

English translation of the International Application as filed

DESCRIPTION

5 **TITLE OF THE INVENTION: TWO-DIRECTIONALLY MOVABLE TABLE**

TECHNICAL FIELD

[0001]

10 The present invention relates to a structure of a two-directionally movable table for use in a bonding apparatus.

BACKGROUND ART

[0002]

15 In bonding apparatuses such as wire-bonding apparatuses, an XY table is used as a two-directionally movable table on which a bonding target such as a semiconductor device is movable in X and Y directions, i.e., two horizontal mutually-perpendicular directions. Such
20 an XY table includes a lower table to be guided and moved with an X-direction motor in the X direction and an upper table to be guided with a guide on the upper surface of the lower table and moved with a Y-direction motor in the Y direction. The upper table is configured to move in the
25 Y direction on the lower table, which is configured to move in the X direction, so as to be freely movable in the X and Y directions.

[0003]

There has been proposed an XY table of the type

mentioned above in which a movable member of a Y-direction motor is connected and fixed to an upper table for high-accuracy positioning (see Patent literature 1, for example).

5

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0004]

10 Patent literature 1: JP2002-329772

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

15 [0005]

However, in the XY table of the related art described in Patent literature 1, the movable member of the Y-direction motor, which is connected and fixed to the upper table, is moved in the X direction together with the upper table. This requires the X-direction motor, which is configured to move the lower table in the X direction, to move the lower and upper tables and the movable member of the Y-direction motor in the X direction. If the movable member of the Y-direction motor is heavy, the load on the X-direction motor increases, suffering from a problem in that the travel speed of the lower table cannot be increased easily and thereby the bonding apparatus cannot be operated at high speed.

[0006]

Also, in the XY table of the related art described in Patent literature 1, the movable member of the Y-direction motor is attached in a manner protruding from near the upper surface of the upper table in the Y direction and therefore is subject to a Y-direction reaction force as well as a bending moment reaction force from the upper table when driving the upper table in the Y direction. This bending moment may cause the movable member to vibrate, which may result in a fluctuation in the pressing load of the capillary during bonding, suffering from a problem of possible reduction in bonding quality. If the movable member of the Y-direction motor is heavy, the frequency component contained in the back-and-forth movement of the upper table becomes approximate to the natural frequency of the movable member, which may result in an increased vibration, also suffering from a problem of possible reduction in bonding quality. In order to avoid such reduction in bonding quality, the working speed of the XY table cannot be increased, suffering from a problem in that the bonding apparatus cannot be operated at high speed.

[0007]

Further, since the movable member of the Y-direction motor described in Patent literature 1 is formed by mounting a coil on a flat plate, it is often the case that heat produced when a current flow in the coil cannot be dissipated sufficiently. In this case, output reduction due to temperature rise and therefore electrical resistance increase in the coil and/or thermal displacement due to expansion of components around the

coil may cause a reduction in bonding accuracy, which makes it difficult to apply a large current, suffering from a problem in that the travel speed of the movable member of the Y-direction motor cannot be increased easily.

5 [0008]

It is hence an object of the present invention to provide a bonding apparatus that can be operated at high speed.

10 **MEANS FOR SOLVING THE PROBLEMS**

[0009]

The present invention is directed to a two-directionally movable table movable in two directions, first and second directions, perpendicular to each other
15 in the same plane, the table including: a first table configured to be guided in the first direction and driven in the first direction with a first motor; a second table configured to be guided in the second direction with a second directional guide provided on the upper surface of
20 the first table and driven in the first direction together with the first table as well as in the second direction with a second motor; and a movable member including a movable arm movable in the first and second directions together with the second table, formed as a
25 fiber-reinforced plastic hollow body with a rectangular cross section extending in the second direction with one end thereof being fixed to the second table and, in each short side surface, provided with an opening elongated in the second direction, and an annular drive coil inserted

into the opening to be attached to the movable arm and partially protruding from the opening in the width direction of the movable arm.

