

② Replacement

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SPECIFICATION

TITLE OF THE INVENTION

Sheet-Bonding Method

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a sheet-bonding method and more particularly to a sheet-bonding method for bonding a dicing sheet to a workpiece made of a breakable material such as ceramic to be used to compose a piezoelectric element, without generating bubbles therebetween.

Description of the Prior Art

Fig. 5 is a process illustrative view showing an example of a conventional sheet-bonding method which forms the background of the present invention. A workpiece 1 is a thin plate made of ceramic or the like. As a pre-process in dicing the workpiece 1 to a predetermined configuration, a dicing sheet 2 made of plastic film or the like is bonded to a main surface of the workpiece 1 to prevent a cutting blade from damaging a table on which the workpiece 1 has been placed and prevent the cut workpiece 1 from being scattered in cutting the workpiece 1 by means of a dicer. Pressure sensitive adhesive agent is applied to the to-be-bonded side of the dicing sheet 2 before it is bonded to the workpiece 1.

The generation of bubbles between the workpiece 1 and



the dicing sheet 2 resulting from permeation of air therebetween in bonding the dicing sheet 2 to the workpiece 1 causes the workpiece 1 to be separated from the dicing sheet 2 or cracked or broken in dicing the workpiece 1 with the dicer. In the sheet-bonding method shown in Fig. 5, a pressing roller 3 is used to press the dicing sheet 2 against the workpiece 1 so as to prevent the occurrence of this problem, i.e., so as to prevent bubbles from being generated between the workpiece 1 and the dicing sheet 2.

Fig. 6 is a process illustrative view showing another example of a conventional sheet-bonding method. In this sheet-bonding method, the workpiece 1 is held on the lower end surface of a pressurizing head 4. The pressurizing head 4 is moved toward the dicing sheet 2 to press the workpiece 1 against a main surface of the dicing sheet 2 and bond the former to the latter. In the sheet-bonding method shown in Fig. 6, the pressurizing head 4 is used to press the workpiece 1 against the dicing sheet 2 so as to prevent bubbles from being generated therebetween.

The sheet-bonding methods have, however, problems that the pressing roller 3 or the pressurizing head 4 applies a great stress to the workpiece 1, thus causing the workpiece 1 to be cracked or broken if the workpiece 1 made of ceramic is thin.

SUMMARY OF THE INVENTION



It is , therefore , the primary object of the present invention to provide a sheet-bonding method which prevents bubbles from being generated and a workpiece from being cracked or broken to a possible highest degree.

A sheet-bonding method according to the present invention comprises the steps of: holding a workpiece; holding a sheet to be bonded to one main surface of the workpiece; forming a first space substantially sealed and including the space between the sheet and the workpiece accommodated therein; forming a second space opposed to the first space, with the sheet sandwiched therebetween; setting an atmospheric pressure in the first space to be lower than that in the second space; and bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

The difference between the atmospheric pressure in the first space and that in the second space may be generated by increasing the atmospheric pressure in the second space in carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by utilizing the difference between the atmospheric pressure in the first space and that in the second space.



The difference between the atmospheric pressure in the first space and that in the second space may be generated by reducing the atmospheric pressure in the first space in carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by utilizing the difference between the atmospheric pressure in the first space and that in the second space. In this case, the atmospheric pressure in the second space may be increased simultaneously with the operation of reducing the atmospheric pressure in the first space.

A step of reducing the atmospheric pressure in the first space and that in the second space may be performed before carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

A porous permeable material may be provided in the second space so as to prevent the sheet from being flexed into the second space.

