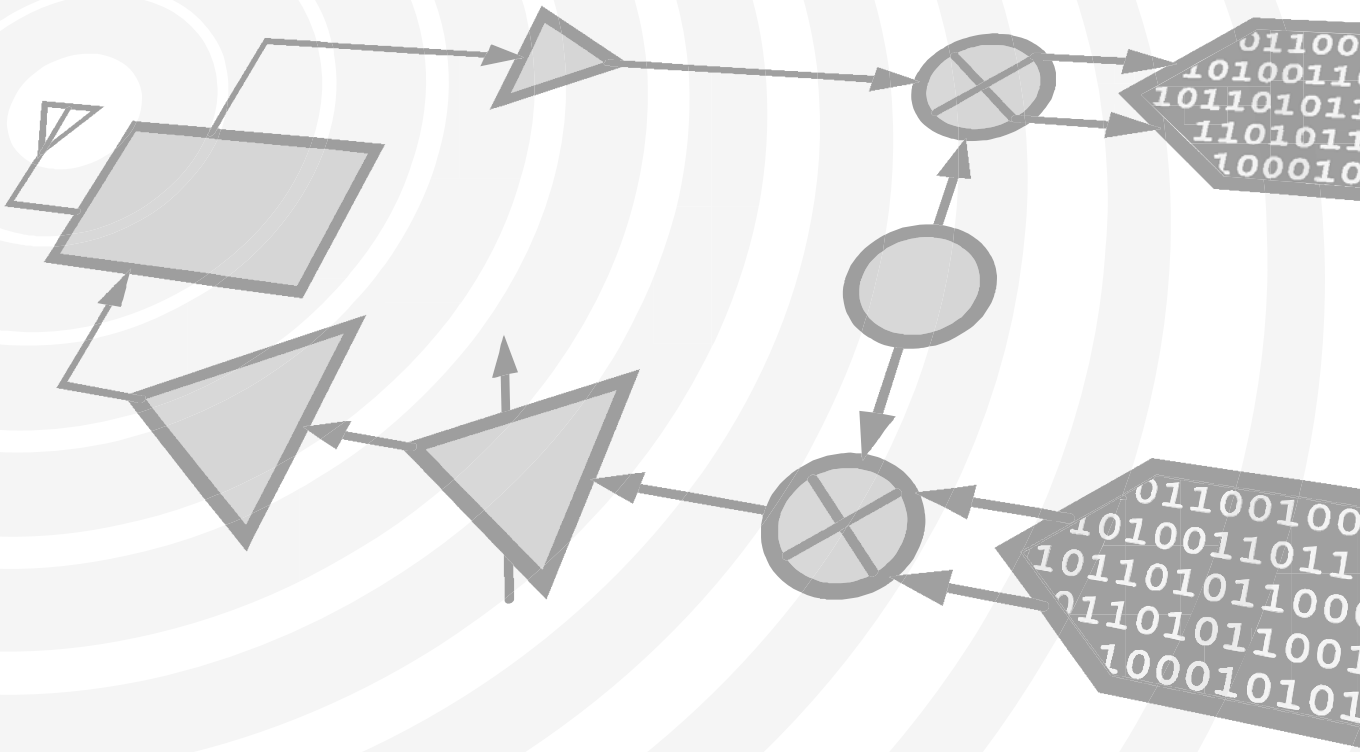
ANALOG DEVICES

Hittite MICROWAVE PRODUCTS FROM ANALOG DEVICES

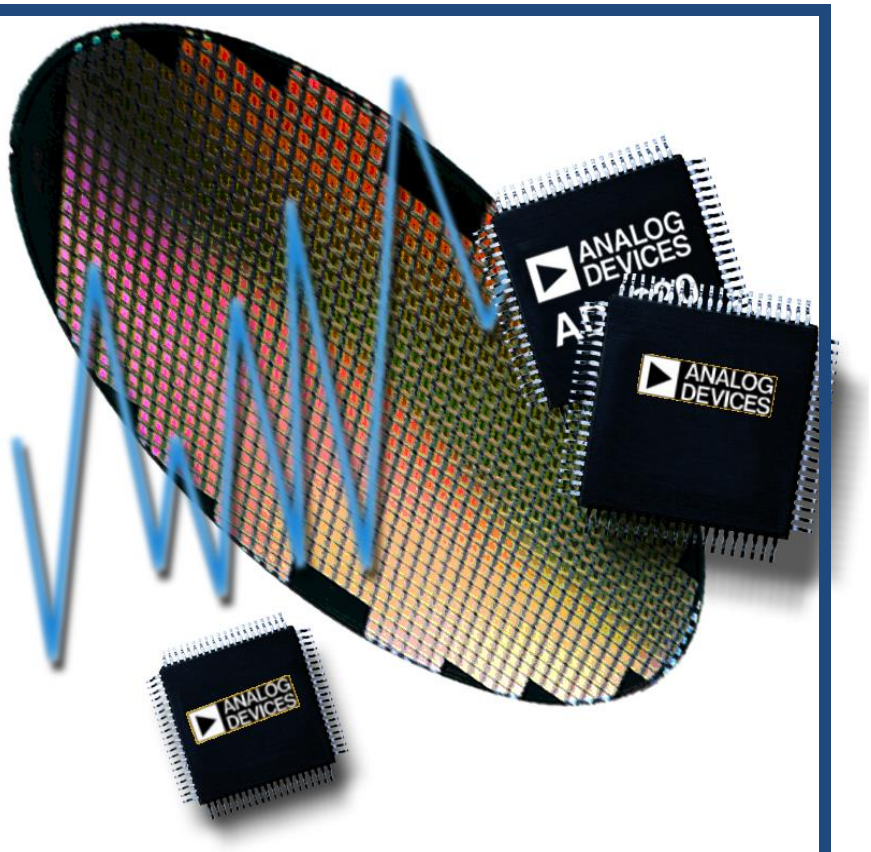
Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



