Reliability Monitor Report

High Temperature Operating Life
Data Retention Bake
Temperature Cycle
Temperature & Humidity Bias/ HAST
Steam Pressure Pot

FIRST QUARTER 2004
ATMEL PROPRIETARY
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Reliability Monitor Report

Date: March 15, 2004

Executive Summary

The intent of the Reliability Monitor Program is to measure the reliability of previously qualified devices on a quarterly basis. This is achieved by selecting representative devices within a process or package family and performing a series of reliability tests to ensure that the reliability has not deteriorated over time. Listed below are the overall results for the last quarter.

1. **High Temperature Operating Life (125°C - 150°C)**
   - Failure Rate: 2 FITS (4.9M device-hours)
   - Note: The Exponential Model is used to derive FIT rates (60% Confidence $E_A = 0.7$ eV). Also, Thermal and Voltage Acceleration are used to compute the overall acceleration factor. Weighted acceleration factors (WAF) for a group of products are calculated by taking the weighted average of each device’s acceleration factor multiplied by its corresponding device hours.

2. **Data Retention Bake (150°C)**
   - Failure Rate: 12 FITS (304K device-hours)
   - Note: The Exponential Model is used to derive FIT rates (60% Confidence $E_A = 0.7$ eV). Since there is no bias applied during testing and the stress temperature is fixed for all devices at 150°C, the acceleration factor is 259 for all groupings.

3. **Temperature Cycle (-65°C to 150°C)**
   - Failure Rate: 0.17% (3 failure out of 1,729)

4. **Temperature Humidity Bias (85°C/85%RH) and HAST (130°C/85%RH)**
   - Failure Rate: 0.00% (0 failures out of 1.3M device-hours)
   - Note: A 20:1 Acceleration Factor is used to combine HAST results with THB.

5. **Steam Pressure Pot (121°C/100%RH)**
   - Failure Rate: 0.00% (0 failures out of 822)

* indicates that preconditioning is performed prior to the stress test.
1 junction temperatures may reach up to 200°C.
# High Temperature Operating Life

(sorted by FAMILY)

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* The Device-Hours computation includes additional read-outs not detailed in the report.
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RELIABILITY MONITOR -- ATMEL PROPRIETARY
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* The Device-Hours computation includes a few 5,000-hour read-outs.
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Failure Description Detail

Q4-2003

a. **Temperature Cycle**, 3 failures, 1000 cycle read point, RF & Auto, 6UH6, MLF/ QFN 28. **Root Cause**: ground bonds were broken. **Corrective Action**: change bonding from normal wedge to “stitch on ball”.

b. **High Temperature Operating Life**, 1 failure, 48 hour read point, Micro, Z92, SSOP 16: **Root Cause**: passivation scratch. **Corrective Action**: Implement high voltage burn in.
# Technology List

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Failure Rate Calculations

**Failure Rate:**

\[
\lambda = \frac{\chi^2 (1 - \frac{\alpha}{100} / 2n + 2) \cdot 10^9}{2 \cdot AF \cdot DH}
\]

where,
- \( \lambda \) = Failure Rate (FITS)
- \( \chi^2 \) = Failure Estimate
- \( \alpha \) = Confidence Level (60% or 90%)
- \( n \) = Number of Failures
- \( AF \) = Overall Acceleration Factor (TAF x VAF)
- \( DH \) = Device Hours

**Thermal Acceleration:**

\[
TAF = e^{\frac{E_A}{k} \left[ \frac{1}{T_f + (P_f \Theta_{JA})} - \frac{1}{T_s + (P_s \Theta_{JA})} \right]}
\]

where,
- \( TAF \) = Thermal Acceleration Factor
- \( E_A \) = Activation Energy (eV)
- \( k \) = Boltzman’s Constant \((8.617 \times 10^{-5} \text{ eV/°K})\)
- \( T \) = Temperature (°K)
- \( f \) = Field Conditions
- \( s \) = Stress Conditions
- \( P \) = Power Dissipation (W)
- \( \Theta_{JA} \) = Thermal Resistance Coefficient - Junction to Ambient (°C/W)

**Voltage Acceleration:**

\[
VAF = e^{Z \cdot [V_s - V_n]}
\]

where,
- \( VAF \) = Voltage Acceleration Factor
- \( V_s \) = Stress Voltage (V)
- \( V_n \) = Nominal Voltage (V)
- \( Z \) = Voltage Acceleration Constant (typically, 0.5 < Z < 1.0)
Definitions

Data Retention Bake (DRB): This test is used to measure a device’s ability to retain a charge for extended periods of time without applying voltage bias. Stressing at high temperatures (150°C for plastic packages) accelerates any discharge causing the memory state to change.

Failures In Time (FITS): This is the unit measure for expressing failure rates and is identical to the expression PPM/ K hours. For example, three failures out of a million components tested for one thousand hours equates to 3 FITS.

High Temperature Operating Life (HTOL): The purpose of this test is to accelerate thermally activated failure mechanisms through the use of high temperatures (typically between 125°C and 150°C), increased voltage, and dynamic bias conditions. Readouts at various time points are taken to determine the Early Failure Rate (EFR) and Intrinsic Failure Rate (IFR). EFR is expressed in defective parts per million (DPPM) and IFR is expressed in Failures in Time (FITS at 55°C).

Highly Accelerated Stress Test (HAST): The purpose of this test is to evaluate a plastic packaged component’s ability to withstand harsh environmental conditions with extreme temperature and humidity levels. The parts are stressed to high temperature (130°C) and relative humidity (85%RH) conditions in a biased state to achieve maximum acceleration.

Steam Pressure Pot (SPP): The test is used to evaluate a plastic packaged component’s ability to withstand severe conditions of pressure (15 psig), temperature (121°C), and humidity (100%RH).

Temperature Cycle (TC): This test is used to measure a product’s sensitivity to thermal stresses due to differences in expansion and contraction characteristics of the die and mold compound by repeated alternating temperature dwells between high and low temperature extremes.

Temperature Humidity Bias (THB): The purpose of this test (85°C/ 85%RH) is identical to HAST. The only difference is that HAST accelerates THB by a factor of 20:1 due to the increase in temperature during test.
Please contact Pete Cannon (x4122) if you would like to be added or removed from this distribution