Quality assurance and reliability

●Quality Assurance Measures

JIS (Japan Industrial Standards) defines reliability to be "the ability for an item to perform a required function under given conditions for a specified time". This can be expressed quantitatively as a failure rate or reliability level. The failure rate of electronic components generally takes the form of a bathtub curve (Fig.1). However, by nature semiconductor devices such as transistors do not experience wear, and therefore the failure rate takes the form of curve B below, with reliability determined by the rate of initial failures and random failures. Initial failures are a manifestation of hidden defects in the manufacturing line.

ROHM endeavors to hold down the rate of initial failures by means of quality control and line control, as well as 100% screening.

Random failures can be regarded as indicative of the characteristic reliability of a product, and are largely affected by the derating level, usage environment, circuit conditions and other usage conditions.

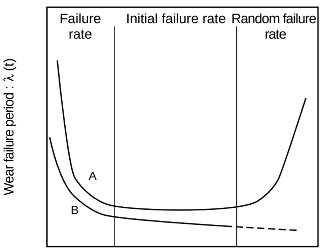


Fig. 1

●Overview of quality assurance measures

(1) Rohm's quality assurance measures are implemented primarily by our Quality Control Department and the quality control groups in each manufacturing department. All members take part in controlling, maintaining, and improving manufacturing lines centering on long and short term themes. In addition, quality assurance is carried out on each line by the members of that line, with the successive line being regarded as their "customer".

(2) Internal standardization is pursued on a company-wide basis, and work is performed strictly according to written standards.

(3) Line performance is determined by statistical process control method and the line managed accordingly.

(4) It is important to eliminate initial failures so that reliability is determined only by the random failure rate. ROHM carries out 100% screening of its products.

(5) Control testing is performed for long term reliability assurance, and measures are carried out to improve understanding of reliability levels.

(6) We require our suppliers to ensure the quality of the materials they deliver. We have each supplier sign a quality assurance contract stating that all materials we purchase must have passed our authorized inspection, with the supplier testing materials based on our standards.

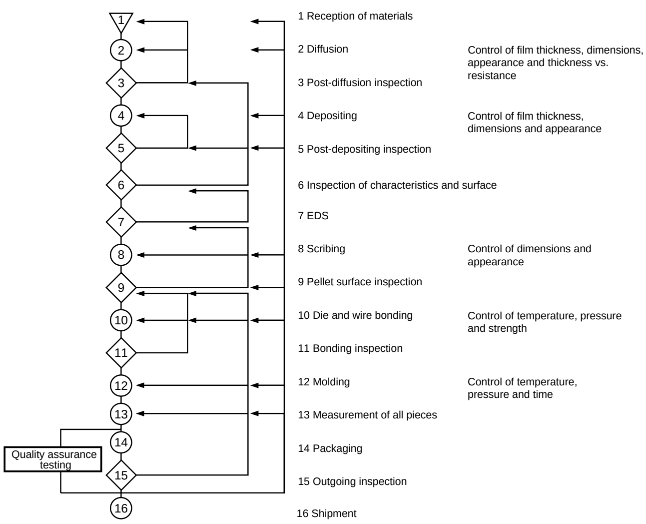


Fig.2

●Overview of manufacturing process

Reliability is one of our primary concerns in manufacturing semiconductor devices. We perform multiple quality authorization tests from the beginning of development through the beginning of mass production, and only bring those products which have passed tests into mass production. After mass production begins, we continue to carry out the aforementioned quality assurance measures.

●Reliability design and process technology

ROHM has made significant advances toward higher reliability in the areas of transistor design, process technology and assembly technology. These advances have been made though control technology, improvement of equipment precision, and introduction of new technology.

(1) Stabilization of element surfaces

One type of transistor failure is the deterioration of the surface of the element leading to lowered isolation voltage and h_{FE}. ROHM carries out the following measures to prevent this problem.

1) Over-passivation to protect aluminum wires and prevent external contamination. This over-passivation uses a nitride layer which achieves a reliability far surpassing that of previous phosphorus glass processes.
2) Clean processes
   We carry out measures to increase material purity, enhance cleaning techniques, improve wafer handling, and prevent dust at all stages including the assembly process.
3) Process control
   We use automated measurement for protective layer control, including such factors as film thickness, refractive indices, and control of mobile ions based on the BT method.

(2) Improved reliability in the assembly process

1) Our die and wire bonding processes are fully automated, and use pattern recognition for positioning. We develop our own high-performance equipment which has superb precision and stability.
2) Our molds are based on a reliability analysis of resin materials and mold manufacturing, and are designed to attain ideal conditions to match the material.
3) In addition to measurement at normal temperatures, we have also introduced special measurements to screen out line-break defects and surface defects, thereby attaining a higher reliability.

●Reliability assurance testing

Reliability testing is conducted to examine the quality of manufactured products, their durability over time, and their physical and chemical durability. Reliability testing is also conducted to ascertain design levels and failure limit levels. A variety of external stresses affect reliability, Including functional stresses such as electrical and mechanical stresses, environmental stresses such as temperature, humidity and vibration, the skill of the user, and service systems. We conduct life and environmental tests involving simulations to determine stress resulting from practical use. Furthermore, it is not sufficient in reliability testing to simply determine a standard for acceptance and rejection, we also must examine and evaluate changes in characteristics over time and characteristic distributions.

In order to improve and assure the reliability of all our products, ROHM conducts reliability forecasts and performs the following quality assurance tests based on the Japanese Industrial Standards.

