

## Features

- GaN on Si HEMT D-Mode Transistor Die
- Suitable for linear and saturated applications
- Broadband Operation DC - 3.5 GHz
- 28 V Operation
- 12 dB Gain @ 2.5 GHz
- 54% Drain Efficiency @ 2.5 GHz
- 100% DC Tested
- Active Area Periphery: 16 mm
- Chip Dimensions: 0.60 mm x 4.49 mm x 0.1 mm
- RoHS\* Compliant
- Export Classification: EAR99

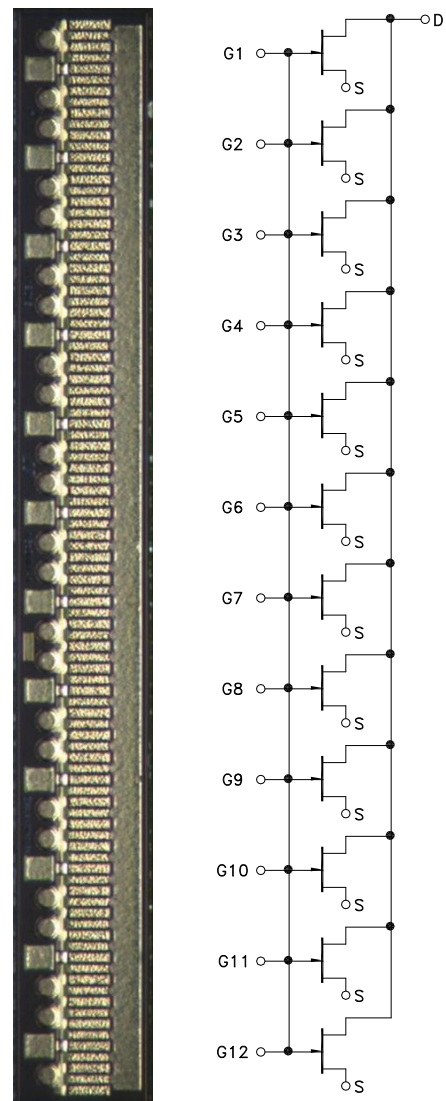
## Description

The MATR-GSHC03-160150 GaN HEMT is a wideband transistor die optimized for DC - 3.5 GHz operation. This device supports CW, pulsed, and linear operation with output power levels to 45 W (46.5 dBm).

The MATR-GSHC03-160150 is ideally suited for defense communications, land mobile radio, avionics, wireless infrastructure, ISM applications and VHF/UHF/L/S-band radar.

Built using the SIGANTIC® process - a proprietary GaN-on-Silicon technology.

## Functional Schematic



## Ordering Information

Part Number	Package
MATR-GSHC03-160150	Bare Die in Waffle Packs

## Pin Configuration

Pin No.	Pin Name	Function
G1-G12	RF <sub>IN</sub> / V <sub>G</sub>	RF Input / Gate
D	RF <sub>OUT</sub> / V <sub>D</sub>	RF Output / Drain
S	Back-side <sup>1</sup>	Ground / Source

1. The die backside must be connected to RF and DC ground. This path must also provide a low thermal resistance heat path.

1 \* Restrictions on Hazardous Substances, European Union Directive 2011/65/EU.

## GaN Wideband Transistor Die 28 V, 45 W, DC - 3.5 GHz

Rev. V1

### RF Electrical Specifications<sup>2</sup>: $T_C = 25^\circ\text{C}$ , $V_{DS} = 28\text{ V}$ , $I_{DQ} = 400\text{ mA}$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Small Signal Gain	CW, 2.5 GHz	$G_{SS}$	-	13.5	-	dB
Saturated Output Power	CW, 2.5 GHz	$P_{SAT}$	-	47.3	-	dBm
Drain Efficiency at Saturation	CW, 2.5 GHz	$\eta_{SAT}$	-	57	-	%
Power Gain	2.5 GHz, $P_{OUT} = 45\text{ W}$	$G_P$	-	12	-	dB
Drain Efficiency	2.5 GHz, $P_{OUT} = 45\text{ W}$	$\eta$	-	54	-	%
Ruggedness: Output Mismatch	All phase angles	$\Psi$	VSWR = 15:1, No Device Damage			

