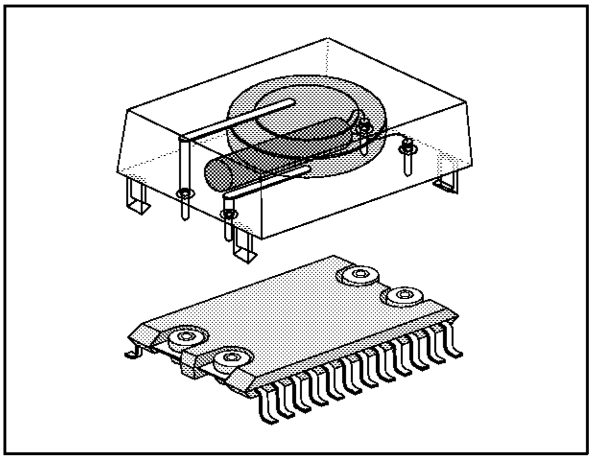
SGS-THOMSON MICROELECTRONICS

QUALIFICATION REPORT

ZEROPOWER and TIMEKEEPER SRAM SURFACE MOUNTED SNAPHAT PACKAGE

INTRODUCTION



Since their introduction 10 years ago by SGS-THOMSON, ZEROPOWER RAMs, self contained battery backed-up static memories, have offered the system designer a non-volatile memory with excellent performance characteristics. To date, though, all battery-based non-volatile SRAMs have been offered in some form of a 600 mil dual-in-line package. The non-volatile technology has not evolved into surface mount configurations for the primary reason that the energy cell cannot survive the ultra high temperatures needed for solder re-flow. The new SNAPHAT™ package from SGS-THOMSON overcomes this obstacle and offers the industry's first integrated battery backed SRAM that can be surface mounted. This revolutionary surface mount design combines the company's patented monolithic memory and battery control circuitry with a unique battery housing and small outline package to form a highly compact SMT solution.

The SNAPHAT package consists of two parts: a JEDEC standard 330 mil Small Ouline package (SO) and the attachable battery housing. The SO package has two conventional press fitted sockets at both ends. Once the SO and other surface mount components are attached to the printed circuit board the battery housing, with its four interconnect pins mechanically, locks to the SO package to provide energy backup in the event of system power loss.

SGS-THOMSON designed the SNAPHAT package with long term reliability in mind. Critical contact points at the socket and battery package pins are gold plated to resist oxidation. Internally, each socket contains six independent contact fingers to form redundant connections between the two components. These sockets were designed to provide high point contact force to scrape away potential contamination from the users assembly process. Furthermore, the battery package has two flexible snaps at both ends to firmly secure the housing to the SO package.

In addition to the ZEROPOWER® RAM, a TIMEKEEPER™ RAM, which incorporates a built-in real time clock, is also offered in the SNAPHAT package. This device includes a crystal in the attachable housing which allows the timekeeping function to continue in the absence of system power. When assembled, the SNAPHAT ZEROPOWER RAM and TIMEKEEPER RAM offer a non-volatile memory and real time clock solution with the smallest footprint and form factor on the market today.

Director of
Memory Products Group
Quality Control & Reliability

QUALIFICATION TEST PLAN

The qualification strategy included stressing the SNAPHAT housing and SO package separately as well as assembled in module form. This allowed evaluation of all possible failure modes. The test vehicle was chosen to be the M48T08. Each component has different reliability and manufacturing concerns that were addressed in qualification. These are summarized in Table 1.

Based on this analysis, the qualification test plan, described in Table 2, 3 and 4, was used to qualify the ZEROPOWER SNAPHAT package. Specific details of the test methods are in the chapter ”Description of Qualification Tests”. Samples for stress were taken from 4 backend production lots and were divided equally between the stresses. The results of the stressing are described in the chapter ”Qualification Test Results”.

