

"PLASTIC MOLDED ELECTRONIC DEVICE"

1 BACKGROUND OF THE INVENTION

The present invention relates to a plastic molded electronic device using a resin molding composition of high moldability which gives cured products having excellent adhesive property, electric
5 properties and heat resistance, for example semiconductor devices of plastic molded type sealed with such a resin composition.

DESCRIPTION OF THE RELATED ART

The outer packagings of electronic devices and
10 semiconductor devices such as a transistor, IC, LSI and VSLI are classified into two groups. One is the hermetic seal type which utilizes metals, glasses, ceramics etc., and the other is the plastic molded type which utilizes thermoplastic resins or thermosetting resins.

15 The former is superior in airtightness but is very expensive. By contrast, the latter can be produced at a very low cost by mass production. Owing to the low manufacturing cost and the advance in materials and production technique for semiconductor devices or sealing
20 resins in recent years, 80% or more of the semiconductor products have come to be occupied with the plastic molded type semiconductors produced by transfer molding with thermosetting resins, among which epoxy resins are mainly used.

1 However, the semiconductor devices are becoming more
integrated year after year and, as a result, the industry
advances toward a larger chip size and a finer and more
multi-layered wiring. As for the shape of packages, owing
5 to the trend toward higher density and automation of
packaging, the package size becomes smaller and thinner
and the shape of package also shifts from the conventional
pin insertion type package, typical example of which is
DIP (Dual Inline Package), to the surface-mounting type
10 packages including QFP (Quad Flat Package), SOJ (Small
Outline J-bended Package) and PLSCC (Plastic Leaded Chip
Carrier).

 With the increase in degree of integration,
the changes in size and shape of package and
15 mounting method, the surface of a chip becomes finer and
the sealing resin layer of a package gradually becomes
thinner. Moreover, with the shift from the pin insertion
type to the surface-mounting type, the package has come
to be exposed to higher temperatures than before during
20 mounting. Consequently, when a sealed device is subjected
to a drastic temperature change, local heating or the
like, the thermal stress increases due to the difference
between the thermal expansion coefficients of the
constituents of semiconductor device (sealing resin,
25 chip, frame etc.) and thereby the sealing resin, chip or
passivation film formed on the chip surface is cracked or
the wiring on the chip surface is broken, shorted or
misregistered. Thus are caused problems such as the

1 fluctuation of characteristic properties of the device
and the reduction of reliability thereof.

These problems become more emphasized as the
mounting method for packages shifts from the pin inser-
5 tion type to the surface-mounting type.

In manufacturing the conventional pin inser-
tion type package, the pin is inserted into the through-
hole of the substrate and soldered at the backside of the
substrate. Accordingly, the temperature of the package
10 mounted on the substrate is elevated to only about 100°-
130°C and hence there has scarcely arisen the problem
that the reliability of sealed product is reduced by the
thermal stress experienced during mounting. In manufac-
turing the surface-mounting type package, on the other
15 hand, mounting is conducted by means of infrared reflow
or vapor reflow with an inert gas, whereby the whole
package is exposed to an elevated temperature of 200°C or
more. Consequently, the thermal stress increases due to
the differences between the thermal expansion coefficients
20 of the constituents of semiconductor device (sealing
resin, chip, frame, etc.) and thereby the sealing resin,
chip or passivation film formed on the chip surface is
cracked or the wiring is broken, shorted or misregistered.
Thus are caused problems such as the fluctuation of
25 characteristic properties of the device and the reduction
of reliability thereof.

Although the temperature at which plastic molded
type semiconductors are usable has been generally

1 considered to be about 125°C at the highest, heat-
resistant plastic molded type semiconductor devices
usable at more elevated temperatures have come to be
required as the range of the use is widened. Plastic
5 molded type semiconductors of the prior art develop
defective connection at the joint between the gold wire
and aluminum electrode when allowed to stand for a
long time at an elevated temperature of 200°C or more
and are thus poor in the so-called high-temperature life.
10 Therefore, a material having a high heat resistance,
adhesive property, low stress development, and moisture
resistance has been desired for semiconductor sealing
material.

