

METHOD OF PRODUCING A JOINED ARTICLE
THROUGH BONDING WITH LOW MELTING POINT GLASS

The present invention relates to a method of joining two articles to produce
5 a joined body, with low-melting glass.

A large number of articles are formed from component parts by using a low-
melting glass as a bonding material. An example of an article bonded with low-
melting glass is an IC chip (a semiconductor device having an integrated circuit)
mounted on a ceramic substrate sealed with a ceramic cap together with lead wires
10 acting as external connection terminals. A particular type of such a package is
termed a "cer-dip."

In order to produce such a cer-dip, first, lead wires are mounted on
peripheral portions of a main surface of a ceramic substrate on which low-melting
glass has been applied and baked. A conductive material (for example, a silver
15 plated plate or the like) on which low-melting glass has been applied and baked, is
mounted in a recess in the ceramic substrate disposed to receive an IC chip.

Thereafter, the low-melting glass is heated so that the conductive material and
the lead wires are bonded to the ceramic substrate.

Thereafter, an IC chip is mounted on the conductive material by means of
20 soldering, and wire-bonding is performed between the chip and the lead wires.
Lastly, a ceramic cap, on which the low-melting glass has been applied and baked,
is bonded to the ceramic substrate so as to seal the ceramic substrate to complete the
process. Fig. 13 shows a flow chart of this process.

In such an article in which bonding is performed by heating baked low-
25 melting glass, however, bubbles (voids in the glass) are generated in the low-melting
glass during bonding.

The generation of such bubbles causes problems because they reduce the
thermal conductivity between the silver Plated plate and the ceramic substrate. This
may cause defective soldering of the IC chip to the silver plated plate and in
30 addition, heat from the IC chip is not effectively conducted away from the package
during use of the device. Furthermore, there is a risk of causing leakage in the cap
seal between the ceramic substrate and the ceramic cap.

An object of the present invention is therefore to provide a method of producing a joined body through low-melting glass bonding in which bubbles generated during bonding by heating the low-melting glass can be reduced.

To achieve these and other objects of the invention there is provided a method of joining two articles by means of a low-melting point glass, the method comprising the steps of:

providing a first article to be joined, the first article having a first bonding surface;

applying a layer of low-melting point glass to the first bonding surface, the layer having a plurality of recesses in the outer peripheral edge of the layer;

applying a second article to the layer of low melting point glass;

heating the first and second articles and the layer of low-melting point glass to a temperature above the melting point of the glass; and

solidifying the glass to join the first and second articles.

Preferably, a low melting point glass layer thinner than the glass layer applied to the first bonding surface is formed in the recesses.

It is also preferred that the method include the step of applying the low-melting point glass using a mask member to form the glass layer where the mask member includes at least one protrusion disposed to form the recesses.

The notched portions or the portions with reduced thickness formed in the outer peripheral edge of the low-melting point glass before bonding is performed by heating the low-melting point glass, allow any bubbles generated in the glass during the bonding to escape through the notch portions thereby reducing the occurrence of bubbles in the bonded article.

An embodiment of the method of producing a joined body through bonding with low-melting glass according to the present invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a cross-sectional view showing a bonded article such as a cer-dip;

Fig. 2 is a sectional side view of a low-melting glass applied to a silver plate;

Fig. 3 is a plan view showing a conventional mask;

Fig. 4 is a plan view showing a special mask;

Figs. 5 through 8 are plan views showing special masks having variously-shaped protrusions;

Fig. 9 is a plan view of a conventional mask which has been used for applying low-melting glass onto a lead attaching surface;

5 Figs. 10 and 11 are plan views showing a number of special masks according to the present invention; and,

Fig. 12 is a flow chart for explaining the process for producing an IC package according to the invention.

10 With reference first to Fig. 1, which is a sectional view showing an IC package having a glass-sealed body using low-melting glass, the package is produced in such a manner that an IC chip (a semiconductor device having an integrated circuit formed therein) 3 and lead wires 4 to be electrically connected to the IC chip 3 to act as external connection terminals are sealed with a ceramic cap 8 by use of low-melting glass 5 on a ceramic substrate 2. The ceramic components to be bonded
15 consist preferably of alumina.

The low-melting glass 5, which functions as an insulator and an adhesive is repeatedly applied, for example in two, three or four layers, onto a lead-wire receiving surface 2a which is a peripheral portion of the ceramic substrate 2 and onto a rear surface (at the ceramic substrate 2 side) of a silver plated plate 7 which is a material to be bonded according to the present invention and is used as a conductive
20 material of the IC chip 3 when the IC chip 3 is mounted. A conductor receiving portion 2b of the ceramic substrate 2 accommodates the silver plated plate 7. After the lead wires and metal plate are appropriately placed using the low-melting point glass, the low-melting glass 5 is heated above its melting point.

