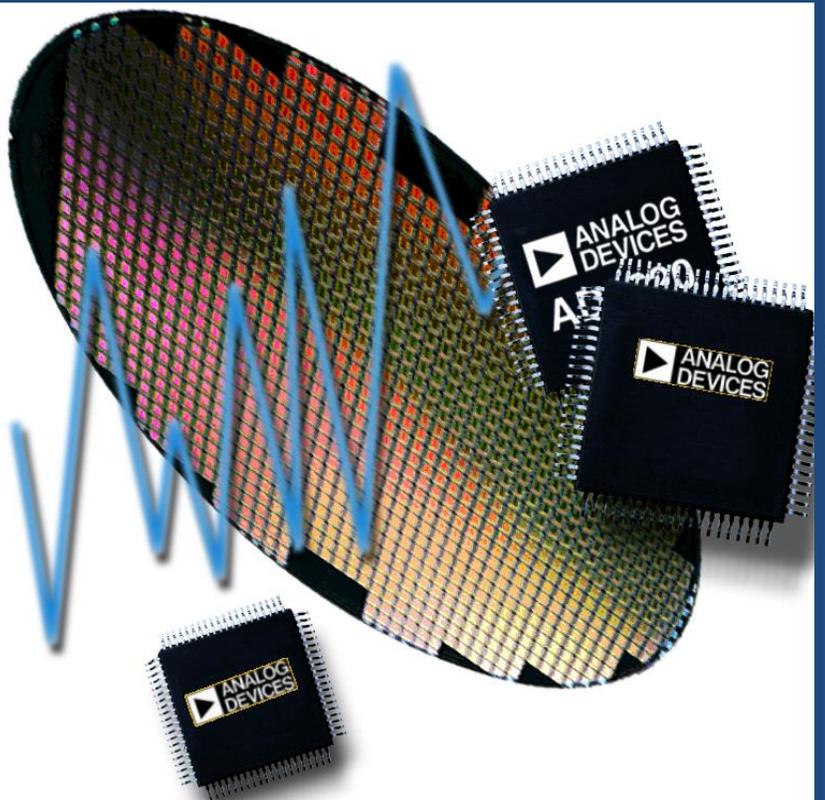


Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED





Reliability Report

| | |
|----------------------|----------------------------------|
| Report Title: | Qualification Test Report |
| Report Type: | See Attached |
| Date: | See Attached |

Process FIT Rate Report

QTR: 2013- 00229

Rev: 02

Wafer Process: GaAs HBT-B

| | |
|---------------|---------------|
| HMC311 | HMC457 |
| HMC313 | HMC461 |
| HMC314 | HMC480 |
| HMC315 | |
| HMC323 | |
| HMC324 | |
| HMC326 | |
| HMC327 | |
| HMC381 | |
| HMC395 | |
| HMC396 | |
| HMC397 | |
| HMC405 | |
| HMC406 | |
| HMC407 | |
| HMC408 | |
| HMC409 | |
| HMC413 | |
| HMC414 | |
| HMC415 | |
| HMC450 | |
| HMC452 | |
| HMC453 | |
| HMC454 | |
| HMC455 | |

Hittite Microwave Corporation is committed to:

- *Supplying products of the highest quality*
- *Advance in state-of-the-art technology that supports our products*
- *Enhance our competitive position with superior product standards*

Hittite's employees recognize the responsibility to:

- *Take the initiative to ensure product quality*
- *Create an environment where the highest standards are maintained*
- *Continue to improve quality practices*

Introduction

The testing performed for this report is designed to accelerate the predominant failure mode, electro-migration (EM), for the devices under test. The devices are stressed at high temperature and DC biased to simulate a lifetime of use at typical operating temperatures. Using the Arrhenius equation, the acceleration factor (AF) is calculated for the stress testing based on the stress temperature and the typical use operating temperature.

This report is intended to summarize all of the High Temperature Operating Life Test (HTOL) data for the GaAs HBT-B process. The FIT/MTTF data contained in this report includes all the stress testing performed on this process to date and will be updated periodically as additional data becomes available. Data sheets for the tested devices can be found at www.hittite.com.

