

EPOXY RESIN COMPOSITION

FIELD OF THE INVENTION

5 The present invention relates to an epoxy resin compound used for sealing of semiconductor devices, which consists of well dispersed raw materials, especially fine filler, and consequently provides an excellent flowability epoxy resin compound.

10 BACKGROUND OF THE INVENTION

Electronic parts such as diodes, transistors, integrated circuits and the like have typically been sealed with a thermosetting resin. In integrated circuits, thermosetting resins have been used. In particular, an epoxy resin obtained by
15 curing an ortho-cresol novolac epoxy resin or di-cyclo-pentadiene type with a novolac type phenolic resin was found to have excellent heat and moisture resistance.

However epoxy resins cannot act as encapsulants alone due to their high coefficient of thermal expansion (CTE) and low thermal conductivity.
20 Many other additives, such as inorganic filler, coloring agent, stress-relief agent, accelerator and etc are employed with epoxy resin to enhance the performance of epoxy resin compounds.

In recent years, with higher integration of integrated circuits, chips have becomes larger and surface-mounted have been gradually switched from DIP
25 (Dual Inline Package) to small thin flat packages such as SOP (Small Outline Package), SOJ (Small Outline J-leads), PLCC (Plastic Leaded Chip Carrier) and the like. Thus, large chips are sealed in a small thin package. This, however, produces problems such as generation of cracks caused by stress, reduction in moisture resistance caused by said cracks, and the like.

30 In the soldering step, in particular, the package is suddenly exposed to high temperature of 200 °C or above, which invites cracking of the package or separation of sealing resin from chips, which causes reduction in moisture resistance.

Fillers are employed in epoxy resins for many reasons. The main functions of filler are to control the viscosity, and reduce the mold shrinkage and coefficient of thermal expansion. In addition, by increasing the filler content in a compound, lower water absorption of epoxy resin can be achieved. This will greatly enhance the moisture resistance of the compound and in turn improve the final solder crack reliability of the compound. However, by increasing the filler loading of a compound, interaction between fillers will increase during molding. As a result, flowability of compounds often becomes difficult. This is especially significant for filler particles with sharp edges such as crystalline fillers and flake fused fillers. To address this problem, fillers are often used in compounds in controlled particle size distributions. By including a mixture of fine particles and coarse particles, interparticle impact will be reduced and overall compound flowability can be improved [1].

Some examples of prior art are as follow:

US Patent 6,054,222 and 5,908,882 disclose an epoxy resin composition comprising an epoxy resin, a curing agent, a cure accelerator, a carbon black and a silica powder. In US Patent 6,054,222, the silica powder composed of three groups of silica powder differing in particle diameter ranging from 5 to 75 μm , 0.2 to 0.9 μm and 0.01 to 0.08 μm and the mixing ratios based on the total of silica powder is 50-90% 10-35% and 0.1-5% by weight respectively. The composition disclosed did not include the use of crystalline filler and this could result in poor reliability due to weaker flexural strength of using purely fused silica powder alone.

In US Patent 5,908,882, the silica powder has an average particle diameter of not more than 30 μm , 5-30% and 15-45% by weight of silica having an average particle diameter of not more than 7 μm and 5 μm respectively in the total resin content and the maximum particle diameter of the total resin content of not more than 150 μm . The composition disclosed did not include the ratio of crystalline/fused filler. Furthermore, the disclosed composition of maximum particle diameter of the total resin content of not more than 150 μm could result in poor flowability and moldability.

US Patent 6,005,030 discloses an epoxy resin composition comprising an epoxy resin, a curing agent and inorganic filler, wherein the inorganic filler

compose 15-50% and 50-85% by weight of 75 to 150 μm and less than 75 μm in particle size respectively. The composition disclosed did not include particle size below 12 μm and thus could result in poor flowability and moldability.

Any discussion of documents, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms a part of the prior art base or the common general knowledge in the relevant art in Singapore or elsewhere in the world on or before the priority date of the disclosure and claims herein. All statements as to the date or representation as to the contents of these documents is based on the information available to the applicant and does not constitute any admission as to the correctness of the dates or contents of these documents.

