

BONDING DEVICE

BACKGROUND

5 1. Technical Field

The present invention relates to a bonding device for bonding an electronic part onto a substrate and, more particularly, to a bonding device that is suitable for heating an electronic part using laser beams and bonding the electronic part onto a substrate.

10 2. Description of the Related Art

Japanese Unexamined Patent Application Publication No. 2010-129890 discloses a bonding device including a laser oscillator configured to generate laser beams, a beam guide means configured to guide the laser beams generated by the laser oscillator, and a bonding tool configured to be heated by the laser beams guided by the beam guide means, wherein an
15 electronic part held in place by the bonding tool is bonded onto a substrate by heating the bonding tool.

The bonding tool disclosed in accordance with Japanese Unexamined Patent Application Publication No. 2010-129890 is configured to uniformly heat the overall area of the bonding tool, and thus the overall area of the electronic part is also uniformly heated.

20 However, when heat is more easily dissipated from the peripheral region of an electronic part than from the inside region thereof, the peripheral region of the electronic part is cooled to a lower temperature even when the overall area of the electronic part is uniformly heated. In practice, it is difficult to uniformly heat the overall area of the electronic part using the conventional bonding device.

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SUMMARY

Accordingly, the present invention has been made keeping in mind the above problems occurring in the conventional technology, and the present invention is directed to the provision of
5 a bonding device in which the heating-target area of a bonding tool is divided into a plurality of regions and the plurality of regions are heated to different temperatures, thereby being able to heat the overall area of an electronic part under appropriate conditions.

In accordance with an aspect of the present invention, there is provided a bonding device for bonding an electronic part, held in place by a bonding tool, onto a substrate by heating the
10 bonding tool, the bonding device including a laser oscillator configured to generate laser beams; a beam guide means configured to guide the laser beams generated by the laser oscillator; and a bonding tool configured to be heated by the laser beams guided by the beam guide means; wherein the laser oscillator includes a plurality of laser oscillators and the beam guide means includes a plurality of beam guide elements, laser beams generated by the respective laser
15 oscillators are radiated onto a plurality of heating-target regions of the bonding tool via the respective beam guide elements so that the plurality of heating-target regions can be heated to different temperatures, and insulation means configured to suppress the transfer of heat between the plurality of heating-target regions is formed in the bonding tool.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a partial sectional view of a bonding device according to a first embodiment of

the present invention;

FIG. 2 is a diagram of the detailed configuration of the laser oscillator of FIG. 1;

FIG. 3 is a diagram illustrating the relationships of disposition between the regions of an electronic part and optical fibers;

5 FIG. 4 is a diagram illustrating the intensity distribution (beam profile) of laser beams in a section taken along line IV-IV of FIG. 3;

FIG. 5 is a sectional view taken along line V-V of FIG. 1;

FIG. 6 is a diagram of the bottom surface of a bonding tool in accordance with the first embodiment of the present invention;

10 FIG. 7 is a diagram similar to FIG. 3 in accordance with a second embodiment of the present invention;

FIG. 8 is a diagram illustrating the relationships between optical fibers and laser oscillators;

FIG. 9 is a diagram of the bottom surface of a bonding tool in accordance with the
15 second embodiment of the present invention; and

FIG. 10 is a diagram of the bottom surface of a bonding tool in accordance with a third embodiment of the present invention.

DETAILED DESCRIPTION

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The present invention will be described with reference to embodiments illustrated in the accompanying diagrams. Referring to FIG. 1, a bonding device 1 is configured to bond an electronic part 3, such as a semiconductor chip, onto a substrate 2. In an embodiment illustrated in FIG. 3, the electronic part 3 is formed in a square shape. Accordingly, a heating-target area S
25 configured to heat the overall area of the electronic part 3 is also formed in a square shape in

accordance with the shape of the electronic part 3. The four corners of the heating-target area S form corner regions S1.

As illustrated in FIG. 1, the bonding device 1 includes a substrate stage 4 configured to move the substrate 2 along X and Y directions in a lateral plane while supporting the substrate 2;
5 a bonding head 5 disposed above the substrate stage 4; a lifting/lowering loading mechanism 6 configured to selectively lift and lower the bonding head 5; a laser oscillator 7 configured to generate laser beams L; and a beam guide means 8 configured to guide the laser beams L generated by the laser oscillator 7 into the bonding head 5.

The bonding head 5 includes a hollow cylindrical housing 5A. A tool base 13, including
10 two layers of transparent members 11 and 12, is laterally fastened in the lower end portion of the inside of the housing 5A. A bonding tool 14 is detachably sucked onto and held on the bottom surface of the tool base 13, and the electronic part 3 is detachably sucked onto and held on the bottom surface of the bonding tool 14.

