SP Industrial NAND Flash Products Data Retention

Introduction

NAND Flash technology is subject to physical degradation that can eventually lead to device failure. There are two end-of-life parameters to specify the performance of NAND Flash products: Program/Erase endurance and data retention. This application note provides a perspective on NAND Flash technology reliability testing methodology and discusses the influence of key factors in terms of data retention.

Industrial Standard

JEDEC standard JESD22-A117 indicates that over-stressing a NAND Flash product during reliability evaluation will impact the data retention after Program/Erase cycling.

- Refers to KIOXIA/WD reliability tests for BiCS technology to implement SP Industrial SSD Data Retention

Test Items	Conditions	Preferred Standards
Write/Erase Endurance	Tc= 85 degree Celsius, 3k Cycles	JEDEC JESD22-A117
Data Retention	Tc=85 degree Celsius, 83 hours Equivalent to 1 year at 40 degrees Celsius Assumption activation energy (Ea)=1.0eV	KIOXIA standard

- Reliability test result of Data Retention(reference: KIOXIA/WD NAND Flash Reliability report)

Device Type	Pre-condition	Conditions	Sample Size	Number of Failures
BiCS Technology NAND Flash	Tc= 85 degree Celsius, 3k Cycles	Tc=85 degree Celsius, 83 hours	40	0
Failure Criteria: NAND Flash is defined as a failure if physical random data that is randomly programmed per cycle is uncorrectable with 120-bit ECC per 1024 bytes and the applicable read retry sequences.				

Factors affecting data retention after program/erase cycling

Data retention is determined by three main parameters:

- System Field Temperature (Program/Erase Cycling and Data Storage)
  - 40 degree Celsius is common assumption
- Total number of Program/Erase Cycles
  - 300 PE cycles (10%)
  - 3,000PE cycles (100%)
- Cycling Interval Time:
  - 3K PE cycles over 3 years at 40 degree Celsius, Average Interval time= 3 yearsx365x24x3600=31,536 seconds

These factors can significantly impact the retention lifetime after Program/Erase cycling. To ensure that the reliability design of the product is suitable for a particular customer application, a good understanding of these parameters is essential.

Arrhenius equation

Temperature is a significant modifier for endurance and data retention. Most of the time, a continuous high or low temperature is not typical for most applications. There is always a distribution of use at different temperatures. However, an average use temperature can be calculated from a complex temperature profile through the Arrhenius equation.

Higher temperatures increase the impact to the average field temperature. Lower storage temperatures can increase retention lifetime.

$$At = \exp\left[\left(\frac{Ea}{kb}\right)\times\left(\frac{1}{T_{field}} - \frac{1}{T_{reference}}\right)\right]$$

$$Lifetime_{FieldTemp} = At \times \left(Lifetime_{55°C}\right)$$

At: Acceleration temperature factor

Ea: MB activation energy: 1.0eV,(KIOXIA BiCS Technology)

kb: Boltzmann constant= 8.62 1E-5 eV/K,

Data Retention of SP Industrial Flash products

SP Industrial flash products implemented with high quality NAND Flash chips to make sure to meet data retention specifications.

- Data Retention: 10 Years @ Life Begin / 1 Year @ Life End at 40 degree Celsius

During the NPI process SP Industrial flash products are implemented with Data Retention test under 85 degree Celsius 83 hours condition and verify data integrity via H2 program without any error to make sure to meet specification

Used case for special application requirement

Customer would like to request special application requirement as below:

- Data Retention: 1 Year @ 10% PE cycles at 70 degree Celsius

Based on the Arrhenius equation, the test condition will be changed to 125 degrees Celsius for 83 hours to make sure if it meets the requirement or not.

Ea	Ea/K	Td (°C)	Ts (°C)	AFT	Lstress (Hr)	Lnormal (Hr)	Lnormal (Days)	Lnormal (Months)	Lnormal (Years)
1.0	11,600.92807	40	85	105.51372	83	8,758	365	12	1.014
1.0	11,600.92807	70	125	107.11331	83	8,890	370	12	1.029