### DC Electrical Characteristics: $T_C = 25^\circ\text{C}$

Parameter	Test Conditions	Symbol	Min.	Typ.	Max.	Units
Drain-Source Leakage Current	$V_{GS} = -8\text{ V}$ , $V_{DS} = 100\text{ V}$	$I_{DLK}$	-	-	16	mA
Gate-Source Leakage Current	$V_{GS} = -8\text{ V}$ , $V_{DS} = 0\text{ V}$	$I_{GLK}$	-	-	8	mA
Gate Threshold Voltage	$V_{DS} = 28\text{ V}$ , $I_D = 16\text{ mA}$	$V_T$	-2.3	-1.5	-0.7	V
Gate Quiescent Voltage	$V_{DS} = 28\text{ V}$ , $I_D = 400\text{ mA}$	$V_{GSQ}$	-2.1	-1.2	-0.5	V
On Resistance	$V_{DS} = 2\text{ V}$ , $I_D = 120\text{ mA}$	$R_{ON}$	-	0.22	-	$\Omega$
Maximum Drain Current	$V_{DS} = 7\text{ V}$ pulsed, pulse width 300 $\mu\text{s}$	$I_{D,MAX}$	-	9.2	-	A

2. Typical RF performance of packaged die in MACOM RF evaluation board. Refer to MACOM product NPT1015 for details.

## Absolute Maximum Ratings<sup>3,4,5</sup>

Parameter	Absolute Maximum
Drain Source Voltage, $V_{DS}$	100 V
Gate Source Voltage, $V_{GS}$	-10 to 3 V
Gate Current, $I_G$	32 mA
Junction Temperature, $T_J$	+200°C
Operating Temperature	-40°C to +85°C
Storage Temperature	-65°C to +150°C

3. Exceeding any one or combination of these limits may cause permanent damage to this device.

4. MACOM does not recommend sustained operation near these survivability limits.

5. Operating at nominal conditions with  $T_J \leq 200^\circ\text{C}$  will ensure MTTF >  $1 \times 10^6$  hours.

## Thermal Characteristics<sup>6,7</sup>

Parameter	Test Conditions	Symbol	Typical	Units
Thermal Resistance	$V_{DS} = 28 \text{ V}$ , $T_J = 180^\circ\text{C}$	$R_{\theta JC}$	2.1	°C/W

6. Typical Thermal Characteristics of packaged die in CPC flanged device attached using AuSn pre-form with minimal voiding. Refer to MACOM product NPT1015 for details.

7. Junction temperature ( $T_J$ ) measured using IR Microscopy. Case temperature measured using thermocouple embedded in heat-sink.

## Bias Sequencing

### Turning the device ON

1. Set  $V_{GS}$  to the pinch-off ( $V_P$ ), typically -5 V.
2. Turn on  $V_{DS}$  to nominal voltage (28 V).
3. Increase  $V_{GS}$  until the  $I_{DS}$  current is reached.
4. Apply RF power to desired level.

### Turning the device OFF

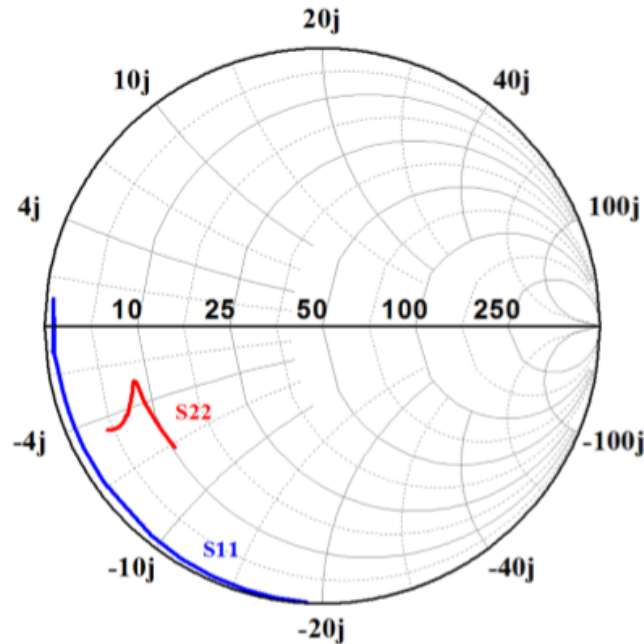
1. Turn the RF power off.
2. Decrease  $V_{GS}$  down to  $V_P$ .
3. Decrease  $V_{DS}$  down to 0 V.
4. Turn off  $V_{GS}$ .

