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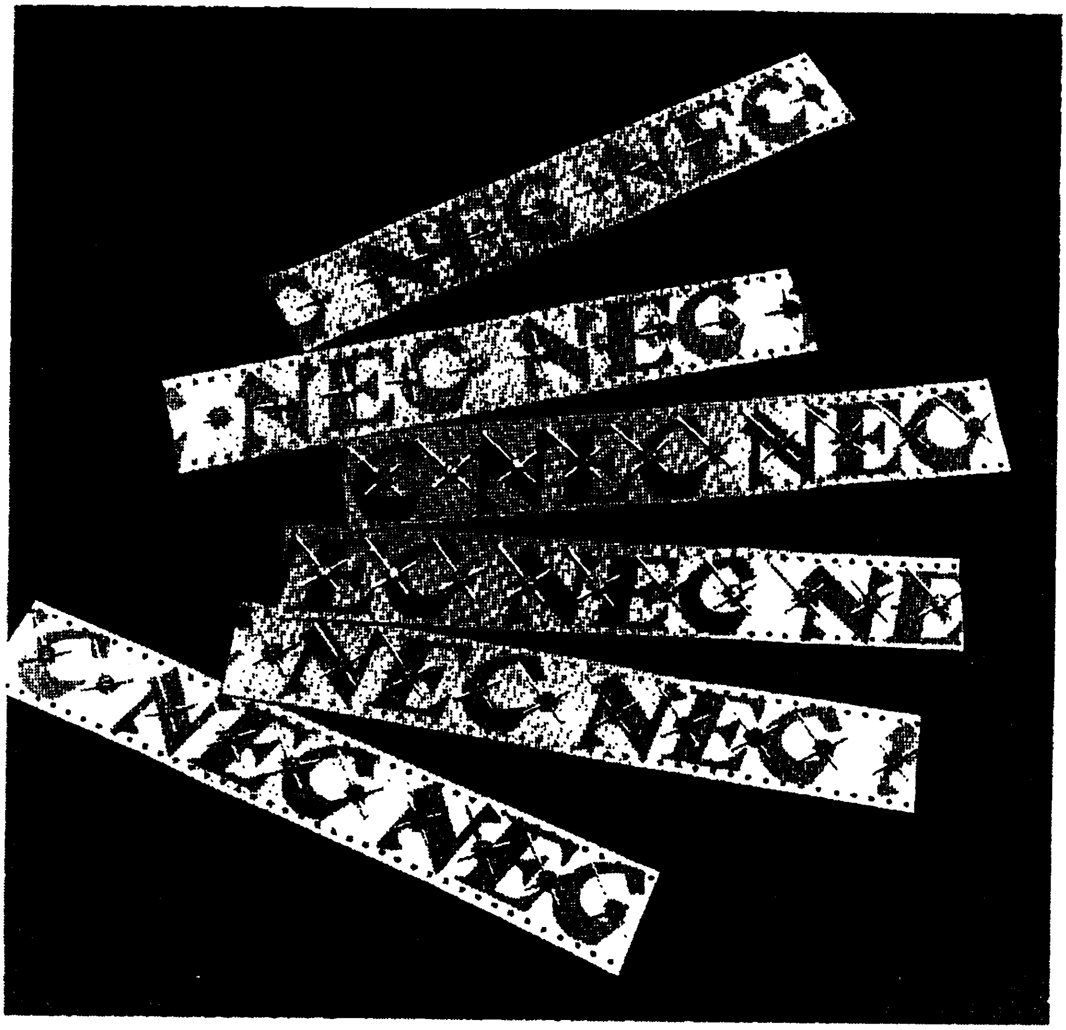
APPLICATION NOTE

DISKMOLD

NEW HIGH-FREQUENCY TRANSISTOR PACKAGE "DISKMOLD"

— Its Construction and Applications —



Nippon Electric Co.,Ltd.

APPLICATION NOTE NEW HIGH-FREQUENCY TRANSISTOR PACKAGE "DISKMOLD" TEP-1003 JULY-79

CONTENTS

Introduction

INTRODUCTION

Diskmold transistors are small disk type active elements designed for use in TV tuners and CATV sets. A typical example of small disk type active elements we have so far is microdisk transistors (housed in ceramic packages), which have been used in large volume in the fields of applications to VHF - UHF TV-tuners and high-density mounting of hybrid integrated circuits, etc., because of their special features that is the availability of varieties of types for entertainment applications ranging from low frequency to UHF frequency, distinguished HF characteristics and compactness. Meanwhile, plastic mold transistors (such as TO-92) featuring much lower cost, higher stability, and higher reliability have been also employed widely for entertainment use. Although microdisk transistors are still used widely, mainly in TV tuners, as compact, flat package devices with excellent high-frequency characteristics, market requirements for price and quality are becoming more exacting. Under these circumstances, we have just succeeded in developing diskmold transistors replaceable with microdisk transistors used so far.

1. FEATURES OF DISKMOLD TRANSISTORS

Diskmold transistors developed provide the following features.

(1) With a compact, flat package and T-shaped leads, the diskmold transistors have excellent RF characteristics because of their low RF losses, small stray capacitances and lead inductances as microdisk transistors.

(2) Being housed in compact packages, diskmold transistors have small space factors and are most suitable for high-density mounting.

(3) Microdisk transistors use low-melting point glass for sealing and may somehow be subject to thermal stress and mechanical shocks and vibration depending on the usage. Diskmold transistors employ resin encapsulation and have improved strength against thermal and mechanical stresses ensuring ease of handling.

(4) In spite of their compact packages diskmold transistors employ such resin as has a strong adhesiveness between the resin and metal (leads), achieving as high reliability as that of conventional plastic molded transistors such as (TO-92).

(5) The specification of diskmold transistors specifies them to be easily replaceable with conventional microdisk transistors.

2. CONSTRUCTION AND MANUFACTURING METHOD

2-1 Package Construction

Figs. 1 and 2 show the package construction of diskmold transistors. Their packages are formed with disk-shaped resin of 1.8 mm in thickness and 3.8 mm in diameter as typical values. Diskmold transistors are available in two types, one having three leads (Fig. 1) and the other having four leads (Fig. 2) as in the case of microdisk transistors.

