Data Retention Performance of 0.5 µm FRAM Products

RAMTRON

Authors: Shan Sun, Bob Sommervold, Terri Culbreth, Tom Davenport

OVERVIEW

This document supports the change in the data retention specification from 10 years to 45 years at 85°C. The approved change is based on an activation energy of 1.5 eV and cumulative Quality Assurance Monitor (QAM) data for 0.5 µm process 5V 2T2C and 5V 1T1C parts. It has been confirmed that this activation energy can also be used for 0.5 µm process 3V 2T2C products. The specification applies to all 0.5 µm process 5V 2T2C, 5V 1T1C FRAM products, and 3V 2T2C serial FRAM products.

RETENTION LIFE TIME PREDICTION

5V 2T2C and 5V 1T1C Products

From September 2002 to March 2004, a large number (32,145) of 5V 2T2C and 1T1C parts were tested in accordance with the Ramtron quality assurance monitoring (QAM) procedure. In the QAM flow, parts were baked at 175°C for 23 hours and then read at room temperature. There were 22 parts that contributed to the failure rate calculation as an output of the cumulative data from the QAM procedure. Based on this failure rate and an activation energy of 1.5 eV, the retention life times at various temperatures are calculated. The results are shown by open circles in Figure 1. The data conservatively predicts the data retention lifetime is 45.9 years at 85°C. Note that this curve is based on highly accelerated tests (bake at 175°C).

The validity of the prediction curve was substantiated by tests run without thermal acceleration. Two lots of 328 parts total (FM25640, 5V, 2T2C) were baked at 125°C for 10,000 hours and tested at 125°C. Zero failures were observed. The actual retention time of at least 10,000 hours with zero failure at 125°C surpassed the predicted retention time of 3032 hours shown on the prediction curve. The 10,000 hour data point is shown by the square shape in Figure 1.

The validity of the prediction curve was substantiated by tests run with less acceleration, i.e. baked parts at 175°C and test at 125°C and 105°C. Three different process lots with 239 parts total (FM25640, 5V, 2T2C) were baked at 175°C for 3000 hours and tested at 125°C. Only two data points representing lifetime limits were observed. Based on this result and the activation energy of 1.5 eV, the predicted retention time at 125°C is 45 years with a failure rate of 33 FIT with 60% confidence. Another three lots with 100 parts (FM25640, 5V, 2T2C) from each were baked at 175°C for 2982 hours and tested at 105°C. Only one data point representing a lifetime limit was detected. Based on this data and the activation energy of 1.5 eV, the predicted retention time is 454 years at 105°C with a failure rate of 2 FIT with 60% confidence. The results are shown in Figure 1 as the diamond shapes. In summary, the results of testing 5V 2T2C devices with little or no acceleration indicate a lower failure rate than that predicted by the highly accelerated prediction curve.