A step of preventing a tensile force from being applied to the sheet by moving the workpiece toward the sheet so as to prevent the sheet from being separated from the workpiece by the tensile force may be performed after carrying out the



step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

According to the present invention, the first and second spaces are formed in such a manner that both spaces are opposed to each other, with the sheet sandwiched therebetween. The workpiece is held in the first space. The sheet is flexed into the first space by setting the atmospheric pressure in the first space to be lower than that in the second space. The flexed sheet is brought into contact with the workpiece gradually in the order from the center of the main surface thereof to the periphery of the main surface thereof and pressed against the workpiece and bonded to the main surface of the workpiece due to the difference between the atmospheric pressure in the first space and that in the second space.

In the sheet-bonding method according to the present invention, the flexed sheet is brought into contact with the main surface of the workpiece and bonded thereto gradually from the vicinity of the lowermost point of the flexed portion thereof to the periphery thereof. Thus, the sheet-bonding method prevents bubbles from being generated between the sheet and the workpiece. Further, the sheet is pressed against the workpiece by utilizing the difference between



the atmospheric pressure in the first space and that in the second space. Therefore, the entire to-be-bonded surface of the sheet can be uniformly pressed against the workpiece, and further, an excessive stress can be prevented from being applied to the workpiece. Accordingly, there is little possibility that the workpiece is crackled or broken.

Bubbles can be prevented from being generated to a higher degree by reducing the atmospheric pressure in the first and second spaces before bonding the sheet to the workpiece.

A porous permeable material may be provided in the second space to suck the sheet thereto, thus preventing the sheet from being flexed into the second space.

The sheet can be prevented from being separated from the workpiece by preventing a tensile force from being applied to the sheet by moving the workpiece toward the sheet after carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

The above and further objects, features, aspects, and advantages of the present invention will be more fully apparent from the following detailed description with the accompanying drawings.



BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a process illustrative view showing an embodiment of the present invention.

Fig. 2 is a perspective view showing a sheet-holding member according to the embodiment shown in Fig. 1.

Fig. 3 is a sectional view showing a sheet-bonding apparatus according to another embodiment of the present invention.

Fig. 4 is a sectional view showing a sheet-bonding apparatus according to still another embodiment of the present invention.

Fig. 5 is a process illustrative view showing an example of a conventional sheet-bonding method which forms the background of the present invention.

Fig. 6 is a process illustrative view showing another example of a conventional sheet-bonding method which forms the background of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a process illustrative view showing an embodiment of the present invention. First, a sheet-sucking apparatus to be used in carrying out the sheet-bonding method is described below. A sheet-bonding apparatus 10 according to this embodiment comprises a base member 12 approximately U-shaped in section. A sucking hole 14 serving as a workpiece-holding means is formed at



approximately the center of the bottom wall of the base member 12. The sucking hole 14 is for sucking and holding workpiece 1. The sucking hole 14 is connected with a sucking device(not shown). The workpiece 1 to be used in this embodiment is a plate-shaped sheet made of ceramic or the like used to compose a piezoelectric element.

A first atmospheric pressure-adjusting hole 16 is formed alongside of the sucking hole 14 formed on the bottom wall of the base member 12. The first atmospheric pressure-adjusting hole 16 is connected with a atmospheric pressure-adjusting device(not shown) which adjusts the atmospheric pressure in a first space 20 by sucking air present therein or supplying air therein. The atmospheric pressure-adjusting device will be described later.

A sheet-holding member 18 rectangular frame-shaped in a plan view is placed on the base member 12. The sheet-holding member 18 holds the dicing sheet 2 by bonding the dicing sheet 2 thereto. The sheet-holding member 18 is sandwiched between the base member 12 and a hood member 22 which will be described later. Fig. 2 is a perspective view showing the sheet-holding member 18 according to the embodiment shown in Fig. 1. The outer dimension of the sheet-holding member 18 is set to be identical to that of the base member 12. A rectangular through-hole, the outer dimension of which is greater than that of the workpiece 1 is formed on



the sheet-holding member 18.