PACKAGE DIMENSIONS (Unit: mm)

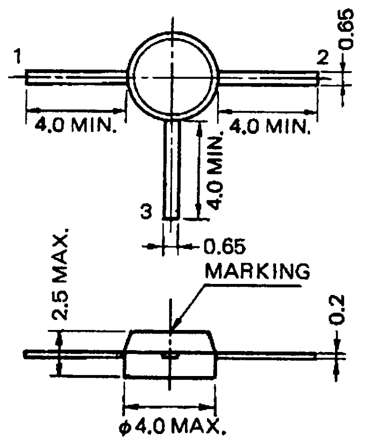


Fig. 1 DISKMOLD Transistor with 3 Leads

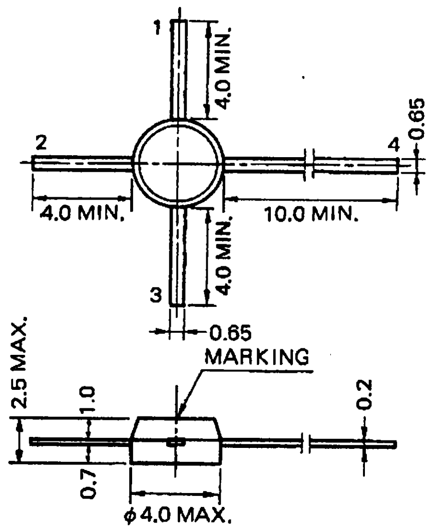


Fig. 2 DISKMOLD Transistor with 4 Leads

Connectors

DISKMOLD Transistor (Fig. 1)	DISKMOLD Transistor (Fig. 2)	Field Effect Transistor (Fig. 2)
1. Base	1. Base (or Emitter)	1. Gate 2
2. Emitter	2. Emitter (or Base)	2. Gate 1
3. Collector	3. Base (or Emitter)	3. Source
	4. Collector	4. Drain

2-2 Construction and Manufacturing Method

(1) Construction

Figs. 3 and 4 show the interior construction (models) of 3-lead and 4-lead diskmold transistors, respectively.

The active element (chip) of Fig. 3 is mounted on the lead ribbon of lead 3 and is connected through the electrodes of the chip to leads 1 and 2 by inner wires (gold wires). Fig. 4 shows the construction of such a type that has an improved RF characteristics by providing lead 1 between leads 2 and 4 (where leads 1 and 3 are shorted to each other).

The package is molded with an uninflammable epoxy resin. Leads are made of steel dipped by solder with a lead-tin solder.

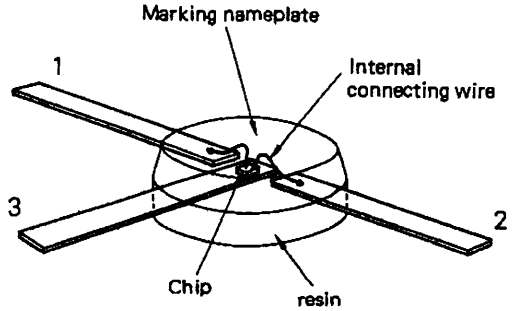


Fig. 3 Interior Construction of 3-Lead DISKMOLD Transistor

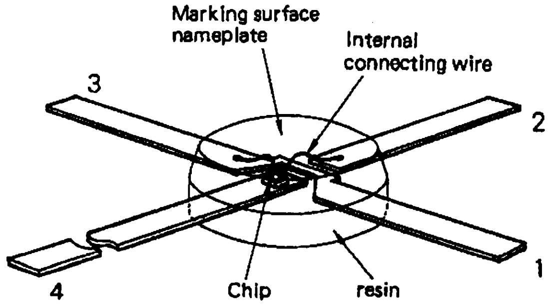


Fig. 4 Interior Construction of 4-Lead DISKMOLD Transistor

(2) Manufacturing method

The method of manufacturing diskmold transistors is based on the manufacturing method of conventional microdisk transistors and small-signal mold transistors. To produce diskmold transistors, first prepare the lead frame (ribbon), then insert the lead frame into an automated element manufacturing equipment for chip mounting by a special solder and interconnection of the electrodes of the chip and external leads (ribbons) with Internal Connecting wires, and resin shielding is made semi-automatically by batch processing, as shown in the flow diagram of Fig. 5.

Then, after effecting stabilization of high-temperature aging, etc., the leads are cut and DC items (and AC items when required) are all selected by an automatic selector. After this, rejection of defective products and classification of products by performance characteristic are performed and marked. This completes all process of manufacturing diskmold transistors.