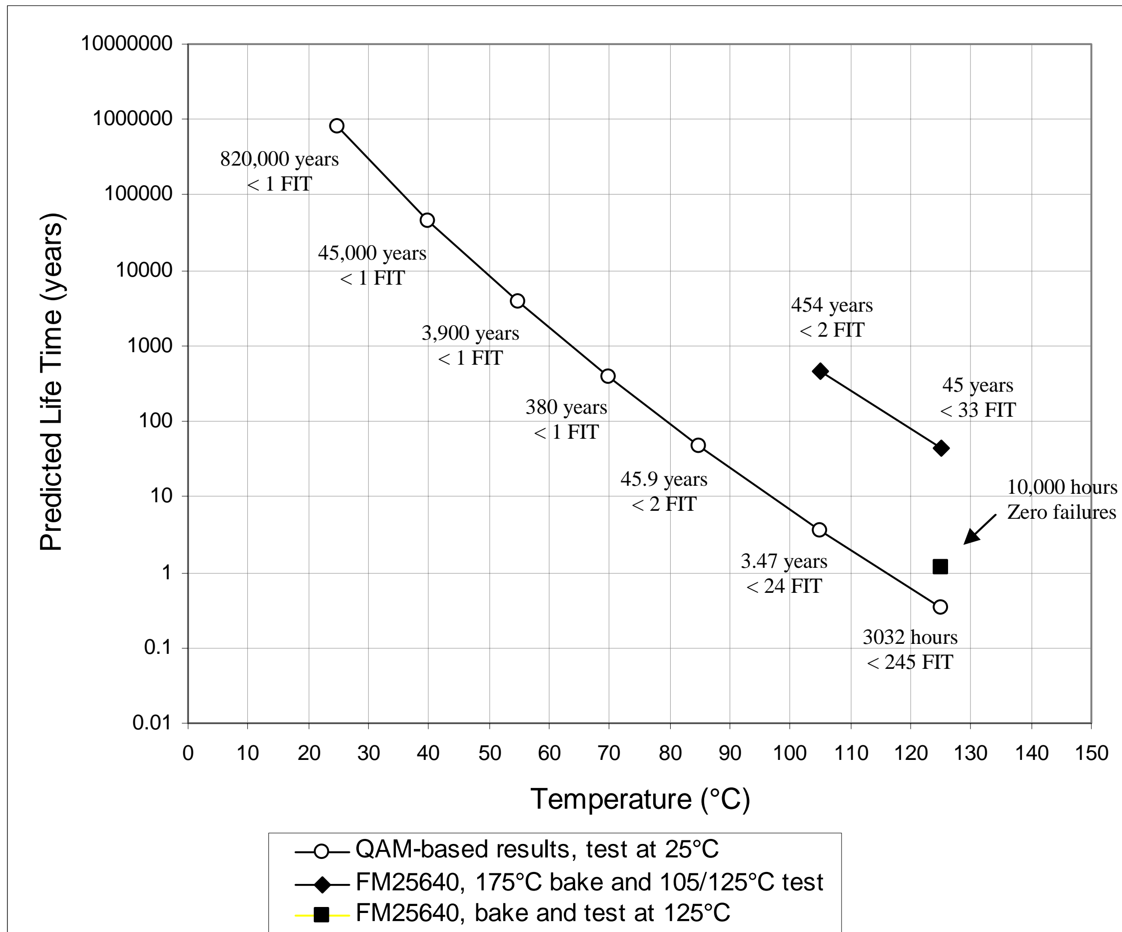

Figure 1. 5V 2T2C and 5V 1T1C Data Retention Prediction based on E_A = 1.5 eV (60% C.I.)

3V 2T2C Products

From August 2002 to January 2004, a large number (11,229) of 3V 2T2C parts were tested in accordance with the Ramtron QAM procedure. There were 19 parts that provided lifetime limit information from the QAM results. Based on this data and an activation energy of 1.5 eV, the retention lifetimes at various temperatures are predicted by the open circles in Figure 2. The retention lifetime is same as that for 5V parts but the FIT number for 3V parts are higher than 5V parts at the same temperature, due to the error associated with the smaller sample size.

In a similar fashion to the prediction for 5V parts, the validity of the 3V prediction curve was substantiated by tests run without thermal acceleration. Four lots of 1315 parts in total (FM25CL64, 3V, 2T2C) were baked at 125°C for 10,000 hours and tested at 125°C. Zero failures were observed. The result is shown by the square shape in Figure 2.

The validity of the prediction curve was also substantiated by tests with less acceleration, i.e. baked parts at 150°C and test at 105°C. Two lots with 50 parts (FM25CL64, 3V, 2T2C) in each were baked at 150°C for 2000 hours and tested at 105°C. Only one data point representing the lifetime limit was found. Based on this data and E_A of 1.5 eV, the predicted retention time is 30.6 years at 105°C with a failure rate of 75 FIT with 60% confidence, shown by the diamond shape in Figure 2. The failure rate of 75 FIT is due to the small sample size. In summary, the results from testing 3V 2T2C devices with little or no acceleration are above the highly accelerated prediction curve.

