Quality assurance and reliability

●ROHM product quality

We put quality first "Quality" here refers to both the integrity of the products that we manufacture and price and timely delivery of those products to our customers. Although we put the utmost effort into each one of these factors, we give particular emphasis to the integrity of the product.

We are striving to minimize defects in our semiconductor devices both at the initial defect stage and at the incidental defect stage. The incidental defect rate is approaching a constant value. Most device manufacturers are approaching the same level in products where there are no major design problems. Therefore, we are making supreme efforts to bring semiconductor devices to our customers which have already been appropriately screened. By eliminating devices with hidden defects, we have reduced our customer-perceived defect rate λi to a level as close as possible to the incidental defect rate λr. These efforts insure that our customers are receiving products with a minimum defect rate. Our products have earned a reputation for their high reliability with our customers.

●Quality assurance system

Our quality assurance system requires testing at each major step in the manufacturing process. In addition, precise inspections are conducted after final assembly. For example, after the wafers are processed, the electrical characteristics of the wafers are measured to gauge the accuracy of each process. A short-term endurance test is carried out on each wafer. These tests allow us to assure the reliability of the wafers. After the diodes are assembled, we ensure the quality of all products by conducting multiple measurements at a high degree of precision. Fig. 1 shows our system for quality assurance.

●Quality assurance activities

(1) Education and training

In accordance with the fundamental goals of our company, we educate and train all our personnel in every division so they can produce reliable, quality products. Particular emphasis is placed on quality control, production control, research and design, purchasing, manufacturing, and management.

(2) Inspection and calibration

All measuring devices used in manufacturing process undergo periodic inspection and recalibration based on our own critical measuring device standards.

(3) Manufacturing control

ROHM has developed internal standards to control materials testing, manufacturing conditions, inspection methods, and other operations. Additionally, dust, humidity and temperature are strictly controlled in the manufacturing areas, in accordance with ROHM standards.

●Reliability testing

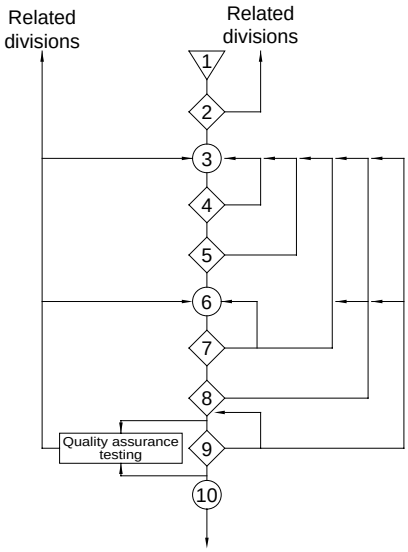
In order to verify the reliability of the finished products and the state of the quality control program for the entire manufacturing process, we periodically carry out reliability test on the products that we manufacture.

Table 1

No.	Test	Test conditions	Tolerance	Related standards
1	Solderability	Immersion for 5 seconds in 230°C solder bath	Length of solder on lead must be > 1 mm	JIS C 7021 A-2
2	Tensile strength of terminal lead	Pull terminal lead with 500g load for 5 seconds		JIS C 7021 A-11
3	Solder heat resistance	Immerse 1.5mm of terminal lead in 350°C solder bath	① V_F<U* × 1.1 ② I_R<U* × 2.0 ③ $\lvert\Delta V_2\rvert$: 2% ④No mechanical damage	JIS C 7021 A-1
4	Boiling	5 hours at 100°C		
5	Thermal cycling	20 ∾ of Tstg (Min.) / Ta / Tstg (Max.)		JIS C 7021 A-4
6	Thermal shock	15 ∾ of −65°C (5') / 100°C (5')		JIS C 7021 A-3
7	Pressure cooker	125°C and atmospheric pressure of 2 at relative humidity of 85%, for 4 hours		
8	Exposure to high temperature and humidity	Ta=85°C RH=85%, for 1,000 hours		JIS C 7021 B-11
9	Aging test at high temperature	Ta=Tstg (Max.), for 1,000 hours		JIS C 7021 B-10
10	Small signal diode load life	Ta=25°C, I_F=I_O for 1.5 hours on, 0.5 hours off, repeated over 1,000 hours		JIS C 7021
11	Constant voltage diode continuous operation	Ta=25°C Pd=Pd (Max.), for 1,000 hours		JIS C 7021 B-2
12	Rectifier diode continuous operation	I_F=I_O Ta≤Tj (Max.), for 1,000 hours		JIS C 7021 B-13
13	Variable capacitance diode, high temperature reverse bias life	V_R=V_{RM} Ta≤Tj (Max.), for 1,000 hours		JIS C 7021 B-3