A laser beam exit corresponding to one end of the beam guide means 8 is laterally
15 connected to the upper portion of the side of the housing 5A, and a laser beam entrance corresponding to the other end of the beam guide means 8 is coupled to the laser oscillator 7.

The laser beams L generated by the laser oscillator 7 are laterally irradiated toward the axial center of the housing 5A via the beam guide means 8, and are condensed into a required size by a condensing lens 15. The laser beams L laterally irradiated are vertically downwardly
20 reflected by a reflecting mirror 16 disposed at the center of the upper portion of the inside of the housing 5A, are transmitted through the tool base 13, and are then irradiated onto the bonding tool 14, thereby heating the bonding tool 14. Accordingly, the electronic part 3 held on the bonding tool 14 is also heated.

The operations of the substrate stage 4, the lifting/lowering loading mechanism 6 and the
25 laser oscillator 7 are controlled by a controller (not illustrated). When the controller activates the

laser oscillator 7, the laser beams L are generated by the laser oscillator 7, are guided into the bonding head 5 by the beam guide means 8, and are then irradiated onto the bonding tool 14, thereby heating the bonding tool 14.

As illustrated in FIG. 2, the laser oscillator 7 according to the present embodiment includes four laser oscillator sets 7A to 7D, and each of the four laser oscillator sets 7A to 7D includes eight laser oscillation elements 21 that are arranged in series. Accordingly, the laser oscillator 7 includes a total of 32 laser oscillation elements 21.

The eight laser oscillation elements 21 of each laser oscillator set are arranged in series, and are connected to a power source (not illustrated). The eight laser oscillation elements 21 of the laser oscillator set are powered to output laser beams L at the same output level by the power source.

Furthermore, the two laser oscillator sets 7A and 7B constitute a first laser oscillator, and the other laser oscillator sets 7C and 7D constitute a second laser oscillator 7C and a third laser oscillator 7D, respectively.

As described above, in the present embodiment, eight laser oscillation elements 21 are connected in series to each other in a group, and thus all the laser oscillation elements 21 can be controlled in groups, thereby facilitating the control of the laser oscillation elements 21. Furthermore, since the number of power sources can be reduced, the initial cost of the bonding device 1 can be reduced, and additionally the management cost thereof can be reduced because power consumption can be reduced.

Referring to FIG. 3, in the present embodiment, the heating-target area S is divided into three types of regions. In greater detail, the heating-target area S is divided into the above-described four corner regions S1, inside regions S2 corresponding to the inside portions of the electronic part 3, and outside regions S3 corresponding to the peripheral portion of the electronic part 3 excluding the corner regions S1 and the inside regions S2.

Of the first to third laser oscillators, the first laser oscillator 7A and 7B is set to a maximum output level, and thus directly heats the bonding tool 14 at the maximum output level, thereby heating the corner regions S1 (see FIG. 3) corresponding to the corners of the electronic part 3 at the maximum output level.

5 Meanwhile, the second laser oscillator 7C is set to a minimum output level, and thus heats the inside regions S2 corresponding to the inside portions of the electronic part 3 at the minimum output level. The third laser oscillator 7D is set to an intermediate output level, and thus heats the outside regions S3 at the intermediate output level.

As described above, the laser oscillator sets 7A to 7D are set to the different output levels
10 so that the heating-target area S of the electronic part 3 is uniformly heated as much as possible. By way of example, the laser oscillation elements 21 constituting the first laser oscillator 7A and 7B are set such that they can generate a laser beam at a 100% output level, the laser oscillation elements 21 constituting the third laser oscillator 7D are set such that they can generate a laser beam at a 60 to 70% output level, and the laser oscillation elements 21 constituting the second
15 laser oscillator 7C are set such that they can generate a laser beam at a 20 to 40% output level.

As illustrated in FIG. 3, the beam guide means 8 includes a bundle of 36 optical fibers f1 to f36 having the same outside diameter, and is configured such that respective laser beams L that have passed through different beam guide paths for the respective optical fibers f1 to f36 are guided into the bonding head 5 and are irradiated onto the heating-target area S of the electronic
20 part 3 in the form of spots, thereby heating the overall area of the electronic part 3.

The laser beam exits of the 36 optical fibers f1 to f36 are fastened in the form of a bundle inside a hollow cylindrical casing 22 laterally attached to the upper portion of the side of the housing 5A illustrated in FIG. 1, and are laterally connected to the side of the housing 5A through the casing 22, thereby optically facing the regions S1 to S3 of the electronic part 3 via
25 the condensing lens 15, the reflecting mirror 16 and the bonding tool 14.

More specifically, the laser beam exits of the 36 optical fibers f1 to f36 form a bundle in the form of a matrix in which six rows and six columns are arranged at regular intervals. The optical fibers f1 to f36 are arranged in order from the upper left corner of the matrix to the lower right corner thereof. Furthermore, the 36 optical fibers f1 to f36 are divided into three groups in accordance with the three regions S1 to S3.