SUMMARY OF THE INVENTION

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The objective of this invention is to provide an epoxy resin composition, which, through the use of a mixture of crystalline and fused fillers, can achieve good moldability and reliability, especially when encapsulating a large, and high pin-count IC package.

20 According to the present invention, there is provided an epoxy resin composition comprising:

- (A) an epoxy resin;
- (B) a phenolic novolac curing agent;
- (C) an inorganic filler, of mixed crystalline and fused type, with an amount of 70 to 90% by weight based on the total resin composition; and
- (D) a curing accelerator

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Suitably the weight percentages of the components of the total resin composition fall within the following ranges:

- (A) 6% to 20%
- (B) 3% to 12%
- (C) 70% to 90%
- (D) 0.05% to 0.8%

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and the ratio of (A) to (B) is between 1.2 and 2.5.

It may further include carbon black. The carbon black may be present at a level of 0.1% to 2% by weight, expressed as a weight percentage of the total resin composition.

5 The resin may be formulated to have a spiral flow between 80cm and 130cm more preferably between 90cm and 125cm. It may be formulated to have a flexural modulus between 1600kgf/mm² and 2200kgf/mm² more preferably between 1800kgf/mm² and 2050 kgf/mm².

BRIEF DESCRIPTION OF THE DRAWINGS

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Figure 1 shows a spiral flow mold die.

DETAILED DESCRIPTION OF THE INVENTION

15 A crystalline-filler based compound tends to give poor moldability, especially when used to encapsulate large packages. During molding of a crystalline-filler based compound, interaction and friction between the sharp edges of the regular, geometrically shaped filler render the flow of compound difficult. At the same time, due to layers of inert liquid being trapped on the
20 uneven surface of the fillers, there is an effective increase in the filler concentration, thereby making the flow difficult [1]. This will give the compound poor flowability. Poor compound flowability in turn creates other moldability problems such as voids, wire sweep and poor adhesion. At the same time, crystalline-filler based compounds exert very high stress within the package
25 itself, thereby subjecting the package to high reliability failure. Measurement of the stress of a 100% by weight crystalline-filler compound will give a very high value.

Fused filler, on the other hand, with its finer and wider particle size distribution, provides less hindrance in compound flow and exerts lesser stress
30 on the package. To retain the benefits of high thermal conductivity and low cost of crystalline filler, applicant's have found fused filler can be added at a certain percentage to a crystalline-filler compound to improve flowability and reliability. In addition, a wide filler size distribution can be employed to enhance flowability

and packing. Smaller particles, interposed between larger particles, can act as a lubricant to facilitate the rotation of bigger particles. This helps to reduce inter-particle impact, thus improving the flowability and reducing the viscosity [1]. Applicant's have found a good combination of crystalline and fused filler, with a wide particle size distribution, should give good compound flowability and improved package reliability.

For high crystalline filler loadings, flowability becomes worse. Therefore, even with a good combination of crystalline and fused filler with a wide filler size distribution, the targeted flow and viscosity may still not be achieved. In this case, it is preferable to use low viscosity resin and hardener to aid in compound flow. Total filler content is preferably between 70 –90% by weight, above which the flowability can be poor. Below 70% by weight, the Moisture Sensitivity Level (MSL) performance may deteriorate due to higher water absorption and weaker flexural strength.

A purely crystalline-filler based compound of more than 70 % by weight filler content has poor moldability, with internal and external void problem, and poor package reliability, not even achieving Joint Electron Devices Engineering Council (JEDEC) Moisture Sensitivity Level (MSL) 3, with a stress as high as ~3.8 or more. By replacing 25-75 % by weight of the crystalline filler with fused filler, flowability improved significantly with spiral flow increasing by up to 1.5 times and better moldability achieved. At the same time, package reliability is able to achieve up to JEDEC MSL 2A and stress falling to ~3.0. In one aspect of the invention, epoxy resin with viscosity of 0.8 - 1.8poise ICI at 150 °C and phenolic resin with viscosity of 1.5 – 3.0 poise ICI at 150 °C are used although the preferred embodiment of the invention utilises epoxy resin with viscosity of 1.8poise ICI 150 °C and phenolic resin with viscosity of 1.5poise ICI at 150 °C.

