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DESCRIPTION



CUSHIONING BODY FOR GLASS SUBSTRATES AND PACKAGED ARTICLE
USING THE CUSHIONING BODY

TECHNICAL FILED

This invention relates to a cushioning body for protecting a glass substrates comprising a glass base having formed thereon an electronic part such as a semiconductor device from damages due to vibration during transportation. The invention also relates to a packaged article in which a plurality of the above-described glass substrates are packaged together.

BACKGROUND ART

In recent years, electronic or electric devices, particularly liquid displays or plasma displays which are one of peripheral devices for personal computers, and portable terminals represented by mobile phones, are devices production amount of which has been drastically increased with the development of the industry of information technology represented by internet. It has eagerly been demanded to develop technology relating to cushioning bodies to be used for packaging or transporting such devices. Of the devices, glass substrates having

formed thereon electronic parts such as semiconductor devices, for example, glass substrates used for color filters, TFT liquid crystal cells (substrates having formed thereon a circuit in which thin film transistors are incorporated) and liquid crystal panels, have such a thin thickness that they are susceptible to impact or vibration during transportation and, in addition, they are so susceptible to be influenced from outside due to their extremely fine structure that they are difficult to handle. Especially, in the case of transporting glass substrates before processing or semi-completed products before final products, they are handled with the above-described electronic parts being laid bare, and hence they are adversely affected more strongly by static electricity or dusts to lose their performance in some cases.

Thus, many packaging techniques have been proposed for safely transporting the glass substrates with no damages.

As one example thereof, there is illustrated a technique disclosed in Japanese Patent Laid-Open No. 319456/1993. The gist of the technique is that a cushioning body which comprises a polyolefin bead foamed body having specific properties and which has a substantially L-letter shaped cross section and a plurality of substrate-inserting grooves on the inside

surface along the L-letter. Upon packaging glass substrates, a plurality of glass substrates are disposed in parallel with one another at a predetermined interval to define a rectangular parallelepiped, and each corner of the respective substrates was inserted into the substrate-inserting groove of the cushioning body to fit the four sides of the rectangular parallelepiped making a right angle with the surface of the substrate into the cushioning bodies, followed by, if necessary, fixing with a fixing member such as an elastic or a tape.

However, in the case of fixing by applying a fixing member such as an elastic or a tape to outside of the cushioning bodies, its binding force concentrates on the corner of the cushioning bodies so that the L-letter of the cushioning body is widened and the glass substrates come off the substrate-inserting grooves, thus failing to fully exert the protecting function.

Also, in the aforesaid L-letter shaped cushioning bodies, the width of the substrate-inserting groove is the same as, or slightly narrower than, the thickness of glass substrates, and the glass substrates are fixed utilizing the high elastic recovery of polyolefin bead foamed body upon compression, which is characteristic of the beads. Thus, although this is effective for preventing generation of dust due to vibration and friction with glass

substrates during transportation, the frictional resistance with the glass substrate exerts adverse effects upon packaging the glass substrates which is the essential purpose and, when the glass substrates are forcibly inserted into the grooves, the glass substrates having a thickness as thin as about 0.4 to about 1.0 mm easily bend and are liable to be damaged. Thus, there arises a problem that it takes a long time if the operation is made carefully to avoid such damage. The same applies to the case of unpackaging the substrates. In particular, in view of saving labor, automatic packaging machines and unpackaging machines have recently been introduced, but the above-described problem is liable to cause troubles, and it has been pointed out that L-letter shaped cushioning bodies are not actually suitable for automation.

Further, upon inserting the glass substrates into the substrate-inserting grooves, fine scuff marks may be formed on the glass substrate surface due to frictional resistance force, which is another problem.

In view of the above-described problems, an object of the invention is to provide a cushioning body for glass substrates which prevents the glass substrate from coming off the groove at the end portion of the L-letter of the cushioning body upon packaging the glass substrates and which can safely protect the glass substrates even when an

external force such as vibration or drop impact is applied thereto during transportation or handling. Furthermore, it is also an object of the invention to provide a cushioning body for glass substrates, which is suitable for automation of packaging and unpackaging of glass substrates, which does not easily generate dusts even when frictionally slid against the glass substrate and which has excellent durability enabling to be used several times. Still further, an object of the invention is to provide a packaged article formed by using the cushioning bodies.

DISCLOSURE OF THE INVENTION

In a first aspect, the cushioning body for glass substrates according to the invention comprises a polyolefin bead foamed body and has a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate, on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion, and on outside surface of which at least one fixing member-guiding groove is defined along the L-letter, wherein the thickness of the cushioning body based on the bottom portion of the fixing member-guiding groove is

gradually reduced from both ends of the L-letter toward the corner portion.

The above-described first cushioning body of the invention includes, as a preferred embodiment, an embodiment wherein the bottom portion of the fixing member-guiding groove is beveled at the corner portion.

In a second aspect, the cushioning body for glass substrates according to the invention comprises a polyolefin bead foamed body and has a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate, on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion, wherein the thickness of the cushioning body is gradually reduced from both ends of the L-letter toward the corner portion.

In a third aspect, the cushioning body for glass substrates according to the invention comprises a polyolefin bead foamed body and has a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate, on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion,

wherein protrusions being formed outside at both ends of the L-letter.

The above-described second and third cushioning bodies for glass substrates according to the invention include, as preferred embodiments, embodiments wherein an outer corner portion is beveled.

In addition, the above-described cushioning bodies of the invention include, as preferred embodiments: an embodiment wherein a notch groove is defined inside the cushioning body in a direction at right angles to the substrate-inserting grooves; an embodiment wherein the cushioning body has a maximum thickness of is 10 to 60 mm and a ratio of the two sides of the L-letter is 1.0 to 3.0 based on the shorter side, and the substrate-inserting grooves have a width of 1.0 to 4.0 times as much as the thickness of the glass substrates, a depth of 3 to 15 mm, and a groove pitch of 6 to 100 mm; and an embodiment wherein the polyolefin bead foamed body has an average particle size of formed particles of 1.5 to 5.0 mm, has a fusion rate of 70% or more, a compressive elastic exponent of 3.9 to 490, and a recovery rate of 60% or more.