Table1 Quality assurance tests

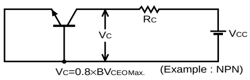
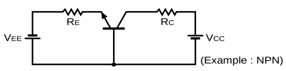
Test	Description	Specified values
A-1 ES Soldering heat resistance	1. Pb : Sn=4 : 6 (H63A) eutectic solder is used. 2. Immersed once in 260±5˚C solder bath to point 1.5mm from base of terminal for 10±1 seconds (for mini-mold types entire product is immersed). 3. Left at normal temperature for at least two hours after immersion.	1) No mechanical damage. 2) $I_{CBO} \leq 2S_U$ $I_{EBO} \leq 2S_U$ 3) $\lvert \Delta h_{FE} / h_{FE} \rvert \leq 20\%$ For Darlington devices, ≤40%
A-2 SOLDA Solderability	1. Pb : Sn=4 : 6 (H63A) eutectic solder is used. 2. Rosin dissolved in isopropyl alcohol (25%) is used for flux. 3. Immersed in flux to point 1.0 mm from base of terminal for 10 seconds, then immersed in 230±5˚C solder bath to point 1.0mm from body for 3±0.5 seconds (for mini-mold types entire product is immersed). 4. Left to sit naturally after immersion, and then cleaned in isopropyl alcohol to remove flux.	Enlarge 10 to 20 times and verify that solder smoothly coats at least 95% of the immersed surface.
A-3 HS Thermal shock	1. Immersed in 100^{+0}_{-5} ˚C bath for five minutes, then within 10 seconds immersed in 0^{+5}_{-0} ˚C bath for five minutes. 2. This is repeated 100 times. 3. After final cycle, product is left for at least 2 hours at room temperature.	1) No mechanical damage. 2) $I_{CBO} \leq 2S_U$ $I_{EBO} \leq 2S_U$ 3) $\lvert \Delta h_{FE} / h_{FE} \rvert \leq 20\%$ For Darlington devices, ≤40%
A-4 TCY Temperature cycle	1. After leaving in $Tstg_{Min.}$ air for 30 minutes, product is kept at room temperature for 10 minutes, then left in $Tstg_{Max.}$ air for 30 minutes. 2. This is repeated 200 times. 3. After final cycle, product is left at room temperature for at least two hours.	
B-2 THB High-temperature, high-humidity reverse bias	1. Ta=85±30˚C 2. RH=85^{+5}_{-0} % 3. Voltage is applied as shown below.  4. Test time is 1000 hours. 5. After test, product is left at room temperature for at least two hours.	
B-3 PCT Pressure cooker	1. Ta=121˚C, 100%RH 2. P=203kPa {2atm} Test time is 150 hours (100 hours for mini-mold types). 3. After test, product is left at normal temperature for at least two hours.	
B-4 LL Load life	1. Apply $P_{CMax.}$ with Ta=25±5˚C. 2. Do above using following circuit.  3. Test time is 1000 hours. 4. After test, product is left at normal temperature for at least two hours.	
B-5 HTRB High-temperature reverse bias	1. Ta=125±2˚C 2. Test circuit is same as B-2 THB. 3. Test time is 1000 hours. 4. After test, product is left at normal temperature for at least two hours.	
B-6 ST High temperature	1. Ta=$Tstg_{Max.}$ 2. Test time is 1000 hours. 3. After test, product is left at normal temperature for at least two hours.	
C-1TENS Terminal strength (tensile)	1. Body of product being tested is secured, and 9.8N (1kgf) load is applied in the axial direction for 5±1 seconds (2.94N (300g) load for mini-mold types).	No displacement of terminal relative to body, damage, or looseness.

Table2 Results of transistor reliability tests

Reliability level : 60%

Test	Soldering heat resistance			Thermal shock				Temperature cycle				High-temperature, high-humidity reverse bias				Pressure cooker				Load life				High-temperature reverse bias				High temperature			
Test conditions	10 sec. immersion in 260±5°C eutectic solder bath.			100°C for 5min. / 0°C for 5min. Transfer within 10 sec. T=100Cycle				Ta=55 / 25 / 150 / 25°C t=30 / 10 / 30 / 10min. T=200Cycle				Ta=85±2°C, RH=85±5% Apply $V_{CES}=V_{CEO}\times0.8$ T=1000h				Ta=121°C, RH=100% P=203kPa {2atm} T=150h [100h]				Ta=25±5°C Apply P_{CMax} T=1000h				Ta=150±2°C Apply $V_{CEO}=V_{CEO}\times0.8$ T=1000h				Ta=150±2°C T=1000h			
TYPE	n (pcs)	r (pcs)	P (%)	n (pcs)	r (pcs)	T (C. C)	λ (1 / Cy)	n (pcs)	r (pcs)	T (C. C)	λ (1 / Cy)	n (pcs)	r (pcs)	T (C. h)	λn (1 / h)	n (pcs)	r (pcs)	T (C. h)	λ (1 / h)	n (pcs)	r (pcs)	T (C. h)	λ (1 / h)	n (pcs)	r (pcs)	T (C. h)	λ (1 / h)	n (pcs)	r (pcs)	T (C. h)	λ (1 / h)
2SC4617 General purpose EMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SA1774 General purpose EMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SC4081 General purpose UMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SA1576A General purpose UMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SC2412K General purpose SMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SA1037AK General purpose SMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
DTC124EKA Built-in resistors SMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
DTA124EKA Built-in resistors SMT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SD1664 Mini-power MPT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SB1132 Mini-power MPT3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SB1184 Power CPT 3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}
2SD1760 Power CPT 3	264	0	0	264	0	2.64×10^{4}	3.47×10^{-5}	540	0	108×10^{3}	8.49×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	264	0	264×10^{2}	3.47×10^{-5}	132	0	132×10^{3}	6.94×10^{-6}	264	0	264×10^{3}	3.47×10^{-6}	44	0	44×10^{3}	2.08×10^{-5}

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