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COMPOSITE FILM AND LEAD FRAME WITH COMPOSITE FILM ATTACHED

BACKGROUND OF THE INVENTION



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1. Field of the invention

The present invention relates to a trilayer composite film for use in semiconductor packages such as LOC (Lead on Chip), COL (Chip on Lead), composite lead frames with heat sinks attached, etc., and a lead frame to which the composite film is attached by punching.

2. Description of the Prior Art

In semiconductor packages such as LOC and COL, a composite film with a base film attached is used for bonding chips to lead frames. Generally, for application to a lead frame, a composite film is punched out and the bonding elements thus obtained are pressed against required parts of the lead frames. Upon punching, the composite film undergoes high normal stress and shear stress, so that burrs or flashes are generated as powders and threads at the edge of the composite film punched. These burrs or flashes cause a decrease in the yield and productivity of the lead frames with composite films attached, as well as having fatal influence on the reliability of the semiconductor package chips.

Many attempts have been made to prevent the occurrence of the burrs and flashes. For example, U. S. Pat. Nos. 5,593,774 and 5,998,020 disclose improvements in which the composite films employ a base film having such an edge tearing resistance defined within a certain range as to suppress the occurrence of burrs and flashes at the edge of the composite films upon punching.

Recently, attempts have been made to lower the temperature at which chips are bonded to lead frames, as much as possible, thereby bringing about an improvement in the reliability of semiconductor devices. In detail, upon bonding at high temperature, thermal impact is applied to semiconductor devices. To prevent or significantly alleviate the thermal impact, the bonding temperature at which semiconductor chips are bonded to lead frames is reduced by use of a composite film comprising an adhesive with a low glass transition temperature. However, upon punching a composite film with an adhesive of low glass transition temperature, the adhesive is melted and attached to the puncher owing to its low glass transition temperature, causing the problem that the puncher must be more frequently cleaned.

The molten attachments on the puncher are formed owing to the frictional heat generated by the friction between the puncher and the composite film upon punching. An adhesive

whose glass transition temperature is much lower than that of a base film is melted owing to the frictional heat generated upon punching, and the molten adhesive is attached to the puncher. Therefore, the contaminated puncher must be cleaned or replaced, giving rise to a great decrease in the productivity of lead frames with composite films attached.

SUMMARY OF THE INVENTION

Leading to the present invention, the intensive and thorough research into the formation of molten attachments on punchers upon punching composite films, conducted by the present inventors, resulted in the finding that a modification of the thickness of the composite film and the adhesive, in conjunction with the glass transition temperature of the adhesive, can effectively suppress the occurrence of the molten attachments.

Therefore, it is an object of the present invention to provide a composite film for use in semiconductor packaging, which are restrained from generating molten attachments on punchers, thereby extending the cleaning period of punchers and thus improving the productivity of punching processes.

It is another object of the present invention to provide a lead frame with composite film attached to required portions of the lead frame, with which highly reliable

semiconductor packages can be produced at high yield and productivity.

In one aspect of the present invention, there is provided a composite for use in semiconductor packaging, having a structure in which an adhesive is laminated on each side of a heat-resistant base film, with thickness of the composite film and the thickness and glass transition temperature of the adhesive satisfying the following formulas 1 and 2:

$$0.05 \leq T_A/T \leq 0.45 - (185 - T_g)/500 \quad [1]$$

$$135 \text{ }^\circ\text{C} \leq T_g \leq 185 \text{ }^\circ\text{C} \quad [2]$$

wherein T_A is a thickness of the adhesive layer, T is a thickness of the composite film, and T_g is a glass transition temperature of the adhesive.

In another aspect of the present invention, there is provided a lead frame to which the composite film is attached by punching.

DETAILED DESCRIPTION OF THE INVENTION

Suggested to package semiconductor chips in high densities, an LOC structure, as disclosed in U. S. Pat. No. 4,943,843, uses a composite film (insulating film) between a

lead frame and a semiconductor chip to bond them to each other. Typically, the composite film (insulating film) is composed of a base film and a thermoplastic or thermosetting adhesive attached on both sides of the base film. U. S. Pat. No. 5,583,375 refers to a composite film having a base film 25-125 μm thick, with an adhesive layer ranging, in thickness, from 10 to 30 μm . Most LOC composite films in current use are 25 or 50 μm in thickness with an adhesive 18 or 25 μm thick.

In an aspect, the present invention pertains to a composite for use in semiconductor packaging, having a structure in which an adhesive is laminated on each side of a heat-resistant base film, characterized in that the thickness of the composite film and the thickness and glass transition temperature of the adhesive satisfy the following formulas 1 and 2:

$$0.05 \leq T_A/T \leq 0.45 - (185 - T_g)/500 \quad [1]$$

$$135 \text{ }^\circ\text{C} \leq T_g \leq 185 \text{ }^\circ\text{C} \quad [2]$$

wherein T_A is a thickness of the adhesive layer, T is a thickness of the composite film, and T_g is a glass transition temperature of the adhesive.

