SMART®
Modular Technologies

Technical Brief

Enterprise Memory (Burn-In Process)

Introduction

Burn-in is the process by which Enterprise Memory modules are exercised prior to being placed into the field. Burn-in identifies and forces failure so weak module components are replaced, or that the entire part is replaced. Replacing weak components and/or modules will prevent premature failure, early life mortality failure, or other latent defects which can occur in customer applications.

Primary failure types are outlined below:

1. **Immediate failures:** During system startup and testing, failures are removed, which reduces production and administrative delays.
2. **Functional failures:** Burn-in memory can successfully perform multiple applications, simultaneously, while non burn-in memory can be prone to computational delays. Those failures and delays are reduced, which improves operational efficiency of the systems.
3. **Field Failures:** Most importantly, reduction of field failures, over the life of the system, diminishes costs and enhances every member's reputation across the supply chain.

All memory modules can be made to fail through a sufficiently stringent burn-in process. The key is to establish a proper balance between exercising maximum component thresholds versus how modules are used during normal operating conditions over their service life. The duration of the burn-in test process is important as it needs to be long enough to stress the system and confidently assure manufacturers and customers that every identifiable flaw has been found. By putting these modules through this stress, there should be no problems during deployment.

Burn-In modules are tested in server motherboards at rated speeds, exercising a node for billions of operations to provoke weaknesses. SMART uses temperature and time to achieve maximum burn-in effectiveness. Custom thermal chambers provide high temperature conditions. Burn-in time is adjusted, depending on the density of the module being tested.

- Chart 1, below, shows 31 modules that failed during burn-in. According to the chart, the last failure occurred within 600 minutes. A single bit error counts as a failure. The remaining passing modules may be run days longer to confirm there are no more failures after 10 hours.

