MMICB RELIABILITY

Application Note # 42

MWTD Semiconductor Marketing
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Introduction

This application note provides information regarding the reliability performance of GaAs integrated circuits and components fabricated with the MMICB process at MWTD. The objective is to compile and summarize the reliability test results in a concise format. It is intended to be used by the customer who wishes to know detailed reliability test results to aid in the determination of the reliability of their end-product.

Included in this application note is a description of the reliability experiments performed and the test results for the following topics:

- High Temperature Operating Life (HTOL) results for MMICB circuit components: FET's, silicon nitride capacitors, and resistors.
- Ruggedness when exposed to Electrostatic Discharge (ESD) or high power continuous wave (CW) RF signals.
- Environmental tests including sensitivity to hydrogen or humid environments and capacitor thermal cycling.
- Bonding pad adhesion: Wire bond-pull results.
- Circuit level reliability.

Nomenclature

BV_{GDO}: DC Gate-to-drain reverse breakdown voltage with the source floating.
BV_{GSS}: DC Gate-to-source breakdown voltage with drain and source connected.
DUT: Device Under Test.
E_A: Activation energy.
ESD: Electrostatic Discharge voltage.
FITs: Failures per billion operating hours. (1000 FITs is approximately a 1% failure rate per 1 year.)
HTOL: High temp operating life.
I_{DD},I_{DS}: DC drain supply current.
I_{DSS}: Drain current with gate connected to the source.
λ: Failure rate at a specified temperature and time.
MTTF: Median Time To Failure.
P_D: DC power dissipation.
P_{inc}: RF power incident on DUT.
P_{out}: RF power out of DUT.
P_{ref}: RF power reflected from DUT.
P_S: RF source power.
σ: Shape factor of the failure distribution.
$\theta_{TH}(T,P)$: Thermal resistance at temperature T with DC power dissipation $P=P_D$.
T_A: Ambient temperature.
T_B: DUT backside temp.
T_{ch}: Channel temperature.
T_o: Channel temperature at which data is known.
V_{DD},V_{DS}: DC drain supply voltage.

Process Enhancements

The MMICB process was developed to enhance the performance and reliability of the MMICA process for better market coverage and customer satisfaction. The primary objectives that were met by the MMICB product/process development project are:

- *Increased Output Power.*
- *Reduced Anomalies* - Sidegating threshold voltage and transients, low frequency oscillations, and substrate breakdown.
- *Eliminated Reliability Concerns* - Parametric drifts, hydrogen sensitivity, and humidity sensitivity.
- *Improved Process Control.*

The MMICB process features the following enhancements that improve reliability:

- Increased silicon nitride capacitor dielectric thickness for improved capacitor reliability.
- Improved gate passivation process to prevent gate barrier-height degradation in a hydrogen rich atmosphere.
- Improved gate process and channel passivation process to significantly reduce performance drifts in humid environments.
- New double recess channel trough and E-beam written gate.
- Thicker protective polyimide overcoat.