

DIE BONDER AND METHOD FOR DETECTING MISALIGNED WORKPIECES

Field of the Invention

5 The present invention relates to backend processes of semiconductor dies in the semiconductor industry. In particular, this invention relates to a die bonder having an indexer for moving a workpiece along a conveying direction and a method for detecting misaligned workpieces.

Background of the Invention

10 Die bonders in the art enable bonding of semiconductor dies to workpieces such as leadframes. In a typical die bonding process, a leadframe is heated to a temperature that is sufficient to melt a bonding adhesive. Generally, the bonding adhesive for power electronic devices is solder. Generally, heat is provided during
15 conveyance of workpieces according to a temperature profile. The temperature profile provides a temperature gradient to be raised and then lowered gradually along a conveying distance.

 A common problem in this die bonding process for power electronic devices
20 is the oxidation of the leadframe and the solder at elevated temperatures above 100 degrees Celsius. Oxides formed by the oxidation reduce the quality of subsequent manufacturing processes as well as adversely affect the reliability of the final products.

25 Typically, to prevent oxidation of bonding surfaces, a workpiece is heated in a chamber or a furnace. Such a furnace is usually enclosed or sealed to prevent, or at least alleviate, entry of oxygen. Hence, visual inspection of the workpiece that is being conveyed within the furnace is not possible. Consequently, any damage to or misalignment of the workpiece is usually not detected until the workpiece exits the

furnace. This is unproductive and expensive in terms of material costs due to damaged workpieces.

Furthermore, misplaced semiconductor chips because of misaligned
5 workpieces can cause severe quality as well as productivity problems in subsequent manufacturing processes such as wire bonding or molding. Such quality problems would result in a reduced lifetime of the semiconductor chips or in the failure of the subsequent manufacturing processes.

10 To alleviate this problem in the use of an enclosed furnace, US Patent No. 4,975,050, issued to Yamazaki et al and assigned to Kabushiki Kaisha Shinkawa, describes a device having a lid made of a transparent material or having a transparent plate through which workpieces can be viewed. However, such an approach requires a human operator or a plurality of cameras placed along the conveying distance of
15 the device. This approach is therefore expensive and prone to human errors when human operators are involved.

Therefore, a need clearly exists for a high temperature die bonder to detect misaligned workpieces without having to use human operators or requiring
20 modifications to mount cameras.

Brief Summary of the Invention

The present invention seeks to provide an indexer, a die bonder having the indexer and a method for detecting misaligned workpieces.
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Accordingly, in one aspect, the present invention provides an indexer for moving a workpiece along a conveying direction, the indexer comprising:
a workpiece track;

30 a movement actuator mount coupled to the workpiece track at one or more positions along the conveying direction, the movement actuator mount being

disposed at a predetermined distance from the workpiece track at each of the one or more positions when the workpiece is being conveyed on the workpiece track;

5 and

one or more spatial detectors coupled to the movement actuator mount at one or more detector positions for detecting when the predetermined distance deviates more than a predetermined limit.

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In another aspect, the present invention provides a die bonder comprising:

an indexer for moving a workpiece along a conveying direction and having:

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a workpiece track;

a movement actuator mount coupled to the workpiece track at one or more positions along the conveying direction, the movement actuator mount being disposed at a predetermined distance from the workpiece track at each of the one or more positions when the workpiece is being conveyed on the workpiece track;

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and

one or more spatial detectors coupled to the movement actuator mount at one or more detector positions for detecting when the predetermined distance deviates more than a predetermined limit;

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and

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a controller, coupled to the one or more spatial detectors, for controlling conveyance of the workpiece.

In a yet another aspect, the present invention provides a method for detecting misaligned workpieces on a workpiece track, the method comprising the steps of:

5 monitoring a predetermined distance between the workpiece track
 and a movement actuator mount, the movement actuator mount being
 coupled to the workpiece track at one or more positions along the
 workpiece track;

 and

10 generating a control signal when the predetermined distance
 deviates more than a predetermined limit at one or more monitoring
 positions.

15 In a further aspect, the present invention provides an indexer for moving a
workpiece along a conveying direction, the indexer comprising:

 a workpiece track;

20 a movement actuator mount coupled to the workpiece track;

 and

 at least one vibration sensor, coupled to the movement actuator
25 mount to detect when vibrations of the movement actuator mount
 exceeds a vibration reference level.