Studies based on different ratios of crystalline/fused silica filler shows that longer spiral flow can be achieved with a mixture of crystalline and fused inorganic silica fillers with a particle distribution of crystalline silica filler between 25 to 45 % by weight for particle size below 12 μm , between 55 to 75 % for particle size between 12 to 90 μm and below 3 % by weight for particle size above 90 μm , and, particle distribution of fused silica filler between 25 to 45 % by weight for particle size below 10 μm , between 55 to 75 % by weight for particle size between 10 to 100 μm and below 3 % by weight for particle sizes

above 100 μm . In a preferred embodiment, the mixture of crystalline silica filler has a particle distribution between 25 to 35 % by weight for particle size below 12 μm , between 55 to 65 % by weight for particle size between 12 to 90 μm and below 3 % by weight for particle size above 90 μm and fused silica filler
5 has a particle distribution between 25 to 35 % by weight for particle size below 10 μm , between 55 to 65 % by weight for particle size between 10 to 100 μm and below 3 % by weight for particle size above 100 μm .

For samples which use crystalline/fused silica filler, for crystalline silica filler below 25 % by weight for particle size below 12 μm , above 65 % by weight
10 for particle size between 12 to 90 μm and above 3 % by weight for particle size above 90 μm , and, particle distribution of fused silica filler between below 25 % by weight for particle size below 10 μm , above 65 weight percent for particle size between 10 to 100 μm and above 3 % by weight for particle size above 100 μm did not exhibit good flowability and this in turn caused voiding. Also,
15 due to poor wettability, delamination on top die after MSL 3 and MSL 2A and internal cracking after MSL 2 were detected.

The earliest materials used for plastic packaging of microelectronic devices were silicones, phenolics and bisphenol A (BPA) epoxies because of their excellent molding characteristics. Silicones were used as molding
20 compounds because of their high-temperature performance and purity. Poor adhesion of silicones with the device and metallization resulted in device failure in salt spray tests and flux penetrants during soldering. Although epoxy materials offer much better adhesion than silicones, the common epoxides such as BPA have a low glass transition temperature in the range of 100 to
25 120 $^{\circ}\text{C}$, and high concentrations of corrosion agents such as chloride ions [2].

In the formulation for this application, ortho-cresol-novolac epoxy resins displaced BPA materials because of their high epoxide functionality and improvement in heat-distortion temperature. Mold compounds have moved steadily toward all epoxy systems as the high temperature novolac materials
30 were improved and the hydrolyzable impurity levels were driven below 20ppm [2].

The binder system of a plastic encapsulant product consists of an epoxy resin of cresol novolac type or di-cyclo-pentadiene type, hardener or curing

agent, and an accelerating catalyst system. The chemically active compounds known as curing agents accomplish the conversion of different epoxies from liquid state to tough, hard thermoset solid state.

5 In this case, incorporation of phenol novolac is used to increase cure speed. The glass transition curing temperature is maximized at an epoxide to hydroxyl of about unity.

The curing accelerator used in the present composition can be any material as long as it can accelerate the reaction between the epoxy group of the component (B) and the hydroxyl group of the component (C). There can be
10 widely used those curing accelerators generally used in sealing materials, such as diazabicycloundecene (DBU), triphenylphosphine (TPP), benzyldimethylamine (BDMA), 2-methylimidazole (2-MZ) and the like. These compounds can be used alone or in combination of two or more. The curing accelerator used is preferably 0.01 to 0.6% by weight in the total epoxy resin
15 composition. In the preferred embodiment, 0.1 to 0.4% of triphenylphosphine (TPP) by weight of the total epoxy resin of triphenylphosphine (TPP) is used.