[0010]

5 In the two-directionally movable table according to the present invention, the movable member can preferably be configured such that the length of the opening of the movable arm in the second direction is greater than the external length of the drive coil in the direction
10 perpendicular to the insertion direction, and that the internal length of the drive coil in the insertion direction is greater than the width of the movable arm, and that the space inside the drive coil is in communication with the space outside the movable arm.

15 [0011]

 The two-directionally movable table according to the present invention can preferably further include a nozzle for blowing air directly onto the drive coil in the movable member. The two-directionally movable table according to
20 the present invention can preferably be arranged such that the first table is an X-direction table and the second table is a Y-direction table.

ADVANTAGES OF THE INVENTION

25 [0012]

 The present invention offers the advantage of providing a bonding apparatus that can be operated at high speed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a plan view of an XY table according to an exemplary embodiment of the present invention.

5 FIG. 2 is a front view of the XY table according to the exemplary embodiment of the present invention.

FIG. 3 is a side view of the XY table including a Y-direction movable member according to the exemplary embodiment of the present invention.

10 FIG. 4 is a perspective view of the Y-direction movable member in the XY table according to the exemplary embodiment of the present invention.

FIG. 5 is a plan view of an XY table according to another exemplary embodiment of the present invention.

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EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0014]

A wire-bonding apparatus 100 according to a preferred exemplary embodiment of the present invention will hereinafter be described in detail with reference to the accompanying drawings. As shown in FIG. 1, the wire-bonding apparatus 100 includes an XY table 10 provided with a lower table 13 and an upper table 21 that are arranged, respectively, in X-axis (along line X-X) and Y-axis (along line Y-Y) directions, i.e., of coordinate axes perpendicular to each other in a plane. The lower and upper tables 13 and 21 are connected, respectively; with an X-direction motor 30 and a Y-direction motor 40, so that the tables 13 and 21 can be driven, respectively,

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in the X and Y directions with the respective motors 30 and 40. On the upper table 21 is placed a bonding head 101 for vertically moving a capillary 103 attached at a leading end of a bonding arm 102. As shown in FIG. 1, the direction in which the bonding arm 102 expands is Y direction, and the direction perpendicular thereto is X direction.

[0015]

As shown in FIG. 2, the X-direction motor 30 is installed on the upper surface of a cabinet 11 via an X-direction guide rail 37. The X-direction motor 30 is, for example, a voice coil motor, which, as is well known, includes an X-direction motor stator 31 having a permanent magnet 32 and an X-direction movable member 33 having a coil 34. The X-direction movable member 33 is held inside the X-direction motor stator 31 with an X-direction guide not shown, which makes the X-direction movable member 33 movable only in the X direction. The X-direction guide is, for example, a well-known direct acting type one employing a cross roller guide or the like. The X-direction motor stator 31 is held with the X-direction guide rail 37 to be movable in the X direction, in which the X-direction movable member 33 is driven, but not movable in the Y direction.

[0016]

The X-direction movable member 33 is provided with a bracket 36 on the side nearer the lower table 13. The bracket 36 is fixedly coupled to a bracket 16 in the lower table 13 with a bolt. The lower table 13 is held on a table

holder 12 via an X-direction guide rail 14 in a manner movable in the X direction, in which the X-direction movable member 33 is driven, but not movable in the Y direction. The table holder 12 is fixed to the cabinet 11. It is here assumed that the weight of the X-direction motor stator 31 is greater than the total weight of the X-direction movable member 33, the lower table 13, and additionally a Y-direction movable member 43, the upper table 21, and the bonding head 101 loaded on the lower table 13.

[0017]

As shown in FIG. 2, an X-direction motor stator speed sensor 38 for detecting the travel speed of the X-direction motor stator 31 in the X direction is installed in the cabinet 11. A lower table sensor 18 for detecting the position and travel speed of the lower table 13 in the X direction is mounted on the upper surface of the table holder 12.