25 When the low-melting glass 5 melts in contact with the silver plated plate 7, it rises at the peripheral portion of the silver plated plate 7 owing to its surface tension as shown in Fig. 2. This may be a factor of generation of bubbles (glass voids) when the silver plated plate 7 is bonded to the recess 2b of the ceramic substrate 2. This portion of the substrate ultimately receives the IC chips 3. If
30 bonding is performed by using low-melting glass, bubbles are generated in the low-melting glass 5 during bonding, and therefore it is necessary to make any such bubbles escape.

In this embodiment, therefore, when a coating of low-melting glass 5 is formed, the glass printing masks as shown in Figs. 3 and 4 are used in combination or the glass printing mask of Fig. 4 is used singly. The glass printing mask of Fig. 3 is a conventional mask 8 having an opening 8a therein but the glass printing mask of Fig. 4 is a special mask 9 which has been invented to reduce the retention of bubbles. The special mask 9 has protrusions 9a formed at its inner peripheral portions for that purpose.

If the coating with the low-melting glass 5 is formed by using the mask 9, recess portions in the glass coating (not shown), and which are the notched recess portions according to the present invention, are formed corresponding to the protrusions 9a in the opening 9b of the mask 9 at the outer peripheral portions of the coating low-melting glass 5.

A low-melting glass (type LS-2001B) 5 was repeatedly applied onto the silver plated plate 7 in two layers by using the conventional mask 8 and the special mask 9 in combination in a manner as shown in Table 1. The low-melting glass 5 was then heated. Thereafter, the silver plated plate 7 was mounted on the recess portion 2b of the ceramic substrate 2 and the low-melting glass 5 was again heated so that the silver plated plate 7 was bonded to the ceramic substrate 2. Table 2 shows the measurement results of the rate of bubble generation.

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TABLE 1Kind of Mask

<u>Sample</u>	<u>First Layer</u>	<u>Second Layer</u>	<u>Baking Temperature</u>
A	Conventional mask	special mask	450°C
25 B	special mask	special mask	450°C
C	special mask	conventional mask	450°C
D	conventional mask	conventional mask	450°C

TABLE 2

		<u>Rate of Bubble Generation (%)</u>							
	<u>Sample</u>	1	2	3	4	5	X	Min	Max
5	A	1.4	0.9	0.9	0.9	1.4	1.1	0.9	1.4
	B	3.7	3.7	3.7	3.7	2.3	3.4	2.3	3.7
	C	4.6	4.6	1.9	5.1	5.1	4.3	1.9	5.1
	D	4.6	7.4	5.6	5.6	8.3	6.3	4.6	8.3

10 The measurement of bubble generation (%) was determined by means of radiography on five pieces for every sample (A-D) which were produced with various combinations of the conventional mask 8 and the special mask 9. The rate of bubble generation shown in Table 2 is represented by the ratio of the sectional area of bubbles to the sectional area, in the direction of the main surface of the low-melting glass 5 applied on the silver plated plate 7.

15 In the measurement of the rate of bubble generation in the case where the low-melting glass 5 was applied onto the silver plated plate 7 by using the conventional mask 8 and the special mask 9 in combination as described above, the best measurement result was obtained when the conventional mask 8 and the special mask 9 were used in formation of the first and second layers on the silver plated plate 7 respectively as shown in the case of the sample A.

20 Next, the rate of bubble generation was measured in the case where the protrusions 9a of the special mask 9 were changed in shape in the combination of masks (the conventional mask 8 and the special mask 9 being used for formation of the first and second layers respectively) used to obtain the sample A in which the best results were obtained. Table 3 shows the measurement results.

25 Four kinds of samples of the special mask 9 having variously shaped protrusions 9a formed as shown in Figs. 5 through 8 were prepared, and measurement was performed by use of those masks.

30 The samples 1, 2, 3, and 4 are shown in Fig. 5, Fig. 6, Fig. 7, and Fig. 8 respectively.

TABLE 3

	<u>Sample</u>	<u>Rate of Bubble Generation (%)</u>				<u>X</u>
	1	3.2	2.3	1.4	2.8	2.43
5	2	0.0	0.9	1.4	0.0	0.58
	3	0.9	0.9	0.5	0.7	0.75
	4	1.9	1.9	4.6	3.7	3.03

As seen from Table 3, the rate of bubble generation was small in all the samples in comparison with the samples in which only the conventional mask was used, and good measurement results were obtained especially in the sample 2 of Fig. 6 and in the sample 3 of Fig. 7.

As apparent from the foregoing measurement results of the rate of bubble generation, in the case where coating with the low-melting glass 5 is performed by use of the special mask 9 having the protrusions 9a formed thereon, recess portions are formed in the outer peripheral portions of the low-melting glass coating 5. These recesses act as gas escape grooves for bubbles generated when bonding of the silver plated plate 7 is performed, so that the amount of bubbles generated is lowered.