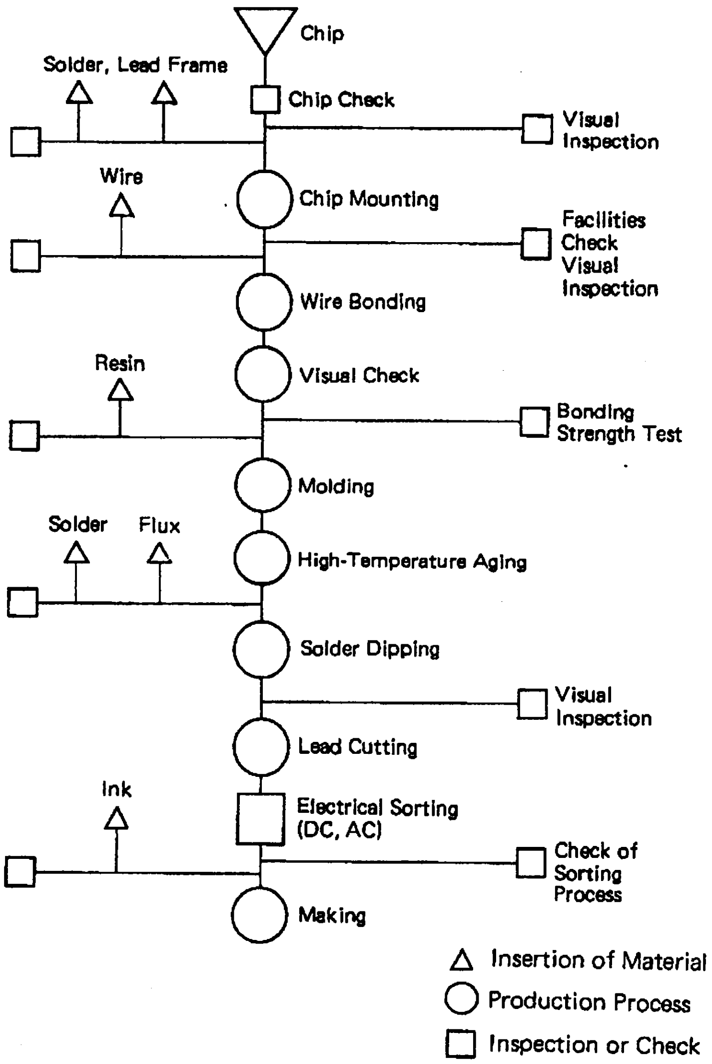


Fig. 5 Manufacturing Process

3. APPLICATIONS AND TYPES OF DISKMOLD TRANSISTORS

For discrimination from the existing microdisk transistors and equivalent, diskmold transistors have product nomenclature with (B) as shown below, except for new products.

Example

2SC1070 . . . . .Microdisk transistor
2SC1070 (B) . . . . Diskmold transistor

TABLE 1

Type No.	Structure	Application	Absolute Maximum Rating (Ta=25°C)						Electrical Characteristics					
			V_{CBO} (V)	V_{CEO} (V)	V_{EBO} (V)	Ic (mA)	P_T (mW)	T_j (°C)	Rank vs. Marking	I_{DSS}, h_{FE} or I_{AGC}	Condition	Cob (pF) TYP.	f_T (MHz) TYP.	Gp (dB) TYP.
3SK74	Si N-ch Dual Gate MOS FET	VHF band RF amplifier	(BV_{DSX}) 20	(V_{G1S}) ±10	(V_{G2S}) ±10	(I_D) 20	200	(Tch) 125	K L M	17 ~ 25mA 9 ~ 19mA 7 ~ 11mA	I_{DSS} V_{DS}=6V V_{G1S}=0 V_{G2S}=3V	(Crss) 0.03	(Y_{fs}) 20m℧	22
3SK87	Si N-ch Dual Gate MOS FET λ/2-Tuner	UHF band RF amplifier	(BV_{DSX}) 20	(V_{G1S}) ±10	(V_{G2S}) ±10	(I_D) 25	200	(Tch) 125	K	0~10mA	I_{DSS} V_{DS}=10V V_{G1S}=0 V_{G2S}=4V	(Ciss) 2.3	(Y_{fs}) 22m℧	18
3SK88	Si N-ch Dual Gate MOS FET λ/4-Tuner	UHF band RF amplifier	(BV_{DSX}) 20	(V_{G1S}) ±10	(V_{G2S}) ±10	(I_D) 25	200	(Tch) 125	K	0 ~ 10mA	I_{DSS} V_{DS}=10V V_{G1S}=0 V_{G2S}=4V	(Ciss) 2.0	(Y_{fs}) 17m℧	16
2SC287A(B)*	NPN Si Ep	VHF band Oscillator	35	15	4.0	20	200	125	E F	100 ~ 200 60 ~ 120	h_{FE} V_{CE}=10V I_C=5mA	0.8	1100	–
2SC288A (1-B)*	NPN Si Ep	UHF Oscillator	35	15	4.0	20	200	125	E F	100 ~ 200 60 ~ 120	h_{FE} V_{CE}=10V I_C=5mA	1.05	1100	–
2SC288A (5-B)*	NPN Si Ep	UHF Oscillator	35	15	4.0	20	200	125	E F	100 ~ 200 60 ~ 120	h_{FE} V_{CE}=10V I_C=5mA	0.8	1300	–
2SC605(B)*	NPN Si Ep	VHF band Mixer	30	30	4.0	20	200	125	K L	100 ~ 200 60 ~ 120	h_{FE} V_{CE}=10V I_C=3mA	0.6	500	–
2SC606 (B)*	NPN Si Ep	VHF band RF amplifier	30	30	4.0	20	200	125	V T	–8 ~ –10mA –9 ~ –11mA	I_{AGC} I_E at PG–30dB	0.6	550	23
2SA983	PNP Si Ep	UHF band RF amplifier (with forward AGC)	–30	–35	–4.0	–20	200	125	K L M	8.5 ~ 9.8mA 8.0 ~ 9.0mA 7.2 ~ 8.5mA	I_{AGC} I_E at PG–30dB	0.5	1000	16
2SC1070(B)*	NPN Si	UHF band RF amplifier (with forward AGC)	30	25	4.0	20	200	125	K L	–9 ~ 11mA –8 ~ 10mA	I_{AGC} I_E at PG–30dB	0.6	900	16
2SC2363	NPN Si Ep	UHF band Mixer and Oscillator	30	14	3.0	50	200	125	K L	100 ~ 200 60 ~ 120	h_{FE} V_{CE}=10V I_C=10mA	0.85	2300	(Gcb) 12.5
2SC2368	NPN Si Ep	UHF/VHF CATV Low-noise amplifier	30	14	3.0	50	250	150	K	40 ~ 200	h_{FE} V_{CE}=10V I_C=10mA	0.7	3000	(MAG) 17
2SC2369	NPN Si Ep	UHF (Microwave) band low-noise	30	12	3.0	70	250	125	K	40 ~ 200	h_{FE} V_{CE}=10V I_C=20mA	0.75	4500	(MAG) 17

* Replaceable with conventional microdisk transistor

4. ELECTRICAL CHARACTERISTICS

The method of determining the absolute maximum rating and electrical characteristics of diskmold transistors is the same as the method for determining those of microdisk transistors. Diskmold transistors differ from microdisk transistors in that plastic packages used to increase allowable power loss and thus provide more margin in circuit design.
Tables 2 and 3 give general performance characteristics of diskmold transistor and other existing similar transistors for comparison. Fig. 6 shows parasitic elements of a diskmold transistor.