As the conventional molding materials for
15 sealing semiconductors, there have been widely used epoxy
resin molding materials with a curing agent such as
phenol novolak resin and acid anhydrides. However, the
heat resistance of the epoxy resins are, when the glass
transition temperature of cured product is taken as the
20 measure of the heat resistance for example, 150°-180°C
and are not satisfactory for meeting the above-mentioned
requirements. Nevertheless, the heat resistance alone
can be considerably improved by using multi-functional
epoxy resins, phenol resins of higher molecular weight,
25 or multi-functional acid anhydrides as a curing agent.

However, the cured product of these resin
compositions are not satisfactory in adhesive property,
moisture resistance and electric properties and have been

unable to be used in practice as materials for electronic parts. As heat-resistant resins other than epoxy resins, for example polyimide resin and polyphenylene sulfide (PPS) have already been known.

5 However, as compared with epoxy resin molding materials, conventional molding materials using polyimide resin are markedly poor in curing characteristics, mold release, etc. They are also unsatisfactory in adhesion to chips and lead frames and
10 in moisture resistance. PPS is unsatisfactory in resistance to soldering heat. Thus, these resins have not yet been applied to any practical uses as molding material for electronic device.

The present invention has been made in view of
15 the above, and an object thereof is to provide a plastic molded electronic device using a phenolic resin composition of high moldability which when cured has excellent adhesive property, electric properties and heat resistance.

20

25

SUMMARY OF THE INVENTION

According to the present invention, there is provided a plastic molded electronic device, wherein the device is sealed or transfer-molded with a phenolic resin molding composition comprising a resin component consisting of a phenolic resol resin and a cure-rate controlling agent in a weight ratio of from 75:25 to 95:5, the phenolic resin molding composition having a purity such that it gives, when ground and extracted by heating with 10 times the amount of hot water at 120°C for 100 hours or more, an extract having an electric conductivity of 100 μ S/cm or less, a pH of 4-7 and a halogen ion content of 10 ppm or less (calculated as content in the molding composition).

Preferably the cure-rate controlling agent is at least one epoxy resin.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing the results of tests for examining the influences of a variety of molding materials (in the form of molded products) on the connection

1 strength and life at an elevated temperature of the
joint of gold wire with an aluminum electrode. Fig. 2 is
a schematic cross-sectional view of a test apparatus used
in the tests of Fig. 1. Fig. 3 is a gel permeation
5 chromatograph showing the molecular weight distribution
of one example of the resol-type phenol resin used in the
present composition.

The numerals in the Figures mean the following.

1: silicon chip, 2: gold wire, 3: lead frame, 4: silver
10 paste, 5: cured resin, 6: glass ampoule.

In order to solve the above-mentioned problems,
the present inventors have made extensive studies on
phenol resins, which had been regarded as almost
practically unusable as a material for electronic parts
15 due to their high content of ionic impurities and poor
electric properties, including studies on methods for
increasing the purity, improving the electric properties,
and application to molding materials, of phenol resins.
As a result, it has been found unexpectedly that the
20 phenol resin composition used in the invention has good
moldability, adhesive property, electric properties,
moisture resistance and heat resistance and gives sealed
products excellent in resistance to soldering heat and
in the strength and life of the connection of the joint
25 of gold wire with an aluminum electrode in a long time
standing at high temperatures. Thus, the present inven-
tion has been arrived at.

The present invention has an excellent feature

1 of making it possible, particularly by use of a resol-
type phenol resin, to attain the flame resistance V-0
without incorporation of a flame retardant.

In the preferred molding composition used in the present
5 invention, the resin component consisting of a phenolic resol
resin and an epoxy resin preferably has a low content
of ionic impurities such that when extracted with 10
times the amount of hot water at 120°C for 100 hours or
more the extract has an electric conductivity of 100
10 μ S/cm or less, a pH of 4-7 and a content of extracted
halogen ions of 10 ppm or less. Fillers may be added as
occasion demands. Although the filler is not particularly
restricted, it is preferably an inorganic particulate
substance. More preferably, it is at least one inorganic
15 particulate substance selected from fused silica,
crystalline silica, and alumina, having an average
particle diameter of 1-30 μ m. Particularly preferred is
spherical fused silica.