That is, as illustrated in FIG. 3, the laser beam exits of four optical fibers are arranged to optically face each of the four corner region S1. In greater detail, four optical fibers f1, f2, f7 and f8 are arranged to optically face the upper left corner region S1, four optical fibers f5, f6, f11 and f12 are arranged to optically face the upper right corner region S1, four optical fiber f25, f26, f31 and f32 are arranged to optically face the lower left corner region S1, and four optical fiber f29, f30, f35 and f36 are arranged to optically face the lower right corner region S1.

A total of 16 optical fibers constitute a first group of optical fibers. Furthermore, of the 16 optical fibers of the first group, a set of eight optical fibers, including the four optical fibers f1, f6, f31 and f36 arranged at the outermost corners of the respective corner regions S1 and the four optical fibers f8, f11, f26 and f29 arranged at locations diagonal to the locations of the four optical fibers f1, f6, f31 and f36, that is, at the innermost corners of the respective corner regions S1, have their laser beam entrances that are connected to the respective laser oscillation elements 21 of the laser oscillator set 7A, as illustrated in FIG. 2.

Furthermore, the laser beam entrances of a set of remaining eight optical fibers f2, f5, f7, f12, f25, f30, f32 and f35 optically facing the corner regions S1 are connected to the respective laser oscillation elements 21 of the laser oscillator set 7B.

As a result, laser beams generated by the first laser oscillator 7A and 7B set to the maximum output level are irradiated onto the four corner regions S1 via the first group of 16 optical fibers.

The output level of the laser oscillator set 7A, including the laser oscillation elements 21

connected to the corresponding optical fibers f1, f6, f31 and f36, may be set to a value higher than the value of the output level of the laser oscillator set 7B.

Of the remaining 16 optical fibers, 12 optical fiber f9, f10, f14 to f17, f20 to f23, f27 and f28 constitute a second group of optical fibers. The laser beam exits of the second group of optical fibers optically face the inside regions S2.

Meanwhile, in the present embodiment, an irradiation-free region S2' onto which a laser beam is not irradiated is formed in a center region surrounded by the inside regions S2, that is, in the center portion of the electronic part 3. Of the optical fibers of the second group, the four center optical fibers f15, f16, f21 and f22 have their laser beam exits that optically face the irradiation-free region S2'. Accordingly, these four optical fibers do not need to irradiate laser beams, and thus are not connected to the second laser oscillator 7C.

In contrast, the laser beam entrances of the remaining eight optical fibers f9, f10, f14, f17, f20, f23, f27 and f28 are connected to the second laser oscillator 7C set to the minimum output level (see FIG. 3). Accordingly, laser beams generated by the second laser oscillator 7C set to the minimum output level are guided to the inside regions S2, other than the irradiation-free region S2', via the total of eight optical fibers of the second group, and heat the inside regions S2.

Meanwhile, the optical fibers f15, f16, f21 and f22 optically facing the irradiation-free region S2' may be omitted.

The last eight optical fibers f3, f4, f13, f18, f19, f24, f33 and f34 constitute a third group of optical fibers. The laser beam exits of the optical fibers of the third group optically face the outside regions S3 (see FIG. 3), and the laser beam entrances thereof are connected to the third laser oscillator 7D set to the intermediate output level (see FIG. 2).

Accordingly, laser beams generated by the third laser oscillator 7D set to the intermediate output level are guided to the outside regions S3 via the total of eight optical fibers

of the third group, and then heat the outside regions S3.

Meanwhile, in the present embodiment, the intensity distribution (beam profile) of the laser beams L is in Gaussian mode (see f6, f12, f18, f24, f30 and f36 of FIG. 4). In the Gaussian mode, the intensity of a corresponding laser beam L in each irradiation spot is highest in the optical axis region of the laser beam L, and the intensity decreases across a region around the optical axis. That is, the intensity of the neighboring laser beams L is weak between the laser beams. Furthermore, using this characteristic, a groove 12B constituting part of a chip suction path 23 is used to suck the electronic part 3 is formed in a range between neighboring rows of laser beams L, as will be described later.

Referring back to FIG. 1, the tool base 13 and its adjacent configurations are described. In the present embodiment, the tool base 13 has a stacked structure in which the transparent member 11 made of sapphire is used as an upper layer and the transparent member 12 made of quartz is used as a lower layer.