[0018]

As shown in FIG. 3, the Y-direction motor 40 is held on the upper surface of the cabinet 11 via a Y-direction motor holder 17 and a Y-direction guide rail 47 in a manner movable in the Y direction. The Y-direction motor 40 is, for example, a planar linear motor, which includes a Y-direction motor stator 41 having a permanent magnet 42 and a plate-like Y-direction movable member 43 having a coil 44 shown in FIG. 1.

[0019]

As shown in FIG. 3, the Y-direction movable member

43 is provided with a bracket 46 on the side nearer the upper table 21. The bracket 46 of the Y-direction movable member 43 is fixed to the upper surface of the upper table 21 with a bolt 23. The upper table 21 is held on the lower table 13 via a Y-direction guide rail 22 extending in the Y direction. The upper table 21 is thus configured to be movable in the X direction together with the lower table 13 as well as in the Y direction on the upper surface of the lower table 13, that is, the upper table 21 is movable in both the X and Y directions. The Y-direction movable member 43, which is fixed to the upper table 21, is also configured to be movable in both the X and Y directions together with the upper table 21.

[0020]

As shown in FIG. 1, the permanent magnet 42, which serves as magnetic field forming means in the Y-direction motor stator 41, is provided extensively to the ends of the Y-direction motor stator 41, resulting in that the permanent magnet 42 covers the entire region of the movement of the coil 44 in the X direction, which serves as a magnetomotive section in the Y-direction movable member 43. In addition, the weight of the Y-direction motor stator 41 is greater than the total weight of the Y-direction movable member 43, the upper table 21, and the bonding head 101.

[0021]

The lower table sensor 18 is mounted on the table holder 12 to detect the position and speed of the lower table 13. On the upper surface of the lower table 13 is

mounted an upper table sensor 19 for detecting the position and travel speed of the upper table 21 in the Y direction. A Y-direction motor stator speed sensor 48 for detecting the travel speed of the Y-direction motor stator 41 is
5 installed in the Y-direction motor holder 17. There is also provided a nozzle 55 for blowing cooling air to cool the Y-direction movable member 43, the nozzle 55 being installed in such a manner that the air outlet thereof faces the coil 44.

10 [0022]

The following gives a brief description of an operation of the thus arranged XY table 10. When a position command signal for moving the lower table 13 to a predetermined position is output from a controller not
15 shown, the X-direction movable member 33 is accelerated to move in the X direction, so that the lower table 13 is guided with the X-direction guide rail 14 to move also in the X direction. In contrast, the X-direction motor stator 31, which is provided along the X-direction guide
20 rail 37 in a manner movable in the X direction, is subject to a force of the same magnitude in the opposite direction as a reaction to the movement of the X-direction movable member 33 and the lower table 13, and then accelerated to move in the direction opposite to that of the movement of
25 the lower table 13. Since the X-direction motor stator 31 thus moves in the direction opposite to that of the movement of the lower table 13, the cabinet 11 theoretically has no momentum and thereby hardly vibrates at all.

[0023]

The position and speed of the lower table 13 is then detected with the lower table sensor 18 and fed back to the controller, and thereafter a voltage is applied to the coil 34 in the X-direction motor 30 such that the lower table 13 is controlled to come to a predetermined position. The position and speed of the X-direction motor stator 31 is also detected with the X-direction motor stator speed sensor 38, and then compensation for the electric power consumed for the movement of the X-direction motor stator 31 is input to the coil 34.

[0024]

Similarly, when a position command signal for moving the upper table 21 to a predetermined position is output from the controller not shown, the Y-direction movable member 43 is accelerated to move in the Y direction, so that the upper table 21 is guided with the Y-direction guide rail 22 to move also in the Y direction. In contrast, the Y-direction motor stator 41, which is provided along the Y-direction guide rail 47 in a manner movable in the Y direction, is subject to a force of the same magnitude in the opposite direction as a reaction to the movement of the Y-direction movable member 43 and the upper table 21, and then accelerated to move in the direction opposite to that of the movement of the upper table 21. Since the Y-direction motor stator 41 thus moves in the direction opposite to that of the movement of the upper table 21, the cabinet 11 and the table holder 12 theoretically have no momentum and thereby hardly vibrate at all.