The composite film of the present invention has a base film with an adhesive on both sides. Typically, the

composite film is prepared by coating an adhesive on both sides of a base film and drying it. An adhesive may be applied to one side of a base film, dried and then applied to the other side of the base. Alternatively, an adhesive may be coated on both sides of a base film simultaneously or in order and then dried. Also, different adhesives may be applied to both sides of a base film.

Suitable for use in the base film of the present invention is a heat-resistant, engineering plastic, examples of which include polyimide, polyamide, polysulfone, polyphenylene sulfide, polyarylate, and polyethersulfone. The thickness of the base film is preferably on the order of 10-125 μm and more preferably on the order of 25-75 μm .

Since the composite film is used in a semiconductor packaging process which is typically conducted at as high as or higher than 300 $^{\circ}\text{C}$, the base film is required to be high in glass transition temperature and have a low coefficient of thermal expansion. Preferred is a base film that has a glass transition temperature of 250 $^{\circ}\text{C}$ or higher and a coefficient of thermal expansion of 30 ppm/ $^{\circ}\text{C}$ as measured according to ASTM D-691-91.

To achieve a high adhesion strength between the base film and the adhesives, the base film may be subjected to various surface treatments, which are exemplified by chemical treatment such as alkali treatment and silane coupling agent

treatment, and physical treatment such as sand blasting, plasma treatment and corona treatment. Also, it is possible to use, in combination, two or more treatments which are the most suitable for the adhesives and base film used. Of various surface treatments, plasma treatment is the most effective in terms of the improvement in adhesion strength.

Another technique for increasing the adhesion strength between the base film and the adhesives is coextrusion. An adhesive material with a glass transition temperature of 150-300 °C is coextruded, along with the base film, to a thickness of 0.5-10 μm on one side or both sides of the base film. Preferably, the glass transition temperature of each of the adhesive layers thus formed is lower than that of the base film.

Increasing the adhesion strength between the base film and the adhesives may resort to the intercalation of a primer coating between the base film and the adhesives. In this regard, a primer with a glass transition temperature of 200 °C or less is coated to a thickness of 5 μm or less and preferably to a thickness of 0.5 μm or less on both sides of the base film, in advance of the application of the adhesives. The glass transition temperature of the primer must be lower and is preferably and preferably 50 °C lower than that of the base film.

In addition, the drying temperature after the

application of the adhesives and/or the solvent used may affect the adhesion strength.

Suitable in the present invention is an adhesive, based on a heat-resistant, thermoplastic resin, with a glass transition temperature of 135-185 °C. Preferably, the thermoplastic resin is a polyimide or polyamide with a weight average molecular weight of 15,000 to 100,000. The term "polyimide" as used herein means not only polyimide, but also any other resin containing imide bonds, such as polyamideimide, polyesterimide or polyetherimide.

If the glass transition temperature of the heat-resistant adhesive is lower than 135 °C, inner leads may be moved during a wire bonding process. On the other hand, a glass transition temperature above 185 °C requires too high a temperature for bonding leads or chips and too long a bonding time. When a thermoplastic adhesive with a weight average molecular weight less than 15,000 is employed, desired polymer properties cannot be obtained. On the other hand, a thermoplastic adhesive with a weight average molecular weight greater than 100,000 suffers the problem of being too viscous upon coating.

Fillers may be added to the adhesive. Examples of useful fillers include inorganic particles such as silica, glass, calcium carbonate, etc., metal particles such as silver, copper, etc., and organic particles such as acryl,

polyimide, gum, etc. In order to increase the bonding force between the inorganic particles and the heat-resistant adhesive, a coupling agent may be also added. Examples of useful coupling agents include vinyltrimethoxysilane, vinyltriethoxysilane, γ -methacryloxy-propyltrimethoxysilane, titanates, aluminum chelates, and zircoaluminates.

An adhesive varnish is prepared by dissolving a thermoplastic resin in an organic solvent. For use in applying the adhesive varnish to the base film, a coater is used, examples of which include, but are not limited to, a comma type, a reverse type, and a die type, with preference for a die type coater in an aspect of preventing the occurrence of external impurities and bubbles.

As a drying means for drying the polyimide varnish after coating the adhesive varnish onto one side or both sides of the base film, there is used a roll carrier in which a roll is moved with the coated film loaded. In the case of coating the adhesive varnish onto both sides of the base film, the drying means takes a floating carrier manner in which the film is carried without contact with a roll. A process comprising coating an adhesive on both sides of a base film simultaneously or sequentially and then drying it is favorable for productivity and workability, but requires a floating carrier. A close examination of various factors including initial drying temperature, wind direction, etc.,

must be made in order to define an optimal drying process.