The stacked two transparent members 11 and 12 are inserted into the lower end portion of the inside of the housing 5A. The bottom surface of the transparent member 12 is laterally held in place by an annular fastening member 24 at a height that is approximately the same as that of the bottom surface of the housing 5A. Meanwhile, the top surface of the transparent member 11 in a stacked state is pressed and laterally held in place by an annular stopper 25 that is inserted into the housing 5A. Accordingly, the two transparent members 11 and 12 that constitute the tool base 13 are laterally supported in the lower end portion of the inside of the housing 5A, and also the bottom surface of the transparent member 11 and the top surface of the transparent member 12 are brought into airtight contact with each other.

In the present embodiment, a tool suction path 26 is formed through the housing 5A, the stopper 25 and the tool base 13, whereas the chip suction path 23 is formed through the housing 5A, the two transparent members 11 and 12 and the bonding tool 14. When a negative pressure

is supplied by a negative pressure source 27 to the tool suction path 26 through a conduit 28, the bonding tool 14 can be sucked onto and held in place by the bottom surface of the tool base 13 (that is, the bottom surface of the transparent member 12). Furthermore, when a negative pressure is supplied by a negative pressure source 32 to the chip suction path 23 through a conduit 31, the electronic part 3 can be sucked onto and held in place by the bottom surface of the bonding tool 14 that is being held in place by the tool base 13.

As illustrated in FIGS. 1 and 5, four through holes 13A are formed through the upper and lower transparent members 11 and 12 (the tool base 13) in accordance with the four corners of the square bonding tool 14. The upper ends of these through holes 13A are configured to communicate with a groove 25A that is formed on the bottom surface of the stopper 25. The groove 25A of the stopper 25 is connected to one end of the conduit 28 through an L-shaped communication hole 25B that is formed through the stopper 25 and the housing 5A. The tool suction path 26 is formed by the four through holes 13A, the groove 25A of the stopper 25, and the communication hole 25B.

The other end of the conduit 28 is connected to the negative pressure source 27, and the operation of the negative pressure source 27 is controlled by the controller. When bonding is performed by the bonding device 1, the negative pressure source 27 is operated by the controller. Accordingly, since a negative pressure is supplied to the tool suction path 26 during a bonding process, the bonding tool 14 is sucked onto and held in place by the bottom surface of the tool base 13 (that is, the bottom surface of the transparent member 12).

Next, the chip suction path 23 is described. A through hole 12A is vertically formed through the center of the lower transparent member 12. Furthermore, the rectilinear groove 12B that extends from the upper end of the through hole 12A and that reaches the inside surface of the housing 5A is formed on the top surface of the transparent member 12. A lateral through hole 5B is formed through the housing 5A in accordance with the location of the outer end of the

groove 12B, and one end of the conduit 31 is connected to the through hole 5B.

The rectilinear groove 12B is formed on the top surface of the transparent member 12 so that it is located between two neighboring rows of irradiation spots of the laser oscillation elements 21 (see FIG. 5). Since the overall rectilinear groove 12B is covered with the bottom surface of the transparent member 11, the internal space of the rectilinear groove 12B is formed as a lateral hole that extends from the center to the outside. Furthermore, a connection path 29 is defined in the tool base 13 by the through hole 12A of the transparent member 12 and the internal space of the groove 12B. That is, the connection path 29 forms the section of the chip suction path 23 in which the connection path 29 intersects the laser beams L irradiated by the respective laser oscillation elements 21.

Meanwhile, the vertical through hole 14A is formed through the center of the bonding tool 14. When the bonding tool 14 is sucked onto and held in place by the bottom surface of the tool base 13, the through hole 14A of the bonding tool 14 and the through hole 12A of the tool base 13 communicate with each other (see the state of FIG. 1).

Furthermore, one end of the conduit 31 is connected to the through hole 5B of the housing 5A, and the other end of the conduit 31 is connected to the negative pressure source 32. Since the operation of the negative pressure source 32 is controlled by the controller, the electronic part 3 is sucked onto and held on the bottom surface of the bonding tool 14 in such a way that the controller supplies a negative pressure by the negative pressure source 32 to the chip suction path 23 when required.

In the present embodiment, a suction groove 14B configured to communicate with the through hole 14A is formed on the bottom surface of the bonding tool 14, that is, a suction surface configured to suck and support the electronic part 3, as illustrated in FIG. 6, and the electronic part 3 is sucked onto and held in place by the bottom surface of the bonding tool 14 via the suction groove 14B. The overall suction groove 14B is sealed by the electronic part 3,

and accordingly a negative pressure supplied to the suction groove 14B is not released to the outside.

Accordingly, in the present embodiment, the chip suction path 23 is defined by the suction groove 14B of the bonding tool 14, the through hole 14A, the connection path 29, the
5 through hole 5B of the housing 5A, and the conduit 31.

Furthermore, an insulation groove 41 is formed on the bottom surface of the bonding tool 14 as an insulation means configured to suppress the transfer of heat between the multiple heating-target regions S1 to S3.