The dicing sheet 2 is bonded to a main surface of the sheet-holding member 18. The dicing sheet 2 is made of a material such as a plastic film flexible and airtight. A pressure sensitive adhesive layer 2a is formed on a to-be-bonded surface of the dicing sheet 2. When the dicing sheet 2 has been bonded to the sheet-holding member 18 by means of the adhesive layer 2a of the dicing sheet 2, the unbonded region of the adhesive layer 2a is uncovered in the through-hole formed in approximately the center of the sheet-holding member 18. The sheet-holding member 18 is placed on the base member 12, with the adhesive layer 2a opposed to a main surface of the workpiece 1. Consequently, the first space 20 surrounded and substantially sealed with the base member 12, the sheet-holding member 18, and the dicing sheet 2 is formed.

As shown in Fig. 1, the hood member 22 approximately U-shaped in section is placed on the sheet-holding member 18 in such a manner that the hood member 22 covers the dicing sheet 2. Consequently, a second space 24 surrounded and substantially sealed with the hood member 22 and the dicing sheet 2 is formed. At this time, the dicing sheet 2 is held by the hood member 22 and the sheet-holding member 18 by being sandwiched therebetween.

A second atmospheric pressure-adjusting hole 26 is



formed on the hood member 22 at approximately the center thereof. The second atmospheric pressure-adjusting hole 26 is connected with an atmospheric pressure-adjusting device(not shown) which adjusts the atmospheric pressure in the second space 24 by sucking air present therein or supplying air to therein. As the atmospheric pressure-adjusting device, a compressor, a vacuum pump or the like is used.

The sheet-bonding method according to this embodiment is described below with reference to Fig. 1. First, as shown in Fig. 1(A), the workpiece 1 is held on the base member 12 by being sucked by the sucking hole 14 positioned at approximately the center of the base member 12. The dicing sheet 2 is bonded to the sheet-holding member 18. The sheet-holding member 18 is placed on the base member 12, with the adhesive layer 2a of the dicing sheet 2 opposed to the workpiece 1. Consequently, the first space 20 is formed. Then, the hood member 22 is placed on the sheet-holding member 18 to form the second space 24. The dicing sheet 2 and the sheet-holding member 18 are held by the hood member 22 and the base member 12 by being sandwiched therebetween.

Then, the air in the first space 20 is sucked through the first atmospheric pressure-adjusting hole 16 to reduce the atmospheric pressure therein. At the same time, the air



in the second space 24 is sucked through the second atmospheric pressure-adjusting hole 26 to reduce the atmospheric pressure therein. The reason for reducing the atmospheric pressure in the first space 20 and the second space 24 simultaneously is to prevent the air from permeating between the workpiece 1 and the dicing sheet 2, i.e., to prevent bubbles from being generated therebetween to a possible highest degree.

Then, the sucking of the air in the second space 24 is stopped, while the atmospheric pressure-reduced state in the first space 20 is maintained. Then, air is gradually fed into the second space 24 to increase the atmospheric pressure therein. Consequently, the atmospheric pressure in the second space 24 becomes gradually higher, thus exceeding the atmospheric pressure in the first space 20. As a result, as shown in Fig. 1(B), the dicing sheet 2 is flexed into the first space 20 to form a bow configuration in section. Because the dicing sheet 2 is held by the sheet-holding member 18 having an area greater than that of the workpiece 1 to which the dicing sheet 2 is bonded, the dicing sheet 2 is flexed to the greatest degree at approximately the center thereof. The center of one main surface of the dicing sheet 2, namely, the lowermost point of the sectionally bow-shaped portion of the main surface thereof is initially brought into contact with the center of



the main surface of the workpiece 1 and pressed against the workpiece 1, because the atmospheric pressure in the second space 24 is higher than that in the first space 20.