Removal of the solvent of the adhesive varnish from the coated film requires gradual drying at 50-250 °C over 3-20 min. Rapid heating is highly apt to cause the generation of bubbles in the adhesive layers, resulting in defectives upon bonding to lead frames and thus poor reliability of the semiconductor packages obtained. Thus, in order to form a coating layer free of bubbles, the drying temperature is preferably increased as slowly as possible until 90 % of the solvent of the adhesive coated on the base film is removed.

In another aspect, the present invention pertains to a lead frame to which the composite film is attached.

The composite film of the present invention is punched out and attached to a lead frame. The lead frame may have any structure. In a typical structure, a lead frame has a composite film attached to a predetermined portion thereof, with inner and outer lead portions being connected to a semiconductor chip and connected to external circuits, respectively.

The effective bonding of the composite film to lead frames is conducted by repeating a punching/pressing cycle in which a lead frame is loaded within 0.3-1.5 sec below the composite film, with one adhesive layer facing the lead frame, and punched into strips which are continuously pressed against predetermined portions of the lead frame body at a

pressure of 0.1 to 10 MPa for 0.1 to 5 seconds. Typically, the cycle has a time period of 0.8-5 sec. The forms of the punched-out composite film strips vary with the forms of chips, the locations of chips on lead frames or the designs of lead frames. At the time of punching, the lead frame body is generally heated to 200 to 350 °C.

It was experimentally found that when being punched out, the composite film satisfying the formulas 1 and 2 generates almost no molten attachments on punchers.

Having generally described this invention, a further understanding can be obtained by reference to certain specific examples which are provided herein for purposes of illustration only and are not intended to be limiting unless otherwise specified.

In the following examples and comparative examples, composite films were evaluated for the occurrence of molten attachments on punchers in terms of the punching cleaning period, the time to the generation of defective punched strips owing to the contamination of the punchers with molten composite films. In this regard, the clearance of punchers were set to 4 % of the thickness of the composite film. In a punching/bonding cycle, the time it took to load a lead frame to a desired position was set to 0.6 while the punching and bonding processes of composite films was preformed at a pressure of 30 MPa within 0.4 sec.

EXAMPLE 1

Each side of a polyimide film 75 μm thick, having a glass transition temperature of 300 $^{\circ}\text{C}$ or higher and a coefficient of thermal expansion of 12 $\text{ppm}/^{\circ}\text{C}$, was coated with a polyimide adhesive (weight average molecular weight 50.000, $M_w/M_n=2.1$) having a glass transition temperature of 170 $^{\circ}\text{C}$, at a thickness of 15.0 μm , and dried, to produce a trilayer composite film 105 μm thick in total, with a thickness ratio of the adhesive to the composite film being 0.29. The composite film was placed over a nickel alloy 42 lead frame heated to 320 $^{\circ}\text{C}$, and was then punched with the aid of a puncher to give strips which were then continuously pressed against the lead frame for 0.4 sec at a pressure of 30 MPa, to produce a lead frame with a composite film attached.

EXAMPLE 2

The same procedure as in Example 1 were conducted, with the modification that an adhesive was coated to a thickness of 22.5 μm on each side of a polyimide base film, to give a trilayer composite film 115.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film

being 0.39.

COMPARATIVE EXAMPLE 1

The same procedure as in Example 1 were conducted, with the modification that an adhesive was coated to a thickness of 32.5 μm on each side of a polyimide base film, to give a trilayer composite film 140.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.46.

COMPARATIVE EXAMPLE 2

The same procedure as in Example 1 were conducted, with the modification that an adhesive was coated to a thickness of 32.5 μm on each side of a base film 50 μm thick, to give a trilayer composite film 115.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.57.

EXAMPLE 3

Each side of a polyimide film 75 μm thick, having a glass transition temperature of 300 °C or higher and a coefficient of thermal expansion of 12 ppm/°C, was coated

with a polyimide adhesive (weight average molecular weight 50.000, $M_w/M_n=2.1$) having a glass transition temperature of 150 °C, at a thickness of 15.0 μm , and dried, to produce a trilayer composite film 100 μm thick in total, with a thickness ratio of the adhesive to the composite film being 0.30. The composite film was placed over a nickel alloy 42 lead frame heated to 320 °C, and was then punched with the aid of a puncher to give strips which were then continuously pressed against the lead frame for 0.4 sec at a pressure of 30 MPa, to produce a lead frame with a composite film attached.

COMPARATIVE EXAMPLE 3

The same procedure as in Example 3 were conducted, with the modification that an adhesive was coated to a thickness of 27.5 μm on each side of a polyimide base film, to give a trilayer composite film 130.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.42.