The packaged article according to the invention, in a first aspect, has features that a plurality of glass substrates are disposed in parallel with one another at a predetermined interval to define a rectangular

parallelepiped, the corner portion of the respective substrates is inserted into the substrate-inserting groove of the first cushioning body for glass substrates to thereby fit the four sides of the rectangular parallelepiped that make a right angle with the surface of the cushioning body, into the cushioning body, and the assembly is fastened by binding with a long fixing member along the fixing member-guiding groove of the cushioning body.

the packaged article according to the invention, in a second aspect, has features that a plurality of glass substrates are disposed in parallel with one another at a predetermined interval to define a rectangular parallelepiped, the corner portion of the respective substrates is inserted into the substrate-inserting groove of the second or third cushioning body for glass substrates to thereby fit the four sides of the rectangular parallelepiped that make a right angle with the surface of the cushioning body, into the cushioning body, and the assembly is fastened by binding with a long fixing member along the outside of the L-letter of the cushioning body.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing one embodiment of the cushioning body according to the invention.

Fig. 2 is a perspective view showing one embodiment of the packaged article according to the invention.

Fig. 3(a) to Fig. 3(e) are sectional diagrams showing embodiments of the cushioning bodies according to the invention.

Fig. 4(a) to Fig. 4(c) are sectional diagrams showing examples of the constitution of the substrate-inserting groove of the cushioning body according to the invention.

Additionally, in the drawings, numeral 1 designates a cushioning body; 2, a substrate-inserting groove; 3, a fixing member-guiding groove; 4, a protrusion; 21, a glass substrate; 22, a fixing member; 31, wall surface of the cushioning body; 32, a bottom portion of the substrate-inserting groove; 33, an end of the L-letter; 34 and 34', a corner portion of the L-letter; 35, a bottom portion of the fixing member-guiding groove; 36, a beveled portion; 37, a notch groove; 38, a protrusion; and 39, a depression.

BEST MODE FOR CARRYING OUT THE INVENTION

The cushioning body of the invention comprising a polyolefin bead foamed body having a substantially L-letter shaped cross section has a feature that its thickness at the end of the L-letter is made thicker than

that at its corner portion. Thereby, when packaging glass substrates followed by binding the assembly with a fixing member from outside, the fixing member goes, at the end of the L-letter, an outer position than that at the corner portion, which serves to prevent the binding force of the fixing member from concentrating on the corner portion and enables the binding force to uniformly press the whole cushioning body to thereby protect the glass substrates.

In the invention, specific constitutions in which the thickness of the cushioning body at the end of L-letter is made thicker than that at the corner portion are as follows.

(1) Fixing member-guiding grooves are formed such that the depth thereof becomes deeper from the ends of the L-letter toward the corner portion, thereby making the thickness of the cushioning body based on the bottom portion of the fixing member-guiding groove gradually reducing from the ends of L-letter toward the corner portion;

(2) Without forming the fixing member-guiding grooves, the cushioning body is molded so that the thickness of itself is gradually reduced from the ends of L-letter to the corner portion; and

(3) Protrusions are formed outside at both ends of the L-letter of the cushioning body.

The cushioning body and the packaged article, in which a plurality of glass substrates are integrally packaged using the cushioning body, are specifically described below by reference to embodiments.

Fig. 1 is a perspective view showing one embodiment of the cushioning body of the invention having the structure described in item (1) above. In Fig. 1, numeral 1 designates a cushioning body; 2, a substrate-inserting groove; 3, a fixing member-guiding groove; and 4, a protrusion separating adjacent substrate-inserting grooves from one another. Fig. 2 is a perspective view showing one embodiment of the packaged article of the invention in which a plurality of glass substrates are packaged by using four cushioning bodies of the invention. In Fig. 2, numeral 21 designates a glass substrate and numeral 22 designates a fixing member, and the same numerals as in Fig. 1 designate the same members.

The cushioning body 1 of the invention functions to protect the corner portions of the glass substrates 21 and integrally fix a plurality of the glass substrates, and packaging is conducted by using two or more, preferably 4, of the cushioning bodies.

As is shown in Fig. 1, the cushioning body 1 of the invention has a substantially L-letter shaped cross

section in conformity with the shape of the corner portion of the glass substrate and, in order to fix two sides forming the corner portion of the glass substrate, a plurality of substrate-inserting grooves 2 are provided along the L-letter in a state of being separated from one another by the protrusions 4.

Also, in the constitution described in item (1) above, the fixing member-guiding groove 3 is formed along the L-letter. As is shown in Fig. 2, the fixing member-guiding groove 3 is used for binding the packaged glass substrates 21 by winding the fixing member 22 along the fixing member-guiding groove 3. In the invention, in the case of providing the fixing member-guiding groove 3, the thickness of the cushioning body 1 is changed so that its thickness at the bottom portion is gradually reduced toward the corner portion. Fig. 3(a) schematically shows the cross section of the cushioning body 1 of Fig. 1 along the fixing member-guiding groove 3 and the substrate-inserting groove 2. In Fig. 3, numeral 31 designates the outer surface of the cushioning body 1; 32, the bottom portion of the substrate-inserting groove 2; 33, the end of L-letter of the cushioning body 1; 34 and 34', the corner portions of the L-letter; 35, the bottom portion of the fixing member-guiding groove 3; 36, the beveled portion; 37, the notch groove; 38, the protrusion; and 39,

the depression. Additionally, in the following descriptions, the thickness at the corner portion 34 or 34' means the thickness of the cushioning body on the shorter side and the longer side at the inside corner portion of the L-letter.

As is shown in Fig. 3(a), the thickness of the cushioning body at the bottom portion 35 of the fixing member-guiding groove is gradually decreased towards the corner portion 34' from the end 33 of the L-letter by forming the fixing member-guiding groove so that its depth is smaller at the end 33 of the L-letter and is larger at the corner portion 34' thereof. As a result, upon winding a long fixing member along the fixing member-guiding groove after packaging the glass substrates, the distance from the fixing member to the glass substrate is larger at the end 33 than at the corner portion 34', which serves to prevent the binding force of the fixing member from concentrating on the corner portion 34'.

