FOD ADHESIVE FILM AND SEMICONDUCTOR PACKAGE INCLUDING THE SAME

BACKGROUND

1. **Field**

[0001] The present disclosure relates to a controller die-embedding adhesive film applied to a semiconductor package having a FOD (film on die) scheme and to a semiconductor package using the adhesive film.

2. Description of Related Art

[0002] In a conventional semiconductor package manufacturing process, attaching a semiconductor chip to a lead frame or a circuit substrate member includes a multi-step process including a process in which a liquid adhesive is injected and applied to a pad for fixing a die, a semiconductor chip is mounted thereon, and the liquid adhesive was cured at a high temperature for a certain time, and the bonding pad of the semiconductor chip and a bonding region of a substrate are bonded with each other via a wire to enable electrical signal exchange therebetween, and a molding process surrounding the semiconductor chip and the wire. A liquid adhesive which has been widely used conventionally has disadvantages such as defects, and foams in the wire bonding due to a protrusion, or inclination of a semiconductor element, and difficulty in controlling a thickness. Therefore, in recent years, instead of the liquid adhesive, an adhesive film is mainly used.

[0003] Recently, due to trends of miniaturization, high functionality, and high-capacity of an electronic device, a need for high density and high integration of a semiconductor package has rapidly increased. Thus, a size of the semiconductor chip has increased. In order to improve the integration, a stack structure package scheme of stacking chips in multiple levels is widely used.

[0004] In the semiconductor package, a controller die for controlling a signal between or operations of semiconductor devices is used. The controller die is usually located on an outer periphery of a semiconductor or on a top face of the semiconductor due to structural characteristics thereof.

[0005] However, when the controller die is located on the outer periphery of the semiconductor, an area of the semiconductor package increases, which limits size reduction of the package. When the controller die is located on the top face of the semiconductor, a length of a wire required to connect to the controller becomes longer. Thus, a resistance increases, thus making it difficult to transmit a signal at high speed.

[0006] Therefore, embedding the controller die in a bottom of a semiconductor stack structure allows securing a structure for realizing efficient utilization of the package area and the high-speed transmission of the signal. In order to embed the controller die in the bottom of the semiconductor stack, a FOD (film on die) adhesive film having a thickness thicker than the controller die is used.

[0007] However, in the semiconductor package to which the FOD adhesive film is applied, a semiconductor die (wafer chip) stacked on the FOD adhesive film and a semiconductor die stacked on a die attach film should be separately managed. Accordingly, the semiconductor package to which the FOD adhesive film is applied has a problem in that a yield thereof is reduced compared to that of a general semiconductor package.

[0008] Further, when a cutting process in which the FOD adhesive film is cut to a certain size is carried out for applying the FOD adhesive film to the semiconductor package, there has been a problem that a pickup error increases due to excessive fusion of the adhesive layer.

[0009] In addition, when transferring the FOD adhesive film to apply the FOD adhesive film to the semiconductor package, there is a problem that a jam occurs due to a relatively larger thickness of the FOD adhesive film.

[0010] Further, when a die attach process of attaching the FOD adhesive film to the substrate and stacking the semiconductor die on the FOD adhesive film, the controller die is not well embedded in the FOD adhesive film and thus a stacking failure of the semiconductor die occurs.

[0011] Due to the above problems, a related industry has avoided the semiconductor package to which the FOD adhesive film is applied.

[0012] Accordingly, a novel FOD adhesive film that may solve the above problems is required.

SUMMARY

[0013] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify all key features or essential features of the claimed subject matter, nor is it intended to be used alone as an aid in determining the scope of the claimed subject matter.

[0014] A purpose of the present disclosure is to provide a FOD adhesive film having new physical properties and a novel structure in order to solve the above technical problems.

[0015] Further, a purpose of the present disclosure is to provide a semiconductor package using the FOD adhesive film, wherein the package may be manufactured using a simple manufacturing process and has a high manufacturing yield.

[0016] A FOD adhesive film according to the first embodiment of the present includes a novel stack structure in which a support layer is stacked on one face of an adhesive layer. Accordingly, disclosed herein is a FOD (film on die) adhesive film having a stack structure in which a support layer is stacked on one face of an adhesive layer, wherein the adhesive layer is for embedding at least a portion of a controller die included in a semiconductor package, wherein the support layer is for protecting the adhesive layer to prevent cutting defects due to fusion of the adhesive layer when the adhesive layer is cut, wherein surface energy of the support layer is 40 dyne/cm or greater, wherein elongation-at-break of the support layer is 100% or smaller, and elongation-at-break of the adhesive layer is 20% or greater, wherein adhesion of the support layer to the adhesive layer is 20 gf/cm or greater.

[0017] Further, a FOD adhesive film according to a second embodiment of the present disclosure includes an adhesive layer having a controlled probe tack measurement value and a controlled melt viscosity.