In the present embodiment, in order to insulate the four corner regions S1 from the
10 heating-target regions S2 and S3, a total of four parallel insulation grooves 41A, including two pairs of parallel insulation grooves 41A, are formed in the upper, lower, left and right regions of FIG. 6. The total of four insulation grooves 41A are located between the four corner regions S1 and the heating-target regions S2 and S3. In this case, the insulation grooves 41A also perform insulation between the inside regions S2 and the irradiation-free region S2' surrounded by the
15 inside regions S2.

Furthermore, a total of four insulation grooves 41B are formed between the inside regions S2 and the outside regions S3, and the transfer of heat between the inside regions S2 and the outside regions S3 can be suppressed by these four insulation grooves 41B.

The insulation grooves 41A and 41B communicate with the suction groove 14B, and a
20 negative pressure can be supplied to each of the insulation grooves 41A and 41B. As described above, the negative pressure can be supplied to the insulation grooves 41A and 41B, and thus this configuration can increase the insulation effect of the insulation grooves 41A and 41B compared to a configuration in which a negative pressure is not supplied to the insulation grooves 41A and 41B. However, the overall insulation grooves 41A and 41B are sealed by the
25 electronic part 3 in order to prevent the negative pressure from being released from the insulation

grooves 41A and 41B to the outside.

Furthermore, the depth of the insulation groove 41 is large in order to efficiently suppress the transfer of heat between both sides of the insulation groove 41, whereas the depth of the suction groove 14B is small because it is sufficient if a negative pressure can be supplied to
5 the suction groove 14B.

In the above-described configuration, at the beginning of bonding, the controller supplies a negative pressure from the negative pressure source 27 to the tool suction path 26, and thus the bonding tool 14 is sucked onto and held in place by the bottom surface of the tool base 13. Furthermore, a negative pressure is supplied by the negative pressure source 32 to the chip
10 suction path 23 by the controller, and thus the electronic part 3 is sucked onto and held in place by the bottom surface of the bonding tool 14. In this case, since the suction groove 14B and the insulation groove 41 are sealed by the electronic part 3 as described above, the negative pressure supplied to the chip suction path 23 does not leak to the outside.

Thereafter, the controller lowers the bonding head 5 using the lifting/lowering loading
15 mechanism 6 after aligning the electronic part 3 held in place by the bonding tool 14 with the substrate 2 by operating the substrate stage 4. Accordingly, the electronic part 3 sucked onto and held in place by the bonding tool 14 is brought into contact with and pressed by the substrate 2. From this point in time, the controller operates the laser oscillator 7, and thus a plurality of laser beams L is generated by the respective laser oscillation elements 21. Then, the plurality of laser
20 beams L is guided into the housing 5A via the beam guide means 8 including a plurality of optical fibers f1 to f36 (excluding f15, f16, f21, and f22), is condensed by the condensing lens 15, is vertically downwardly reflected by the reflecting mirror 16, and is then irradiated onto the tool base 13.

Since the plurality of optical fibers f1 to f36 forms a bundle in the form of a matrix as
25 described above, the irradiation spots of the laser beams L are arranged in the form of a matrix

when the laser beams L are irradiated from the optical fibers f1 to f36 to the tool base 13 (see FIGS. 3 and 5).

In this case, as illustrated in FIG. 5, in order to prevent a laser beam L from being scattered by the through hole 12A of the tool base 13, the irradiation-free region S2' onto which an laser beam L is not irradiated is formed around the through hole 12A.

Furthermore, the rectilinear groove 12B of the chip connection path 29 to which the negative pressure is supplied is formed between two neighboring rows of laser beams L, and the intensity profile of the laser beams L is in Gaussian mode, as illustrated in FIG. 4. Accordingly, although the groove 12B is formed in the tool base 13, a loss of heat of the laser beams L attributable to the groove 12B can be suppressed to a minimum level.

Furthermore, when the laser beams L are transmitted through the tool base 13 including the two transparent members 11 and 12 and are irradiated onto the bonding tool 14, the bonding tool 14 is heated by the laser beams L, and the electronic part 3 and bumps 35 (see FIG. 1) disposed at a plurality of portions of the bottom surface of the electronic part 3 are also heated.

In this case, maximum-output level laser beams are guided from the first laser oscillator 7A and 7B to the four corner regions S1 prone to the lowest temperature, minimum-output level laser beams are guided from the second laser oscillator 7C to the inside regions S2 prone to the highest temperature, and intermediate-output level laser beams are guided from the third laser oscillator 7D to the outside regions S3 prone to an intermediate temperature, thereby enabling the overall area of the electronic part 3 to be uniformly heated as much as possible.

In this case, the insulation grooves 41 configured to suppress the transfer of heat are formed between the corner regions S1, the inside regions S2, the outside regions S3 and the irradiation-free region S2' in the bonding tool 14, and thus this configuration can efficiently heat the overall area of the electronic part to preferred temperatures compared to a configuration in which no insulation grooves 41 are provided.