Table 1. Reliability Concerns Failure versus Stress Matrix

Component and Potential Failure Mechanism	Stress Used to Verify Reliability
SO Package	
”POPCORN” Failures	Resistance to Surface Mount
Bonding Failures	Temperature Cycling: –40°C to 125°C
Moisture Induced Failures	Autoclave and HAST
Female Pin Corrosion	Autoclave and HAST
SNAPHAT Housing	
Battery and Crystal Welds	100°C, 125°C, 140°C Storage, Temperature Cycle Welding Characterization, Pull Strengths
Poor Battery Lifetime	100°C, 125°C, 140°C Storage, Temperature Cycle
Male Pin Plating Peeling, Cracking	100°C, 125°C, 140°C Storage, Temperature Cycle
Module - SO and SNAPHAT	
Operational Life Failures	Accelerated Life at 125°C
Moisture Induced Failures	Temperature and Humidity
Loss of Memory with Vcc = 0	85°C Storage, Temperature Cycle, both with Patterns
Male/Female Pin Corrosion	Temperature and Humidity, Post Stress Visual Inspection

Table 2. Qualification Test Plan - Module

Stress	Condition	Duration	Samples
Temperature & Humidity	T_A = 85°C, R.H. = 85%, Vcc = 5.5V	959 hrs	70
Temperature Cycling	–40°C to 125°C	1000 cycles	78
High Temperature Storage with Patterns	T_A = 85°C	1000 hrs	78

Table 3. Qualification Test Plan - SO Package

Stress	Condition	Duration	Samples
Operational Life	Vcc = 7V, T_A = 125°C	1000 hrs	276
HAST	T_A = 131°C, R.H. = 85%, Vcc = 5.5 V	196 hrs	44
Autoclave	T_A = 121°C, R.H. = 100%, Unbiased	240 hrs	45
Temperature Cycling	–40°C to 125°C	1000 cycles	102
Resistance to Surface Mounting	See "Description of Qualification Tests"		10

Table 4. Qualification Test Plan - SNAPHAT Housing

Stress	Condition	Duration	Samples
High Temperature Storage	100°C	OCV –3 Sigma < 2.0 Volts	98
High Temperature Storage	125°C	OCV –3 Sigma < 2.0 Volts	98
High Temperature Storage	140°C	OCV –3 Sigma < 2.0 Volts	98

DESCRIPTION of QUALIFICATION TEST

The qualification devices for this program were sampled from four separate assembly lots. All samples were processed through the standard production flow including Final Test as described in Table 2, 3 and 4. These units were subjected to the reliability tests described as follows.

High Temperature Operational Life

High Temperature Operating Life (H.T.O.L) testing was performed to accelerate failure mechanisms which are thermally activated through the application of extreme temperatures and biased operating conditions. H.T.O.L. testing was performed at 125°C and 7.0 volts. The high voltage stress increases electric field strength across the gate and interlevel oxides well beyond the level any device will encounter during application, thereby providing maximum acceleration for potential dielectric breakdown failures. This stress also increases the active currents and power dissipation, thereby increasing the acceleration for electromigration failures. The devices were exercised by sequentially addressing all cells in the memory array and alternately writing and reading complementing data.

Temperature and Humidity Biased Test

Temperature Humidity Bias (T.H.B.) testing was performed to assess the moisture resistance of plastic encapsulated devices. Failure mechanisms expected are primarily corrosion of the external leads and connections, and the aluminum traces within the IC's. The test samples were stressed at 85°C and 85% RH and statically biased to achieve minimum power dissipation and junction heating. Input pins were alternately biased to V_{CC} and V_{SS} in order to maximize the number of biased gaps and accelerate electrolytic corrosion of the metallization. This stress was performed for 959 hours. Extreme care was taken to prevent dryout of the packages during the period when the devices were removed from stress for the electrical readouts by storing them in a 25°C, 85% RH wet-box. The initial and final electrical tests were performed at 70°C; however, all interim tests were performed at 25°C to prevent baking the moisture out of the devices during test.

Temperature Cycling

Temperature cycle testing accelerates the effects of the thermal expansion coefficient mismatch among the different components within any given die and packaging system. This stress was performed in accordance with MIL-STD-883C, Method 1010. Qualification components were stressed from –40°C to 125°C for a minimum of 1000 cycles. Modules were tested with a ”final pattern” written into the memory array. As readpoints was occurred, the memory was read to see if this pattern remained in the memory. Failure to read the proper data is cause for stress failure.

High Temperature Storage - SNAPHAT

This stress accelerates the evaporation of the liquid electrolyte within the battery as indicated by the decreasing battery voltage over time. Three temperatures 140°C, 125°C, 100°C will be used to determine an acceleration factor for the evaporation. The resultant data will be compared to historical values when stressing is completed later in 1994. The effects of high temperature stressing on the physical joints through aging and expansion of dissimilar materials will also be assessed.