[0018] Further, a semiconductor package according the present disclosure includes a FOD adhesive film including a novel stack structure in which a support layer is stacked on one face of an adhesive layer, and has a structure in which at least a portion of a controller die is embedded in the adhesive layer. Accordingly, disclosed herein is a semiconductor package comprising: a substrate; a controller die mounted on the substrate; a FOD adhesive film formed

on the substrate; and a semiconductor die stacked on the FOD adhesive film, wherein the FOD adhesive film has a stack structure in which a support layer is stacked on one face of the an adhesive layer, wherein at least a portion of the controller die is embedded in the adhesive layer, wherein the support layer is for protecting the adhesive layer to prevent cutting defects due to fusion of the adhesive layer when the adhesive layer is cut, wherein surface energy of the support layer is 40 dyne/cm or greater, wherein elongation-at-break of the support layer is 100% or smaller, and elongation-at-break of the adhesive layer is 20% or greater, wherein adhesion of the support layer to the adhesive layer is 20 gf/cm or greater.

[0019] Effects in accordance with the present disclosure may be as follows but may not be limited thereto.

[0020] The FOD adhesive film according to the first embodiment of the present disclosure includes the new stack structure in which the support layer is stacked on one face of the adhesive layer. Thus, the FOD adhesive film has an excellent effect that the support layer significantly reduces occurrence of defects during the cutting process.

[0021] Further, the FOD adhesive film according to the second embodiment of the present disclosure includes the adhesive layer having the controlled probe tack measurement value and the controlled melt viscosity, thereby significantly reducing defects in a FOD adhesive film transfer process and the die attach process.

[0022] Further, in the semiconductor package to which the FOD adhesive film according to the present disclosure is applied, the semiconductor die stacked on the FOD adhesive film and the semiconductor die stacked on the die attach film need not be separately managed. Thus, a yield of the package dramatically increases compared to that of a semiconductor package to which a conventional FOD adhesive film is applied.

[0023] Moreover, the effect of the present disclosure is not limited to the above effects. It should be understood to include all possible effects derived from descriptions of the present disclosure or a configuration as set forth in the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0024] FIG. 1 is a cross-sectional view showing a FOD adhesive film according to one embodiment of the present disclosure.

[0025] FIG. 2 is a cross-sectional view showing a FOD adhesive film according to another embodiment of the present disclosure.

[0026] FIG. 3 is a process diagram schematically showing a process of applying a FOD adhesive film according to the present disclosure to a semiconductor package.

[0027] FIG. 4 is a cross-sectional view showing a semiconductor package according to the present disclosure.

DETAILED DESCRIPTIONS

[0028] For simplicity and clarity of illustration, elements in the figures are not necessarily drawn to scale. The same reference numbers in different figures represent the same or similar elements, and as such perform similar functionality. Further, descriptions and details of well-known steps and elements are omitted for simplicity of the description. Furthermore, in the following detailed description of the present disclosure, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be understood that the present disclosure may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the present disclosure.

[0029] Examples of various embodiments are illustrated and described further below. It will be understood that the description herein is not intended to limit the claims to the specific embodiments described. On the contrary, it is intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the present disclosure as defined by the appended claims.

[0030] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the present disclosure. As used herein, the singular forms "a" and "an" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "includes",

and "including" when used in this specification, specify the presence of the stated features, integers, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, operations, elements, components, and/or portions thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expression such as "at least one of" when preceding a list of elements may modify the entire list of elements and may not modify the individual elements of the list.

[0031] It will be understood that, although the terms "first", "second", "third", and so on may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the spirit and scope of the present disclosure.

[0032] It will be understood that when an element or layer is referred to as being "connected to", or "coupled to" another element or layer, it may be directly on, connected to, or coupled to the other element or layer, or one or more intervening elements or layers may be present. In addition, it will also be understood that when an element or layer is referred to as being "between" two elements or layers, it may be the only element or layer between the two elements or layers, or one or more intervening elements or layers may also be present.

[0033] In addition, it will also be understood that when a first element or layer is referred to as being present "on" or “beneath” a second element or layer, the first element may be disposed directly on or beneath the second element or may be disposed indirectly on or beneath the second element with a third element or layer being disposed between the first and second elements or layers.

[0034] Unless otherwise defined, all terms including technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this inventive concept belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent

with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0035] Moreover, in implementing the present disclosure, a component may be subdivided for convenience of description. However, sub-components may be implemented in one unit or module. Alternatively, one component may be divided into multiple units or modules.

[0036] Hereinafter, a FOD adhesive film according to the present disclosure and a semiconductor package including the same will be described in detail.

[0037] FOD (film on die) adhesive film

[0038] 1. FDO adhesive film according to first embodiment

[0039] Referring to FIG. 1, a FDO adhesive film 100 according to the first embodiment of the present disclosure has a stack structure in which a support layer 20 is stacked on one face of an adhesive layer 10. In addition, the stack structure of the FOD adhesive film according to the present disclosure is applied to the semiconductor package in a non-modified manner.

[0040] In the conventional FOD adhesive film, only the adhesive layer was applied to the semiconductor package. To the contrary, the FOD adhesive film 100 according to the present disclosure includes the stack structure in which the support layer 20 is stacked on one face of the adhesive layer 10. The stack structure is applied to the semiconductor package. Thus, the FOD adhesive film 100 according to the present disclosure has a different configuration from that of the conventional FOD adhesive film in that the FOD adhesive film 100 according to the present disclosure has a stack structure of at least two layers.

[0041] The support layer 20 included in the FOD adhesive film according to the present disclosure is stacked on one face of the adhesive layer 10 may protect one face of the adhesive layer 10 and may function as an intermediate layer on which the semiconductor die to which a die attach film is attached is loaded.