* U : Upper limit of standard

●Diode quality assurance system



1. Receive the raw materials	Monitor quality at manufacturing at supplier's factory. Confirm receipt of monthly quality report.
2. Inspect the raw materials	Inspect samples of the raw material batch, and conduct physical and chemical analysis.
3. Manufacture the wafers	Initiate in-process quality control.
4. Inspect the pellets	Exterior inspection and measurement of electrical characteristics.
5. Quality assurance testing	Assess yield by inspecting first assemblies. Test short term endurance and static characteristics.
6. Assemble the diodes	Initiate in-process quality control.
7. Screen the diodes	Screen all products by testing electrical and thermal properties.
8. Inspect all diodes	Inspect exterior and electrical characteristics on all products.
9. Inspect product	Inspect exterior and electrical characteristics on random sampling of products.
10. Ship products	

Fig. 1 Quality assurance testing system

●Predicting reliability

One of the most frequently used methods for predicting reliability of electronic components is described in MILHDBK-217F, “Prediction of Reliability in Electronic Devices”. For your reference, we will summarize the section related to semiconductor devices.

●Predicting the failure rate in discrete semiconductor devices

The model shown here predicts the failure rate of low-frequency diodes. This model predicts the failure rate (λp) for discrete semiconductor devices using the formula :

$\lambda p = \lambda b \times \pi T \times \pi S \times \pi C \times \pi Q \times \pi E / 10^6$ hr

where :

λb=The basic failure rate shown in Table 2 determined by diode type and application.

πT=Temperature factor (Tables 3 and 4)

πS=Electrical stress factor (Table 5)

πC=Contact structure factor (Table 6)

πQ=Quality factor (Table 7)

πE=Environmental factor (Table 8)

Table 2. Basic failure rate model (λb)

Diode type/application	λb
Analog diode, for general use	.0038
Switching diode	.0010
Power rectifier, for fast recovery	.069
Power rectifier, Schottky power diode	.0030
High-voltage, multi-layered power rectifier	.005 / junction
Transient suppressor/varistor diode	.0013
Current regulator	.0034
Voltage regulator and standard voltage application (avalanche and Zener diodes)	.0020

Table 3. Temperature factor (π_T) (Applicable to voltage regulator, standard voltage application, and current regulator diodes)

Tj (˚C)	π_T	Tj (˚C)	π_T
25	1.0	105	3.9
30	1.1	110	4.2
35	1.2	115	4.5
40	1.4	120	4.8
45	1.5	125	5.1
50	1.6	130	5.4
55	1.8	135	5.7
60	2.0	140	6.0
65	2.1	145	6.4
70	2.3	150	6.7
75	2.5	155	7.1
80	2.7	160	7.5
85	3.0	165	7.9
90	3.2	170	8.3
95	3.4	175	8.7
100	3.7		

$$\pi_T = \exp\left(-1925\left(\frac{1}{Tj+273} - \frac{1}{298}\right)\right)$$

Tj=Junction temperature (˚C)

Table 4. Temperature factor (π_T) (Applicable to analog for general use, switching, fast recovery, power rectifier, and transient suppressor diodes)