[0025]

The position and speed of the upper table 21 is then detected with the upper table sensor 19 and fed back to the controller, and thereafter a voltage is applied to the coil 44 in the Y-direction motor 40 such that the upper
5 table 21 is controlled to come to a predetermined position. The position and speed of the Y-direction motor stator 41 is also detected with the Y-direction motor stator speed sensor 48, and then compensation for the electric power
10 consumed for the movement of the Y-direction motor stator 41 is input to the coil 44.

[0026]

As described heretofore, in the XY table 10, the lower table 13 is driven in the X direction with the
15 X-direction motor 30, while the upper table 21, which is mounted on the lower table 13 slidably in the Y direction, is driven in the Y direction with the Y-direction motor 40, which causes the upper table 21 to be moved in the X and Y directions. With the movement of the upper table
20 21 in the X and Y directions, the Y-direction movable member 43, which is fixed to the upper table 21, is also moved in the X and Y directions.

[0027]

The Y-direction movable member 43 will next be
25 described in detail with reference to FIG. 4. The Y-direction movable member 43 includes a movable arm 43a formed as a carbon fiber-reinforced plastic pipe with a rectangular cross section, an opening 43b formed in a side plate 43h on each short side of the movable arm 43a, an

annular coil 44 inserted into the opening 43b along the width direction (X direction) of the movable arm 43a and fixed to the movable arm 43a, a bracket 46 provided at one end of the movable arm 43a, a dynamic damper 50 provided at the other end opposite the bracket 46, and a cable 43d for supplying electric power to the coil 44. With a bolt inserted into a hole 43c that is provided in the bracket 46, the Y-direction movable member 43 is fixed to the upper table 21 in such a manner that the longitudinal direction thereof corresponds to the Y direction.

[0028]

The movable arm 43a is formed as a carbon fiber-reinforced plastic pipe with a rectangular cross section having an approximately constant thickness "t", a width W_1 , and a height H_1 , where $W_1 > H_1$, in which a number of fibers run in the longitudinal direction (Y direction) of the movable arm 43a so that the strength in the longitudinal direction (Y direction) is greater than that in the width direction. The movable arm 43a is hollow.

[0029]

The coil 44, which is fitted into the Y-direction movable member 43, has an approximately elongated annular shape and a rectangular cross section. The external length W_2 of the coil 44 in the width direction (X direction) of the movable arm 43a is greater than the width W_1 of the movable arm 43a. The internal length W_3 of the coil 44 in the width direction (X direction) of the movable arm 43a is also greater than the width W_1 of the movable arm 43a. The length of the opening 43b in the longitudinal

direction (Y direction) of the movable arm 43a, in which the coil 44 is inserted, is represented by L_1 , which is slightly greater than the length L_2 of the coil 44 in the longitudinal direction (Y direction) of the movable arm 43a. The height H_2 of the coil 44 is approximately equal to the internal face-to-face height $H_3 = H_1 - 2 \times t$ of the movable arm 43a in the thickness direction thereof. The coil 44 is then inserted into the opening 43b of the movable arm 43a in the width direction (X direction) of the movable arm 43a and adhesively fixed between the upper and lower plates 43f and 43g of the movable arm 43a in such a manner that the outer and inner surfaces of the coil 44 in the width direction protrude from each lateral side of the movable arm 43a in the width direction of the movable arm 43a.

[0030]

In each side plate 43h of the movable arm 43a is formed an opening 43e between the inner surfaces of the coil 44, the opening having a length W_4 equal to the internal length of the coil 44 in the longitudinal direction (Y direction) of the movable arm 43a and a height equal to the internal face-to-face height H_3 of the movable arm 43a. The opening 43e provides communication to the space 45 inside the coil 44 in the hollow movable arm 43a, so that the space 45 inside the coil 44 is in communication with the space outside the movable arm 43a.

