MTBF Analysis for AH1

AH2, AH3, AH4, AH11, AH22, AM1, AG101, FH1, FHF1, AH101, AH102 Included By Similarity

For the AH1 data sheet, the Mean Time Before Failure (MTBF) vs. Temperature curve is from the equation:

$$MTBF = A \cdot e^{\left(\frac{E_a}{kT}\right)}$$

Where:

$A =$	3.71×10^{-12} (hrs)	(Pre-exponential Factor)
$E_a =$	1.5 (eV)	(Activation Energy)
$k =$	8.617×10^{-5} (eV/ºC)	(Boltzmann's Constant)

The Activation Energy and the Pre-exponential Factor were experimentally determined from reliability work performed at WJ Communications. The following is a brief description of how these values were determined.

The most common way to determine the activation energy is by performing a three-temperature reliability test. The three-temperature test is where an elevated temperature is used to accelerate the time to failure. A specific time is measured at which 50% of the devices fail for each given temperature. A Time vs. Temperature graph is generated and the data is fit to an Arrhenius Function. The Pre-exponential factor and Activation Energy are determined from the fit to the data.

In the case of the WJ MESFET process, this technique was not used, due to the fact that we did not have enough failures during FET life testing. The FETs were tested for up to 3,700 hours at a base plate temperature of 220º C, which corresponds to a channel temperature of approximately 250º C. Under these conditions, there were not a sufficient number of failures to get accurate data. As the temperature is increased to further accelerate failure, other failure modes, such as ohmic metal diffusion, begin to appear. This type of failure mode would not appear under normal operating conditions and can be traced to the elevated temperature and not to the accelerated failure of the device. To fulfill the three-temperature test even if the junction temperature 250º C is used as the "lower" temperature in a three-temperature test, two higher temperatures are required. As stated above, these higher temperatures would not yield the failures of the appropriate mode. If 250º C is used as a "higher" temperature, the time required to generate the required number of failures at the lower temperatures would be prohibitive.

As a result of this "lack of failures," we have conducted independent tests on each portion of the FET structure in order to determine a failure rate. Life tests were performed on Ohmic Metal, MIM Capacitors, Overlay Metal and Gate Metal. From these tests, Gate Metal Electron-migration was determined to be the most likely failure mode in the MESFET structure. The three-temperature testing for the Gate Metal resulted in the 1.5 eV activation energy and 3.71×10^{-12} hrs, which we believe is a lower bound for the WJCI MESFET process. As a part of our efforts to ensure the reliability of our products, gate electron-migration tests are designed into our PCM block and are tested on every production wafer.

Using these measured values and assuming the recommended worst case junction temperature of 155ºC = 428º K:

$$MTBF \;=\; A\cdot e^{\left(\frac{E_a}{kT}\right)} \;=\; 3.71\,\mathrm{x}\,10^{-12}\cdot \mathrm{e}^{\left(\frac{1.5}{8.617\,\mathrm{x}\,10^{-5}\cdot 428}\right)} \;=\; 1{,}709{,}350 \quad (\mathrm{hrs})$$

$$1.7\,million \quad (hrs) \;=\; \frac{1\ (year)}{24\cdot 365\ \ (hrs)} \;=\; 195\ \ (years)$$