In another aspect, the present invention provides a die bonder comprising:

 an indexer for moving a workpiece along a conveying direction, the
30 indexer comprising:
 a workpiece track;

a movement actuator mount coupled to the workpiece track;
and
at least one vibration sensor, coupled to the movement
actuator mount to detect when vibrations of the movement
5 actuator mount exceeds a vibration reference level;
and
a controller, coupled to the at least one vibration sensor, for
controlling conveyance of the workpiece.

10 In yet another aspect, the present invention provides a method for detecting
misaligned workpieces on a workpiece track, the method comprising the steps of:
monitoring vibrations of a movement actuator mount, the
movement actuator mount being coupled to the workpiece track at one
or more positions along the workpiece track;
15 and
generating a control signal when the vibrations exceed a vibration
reference level.

Brief Description of the Drawings

20 A preferred embodiment and an alternate embodiment of the present
invention will now be more fully described, by way of example, with reference to the
drawings of which:

FIG. 1 is a perspective view of an indexer having a workpiece track and a
25 movement actuator mount in accordance with the preferred embodiment;

FIG. 2 is a perspective view of the indexer of FIG. 1 without the workpiece
track;

30 FIG. 3 is an exploded perspective view of a movement actuator for mounting
to the movement actuator mount of FIG. 1;

FIGs. 4A and 4B are two exploded perspective views of a spatial detector for the indexer of FIG. 1;

5 FIG. 5 is a flowchart of a method for detecting misaligned workpieces on the workpiece track of FIG. 1;

FIG. 6 is a perspective view of a motor coupler and a motor for an indexer in accordance with the alternate embodiment of the invention;

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and

FIG. 7 is a flowchart of a method for detecting misaligned workpieces on a workpiece track of the indexer in the alternate embodiment.

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Detailed Description of the Drawings

20 An indexer, a die bonder having the indexer, a method for detecting misaligned workpieces conveyed by the indexer in accordance with a preferred embodiment and an alternate embodiment of the invention are described. In the following description, details are provided to describe the preferred and the alternate embodiments. It shall be apparent to one skilled in the art, however, that the invention may be practiced without such details. Some of these details may not be described at length so as not to obscure the invention.

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There are many advantages of the embodiments of the invention. One advantage of the preferred embodiments is that workpieces such as leadframes are effectively monitored for misalignment when conveyed within the indexer without using expensive cameras or vision devices.

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Another advantage of the embodiments is that the indexer can be adapted to detect misalignment of workpieces in furnaces that operate at high temperatures.

5 A further advantage of the embodiments is that misalignment of a workpiece in the indexer is indirectly detected at another location. Consequently, limitations of detecting such misalignment due to high temperatures in a furnace in which the indexer is applied are avoided.

Referring now to FIG.1, a perspective view of an indexer 10 having a workpiece track 12 and a movement actuator mount 14 in accordance with a preferred embodiment is shown. In the preferred embodiment shown in FIG. 1, the indexer 10 is adapted to convey workpieces (not shown) in a conveying direction for a furnace of a die bonder (not shown). The conveying direction is indicated with an arrow 16.

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The furnace has a pre-bonding section 18 and a post-bonding section 20. A bonding section 22 is disposed between the pre-bonding section 18 and the post-bonding section 20. A temperature profile is maintained in the furnace to regulate temperatures along a conveying distance of the workpiece track 12. In the pre-bonding section 18, the temperature gradually rises from an input 24 to an output 26 just before the bonding section 22. The temperature at the output 26 has to be sufficient to melt bonding adhesives used for bonding semiconductor dies to a workpiece (not shown) such as a leadframe. This temperature is typically about 300 to 500 degrees Celsius.

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The movement actuator mount 14 is coupled to the workpiece track 12 at five positions 28a,28b,28c,28d,28e along the conveying direction using, respectively, five movement actuators 30a,30b,30c,30d,30e. FIG. 2 is a perspective view of the indexer 10, without the workpiece track 12 and the furnace, showing the five movement actuators 30a,30b,30c,30d,30e.

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Further to the workpiece track 12 and the movement actuator mount 14, the indexer 10 further comprises five spatial detectors 32a,32b,32c,32d,32e, respectively coupled to each other via a camshaft 34.

5 The movement actuator mount 14 couples to a first motor 36 that provides power, via a timing belt 38, to move the movement actuator mount 14 in a linear or x-axis direction that is substantially parallel to the conveying direction. Rotary power from the first motor 36 is transferred to linear motion of the movement actuator mount 14 via a motor coupler 40.