The curing accelerator is preferably used in an amount of 0.1 to 0.4 % by weight in the total epoxy resin composition. In an amount less than 0.1 % by weight, hardness of the resulting molded product decreases and mold release
20 characteristics may tend to deteriorate. In an amount more than 0.4 % by weight, the reaction can proceed undesirably fast and fluidity tends to decrease.

The present epoxy resin composition used for sealing comprises, as essential components, an epoxy resin, a curing agent, an inorganic filler and a curing accelerator. The resin composition may further comprise, if necessary,
25 various additives such as silane coupling agent, flame retardant (e.g. brominated epoxy resin, antimony trioxide or hexabromobenzene, Phosphorus), coloring agents (e.g. carbon black or red iron oxide), releasing agent (e.g. natural wax or synthetic wax), stress- reducing additive (e.g. silicone oil or rubber), and the like. In one embodiment of the invention, the epoxy resin
30 composition further includes carbon black. The carbon black may be present at a level of 0.1% to 2% by weight, expressed as a weight percentage of the total resin composition.

In producing the present epoxy resin composition for sealing as a molding material, an epoxy resin, a curing agent, a curing accelerator, filler and

other additives are mixed sufficiently and uniformly using hot rolls, a kneader or the like; and the kneaded product is cooled and ground. The molding material thus obtained can be used for sealing, coating, insulation, etc. of electronic parts or electric parts.

5 The present invention is hereinafter described specifically by way of Examples. The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to make and use the present invention, and are not intended to limit the scope of what the inventors regard as their invention nor are they intended to represent
10 that the experiments below are all and only experiments performed. Efforts have been made to ensure accuracy with respect to numbers used (e.g. amounts, temperature, etc) but some experimental errors and deviations should be accounted for. In the Examples, the amount of each component used in compounding is parts by weight.

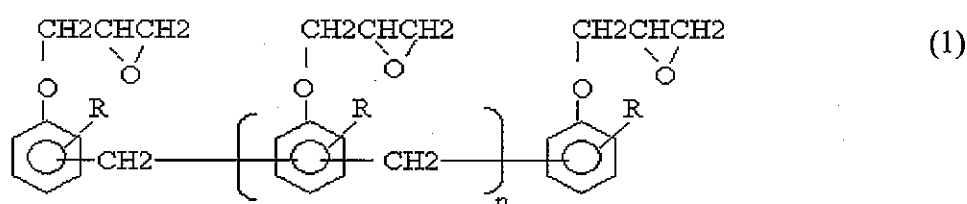
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EXAMPLES

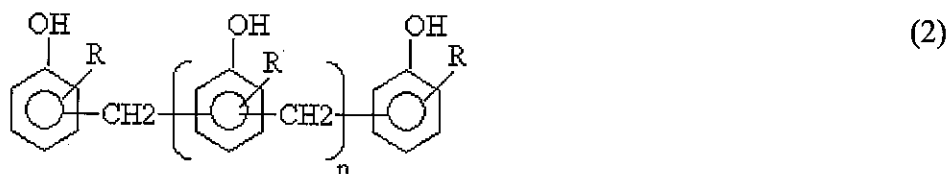
Example 1

The following components of the following proportions are mixed at room temperature in a mixer:

	Parts by weight
Cresol novolac type of epoxy compound (softening point: 55 °C, epoxy equivalent: 196g/eq) represented by Formula I	12.33
Phenolic novolac curing agent (melting point: 75 °C, hydroxyl equivalent = 105g/eq) represented by Formula II	6.20
Triphenylphosphine (TPP)	0.18
Crystalline silica	38.44
Fused silica	38.44
Carbon Black	0.30
Others (quantity of in example 1 in Table 1 will vary)	3.70



wherein R which may be the same or different, is an atom or group selected from the group consisting of hydrogen atom, halogen atoms and C₁ to C₄ alkyl groups; and n is an integer of 0-10



- 5 wherein R is independently an atom or group selected from hydrogen atom, a halogen and an alkyl group; and n is an integer of 0-10.