Since the phenolic resol resin used in the
20 present invention has a reactive methylol group and
hydroxyl group in the molecule, in principle it can be
heat-cured by itself. Moreover, even when no curing
agent is used, the cure rate is considerably higher than
that of such thermosetting resins as epoxy resin. How-
25 ever, when such a fast-curing resin is used for a molding
material, coating material or laminating material for
electronic parts, it is difficult to mold the resin into
a specified shape, or mold it without developing voids

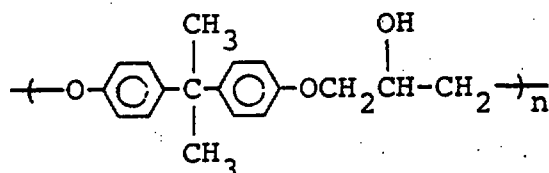
1 or damaging the insert, owing to the excessively short
flowable time of the material. Accordingly, in the
present invention a cure rate controlling agent is used
together with the phenolic resol resin in order to
5 regulate the curing property, viscosity, flowability etc.
of the resin. Though the cure rate controlling agent is
not specifically restricted, it is preferably an epoxy
resin.

The weight ratio of the phenolic resol resin
10 to the cure rate controlling agent is
75:25 to 95:5, preferably 75:25 to 90:10.

The reason why the proportion of the cure
rate controlling agent should be 5-25% by weight relative
to the total resin component is that when the proportion
15 is less than 5% by weight, the curing property, viscosity,
flowability etc. of the resin cannot be regulated
sufficiently, whereas when the amount of the agent is high
advantageous characteristics inherent to the phenolic
resol resin such as heat resistance (or high-temperature
20 property), flame resistance, etc. deteriorate.

The phenolic resol resin referred to
herein is a resin synthesized by the condensa-
tion of a phenol such as phenol or cresol with formal-
dehyde in the presence of a basic catalyst such as
25 ammonia, hexamine and amines. In the reaction, it is
preferable to carry out the reaction for a time long
enough to reduce the amount of unreacted starting materials.
It is also preferable that the molecular weight is

1 suitably large in view of the curing property and
 flowability of the resulting resin. Further, in order
 to remove the unreacted starting materials and ionic
 impurities, the reaction product is, after being neutralized
 5 with an acid, preferably washed with water or subjected
 to steam distillation and then thoroughly dried under
 reduced pressure, or as occasion demands, treated with an
 ion-exchange resin, ion-exchanger or the like. The epoxy
 resin referred to in this invention is a group of
 10 synthetic resins containing the group



wherein n is 0 to 9. It is, for example, a resin obtained
 by the condensation of bisphenol A or a phenol novolak
 resin with epichlorohydrin. Also with said epoxy resin,
 the reaction product is preferably freed thoroughly of
 15 unreacted starting materials and ionic impurities. Since
 the ionic impurities contained in these resin components
 are of many varieties, it is difficult to specify an
 allowable content for each individual impurity. However,
 it is specified that when the resin component is extracted
 20 with 10 times the amount of hot water at 120°C for 100
 hours or more, the extract has an electric conductivity
 of 100 $\mu\text{S}/\text{cm}$ or less, a pH of 4-7 and a content of
 extracted halogen ions of 10 ppm or less.

The molding composition used in the present invent-
 25 ion may incorporate an inorganic filler with the aim of

1 improving the thermal expansion coefficient, thermal
conductivity, elastic modulus, etc. of the cured product.
Usually, the filler is used in the range of 55-80% by
volume, preferably 50-70% by volume, relative to the
5 total volume of the composition. This is because when
the proportion is less than 55% by volume, the above-
mentioned properties can be difficultly improved satis-
factorily, whereas when the proportion exceeds 80% by
volume, the resulting material tends to undergo a marked
10 increase of viscosity and decrease of flowability. The
kind of inorganic fillers is not critical and various
compounds can be used. For electronic parts,
however, it is preferably that thermally and chemically
stable fillers are used. Specifically, at least one
15 inorganic particulate substance selected from fused
silica, crystalline silica, and alumina is more prefer-
able. In particular, spherical fused silica is most
preferable. Because it has recently come to be commer-
cially produced in a large scale, not only has itself a
20 small thermal expansion coefficient but also gives, when
mixed with resin, a slight increase in viscosity and
decrease in flowability to the product. These fillers
preferably have an average particle diameter in the range
of 1-30 μm . This is because when the average particle
25 diameter is less than 1 μm , an increase in viscosity and
marked decrease in flowability of the resin composition
tend to occur. Whereas when it exceeds 30 μm , the resin
composition is liable to undergo separation of the resin

1 component from the filler during molding, resulting in
non-uniform cured products and fluctuation of physical
properties of cured products, or to show a poor capability
in filling narrow crevices.