Also, in order to prevent the binding force of the fixing member from concentrating on the corner portion 34' of the bottom portion 35 of the fixing member-guiding groove, it is preferred to previously bevel for forming a beveled portion 36 as shown in Fig. 3(b). By forming the beveled portion 36, possibility for the fixing member to dig into the cushioning body to damage is eliminated, and

deformation distortion at the corner portion 34' is reduced, which serves to reduce the force of widening the end portions 33 of the cushioning body toward the outside. The beveled portion 36 may be plane or curved.

Additionally, as is shown in Fig. 3(c), it is preferred to form one or more notch grooves 37 on the inside of the cushioning body in the direction at a right angle with the substrate-inserting groove (direction at a right angle with the paper), whereby the notch grooves 37 absorb, upon binding with the fixing member, the deformation stress of widening the end portion 33 toward outside and prevent the stress from spreading to the end portion 33. Additionally, the notch groove 37 may be of a substantially U-letter shape as well as a substantially V-letter shape as shown in Fig. 3(c).

Also, in Figs. 3, the protrusion 4 is partly removed at the inside of the corner portion 34 on the shorter side to form depression 39. This is a constitution which is designed for preventing breakage of the glass substrate at the corner portion most susceptible to damage when receiving vibration impact or drop impact during transportation. Additionally, in the depression 39, it suffices for the protrusion 4 to be removed to the bottom portion 32 of the substrate-inserting groove. In addition, in view of preventing breakage of the glass substrate at

its corner portion, it is preferred to form the depression to deeper than the bottom portion 32.

One example of the invention of the aforesaid constitution (2) wherein the end 33 of the L-letter of the cushioning body is made thicker than at the corner portion 34 is shown in Fig. 3(d), and one example of the constitution (3) in Fig. 3(e). In Fig. 3(d), the cushioning body is so formed that the thickness of the cushioning body itself is gradually decreased from the end 33 of the L-letter toward the corner portion 34. In this case, no fixing member-guiding grooves are particularly formed, and hence the width and binding position of the fixing member can be freely selected. Also, in Fig. 3(e), protrusion 38 is formed on the outside of the end 33 of the L-letter and, as a result, the thickness of the cushioning body at its end 33 is made thicker than at the corner portion 34. The protrusion 38 may be integrally formed with the cushioning body, or may be formed by adhering a separately formed plate to the cushioning body through heat welding or with an adhesive. In the latter case, the plate may be made of a material which is the same as, or different from, that of the cushioning body.

Also in the constitutions of Fig. 3(d) and Fig. 3(e), it is possible to appropriately form the beveled portion

36 or the notch groove 37 as shown in Fig. 3(b) or Fig. 3(c).

Next, preferred outer dimensions of the cushioning body of the invention are described below.

The ratio of the lengths of the two sides of the L-letter (lengths of the portions with which the glass substrate comes into contact) is preferably 1.0 or more, more preferably 3.0 or less, based on the length of the shorter side. Where the ratio is within this range, the longer side and the shorter side well balance with each other, and rectangular glass substrates can be fixed with an extremely good stability. In addition, the possibility for the glass substrates to be damaged due to bending is much reduced. The ratio is still more preferably less than 2.7.

With the ratio being within the above range, the length of the shorter side is preferably 10% or more, more preferably 45% or less, of the length of the shorter side of the glass substrate to be packaged. Further, 15% or more is still more preferred, and 40% or less is most preferred. When the length of the shorter side of the cushioning body is within the above-described range, risk of the glass substrate being damaged can be avoided even when it receives a drop impact and the like, since there

are provided the cushioning bodies that can sufficiently absorb the impact force. In addition, since the stress to be applied to the cushioning body (own weight of the glass substrates) is reduced, generation of dust during transportation due to contact friction by vibration can be depressed, thus a satisfactory cleanness being attained as well.

As to specific dimensions of the cushioning body, the length of the shorter side is preferably 100 mm or more, more preferably 500 mm or less. The length of the longer side is preferably 100 mm or more, more preferably 500 mm or less. Also, the length in the direction at a right angle with the shorter side and the longer side is preferably 150 mm or more, more preferably 600 mm or less, though depending upon the number of the glass substrates to be packaged.

In view of the size and weight of glass substrates, the number of glass substrates to be packaged and the compressive elastic exponent of the cushioning body, the maximum thickness of the cushioning body of the invention is preferably 10 mm or more, more preferably 60 mm or less, with 15 mm or more and/or 40 mm or less being still more preferred. When the outer dimensions and the maximum thickness are within the above-described ranges, the cushioning bodies can be used as cushioning bodies

permitting to stably fix all of glass substrate products of various dimensions as well as cushioning bodies for glass substrates before being processed. In addition, they can exhibit the function of sufficiently protecting glass substrates from the impact during transportation.

Also, in the case of forming the fixing member-guiding groove as shown in Fig. 3(a), the depth of the groove is preferably 0.5 mm or more, more preferably 5 mm or less, at the end 33, and is preferably 2 mm or more, more preferably 15 mm or less, at the corner portion 34'. When the fixing member-guiding groove is formed so that the depth of the fixing member-guiding groove falls within the above-described range, positional deviation of the fixing member is of course prevented and, since binding force is uniformly applied all over the full length of the shorter side and the longer side of the cushioning body upon binding the assembly with the fixing member, leg-widening deformation of the cushioning body can be prevented, thus four corner portions of the glass substrates being stably fixed. Hence, the cushioning bodies exert a satisfactory function of protecting the glass substrates. In Fig. 3(a), the fixing member-guiding groove is formed up to the end 33. The fixing member-guiding groove may be formed so as to constitute the same plane as the outer wall 31 of the cushioning body at the

vicinity of the end 33. In this case, the fixing member-guiding groove is spaced from the end 33 by preferably 10 mm or more. More preferably, the fixing member-guiding groove is formed so that its depth is gradually increased from the position spaced from the end 33 by 100 mm or less toward the corner portion 34'. Within this range, there occurs no positional deviation of the fixing member during transportation and, in addition, there is obtained the same effects as that obtained by forming the fixing member-guiding groove from the end 33.