**GaN Wideband Transistor Die**  
**28 V, 45 W, DC - 3.5 GHz**

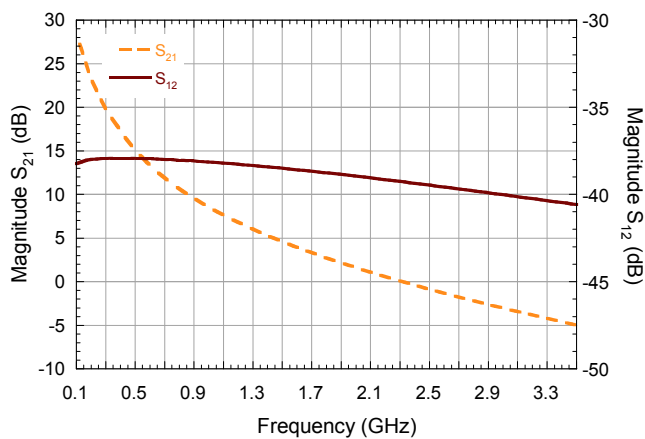
Rev. V1

**Typical Packaged s-parameters<sup>8,9</sup>:  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 360\text{ mA}$ ,  $T_C = 25^\circ\text{C}$**   
**Reference Plane at Device Leads**

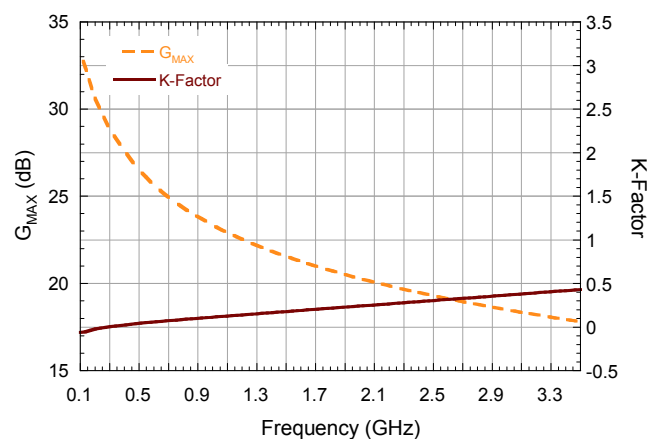
*$S_{11}$  and  $S_{22}$  vs. Frequency (0.1 GHz—3.5GHz)*



*$S_{21}$  and  $S_{12}$  vs. Frequency*



*$G_{MAX}$  and K-Factor vs. Frequency*

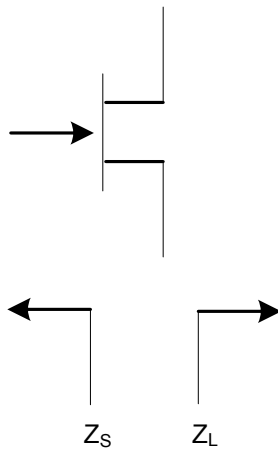


8. Contact MACOM for s-parameter file in .s2p format
9. Typical s-parameters of packaged die. Refer to MACOM product NPT1015 for details.

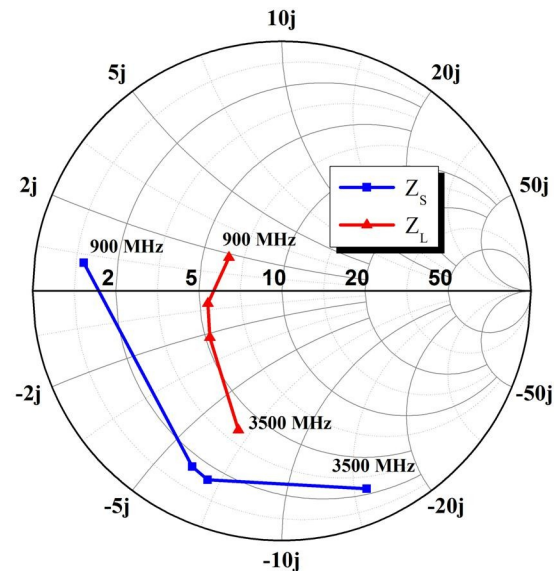
**Typical Packaged Load-Pull Performance<sup>10</sup>:  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 400\text{ mA}$ ,  $T_C = 25^\circ\text{C}$**   
**Reference Plane at Device Leads, CW Drain Efficiency and Output Power Tradeoff Impedance**