5 In the present composition, various additives
other than those mentioned above may be used according
to necessity. Such additives include curing catalysts
for encouraging the setting reaction of resin, flexibility-
imparting agents for increasing the toughness or decreas-
10 ing the elastic modulus of the cured product, coupling
agents for enhancing the adhesion of the resin component
with the filler, dyes or pigments for coloring, and mold
release agents for improving the mold release of the
cured product from the mold, within a range not deleterious
15 to the object of the invention.

When the filler or the respective additives
mentioned above contain a large amount of ionic impurities,
the reliability of the final product is greatly reduced
as in the case of the resin component. There-
20 fore, it is preferable that, when the additive is extracted
with 10 times the amount of hot water at 120°C for 100
hours or more, the extract has an electric conductivity
of 100 μ S/cm or less, a pH of 4-7 and a content of
extracted halogen ions of 10 ppm or less with regard to
25 these additives either.

To reduce the adverse effect of such ionic
impurities exerted on the reliability of the final
products, fine particles of an ion-exchange resin or an

1 ion-exchanger may also be incorporated directly to the
resin composition. Particularly preferable are the so-
called inorganic ion-exchangers such as hydroxide and
hydrated oxide of antimony or bismuth, phosphorus
5 antimonic acid, zirconium antimonate, titanium antimonate,
tin antimonate, chromium antimonate, and tantalum antimo-
nate. Fine particles of direct ion-exchange resins or
ion-exchangers may be incorporated in a proportion of 5
parts by weight or less, preferably in the range of 0.01-
10 5 parts by weight, more preferably 0.1-1 part by weight
relative to 100 parts by weight of the resin composition.
Thereby a remarkable improvement can be obtained in
preventing the corrosion and breaking of aluminum wiring
and electrodes in the moisture resistance test of plastic
15 molded type semiconductors, and in preventing the defec-
tive connection at the gold wire-aluminum electrode joint
in the high-temperature standing test of plastic molded
type semiconductors.

The epoxy-modified phenol resin used in the
20 invention is assumed to exhibit desirable electric and
other properties as compared with prior molding resins
attributable to the removal of ionic impurities
attained by high degree of purification. The success
in attaining the flame resistance V-O is assumed to be
25 due to the phenol resin component itself.

The method of preparation and purification of

phenolic resol resin used in the present composition is illustrated below by one example.

Preparation Example 1

Synthesis of phenolic resol resin

5 In a 3-liter flask were placed 500 g of phenol, 550 g of 30% formalin and 25 g of 25% aqueous ammonia solution, and the resulting mixture was gradually heated with stirring and then heated under reflux at 90°C for 60 minutes. The inner pressure of the flask was then
10 reduced to 20 mmHg to remove condensation water and unreacted components.

 Then, 500 g of the reaction product was placed in another 3-liter flask, 1 liter of deionized water was added thereto, and the mixture was stirred vigorously at
15 90°C for 15 minutes.

 After cooling, the upper, aqueous layer was removed, 1 liter of deionized water was again added to the remaining lower layer, and the mixture was stirred vigorously at 70°C for 15 minutes, then cooled, and the
20 upper, aqueous layer was removed.

 After the above operation had been repeated 5 times, the reaction product was heated up to 90°C under reduced pressure to remove water, whereby the desired phenolic resin resin was obtained.

25 The melting point and curing characteristic of the phenolic resol resin obtained above are shown in Table 1. Further, 50 g of deionized water was added to

- 1 5 g of the resol-type phenol resin and heated at 120°C for 120 hours. The pH and electric conductivity of the water after said heating and the result of analysis of extracted ionic impurities by ion exchange chromatography
- 5 are also shown in Table 1.

Table 1

Softening point (°C)		65
Gellation time (min), 170°C		35
Properties of extract (after 120 hr/120°C)	pH	6.0
	Electric conductivity (μ S/cm)	30
	Cl ⁻ (ppm) *	10
	Br ⁻ (ppm) *	<1

Note *: Calculated in terms of concentration in resin

Further, the molecular weight distribution was determined by gel permeation chromatography. The result is shown in Fig. 3 as a graph which relates the retention time (as abscissa) with the relative intensity (as
 10 ordinate).