[0042] In addition, the support layer 20 has controlled surface energy of 40 dyne/cm or greater and controlled elongation-at-break of 100% or smaller.

[0043] When the surface energy of the support layer 20 is lower than 40 dyne/cm, the support layer 20 and the adhesive layer 10 may be separated from each other in the cutting process of the FOD adhesive film. Further, when the surface energy of the support layer is lower than 40 dyne/cm, a product failure may occur due to lack of an interfacial adhesion between the support layer 20 and the adhesive layer 10. Preferably, an upper limit of the surface energy of the support layer 20 may be 100 dyne/cm.

[0044] Further, when the elongation-at-break of the support layer 20 exceeds 100%, a defect may occur due to stretching of the support layer 20 in the cutting process of the FOD adhesive film. Preferably, a lower limit of the elongation-at-break of the support layer 20 may to 20%.

[0045] A material of the support layer 20 is not limited particularly, as long as the support layer 20 protects one face of the adhesive layer 10 and functions as an intermediate layer on which the semiconductor die to which a die attach film is attached is loaded. Preferably, the support layer 20 may be made of at least one selected from a group consisting of polyimide, (PI), polyimideamide, polyetherimide (PEI), polyethyleneterephtalate (PET), polyethylenenaphthalate (PEN), and polyetheretherketon (PEEK).

[0046] Preferably, the support layer 20 may have a thickness of 5 to 50 ㎛. When the thickness of the support layer 20 is smaller than 5 μm, possibility of defect occurrence in the process of cutting the FOD adhesive film increases because the support layer 20 does not have a sufficient thickness to protect one face of the adhesive layer 10. Further, when the thickness of the support layer 20 exceeds 50 μm, there is a problem such as cost increase due to an unnecessarily large thickness.

[0047] Further, the adhesive layer 10 included in the FOD adhesive film 100 according to the present disclosure has a function of embedding therein at least a portion of the controller die included in the semiconductor package.

[0048] Further, the elongation-at-break of the adhesive layer 10 may be controlled to 20% or greater. When the elongation-at-break of the adhesive layer 10 is lower than 20%, a defect may occur on a cut surface due to cracking of the adhesive layer 10 in the cutting process of the

FOD adhesive film. Preferably, an upper limit of the elongation-at-break of the adhesive layer 20 may be 100%.

[0049] As described above, in the FOD adhesive film according to the present disclosure, the physical properties of the support layer 20 and the adhesive layer 10 may be controlled, thereby removing the defects otherwise occurring in the cutting process.

[0050] In addition, factors for controlling the properties of the support layer 20 and the adhesive layer 10 is not particularly limited. Preferably, the physical properties thereof may be controlled by appropriately adjusting various factors such as components and compositions of the support layer 20 and the adhesive layer 10.

[0051] The adhesive layer 10 may be formed at a known optimum composition ratio such that the controller die is embedded therein and proper fillet, wire sagging prevention, proper curing, moisture resistance, and heat resistance are secured.

[0052] Preferably, the adhesive layer 10 may contain an acrylic copolymer, an epoxy resin, and an inorganic filler.

[0053] The acrylic copolymer contained in the adhesive layer 10 may have a glass transition temperature of 0°C to 20°C and a weight average molecular weight of 100,000 to 500,000. In this connection, when the weight average molecular weight of the acrylic copolymer is lower than 100,000, film formation of the adhesive layer may not be achieved. Further, fluidity of the adhesive layer becomes excessive, which may cause wire bonding pad contamination. In addition, when the weight average molecular weight of the acrylic copolymer exceeds 500,000, polymerization may not occur. Further, coating properties may be poor. Thus, it is preferable that the weight average molecular weight of the acrylic copolymer is 100,000 to 500,000 in consideration of the stacking of the support layer thereon. Further, when the glass transition temperature of the acrylic copolymer is lower than 0°C. A tack (stickiness) of the adhesive layer itself is strong, which may lead to a decrease in yield in a pick-up process. When the glass transition temperature exceeds 20°C, the adhesion properties are lowered, which may cause voids in a mounting process.

[0054] In addition, the acrylic copolymer may be an epoxy group-containing acrylic copolymer, and may contain 3 to 15% by weight of glycidyl acrylate or glycidyl methacrylate. When a content of the epoxy group in the acrylic copolymer is smaller than 3% by weight, compatibility between the acrylic copolymer and the epoxy resin is insufficient. When the content of the epoxy group exceeds 15% by weight, a viscosity increase rate due to curing is high, so that the controller die may not be sufficiently embedded in the adhesive layer due to thermal pressure in the curing process.

[0055] Further, the adhesive layer 10 may contain the epoxy resin. More specifically, the epoxy resin may include at least one selected from a group consisting of bisphenol-based epoxy resin, biphenyl-based epoxy resin, naphthalene-based epoxy resin, fluorene-based epoxy resin, phenol novolac-based epoxy resin, cresol novolac-based epoxy resin, trishydroxylphenylmethane-based epoxy resin, and tetraphenylmethane-based epoxy resin. Preferably, the epoxy resin may include a mixture of at least two selected from bisphenol-based epoxy resins, phenol novolac-based epoxy resins, and cresol novolac-based epoxy resin. In this connection, the bisphenol-based epoxy resin may include bisphenol A-type epoxy resins, bisphenol F-type epoxy resins, bisphenol S-type epoxy resins, hydrogenated bisphenol A-type epoxy resins, and bisphenol AF-type epoxy resins.