Glossary of Terms & Definitions:

1. **HTOL:** High Temperature Operating Life. This test is used to determine the effects of bias conditions and temperature on semiconductor devices over time. It simulates the devices' operating condition in an accelerated way, through high temperature and/or bias voltage, and is primarily for device qualification and reliability monitoring. This test was performed in accordance with JEDEC JESD22-A108.
2. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
3. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.

Hittite Microwave Corporation is committed to:

- *Supplying products of the highest quality*
- *Advance in state-of-the-art technology that supports our products*
- *Enhance our competitive position with superior product standards*

Hittite's employees recognize the responsibility to:

- *Take the initiative to ensure product quality*
- *Create an environment where the highest standards are maintained*
- *Continue to improve quality practices*

Qualification Sample Selection:

All qualification devices used were manufactured and tested on standard production processes and met pre-stress acceptance test requirements.

Summary of Qualification Tests:

HMC414 (QTR2002-00020)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 74 | 74 | Complete | |
| HTOL, 1000 hours | 74 | 74 | Complete | |
| Post Electrical Test | 74 | 74 | Pass | |
| | | | | |

HMC454 (QTR2007-00003)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 102 | 102 | Complete | |
| HTOL, 1000 hours | 102 | 102 | Complete | |
| Post Electrical Test | 102 | 102 | Pass | |
| | | | | |

Hittite Microwave Corporation is committed to:

- Supplying products of the highest quality
- Advance in state-of-the-art technology that supports our products
- Enhance our competitive position with superior product standards

Hittite's employees recognize the responsibility to:

- Take the initiative to ensure product quality
- Create an environment where the highest standards are maintained
- Continue to improve quality practices

HMC395 (QTR2012-00197)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 125 | 125 | Complete | |
| HTOL, 240 hours | 125 | 125 | Complete | |
| Post Electrical Test | 125 | 125 | Pass | |
| | | | | |

HMC395 (QTR2012-00197)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 5 | 5 | Complete | |
| HTOL, 1000 hours | 5 | 5 | Complete | |
| Post Electrical Test | 5 | 5 | Pass | |
| | | | | |

HMC313 (QTR2012-00199)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 143 | 143 | Complete | |
| HTOL, 240 hours | 143 | 143 | Complete | |
| Post Electrical Test | 143 | 143 | Pass | |
| | | | | |

Hittite Microwave Corporation is committed to:

- Supplying products of the highest quality
- Advance in state-of-the-art technology that supports our products
- Enhance our competitive position with superior product standards

Hittite's employees recognize the responsibility to:

- Take the initiative to ensure product quality
- Create an environment where the highest standards are maintained
- Continue to improve quality practices



20 Alpha Road, Chelmsford, MA 01824
 Ph: 978.250.3343 Fax: 978.250.3373
 www.hittite.com



Process FIT Rate Report

QTR: 2013- 00229

Rev: 02

Wafer Process: GaAs HBT-B

HMC313 (QTR2012-00199)

| TEST | QTY IN | QTY OUT | PASS/FAIL | NOTES |
|----------------------|--------|---------|-----------|-------|
| Initial Electrical | 12 | 12 | Complete | |
| HTOL, 1000 hours | 12 | 12 | Complete | |
| Post Electrical Test | 12 | 12 | Pass | |
| | | | | |

Hittite Microwave Corporation is committed to:

- *Supplying products of the highest quality*
- *Advance in state-of-the-art technology that supports our products*
- *Enhance our competitive position with superior product standards*

Hittite's employees recognize the responsibility to:

- *Take the initiative to ensure product quality*
- *Create an environment where the highest standards are maintained*
- *Continue to improve quality practices*

GaAs HBT-B Failure Rate Estimate

Based on the HTOL test results, a failure rate estimation was determined using the following parameters:

With device ambient case temp, $T_c = 85^\circ\text{C}$

HMC414 (QTR2002-00020)

Operating Junction Temp (T_{oj}) = 141°C (414°K)

Stress Junction Temp (T_{sj}) = 211°C (484°K)

HMC454 (QTR2007-00003)

Operating Junction Temp (T_{oj}) = 140°C (413°K)

Stress Junction Temp (T_{sj}) = 195°C (468°K)

HMC395 (QTR2012-00197) (240 hour test)