TABLE 2 General Performance Characteristics of DISKMOLD Transistor and Other Similar Transistors

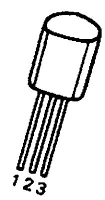
Type of Transistor	Operating Frequency	Power Dissipation	Junction Temperature	Storage Temperature	Size	Package
DISKMOLD Transistor	~2GHz	~ 200mW	~ 125°C	–55 ~ +125°C	ϕ3.8x1.8 mm	Plastic
Microdisk Transistor	~ 1GHz ~	~ 150mW	~ 150°C	–65 ~ +150°C	ϕ3.5x1.5 mm	Ceramic
Signal Mold Transistor (TO-92)	~ 1GHz ~	250 ~ 600mW	~ 125°C	–55 ~ +125°C	5x5x4.0mm	Plastic

TABLE 3 Stray Capacitances between Terminals of Transistors for Comparison

		Cc (1-2)	Cc (1-3)	Cc (1-4)	Cc (2-3)	Cc (2-4)
3-Lead Transistors	DISKMOLD Transistor	0.02pF	0.13pF	—	0.13pF	—
	Microdisk Transistor	0.02pF	0.13pF	0.13pF	0.14pF	—
4-Lead Transistors	DISKMOLD FET	0.14pF	0.13pF	0.14pF	0.13pF	0.02pF
	DISKMOLD Transistor	0.14pF	Internal Short	0.14pF	0.14pF	0.02pF
	Microdisk Transistor	0.13pF	Internal Short	0.13pF	0.14pF	0.02pF
Signal Mold Transistor		0.33pF	0.19pF	—	0.33pF	—

Note 1: Cc (1-2) denotes stray capacitance between leads 1 and 2. Figures in ( ) correspond to those given in Figs. 1 and 2.

Note 2: Terminal No. of signal mold transistor are: Terminal 1 (emitter), Terminal 2 (collector), and Terminal 3 (base).



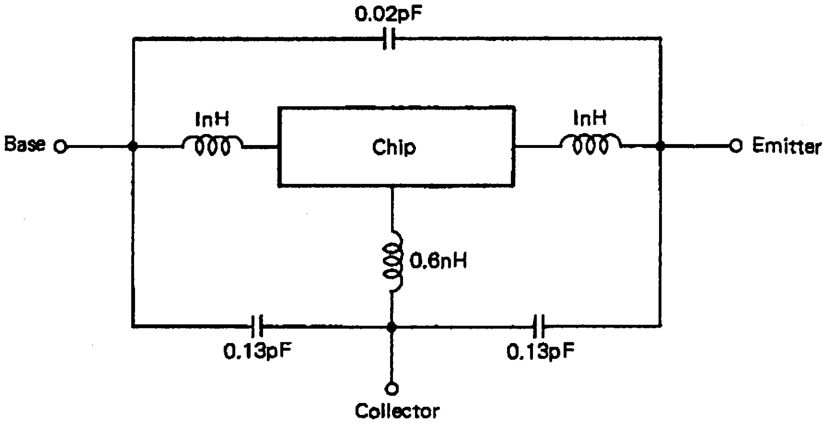


Fig. 6 Parasitic Elements of DISKMOLD Transistor

Allowable power dissipation and thermal resistance

In general, allowable loss P_T is given by:

$$P_T = \frac{T_{jMAX.} - Ta}{R_{th}}$$

where $T_{jMAX.}$ is the maximum junction temperature, Ta the ambient temperature, and R_{th} the thermal resistance of the device.
The thermal resistance of a diskmold transistor in free air is 0.5°C/mW.
Fig. 7 shows data of allowable power dissipation of a diskmold transistor.

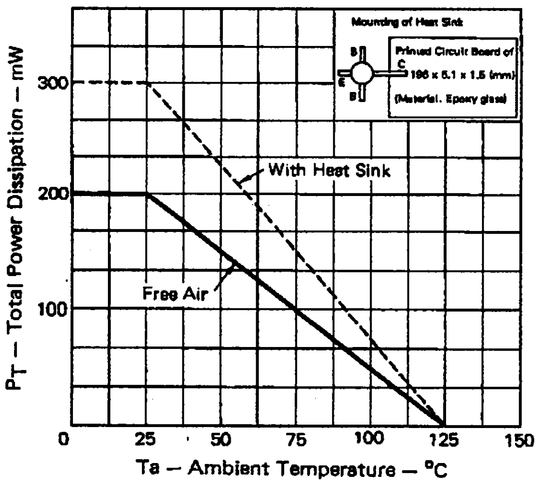


Fig. 7 P_T vs. T_a

5. RELIABILITY

The reliability of diskmold transistors has been confirmed by a similar evaluation method as used in evaluating plastic mold transistors.
In general, plastic mold type transistors differ from hermetic sealed transistors (metal canned, microdisk transistors) in modes of failure.

That is, plastic mold type transistors differ from hermetic sealed transistors in the following three properties.

(1) Moistureproof property
(2) Thermal stress
(3) Mechanical strength

5-1 Moistureproof Property

The damproof property of plastic mold products depends greatly on the properties of the resin in use. Moisture absorption of resin increases leakage current and when moisture reaches the chip, characteristic degradation or wire breakdown due to melting of electrodes may be caused.
Diskmold transistors use such a resin that provides an excellent adhesiveness between the resin and metal (between leads), achieving nearly equal moistureproof property as that of conventional signal mold transistors despite of their compactness.

5-2 Thermal Stress

Thermal stress causes expansion or contraction of resin, giving stress to internal wirings.
Gold wires are used as internal wirings of diskmold transistors. Gold wires are sufficiently strong to withstand expansion and contraction of the resin in use. A new bonding method is introduced in addition to the improvement in strength against thermal stress which is a demerit of microdisk transistors.

5-3 Mechanical Strength

Mechanical strength depends on the adhesiveness between the resin and metal (between leads).
Diskmold transistors use a resin of higher adhesiveness and improved lead frames to achieve much higher mechanical strength than conventional microdisk transistors and thus can be used without anxiety.

5-4 Reliability Control Procedure of DISKMOLD Transistors

Reliability control of diskmold transistors is effected by the procedure shown in Fig. 8. All control data are properly feed back to respective processes to establish systematization for maintaining high-stability performance.

