NBB Series and NDA Series Reliability

This application note provides additional information on component reliability with varying device junction temperature, and the effect of the package used on junction temperature. This information is provided for the NBB Series HBT Broadband Feedback Amplifiers and NDA Series HBT Distributed Amplifiers.

Device Reliability

RFMD uses an industry-proven, high-performance, high-reliability gallium indium phosphide on gallium arsenide (InGaP/GaAs) heterojunction bipolar transistor (HBT) technology for its NBB series and NDA series broadband amplifiers.

This process has completed in excess of 1 million device hours of accelerated life testing. The test device used has two emitter fingers of size 3µm by 20µm. The device was operated at 3V and with a current density of 25KA/cm^2. The test device is of comparable size to device sizes in the NBB series and NDA series of components. Additionally, the operating point, both of voltage and current, was comparable to the nominal operating point of the device. Testing was performed at five junction temperature points (257°C, 275°C, 285°C, 300°C and 315°C) with 50 to 100 devices tested at each temperature.

Figure 1 shows the device results with extrapolation of Mean Time to Failure (MTTF) for lower junction temperatures.

Results show that for a device junction temperature of 150°C the mean time to failure is greater than 2 million hours. For a device junction temperature of 125°C the mean time to failure is 30 million hours.

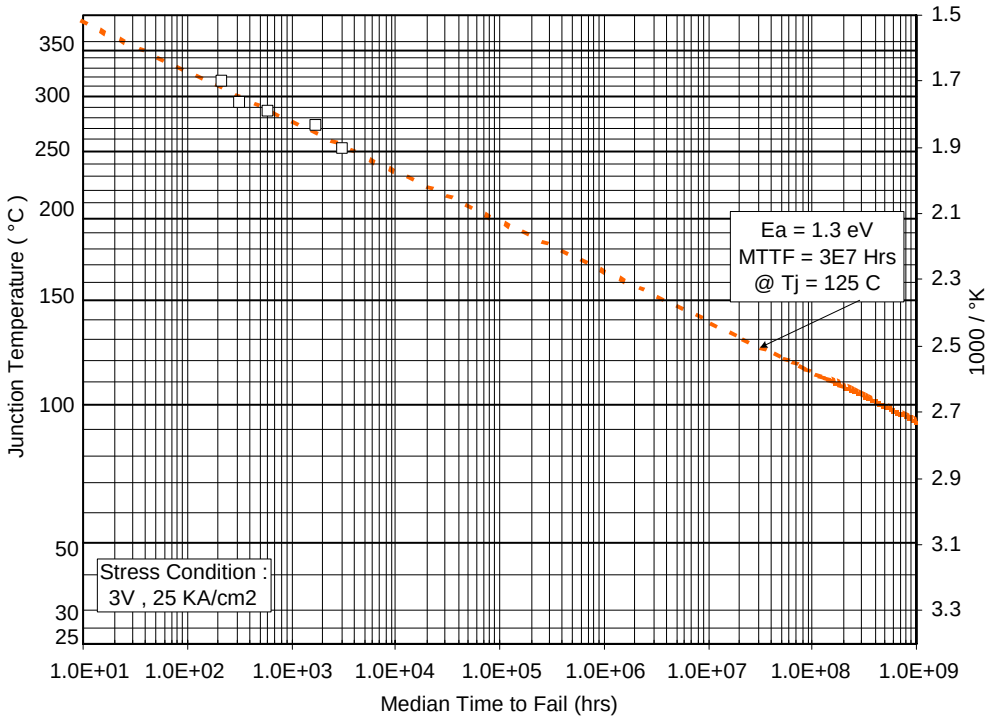

Figure 1. MTTF for Test Device

Packaged Component Reliability

All NBB and NDA products complete a junction temperature measurement before design qualification is completed. The test verifies device junction temperature in the package at the maximum recommended baseplate operating temperature.

From Figure 1, RFMD recommends that all NBB and NDA products be operated with a junction temperature below 150°C to ensure MTTF greater than 1 million hours.

The junction temperature is dependent upon several key factors:

1. Baseplate temperature

2. Package type

3. Device bias

4. Die to package attachment process

5. Package to board attachment process

6. Board via layout

Each of these key factors is addressed during thermal junction measurements. Details are given below.

RFMD recommends that these devices be used at a baseplate temperature no greater than 85°C, to ensure that the device junction temperature limit outlined above is maintained. Therefore all device junction thermal measurements are performed on components at 85°C baseplate temperature.

RFMD tests all die types in every package style offered. For the NBB series and NDA series the package styles currently offered are the Micro-X 4-lead surface mount ceramic package and surface mount ceramic multi pin grid array (MPGA) package.

The junction temperature measurement is carried out at three bias points:

Low current, Id set between half the recommended current and the recommended bias current.
Nominal current, Id set at nominal recommended current.
Limiting current, Id is set to the draw the maximum current while maintaining a device junction temperature of 150°C.

Die are mounted in packages using the standard manufacturing process. However the package lids are not fitted to allow the die junctions to be viewed during testing.