Chart 1: DIMM Failures over Time

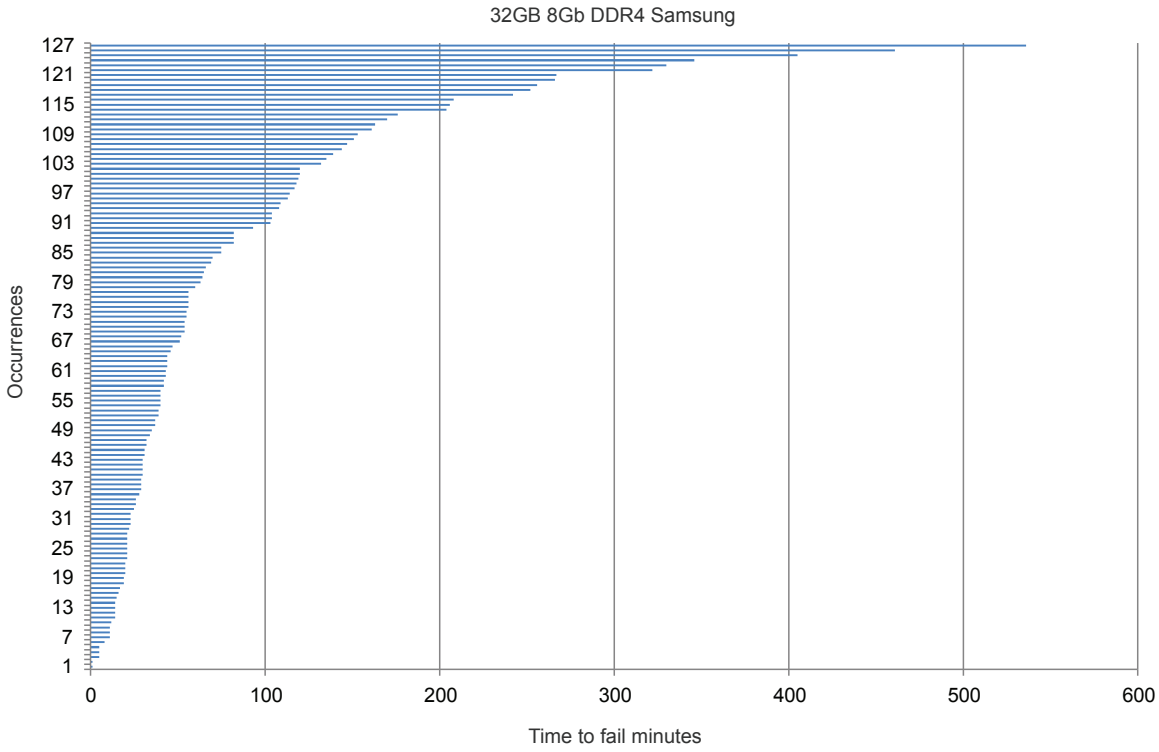
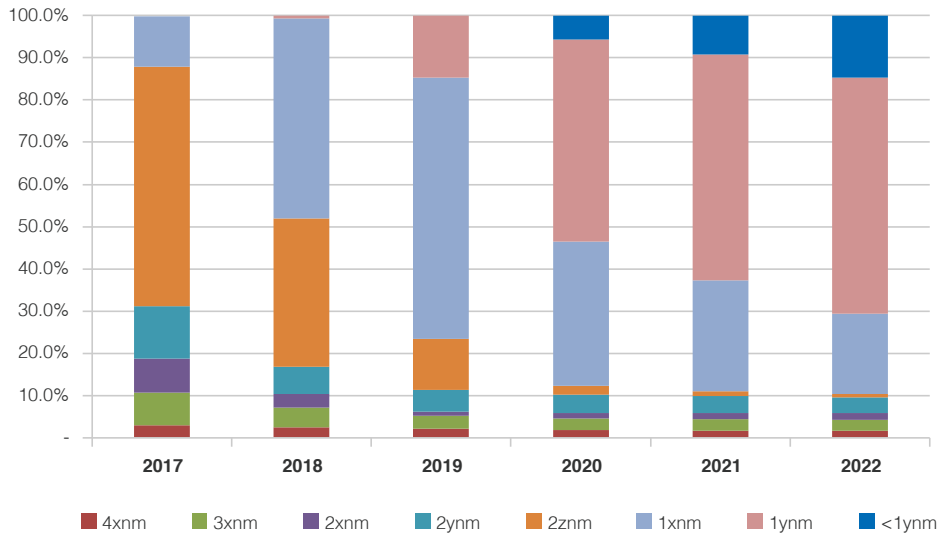


Chart 2: DRAM Process Migration Summary



According to the chart, SMART uses data collected from thousands of modules from multiple DRAM suppliers to ensure a valid statistical profile.

Improving profit and performance, with elements such as shrink, are continuous factors in the DRAM process. Constant scaling, like shrinks, present production challenges. The types and percentages of burn-in fallout is an excellent indicator of how these challenges have been addressed. According to the chart,

SMART burn-in removes modules that exhibit no boot, hangs, unrecognized memory, reboots, and correctable and uncorrectable ECC. Analysis of fallout by vendors is categorized into different types of failure. The percentage decrease can be a window into their improvements. A typical fallout breakdown is shown in Chart 3.

In a typical work order which might be 500 modules, Chart 4 below shows 200 – 3K DPPM. These are more than six modules that don't show up at a customer's doorstep.

Fallout are those modules that do not ship to the customer. Field failures are those returned from a contract manufacturer or the end user. Returns go through failure analysis at SMART and are used to strengthen the burn-in procedure and to calculate ongoing DPPM. The test history of every module has been previously stored at module creation. Generally the lower the DPPM at the contract manufacturer, the lower the chances for and end-customer field failure.