[0031]

The bracket 46 is constituted by a metal block with a size tightly fittable into the movable arm 43a formed

as a pipe with a rectangular cross section, and fitted into the movable arm 43a through one end face thereof and, after fixed adhesively, formed with the hole 43c for attachment to the movable arm 43a. Since the metal block has only
5 a length penetrable to a depth slightly deeper than the position of the attachment hole 43c, the movable arm 43a is almost entirely hollow.

[0032]

The dynamic damper 50, which is attached to the other
10 end face of the movable arm 43a opposite the bracket 46, includes a flat plate 51 protruding from the movable arm 43a and a weight 52 mounted on the upper surface of the flat plate 51. The flat plate 51 includes a connection 53 tightly fittable into the rectangular-piped movable arm
15 43a to provide connection between the flat plate 51 and the movable arm 43a, and the connection 53 is fixed adhesively to the movable arm 43a. Further, on the surface of the flat plate 51 opposite the weight 52 is attached a damping member for vibration damping. The damping
20 member may be attached with a double-sided adhesive tape, for example. The dynamic damper 50 is configured to disperse the vibration peak of the Y-direction movable member 43 using the weight 52 and the damping member.

[0033]

25 The thus arranged Y-direction movable member 43, which is formed of carbon fiber-reinforced plastic, configured with and high-strength properties, and is hollow except the bracket 46 and the portion of the coil 44 inserted into the movable arm 43a, is very light

relative to conventional Y-direction movable members. In addition, carbon fibers ensure strength in the longitudinal direction, and the upper and lower plates 43f and 43g of the movable arm 43a are reinforced vertically with the side plates 43h as well as the metal block, annular coil 44, and connection 53 fitted into the movable arm 43a, which allow for a very high bending strength about the X axis. This lightweight and high-stiffness structure allows the frequency in the primary vibration mode to be increased, in which the dynamic damper 50 side vibrates vertically with the bracket 46 fixed to the upper table 21 serving as a fixed point. In this exemplary embodiment, the weight can be about half and the natural frequency can be about 1.5 times those of conventional Y-direction movable members.

[0034]

Accordingly, the travel speed of the tables 13 and 21 can be increased without increasing the output of the motors 30 and 40. In addition, since the Y-direction movable member 43 has a high natural frequency, the frequency component contained in the back-and-forth movement of the upper table 21 can differ from the natural frequency of the Y-direction movable member 43, which can reduce the occurrence of vibration, whereby the travel speed of the upper table 21 can be increased.

[0035]

Further, since the Y-direction movable member 43 is arranged as shown in FIG. 4, in which the coil 44 protrudes from each lateral side of the movable arm 43a, the nozzle

55 shown in FIG. 1 can blow cooling air directly onto the coil 44, whereby the coil 44 can be cooled efficiently. Moreover, the cooling air passes through the opening 43e in each lateral side of the movable arm 43a to get into the space 45 inside the coil 44 and cool the inner surface of the coil 44, whereby the coil 44 can be cooled over a larger area. This can improve the efficiency of cooling and thereby suppress the rise in the temperature of the coil 44. Furthermore, expansion of surrounding components due to thermal influences is less likely to occur, whereby the bonding accuracy can be improved and the travel speed of the Y-direction movable member 43 can be increased by applying a larger current.