These results reveal that the purified phenolic resol resin contains only a very small amount of ionic impurities.

Further, it is apparent from Fig. 3 that the
 15 reaction product comprises mainly multinuclear components of two, three or more nuclei and contains little of the

1 unreacted low molecular weight components.

Molding compositions for use in the present invention will be described further in detail below in the following Examples.

Examples 1-3

5 Molding materials were prepared by using, in mixing ratios shown in Table 2 later, a phenolic resol resin purified by the above-mentioned method and a bisphenol A-type epoxy resin as the resin component, spherical fused silica having an average particle diameter
10 of 15 μm as the filler, epoxysilane as the coupling agent, montanic acid ester wax as the mold release agent, and carbon black as the coloring agent. The respective starting materials were kneaded by using a two-axle roll at a roll surface temperature of about 60-75°C for about
15 10 minutes.

Examples 4 (Comparative), 5 and 6

Three kinds of molding materials were prepared in the same manner as described above and by using the same starting materials as in the above Examples in
20 mixing ratios shown in Table 2.

Example 7 (Comparative)

A molding material of the same mixing ratio as in Example 2 as shown in Table 2 was prepared by using as the resin component an unpurified resol-type phenol
25 resin (softening point: 60°C; gelation time: 30 sec;

1 pH, electric conductivity, and extracted Cl ion content of aqueous extract after 120 hours of extraction at 120°C: respectively 9.5, 4500 μ S/cm and 1540 ppm).

Example 8 (Comparative)

5 A molding material was prepared by kneading 90 parts by weight of an o-cresol novolak-type epoxy resin (epoxy equivalent: 195, softening point: 75-80°C) and 10 parts by weight of a brominated bisphenol A-type epoxy resin (epoxy equivalent: 394, softening point: 10 65°C) as the resin component, 55 parts by weight of a phenol novolak resin (hydroxyl equivalent: 106, curing temperature: 65°C) as the curing agent, 1.0 part by weight of triphenylphosphine as the cure accelerator, 470 parts by weight of fused silica having an average 15 particle diameter of 15 μ m as the filler, 10 parts by weight of antimony trioxide as the flame retarding assistant, 3.0 parts by weight of epoxysilane as the coupling agent, 1.0 part by weight of montanic acid ester wax as the mold release agent, and 1.0 part by weight of 20 carbon black as the coloring agent, with a two-axle roll in the same manner as in the above Example.

Example 9 (Comparative)

A non-flame resistant type epoxy resin molding material was prepared by kneading 100 parts by weight of 25 an o-cresol novolak-type epoxy resin (epoxy equivalent: 195, softening point: 75-80°C) as the resin component,

1 58 parts by weight of a phenol novolak resin (hydroxyl
equivalent: 106, softening point: 65°C) as the curing
agent, 1.0 part by weight of triphenylphosphine as the
cure accelerator, 480 parts by weight of spherical fused
5 silica having an average particle diameter of 15 μ m as
the filler, 3.0 parts by weight of epoxysilane as the
coupling agent, 1.0 part by weight of montanic acid ester
wax as the mold release agent, and 1.0 part by weight of
carbon black as the coloring agent, with a two-axle roll
10 in the same manner as the above Example.

Each of the molding materials thus obtained
was examined for its moldability at 170°C. Separately,
it was molded at a mold temperature of 170°C, molding
pressure of 70 kg/cm² and a molding time of 90 sec and
15 then post-cured at 180°C for 15 hours. The molded product
was examined for its various properties. Further, the
molded product was ground to pass through a 100-mesh
screen, then 50 g of deionized water was added to 5 g of
the resulting powder, the mixture was heated at 120°C for
20 120 hours, and the resulting water was examined for pH
and electric conductivity and analyzed for ionic impurities
extracted. The results of these tests are collectively
shown in Table 2. The adhesive property in the Table
refers to the value obtained by sealing the tip of a
25 42 alloy specimen 0.25 mm thick and 5 mm wide with each
molding material (sealed part: 10 mm) and subjecting
the specimen to a drawing test.