10 The five spatial detectors 32a,32b,32c,32d,32e couple to a second motor (not shown) that provides power, via a timing belt 42, to rotate the cam shaft 34. Rotation of the camshaft 34 causes the movement actuator mount 14 to move in another linear or z-axis direction that is substantially perpendicular to the conveying direction. An
15 arrow 44 indicates this other linear or z-axis direction. The z-axis movement of the movement actuator mount 14 is described later.

 Movement of the movement actuator mount 14 in the above two linear directions, corresponding to the arrows 16,44, enables the five movement actuators
20 30a,30b,30c,30d,30e to provide a walking beam that moves a workpiece in the conveying direction.

 FIG. 3 is an exploded perspective view of a movement actuator 30 that exemplifies the five movement actuators 30a,30b,30c,30d,30e. The movement
25 actuator comprises a finger member 50 and a finger coupling mount 52. The finger member 50 has a track coupler 54 with a protrusion 56 for engaging an aperture (not shown) disposed on the workpiece. The finger coupling mount 52 has a mount guide 58 and a finger coupler 60.

30 The mount guide 58 has a setscrew slot 62 for a setscrew 64 that locks the movement actuator 30 to a fixed position along the movement actuator mount 14.

This fixed position can be changed during set-up of the indexer 10 to accommodate workpieces of different designs.

5 A coupling distance between the workpiece track 12 and the movement actuator mount is set depending upon the position at which the finger member 50 is mounted to a finger groove 66 on the finger coupler 60. FIG. 3. shows two finger screw slots 68,70 for mounting the finger member 50 to the finger groove 66. Each of these two finger screw slots 68,70 provides a range of positions for mounting the finger member 50 to thereby vary the coupling distance.

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The coupling distance provides a predetermined distance at which the movement actuator mount 14 is spaced apart from the workpiece track 12 at each of the five positions 28a,28b,28c,28d,28e when a workpiece is being conveyed on the workpiece track 12 by the five movement actuators 30a,30b,30c,30d,30e.

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As shown in FIG. 2, the five spatial detectors 32a,32b,32c,32d,32e are for detecting when the predetermined distance deviates more than a predetermined limit. FIGs. 4A and 4B are two exploded perspective views of a spatial detector 32 that exemplifies the five spatial detectors 32a,32b,32c,32d,32e. The spatial detector 32
20 has an upper portion 80 and a lower portion 82. The upper portion 80 and the lower portion 82 are coupled to each other and a spring 84 biases the upper portion 80 and the lower portion 82 towards each other.

The upper portion 80 has a top surface 86 at which are mounted two rollers
25 88,90. These two rollers 88,90 engage the movement actuator mounts 14 to enable movement in the linear direction indicated by the arrow 16. A shaft housing 92 is disposed on the upper portion 80 for coupling to the lower portion 82.

The lower portion 82 comprises a cam slot 94 and a proximity sensor 96.
30 The cam slot 94 receives the camshaft 34 for movement of the movement actuator mount 14 in the z-axis direction indicated by the arrow 44. The proximity sensor 96

is for sensing a detector plate 98 mounted to the upper portion 80. When the upper portion 80 and the lower portion 82 are in close proximity to each other in a normal down position, the proximity sensor 96 detects proximity of the detector plate 98 and triggers a flag with a trigger signal. The trigger signal is then provided to a controller
5 (not shown) such as, for example, a computer that processes the trigger signal and controls the first motor 36 and the second motor.

While indexing a workpiece, the protrusion 56 of the finger member 50 engages an indexing position on the workpiece in the z-axis direction. Movement of
10 the movement actuator mount 14 as a walking beam therefore enables the workpiece to be conveyed in the conveying direction. Such a walking beam requires the movement actuator mount 14 to move up or down in the z-axis direction and the flag is triggered accordingly by the proximity sensor 96.

15 However, if the protrusion 56 of the movement actuator 30 does not engage the indexing position as described in the above, then the predetermined distance between the workpiece track 12 and the movement actuator mount 14 at the position 28 of that movement actuator 30 is affected. Implementing the movement actuator mount 14 with an elongated rod that is resilient in the z-axis direction enables any
20 change to the predetermined distance to be translated via the elongated rod to one or more of the spatial detectors 32a,32b,32c,32d,32e. In other words, the change to the predetermined distance causes a distortion of the elongated rod in the z-axis direction.