The mixed powder was kneaded at 70 to 100 °C. using a bi-axial roll, cooled and ground to obtain a molding material.

- Then, the epoxy resin composition was subjected to the following
10 evaluation tests:

(1) Spiral flow measurement

- A certain amount of molding material sufficient to give a cull thickness of $3 \pm 0.3\text{mm}$ was weighed. A spiral flow mold die as shown in Figure 1 was placed in the molding machine and was heated up to 175 °C. When the
15 temperature reached 175 °C, a measured amount of molding material was poured into the transfer pot and plunger was lowered. The molding pressure used is 63kg/cm². The material was molded for 120sec then the mold press was opened, the spiral flow length (up to the lustrous tip) was measured after the mold die was taken out from the molding machine.

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(2) Stress measurement

$$\text{Stress at } T^{\circ}\text{C} \approx (\alpha_1 - \alpha_{\text{chip}})(T - T_g)E_1 + (\alpha_2 - \alpha_{\text{chip}})(T_g - 175)E_2$$

$$\text{Stress} = 0 \text{ at } 175^{\circ}\text{C (Mold Temp.)}, \alpha_{\text{chip}} = 0.3 \times 10^{-5},$$

- 25 where

α_1 - coefficient of thermal expansion of compound below the glass transition temperature, T_g

α_{chip} - coefficient of thermal expansion of IC chip, $\sim 0.3 \times 10^{-5} / ^{\circ}\text{C}$

E_1 - flexural modulus of compound measured at 25 °C

- 30 E_2 - flexural modulus of compound measured at 240 °C

(3) Measurement of coefficient of thermal expansion

The molding material was made into tablets and then molded into specimens of diameter 15 ± 2 mm, thickness 3-5 mm, using a 75 ton transfer molding machine. The specimens were subjected to testing by the Thermal Mechanical Analyzer that measured the glass transition temperature, T_g , and the coefficients of thermal expansion below and above T_g .

(4) Measurement of flexural modulus

The molding material was made into tablets and molded into specimens of dimensions :

Length : minimum 60 mm

Width : 10 ± 0.5 mm

Thickness : 4 ± 0.2 mm

The specimens were then subjected to testing by the Tensilon machine at 20 to 25 °C which measured the Flexural strength and Flexural modulus of the compound where:

Flexural strength : the ability of a material to withstand bending forces applied perpendicular to its longitudinal axis with simply supported ends may be defined as

$$\text{Flexural strength} = \frac{3 \cdot L_v \cdot P}{2 \cdot W \cdot H^2}$$

L_v = span of support (mm)

W = width of test specimen (mm)

P = Load applied to fracture test specimen (kgf)

H = Height of test specimen (mm)

Flexural modulus : a measure of the stiffness of the material during the first or initial part of the bending process [3].

(5) Moldability

The molding material was made into cylindrical tablets of diameter 40 mm by 28.60 g before it was molded into 100L Quad-Flat-Packages (QFP), 14 mm x 20 mm x 2.7 mm, encapsulating chips of size 7.5 mm x 7.5 mm under the conditions of 175 °C, 100 kg/cm² and 120 seconds, using a low pressure

transfer molding machine. The packages sealed with these chips are used to obtain devices for moldability check, in this case, internal and external void and for the solder crack resistance test.

5 (6) Solder crack resistance test

The devices for the solder cracking test were allowed to stand in an atmosphere of 30°C/60%RH for 192 hours for MSL 3 testing according to JEDEC (Joint Electron Devices Engineering Council) standard. Then, the devices were passed through the IR reflow oven of 260 °C as peak
10 temperature for 10 seconds three times. Thereafter, the cracks present at the surfaces of the devices were observed using a microscope. In addition, the packages are also scanned using CSAM (C-mode Scanning Acoustic Microscope) for delaminated interfaces. The result was expressed as the number of cracked/delaminated devices/ total number. The test was repeated
15 for Moisture Sensitivity Level -2A testing where the devices were soaked in conditions of 60 °C/60%RH for 120hours before passing through IR reflow oven at 260 °C three times.