As shown in Fig. 1(C), the atmospheric pressure in the second space 24 is kept to be increased. As a result, the dicing sheet 2 is pressed against the workpiece 1 in the order from the center of the main surface of the workpiece 1 to the periphery of the main surface thereof and bonded to the entire main surface thereof. After the dicing sheet 2 is bonded to the entire main surface of the workpiece 1, the operation for reducing the atmospheric pressure in the first space 20, the operation for increasing the atmospheric pressure in the second space 24, and the operation for sucking the workpiece 1 by means of the sucking hole 14 are stopped. As a result, the workpiece 1 is moved upward by the tensile force of the dicing sheet 2, as shown in Fig. 1(D). After the base member 12 and the hood member 22 are separated from each other vertically, the workpiece 1 to which the dicing sheet 2 has been bonded is transported to a place at which a subsequent process is performed, with the workpiece 1 being held by the sheet-holding member 18.

In the sheet-bonding method according to this embodiment, the flexed dicing sheet 2 is bonded to the main surface of the workpiece 1 gradually from the point of the main surface of the workpiece 1 corresponding to the



lowermost point of the flexed portion of the dicing sheet 2 to the periphery of the main surface of the workpiece 1. Thus, the sheet-bonding method prevents air from permeating between the dicing sheet 2 and the workpiece 1 and hence, prevents bubbles from being generated therebetween. Further, the method of pressing the dicing sheet 2 by utilizing the difference between the atmospheric pressure in the first space 20 and that in the second space 24 provides the following advantages: Firstly, the entire dicing sheet 2 is pressed against the main surface of the workpiece 1 at a uniform pressure; secondly, the force for pressing the dicing sheet 2 against the workpiece 1 can be adjusted easily by adjusting the atmospheric pressure in the first space 20 and that in the second space 24; and thirdly, an excessive stress can be prevented from being applied to the workpiece 1 and thus, there is little possibility that the workpiece 1 is crackled or broken.

Fig. 3 is a sectional view showing a sheet-bonding apparatus according to another embodiment of the present invention. The sheet-bonding apparatus 10 comprises a plate-shaped porous material 28 having permeability. The porous material 28 is positioned in the second space 24. In order to prevent the dicing sheet 2 from being flexed into the second space 24 in reducing the atmospheric pressure in the second space 24, the porous material 28 is in contact



with one main surface of the dicing sheet 2 opposite to its other main surface confronting the workpiece 1. The porous material 28 having permeability sucks the dicing sheet 2 thereto in reducing the atmospheric pressure in the second space 24, thus preventing the dicing sheet 2 from being flexed toward the side opposite to the workpiece-positioned side and preventing the generation of bubbles to a high degree in bonding the dicing sheet 2 to the workpiece 1.

Fig. 4 is a sectional view showing a sheet-bonding apparatus according to still another embodiment of the present invention. The sheet-bonding apparatus 10 comprises a workpiece-holding member 30 serving as a workpiece-holding means and movable vertically. A second sucking hole 32 for sucking the workpiece 1 is formed on the workpiece-holding member 30 in such a manner that the second sucking hole 32 penetrates vertically through the center thereof. The second sucking hole 32 is connected with the sucking hole 14 formed on the base member 12 by means of a connection pipe 34 such as a rubber pipe which is elastic. The workpiece 1 is sucked by a sucking device(not shown) connected with the sucking hole 14. As a result, the workpiece 1 is held by the workpiece-holding member 30, with the workpiece 1 being sucked by the second sucking hole 32. As the sucking device, a vacuum pump or the like is used.

The workpiece-holding member 30 is vertically movably



held by a hydraulic cylinder 36. The dicing sheet 2 is bonded to the workpiece 1 in a method similar to the above-described method by moving the workpiece-holding member 30 downward. Thereafter, the workpiece-holding member 30 is moved upward by the hydraulic cylinder 36 so as to eliminate the tensile force applied to the flexed dicing sheet 2. In this manner, the dicing sheet 2 can be prevented from being separated from the workpiece 1.