Tj (˚C)	π_T	Tj (˚C)	π_T
< 25	1.0	105	9.0
30	1.2	110	10
35	1.4	115	11
40	1.6	120	12
45	1.9	125	14
50	2.2	130	15
55	2.6	135	16
60	3.0	140	18
65	3.4	145	20
70	3.9	150	21
75	4.4	155	23
80	5.0	160	25
85	5.7	165	28
90	6.4	170	30
95	7.2	175	32
100	8.0		

$$\pi_T = \exp\left(-3091\left(\frac{1}{Tj+273} - \frac{1}{298}\right)\right)$$

Tj=Junction temperature (˚C)

Table 5. Electrical stress factor (π_S)

S, Stress	π_S
Transient suppressor, voltage regulator, standard voltage application, and current regulator	1.0
All others	
Vs≤.30	0.054
.3<Vs≤.40	0.11
.4<Vs≤.50	0.19
.5<Vs≤.60	0.29
.6<Vs≤.70	0.42
.7<Vs≤.80	0.58
.8<Vs≤.90	0.77
.9<Vs≤1.0	1.0

For all except transient suppressor, voltage regulator, standard voltage application, and current regulator diodes:

$\pi_S = 0.54$ (Vs≤.3)

$\pi_S = Vs^{2.43}$ (.3<Vs≤1)

Vs=Voltage stress ratio=$\frac{\text{Applied voltage}}{\text{Constant voltage}}$

Voltage is diode reverse voltage.

Table 6. Contact structure factor (π_C)

Contact structure	π_C
Metal connectors	1.0
Non-metallic connectors and spring-loaded contacts	2.0

Quality factor=2.4 (from MIL-HDBK-217F)
Enviroment factor=9.0 (from MIL-HDBK-217F)

Table 7. Quality factors (π_Q)

Quality	π_Q
JANTXV	0.7
JANTX	1.0
JAN	2.4
Lower quality	5.5
Plastic	8.0

Table 8. Environment factors (π_E)

Environment		π_E
G_B	Ground, benign	1.0
G_F	Ground, fixed	6.0
G_M	Ground, mobile	9.0
N_S	Naval, sheltered	9.0
N_U	Naval, unsheltered	19
A_{IC}	Airbone, inhabited, cargo	13
A_{IF}	Airbone, inhabited, fighter	29
A_{UC}	Airbone, uninhabited, cargo	20
A_{UF}	Airbone, uninhabited, fighter	43
A_{RW}	Airbone, rotary winged	24
S_F	Space, flight	.50
M_F	Missile, free flight	14
M_L	Missile, launch	32
C_L	Cannon, launch	320

●Example of predicted failure rate calculations

[Question]

What would be the Predicted faibure rate for a switching diode (Specifications DO-35 package, $T_{Max.}$=175°C, P=500mW, quality equivalence : JAN grade, contact structure : non-metallic alloy and spring –loaded contact) operated at a case temperature of 62%, a rated load of 60%, a constant voltage of 30%, and a room temperature of Ta=25°C?

[Calculation]

(1) Because this is a switching diode, λb=0.0010 (based on Table 2).

(2) P=500mW with a load of 50%, at a case temperature of 55°C.

$Tj=Tc+*\theta_{JC}P$

$=62°C+10°C / W\times 0.30W=65°C$

where π_T=3.4, based on Table 4.

(3) From Table 5 : π_S=0.054

(4) From Table 6 : π_C=2.0

(5) From Table 7 : π_Q=2.4

(6) From Table 8 : π_E=9.0

(7) $\lambda p=\lambda b\times\pi_T\times\pi_S\times\pi_C\times\pi_Q\times\pi_E/10^6$hours = 0.0079/$10^6$hours = 7.9

$*\ \theta_{JC}$ is the junction-to-case thermal resistance of a diode with a case similar to the DO-35 package.

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