Table 2

Item		Example 4	Example 1	Example 2
Composition (part by weight)	Resol-type phenol resin	100	90	80
	Epoxy resin	0	10	20
	Filler	300**	300	300
	Coupling agent	2	2	2
	Mold release agent	1	1	1
	Coloring agent	1	1	1
Moldability	Melt viscosity (P)	2500	600	350
	Spiral flow (inch)	3	32	50
	Gellation time (sec)	15	18	23
	Glass transition temp. (°C)	250	235	230
Properties of cured product	Linear expansion coefficient (10-5/°C)	1.5	1.6	1.6
	Bending strength (kg/mm ²)	20	19	18
		250°C	2.5	3.2
	Flame resistance (UL-94, 1.6 mmt specimen)		V-0	V-0
	Extract properties (120 h/120°C)	pH	6.0	5.8
		Conductivity (μS/cm)	60	70
		Cl (ppm)	<1	2
		Br (ppm)	<1	<1
	Adhesive property (kg/mm ²)*		0.3	1.2
	Adhesive property (kg/mm ²)*		1.2	1.5

- Cont'd -

Table 2 (Cont'd)

Example 3	Example 5	Example 6	Example 7	Example 8	Example 9
75	70	60	80*	Described in the text	
25	30	40	20		
300	300	300	300		
2	2	2	2		
1	1	1	1		
1	1	1	1		
310	205	115	515	200	240
56	60	90	28	40	38
25	25	40	19	25	25
220	210	180	230	170	170
1.6	1.7	1.8	1.6	2.0	1.9
19	18	14	18	13	12
3.0	2.0	1.0	3.4	0.8	0.7
V-0	V-1	HB	V-0	V-0	HB
5.5	5.5	4.8	8.8	4.5	4.5
76	72	75	1500	120	80
4	6	10	500	15	12
<1	<1	<1	<1	20	<1
1.5	1.6	1.4	1.3	0.8	0.9

Note

* Unpurified resol-type phenol resin was used.

** Corresponding to about 62% by volume

*** In terms of drawing strength of realed product (sealed part: 10 mm) of 42 alloy specimen (0.25 mm thick, 5 mm wide)

1 Further, the following test was made to reveal
the influence of the molding material of the present
invention exerted, when the material is used for electronic
parts, on the corrosion and the connection reliability of
5 the aluminum electrode and the gold wire-aluminum
electrode joint of semiconductor devices. As shown in
Fig. 2, each of the various molded articles was placed
together with a bare element to which a gold wire had
been bonded in a glass ampoule having an inner diameter
10 of 30 mm and a length of 150 mm, then the whole was
heated at 230°C, and the change of the joining strength
of gold with aluminum with the elapse of time during the
heating was determined. The results obtained are shown
in Fig. 1.

15 Thus, Fig. 1 is a graph showing the influences
of a variety of molding materials (in the form of molded
products) on the connection reliability at high tempera-
ture of the gold wire - aluminum electrode joint in terms
of a relation between the heating time at 225°C (hours,
20 as abscissa) and the gold/aluminum joining strength (g,
as ordinate).

Fig. 2 is a schematic cross-sectional view of
the test apparatus and the specimen used in the test
method of Fig. 1. In Fig. 2, numeral 1 denotes a silicon
25 chip, 2 gold wire, 3 lead frame, 4 silver paste (adhesive
agent), 5 cured resin (molded product) and 6 glass
ampoule.

As is apparent from Table 2, while the molding

1 material of Comparative Example 4, in which resol-type
phenol resin is used alone as the resin component, has
a high melt viscosity and very poor moldability, the
molding materials of Examples 1 to 3
5 which contain epoxy resin compounded therein,
not only have a good moldability but also show good high-
temperature properties (glass transition temperature and
bending strength) as molded products. However, when the
amount of compounded epoxy resin is increased as shown in
10 Examples 5 and 6, the high-temperature properties of the
molded product deteriorate as in the epoxy resin molding
materials shown in Examples 8 and 9, and further the
flame resistance of the molded product lowers and becomes
unable to fulfil the flame resistance grade V-0 of the
15 UL standards. Further, the properties of extracts
determined with pulverized molded products show that when
the resol-type phenol resin is used after purification,
the pH shows neutrality to weak acidity, electric conduc-
tivity is low, and the amount of extracted halogen ions
20 is also low. The adhesive property to 42 alloy is also
substantially good as compared with prior epoxy resin
molding materials.