[0036]

Although the cooling air blowing nozzle 55 is arranged outside the Y-direction movable member 43 and faces the coil 44 in the above description of this exemplary embodiment, the nozzle 55 may be inserted into the hollow space on the side of the movable arm 43a where the bracket 46 is provided to cool the coil 44. Although the internal length W_3 of the coil 44 in the width direction (X direction) of the movable arm 43a is also greater than the width W_1 of the movable arm 43a and the opening 43e is formed in each lateral side of the movable arm 43a to provide communication to the space 45 inside the coil 44 in the above description of this exemplary embodiment, the internal length W_3 of the coil 44 in the width direction (X direction) of the movable arm 43a may be smaller than the width W_1 of the movable arm 43a so that only the outer

surface of the coil 44 protrudes from each lateral side of the movable arm 43a and thus the opening 43e is not formed.

[0037]

5 Although the Y-direction movable member 43 is formed as a carbon fiber-reinforced plastic rectangular pipe in the above description of this exemplary embodiment, the Y-direction movable member 43 may not have a rectangular-piped structure as long as it is hollow, but
10 have, for example, a sandwich structure in which honeycombs and/or ribs are placed between upper and lower plates of carbon fiber-reinforced plastic. Although the Y-direction movable member 43 is formed as a carbon fiber-reinforced plastic rectangular pipe in the above
15 description of this exemplary embodiment, the XY table 10 may have a different configuration as shown in FIG. 5 in which an X-direction motor 60 and a Y-direction motor 70 are arranged contrary to the configuration shown in FIG. 1. In this case, the movable member of the X-direction
20 motor 60 would be formed as a carbon fiber-reinforced plastic rectangular pipe.

[0038]

It should be appreciated that the present invention is not limited to the embodiment described above, and any
25 variations and modifications can be made without departing from the spirit and the technical scope of the present invention as defined in the appended claims.

REFERENCE NUMERALS

[0039]

10	XY table
11	cabinet
12	table holder
5 13	lower table
14, 37	X-direction guide rail
16, 36, 46	bracket
17	Y-direction motor holder
18	lower table sensor
10 19	upper table sensor
21	upper table
22, 47	Y-direction guide rail
23	bolt
30	X-direction motor
15 31	X-direction motor stator
32, 42	permanent magnet
33	X-direction movable member
34, 44	coil
38	X-direction motor stator speed sensor
20 40	Y-direction motor
41	Y-direction motor stator
43	Y-direction movable member
43a	movable arm
43b, 43e	opening
25 43c	hole
43d	cable
43f	upper plate
43g	lower plate
43h	side plate

	45	space
	48	Y-direction motor stator speed sensor
	50	dynamic damper
	51	flat plate
5	52	weight
	53	connection
	55	nozzle
	100	wire-bonding apparatus
	101	bonding head
10	102	bonding arm
	103	capillary

CLAIMS

1. A two-directionally movable table movable in two directions, first and second directions, perpendicular to each other in the same plane, the table comprising:

a first table configured to be guided in the first direction and driven in the first direction with a first motor;

a second table configured to be guided in the second direction with a second directional guide provided on the upper surface of the first table and driven in the first direction together with the first table as well as in the second direction with a second motor; and

a movable member comprising a movable arm movable in the first and second directions together with the second table, formed as a fiber-reinforced plastic hollow body with a rectangular cross section extending in the second direction with one end thereof being fixed to the second table and, in each short side surface, provided with an opening elongated in the second direction, and an annular drive coil inserted into the opening to be attached to the movable arm and partially protruding from the opening in the width direction of the movable arm.

2. The two-directionally movable table according to claim 1, wherein

the movable member is configured such that the length of the opening of the movable arm in the second direction is greater than the external length of the drive coil in

the direction perpendicular to the insertion direction,
and that the internal length of the drive coil in the
insertion direction is greater than the width of the
movable arm, and that the space inside the drive coil is
5 in communication with the space outside the movable arm.

3. The two-directionally movable table according to
claim 1, further comprising a nozzle for blowing air
directly onto the drive coil in the movable member.

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4. The two-directionally movable table according to
claim 2, further comprising a nozzle for blowing air
directly onto the drive coil in the movable member.

15 5. The two-directionally movable table according to
claim 1, wherein the first table is an X-direction table
and the second table is a Y-direction table.