Frequency (MHz)	$Z_S$ ( $\Omega$ )	$Z_L$ ( $\Omega$ )	$P_{SAT}$ (W)	$G_{SS}$ (dB)	Drain Efficiency @ $P_{SAT}$ (%)
900	$1.1 + j0.7$	$6.3 + j1.8$	53.7	22.5	65.1
2200	$1.6 - j6.0$	$5.4 - j0.6$	53.2	15.8	64.8
2500	$1.5 - j6.7$	$5.2 - j2.2$	50.9	15.0	60.8
3500	$2.6 - j15$	$3.9 - j6.3$	42.0	13.9	55.4

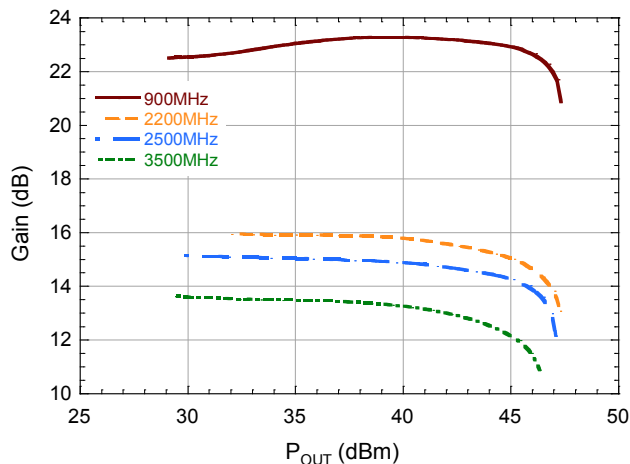
**Impedance Reference**



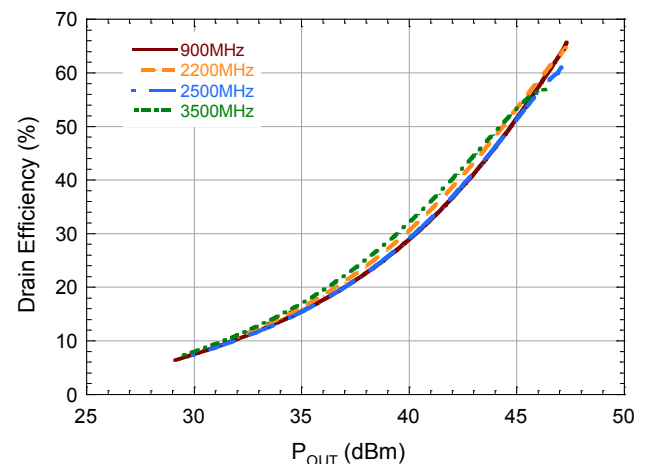
**$Z_S$  and  $Z_L$  vs. Frequency**



**Gain vs. Output Power**



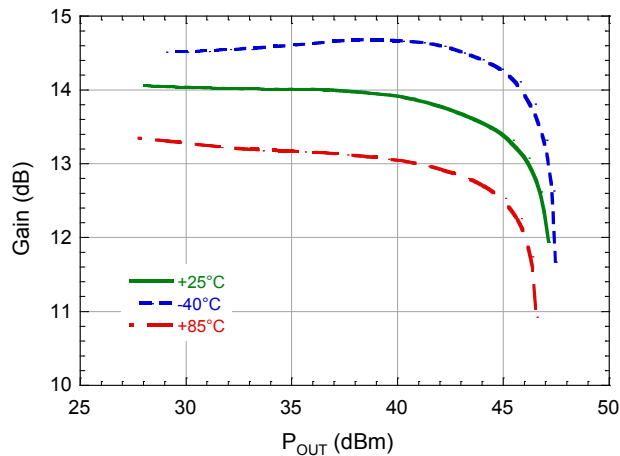