Fig. 1 shows one of the most important features
of the present invention. It is apparent from Fig. 1
25 that the molded product according to the present invention
gives only an extremely little influence on the corrosion
of the aluminum electrode and the connection reliability
of the gold wire-aluminum joint. Such phenomena of

1 corrosion or deterioration of reliability are generally
considered to be due to the effect of the thermal decom-
position product of a brominated compound incorporated
into a molding material as a flame retardant. This is
5 evidenced from the comparison of Example 8 with Example
9. The molding material of the present invention can be
highly flame resistant without incorporation of such a
flame retardant and thus exhibits excellent character-
istic properties as described above.

10 Example 10

Semiconductor devices were sealed by using
each of the molding materials obtained above and the
various reliabilities were evaluated. The semiconductor
device used had an aluminum wiring on the surface, and a
15 chip 6x8 mm square in size was adhered to the tab of a
lead frame with silver paste, the aluminum electrode on
the chip and the lead frame being connected electrically
with gold wire. The package was 15x20 mm in size and 2
mm in thickness, and the semiconductor device was sealed
20 so as to be situated around the center of the package.
Sealing was conducted with a transfer molding machine.
Molding was carried out under conditions of a mold tem-
perature of 170°C, molding pressure of 70 kg/cm² and
molding time of 1.5 minutes. The molded products were
25 thereafter post-cured at 170°C for 15 hours. Then the
sealed products thus obtained were subjected to a pressure
cooker test (PCP) at 121°C and 2 atm. to examine the time

1 which elapsed until the development of corrosion and
defect of aluminum wiring. Further, the sealed products
were allowed to stand in a high-temperature bath at 225°C
to examine the time which elapsed until the development
5 of defective connection at the joint of gold wire with
aluminum wiring. Further, the sealed products were
allowed to stand at 65°C and at a relative humidity of
95% for 168 hours and then heated in a vapor reflow bath
at 215°C for 150 seconds to examine the development of
10 package cracks. The results of these tests are collec-
tively shown in Table 3.

It is apparent from Tables 2 and 3 that the
respective properties examined of the molded product of
the present invention are highly excellent as compared
15 with those of the prior art products.

Table 3

Item		Example 4	Example 1	Example 2	Example 3
Development rate of corrosion defect of aluminum wiring *1	After 300 h	Sample preparation was impossible owing to breaking of gold wire during molding.	0/10	0/10	0/10
	" 500 h		0/10	7/10	0/10
	" 1000 h		5/10	3/10	2/10
	" 2000 h		10/10	10/10	7/10
Development rate of defective connection at gold/aluminum joint *2	After 50 h		0/10	0/10	0/10
	" 100 h		0/10	0/10	0/10
	" 200 h		2/10	0/10	0/10
	" 500 h		10/10	10/10	6/10
Crack development rate of humidified package in reflow *3		0/10	0/10	0/10	0/10

Note

*1: Moisture resistance test in steam at 121°C and 2 atm.

*2: Standing test in high-temperature bath at 225°C

*3: Crack development rate of package when heated in vapor reflow bath at 215°C for 150 sec after standing at 65°C and 95% RH for 168 hours.

(Respective values in the Table indicate the number of defective samples relative to the total number of samples.)

- Cont'd -

Table 3 (Cont'd)

Example 5	Example 6	Example 7	Example 8	Example 9
0/10	0/10	5/10	0/10	0/10
0/10	3/10	10/10	1/10	0/10
6/10	10/10	-	8/10	3/10
10/10	-	-	10/10	10/10
0/10	0/10	1/10	8/10	0/10
0/10	1/10	7/10	10/10	0/10
1/10	4/10	10/10	-	2/10
10/10	10/10	-	-	10/10
0/10	2/10	0/10	10/10	10/10

1 Examples 11 to 13 and Example 14 (Comparative)

Molding materials were prepared by using, relative to 80 parts by weight of the phenolic resol resin prepared in Preparation Example 1 described above. 5 used as the resin component, an epoxy resin, an inorganic ion exchanger of antimony type (IXE-300, mfd. by Toagosei Chemical Industry Co., Ltd.), of bismuth type (IXE-500, ditto), or of the binary mixture type of the two (IXE-600, ditto) as the ion .changer, spherical fused silica having an 10 average particle size of 15 μ m as the filler, montanic acid ester wax as the mold release agent, and carbon black as the coloring agent respectively in the mixing ratios shown in Table 4. The respective starting materials were kneaded by using two-axle roll 20 inches in diameter at 15 a roll surface temperature of about 60°C for about 10 minutes.