[0056] Further, the epoxy resin may include an epoxy resin in a liquid phase at 10 ℃ to 35 ℃; and an epoxy resin in a solid phase at 10°C to 35°C, which may be contained in the adhesive layer at an appropriate ratio. The liquid epoxy resin may have an epoxy equivalent of 150 to 210 g/eq and a viscosity of 10,000 to 15,000 cps 25 ℃, preferably, the epoxy equivalent of 170 to 200 g/eq and the viscosity of 10,500 to 14,500 cps 25°C. The solid epoxy resin may have an epoxy equivalent of 180 to 240 g/eq and a softening point of 50°C to 70°C, preferably, the epoxy equivalent of 195 to 225 g/eq and the softening point of 50°C to 65°C.

[0057] Further, the adhesive layer 10 according to the present disclosure may contain the inorganic filler. The inorganic filler may preferably include a spherical powder having an average particle diameter of about 0.1 μm to 2 μm. In this connection, when the average particle diameter of the inorganic filler is smaller than 0.1 μm, there may be a problem that the particles agglomerate in the adhesive layer. When the diameter exceeds 2 μm, the controller die and/or

the semiconductor die may be subjected to pattern damage or cracks due to the inorganic filler. Further, decrease in adhesion of the adhesive layer may occur.

[0058] The spherical powder may include at least one selected from alumina, silica, magnesium hydroxide and calcium carbonate. Preferably, the spherical powder may include one or more selected from alumina and silica.

[0059] Preferably, the adhesive layer 10 may have a thickness of 60 to 150 ㎛. When the thickness of the adhesive layer 20 is smaller than 60 ㎛, the adhesive layer 20 does not have a sufficient thickness to embed the controller die therein. Thus, there is a high possibility that the semiconductor package is defective. Further, when the thickness of the adhesive layer 10 exceeds 150 ㎛, cost increase may occur due to an unnecessary larger thickness, and a resin flow phenomenon occurs excessively during the die attach process, such that the bonding pad is contaminated.

[0060] In the adhesive film according to the present disclosure, it is preferable that adhesion of the support layer to the adhesive layer is controlled to 20 gf/cm or greater. Preferably, the adhesion may be measured and controlled in a B-stage. In this connection, the B-stage means a semi-cured state of the adhesive layer in which a solvent is dried away using hot air drying. When the adhesion is lower than 20 gf/cm, peeling between the support layer and the adhesive layer may occur in the process of cutting the adhesive film. Preferably, an upper limit of the adhesion may be set to 100 gf/cm.

[0061] In addition, referring to FIG. 2, a FOD adhesive film 101 according to the present disclosure may further include a release film 30 on the other face of the adhesive layer 10 (opposite to one face thereof on which the support layer 20 is stacked). Further, a further release film 30 may be further present on one face of the support layer 20.

[0062] A material of the release film 30 may be a polymer film material and may not be limited particularly as long as the polymer film material protects the FOD adhesive film 101. Preferably, polyethyleneterephtalate (PET) may be used for the material of the release film 30.

[0063] FIG. 3 schematically shows a process for transferring, cutting, picking up and applying the FOD adhesive film 100 according to the present disclosure to the semiconductor package which will be described below.

[0064] When the FOD adhesive film 100 according to the present disclosure includes the release film 30, first, the release film is removed therefrom. In another example, when the FOD adhesive film 100 does not include the release film 30, the release film removal process is omitted.

[0065] Next, the FOD adhesive film 100 is transferred and is subjected to a cutting process such that the film 100 is cut to a certain size using a blade. Thereafter, the cut FOD adhesive film 100 is picked up and applied to the semiconductor package.

[0066] As described above, when the FOD adhesive film is cut to a certain size for applying the FOD adhesive film to the semiconductor package, a pickup error may increase due to excessive fusion of the adhesive layer.

[0067] However, unlike the conventional FOD adhesive film, the FOD adhesive film 100 according to the present disclosure has the stack structure in which the support layer 20 is stacked on the adhesive layer 10. Thus, during the cutting process, excessive fusion of the adhesive layer 10 is suppressed by the support layer 20, thereby significantly reducing the occurrence of the pickup error.

[0068] <u>2. FDO adhesive film according to second embodiment</u>

[0069] Hereinafter, a FOD adhesive film according to the second embodiment of the present disclosure may include the adhesive layer having a probe tack measurement value of 15 gf or smaller, and a melt viscosity of 2000 to 9000 Pa·s at 110°C.

[0070] The adhesive layer used in the FOD adhesive film has a function of embedding therein at least a portion of the controller die included in the semiconductor package. Further, the adhesive layer may be formed at a known optimum composition ratio such that the controller die is embedded therein, and proper fillet, wire sagging prevention, proper curing, moisture resistance, and heat resistance are secured. According to the present disclosure, the adhesive

layer has a probe tack measurement value of 15 gf or smaller, and a melt viscosity of 2000 to 9000 Pa·s at 110° C.