When the above bonding is terminated, the supply of the negative pressure by the negative pressure source 32 to the chip suction path 23 is shut off in response to a command from the controller, the support of the electronic part 3 by the bonding tool 14 is released. Thereafter, the bonding head 5 is lifted by the lifting/lowering loading mechanism 6, and then
5 subsequent bonding may be initiated.

FIG. 7 illustrates a second embodiment of the present invention. In the present embodiment, a heating-target area S is divided into four types of regions.

That is, in the present embodiment, the heating-target area S is divided into four corner regions S1, corner-adjacent regions S4 surrounding the corner regions S1, respectively, outside
10 regions S3 corresponding to the outside circumferential region of the electronic part 3 excluding the corner regions S1 and the corner-adjacent regions S4, and inside regions S2.

Furthermore, in the present embodiment, the 36 optical fibers f1 to f36 are arranged parallel to each other in a bundle, and the laser beam entrances of the optical fibers f1 to f36 are connected to the laser oscillators 7-1 to 7-36, respectively, as illustrated in FIG. 8. That is, the
15 laser oscillators are connected to the respective optical fibers, and thus the laser output of each of the laser oscillators can be controlled.

As illustrated in FIG. 7, of the four corner regions S1, the optical fiber f1 optically faces the upper left corner region S1, the optical fiber f6 optically faces the upper right corner region S1, the optical fiber f31 optically faces the lower left corner region S1, and the optical fiber f36
20 optically faces the lower right corner region S1.

Furthermore, the four laser oscillators 7-1, 7-6, 7-31 and 7-36 connected to these four optical fibers f1, f6, f31 and f36 are set to a high output level.

Furthermore, of the four corner-adjacent regions S4 surrounding the corner regions S1, respectively, the three optical fibers f2, f7 and f8 optically face the upper left corner-adjacent
25 region S4, the three optical fibers f5, f11 and f12 optically face the upper right corner-adjacent

region S4, the three optical fibers f25, f26 and f32 optically face the lower left corner-adjacent region S4, and the three optical fibers f29, f30 and f35 optically face the lower right corner-adjacent region S4.

Furthermore, the 12 laser oscillators 7-2, 7-7, 7-8, 7-5, 7-11, 7-12, 7-25, 7-26, 7-32, 7-29,
5 7-30 and 7-35 connected to a total of these 12 optical fibers are set to a second high output level.

Furthermore, in the present embodiment, a total of eight optical fibers f3, f4, f13, f18, f19, f24, f33 and f34 optically face the outside regions S3. The eight laser oscillators 7-3, 7-4, 7-13, 7-18, 7-19, 7-24, 7-33 and 7-34 connected to the total of eight optical fibers are set to a third high output level.

10 Finally, in the present embodiment, a total of 12 optical fibers f9, f10, f14, f15, f16, f17, f20, f21, f22, f23, f27 and f28 optically face the inside regions S2. In the present embodiment, an irradiation-free region S2' is formed in a center region surrounded by the inside regions S2 in the same manner as in the first embodiment. The four optical fibers f15, f16, f21 and f22 optically face the irradiation-free region S2'.

15 Accordingly, the four laser oscillators 7-15, 7-16, 7-21 and 7-22 connected to the four optical fibers f15, f16, f21 and f22 optically facing the irradiation-free region S2' are neither activated nor generate laser beams. It will be apparent that if the bonding device 1 is implemented as a device dedicated to the electronic part 3, these four laser oscillators 7-15, 7-16, 7-21 and 7-22 may be omitted.

20 Meanwhile, the 12 laser oscillators 7-9, 7-10, 7-14, 7-17, 7-20, 7-23, 7-27 and 7-28 connected to a total of eight optical fibers f9, f10, f14, f17, f20, f23, f27 and f28 optically facing the inside regions S2, other than the irradiation-free region S2', are set to a fourth high output level, that is, the lowest output level.

Furthermore, as illustrated in FIG. 9, in the present embodiment, in order to suppress the
25 transfer of heat between all the five types of heating-target regions S1 to S4, S2', a total of eight

insulation grooves 41 are formed on the bottom surface of the bonding tool 14.

As can be seen from FIG. 9, for example, although the upper left corner-adjacent region S4 is heated to the same temperature by three optical fibers f2, f7 and f8, regions heated by the optical fibers f2, f7 and f8, respectively, are insulated from each other by the insulation grooves 41. As described above, even regions heated to the same temperature may be insulated from each other. Accordingly, as indicated by the imaginary lines of FIG. 9, insulation grooves 41 may be formed between all the 36 regions that are heated by the 36 optical fibers f1 to f36.