High Temperature Storage with Patterns - Module

To determine the modules ability to retain patterns at high storage temperatures a test pattern was written into the memory of a completed SNAPHAT module. V_{CC} was then removed and the unbiased units were stored in an 85°C oven. The first test at each readpoint is the verification of this pattern, and a failure is revealed if it is corrupted or missing.

Resistance to Surface Mounting

The effects of surface mounting the SO package were determined by using a series of preconditions, stresses, and evaluations. The flow is listed in Table 5. Devices were baked dry, then exposed to 10 cycles of –40°C to 60°C temperature cycle which stresses the leadframe-to-plastic interface in order to later maximize moisture uptake. The units were then put into an 85°C, 35% relative humidity chamber for 168 hours which gave the units a moisture content of approximately 1400 PPM by weight. This was immediately followed by exposure to an infrared radiation source which produced a maximum body temperature of 215°C as measured with a thermocouple. Post stress testing included 30x external visual inspection for cracks, electrical test for die cracks, and internal cross-sectioning for diepad-to-leadframe cracks.

Table 5. Resistance to Surface Mounting Stress Flow

Stress	Condition	Duration
Storage	125°C	24 hrs
Temperature Cycling	–40°C to 60°C	10 cycles
Moisture Exposure	85°C, R.H. = 35%	168 hrs
Infrared Exposure	215°C Max	45 sec
Visual Inspection	External for Cracks	-
Electrical Test	Final Test	-
Cross Section	Internal for Cracks	-

QUALIFICATION TEST RESULTS

This section contains the results of the stressing as described in chapter "Qualification Test Plan". Four backend lots were assembled and submitted for reliability testing. The stresses used, along with the results at each readpoint, have been compiled in the tables below.

Module Stressing Results

Biased Temperature and Humidity stressing produced no failures through 2000 hours of stress. A sample of units were deprocessed at this readpoint for evidence of internal metal corrosion and gold contact deterioration including cracking, peeling, and corrosion. No degradation of any kind was detected.

Also on Temperature Cycling and 85°C storage with patterns, no data corruption failures occurred indicating the SNAPHAT housing to SO package connections remained intact throughout the stress. Post stress inspection of both the male and female connection pieces after 1000 cycles indicate no corrosion or other physical deformation.

SNAPHAT Housing Stressing Results

The 100°C, 125°C, and 140°C high temperature storage tests have exhibited battery lifetimes comparable to the standard CAPHAT™ package. Stressing will continue until battery end of life which is expected to be later in 1994. Brand Permanency, Physical Dimension, and X-ray all indicated good construction and dimensional characteristics.

Table 6. Qualification Tests Results - Module

Stress	Readpoint	Samples	Failures	Notes
Temperature & Humidity: 959 hours	548 hrs 959 hrs 1500 hrs	70 70 70	0 0 0	
Temperature Cycling: –40°C to 125°C with Stored Patterns	100 cycles 300 cycles 1000 cycles 2000 cycles	77 77 77 77	0 0 0 0	
Storage with Stored Patterns: 85°C	168 hrs 500 hrs 1000 hrs	78 78 78	0 0 0	

Table 7. Qualification Tests Results - SNAPHAT

Stress	Readpoint	Samples	Failures	Notes
High Temperature Storage: 140°C	1000 hrs	98	mean –3 Sigma < 2.0 Volts	1
High Temperature Storage: 125°C	1500 hrs	98	mean –3 Sigma < 2.0 Volts	1
High Temperature Storage: 100°C	2000 hrs	98	0	1
Brand Permanency	-	16	0	
Physical Dimension	-	5	0	
X-Ray	-	20	0	

Note: 1. Readpoint indicates last time units did not fail failure criteria.

QUALIFICATION TEST RESULTS (cont'd)

SO Stressing Results

Operational Life stressing did not produce failures. The M48T08 device used in this qualification is a mature, well documented product. The technology to manufacture this die was not the focus of this qualification. However interactions with the minor process changes from standard SO package manufacturing and the die were examined.

The temperature cycle test performed on the SO samples increased the sample size for this stress and allowed the measurement of parameters not tested in the module form such as Battery Current (I_{BAT}). No failures occurred in this stress.

HAST and Autoclave were the critical tests to understand if the gold plated connectors would corrode and how resistant to moisture the package and die would be. Post stress, 30x examination of the female pins, which are attached to the SO package, resulted in neither corrosion, cracking, nor peeling of the gold plating.

With the determination of no electrical failures during stress and no evidence of post stress corrosion, the connection and package system chosen have been established to be very reliable.