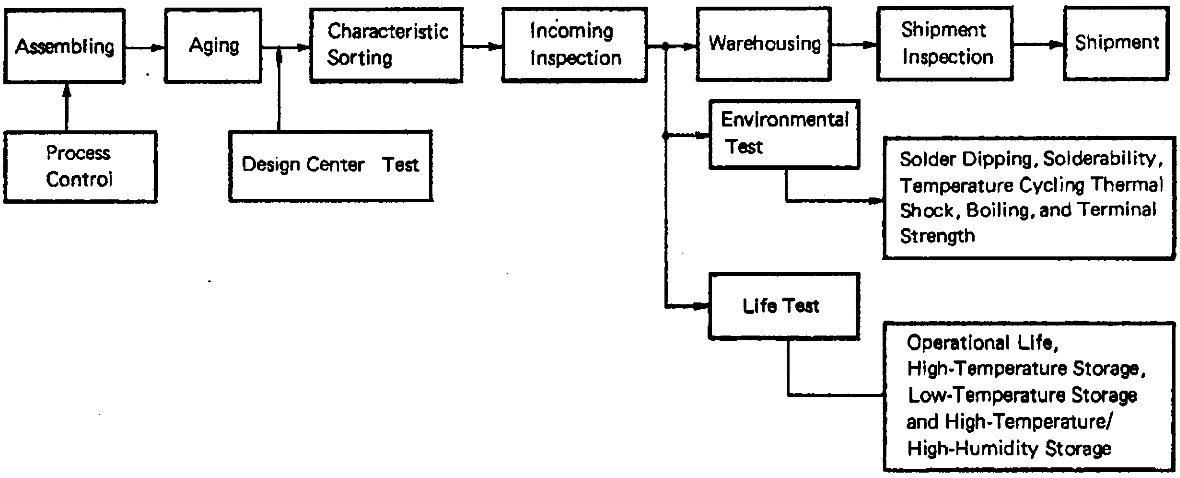


Fig. 8 Reliability Control Procedure

5-5 Reliability Test Data

Reliability tests of diskmold transistors are performed every month regularly. These tests are mostly acceleration tests and some test items are evaluated by their limits. Relationship with actual operating condition can be assured by field data, and we are willing to file test data for submission to customers on request.

TABLE 4 DISKMOLD Transistor Reliability Test

	Test Item	Test Condition	Test Duration	Criterion Items
1	Physical dimensions	Physical dimensions shall meet spec.		Out of spec
2	Strength of Marking	After dipping in chrolothene for 5 min. and drying for 10 sec. by natural drying, lightly rub 5 times.		Marking disappears or not.
3	Solderability	Dipping in melt solder at 230°C (eutectic solder) for 5 sec. using flux.		Solderability
4	Solder dipping	Dipping in melt solder at 260°C (eutectic solder) every 10 sec. using flux.		Characteristic degradation
5	Temperature cycling	High temp.: 125°C, 30 min. Low temp.: –55°C, 30 min.	30 cycles	Characteristic degradation
6	Thermal shock	High temp.: 100°C, 5 min. Low temp.: 0°C, 5 min.	10 cycles	ditto
7	Terminal strength	Force application to lead: 225g, 90° bending	3 times	Breakdown of lead
8	Salty water spraying	Temp.: 35°C, Salt concentration: 0.6%	24 hours	Rust on lead
9	Boiling	Temp.: 100°C with city water	24 hours	Characteristic degradation
10	Operating life	Continued application of power with allowable loss	1000 hours	ditto
11	High-temperature storage life	Temp.: 125°C	1000 hours	ditto
12	Low-temperature storage life	Temp.: –55°C	1000 hours	ditto
13	High-temperature/ High humidity storage life	Temp.: 60°C, Humidity: 90%	1000 hours	Rust on lead Characteristic degradation

Test Data (2SC1070 (B) HHT)