It will be apparent that the bonding tool 14 in which the insulation grooves 41 are formed between all the 36 regions may be also used as the bonding tool 14 of the first embodiment, in which case the compatibility of the bonding tool 14 can be improved.

The other configurations of the present embodiment are the same as those of the first embodiment.

In the second embodiment, the laser output levels of the laser oscillators are set such that assigned output levels increase in order of the laser oscillators connected to the optical fibers whose laser beam exits optically face the inside regions S2, other than the irradiation-free region S2', the laser oscillators connected to the optical fibers whose laser beam exits optically face the outside regions S3, the laser oscillators connected to the optical fibers whose laser beam exits optically face the corner-adjacent regions S4, and the laser oscillators connected to the optical fibers whose laser beam exits optically face the corner regions S1. Accordingly, also in the present embodiment, the overall area of the electronic part 3 can be uniformly heated as much as possible.

In this case, the insulation grooves 41 configured to suppress the transfer of heat are formed between the corner regions S1, the inside regions S2, the outside regions S3, the corner-adjacent regions S4 and the irradiation-free region S2' in the bonding tool 14 in the same manner as in the first embodiment. Accordingly, this configuration can efficiently heat the overall area

of an electronic part to preferred temperatures compared to a configuration in which no insulation grooves 41 are provided.

In particular, in the present embodiment, the laser oscillators 7-1 to 7-36 are provided for the respective optical fibers f1 to f36, and the insulation grooves 41 are formed between all the regions that are heated by the respective optical fibers. Accordingly, the present embodiment is useful to deal with micro-bumps whose molten state is difficult to control because it is possible to precisely control a heating temperature for each of the regions.

Furthermore, in the second embodiment, it may be possible to group laser oscillators configured to generate laser beams at the same output level by connecting these laser oscillators in series to the same power source in the same manner as in the first embodiment.

FIG. 10 illustrates a third embodiment of the present invention. In the present embodiment, a heating-target area S is divided into three types of regions.

That is, in the present embodiment, the heating-target area S is divided into four corner regions S1, four outside regions S3 corresponding to the outside circumferential region of the electronic part 3 excluding the corner regions S1, and a single center inside region S2. These nine regions are formed to have the same area. That is, the heating-target area S of the electronic part 3 is divided into a total of nine regions by dividing the heating-target area S of the electronic part 3 into three equal parts in a vertical direction and also three equal parts in a lateral direction. Furthermore, in the present embodiment, an irradiation-free region is not formed, and thus laser beams are irradiated onto the overall heating-target region S.

More specifically, in the four corner regions S1, the laser beam exits of four optical fibers are arranged to optically face each of the four respective corner regions S1. In greater detail, the laser beam exits of four optical fiber f1, f2, f7 and f8 optically face the upper left corner region S1, the laser beam exits of four optical fiber f5, f6, f11 and f12 optically face the upper right corner region S1, the laser beam exits of four optical fiber f25, f26, f31 and f32

optically face the lower left corner region S1, and the laser beam exits of four optical fiber f29, f30, f35 and f36 optically face the lower right corner region S1.

A laser oscillator connected to these 16 optical fibers is set to the highest output level.

Of the remaining 20 optical fibers, four optical fibers f15, f16, f21 and f22 have their
5 laser beam exits that optically face the single inside region S2. A laser oscillator connected to these four optical fibers is set to the lowest output level.

The last 16 optical fibers optically face the four outside regions S3. In greater detail, the laser beam exits of four optical fibers f3, f4, f9 and f10 optically face the upper center outside region S3, the laser beam exits of four optical fibers f13, f14, f19 and f20 optically face the left
10 center outside region S3, the laser beam exits of four optical fibers f17, f18, f23 and f24 optically face the right center outside region S3, and the laser beam exits of four optical fibers f27, f28, f33 and f34 optically face the lower center outside region S3. A laser oscillator connected to these 16 optical fibers is set to an intermediate output level.

As described above, in the present embodiment, the heating-target area S is divided into
15 nine regions having the same area, and a total of four insulation grooves 41 are formed between the regions S1 to S3 on the bottom surface of the bonding tool 14, thereby suppressing the transfer of heat between the regions.

Since the other configurations of the present embodiment are the same as those of the first embodiment, the present embodiment can achieve operations and effects equivalent to those
20 of the preceding embodiment.

Referring to FIG. 10, in another embodiment, the laser output level of a laser oscillator connected to optical fibers whose laser beam exits optically face outside regions S3 and the laser output level of a laser oscillator connected to optical fibers whose laser beam exits optically face corner regions S1 may be set to the same value, and, furthermore, this value may be higher than
25 that of the laser output level of a laser oscillator connected to optical fibers whose laser beam

exits optically face an inside region S2.