The results of the above-mentioned tests are shown in Table 1.

20 Example 2-6 and Comparative Example 1-3

According to the formulation shown in Table 1, the components were blended and resin compositions were obtained and the tests were obtained in the same manner as in Example 1. The test results obtained are shown in
25 Table 1. The results clearly showed that mixture of crystalline and fused inorganic silica fillers within the defined range is critical in determining moldability namely external and internal voids, and solder crack resistance in terms of delamination on top die surface and internal cracks.

The mixture of crystalline and fused inorganic silica fillers ratio outside of
30 the defined range caused significantly poorer flowability which in turn caused internal and external voids. This poor flowability behaviour also contributed to weaker adhesion due to poorer wetting behaviour and it in turn caused delamination on the top die surface and led to internal cracks.

On the other hand, mixtures of crystalline and fused inorganic silica fillers within the defined range and ratios were able to combine with various softening point cresol novolac epoxy resin and various softening point phenol resin curing agent to achieve acceptable moldability and solder crack resistance criteria.

Example 7-8 and Comparative Example 4-5

According to the formulation shown in Table 1, the components were blended and resin compositions were obtained and the tests were obtained in the same manner as in Example 1. The test results obtained are shown in Table 1. The results again showed that a mixture of crystalline and fused inorganic silica fillers within the defined range is critical in determining moldability namely external and internal voids, and solder crack resistance in terms of delamination on top die surface and internal cracks.

The above-mentioned examples were conducted with a variation of 2% by weight of the total filler content. The mixture of crystalline and fused inorganic silica fillers ratio outside of the defined range caused significantly poorer flowability and adhesion, which in turn caused delamination on the top die surface and lead to internal cracks. The phenomenon is same as for Comparative Example 1-3.

On the other hand, mixtures of crystalline and fused inorganic silica fillers ratio within the defined range are able to achieve acceptable moldability and solder crack resistance criteria.

Example 9 and Comparative Example 6

According to the formulation shown in Table 1, the components were blended and resin compositions were obtained and the tests were obtained in the same manner as in Example 1. The test results obtained are shown in Table 1. The results again showed that a mixture of crystalline and fused inorganic silica fillers within the defined range is critical in determining moldability namely external and internal voids, and solder crack resistance in terms of delamination on the top die surface and internal cracks.

These two examples were conducted with the addition of 5% by weight of the total filler content with Dicyclopentadiene resin. The mixture of crystalline and fused inorganic silica fillers ratio outside of the defined range again caused significantly poorer flowability though the solder crack resistance was able to
5 pass the criteria.

References

1. Shenoy, Aroon V, Rheology of Filled Polymer Systems (1999) Kluwer Academic, The Netherlands, pg 147-150.
- 10 2. Pecht, Michael G., Nguyen, Luu T., Hakim, Edward B. Plastic-Ecapsulated Microelectronics (1995) John Wiley and Sons, New York, pg 25-29.
3. Shah, Vishu, Handbook of Plastic Testing Technology (1998) John Wiley & Sons, New York, pg 56-59.

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All references cited herein are hereby incorporated by reference in their entireties, whether previously specifically incorporated or not, for all purposes. Citation of any reference herein is not intended as an admission that any of the foregoing is pertinent prior art, nor does it constitute any admission as to the
20 contents or date of these documents.

Having now fully described this invention, it will be appreciated by those skilled in the art that the same can be performed within a wide range of equivalent parameters, concentrations, and conditions without departing from the spirit and scope of the invention and without undue experimentation.