**Drain Efficiency vs. Output Power**



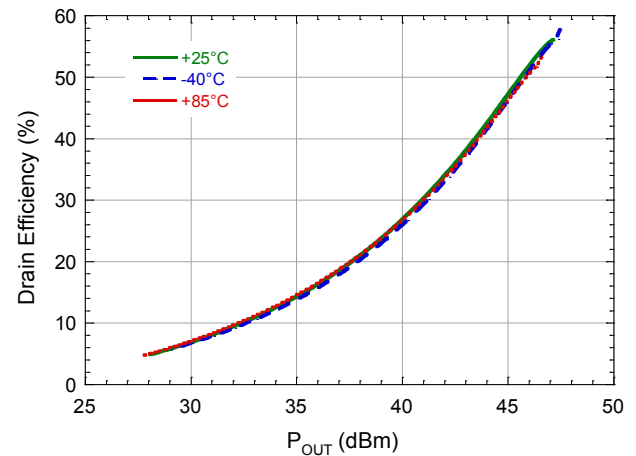
10. Typical RF loadpull performance of packaged die. Refer to MACOM product NPT1015 for details.

**Typical RF Performance<sup>11</sup> as Measured in Narrow-band 2.5 GHz Evaluation Board:**  
**CW,  $V_{DS} = 28$  V,  $I_{DQ} = 400$  mA (unless noted)**

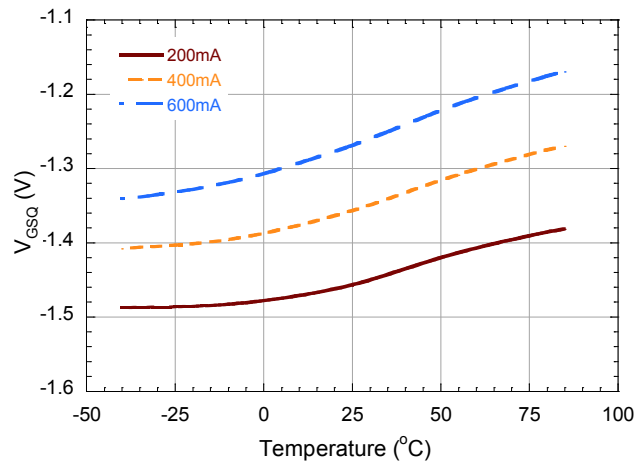
**Gain vs. Output Power over Temperature**



**Drain Efficiency vs. Output Power over Temperature**



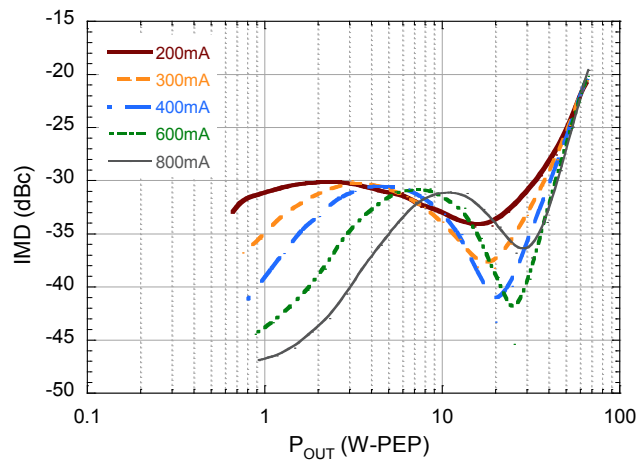
**Quiescent  $V_{GS}$  vs. Temperature**