Further, in the case of changing the thickness of the cushioning body itself as shown in Fig. 3(d), it is preferred to make the thickness at the corner portion 34 smaller than that of the end portion 33 by 1 mm or more, more preferably 10 mm or less, still more preferably 3 mm or more, most preferably 8 mm or less. Also in this case, the same effect as described above can be obtained by forming the cushioning body with a uniform thickness of the end portion 33 to the position as far as 10 mm or more, more preferably 100 mm or less, from the end portion 33 toward the corner portion 34, and gradually reducing the thickness of the cushioning body from the position toward the corner portion 34.

Also, in the case of Fig. 3(e), it is preferred to make the corner portion 34 thinner than the end portion 33

by 1 mm or more, more preferably 10 mm or less. As means to make the corner portion 34 thinner, protrusion 38 is formed in the vicinity of the end portion 33 as shown in Fig. 3(e). The width of the protrusion 38 in the direction along the L-letter is preferably 10 mm or more, more preferably 100 mm or less, still more preferably 20 mm or more, most preferably 80 mm or less.

Further, in the case of forming the beveled portion 36 as shown in Fig. 3(b), the length of the arc or line thereof, in the L-letter cross section, is preferably 3 mm or more, more preferably 60 mm or less in view of the compressive elastic exponent, maximum thickness and length of both sides of the cushioning bodies.

When the beveling is conducted within this range, concentration of the binding force of the fixing member on the corner portion can be avoided upon packaging glass substrates and binding the assembly by winding the fixing member therearound and hence the whole cushioning bodies are uniformly pressed to fix the corner portions of the glass substrates. Thus, there can be obtained more enhanced function of fixing and protecting the glass substrates and, in addition, even when the fixing member is applied with a strong binding force, the fixing member is prevented from digging into the cushioning bodies. Hence, the cushioning bodies can be repeatedly used over a

prolonged period, and a markedly improved durability is attained.

In the case of forming the notch groove 37 as shown in Fig. 3(c), the depth of the notch groove is preferably $1/20$ or more, more preferably $1/2$ or less, of the thickness of the cushioning body at the portion where the notch groove 37 is formed. The width of the groove is preferably 2 mm or more, more preferably 10 mm or less. Additionally, the position and number of the notch groove 37 are not particularly limited, but its position is preferably $1/8$ or more, more preferably $4/5$ or less, of the length of the side (the length of the portion with which the glass substrate come into contact) spaced from the corner portion (the point where the portions of the longer side and the shorter side contacting with the glass substrate come into contact), and its number is preferably 1 or more, more preferably 3 or less. When the notch groove 37 is formed within the above-described ranges, the glass substrates are inserted with enough fixability over the full length of the glass substrate-inserting groove without impairing the rigidity of the cushioning bodies. Thus, the function of protecting the substrates is improved and, in addition, the effect of further reducing the generation of dust due to friction with the cushioning bodies is obtained as well.

Further, in the case of forming the depression 39 as shown in Fig. 3, it is preferred to form the depression 39 so that the bottom portion of the depression 39 reaches the depression 32 of the substrate-inserting groove and, more preferably in view of the size and thickness of the glass substrate and the maximum thickness of the cushioning body, that the depression 39 is formed to the depth of 1 mm or more and 8 mm or less, most preferably 2 mm or more and 6 mm or less, from the bottom portion of the substrate-inserting groove 32. Within these ranges, no external force would be applied to the most fragile corner portion of the glass substrate even if the cushioning bodies suffer distortional deformation due to drop impact, thus extremely reducing the possibility of the glass substrate being damaged. In addition, the structural strength of the cushioning bodies is also retained enough, and hence they can maintain the initial shape even after repeated use. Therefore, they can exhibit the function of fixing and protecting the glass substrates for a long period of time.

The width of the substrate-inserting groove formed in the cushioning body of the invention is preferably 1.0 times to 4.0 times, more preferably 1.2 times to 3.5 times as much as that of the glass substrates to be packaged. Within the ranges, the work of inserting and taking out

the glass substrates manually or by means of an automatic apparatus can be conducted rapidly with a good efficiency, and breakage troubles of the glass substrates in the inserting work are markedly reduced. In addition, fixability of the glass substrate in the substrate-inserting groove is so sufficient that, even when vibration impact is applied thereto, friction between the glass substrate and the cushioning body is depressed, thus dust being rarely generated and the glass substrate being kept clean.

Also, the depth of the substrate-inserting groove is preferably 3 mm or more, more preferably 15 mm or less in view of the size and weight of the glass substrate, the compressive elastic exponent of the cushioning body, and the width of the substrate-inserting groove. Still more preferably it is 5 mm or more, most preferably 10 mm or less. Within the ranges, the glass substrates can be surely fixed in the state of being inserted into the inserting grooves even when they receive vibration impact during transportation or drop impact during handling, and hence breakage troubles that the glass substrates come off the inserting grooves and come into contact with the adjacent substrates can be prevented. Also, since the portion of the glass substrate in contact with the substrate-inserting groove is always in a frictional

contact with the cushioning body due to vibration impact during transportation, there is an extremely high possibility that fine scuff marks are formed on the surface of the glass substrate. Hence, in processing the transported glass substrate to produce a liquid crystal panel, it is general to previously cut off the portion of the substrate having been in contact with the inserting groove of the cushioning body. However, where the depth of the groove is within the above-described range, the portion is extremely small in area, and reduction in yield can be minimized, thus a high productivity being attained. Further, the amount of dust generated due to friction between the glass substrate and the cushioning body is small, thus the cushioning body being desirable in view of cleanness as well.

In view of the kind of the glass substrate (for example, glass itself, color filter, liquid crystal module, liquid crystal, and plasma display panel), the size and weight of the glass substrate, the compressive elastic exponent of the cushioning body, the width of the substrate-inserting groove, and the adaptability for automated insertion and taking out of the glass substrate, the pitch of substrate-inserting grooves is preferably 6 mm or more, more preferably 100 mm or less. Within this range, the work of inserting or taking out the substrates

can be conducted easily and surely and, in addition, the risk can be avoided that the glass substrate is bent by the vibration impact during transportation or the drop impact during handling to come into contact with the adjacent substrate.