[0071] When manufacturing the semiconductor package, the FOD adhesive film undergoes a transfer process. The adhesive layer of the FOD adhesive film has a relatively large thickness and is transferred on the B-stage and thus is jammed. The present inventor pays attention to a fact that the jam phenomenon is suppressed when controlling tack characteristic of the adhesive layer. Then, the present inventor controls the measurement value of the probe tack of the adhesive layer to 15 gf or smaller to suppress the jam phenomenon in the transfer process. The probe tack measurement means a value measured under a probe tack test. More preferably, the probe tack measurement value of the adhesive layer may be 1 to 9 gf. When the measurement value of the probe tack of the adhesive layer is 15 gf or greater, jamming of the adhesive layer frequently occurs due to excessive adhesive properties in the process of transferring the FOD adhesive film.

[0072] In addition, when a die attach process of attaching the FOD adhesive film to the substrate and stacking the semiconductor die on the FOD adhesive film is in progress, the controller die is not well embedded in the FOD adhesive film, and particularly, a stacking failure of the semiconductor die occurs frequently.

[0073] The present inventor pays attention to a fact that when controlling the melt viscosity of the adhesive layer, the controller die may be well embedded in the adhesive layer and the semiconductor die may be well stacked on the adhesive layer. The melt viscosity at 110°C of the adhesive layer may be controlled to 2000 to 9000 Pa·s. More preferably, the melt viscosity at 110°C of the adhesive layer may be 5000 to 8000 Pa·s. When the melt viscosity at 110°C of the adhesive layer is smaller than 2000 Pa·s, the bonding pad may be contaminated by the adhesive layer. Conversely, when the melt viscosity at 110°C of the adhesive layer exceeds 9000 Pa·s, a failure in embedding of the controller die in the adhesive layer may occur and the wire may sag.

[0074] The adhesive layer according to the present disclosure has the measurement value of the probe tack of 15 gf or smaller and the melt viscosity of 2000 to 9000 Pa·s at 110°C.

Accordingly, the jam phenomenon is suppressed in the transfer process, and a defect does not occur in the die attach process.

[0075] Factors for controlling the probe tack measurement value and the melt viscosity of the adhesive layer are not particularly limited. Preferably, the probe tack measurement value and the melt viscosity may be controlled by appropriately adjusting factors such as properties of components constituting the adhesive layer.

[0076] A component and a thickness of the adhesive layer of the second embodiment may be the same as a component and a thickness of the adhesive layer of the first embodiment.

[0077] Further, the FOD adhesive film according to the second embodiment may include the stack structure in which the support layer is stacked on one face of the adhesive layer. The stack structure may be applied to the semiconductor package. The support layer may have the same component and thickness as those of the support layer of the first embodiment.

[0078] **Semiconductor package**

[0079] Hereinafter, a semiconductor package according to the present disclosure will be described in detail.

[0080] Referring to FIG. 4, a semiconductor package according to a first embodiment of the present disclosure includes a substrate 200; a controller die 40 mounted on the substrate 200; a FOD adhesive film 100 formed on the substrate 200; and a semiconductor die 60 stacked on the FOD adhesive film 100.

[0081] The FOD adhesive film 100 includes a stack structure in which the support layer 20 is stacked on one face of the adhesive layer 10. At least a portion of the controller die 40 is embedded in the adhesive layer 10.

[0082] As described above, it is preferable that the surface energy of the support layer is 40 dyne/cm or greater, and the elongation-at-break of the support layer is preferably 100% or smaller. It is preferable that the elongation-at-break of the adhesive layer is 20% or greater.

[0083] The semiconductor package according to a second embodiment of the present disclosure includes the substrate 200; the controller die 40 mounted on the substrate 200; the FOD adhesive film 100 formed on the substrate; and the semiconductor die 60 stacked on the FOD adhesive film 100. The FOD adhesive film 100 includes the adhesive layer 10 having a probe tack measurement value of 15 gf or smaller, and a melt viscosity of 2000 to 9000 Pa·s at 110°C. At least a portion of the controller die 40 is embedded in the adhesive layer 10.

[0084] Preferably, referring to FIG. 4, the FOD adhesive film 100 having a stack structure in which the support layer 20 is stacked on one face of the adhesive layer 10 may be applied to the semiconductor package according to the present disclosure.

[0085] Referring to FIG. 4, in the semiconductor package according to each of the first and second embodiments of the present disclosure, a bonding pad 70 may be formed on the substrate 200, and may be connected to a bonding pad 70 formed on the semiconductor die chip 60 via a wire.

[0086] The semiconductor die 60 may be applied to the semiconductor package while a die attach film 52 is attached to one face of the semiconductor die 60.

[0087] Further, the semiconductor package according to the present disclosure may have a structure in which a stack structure including the semiconductor die 60 is embedded in an EMC (epoxy molding compound) 80.

[0088] In addition, the semiconductor package according to the present disclosure may further include a single or multiple passive elements in the adhesive layer 10; a single or multiple bonding pads 70; and a single or multiple wires.

[0089] Further, the semiconductor package according to the present disclosure may include a die attach film 51 between the controller die 40 and the substrate 200 and a die attach film 52 between the support layer 20 of the FOD adhesive film and the semiconductor die 60.

[0090] As described above, in the semiconductor package to which the conventional FOD adhesive film is applied, the semiconductor die (wafer chip) stacked on the FOD adhesive film and the semiconductor die stacked on the die attach film must be separately managed.