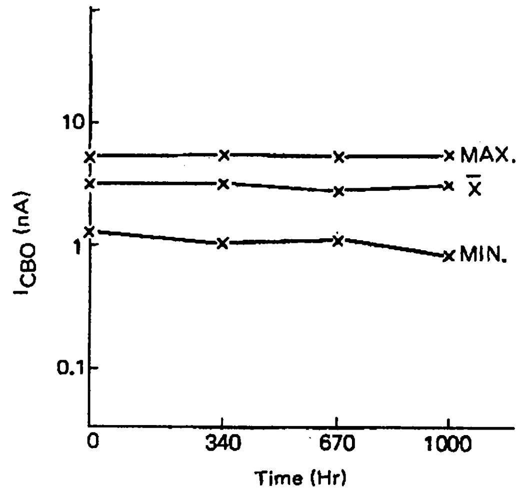


Fig. 9 Aging of I_{CBO}

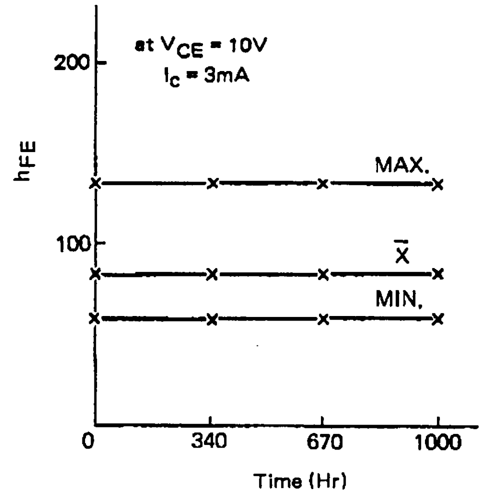


Fig. 10 Aging of h_{FE}

Mechanical Strength Test Data

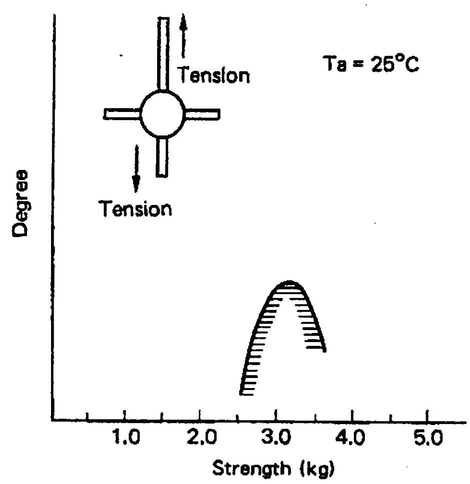


Fig. 11 Tension Strength

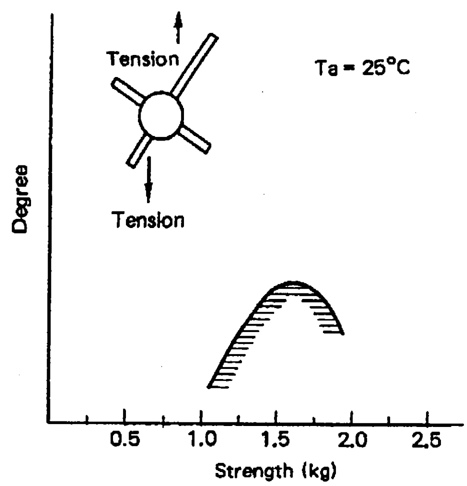


Fig. 12 Tension Strength

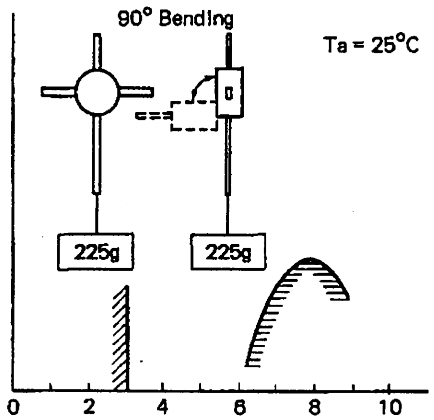


Fig. 13 Bending Strength

6. MOUNTING METHODS OF DISKMOLD

Although diskmold transistors can, of course, be mounted as conventional transistors, they allow introduction of many other new mounting methods. Some examples of mounting diskmold transistors mainly on a printed circuit board are given hereunder. Variations of these examples of mounting may be considered.

6-1 Mounting of Transistors in Conventional Method

(1) Mounting on front side of printed circuit board

Diskmold transistors can be mounted as easily as in the case of other conventional transistors, as shown in Fig. 14. In this mounting method, however, it is sometimes reported that because leads are in ribbon form short and project to three (four) different directions, they will not readily be inserted into the printed circuit board. Meanwhile, NEC has mounting jigs which allow a transistor to be easily mounted into a printed circuit board for microdisk transistor use. The special features of these jigs are in tweezers with a bent tip, a lead shaping jig, and a roller for bending leads. Examples of mounting methods are shown in pages 14 ~ 17 for reference's sake.

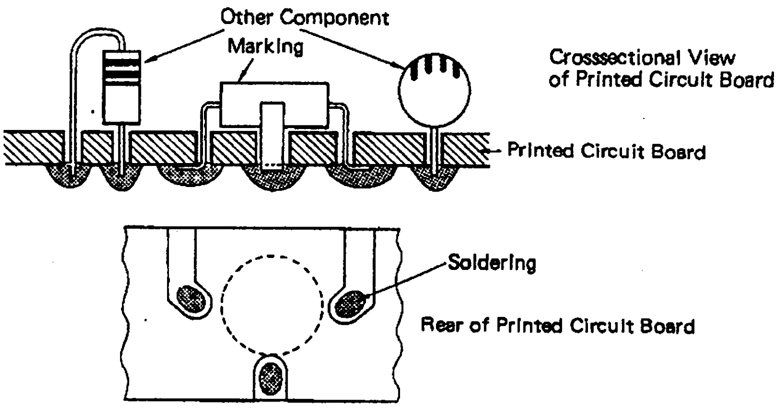


Fig. 14 Mounting on Front Side of Printed Circuit Board

(2) Mounting on Rear of Printed Circuit Board

This method of mounting allows the best use of the outside shape of the diskmold transistor while still using the conventional printed circuit board. By this mounting method, space on the surface of the printed circuit board can be saved completely. It required a considerable time to solder the three (four) leads with a soldering iron. If it is possible to fix these leads in advance to the printed circuit board by adhesive or a like, the solder dipping method may be employed. It has been confirmed that the transistor proper may be dipped in melt solder.

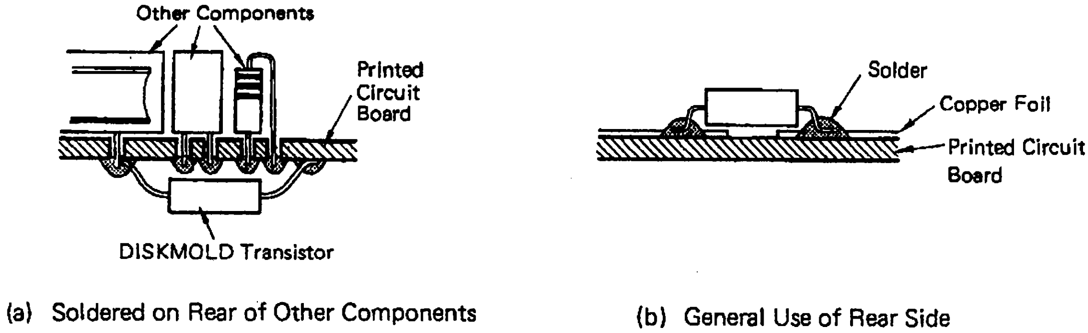


Fig. 15 Mounting on Rear of Printed Circuit Board

6-2 Mounting of DISKMOLD Transistor by Partially Processing Conventional Printed Circuit Board for Tran sis tors

(1) In this mounting method, a diskmold transistor is mounted embedded in a hole, as shown in Fig. 16. Since the diameter of the transistor is 4.0mm maximum, the diameter of the hole should be approx. 4.3mm. It is also allowed to arrange the transistor upside down.

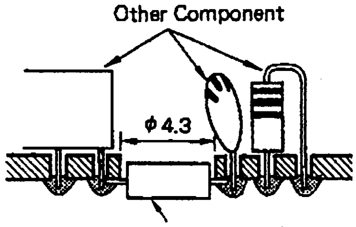


Fig. 16 Mounting by Embedded in Printed Circuit Board

(2) Other Methods
Mounting by seating diskmold transistor in a shallow hole made on printed circuit board as shown in Fig. 17 or mounting as shown in Figs. 18 and 19 are allowed. These mounting methods contribute to efficient use of space on the front or rear surfaces of the printed circuit board. Use of adhesive for fixing the transistor may facilitate soldering work.