www.analog.com

www.hittite.com



Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00228 **Rev: 02**

Wafer Process: GaAs HBT-A

HMC247	HMC433	HMC515	HMC735
HMC358	HMC434	HMC529	HMC736
HMC361	HMC437	HMC530	HMC737
HMC362	HMC438	HMC531	HMC738
HMC363	HMC439	HMC532	HMC739
HMC364	HMC440	HMC533	HMC764
HMC365	HMC443	HMC534	HMC765
HMC369	HMC444	HMC535	HMC783
HMC370	HMC445	HMC582	HMC807
HMC384	HMC447	HMC583	
HMC385	HMC466	HMC584	
HMC386	HMC492	HMC586	
HMC388	HMC493	HMC587	
HMC389	HMC494	HMC588	
HMC390	HMC500	HMC606	
HMC391	HMC505	HMC630	
HMC394	HMC506	HMC631	
HMC398	HMC507	HMC632	
HMC401	HMC508	HMC695	
HMC403	HMC509	HMC698	
HMC416	HMC510	HMC699	
HMC429	HMC511	HMC705	
HMC430	HMC512	HMC732	
HMC431	HMC513	HMC733	
HMC432	HMC514	HMC734	

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*

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

RoHS✓ EARTH FRIENDLY

ISO/TS 16949 TÜV SÜD ISO 9001

Process FIT Rate Report

QTR: 2013- 00228 **Rev: 02**

Wafer Process: GaAs HBT-A

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-A 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. **CDM:** Charged Device Model. A specified ESD testing circuit characterizing an event that occurs when a device acquires charge through some triboelectric (frictional) or electrostatic induction processes and then abruptly touches a grounded object or surface. This test was performed in accordance with JEDEC 22-C101.
2. **ESD:** Electro-Static Discharge. A sudden transfer of electrostatic charge between bodies or surfaces at different electrostatic potentials.
3. **HBM:** Human Body Model. A specified ESD testing circuit characterizing an event that occurs when a device is subjected to an electro-static charge stored in the human body and discharged through handling of the electronic device. This test was performed in accordance with JEDEC 22-A114.
4. **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.
5. **HTSL:** High Temperature Storage Life. Devices are subjected to 1000 hours at 150^{o}C per JESD22-A103.
6. **MSL:** Moisture sensitivity level pre-conditioning is performed per JESD22-A113.
7. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
8. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.
9. **UHAST:** Unbiased Highly Accelerated Stress Test. Devices are subjected to 96 hours of 85% relative humidity at a temperature of 130 □C and pressu JESD22-A118.

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

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:

HMC365 Qualification (QTR2004-00001)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	12	12	Complete	
HTOL, 1240 hours	12	12	Complete	
Post Electrical Test	12	12	Pass	

HMC510 Qualification (QTR2011-00004)

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

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

HMC511 Qualification (QTR2011-00013)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	554	554	Pass	
MSL-3	554	554	Complete	Devices passed post MSL 3 C-SAM.
Final Electrical Test	554	554	Pass	
UHAST	80	80	Complete	80 units from NC94
Final electrical Test	80	80	Pass	
Temp. Cycle	160	160	Complete	80 units from lot MMCR 80 units from lot NC94
Final electrical Test	160	160	Pass	
HTSL	137	137	Complete	61 units from lot MMCR 76 units from lot NC94
Final Electrical Test	137	137	Pass	
HTOL	159	159	Complete	80 units from lot MMCR 79 units from lot NC94
Final Electrical test	159	159	Pass	
Physical Dimensions	22	22	Pass	All dimensions passed per Hittite's datasheet outline drawing.