Also, in the cushioning body of the invention, the protrusions separating adjacent substrates from one another have a sectional shape wherein the top is flat as is shown in Fig. 4(a). However, in consideration of workability upon inserting the glass substrates and generation of dust upon insertion, two-stage shape wherein there is formed on the upper side of the protrusion a guiding portion such as convex (Fig. 4(b)) or trapezoid (Fig. 4(c)) is preferred, with a trapezoid being more preferred. Even when the cushioning body has formed therein the substrate-inserting grooves with a narrow pitch, a metal mold for in-mold molding the cushioning body can be manufactured with a high accuracy. In the figures, t_1 represents the maximum thickness of the cushioning body 1; t_2 , the depth of the substrate-inserting groove; t_3 , the width of the groove; and t_4 , the groove pitch.

Next, materials for constituting the cushioning body of the invention are described below.

The cushioning body of the invention comprises polyolefin bead foamed body. The foamed body is obtained by filling foamable polyolefin beads into a metal mold of a desired shape, heating with steam to foam, and cooling to thereby obtain a molded foam of a desired shape. As the metal mold to be used for the molding, there may be used a metal mold obtained by a casting method. The casting method enables one to produce metal molds having a complicated structure with ease and a high accuracy and, in addition, production cost is 1/10 or less of the cost with metal molds for injection molding, thus being economical and suitable for mass production.

The polyolefin to be used for forming the polyolefin bead foamed body may be of crosslinked type or non-crosslinked type. Specific examples of materials of the resin, there are illustrated polyethylene resins represented by low-density polyethylene, middle-density polyethylene, high-density polyethylene, linear low-density polyethylene, linear ultra-low-density polyethylene, polyethylene produced by using a metallocene catalyst and ethylene-vinyl acetate copolymer, random and block polypropylene copolymer resins between a copolymerizable component of ethylene, butene-1 or 4-methylpentene-1 and propylene, random polypropylene copolymer resins obtained by using a metallocene catalyst,

and a composition obtained by blending two or more of the above-described resins.

Of these, polyethylene resins having a resin density of 0.927 g/cm³ or more are preferred, with polyethylene resins having a resin density of 0.970 g/cm³ or less and random polypropylene copolymer resins between ethylene or butene-1 and propylene being more preferred. When the polyethylene resin density is within the above-described range, the resultant cushioning body has suitable physical properties such as rigidity, flexibility and recovery, and has markedly sufficient practical performance such as markedly improved shape stability, impact cushioning performance upon being dropped, durability against repeated use, and dust generation-preventing properties. Also, in order to obtain a specific compressive elastic exponent, the expansion ratio of the cushioning bodies can be raised relatively higher, which serves to reduce weight and production cost of the cushioning bodies. In addition, since the random copolymer propylene resins between ethylene or butene-1 and propylene have a higher elasticity than that of the polyethylene resins, they are suitable for cushioning bodies for large-sized glass substrates, and have such an excellent shape stability that they can maintain their initial shapes even after

repeated use for a long period of time, thus being preferred.

A first requirement for the cushioning body of the invention comprising the polyolefin bead foamed body is that the foamed particles constituting the cushioning body have an average particle size of preferably 1.5 mm or more, more preferably 5.0 mm or less. Still more preferably, the size is 2.0 mm or more and, most preferably 4.5 mm or less. When the average particle size is within the ranges, the ratio of the surface area to the volume of one foamed particle is so small that reduction in pressure of gas (air) within the particles upon steam heating in the in-mold molding is extremely small, thus sufficient foaming expansion by heating being realized. As a result, slight gaps are scarcely formed between foamed particles located on the surface of the resultant foamed body obtained by the in-mold molding and, in the case of using as cushioning bodies for transporting glass substrates, dust in the air does not invade into the portion, thus an excellent cleanness being attained. Also, in filling the foamable particles into the metal mold, they can be filled even into a fine portion of the substrate-inserting grooves having a narrow width, and hence there can be obtained cushioning bodies with a high accuracy in conformity with the shape and dimension of the metal mold.

Additionally, the average particle size of the foamed beads is a value obtained by drawing 100 mm-long three lines on the surface of the in-mold moldings, measuring the number of foamed particles in contact with the line, and calculating the average particle size C (mm) according to the following formula (A). Additionally, the value is an average of the values obtained for the three lines.

$$C = (1.626 \times L) / N \quad \dots \quad (A)$$

wherein L: centerline length (mm);

N: number of particles

A second requirement for the cushioning body of the invention comprising the polyolefin bead foamed body lies in physical properties of the cushioning body. That is, the cushioning body is required to have a fusion rate of preferably 70% or more, a compressive elastic exponent of preferably 3.9 or more (more preferably 4.90 or less) and a recovery rate of preferably 60% or more.

Additionally, the above-described fusion rate is a numerical value obtained by making a cut of about 1 mm in the cushioning body in the direction of thickness, folding the cushioning body with the cut facing outside to break, measuring the number of the whole foamed particles and the number of the broken particles in the area of the broken section of the full length in the depth direction and about 75 mm in the longitudinal direction, dividing the

number of the broken particles by the number of the whole foamed particles, and representing the thus calculated value in terms of percentage. In the invention, when the fusion rate is 70% or more, properties relating to mechanical strength such as compression strength and tensile strength inherent to the polyolefin bead foamed body can fully be realized. That is, since numberless foamed particles constituting the cushioning body are strongly fused to integrate, it results in a cushioning body having excellent durability and recovery. Hence, in the case of fixing and packaging glass substrates using the cushioning bodies of the invention, the cushioning bodies can sufficiently resist the strong binding force of the fixing member, thus glass substrates can be fixed and packaged at a high level, and possibility of the glass substrates being broken is much more reduced. Further, there exist no fine gaps between the foamed particles on the surface of the cushioning body, and the cushioning body shows substantially no water-absorbing properties in washing with water to be repeatedly conducted every time after use, which provides the advantage of being excellent in drying work.

Also, when the compressive elastic exponent of the cushioning body is within the above-described range, the polyolefin can exhibit the maximum cushioning ability

inherent to it, and the cushioning body has well balanced rigidity and flexibility. In particular, even large-sized substrates having a glass substrate dimension of 500 mm x 600 mm or larger can be stably fixed and protected at an extremely high level. In addition, since the cushioning body has an enough strength to resist an external force to be applied thereto during transportation or handling, it suffers only a slight deformation, and shows an enough durability enabling the cushioning body to be repeatedly used over a long period of time. Also, the expansion ratio of the cushioning body for obtaining a specific compressive elastic exponent can be raised to a comparatively higher level, which serves to reduce the weight and production cost of the cushioning body.