25 Consequently, the distortion leads to one or more spatial detectors 32 being affected as the movement actuator mount 14 is coupled to the spatial detectors 32 via the two rollers 88,90. This prevents an affected spatial detector 32 from effecting the normal down position, which thereby prevents detection of the detector plate 98 by the proximity sensor 96 of that affected spatial detector 32. Hence, the trigger signal
30 is not generated with the flag not triggered.

The controller is configured to stop the first motor 36 and the second motor when the trigger signal is not received within a predetermined time period. Stopping the first motor 36 and the second motor stops conveyance of the workpiece. As such, any subsequent damage that may be caused by misfeeding or misalignment of the workpiece is prevented or at least alleviated.

The magnitude of the distortion of the movement actuator mount 14 or elongated rod can be set so as to provide the predetermined limit. Thus, the detector plate 98 for each of the five spatial detectors 32a,32b,32c,32d,32e are adjusted so that the trigger signal is not generated when the predetermined distance deviates more than the predetermined limit.

FIG. 5 is a flowchart of a method 100 for detecting misaligned workpieces conveyed by the indexer 10. The method starts at step 102 and proceeds to step 104 at which each of the spatial detectors 32 monitors, respectively, the predetermined distance between the workpiece track 12 and the movement actuator mount 14 at each of the five positions 28a,28b,28c,28d,28e.

A control signal is generated at step 106 when the predetermined distance deviates more than the predetermined limit at one or more monitoring positions. This control signal is in response to the non-detection of the trigger signal by the controller. Each of these monitoring positions is located where the detector plate 98 coacts with the proximity sensor 96 for each of the spatial detectors 32a,32b,32c,32d,32e.

Thereafter, the method 100 proceeds to step 108 at which, in response to the control signal, the controller stops the first motor 36 and the second motor from moving the movement actuator mount 14. The method 100 ends at step 110. Thus, the method 100 enables the controller to control the five movement actuators 30a,30b,30c,30d,30e from moving the workpiece when there is a misalignment of that workpiece.

An alternate embodiment of the invention provides an indexer (not shown) that comprises a vibration sensor. In describing the alternate embodiment, elements corresponding to those of the indexer 10 in the preferred embodiment are indicated
5 with the same reference numbers.

In the alternate embodiment, the vibration sensor detects vibrations of a movement actuator mount (not shown). The vibration sensor can be, for example, a piezoelectric sensor 200 that is mounted to the motor coupler 40 as shown in FIG. 6.
10 However, it is to be noted that the piezoelectric sensor 200 may be mounted to any other location of the indexer from which the vibrations of the movement actuator mount can be sensed.

The piezoelectric sensor 200 is adjusted such that a control signal is
15 generated when vibrations that exceed a vibration reference level are detected. The vibration reference level is determined based upon the indexer operating at normal conditions. The control signal is then provided to a controller (not shown) that controls the first motor 36 and the second motor to stop conveyance of a workpiece. Hence, if a crash occurs in which subsequent movement of the workpiece is not
20 possible without adversely affecting the quality of that workpiece, then conveyance of the workpiece can be stopped. For example, a crash occurs if the workpiece undesirably collides with, for example, another workpiece or the workpiece track 12. Consequently, vibrations arising from the crash are transferred to the piezoelectric sensor 200 via the movement actuator mount.

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Other than crashes, abnormal conveyance of a workpiece causes an increase in vibration along the workpiece track 12 that is then transferred to the movement actuator mount. Hence, if there is excess friction of the workpiece against the workpiece track 12, then such a situation can be detected as abnormal and detected
30 by the piezoelectric sensor 200.

With the piezoelectric sensor 200, the indexer in the alternate embodiment does not need to operate with the proximity sensor 96 of the spatial detector 32. As in the preferred embodiment, the indexer of the alternate embodiment enables a problem that arises in one or more locations to be indirectly detected at another
5 location. However, if specific locations of the problem are required, then the spatial detectors 32 are retained for the alternate embodiment to thereby provide information on these specific locations.

FIG. 7 is a flowchart of a method 300 for detecting misaligned workpieces on
10 a workpiece track of the indexer in the alternate embodiment. The method 300 starts at step 302 and proceeds to step 304 at which vibrations are monitored for the movement actuator mount of the indexer under normal operations. At this monitoring step 304, one or more vibration reference levels are determined. Each of the vibration reference levels corresponds to a different stage in indexing a workpiece on
15 the workpiece track 12.

Following the determining step 304, vibrations of the movement actuator mount are then monitored at step 306 and compared with the vibration reference levels. When the vibrations exceed any one of the vibration reference levels, the
20 controller generates a control signal at step 308.

