass                                                                 | Pass                 | Pass*                    |
| 5 | B1 | High Temp Operating Life      | AEC-Q100-005<br>JESD22-A108        | +105°C for<br>1000h,<br>VCC, operating | Lot 1: 77 / 77<br>Lot 2: 77 / 77<br>Lot 3: 77 / 77<br>231 / 231 Pass | 77 / 77 Pass         | Pass*                    |
| 6 | -  | Low Temperature Boot          | JESD22-A108 /<br>SBitNorm<br>00003 | -40°C 8h Soak                          | Lot 1: 25 / 25<br>Lot 2: 25 / 25<br>50 / 50 Pass                     | 25 / 25 Pass         | Pass*                    |

\*Passed by similarity to BiCS5 KIO Flash

## 1.6 Failure Rate

|   | Test                             | Standard          | Failure Rate [1/Bio. Hours] | MTBF [Million hours] |
|---|----------------------------------|-------------------|-----------------------------|----------------------|
| 1 | High Temperature Operating Life* | JEDEC JESD22-A108 | 153 FIT                     | 6,54                 |

Ambient Temperature: 125°C  
 Lot size: 77samples  
 Vccmax: 1,1xVcc  
 Test Duration: 1000hrs  
 Failures after test: 0/77samples  
 Activation energy: 0,7eV  
 Chi-Square Distribution@Confidence Level: 60%  
 Acceleration factor AF AF=AFT\*AV 77,94 (Tj=125°C-55°C)

\*Calculated based on ATS1 variant as products are built with the same components.

## 1.7 AEC-Q100 Test GAP Report

| #  | ID  | Test                                              | Standard                  | Condition             | Comments                                                                                                        |
|----|-----|---------------------------------------------------|---------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------|
| 1  | A3  | Autoclave or Unbiased HAST                        | JESD22-A102/A118          |                       | per similarity THB                                                                                              |
| 2  | A5  | Power Temperature Cycling                         | JESD22-A105               |                       | only for devices with max. rated power > 1W                                                                     |
| 3  | B2  | Early Life Failure Rate                           | AEC Q100-008              |                       | 2400 parts / pass                                                                                               |
| 4  | B3  | NVM Endurance, Data Retention, & Operational Life | AEC Q100-005              | HTDR, per Section 3.2 | One lot with 77 parts / further lots on request                                                                 |
| 5  | C1  | Wire Bond Shear                                   | AEC Q100-001              | acc. to DVS2811       | 5 parts / pass                                                                                                  |
| 6  | C2  | Wire Bond Pull Strength                           | MIL-STD-883 - 2011        | acc. to DVS2811       | 5 parts / pass                                                                                                  |
| 7  | C3  | Solderability                                     | JESD22-B102<br>J-STD-002D |                       | not applicable - only for QFP packages                                                                          |
| 8  | C4  | Physical Dimensions                               | JESD22-B100/B108          |                       | 1 tray / pass                                                                                                   |
| 9  | C5  | Solder Ball Shear                                 | AEC Q100-010              |                       | 10 parts / pass                                                                                                 |
| 10 | C6  | Lead Integrity                                    | JESD22-B105               |                       | only with QFN                                                                                                   |
| 11 | D1  | Electromigration                                  |                           |                       | Test at controller and flash manufacture                                                                        |
| 12 | D2  | Time Dependent Dielectric Breakdown               |                           |                       | Test at controller and flash manufacture                                                                        |
| 13 | D3  | Hot Carrier Injection                             |                           |                       | Test at controller and flash manufacture                                                                        |
| 14 | D4  | Negative Bias Temperature Instability             |                           |                       | Test at controller and flash manufacture                                                                        |
| 15 | D5  | Stress Migration                                  |                           |                       | Test at controller and flash manufacture                                                                        |
| 16 | E1  | Pre- and Post-Stress Electrical Test              | Test to spec              |                       | pass (all duts before and after stress test)                                                                    |
| 17 | E5  | Electrical Distributions                          | AEC Q100-009              |                       | 3 x 30 parts / pass                                                                                             |
| 18 | E6  | Fault Grading                                     | AEC-Q100-007              |                       | Pass / Test at flash manufacture                                                                                |
| 19 | E7  | Characterization                                  | AEC Q003                  |                       | Pass / Test at flash manufacture                                                                                |
| 20 | E9  | Electromagnetic Compatibility                     | SAE J1752/3               |                       | This Test and its accept criteria is performed per agreement between user and supplier on a case-by-case basis. |
| 21 | E10 | Short Circuit Characterization                    | AEC Q100-012              |                       | only for smart power devices                                                                                    |
| 22 | E11 | Soft Error Rate                                   | JESD89-1, -2, -3          |                       | Pass / Test at flash manufacture                                                                                |