Although the glass printing mask is used to form the recess portions in the outer peripheral portions of the low-melting glass in the foregoing embodiment, it would also be possible to cut the coating at the appropriate locations to form such recessed portions.

Further, although measurement was made as to the bubbles generated when the silver plated plate 7 was bonded in the above embodiment, the rate of bubble generation can be reduced by using the special mask 9 on the surface on which the lead wires 4 are to be attached. This will be proved in the following embodiment.

In this second embodiment of the invention, the lead wires 4 were sealed on the ceramic substrate 2 with the ceramic cap 6 through the low-melting glass 5 as in the first embodiment, but glass printing masks as shown in Figs. 9, 10, and 11 were used in various combinations on the lead-wire attaching surface of the ceramic cap. The glass printing mask of Fig. 9 is a conventional mask having an opening 10a therethrough and a centred mask portion 10b. On the other hand, the glass

printing mask of Fig. 10 is a special mask 11 which has been invented to decrease bubbles.

The mask 11 has protrusions 11a formed at its inner peripheral portions of an opening 11b and a central mask portion 11c. The glass printing mask of Fig. 11 has protrusions 12a are formed similarly to the mask of Fig. 10. The protrusions 12a project into the opening 12b that also includes a central mask portion 12c. Samples 11 through 14 were produced by using the masks in various combinations as shown in Table 4, and the rate of bubble generation was measured in the same manner as in the first embodiment. Table 5 shows the measurement results.

TABLE 4

Kind of Mask

	<u>Sample</u>	<u>First Layer</u>	<u>Second Layer</u>	<u>Third Layer</u>	<u>Fourth Layer</u>	<u>Baking Temperature</u>
15	11	10	10	11	11	450°C
	12	10	10	10	11	450°C
	13	10	10	10	12	450°C
	14	10	10	10	10	450°C

TABLE 5

Rate of Bubble Generation (%)

	<u>Sample</u>	<u>10 Measured Values</u>					<u>X</u>	<u>Min</u>	<u>Max</u>
	11	1.4	1.4	1.9	1.8	1.5	1.6	1.3	1.9
		1.6	1.8	1.7	1.7	1.3			
25	12	1.0	1.6	1.4	1.2	1.4	1.3	1.0	1.6
		1.3	1.5	1.1	1.4	1.2			
	13	1.7	1.5	1.2	1.8	1.6	1.5	1.1	1.8
		1.6	1.3	1.5	1.4	1.1			
	14	6.0	3.0	5.5	3.0	4.5	4.9	3.0	6.5
30		6.0	6.5	5.0	4.5	4.5			

As seen from Table 4 and the measurement results of Table 5, in all the samples 11 through 13 in which the special mask according to the present invention

was used for the third layer and/or the fourth layer, the rate of bubble generation was considerably reduced in comparison with the sample 14 in which only the conventional mask was used for each of the first to fourth layers. Thus, it is apparent that the risk of leakage at the cap sealed portion is remarkably reduced.

5 Although the rate of bubble generation was shown by way of example in the foregoing embodiment where the low-melting glass 5 applied successively in two layers, the rate of bubble generation can also be reduced if the special mask 9 is used to form a single layer or three layers or more.

10 Further, although description has been made of the case where an IC package or cer-dip is produced, the present invention is not limited to a cer-dip, but the is applicable to the case of a display panel, a diode, or the like, to be bonded with low-melting glass.

CLAIMS

1. A method of joining two articles by means of a low-melting point glass, the method comprising the steps of:
 - (a) providing a first article to be joined, the first article having a first bonding surface;
 - (b) applying a layer of low-melting point glass to the first bonding surface, the layer having a plurality of recesses in the outer peripheral edge of the layer;
 - (c) applying a second article to the layer of low melting point glass;
 - (d) heating the first and second articles and the layer of low-melting point glass to a temperature above the melting point of the glass; and
 - (e) solidifying the glass to join the first and second articles.
2. The method of claim 1, wherein a low melting point glass layer thinner than the glass layer applied to the first bonding surface is formed in the recesses.
3. The method of claim 1, wherein the step of applying the low melting point glass includes forming the glass layer with a mask member, the mask member including at least one protrusion disposed to form the recesses.
4. The method of claim 1 wherein the first article is a ceramic member and the second article is a metal member.
5. The method of claim 4 wherein the metal member is an electrical lead.
6. The method of claim 4 wherein the metal member is an electrically conductive plate disposed to receive an IC chip.
7. A method according to claim 1, substantially as described with reference to the accompanying drawings.
8. A composite article manufactured in accordance with the method of any of claims 1 to 7.