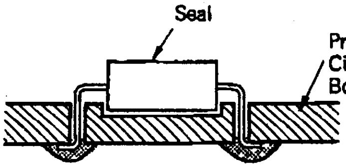


Fig. 17 Mounting by Seating Transistor on Shallow Hole on Printed Circuit Board

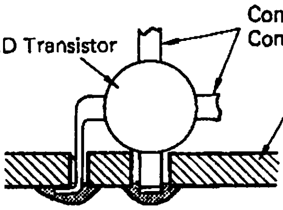


Fig. 18 Mounting by Erecting Transistor

7. CAUTIONS IN HANDLING

In general, various restrictions impose in handling transistors. Misoperation may cause breakdown or quality or reliability degradation. So ratings given in the specification must be met.
Environmental requirements and cautions to be taken upon handling diskmold transistors are given hereunder.

7-1 Mechanical Strength

For maintaining the performance and reliability of diskmold transistors, avoid as much as possible twisting leads. For shaping a lead, fix it at the foot and shape it to avoid the stress at the sealing.

7-2 Soldering Temperature and Flux

The semiconductor device solder thermal resistance requirements set out in JIS C 7021 are: 10 seconds at 260°C and 3 seconds at 350°C. These limits should not be exceeded in soldering.
Among various soldering fluxes, rosin flux is most recommendable. Use of inorganic flux (such as zinc chloride) would require cleaning after solder dipping to avoid the degradation of reliability of the device applied.

7-3 Cleaning

After completion of soldering, flux should be washed away by using such a solvent as alcohol, chlorothene and Freon but dipping for a long time would result in vanishing of the marking and should thus be avoided. When other components are not influenced, ultrasonic cleaning may be employed as rigidness is achieved by using resin encapsulation but in this case the cleaning condition should be set as moderate as practicable.

7-4 Fixation by Resin, etc.

When fixation by resin or a like is employed after mounting the transistor to the printed circuit board in the case of thin-film IC, heat or gas generated upon hardening may give undesirable influences. Resin protection may be accomplished by using epoxy and silicone.

AN EXAMPLE OF MOUNTING OF DISKMOLD TRANSISTOR

Described hereunder is an example of mounting a diskmold (microdisk) transistor developed by NEC. Use of this mounting method will greatly reduce time required for mounting when compared with the mounting method of a single-ended transistor and thus save labor for assembly.

PHOTO 1

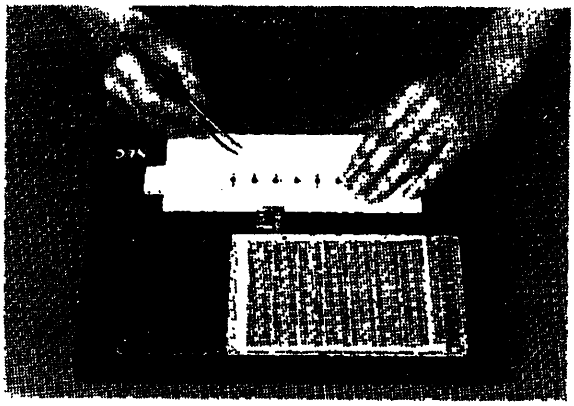


Photo 1

In this mounting method, lead shaping can readily be made and after mounting the diskmold transistor on the printed circuit board, the leads can be fixed bent at a time on the rear rise by means of a roller. The mounting jigs comprise:

(1) Tweezers (of which the tip is so processed that facilitates taking up a diskmold transistor)
(2) Lead former
(3) Roller for bending leads on the rear side.

PHOTO 2

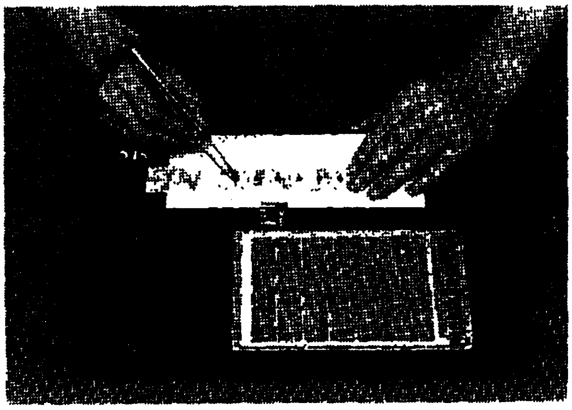


PHOTO 4

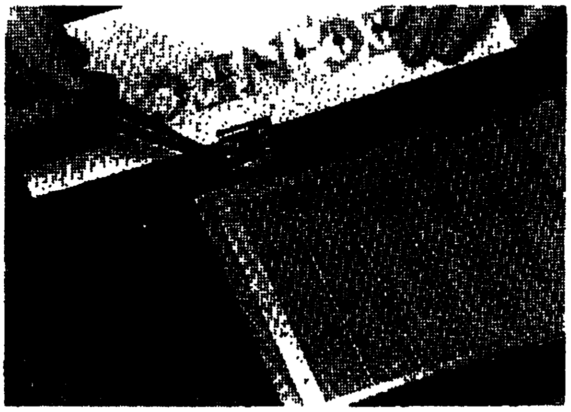


PHOTO 3

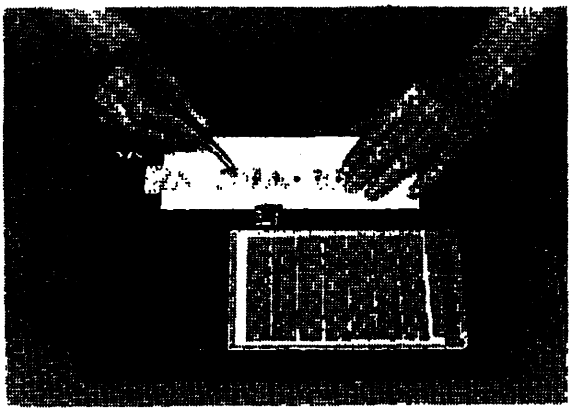
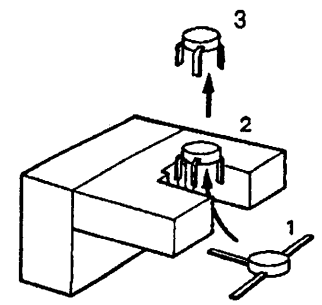


Fig. 19



Acrylic lead bending jig

Photos 2 and 3

Taped diskmold transistor is removed from tape by tweezers and wrapped. Tweezers be such that are processed so as to facilitate picking up diskmold transistor.