Further, since the compressive elastic exponent is within the above-described range and the recovery rate is 60% or more, the cushioning body shows an excellent durability against repeated use which is believed to be the maximal characteristic of the polyolefin bead foamed body, and deformation can be minimized even when frequency of use becomes high.

Additionally, the above-described compressive elastic exponent is a value obtained by dividing the compression elasticity (N/cm^2) by the expansion ratio.

The above-described compression elasticity is a value determined with a sample, whose expansion ratio has been measured as described below, according to JIS K7220, with the compressing rate being 10 mm/min. With a sample of less than 20 mm in thickness, a plurality of the samples are piled to the thickness of about 20 mm to measure.

The expansion ratio is obtained by cutting out a flat sample of 50 mm in width, 50 mm in length and 20 mm in thickness from the cushioning body, measuring the weight (g) of the sample to the order of 10 mg, measuring width, length and thickness of the sample by means of vernier calipers to calculate the volume (cm³), and calculating expansion ratio E (cm³/g) according to the following formula (B).

$$E = \text{Volume/Weight (cm}^3\text{/g)} \quad \dots (B)$$

The recovery is obtained by cutting out a flat sample of 50 mm in width, 50 mm in length and 20 mm in thickness from the cushioning body, compressing the sample to the thickness of 50% of the sample at a compressing speed of 10 mm/min using a compression testing apparatus, Autograph AG-5000D, manufactured by Shimazu Seisaku-sho K.K., then immediately removing the load at the same speed, measuring the thickness at which the load became zero, and calculating the recovery rate R(%) according to the formula (C) shown below. Additionally, with a sample of

less than 20 mm in thickness, a plurality of the samples are piled to the thickness of about 20 mm to measure.

$$R = (T1/T0) \times 100 (\%) \quad \dots (C)$$

wherein T0: thickness (mm) before the test;

T1: thickness (mm) after the test (when the load became zero).

Next, the packaged article of the invention is described below. The packaged article of the invention is formed by packaging a plurality of glass substrates using two or more of the cushioning bodies of the invention as one set, preferably four cushioning bodies as one set. That is, a plurality of the glass substrates are disposed in a parallel position to one another at a predetermined interval to define a rectangular parallelepiped, each corner portion of the respective substrates is inserted into the substrate-inserting groove of the cushioning body of the invention to fit the four sides of the rectangular parallelepiped at a right angle with the surface of the substrate into the cushioning bodies. Then, a long fixing member is wound around the rectangular parallelepiped along the L-letter of the cushioning bodies to bind. In the case where the cushioning bodies have fixing member-guiding grooves, the fixing member is wound around along the fixing member-guiding grooves.

Additionally, as the outermost glass substrate, a dummy glass substrate may be disposed.

Other embodiments of the glass substrate packaged article using the cushioning bodies of the invention than the above-described packaged article are described below.

A plurality of glass substrates are disposed in a parallel position to one another at a predetermined interval to define a rectangular parallelepiped, each corner portion of the respective substrates is inserted into the substrate-inserting groove of the cushioning body of the invention to fit the four sides of the rectangular parallelepiped at a right angle with the surface of the substrate into the cushioning bodies. Then, a long fixing member is wound around the rectangular parallelepiped along the L-letter of the cushioning bodies to bind and fix. After forming the packaged article, the packaged article is wrapped up with a heat-shrinkable resin film, then heat-treated to thereby heat-shrink the film, thus the packaged article being shrink-wrapped.

Additionally, in the case of wrapping the packaged article with the above-described heat-shrinkable resin film, the packaged article may be placed in a bag-shaped or cylinder-shaped film and, preferably after heat-sealing

the end portion of the film, the film may be heat-shrunked to closely adhere to the packaged article.

The above-described packaged article has a feature that the packaged article wherein a plurality of glass substrates are integrally packaged using the cushioning bodies of the invention is shrink-wrapped using a heat-shrinkable film, which enables to facilitate the work of wrapping the packaged article of even large-sized glass substrates and enables automated wrapping. In addition, in the wrapped packaged article, the heat-shrunked film has no looseness at all, and hence there is no possibility that the outermost substrate in the packaged article comes into contact with the film to stain the glass substrate. Thus, there is no necessity of using a dummy substrate, and the cushioning bodies can be effectively used. Further, owing to the contraction stress of the film, the whole cushioning bodies are pressed from outside, and hence the cushioning bodies and the glass substrates are well integrally fixed, which serves to prevent the glass substrates from coming off the grooves or from being damaged. In addition, frictional contact between the glass substrate and the cushioning body due to vibration during transportation is so reduced that generation of scuff marks on the glass substrates or dust deposition can

be prevented, with cleanness of the glass substrates being maintained.

As the heat-shrinkable resin film to be used in the shrink-wrapping, there are illustrated polyolefin resin films and polyvinyl chloride resin films. However, the polyvinyl chloride resin contains various plasticizers and stabilizers in large amounts in order to impart processability and flexibility upon extrusion filming due to the properties thereof. These additives may ooze out onto the film surface with the lapse of time or may cause the phenomenon of evaporation in an extremely slight amount even at ordinary temperature. Hence, they might deteriorate cleanness of the working area for wrapping the glass substrates, or might cause a fatal pollution problem that the additive adhered to hands upon handling the packaged article for wrapping in turn comes into contact with the glass substrates. In addition, although it is preferred to heat-seal the film to seal up the packaged article in order to prevent invasion of dust from outside during transportation, the polyvinyl chloride resin has a poor heat-sealing adaptability and requires an expensive apparatus such as an ultrasonic wave apparatus or a high frequency sealing apparatus. Thus, it is preferred to use the polyolefin resin films.

As the polyolefin resin films, a single-layered or multi-layered product of polypropylene resin or polyethylene resin may be used, with the resin being crosslinked or non-crosslinked.