In bonding the dicing sheet 2 to the workpiece 1, it is possible to flex the dicing sheet 2 by gradually reducing the atmospheric pressure in the first space 20, with the second atmospheric pressure-adjusting hole 26 open. Further, in bonding the dicing sheet 2 to the workpiece 1, it is possible to flex the dicing sheet 2 by gradually increasing the atmospheric pressure in the second space 24, with the first atmospheric pressure-adjusting hole 16 open.

In holding the dicing sheet 2 on the sheet-holding member 18, adhesive agent may be applied to one main surface of the sheet-holding member 18 so as to hold the dicing sheet 2 by means of the adhesive agent.

While the present invention has been particularly described and shown, it is to be understood that such description is used merely as an illustrative view and example rather than limitation, and the spirit and scope of the present invention are determined solely by the terms of



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the appended claims.

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WHAT IS CLAIMED IS:

1. A sheet-bonding method comprising the steps of:

holding a workpiece;

holding a sheet to be bonded to one main surface of the workpiece;

forming a first space substantially sealed and including the space between the sheet and the workpiece accommodated therein;

forming a second space opposed to the first space, with the sheet sandwiched therebetween;

setting an atmospheric pressure in the first space to be lower than that in the second space; and

bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

2. The sheet-bonding method according to claim 1, wherein a step of reducing the atmospheric pressure in the first space and that in the second space is performed, before carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

3. The sheet-bonding method according to claim 1, wherein a porous material having permeability is provided in the



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second space so as to prevent the sheet from being flexed into the second space.

4. The sheet-bonding method according to claim 1, further comprising a step of preventing a tensile force from being applied to the sheet by moving the workpiece toward the sheet so as to prevent the sheet from being separated from the workpiece by the tensile force to be performed after carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof by utilizing the difference between the atmospheric pressure in the first space and that in the second space.

5. A sheet-bonding method comprising the steps of:

holding a workpiece;

holding a sheet to be bonded to one main surface of the workpiece;

forming a first space substantially sealed and including the space between the sheet and the workpiece accommodated therein;

forming a second space opposed to the first space, with the sheet sandwiched therebetween;

setting an atmospheric pressure in the first space to be lower than that in the second space; and

bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by



increasing the atmospheric pressure in the second space.

6. The sheet-bonding method according to claim 5, further comprising a step of reducing the atmospheric pressure in the first space and that in the second space to be performed before carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by increasing the atmospheric pressure in the second space.

7. The sheet-bonding method according to claim 5, wherein a porous material having permeability is provided in the second space so as to prevent the sheet from being flexed into the second space.

8. The sheet-bonding method according to claim 5, further comprising a step of preventing a tensile force from being applied to the sheet by moving the workpiece toward the sheet so as to prevent the sheet from being separated from the workpiece by the tensile force to be performed after carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by increasing the atmospheric pressure in the second space.

9. A sheet-bonding method comprising the steps of:

holding a workpiece;

holding a sheet to be bonded to one main surface of the workpiece;



forming a first space substantially sealed and including the space between the sheet and the workpiece accommodated therein;

forming a second space opposed to the first space, with the sheet sandwiched therebetween;

setting an atmospheric pressure in the first space to be lower than that in the second space; and

bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by further reducing the atmospheric pressure in the first space.

10. The sheet-bonding method according to claim 9, further comprising a step of reducing the atmospheric pressure in the first space and that in the second space to be performed before carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by further reducing the atmospheric pressure in the first space.

11. The sheet-bonding method according to claim 9, wherein a porous material having permeability is provided in the second space so as to prevent the sheet from being flexed into the second space.

12. The sheet-bonding method according to claim 9, further comprising a step of preventing a tensile force from being applied to the sheet by moving the workpiece toward the



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sheet so as to prevent the sheet from being separated from the workpiece by the tensile force to be performed after carrying out the step of bonding the sheet to the main surface of the workpiece by pressing the sheet against the main surface thereof, by further reducing the atmospheric pressure in the first space.

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