In response to the control signal, the controller stops the first motor 36 and the second motor from moving the movement actuator mount at step 310. the method
300 ends at step 312.

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It will be appreciated that although a preferred embodiment and an alternate embodiment of the invention have been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.



Claims

1. An indexer for moving a workpiece along a conveying direction, said
5 indexer comprising:
- a workpiece track;
- a movement actuator mount coupled to said workpiece track at one
10 or more positions along said conveying direction, said movement
actuator mount being disposed at a predetermined distance from said
workpiece track at each of said one or more positions when said
workpiece is being conveyed on said workpiece track;
- 15 and
- one or more spatial detectors coupled to said movement actuator
mount at one or more detector positions for detecting when said
predetermined distance deviates more than a predetermined limit.
- 20
2. The indexer as claimed in Claim 1, wherein said movement actuator
mount comprises an elongated rod, said rod being resilient.
3. The indexer as claimed in Claim 1, and further comprising at least one
25 movement actuator for coupling said movement actuator mount to said
workpiece track.
4. The indexer as claimed in Claim 3, wherein each of said at least one
movement actuator comprises a protrusion for engaging an indexing
30 position on said workpiece.



5. The indexer as claimed in Claim 3, wherein each of said at least one movement actuator is adjustable to set said predetermined limit.
6. A die bonder comprising:
- 5 an indexer for moving a workpiece along a conveying direction and having:
- a workpiece track;
- a movement actuator mount coupled to said workpiece track at one or more positions along said conveying direction,
- 10 said movement actuator mount being disposed at a predetermined distance from said workpiece track at each of said one or more positions when said workpiece is being conveyed on said workpiece track;
- and
- 15 one or more spatial detectors coupled to said movement actuator mount at one or more detector positions for detecting when said predetermined distance deviates more than a predetermined limit;
- and
- 20 a controller, coupled to said one or more spatial detectors, for controlling conveyance of said workpiece.
- 25 7. The die bonder as claimed in Claim 6, wherein said movement actuator mount comprises an elongated rod, said rod being resilient.
8. The die bonder as claimed in Claim 6, and further comprising at least one movement actuator for coupling said movement actuator mount to said
- 30 workpiece track.



9. The die bonder as claimed in Claim 8, wherein each of said at least one movement actuator comprises a protrusion for engaging an indexing position on said workpiece.

5 10. The die bonder as claimed in Claim 8, wherein each of said at least one movement actuator is adjustable to set said predetermined limit.

11. A method for detecting misaligned workpieces on a workpiece track, said method comprising the steps of:

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monitoring a predetermined distance between said workpiece track and a movement actuator mount, said movement actuator mount being coupled to said workpiece track at one or more positions along said workpiece track;

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and

generating a control when said predetermined distance deviates more than a predetermined limit at one or more monitoring positions.

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12. The method as claimed in Claim 11, and further comprising the step of stopping, in response to said control signal, at least one motor from moving said movement actuator mount.



13. An indexer for moving a workpiece along a conveying direction, said indexer comprising:

a workpiece track;

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a movement actuator mount coupled to said workpiece track;

and

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at least one vibration sensor, coupled to said movement actuator mount to detect when vibrations of said movement actuator mount exceeds a vibration reference level.

14. The indexer as claimed in Claim 13, wherein each of said at least one vibration sensor is a piezoelectric sensor.

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15. A die bonder comprising:

an indexer for moving a workpiece along a conveying direction, said indexer comprising:

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a workpiece track;

a movement actuator mount coupled to said workpiece track;

and

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at least one vibration sensor, coupled to said movement actuator mount to detect when vibrations of said movement actuator mount exceeds a vibration reference level;

and

a controller, coupled to said at least one vibration sensor, for controlling conveyance of said workpiece.

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16. The die bonder as claimed in Claim 15, wherein each of said at least one vibration sensor is a piezoelectric sensor.

5 17. A method for detecting misaligned workpieces on a workpiece track, said method comprising the steps of:

monitoring vibrations of a movement actuator mount, said movement actuator mount being coupled to said workpiece track at one or more positions along said workpiece track;

10 and

generating a control signal when said vibrations exceed a vibration reference level.

15 18. The method as claimed in Claim 17, wherein said monitoring step comprises the step of determining one or more vibration reference levels.

20 19. The method as claimed in Claim 17, and further comprising the step of stopping, in response to said control signal, at least one motor from moving said movement actuator mount.