The packages are then mounted to an evaluation board using a standard RF board material, with the recommended via hole layout. This layout uses multiple ground via holes to ensure good thermal dissipation away from the package to the baseplate.

In conclusion, the parts are mounted in a realistic application setting, and the test simulates actual device junction temperature operation at the maximum recommended baseplate temperature for a variety of device biases.

Measurements are performed using a calibrated thermal imaging camera to accurately determine the temperature variation across the die when mounted in the package. Multiple components of each die type and package style are measured to allow an average junction temperature result to be generated.

An example of the thermal image generated is shown in Figure 2. This shows the temperature variation across an NBB-300 (Micro-X style package) at 85°C baseplate temperature, with nominal 50mA device current. The temperature scale is shown below the image. The image clearly shows the region of maximum temperature with a peak temperature of 139°C. This occurs at the transistor junction.

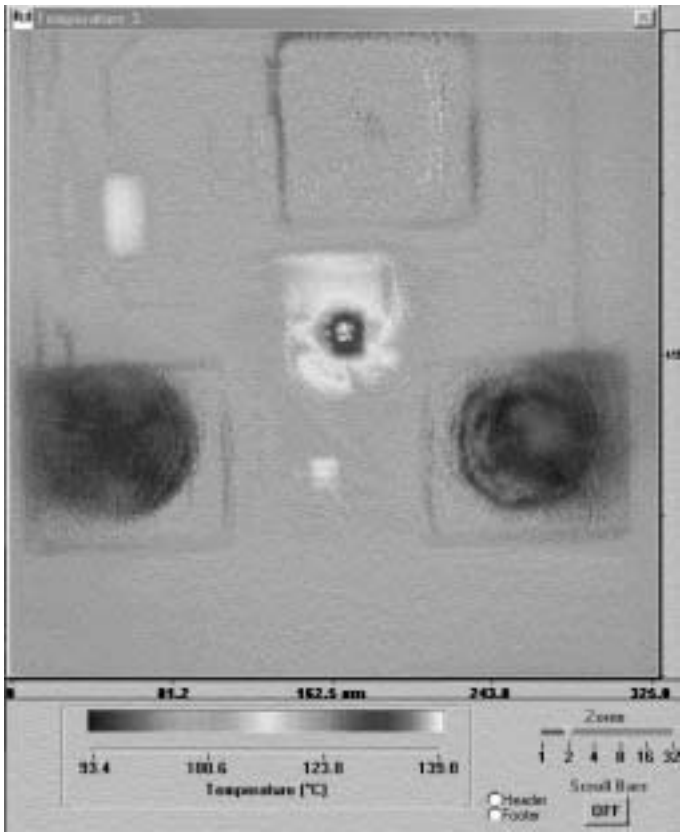

Figure 2. NBB-300 Packaged Die Thermal Image

An example of some results of testing for NBB series and NDA series devices in each package style is given below for a baseplate temperature of 85°C. The results shown are the average junction temperature of the sample measured.

Table 1. NBB Series Micro-X Packaged Junction Temperatures

Part Number	Base Temperature °C	Low			Nominal			Limiting		
		Id	Tj	ΔTj	Id	Tj	ΔTj	Id	Tj	TjΔ
		mA	°C	°C	mA	°C	°C	mA	°C	°C
NBB-300	85	25	105.2	20.2	50	138.0	53.0	57	150.2	65.2
NBB-400	85				47	131.2	46.2	58	150.2	65.2
NBB-500	85				35	120.3	35.3	53	150.2	65.2

Table 2. NBB Series MPGA Packaged Junction Temperatures

Part Number	Base Temperature °C	Low			Nominal			Limiting		
		Id	Tj	ΔTj	Id	Tj	ΔTj	Id	Tj	TjΔ
		mA	°C	°C	mA	°C	°C	mA	°C	°C
NBB-302	85	36	107.6	22.6	50	124.8	39.8	67	151.4	66.4
NBB-502	85	20	97.9	12.9	35	114.3	29.3	57	150.7	65.7

Table 3. NDA Series MPGA Packaged Junction Temperatures

		Id1	Id2	Tj	ΔTj	Id1	Id2	Tj	ΔTj	Id1	Id2	Tj	ΔTj
		mA	mA	°C	°C	mA	mA	°C	°C	mA	mA	°C	°C
NDA-212	85					29	36	133.1	48.1	32	55	150.4	65.4
NDA-312	85	28	36	133.9	48.9	29	42	139.9	54.9	31	55	151.0	66.0
NDA-412	85					29	36	140.0	55.0				

Note there is significant temperature rise from the baseplate temperature under nominal operating condition. This rise is of the order of 30°C to 55°C above the baseplate temperature (85°C), depending on the device.

Additionally, the MPGA package style provides improved thermal performance. Device junction temperatures for NBB parts tested in the MPGA package styles show a reduced junction temperature.

In conclusion, all NBB series and NDA series packaged parts operated at nominal bias with a baseplate temperature of 85°C (maximum recommended baseplate temperature) show an average junction temperature well below the 150°C recommended device junction temperature limit. Hence all NBB series and NDA series packaged parts provide a mean time to failure greater than 1 million hours under these conditions.