COMPARATIVE EXAMPLE 4

The same procedure as in Example 3 were conducted, with the modification that an adhesive was coated to a thickness

of 25.0 μm on each side of a base film 50 μm thick, to give a trilayer composite film 100 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.50.

EXAMPLE 4

On each side of a polyimide film 38 μm thick having a glass transition temperature of 300 °C or higher and a coefficient of thermal expansion of 12 ppm/°C, a polyimide adhesive (weight average molecular weight 50,000, $M_w/M_n=2.1$) with a glass transition temperature of 184 °C was coated to a thickness of 12.5 μm , and dried to produce a trilayer composite film 63.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.40. The composite film was placed over a nickel alloy 42 lead frame heated to 320 °C, and was then punched with the aid of a puncher to give strips which were then continuously pressed against the lead frame for 0.4 sec at a pressure of 30 MPa, to produce a lead frame with a composite film attached.

COMPARATIVE EXAMPLE 5

The same procedure as in Example 4 were conducted, with the modification that an adhesive was coated to a thickness

of 18.5 μm on each side of a base film, to give a trilayer composite film 75.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.49.

COMPARATIVE EXAMPLE 5

The same procedure as in Example 4 were conducted, with the modification that an adhesive was coated to a thickness of 19.0 μm on each side of a base film 25 μm thick, to give a trilayer composite film 65.0 μm thick in total, with a thickness ratio of the adhesive to the total composite film being 0.60.

When the composite films prepared in the above examples and comparative examples were attached to lead frames by use of punchers, the cleaning periods of the punchers were measured, and the results are summarized in Table 1, below.

TABLE 1

Exmp. No.	T (μm)	Base Film Thick. (μm)	T _A (μm)	T _A /T	Critical Thick. Ratio	T _g (°C)	Cleaning Period (hr)
1	105	75.0	30.0	0.29	0.42	170	15
2	115	70.0	45.0	0.39			13
C.1	140	75.0	65.0	0.46			5
C.2	115	50.0	65.0	0.57			3
3	100	70.0	30.0	0.30			13

C.3	130	75.0	55.0	0.42	0.38	150	6
C.4	100	50.0	50.0	0.50			3.5
4	63	38.0	25.0	0.40	0.45	184	12
C.5	75	38.0	37.0	0.49			5
C.6	63	25.0	38.0	0.60			3.5

As evident from the data of Table 1, the composite films of the present invention are excellent in terms of the occurrence of molten attachments on punchers such that the cleaning period of the punchers are significantly lengthened, thereby making a great contribution to the productivity of semiconductor packages.

The present invention has been described in an illustrative manner, and it is to be understood that the terminology used is intended to be in the nature of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, it is to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

CLAIMS

1. A composite for use in semiconductor packaging, having a structure in which an adhesive is laminated on each side of a heat-resistant base film, with thickness of the composite film and the thickness and glass transition temperature of the adhesive satisfying the following formulas 1 and 2:

$$0.05 \leq T_A/T \leq 0.45 - (185 - T_g)/500 \quad [1]$$

$$135 \text{ }^{\circ}\text{C} \leq T_g \leq 185 \text{ }^{\circ}\text{C} \quad [2]$$

wherein T_A is a thickness of the adhesive layer, T is a thickness of the composite film, and T_g is a glass transition temperature of the adhesive.

2. The composite film as set forth in claim 1, wherein the adhesive ranges from 135 to 185 $^{\circ}\text{C}$ in glass transition temperature and from 15,000 to 100,000 in weight average molecular weight.

3. The composite film as set forth in claim 1, wherein the base film has a glass transition temperature of 250 $^{\circ}\text{C}$ or higher and a coefficient of thermal expansion of 30 ppm/ $^{\circ}\text{C}$.

4. The composite film as set forth in claim 1, wherein the base film is made of polyimide or polyamide.

5 The composite film as set forth in claim 1, wherein the base film is made of a polymer selected from the group consisting of polyimide, polyamide, polysulfone, polyphenylene sulfide, polyetheretherketone, polyarylate, and combinations thereof.

6. A lead frame with a composite film attached, said composite film comprising a base film, each side of which is coated with an adhesive, in which the thickness of the composite film and the thickness and glass transition temperature of the adhesive satisfy the following formulas 1 and 2:

$$0.05 \leq T_A/T \leq 0.45 - (185 - T_g)/500 \quad [1]$$

$$135 \text{ }^\circ\text{C} \leq T_g \leq 185 \text{ }^\circ\text{C} \quad [2]$$

wherein T_A is a thickness of the adhesive layer, T is a thickness of the composite film, and T_g is a glass transition temperature of the adhesive.