Such polyolefin resin films have at least 15% or more, more preferably 90% or less, heat-shrinking ratio at 120°C in the direction of at least one of longitudinal direction and transverse direction. Most preferably, the heat-shrinking ratio is 20% or more. Still more preferably, it is 15% or more and 90% or less in the directions of both longitudinal direction and transverse direction. When subjected to heat-shrinking within the ranges, the packaged article can be shrink-wrapped tightly with no looseness, and hence there is no risk of the glass substrates being stained due to contact between the glass substrates and the film. Additionally, the heat-shrinking ratio is a value obtained by measuring at 120°C according to ASTM D-2732.

Also, the maximum heat-shrinking stress at 120°C is preferably 0.15 N/mm² or more, more preferably 5 N/mm² or less in at least one of transverse direction and longitudinal direction. Most preferably, it is 0.2 N/mm² or more and 4.5 N/mm² or less. Still more preferably, it is 0.15 N/mm² or more and 5 N/mm² or less in both transverse direction and longitudinal direction.

When the maximum heat-shrinking stress at 120°C is within the above-described ranges, the packaged article can be tightly shrink-wrapped with no looseness and, even when the film is pressed upon handling, the film does not easily come into contact with the glass substrate, thus cleanness of the glass substrate being maintained. In addition, since the heat-shrinking stress is at a suitable level, the film is not broken at the corner portion upon wrapping, and sealed wrapping can be conducted to prevent invasion of dust from outside.

Additionally, the maximum heat-shrinking stress is a value obtained by measuring at 120°C according to ASTM D-2838.

Further, the thickness of the polyolefin resin film is preferably 10 μm or more, more preferably 200 μm or less. Still more preferably, the thickness is 20 μm or more, most preferably 180 μm or less. When the thickness is within the ranges, the film has a suitable body, and hence the work of wrapping the packaged article can be conducted skillfully, easily and efficiently. Also, heat sealing can be conducted with a high welding strength, and the film has enough breaking strength to resist impact during transportation or upon handling.

As the fixing member to be used in the invention, any of long ones of a string or a tape may be used. For example, a polypropylene-made tape is preferably used.

The cushioning bodies of the invention are used as a set of four of them. The four cushioning bodies may be in absolutely the same shape or may be in different shapes from each other. For example, in the case of packaging large-sized glass substrates, larger and thicker cushioning bodies may be used as cushioning bodies positioned at the lower part to resist the weight of the glass substrates.

Additionally, in addition to the use of the cushioning bodies of the invention as a set of four of them as described above, the cushioning bodies of the invention may be used in the following manner. That is, two cushioning bodies of the invention may be fixed at the bottom portion of the inside of a plastic container or a plastic corrugated box having an upper opening, in the opposite directions using holding members for preventing migration of the cushioning bodies, and glass substrates are inserted from the upper opening to fix. If necessary, the upper opening may be closed by a lid to prevent invasion of dust. This use may be employed for custody of the glass substrates. In this case, the vessels can also be used for transportation when the cushioning bodies of

the invention or platy plastic foams are attached to the lid.

EXAMPLES

Example 1 and Reference Example 1

(Glass substrates)

Mother glass for liquid crystal display

Dimensions: 600 mm x 720 mm

Thickness: 0.7 mm

(Foam)

Resin material:

Ethylene-propylene random copolymer of 20 cm³/g in
expansion ratio; average particle size of resin foam
particles: 3.6 mm

Fusion rate: 86%

Compressive elastic exponent: 549 N/cm²

(Cushioning body)

Number of glass substrates to be packaged: 26

External dimensions:

Shorter side: 250 mm

Longer side: 350 mm

Length (at right angle with the shorter side and the
longer side): 300 mm

Maximum thickness: 32 mm

Substrate-inserting groove:

Width: 2.4 mm

Depth: 12 mm

Pitch: 20 mm

Shape of protrusion:

Having vertical walls of 6.5 mm from the bottom portion of the substrate-inserting groove and a trapezoidal top of 8 mm in width of the flat portion and 5.5 mm in height (shape shown by Fig. 4(c))

(Fixing member-guiding groove)

Two fixing member-guiding grooves were formed with a width of 30 mm at the positions spaced by 1/4 of the above-described length (300 mm) of the cushioning body from the both sides. The depth of the grooves was 1 mm at the end portion of the L-letter, and an arc-like beveled portion was formed with a radius of 20 mm, with the depth at the connection between the bottom portion of the groove and the beveled portion being 4 mm.

(Free drop test)

The glass substrates were packaged as shown in Fig. 2 using 4 cushioning bodies described above to prepare a packaged article. In order to evaluate cushioning properties of the cushioning bodies in the packaged article, the packaged article was subjected to free drop test. Additionally, as Reference Example 1, the same test

was conducted using the same cushioning bodies except that the fusion rate was 65%.

Testing conditions:

Height of dropping: 30 cm

Dropped surface of the packaged article:

Only ground surface of packaged article

Number of dropping: 3 times

The packaged article of Example 1 suffered no coming off of the glass substrates even after being dropped 3 times, and maintained the packaged state before the test, with no damages being found. Also, as to deposition of dust of the cushioning bodies to the surface of the glass substrates, dust of a visible size was not found at all.

The packaged article of Reference Example 1 suffered generation of slight chips at the corner portion of the glass substrate in contact with the groove in the longer side direction of the cushioning bodies placed on the ground surface, though the glass substrates did not come off. Detailed observation of the cushioning bodies to investigate the cause of the generation of chips revealed that cracks were formed between foamed beads, and the cause was inferred to be that the glass substrates dug into the cushioning bodies due to the drop impact. In addition, traces of removal of the foamed beads were also found, thus the cushioning bodies were found to be

inferior to the cushioning bodies of Example 1 in durability against repeated use. That is, since fusion rate of the cushioning bodies was as low as 70% or less, they were inferior in mechanical strength essential to cushioning bodies, and excess distortion was supposedly formed upon receiving the drop impact.