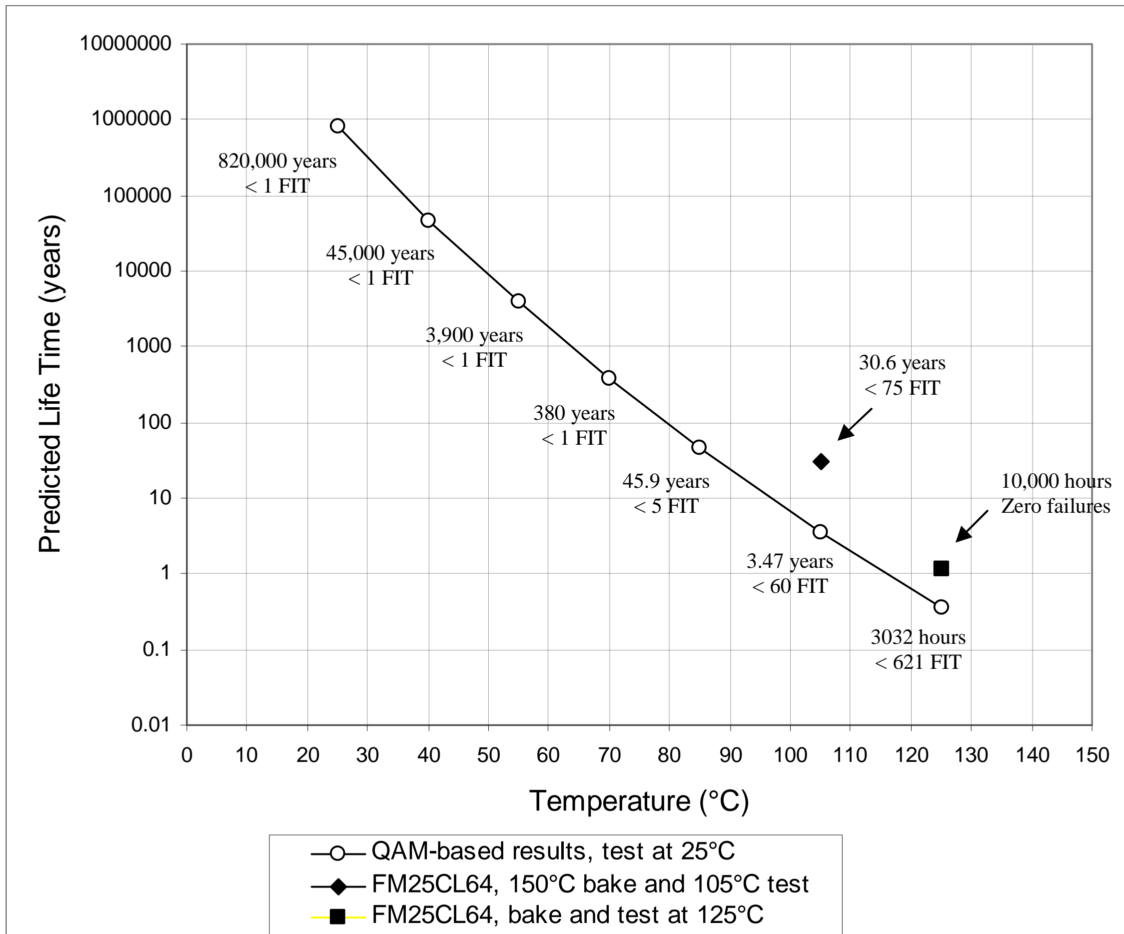

Figure 2. 3V 2T2C Data Retention Prediction based on E_A = 1.5 eV (60% C.I.)

CONCLUSION

Based on the activation energy and QAM results, a retention time prediction curve was generated. The validity of the curve is confirmed by experiments with little or no thermal acceleration. We therefore more accurately represent the data retention specification changing from 10 years to 45 years at 85°C. The change covers all 0.5 µm Fujitsu process 5V 2T2C, 5V 1T1C, and 3V 2T2C serial FRAM products.