Photo 4 and Fig. 19

Diskmold transistor picked up by tweezers is passed through lead shaper (by pulling up transistor).

PHOTO 5

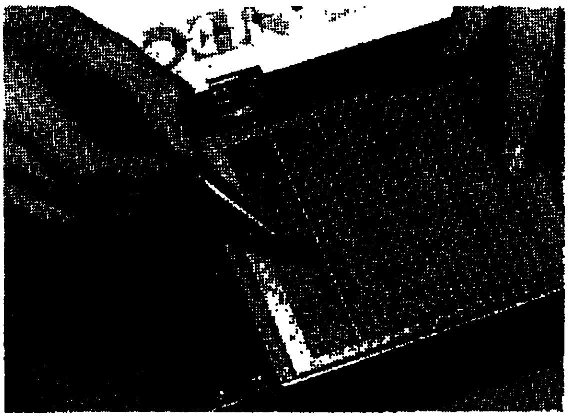


PHOTO 6

Photos 5 and 6

Leads of diskmold transistor are inserted into holes on printed circuit board.

PHOTO 7

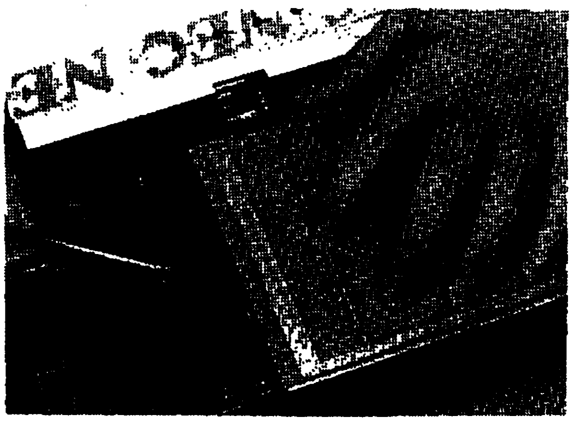
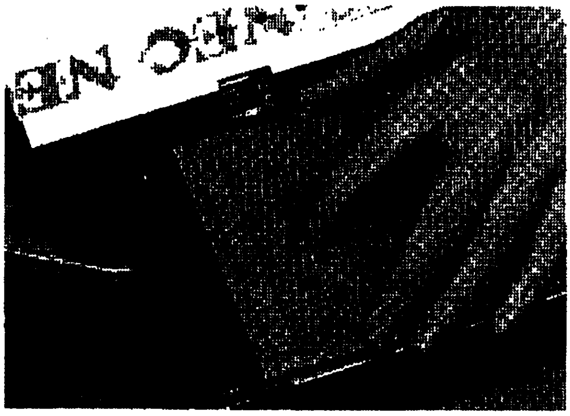


PHOTO 8



Photos 7 and 8

Diskmold transistor with leads inserted into holes on the printed circuit board is depressed by a finger.

PHOTO 9

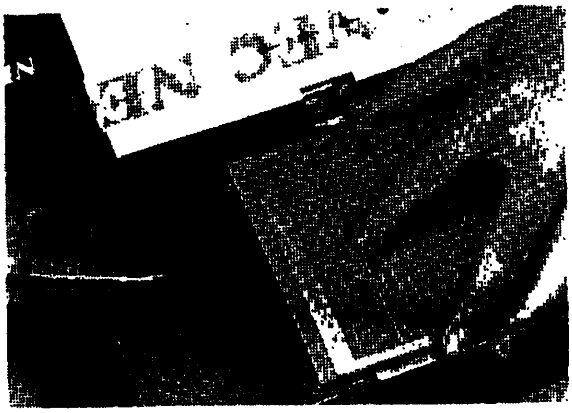
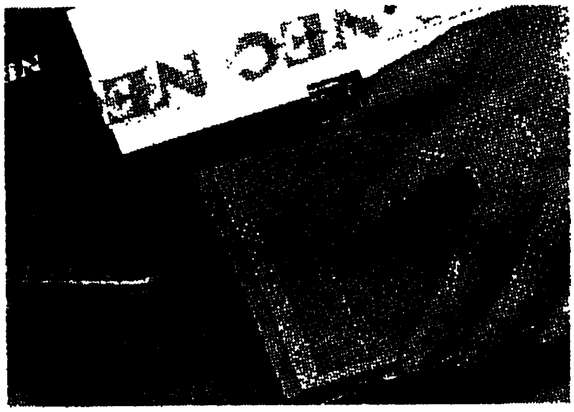


PHOTO 10



Photos 9 and 10

Printed circuit board is slided on the roller while securing the diskmold transistor with a finger.

PHOTO 11

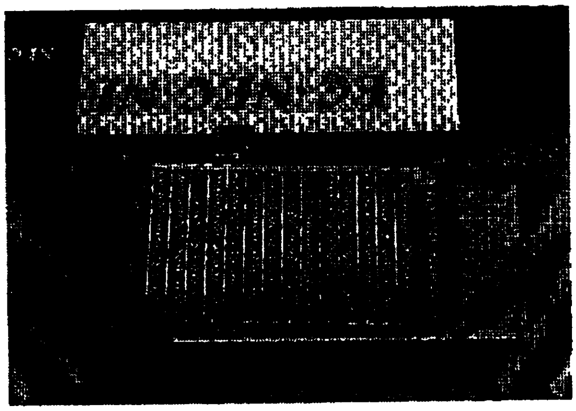


Photo 11

On the rear of printed circuit board the leads are bent and diskmold transistor is fixed.

[redacted]

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