In this embodiment, an overall outside circumferential region, including the corner regions and corresponding to the outside circumferential portion of an electronic part, is heated by laser beams at a higher laser output level than the inside region, and, furthermore, insulation
5 grooves 41 are formed between the overall outside circumferential region and the inside region, thereby further uniformly heating the overall area of the electronic part.

Furthermore, although the insulation grooves 41 have been used as the insulation means in the above embodiments, the insulation means is not limited thereto. By way of example, the insulation means may be implemented as a configuration that is formed by dividing the bonding
10 tool 14 into a plurality of parts, filling an insulation material between the plurality of parts and then combining the plurality of parts with each other.

For example, heat is more easily dissipated from the four corner portions of a square electronic part than from the inside portion thereof. In accordance with at least one embodiment of the present invention, laser beams generated by a first one of a plurality of laser oscillators are
15 irradiated onto heating-target regions corresponding to the four corners of a bonding tool via a first beam guide means, and thus heat the heating-target regions corresponding to the four corners to a higher temperature. In contrast, laser beams generated by a second one of the plurality of laser oscillators are irradiated onto a heating-target region corresponding to the inside portion of the bonding tool via a second beam guide means, and thus heat the heating-target
20 region corresponding to the inside portion to a lower temperature. As a result, the heating-target region corresponding to the inside portion can be heated to a lower temperature than the heating-target regions corresponding to the four corners. In accordance with at least one embodiment of the present invention, the plurality of heating-target regions of an electronic part is independently heated, and thus the overall area of the electronic part can be heated to preferred temperatures.

25 Furthermore, in accordance with at least one embodiment of the present invention, an

insulation means configured to suppress the transfer of heat is formed between heating-target regions corresponding to the four corners of a bonding tool and a heating-target region corresponding to the inside portion of the bonding tool in the bonding tool, and thus the bonding tool can efficiently heat the overall area of an electronic part to preferred temperatures compared to a bonding tool for which an insulation means is not provided.

Although the specific embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

WHAT IS CLAIMED IS:

1. A bonding device for bonding an electronic part, held in place by a bonding tool, onto a substrate by heating the bonding tool, the bonding device comprising:

5 a laser oscillator configured to generate laser beams;
beam guide means configured to guide the laser beams generated by the laser oscillator; and
a bonding tool configured to be heated by the laser beams guided by the beam guide means;

10 wherein the laser oscillator comprises a plurality of laser oscillators and the beam guide means comprises a plurality of beam guide elements, laser beams generated by the respective laser oscillators are radiated onto a plurality of heating-target regions of the bonding tool via the respective beam guide elements so that the plurality of heating-target regions can be heated to different temperatures, and insulation means configured
15 to suppress transfer of heat between the plurality of heating-target regions is formed in the bonding tool.

2. The bonding tool of claim 1, wherein the insulation means comprises one or more grooves formed in the bonding tool.

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3. The bonding tool of claim 2, wherein:

a chip suction path configured to suck and support the electronic part using a negative pressure is formed in the bonding tool;

the electronic part is sucked onto and held in place by the bonding tool via the
25 negative pressure supplied to the chip suction path; and

the grooves are sealed by the electronic part when the electronic part is sucked onto and held in place by the bonding tool, and the grooves are configured to communicate with the chip suction path.

- 5 4. The bonding tool of any one of claims 1 to 3, wherein:

the heating-target area is divided into at least corner regions corresponding to corners of the electronic part having a polygonal shape, and an inside region corresponding to an inside of the electronic part; and

10 the laser oscillator corresponding to the corner regions is set to a higher laser output level than the laser oscillator corresponding to the inside region.

5. The bonding tool of any one of claims 1 to 3, wherein:

15 the heating-target area is divided into at least corner regions corresponding to corners of the electronic part having a polygonal shape, outside regions corresponding to an outside circumferential region of the electronic part, exclusive of the corner regions, and an inside region corresponding to an inside of the electronic part; and

20 laser output levels of the laser oscillators are set such that assigned laser output levels increase in order of the laser oscillator corresponding to the inside region, the laser oscillator corresponding to the outside regions, and the laser oscillator corresponding to the corner regions.

6. The bonding tool of any one of claims 1 to 3, wherein:

25 the heating-target area is divided into at least corner regions corresponding to corners of the electronic part having a polygonal shape, corner-adjacent regions surrounding the corner regions, outside regions corresponding to an outside

circumferential region of the electronic part, exclusive of the corner regions and the corner-adjacent regions, and an inside region corresponding to an inside of the electronic part; and

5 laser output levels of the laser oscillators are set such that assigned laser output levels increase in order of the laser oscillator corresponding to the inside region, the laser oscillator corresponding to the outside regions, the laser oscillator corresponding to the corner-adjacent regions, and the laser oscillator corresponding to the corner regions.