Accordingly, the semiconductor package to which the FOD adhesive film is applied has a problem in that a yield thereof is reduced compared to that of a general semiconductor package.

[0091] However, in the semiconductor package to which the FOD adhesive film according to the present disclosure is applied, the semiconductor die stacked on the FOD adhesive film and the semiconductor die stacked on the die attach film need not be separately managed. In other words, in the semiconductor package to which the FOD adhesive film 100 according to the present disclosure is applied, the semiconductor die stacked on the FOD adhesive film 100 may act as the semiconductor die having the die attach film thereon. Thus, a yield of the package dramatically increases compared to that of a semiconductor package to which a conventional FOD adhesive film is applied.

[0092] <Present Examples>

[0093] 1. Manufacturing and testing of FOD adhesive film according to first embodiment

[0094] (1) Manufacturing of FOD adhesive film according to first embodiment

[0095] In order to manufacture the FOD adhesive film according to the first embodiment, a coating solution forming the adhesive layer was produced using a following composition.

[0096] The acrylic copolymer (Nagase ChemteX Corporation, SG-P307S, a number average molecular weight of 250,000, and a glass transition temperature of 10°C) was prepared.

[0097] Bisphenol A epoxy resin as a liquid epoxy resin at room temperature (15 to 35°C) (Kukdo Chemical Corporation, YD-128, epoxy equivalent: 187g/eq), and cresol novolac epoxy resin as a solid epoxy resin at room temperature (15 to 35°C) (Kukdo Chemical Corporation, YDCN-500- 5P, epoxy equivalent: 206 g/eq) were prepared as a thermosetting resin.

[0098] As a curing agent, a phenol novolac resin (KOLON INDUSTRIES corporation, KPH-F2004, OH equivalent: 106 g/eq, softening point: 120) was prepared.

[0099] As an inorganic filler, spherical silica (DENKA, SFP-30M, an average particle diameter of 0.7 μm) was prepared.

[00100] Further, as a curing accelerator, an imidazole-based curing accelerator (Cuazole 2PH) was prepared.

[00101] A mixture was produced by mixing the above components at a mixing ratio as shown in Table 1 below.

[00102] Next, in order to secure coating properties, the mixture was mixed with methyl ethyl ketone (MEK) in a 1:0.9 weight ratio to produce an adhesive coating solution.

[00103] [Table 1]

Components	Present Examples (Mixing ratio-Wt %)		Comparative Examples (Mixing ratio-Wt %)	
	1	2	1	2
Acrylic	18	20	15	20
Liquid epoxy	15	15	9	13
Solid epoxy	12	10	18	12
Curing agent	14	14	17	14
Organic filler	40	40	40	40
Curing accelerator	1	1	1	1
Elongation-at-	54	68	17	54

break (%)				

[00104]

[00105] Next, a support layer as shown in Table 2 was prepared.

[00106] [Table 2]

Examples	Material of support layer	Thickness (μm)	Surface energy (dyne/cm)	Elongation-at-break (%)
Present Example 1	PEEK	30	48	78
Present Example 2	PET	30	52	75
Comparative Example 1	PEEK	30	48	78
Comparative Example 2	PET	30	35	125

[00107]

[00108] Each of coating solutions shown in Table 1 was applied on the support layer shown in Table 2. A FOD adhesive sheet for a semiconductor package was produced by

laminating a released polyester film on the adhesive coating solution and drying and removing a mixing solvent therefrom in a hot air dryer at 130°C for 5 minutes.

[00109] The surface energy and the elongation-at-break as described in Tables 1 and 2 were measured using a following method.

[00110] 1) Surface energy measurement method

[00111] We applied each prepared film on a flat and rigid support plate to have a uniform film thickness. Surface energy thereof with water was measured using a contact angle meter (Surface Electro Optics Corporation, SEO300A).

[00112] 2) Elongation-at-break measurement method

[00113] Each film to be measured was drilled into Type. 1 dumbbell shape (JIS K 7113) to prepare a test piece which was measured using a pulling test apparatus (JIS B 7721). After marking 100 mm sized marks on the test piece, a tensile tester was used to measure a load (tensile strength) and growth when cutting between marks was performed. In this connection, a tensile rate was 100 mm/min.

[00114] 3) Adhesion measurement method

[00115] In the adhesive films according to the Present Examples and Comparative Examples, adhesion of the support layer to the adhesive layer was measured.

[00116] Adhesion is a value measured under a 180° peeling experiment (measurement temperature: 25° C, peeling rate: 50 mm/min).

[00117] Table 3 shows interfacial adhesion measurements of the Present Examples and Comparative Examples.

[00118] [Table 3]

Examples	Adhesion (gf/cm)

Present Example 1	35
Present Example 2	38
Comparative Example 1	26
Comparative Example 2	14

[00119]

[00120] (2) Fabrication of substrate having controller die embedded in adhesive layer

[00121] A controller chip (die) of 50μm thickness, 3mm × 5mm (short side × long side) was attached to a PCB substrate using a commercially available 10μm die attach film under conditions of a temperature 120°C, a pressure 1kg, and a time 1 second. Thus, the substrate to which the controller die was attached was prepared.