| #  | ID   | Test                           | Standard           | Condition      | Comments                              |
|----|------|--------------------------------|--------------------|----------------|---------------------------------------|
| 23 | E12  | Lead Free                      | Q005               |                | no SMT components used                |
| 24 | F1   | Process Average Test           | AEC Q001           |                | not relevant for qualification        |
| 25 | F2   | Statistical Bin/Yield Analysis | AEC Q002           |                | not relevant for qualification        |
| 26 | G1-4 | Hermetic Package Tests         | Series             |                | Test relevant for customer endproduct |
| 27 | G5   | Package Drop                   |                    | IEC 60068-2-32 | 10 parts / pass                       |
| 28 | G6   | Lid Torque                     | MIL-STD-883 - 2024 |                | no SMT components used                |
| 29 | G7   | Die Shear Strength             | MIL-STD-883 - 2019 |                | no SMT components used                |
| 30 | G8   | Internal Water Vapor           | MIL-STD-883 - 1018 |                | no SMT components used                |

## 2 Detailed Test description

### 2.1 EV Environmental

Tests with different climatic chambers for temperatures and humidity.

(Tabai 914326, Vötsch VT 7012-S2, Vötsch VT<sup>3</sup> 7012-S2, Vötsch VCS<sup>3</sup> 4018-05, Vötsch VCS<sup>3</sup> 7018-05, Fryka TK, Tabai HPS-222).

3.3V was applied to the DUT voltage pins, if specified in the test.

Because long time storage at high temperature accelerates the retention the flash cannot hold its data.

| Temperature                              | 85°C | 125°C | 150°C  |
|------------------------------------------|------|-------|--------|
| accel. factor relative to 40°C           | 168  | 6'000 | 40'000 |
| equivalent years at 40°C (1000h storage) | 19   | 690   | 4600   |

Therefore the cards were unformatted (erases) before they are stored and new preformatted (produced) after the storage for functional test

|     | Test                                                                   | Standard                            | Condition                                                                                                                                                                                                                  |
|-----|------------------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E01 | HTSL<br>High Temperature<br>Storage Life<br>accelerate time<br>effects | JESD22-A103 cond B<br>Tabai HPS-222 | Precondition: new cards (<10PE cycles)<br>store card 1000h @+150°C<br><br>full write read test @105°C<br>Criteria: no functional issues |

|     | Test                                                                                              | Standard                                                                       | Condition                                                                                                                                                                                                                                                                                          |
|-----|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E03 | THB<br>Temperature<br>Humidity Bias Life                                                          | AEC-Q100 Grade 3<br>JESD22-A101<br>Vötsch VCS <sup>3</sup> 7018-5              | <p>Precondition: new cards (&lt;10PE cycles)<br/>store card 1000h @+85°C/85% humidity/3.6V applied to VCC pin</p>  <p>full write read test @105°C<br/>Criteria: no functional issues</p>                        |
| E04 | TC<br>Temp Cycling<br>test mechanical<br>stability due to<br>temperature change<br>induced stress | AEC Q-100<br>Grade 3 Option B<br>JESD22-A104<br>Vötsch VT <sup>3</sup> 7012-S2 | <p>Precondition: new cards (&lt;10PE cycles)<br/>temperature cycling 500 cycles<br/>soak 10minutes @-55°C<br/>soak 10minutes @125°C</p>  <p>full write read test @105°C<br/>Criteria: no functional issues</p> |

| ID  | Test                              | Standard                                          | Condition                                                                                                                                                                                                                                                                 |
|-----|-----------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E06 | LTB00T<br>low temperature<br>boot | JESD22-A108 /<br>SBitNorm 00003<br>Fryka TK       | <p>Precondition: new cards (&lt;10PE cycles)<br/>cool down card to -40°C in card reader (8h)<br/>power up card reader</p>  <p>Criteria:<br/>full functionality after initialization</p> |
| E07 | HTOL                              | AEC-Q100-005<br>JESD22-A108<br>Vötsch VCS3 4018-5 |  <p><b>Test:</b> Fill DUT with data @105°C and then Operating reads, @105°C for 1000h @V<sub>DD</sub></p> <p><b>Criteria:</b> No data errors</p>                                       |