25 While this invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications. This application is intended to cover any variations uses or adaptations of the invention following in general, the principles of the invention and including such departures from the present disclosure as come within
30 known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

Table 1. Epoxy resin compositions and results of the physical properties and reliability

	Examples										Comparative Examples					
	% by weight															
	1	2	3	4	5	6	7	8	9		1	2	3	4	5	6
Cresol novolac type epoxy resin (softening point 55°C, epoxy equivalent: 196 g/eq)	12.33	12.33	12.33	-	-	12.33	13.39	10.31	-		12.33	12.33	12.33	13.39	10.31	-
Phenolic novolac curing agent (softening point 80°C, epoxy equivalent: 104 g/eq)	6.92	6.92	6.89	-	6.92	-	7.04	5.22	2.84		6.92	6.92	6.92	7.04	5.22	2.84
Cresol novolac type epoxy resin (softening point 55°C, epoxy equivalent: 199 g/eq)	-	-	-	12.33	12.33	-	-	-	-		-	-	-	-	-	-
Phenolic novolac curing agent (softening point 88°C, epoxy equivalent: 104 g/eq)	-	-	-	6.92	-	6.92	-	-	-		-	-	-	-	-	-
Dicyclopentadiene resin (softening point: 61°C, epoxy equivalent: 260 g/eq)	-	-	-	-	-	-	-	-	8.17		-	-	-	-	-	8.17
Crystalline silica of distribution defined (25-45% by weight, below 12 um, 55-75% by weight, between 12-90 um and below 3% by weight, above 90 um)	19.22	38.44	46.22	38.44	38.44	38.44	36.94	39.94	42.50		38.44	-	-	-	-	-
Crystalline silica of distribution outside defined range (10-30% by weight, below 12 um, 40-50% by weight, between 12-90 um and below 15% by weight, above 90 um)	-	-	-	-	-	-	-	-	-		-	38.44	38.44	36.94	39.94	42.50
Fused silica powder of distribution defined (23-45% by weight, below 10 um, 55-75% by weight, between 12-100 um and below 3% by weight, above 100 um)	57.65	38.44	30.81	38.44	38.44	38.44	36.94	39.94	42.50		-	38.44	-	-	-	-
Fused silica powder of distribution outside defined range (10-30% by weight, below 10 um, 40-50% by weight, between 12-100 um & below 15% by weight, > 100 um)	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Triphenylphosphine (TPP)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18		0.18	0.18	0.18	0.18	0.18	0.18
Carbon Black	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30		0.30	0.30	0.30	0.30	0.30	0.30
Others	3.70	3.70	3.40	3.70	3.70	3.70	3.31	4.41	3.81		3.70	3.70	3.70	3.31	4.41	3.81
Physical Properties																
Spinal Flow, cm	121	108	106	94	92	95	138	89	101		74	84	71	138	89	92
CTE, 1/°C	1.5	1.7	1.9	1.7	1.7	1.7	1.9	1.6	1.4		1.7	1.8	1.7	1.9	1.6	1.4
Flexural modulus, kgf/mm ²	2020	1850	1970	1850	1850	1850	1840	2030	1990		1880	1930	1830	1840	2030	1990
Stress	2.4	2.6	3.2	2.6	2.6	2.6	3.1	3.1	2.5		3.3	3.7	3.3	3.1	3.1	2.5
External void, >10umils	0/48	2/48	1/48	2/48	0/48	0/48	0/48	1/48	1/48		7/48	7/48	6/48	7/48	5/48	10/48
Internal void, >10umils	0/48	0/48	0/48	0/48	0/48	0/48	0/48	0/48	0/48		3/48	2/48	1/48	1/48	2/48	4/48
QFP-100L at MSL 2A (number of defect package total number)	Internal crack															
	Top die (5in)															
	Bottom pad															
QFP-100L at MSL 3 (number of defect package total number)	Internal crack															
	Top die															
	Bottom pad															

CLAIMS:

1. An epoxy resin composition comprising:
 - (A) an epoxy resin;
 - (B) a phenolic novolac curing agent;
 - 5 (C) an inorganic silica filler of mixed crystalline and fused types with:
 - (i) total filler content at 70-90 % by weight based on the total resin composition;
 - (ii) ratio of crystalline/fused: 0.3-1.5; and
 - 10 (iii) the said inorganic silica filler comprises crystalline silica filler with particle distribution between 25 to 45 % by weight for particle sizes below 12 μm , between 55 to 75 % by weight for particle sizes between 12 to 90 μm and below 3 % by weight for particle sizes above 90 μm and fused silica filler with particle distribution between 25 to 45 % by weight for particle sizes below 10 μm , between 55 to 75
15 % by weight for particle sizes between 10 to 100 μm and below 3 % by weight for particle sizes above 100 μm ; and
 - (D) a curing accelerator.
2. An epoxy resin composition comprising:
 - 20 (A) an epoxy resin;
 - (B) a phenolic novolac curing agent;
 - (C) an inorganic silica filler of mixed crystalline and fused types with:
 - (i) total filler content at 70-90 % by weight based on the total resin composition;
 - 25 (ii) ratio of crystalline/fused: 0.3-1.5; and

- (iii) the said inorganic silica filler comprises crystalline silica filler with particle distribution between 25 to 35 % by weight for particle sizes below 12 μm , between 55 to 65 % by weight for particle sizes between 12 to 90 μm and below 3 % by weight for particle sizes above 90 μm and fused silica filler with particle distribution between 25 to 35 % by weight for particle sizes below 10 μm , between 55 to 65 % by weight for particle sizes between 10 to 100 μm and below 3 % by weight for particle sizes above 100 μm .

(D) a curing accelerator.

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3. An epoxy resin composition according to claim 1 or 2 wherein the weight percentages of the components of the total resin composition fall within the following ranges:

- (A) 6% to 20%
(B) 3% to 12%
(C) 70% to 90%
(D) 0.05% to 0.8%

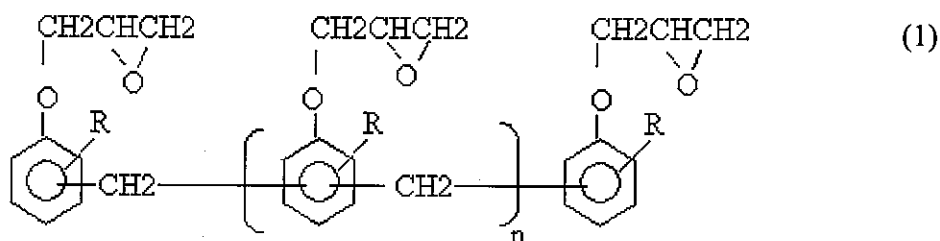
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and the ratio of (A) to (B) is between 1.2 and 2.5.

4. An epoxy resin composition according to claim 1 or 2 including 0.1% to 2% carbon black expressed as a weight percentage of the total resin composition.

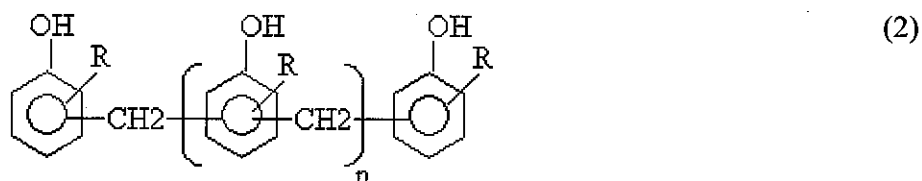
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5. The composition of claim 1 or 2 wherein the epoxy resin (A) is in accordance with Formula (I), and has a viscosity of 0.8~1.8poise ICI at 150°C.



5 wherein R which may be the same or different, is an atom or group selected from the group consisting of hydrogen atom, halogen atoms and C₁ to C₄ alkyl groups; and n is an integer of 0-10.

6. The composition of claim 1 or 2 wherein the phenolic novolac curing agent (B) is in accordance with Formula (II) and has a viscosity of 1.5~3.0poise ICI at 150°C.



wherein R is independently an atom or group selected from hydrogen atom, a halogen and an alkyl group; and n is an integer of 0-10.

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7. The composition of claim 1 or 2 wherein said curing accelerator (D) comprises one or more curing accelerators selected from the group consisting of diazabicycloundecene (DBU), triphenylphosphine (TPP), benzyldimethylamine (BDMA), 2-methylimidazole (2-MZ) and mixtures thereof.

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