[00122] (3) Fabrication of semiconductor package by transferring, cutting, and picking-up FOD adhesive film according to first embodiment and attaching the same to substrate

[00123] Total 100 FOD adhesive film samples were prepared for each specimen of Present Example/Comparative Example by transferring and cutting the prepared FOD adhesive film. The FOD adhesive film sample was picked up using a die-bonding device SPA-300S (brand name, Shinkawa) with 21 needles and a needle height of 0.30mm, and, then, was attached to the substrate having the controller chip attached thereto as manufactured above under conditions of a temperature of 120°C, a pressure of 1kgf, and time of 1 second using the device.

[00124] (4) Evaluation of results

[00125] Present Examples 1 and 2 according to the present disclosure were free of defects in the cutting process. In comparison thereto, in 68% of the samples in Comparative

Example 1, crack occurred on a cut surface of the adhesive layer. In 54% of the samples Comparative Example 2, the support layer and the adhesive layer were peeled from each other.

[00126] As described above, the present example according to the present disclosure having the controlled properties of the support layer and the adhesive layer was free of defects in the cutting process.

[00127] 2. Manufacturing and testing of FOD adhesive film according to second embodiment

[00128] (1) Manufacturing of FOD adhesive film according to second embodiment

[00129] In order to manufacture the FOD adhesive film according to the second embodiment, a coating solution forming the adhesive layer was produced using a following composition.

[00130] The acrylic copolymer (Nagase ChemteX Corporation, SG-P307S, a number average molecular weight of 250,000, and a glass transition temperature of 10°C) was prepared.

[00131] Bisphenol A epoxy resin as a liquid epoxy resin at room temperature (15 to 35°C) (Kukdo Chemical Corporation, YD-128, epoxy equivalent: 187g/eq), and cresol novolac epoxy resin as a solid epoxy resin at room temperature (15 to 35°C) (Kukdo Chemical Corporation, YDCN-500- 5P, epoxy equivalent: 206 g/eq) were prepared as a thermosetting resin.

[00132] As a curing agent, a phenol novolac resin (KOLON INDUSTRIES corporation, KPH-F2004, OH equivalent: 106 g/eq, softening point: 120) was prepared.

[00133] As an inorganic filler, spherical silica (DENKA, SFP-30M, an average particle diameter of 0.7 μm) was prepared.

[00134] Further, as a curing accelerator, an imidazole-based curing accelerator (Cuazole C11Z) was prepared.

[00135] A mixture was produced by mixing the above components at a mixing ratio as shown in Table 4 below.

[00136] Next, in order to secure coating properties, the mixture was mixed with methyl ethyl ketone (MEK) in a 1:0.9 weight ratio to produce an adhesive coating solution.

[00137] [Table 4]

Components	Present Example (Mixing ratio-Wt %)				Comparative Examples (Mixing ratio-Wt %)	
	3	4	5	6	3	4
Acrylic	24	23	18	27	24	30
Liquid epoxy	12	12.5	15	11	20	10
Solid epoxy	12	12.5	12	11	4	10
Curing agent	11	11	14	10	11	9
Organic filler	40	40	40	40	40	40
Curing accelerator	1	1	1	1	1	1

[00138]

[00139] Next, each of the adhesive coating liquids as obtained from Present Examples 3 and 4 and Comparative Examples 3 to 4 was applied onto a released polyester film having a thickness of 30 μm. The coating liquids were dried in a hot air dryer at 130°C for 5 minutes to remove a mixing solvent therefrom, thereby to prepare each FOD adhesive sheet for the semiconductor package.

[00140] Further, the support layer made of a polyetheretherketon (PEEK) and having a thickness of 30 μm was prepared, and each of the adhesive coating solutions obtained from Present Examples 5 and 6 was applied on the PEEK film. Then, a released polyester film was applied on the adhesive coating solutions. The coating liquids were dried in a hot air dryer at 130°C for 5 minutes to remove a mixing solvent therefrom, thereby to prepare each FOD adhesive sheet for the semiconductor package.

[00141] (2) Fabrication of substrate having controller die embedded in adhesive layer

[00142] A controller chip (die) of 50μm thickness, 3mm × 5mm (short side × long side) was attached to a PCB substrate using a commercially available 10μm die attach film under conditions of a temperature 120°C, a pressure 1kg, and a time 1 second. Thus, the substrate to which the controller die was attached was prepared.

[00143] (3) Fabrication of semiconductor package by transferring, cutting, and picking-up FOD adhesive film according to second embodiment and attaching the same to substrate

[00144] Total 100 FOD adhesive film samples were prepared for each specimen of Present Example/Comparative Example by transferring and cutting the prepared FOD adhesive film. The FOD adhesive film sample was picked up using a die-bonding device SPA-300S (brand name, Shinkawa) with 21 needles and a needle height of 0.30mm, and, then, was attached to the substrate having the controller chip attached thereto as manufactured above under conditions of a temperature of 120°C, a pressure of 1kgf, and time of 1 second using the device.

[00145] (4) Result evaluations

[00146] 1) Property measurement of FOD adhesive film

[00147] i) Probe tack measurement

[00148] The probe tack test was performed by applying a pressure of 0.5 N load onto a flat probe of φ10 mm such that the probe presses each adhesive film specimen to be measured for 10 seconds at a temperature of 25°C such that the probe closely contacts the film, and by then measuring a force required to separate the probe from the film. The force may correspond to the probe tack measurement value.