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Solderability	4	4	Pass	Note: Data from previously tested units from a different lot. Two units were tested to JESD22-B102E Method 1 and 2 units to Method 2.
ESD Exposure	3 per Voltage Level	3 per Voltage Level	Complete	Devices tested from lot NC94
Electrical Test	3 per Voltage Level	3 per Voltage Level	Class II	CDM passed 250 Volts

HMC416 QTR2012-00198

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	24	24	Pass	
HTOL, 1000 hours	24	24	Complete	
Final Electrical test	24	24	Pass	

Hittite MICROWAVE CORPORATION

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

HMC361 QTR2012-00255

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	104	104	Pass	
Burn-in, 240 hours	80	80	Complete	
Final Electrical test	80	80	Pass	
HTOL, 1000 hours	24	24	Complete	
Final Electrical test	24	24	Pass	

HMC6XXX (QTR2013-00340)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	6	6	Complete	
HTOL, 5039 hours	6	6	Complete	
Post HTOL Electrical Test	6	6	Pass	

HMC6XXX (QTR2013-00340)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	14	14	Complete	
HTOL, 2000 hours	14	14	Complete	
Post HTOL Electrical Test	14	14	Pass	

Hittite MICROWAVE CORPORATION

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

GaAs HBT-A Failure Rate Estimate

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

With device ambient case temp, Tc = 65°C

HMC365 (QTR2004-00001)
Operating Junction Temp (T_{oj}) =65°C (338°K)
Stress Junction Temp (T_{sj}) = 125°C (398 °K)

HMC510 (QTR2011-00004)
Operating Junction Temp (T_{oj}) =65°C (338°K)
Stress Junction Temp (T_{sj}) = 125°C (398 °K)

HMC511 (QTR2011-00013)
Operating Junction Temp (T_{oj}) =107°C (380°K)
Stress Junction Temp (T_{sj}) = 135°C (408 °K)

HMC416 (QTR2012-00198)
Operating Junction Temp (T_{oj}) =119°C (392°K)
Stress Junction Temp (T_{sj}) = 175°C (448°K)

HMC361 (QTR2012-00255) (240 hour test)
Operating Junction Temp (T_{oj}) =105°C (378°K)
Stress Junction Temp (T_{sj}) = 165°C (438°K)

HMC6XXX (QTR2013-00340) (5039 hour test)
Operating Junction Temp (T_{oj}) =111°C (384°K)
Stress Junction Temp (T_{sj}) = 143°C (416°K)

HMC6XXX (QTR2013-00340) (2000 hour test)
Operating Junction Temp (T_{oj}) =111°C (384°K)
Stress Junction Temp (T_{sj}) = 143°C (416°K)

Device hours:

HMC365 (QTR2004-00001) = (12 X 1240hrs) = 14,880 hours
HMC510 (QTR2011-00004) = (12 X 1000hrs) = 12,000 hours
HMC511 (QTR2011-00013) = (159 X 1000hrs) = 159,000 hours
HMC416 (QTR2012-00198) = (24 X 1000hrs) = 24,000 hours
HMC361 (QTR2012-00255, 240 hour test) = (80 X 240hrs) = 19,200 hours
HMC361 (QTR2012-00255, 1000 hour test) = (12 X 1000hrs) = 12,000 hours
HMC6XXX (QTR2013-00340, 5039 hour test) = (6 X 5039hrs) = 30,234 hours
HMC6XXX (QTR2013-00340, 2000 hour test) = (14 X 2000hrs) = 28,000 hours

For GaAs HBT-A MMIC, Activation Energy = 1.1 eV

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

HMC365 (QTR2004-00001) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/338-1/398)] = 300.3
HMC510 (QTR2011-00004) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/338-1/398)] = 300.3
HMC511 (QTR2011-00013) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/380-1/408)] = 10.1
HMC416 (QTR2012-00198) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/392-1/448)] = 59.1
HMC361 (QTR2012-00255, 240 hour test) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/378-1/438)] = 103.1
HMC361 (QTR2012-00255, 1000 hour test) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/378-1/438)] = 103.1
HMC6XXX (QTR2013-00340, 5039 hour test) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/384-1/416)] = 45.7
HMC6XXX (QTR2013-00340, 2000 hour test) Acceleration Factor = exp[1.1/8.6x10^{-5}(1/384-1/416)] = 45.7

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours =
(14,880x300.3)+(12,000x300.3)+(159,000x10.1)+(24,000x59.1)+(19,200x103.1)+(12,000x103.1)+
(30,324x45.7)+(28,000x45.7) = 1.70x10^{7} 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:

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

$$\lambda_{CL} = \frac{\chi^2_{\%CL,2f+2} \cdot 10^9}{2 \cdot t \cdot ss \cdot AF}$$ at 60% and 90% Confidence Level (CL), with 0 units out of spec and a 65°C package backside temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X \quad 1.70x10^7 \ )] = 1.8/ \quad 3.39x10^7 = \quad 5.39x10^{-8}$ failures/hour or 53.9 FIT or MTTF = $1.85x10^7$ Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X \quad 1.70x10^7 \ )] = 4.6/ \quad 3.39x10^7 = \quad 1.36x10^{-7}$ failures/hour or 135.8 FIT or MTTF = $7.36x10^6$ Hours

Hittite MICROWAVE CORPORATION

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