Chart 3: Types of Fallout

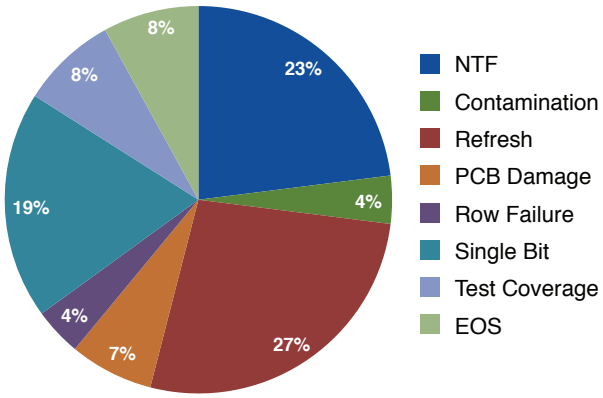
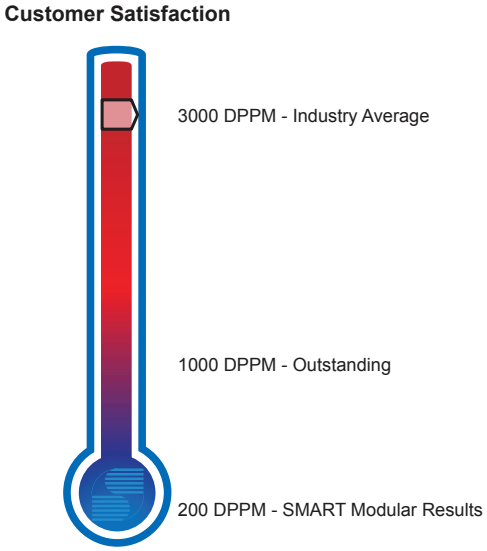


Chart 4: DPPM Fallout Removal



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The SMART failure analysis closely matches customers' reports, and to a lesser extent to the vendor, since SMART's testing is more stringent.

Frequently asked:

Customers ask if there is a way to correlate burn-in ECC results and the occurrences of correctable ECC errors over time? This is usually to establish an acceptable system limit of correctable ECC errors vs time. Some data shows ECC capture quantity does relate to ECC occurrences, but over the life of the module, this could increase. During SMART burn-in, if a single ECC shows up, SMART does not allow that module to ship.

Burn-in memory saves customers money, time, effort, and enhances their reputation with their own customers. By jointly monitoring fallout and field failure data, SMART was able to confirm a $13 million savings for one customer, as an example. Over a shipment of 141,000 modules, field failures were reduced from 2,834 to 226. The cost of a single service call can cost as much as $5,000, based on the combination of field technicians, data center downtime, material costs, and other elements needed for maintaining normal operations.

Booting a 96 module, 64GB LRDIMM a server can be daunting. Days of system testing might have to be restarted, and burn-in modules alleviates this pain.

Conclusion

SMART's overall, comprehensive burn-in process uses customized motherboards, normally based on Intel® Server CPUs, because they are the pervasive industry standard. All burn-in modules have a label with serial numbers and the build and test history of the module is tracked using label serial numbers and SPD serial numbers. The SPD serial number, in this procedure, is particularly useful for remote tracking.

Customers are encouraged to continue sending burn-in failures to SMART because failure analysis during the manufacturing life cycle of the end application identifies anomalies and improvements to the burn-in process for Enterprise Memory.

As part of burn-in, SMART provides additional services as a custom memory manufacturer. These services include manufacturing test history, field traceability, and continuing failure analysis Serialization is the term used for combined manufacturing test history and field traceability. From product birth, SMART tracks its modules for every phase of its modules. System level tests and burn-in are part of this process. In the failure analysis phase, SMART will work with engineers on trial runs and engineering samples to provide the most error-free modules possible.

SMART's focus is to provide OEM customers with the highest quality, most reliable Enterprise Memory modules, all while supporting the latest technologies available in the industry. Burn-in clearly addresses these objectives. SMART is delivering the industry's highest quality DDR3 and DDR4 Enterprise Memory modules and is planning to do the same for DDR5 to provide the highest value to customers.

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For more information, please visit: **www.smartm.com**

Headquarters/North America:
T: (+1) 800-956-7627 • T: (+1) 510-623-1231
F: (+1) 510-623-1434 • E: info@smartm.com

Latin America:
T: (+55) 11 4417-7200 • E: sales.br@smartm.com

Asia/Pacific:
T: (+65) 6678-7670 • E: sales.asia@smartm.com

EMEA:
T: (+44) 0 7826-064-745 • E: sales.euro@smartm.com

Customer Service:
T: (+1) 510-623-1231 • E: customers@smartm.com