Operating Junction Temp (T_{oj}) = 110°C (383°K)

Stress Junction Temp (T_{sj}) = 175°C (448°K)

HMC395 (QTR2012-00197) (1000 hour test)

Operating Junction Temp (T_{oj}) = 110°C (383°K)

Stress Junction Temp (T_{sj}) = 175°C (448°K)

HMC313 (QTR2012-00199) (240 hour test)

Operating Junction Temp (T_{oj}) = 109°C (382°K)

Stress Junction Temp (T_{sj}) = 171°C (444°K)

HMC313 (QTR2012-00199) (1000 hour test)

Operating Junction Temp (T_{oj}) = 109°C (382°K)

Stress Junction Temp (T_{sj}) = 171°C (444°K)

Device hours:

HMC414 (QTR2002-00020) = (74 X 1000hrs) = 74,000 hours

HMC454 (QTR2007-00003) = (102 X 1000hrs) = 102,000 hours

HMC395 (QTR2012-00197, 240 hour test) = (125 X 240hrs) = 30,000hours

HMC395 (QTR2012-00197, 1000 hour test) = (5 X 1000hrs) = 5,000 hours

HMC313 (QTR2012-00199, 240 hour test) = (143 X 240hrs) = 34,320 hours

Hittite Microwave Corporation is committed to:

- Supplying products of the highest quality
- Advance in state-of-the-art technology that supports our products
- Enhance our competitive position with superior product standards

Hittite's employees recognize the responsibility to:

- Take the initiative to ensure product quality
- Create an environment where the highest standards are maintained
- Continue to improve quality practices

HMC361 HMC313 (QTR2012-00199, 1000 hour test) = (12 X 1000hrs) = 12,000 hours

For GaAs HBT-B MMIC, Activation Energy = 1.3 eV

$$AF = \exp \left[\left(\frac{E_A}{k} \right) \cdot \left(\left(\frac{1}{T_{USE}} \right) - \left(\frac{1}{T_{STRESS}} \right) \right) \right]$$

Acceleration Factor (AF):

HMC414 (QTR2002-00020) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/414-1/484)] = 198.9$

HMC454 (QTR2007-00003) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/413-1/468)] = 73.8$

HMC395 (QTR2012-00197, 240 hour test) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/383-1/448)] = 287.9$

HMC395 (QTR2012-00197, 1000 hour test) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/383-1/448)] = 287.9$

HMC313 (QTR2012-00199, 240 hour test) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/382-1/444)] = 264.4$

HMC313 (QTR2012-00199, 1000 hour test) Acceleration Factor = $\exp[1.3/8.6 \text{ e-}5(1/382-1/444)] = 264.4$

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours =

$$(74,000 \times 198.9) + (102,000 \times 73.8) + (30,000 \times 287.9) + (5,000 \times 287.9) + (34,320 \times 264.4) + (12,000 \times 264.4) = 4.54 \times 10^7 \text{ hours}$$

Since there were no failures and we used a time terminated test, F=0, and R = 2F+2 = 2

The failure rate was calculated using Chi Square Statistic:

$$\lambda_{CL} = \frac{\chi^2_{\%CL, 2f+2} \cdot 10^9}{2 \cdot t \cdot SS \cdot AF}$$

at 60% and 90% Confidence Level (CL), with 0 units out of spec and a 85°C package backside temp;

Failure Rate

$$\lambda_{60} = [(\chi^2)_{60,2}] / (2X \ 4.54 \times 10^7) = 1.8 / 9.08 \times 10^7 = 2.02 \times 10^{-8} \text{ failures/hour or 20 FIT}$$

$$\lambda_{90} = [(\chi^2)_{90,2}] / (2X \ 4.54 \times 10^7) = 4.6 / 9.08 \times 10^7 = 5.08 \times 10^{-8} \text{ failures/hour or 51 FIT}$$

Hittite Microwave Corporation is committed to:

- Supplying products of the highest quality
- Advance in state-of-the-art technology that supports our products
- Enhance our competitive position with superior product standards

Hittite's employees recognize the responsibility to:

- Take the initiative to ensure product quality
- Create an environment where the highest standards are maintained
- Continue to improve quality practices