In addition to qualification testing, a Failure Mode and Effects Analysis (FMEA) was documented. A process FMEA is used as a means to assure that, to the extent possible, potential manufacturing concerns have been considered and addressed. In its most rigorous form, an FMEA is a summary of the developement of a process. This includes an analysis of experiences and past concerns relations to potential failures. It then develops a list of potential failure modes ranked according to their effects on the final product, thus establishing a priority system for corrective action considerations. The FMEA is then reviewed and the risk factors reassessed as the corrective actions and controls are implemented and the process matures. Results of this FMEA can be obtained by contacting SGS-THOMSON.

Table 8. Qualification Tests Results - SO

Stress	Readpoint	Samples	Failures	Notes
Operational Life: Vcc = 7V, T_A = 125°C	168 hrs 500 hrs 1000 hrs	276 276 276	0 0 0	
Temperature Cycling: –40°C to 125°C	300 hrs 600 hrs 1000 hrs 1300 hrs	102 102 102 102	0 0 0 0	
HAST	92 hrs 196 hrs	44 44	0 0	
Autoclave	96 hrs 240 hrs	45 45	0 0	
Resistance to Surface mounting	215C IR Reflow after T & H soak	10	0	

FAILURE RATE CALCULATIONS

While adequate models for derating the accelerated test data for the various environmental stresses (T.H.B., Temperature Cycle, HAST) to actual use conditions are not available, the SO package 125°C Operating Life Test data has been derated to 55°C as shown below:

Test	Number Tested	Stress Device-hrs	0.7eV Equiv. 55°C Device-hrs	# Fail	Failure Rate
Operational Life	276	276,000	21.3M	0	< 1 FIT

The stress hours were derated from 125°C to 55°C using the Arrhenius Model by assuming a 0.7 eV activation energy. This gives an estimated device failure rate at 55°C (Tj) of <1 FITS assuming:

a. Arrhenius temperature acceleration of device hours from 125°C to 55°C = 77.4 for 0.7eV .

b. Voltage Acceleration from Vcc = 7V to 5.5V = 90 using the Berman model for the oxide failures.

c. Chi-Squared Failure Distribution, 60% UCL

SUMMARY and CONCLUSIONS

After reviewing all of the qualification data, manufacturing support documentation, and corrective actions that are currently in place, the Surface Mount ZEROPOWER Package has been released to manufacturing.

During the first 3 months of production, this product will be sampled monthly by the SGS-THOMSON Product Monitoring Program in order to assure continual product quality. Samples will then be reviewed quarterly. The data will be published in the quarterly PMP Report published by the Carrollton Quality and Reliability group.

Table 10. Assembly & Test Technical Description

ASSEMBLY

SO PACKAGE

Small Outline Package Type:	28 Pin (MH) 330 mil SO Package (JEDEC MO-059)	
Assembly Location:	Carrollton, Texas	
Female pins:	Shell finish:	200-400 microinches Tin over 100-150 microinches Nickel
	Contact finish:	30-35 microinches Gold over 50-100 microinches Nickel
Die Attach Adhesive:	Ablestik 84-1 LMIS R4 Epoxy	
Leadframe:	Copper with spot silver, Pad Size: 260 mils x 460 mils	
Wire Bonding:	1.0 mil Gold Thermosonic Bonding	
Molding Compound:	Sumikon EME 6300HG	
Cure Conditions:	175°C, 6 hours	
Lead Finish:	Solder-plate, 85% tin, 15% lead	

SNAPHAT HOUSING

Shell:	General Electric Valox 420 SEO Thermoplastic
Encapsulant:	Hysol XES-0491
Male pins:	Brass Alloy 360, 1/2 hard with a plating finish of 30-35 microinches of Gold over and 50-100 microinches of Nickel.

TEST

Test & Finishing Location: Carrollton, Texas

SO PACKAGE

Preburn:	100% 80°C AC-DC-Functional Test, Teradyne 386
Burn-in:	24 hours, 125°C Vcc = 7V
Final Test 1:	100% 80°C AC-DC-Functional Test, Teradyne 386
Final Test 2:	100% 25°C AC-DC-Functional Test, Teradyne 386
Final QA Electrical:	0.1% AQL; n=125, c=0 per lot 25°C, AC-DC-Functional Test
Final QA Visual:	0.25% AQL; n=50, c=0 per lot

SNAPHAT HOUSING

Final Test :	Battery Voltage and Crystal impedance, 80°C, PC based tester using Lab View software.