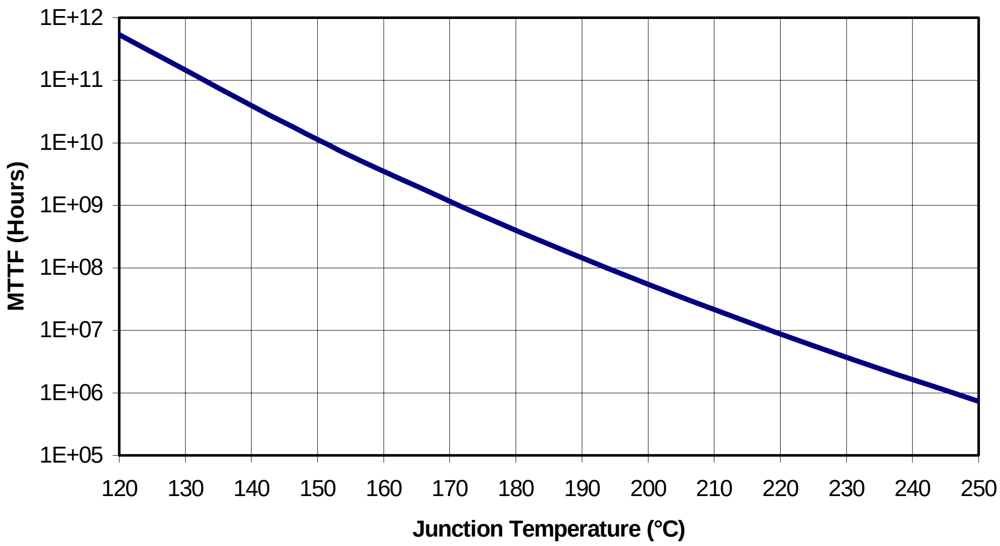
Application Note

MTTF Analysis for Enhanced HBT Process

The Communications Edge ™

Product Information



WJ products, such as the AH110, AH114, AH115, AH116, AH215, and AH312, using an enhanced HBT process have proven to be very reliable at high junction temperatures. Three temperature acceleration tests performed on single finger 12-micron devices were used to establish the activation energy for the process. Lots of 16 devices each were attached to Copper blocks using AuSn solder and then they were biased at 5 Volts (nominal operating voltage) and with current densities of 25 kA/cm^2. Failure acceleration was to be achieved by adjusting the temperature of the baseplate to which the blocks were attached. Junction Temperatures of the devices were determined by measuring the change in the base-emitter voltage (V_{be}) with temperature.

When the tests were performed, it was not possible to produce failures at practical baseplate temperatures of up to 250 ºC (Tj = 315 ºC). At this temperature, no current degradation was seen in the devices after 5600 hours of aging. In order to produce failures, the current density was increased to 75 kA/cm^2 and the voltage was decreased to 2.5 V. At this new bias, Tj increased to 330 ºC, and MTTF equaled 3230 hours where failure was defined as a 20% drop in current. In order to produce additional failures at higher junction temperatures, the current density was increased further. The resulting MTTF curve is shown above. Based upon these tests, the activation energy was determined to be 1.85 eV.

With this information, the Arrhenius equation for the process can be written as follows:

$$\mathbf{MTTF = A^* e^{(Ea/k/Tj)}}$$

Where:
$A = 1.4 \times 10^{-12}$ (hrs) (Constant)
Ea = 1.85 (eV) (Activation Energy)
$k = 8.617 \times 10^{-5}$ (eV/ºK) (Boltzmann's Constant)
Tj = Junction Temperature (ºK)

Assuming continuous operation at a certain case temperature, MTTF and junction temperature can be related to the curve shown above with the following equation:

$$\mathbf{Tj = T_c + R_{th} * V_d * I_d + 273}$$

Where: T_j = Junction Temperature (ºK)
V_d = Device Voltage
I_d = Device Current
R_{th} = Worst-case published thermal resistance (shown on datasheets)
T_c = Case Temperature (ºC)
273 is the factor to convert from ºC to ºK

Based upon this data, a junction temperature of approximately 245 ºC will yield an MTTF of 1 million hours. For most other HBT processes, an MTTF of 1 million hours is reached at junction temperatures of between 150 and 175 ºC. It must be noted that because it was not practical to produce failures using thermal stress applied solely by the baseplate, there is some uncertainty in the calculated activation energy of 1.85. However, because no failures were detected through 5600 hours of testing in devices biased at 5 V and 25kA/cm^2 and subjected to a baseplate temperature of 250 ºC, one can take this point as a solid anchor for the process. If one assumes an activation energy of 1.4 eV (typical of other HBT processes), the computed MTTF at a junction temperature of 200 ºC is still well above 4 million hours. It should also be noted that WJ will not design die to operate at excessive junction temperatures under normal operating conditions (85 ºC case temperature) because the plastic molding compound will degrade before the semiconductor.

The enhanced HBT process is used for the following WJ products: **AH110, AH114, AH115, AH116, AH215,** and **AH312**.