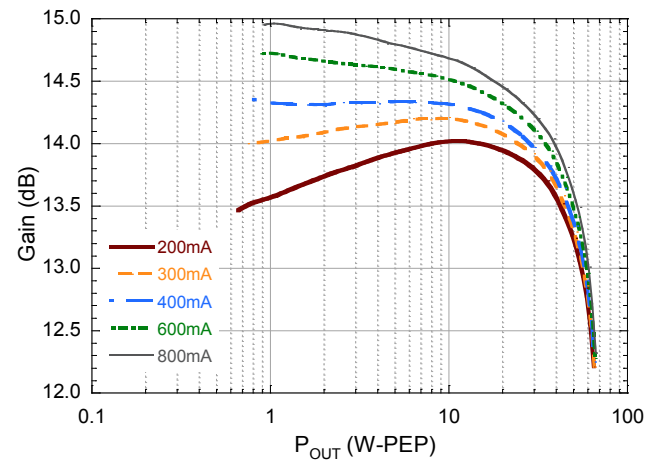
11. Typical RF performance of packaged die in MACOM RF evaluation board. Refer to MACOM product NPT1015 for details.

**Typical 2-Tone Performance<sup>12</sup> as Measured in Narrow-band 2.5 GHz Evaluation Board:**  
**1 MHz Tone Spacing,  $V_{DS} = 28$  V,  $I_{DQ} = 400$  mA,  $T_C = 25^\circ\text{C}$  (unless noted)**

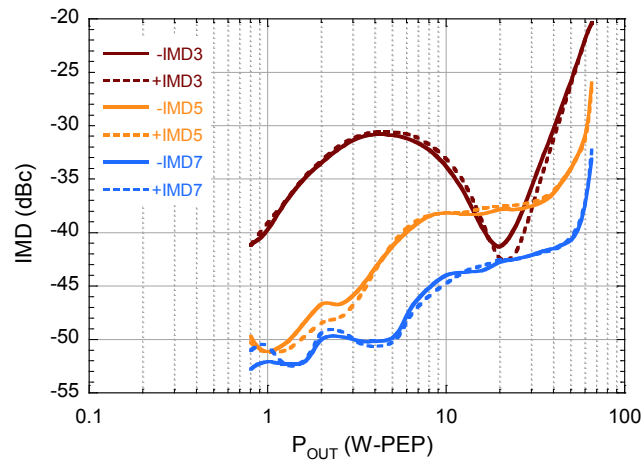
**2-Tone IMD3 vs. Output Power vs. Quiescent Current**



**2-Tone Gain vs. Output Power vs. Quiescent Current**



**2-Tone IMD vs. Output Power**



12. Typical RF performance of packaged die in MACOM RF evaluation board. Refer to MACOM product NPT1015 for details.

## Assembly Notes

### Die Storage

Die should be stored in a dry nitrogen environment with class 1000 or better particle count. Temperature should fall between 65°F and 75°F and relative humidity should be held at 45% +/- 5%. Once die have been fully assembled into a package, module, or other sub-assembly they can be stored according to data sheet recommendations.

### Die Handling and Transfer

Soft tipped vacuum tools, inverted pyramid collets or other standard production die assembly equipment are recommended for die handling. Tweezers can be used but operators must be trained in die handling practices to avoid scratching, chipping, or cracking die, which could lead to immediate or long-term performance or reliability degradation.

GaN on Si HEMT devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these HBM Class 1B devices.

### Die Attach Recommendations

MACOM GaN on Si die may have air bridges and other sensitive structures on the top of the device that can be damaged if excess force or stress is applied to the top side of the die. Ensure that the tooling used during die attach does not damage these structures. Recommended methods of die attach are AuSi or AuSn Eutectic, and Ag-Filled Epoxy.

#### AuSi Eutectic Attach Process

1. Place substrate, chip carrier, or heatsink on a heated work surface at 420°C - 430°C.
2. Pick die using a 2-sided or 4-sided collet.
3. Place die on top of heated substrate with 60g - 100g force (depending on die size).
4. Scrub die approximately 3mils in line with the short dimension of die for 10-15 cycles.
5. Remove substrate with die attached from heated work surface as soon as possible. A delay of more than 5 seconds may compromise through-wafer vias if present.
6. Best results are achieved on an automated die bonder with Nitrogen or forming gas surrounding the part during bonding.
7. Die should never be exposed to temperatures greater than 430°C or held at this maximum temperature for more than 20 seconds.