[00149] Ii) Melt viscosity measurement

[00150] After stacking the adhesive film specimens to a thickness of 600 to 800 ㎛ using a roll laminator, the stacked film was cut into a circular shape of 8mm diameter. A melt viscosity at 110°C thereof was measured using ARES G2 Rheometer (brand name, Texas Instrument company) and using a parallel plate method at a temperature of 25°C to 180°C (increase rate of 20°C/min), a strain of 10%, a frequency of 5rad/sec, and a force 0.5N.

[00151] Table 5 below summarizes measured values of the probe tack and the melt viscosity at 110°C of each specimen

[00152] [Table 5]

Properties	Present Examples				Comparative Examples	
	3	4	5	6	3	4
Probe tack	12	11.8	12	14	18	13
Melt viscosity at	6147	6234	3,487	8,256	5890	11250

110℃						

[00153]

[00154] 2) Defect percentage evaluation

[00155] Present Examples 3 to 6 according to the present disclosure had no defects in the transfer process and the die attach process. In comparison thereto, Comparative Example 3 had a defect percentage of 12% due to the jam phenomenon in the transfer process. In Comparative Example 4, in the die attach process, a defect percentage was 32% due to an embedding error of the controller die.

[00156] Further, unlike Present Examples 3, 4, and Comparative Examples 3 and 4, in Present Examples 5 and 6, the sample was not required to be diced with the wafer, and the semiconductor package may be manufactured using only the wafer to which the die attach film is attached, thus making the manufacturing process simple and allowing the yield thereof to be improved.

[00157] The present disclosure has been described above. However, the present disclosure is not limited to the embodiments as disclosed in the present specification. It is apparent that various modifications may be made thereto by a person skilled in the art within the scope of the technical idea of the present disclosure. In addition, although an effect of a configuration of the present disclosure was not explicitly described while explaining the embodiment of the present disclosure, it is natural that an predictable effect from the configuration should be appreciated.

[00158] The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

WHAT IS CLAIMED IS:

1. A FOD (film on die) adhesive film having a stack structure in which a support layer is stacked on one face of an adhesive layer,

wherein the adhesive layer is for embedding at least a portion of a controller die included in a semiconductor package,

wherein the support layer is for protecting the adhesive layer to prevent cutting defects due to fusion of the adhesive layer when the adhesive layer is cut,

wherein surface energy of the support layer is 40 dyne/cm or greater,

wherein elongation-at-break of the support layer is 100% or smaller, and elongation-at-break of the adhesive layer is 20% or greater,

wherein adhesion of the support layer to the adhesive layer is 20 gf/cm or greater.

2. The FOD adhesive film of claim 1, wherein the FOD adhesive film further includes a release film stacked on the other face of the adhesive layer

3. The FOD adhesive film of claim 1, wherein the support layer is made of at least one selected from a group consisting of polyimide, (PI), polyimideamide, polyetherimide (PEI), polyethyleneterephtalate (PET), polyethylenenaphthalate (PEN), and polyetheretherketon (PEEK).

4. The FOD adhesive film of claim 1, wherein the adhesive layer contains acrylic copolymer, epoxy resin, and inorganic filler.

5. The FOD adhesive film of claim 4, wherein the acrylic copolymer has a glass transition temperature of 0°C to 20°C and a weight average molecular weight of 100,000 to 500,000.

6. The FOD adhesive film of claim 4, wherein the epoxy resin includes at least one selected from a group consisting of bisphenol-based epoxy resin, biphenyl-based epoxy resin, naphthalene-based epoxy resin, fluorene-based epoxy resin, phenol novolac-based epoxy resin, cresol novolac-based epoxy resin, trishydroxylphenylmethane-based epoxy resin, and tetraphenylmethane-based epoxy resin.

7. The FOD adhesive film of claim 4, wherein the epoxy resin includes an epoxy resin in a liquid phase at 10 °C to 35 °C, and an epoxy resin in a solid phase at 10°C to 35°C.

8. The FOD adhesive film of claim 1, wherein the adhesive layer has a thickness of 60 to 150 ㎛.

9. The FOD adhesive film of claim 1, wherein the support layer has a thickness of 5 to 50 ㎛.

10. A semiconductor package comprising:

a substrate;

a controller die mounted on the substrate;

a FOD adhesive film formed on the substrate; and

a semiconductor die stacked on the FOD adhesive film,

wherein the FOD adhesive film has a stack structure in which a support layer is stacked on one face of an adhesive layer,

wherein at least a portion of the controller die is embedded in the adhesive layer,

wherein the support layer is for protecting the adhesive layer to prevent cutting defects due to fusion of the adhesive layer when the adhesive layer is cut,

wherein surface energy of the support layer is 40 dyne/cm or greater,

wherein elongation-at-break of the support layer is 100% or smaller, and elongation-at-break of the adhesive layer is 20% or greater,

wherein adhesion of the support layer to the adhesive layer is 20 gf/cm or greater.

11. The semiconductor package of claim 10, wherein the semiconductor package further comprises a single or multiple passive elements in the adhesive layer; a single or multiple bonding pads; and a single or multiple wires.

12. The semiconductor package of claim 10, wherein the semiconductor package further comprises:

a die attach film between the substrate and the controller die; and

a die attach film between the support layer of the FOD adhesive film and the semiconductor die.