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Example 15 (Comparative)

A molding material was prepared by using a conventional unpurified resol-type phenol resin (aqueous 25 extract after 120 hours of extraction at 120°C showed a pH of 9.5, electric conductivity of 4500 μ S/cm and

- 1 extracted Cl ion content of 1540 ppm) and according to the compounding ratio shown in Table 4.

A variety of tests were made in the same manner as in Tables 1 to 3 with the molding materials of Examples 11 to 15 described above. The results of the tests are collectively shown in Table 4.

Table 4

Item		Example 11	Example 12
Composition (part by weight)	Purified resol-type phenol resin	80	80
	Unpurified "	-	-
	Epoxy resin	20	20
	Inorganic ion exchanger IXE-300	5	-
	" IXE-500	-	5
	" IXE-600	-	-
	Fused silica	300	300
	Coupling agent	2	2
	Mold release agent	2	2
	Coloring agent	1	1
Moldability	melt viscosity (P)	300	320
	Spiral flow (inch)	33	30
	Gellation time (sec)	18	17
	Glass transition temp. (°C)	230	232
Properties of cured product	Linear expansion coefficient (10 ⁻⁵ /°C)	1.5	1.6
	Bending strength (kg/mm ²)	20	20
	Room temp. 250°C	3.6	3.5
	Flame resistance (UL-94, 1.6 mmt specimen)	V-0	V-0
	Adhesive property (kg/mm ²)	1.6	1.5
	pH	5.0	4.8
	Extract properties (120 h/120°C)		
	Conductivity (μS/cm)	55	63
	Cl ⁻ (ppm)	<1	<1
	Br ⁻ (ppm)	<1	<1
	NH ₄ ⁺ (ppm)	5	6

- Cont'd -

Table 4 (Cont'd)

Example 13	Example 14	Example 15
80	80	-
-	-	80
20	20	20
-	-	5
-	-	-
5	-	-
300	300	300
2	2	2
2	2	2
1	1	1
315	305	175
32	33	58
18	17	17
228	230	235
1.5	1.6	1.6
19	20	19
3.5	3.4	3.4
V-0	V-0	V-0
1.6	1.5	1.3
5.2	6.2	8.2
60	125	650
<1	<1	45
<1	<1	25
5	25	135

1 As described above, the resin composition of
the present invention provides useful

electronic parts for which an excellent heat resist-
ance, flame resistance and electric properties and a low
5 ionic impurity content are required.

Further, the plastic molded type semiconductor
device of the present invention is excellent in such
properties as moisture resistance reliability, connection
reliability of the gold wire - aluminum joint, and crack
10 resistance of a package which has been solder-mounted in
a humidified state. Thus, the present invention can
provide highly reliable semiconductor devices.

CLAIMS

1. A plastic molded electronic device, wherein the device is sealed or transfer-molded with a phenolic resin molding composition comprising a resin component
5 consisting of a phenolic resol resin and a cure-rate controlling agent in a weight ratio of from 75:25 to 95:5, the phenolic resin molding composition having a purity such that it gives, when ground and extracted by heating with 10 times the amount of hot water at 120°C
10 for 100 hours or more, an extract having an electric conductivity of 100 μ S/cm or less, a pH of 4-7 and a halogen ion content of 10 ppm or less (calculated as content in the molding composition).
2. A device according to claim 1 wherein the
15 cure-rate controlling agent is at least one epoxy resin.
3. A device according to claim 1 or claim 2 wherein the molding composition further comprises 55 to 80% by volume of an inorganic filler relative to the
20 total volume of the composition.
4. A device according to claim 3 wherein the inorganic filler is at least one of fused silica, crystalline silica, and alumina, and has an average particle diameter of 1-30 μ m.
- 25 5. A device according to any one of claims 1 to 4 wherein said electronic device is a semiconductor



device and includes an aluminum electrode and a gold wire joined to said aluminum electrode.

6. A device according to any one of claims 1 to 5 wherein the phenolic resin molding composition is free
5. from a flame-retarding agent.

7. A plastic molded electronic device according to claim 1, substantially as any herein described in the Examples.
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