♦ RELIABILITY

Reliability demonstration testing is an empirical measurement of time-to-failure during equipment operation. The purpose is to demonstrate to the customer with a certain degree of statistical confidence that the equipment design is capable of meeting the stated reliability requirement. This requirement is usually stated in terms of mean time between failure (MTBF). Reliability demonstration testing is a statistically based sample test.

The United States Military Standard (MIL-STD-883) is SEI's guideline for test methods and procedures. The test items which are not described in MIL-STD-883 are performed in accordance with the Japanese Industrial Standard C-7022 and the Standards of the Electrical Industrial Association of Japan IC-121.

All of the test items shown in Table 4 are applied for newly developed IC's before mass-production. The static burn-in test is conducted to confirm the sufficiency of the steady state operating lifetime, being normally performed at higher temperatures than actual operating conditions, which depends on the IC's; the ambient temperature (T_a) of 200 °C or the junction temperature (Tj) of 175 °C is typically employed. SEI has taken great efforts to establish and to maintain the life time of GaAs devices. In conclusion, SEI's devices were confirmed to possess the typical mean time to failure (MTTF) of 1 million hours at Tj of 150 °C. Furthermore, SEI is shipping all GaAs devices for testing to guarantee the MTTF of 100 thousand hours at Tj of 150 °C.

The static burn-in screening test is applied to all packaged IC's without chip-shipping to efficiently prevent early life failures in the field. The static burn-in screening test duration depends on the IC's; it is typically applied from 48 to 168 hours.

Reliability Qualification Level

A reliability demonstration test is effectively a sampling test. It improves a sampling of objects selected from a population. In reliability demonstration testing, the population encompasses all failures that will occur during the life-span of the device. Thus a test sample consists of a number of times-to-failure, and the population is all the times-to-failure that could occur with one or more devices under test. Assuming an exponential failure model, a test of 10 devices for 100 hours each is mathematically equivalent to a test of 1 device for 1000 hours. As in any sampling test, the sample is assumed to be representative of the population, and the mean value of the various elements of the sample is assumed to be a measure of the true mean of the population. Statistical sampling plans are concerned with the sample size upon which to base a decision as to whether the population is good or bad, and defining the acceptable number of failures per sample.

SEI's activities are focused on minimizing failure rates and obtaining high reliability by

Table 1-7-1. Reliability Test Item

No.	Category	Test Items	Standard			Application	
			MIL	JIS	EIAJ	CS/MP	LOT
1	Durability	Steady State Operating Life	⊙	⊙	⊙	⊙	⊙
2		High Humidity Operating Life			⊙	⊙	
3		High Temperature Storage	⊙	⊙	⊙	⊙	⊙
4		Low Temperature Storage		⊙	⊙	⊙	
5		High Humidity Storage*		⊙	⊙	⊙	
6		Autoclare*			⊙	⊙	
7	Heat Environment	Soldering Heat Resistance		⊙	⊙	⊙	
8		Thermal Shock	⊙	⊙	⊙	⊙	
9		Temperature Cycling	⊙	⊙	⊙	⊙	⊙
10		Damp Heat Cycling		⊙	⊙	⊙	
11	Mechanical Environment	Constant Acceleration**	⊙	⊙	⊙	⊙	
12		Vibration	⊙	⊙	⊙	⊙	
13		Mechanical Shock	⊙	⊙	⊙	⊙	
14		Free Tall		⊙	⊙	⊙	
15	General Environment	Electro-Static Discharge	⊙		⊙	⊙	
16		Terminal Strength	⊙	⊙	⊙	⊙	
17		Solder ability	⊙	⊙	⊙	⊙	

(cf.) MIL : Military Standard 883 (MIL-STD-883)
JIS : Japanese Industrial Standard C-7022 (JIS-C-7022)
EIAJ : Standards of Electrical Industrial Association of Japan IC-121 (EIAJ-IC-121)
* : Applied mainly to plastic-molded IC's
** : Applied mainly to hermetic-sealed IC's

feeding such analysis data back into the circuit designs and the GaAs IC manufacturing process. As reliability tests generally load devices with accelerated stress, most of them should be classified into destructive tests. To cope with such a situation, all device tests must be practical, and therefore, sampled device tests are performed, except screening tests, for reducing the rate of early life failure.

When useful life times are determined precisely or when the reliability of new devices are assessed, sampling sizes are at times larger than those as defined in the rules. We have three levels of the products according to their reliability test program :

ES : Engineering Sample (ES) shipment
CS : Commercial Sample (CS) shipment
MP : Reliability qualification for Mass-Production

The ES means the sample which satisfies all specified electrical performance without completing the reliability program. The CS is defined as the product which has completely satisfied all of the reliability program requirements under SEI's authorized rules. After the product is authorized as the CS, it is produced under the control of initial management; the process variation is carefully observed. The objective is to confirm the stable productivity while maintaining the specified quality. SEI regulates that a product is determined to be MP after successful performance under the initial management program for 3 continuous lots with no problems. If any problems have occurred, the production must be reconsidered with a thorough investigation of the cause.

The test durations which are necessary for acceptance judgment are determined individually. The test durations and the sampling plans differ slightly between the products; the standard plans are as shown below. The sampling ratio to the population is basically determined in the Lot Tolerance Failure Rate (LTFR) of typically 10 % with a 90 % confidence; SEI typically defines the "pass" as no failure for 22 pieces sampling. The reliability test item needed for CS authorization is shown in Table 4. The steady state operating lifetime test is normally performed at higher temperatures than actual operating conditions, which depends on the IC's; T_a of 125 °C or 150 °C for the test duration of 1000 hours is typically employed. The high temperature storage test is performed at 150 °C for 1000 hours. The typical temperature cycling test has a regulation of 100 cycles with the temperature range from -65 °C to 150 °C for 30 minutes each.

Lot Assurance

SEI ships all products through the lot assurance test. The objective is to assure the reliability of each lot. The steady state operating lifetime test is normally performed at higher temperatures than actual operating conditions, which depends on the IC's; T_a of 125 °C or

150 °C for the test duration of 168 hours is typically employed. The high temperature storage test is performed at 150 °C for 168 hours. The temperature cycling test has a regulation of 10 cycles with the temperature range from -65 °C to 150 °C for 30 minutes each.

Screening Test

SEI routinely has whole products except bare chip products tested to remove defects introduced at all levels of fabrication for reduction of the early life failure rate. In the static burn-in test there are slight differences in the test conditions between each product. The typical T_a is 125 °C and the duration ranges from 48 to 168 hours.