#### AuSn Eutectic Attach Process

1. Place substrate, chip carrier, or heatsink on a heated work surface at 250°C.
2. Pick and place a AuSn preform (80/20 composition), approximately the same size as the die, on to the substrate.
3. Pick and place die on top of preform and hold down with 40 - 80g force.
4. Ramp temperature from 250°C to 300 - 320°C in approximately 10 seconds.
5. Dwell for 4 to 6 seconds.
6. (Optional) Scrub die approximately 3 mils in line with short dimension of die for 10-15 cycles.
7. Ramp temperature back down to 250°C and remove substrate with attached die from heater.
8. Best results are achieved on an automated die bonder with Nitrogen or forming gas surrounding the part during bonding.
9. Different die bond tools can be used including: 2-sided collet, 4-sided collet, and rectangular surface pick-up tool.

## Assembly Notes

### Ag-Filled Epoxy Attach Process

1. Apply epoxy to bond site in desirable pattern and proportion.
2. Press die into epoxy.
3. Oven cure with recommended temperature profile for specific epoxy being used.
4. Best results are achieved on an automated die bonder with epoxy dispense capability.

### Wire Bond Recommendations

No active devices or other metallization is present under this GaN on Si die bond pads. All bond pads are terminated with a Au layer to facilitate both ball and wedge wire bonding. Al wire should not be used as this can create inter-metallic growth with the Au bond pads.

### Ball Bonding Process

1. Place the ball on the die and the crescent bond on the circuit to minimize the force applied to the die.
2. Heat substrate with die to 130 - 150°C during wire bonding.
3. Select appropriate size wire to allow for ball size and wire bond placement accuracy on bond pads. Bonds should not overhang the outside of bond pads to avoid contact with exposed metallization from other areas of the die.

### Wedge Bonding Process

1. Bonding may be done in any order with first bond, stitch bond, or last bond placed on die.
2. Heat substrate with die to 130 - 150°C during wire bonding.
3. Select appropriate size wire to allow for bond, tail, and wire bond placement accuracy on bond pads. Bonds should not overhang the outside of bond pads to avoid contact with exposed metallization from other areas of the die.

### Determining if Burn-In is Required

There is no reliability requirement that burn-in be performed. It is highly recommended that, for a given application, key performance parameters in the application circuit be measured pre- and post- burn-in to determine what sensitivities exist, if any. These data can be extrapolated, using engineering judgment, to estimate drift over a longer time period. If more variation is seen than desired, burn-in should be performed.

Note that MACOM published accelerated life and other reliability tests are performed on burned-in devices. In particular, MTTF values are based on drift in  $I_{MAX}$  and are therefore only valid for burned-in devices. Devices that have not been burned in will exhibit the expected increased drift in  $I_{MAX}$  over initial operation.



Rev. V1

121.00

600.00

116.50

42.50 ALL AROUND

12X GATE PAD,  
97.00 X 109.00

24X SOURCE PAD,  
Ø80.00

11X 120.00

4490.00

11X 360.00

150NM1

205NM10X

DRAIN PAD,  
4317.00 X 110.00

DIMENSIONS: MICRONS  
PADS: D = DRAIN  
G = GATE  
S = SOURCE  
THICKNESS: 100µm  
BACKSIDE METAL: Au

155.00

M/A-COM Technology Solutions Inc. All rights reserved.

Information in this document is provided in connection with M/A-COM Technology Solutions Inc ("MACOM") products. These materials are provided by MACOM as a service to its customers and may be used for informational purposes only. Except as provided in MACOM's Terms and Conditions of Sale for such products or in any separate agreement related to this document, MACOM assumes no liability whatsoever. MACOM assumes no responsibility for errors or omissions in these materials. MACOM may make changes to specifications and product descriptions at any time, without notice. MACOM makes no commitment to update the information and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to its specifications and product descriptions. No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document.

THESE MATERIALS ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, RELATING TO SALE AND/OR USE OF MACOM PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, CONSEQUENTIAL OR INCIDENTAL DAMAGES, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. MACOM FURTHER DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. MACOM SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS, WHICH MAY RESULT FROM THE USE OF THESE MATERIALS.

MACOM products are not intended for use in medical, lifesaving or life sustaining applications. MACOM customers using or selling MACOM products for use in such applications do so at their own risk and agree to fully indemnify MACOM for any damages resulting from such improper use or sale.