Example 2 and Comparative Example 1

(Glass substrates)

Mother glass for liquid crystal display

Dimensions: 550 mm x 650 mm

Thickness: 0.7 mm

(Foam)

Resin material:

Crosslinked polyethylene of 20 cm³/g in

expansion ratio and 0.930 g/cm³ in resin density

Average particle size of resin foam particles: 2.8 mm

Fusion rate: 98%

Compression elasticity ratio: 412 N/cm²

Compressive elastic exponent: 41.2

(Cushioning body)

Number of glass substrates to be packaged: 12

External dimensions:

Shorter side: 210 mm

Longer side: 310 mm

Length (at right angle with the shorter side and the longer side): 240 mm

Maximum thickness: 23 mm

Substrate-inserting groove:

Width: 1.5 mm

Depth: 7 mm

Pitch: 20 mm

Shape of protrusion:

Having vertical walls of 3.5 mm from the bottom portion of the substrate-inserting groove and a chevron top of 3.5 mm in height (shape shown by Fig. 4(b))

(Fixing member-guiding groove)

Two fixing member-guiding grooves were provided with a width of 25 mm at the positions spaced by $1/4$ of the length (240 mm) of the cushioning body from the both sides. The grooves were formed from the position 50 mm spaced from the end portion of the L-letter toward the corner portion, and a circular beveled portion of 10 mm in radius at the corner, with the depth at the connection between the bottom portion of the groove and the beveled portion being 3 mm.

(Vibration test)

The glass substrates were packaged as shown in Fig. 2 using four cushioning bodies described above to prepare a

packaged article. In order to evaluate the ability of the cushioning bodies to fix the glass substrates, the packaged article was subjected to vibration test. The vibration test was conducted according to JIS Z0232 by fixing the packaged article onto a vibration-applying table of a vibration tester. As Comparative Example 1, the same test was conducted using the same cushioning bodies except that depth of the fixing member-guiding groove was made 1 mm at all positions.

Testing conditions:

Direction of vibration: up and down

Wave shape of vibration: sine wave

Sweep: log sweep (frequency number 5 to 100 Hz)

Sweeping speed: 0.5 octave/min

Vibration acceleration: ± 0.75 G

Vibration time: 30 minutes

Visual observation of the package-fixed state of the glass substrates after completion of the vibration test revealed that no glass substrates in Example 2 came off the substrate-inserting grooves, though slight looseness was found between the glass substrates and the cushioning bodies. Also, as to deposition of dust of the cushioning bodies to the surface of the glass substrates, dust of a visible size was not found at all.

With the packaged article of Comparative Example 1, the glass substrates came off the substrate-inserting groove on the longer side of two upper cushioning bodies 8 minutes after initiation of the vibration test, and came into contact with the adjacent glass substrates, thus the test being stopped due to the risk of damage.

While the invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

This application is based on Japanese Patent Application No. 396934/2000 filed on Dec. 27, 2000, and the contents thereof are incorporated herein by references.

INDUSTRIAL APPLICABILITY

As has been described hereinabove, the cushioning bodies of the invention prevent concentration of the binding force of a fixing member on the corner portion upon binding with the fixing member, and hence the fixing member favorably presses the glass substrates even at the end portion so as not to put the glass substrates out of the grooves, thus good protecting effect being exhibited.

In particular, by adjusting dimensions of the cushioning bodies and using a foam having specific properties as the foamed body constituting the cushioning bodies, the work of packaging and taking out the glass substrates is made easier, and can suitably be automated. In addition, the cushioning bodies are excellent in dust-preventing properties and durability, and are adapted to be handled in a clean room, and are resistant against repeated use. Thus, in the packaged article of the invention wherein a plurality of glass substrates are packaged, the packaged glass substrates are surely protected from vibration impact or drop impact during transportation, and generation of defective units is markedly depressed.

CLAIMS

1. A cushioning body for glass substrates, comprising a polyolefin bead foamed body and having a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate, on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion, and on outside surface of which at least one fixing member-guiding groove is defined along the L-letter, wherein the thickness of the cushioning body based on the bottom portion of the fixing member-guiding groove is gradually reduced from both ends of the L-letter toward the corner portion.

2. The cushioning body for glass substrates according to claim 1, wherein the bottom portion of the fixing member-guiding groove is beveled at the corner portion.

3. A cushioning body for glass substrates, comprising a polyolefin bead foamed body and having a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate,

on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion, wherein the thickness of the cushioning body is gradually reduced from both ends of L-letter toward the corner portion.

4. A cushioning body for glass substrates, comprising a polyolefin bead foamed body and having a substantially L-letter shaped cross section in conformity with the shape of a corner portion of the glass substrate, on inside surface of which a plurality of substrate-inserting grooves are defined along the L-letter for fixing two sides of the glass substrate forming the corner portion, wherein protrusions are formed outside at both ends of the L-letter.

5. The cushioning body for glass substrates according to claim 4, wherein an outer corner portion of the cushioning body is beveled.

6. The cushioning body for glass substrates according to one of claims 1 to 5, wherein a notch groove is defined inside the cushioning body in a direction at right angle with the substrate-inserting grooves.

7. The cushioning body for glass substrates according to any one of claims 1 to 5, wherein the cushioning body has a maximum thickness of 10 to 60 mm, a ratio of the two sides forming the L-letter of 1.0 to 3.0 based on the shorter side, and the substrate-inserting grooves have a width of 1.0 to 4.0 times as much as the thickness of the glass substrate, a depth of 3 to 15 mm, and a groove pitch of 6 to 100 mm.

8. The cushioning body for glass substrates according to any one of claims 1 to 5, wherein the polyolefin bead foamed body comprises foamed particles having an average particle size of 1.5 to 5.0 mm, and has a fusion rate of 70% or more, a compressive elastic exponent of 3.9 to 490, and a recovery rate of 60% or more.

9. A packaged article comprising:

a plurality of glass substrates;

cushioning bodies for glass substrates according to claim 1, which hold said plurality of glass substrates in a state of being disposed in parallel with one another at a predetermined interval by inserting four corners thereof into the substrate-inserting grooves; and

a long fixing member wound along the fixing member-guiding groove of the cushioning bodies to bind.

10. A packaged article comprising:

a plurality of glass substrates;

cushioning bodies for glass substrates according to claim 3 or 4, which hold said plurality of glass substrates in a state of being disposed in parallel with one another at a predetermined interval by inserting four corners thereof into the substrate-inserting grooves; and

a long fixing member wound along outside of the L-letter of the cushioning body to bind.