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(54) **APPARATUS AND METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE**

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G11C 11/24 (2006.01)

(52) **U.S. Cl.** **365/149**

(57) **ABSTRACT**

The manufacturing apparatus of a semiconductor device includes a jig having a plurality of holders arranged in a row, a controller for controlling the pitch of the plurality of holders arranged in a row, a support means provided with a plurality of semiconductor integrated circuits, and a support means provided with a substrate having a plurality of elements. By mounting the semiconductor integrated circuits on the respective elements by using the jig having the plurality of holders arranged in a row, semiconductor devices are manufactured.

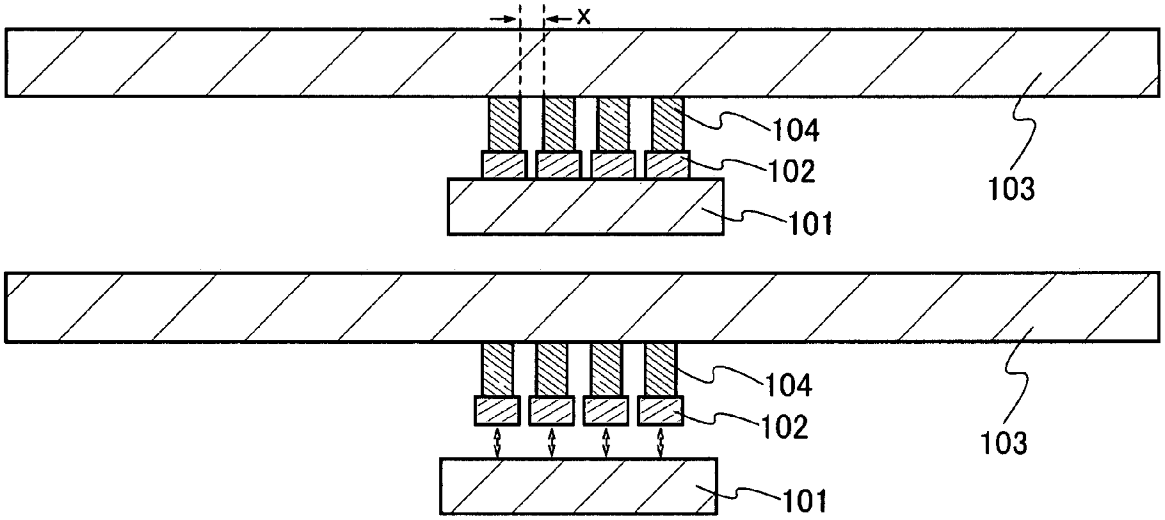

FIG. 1A

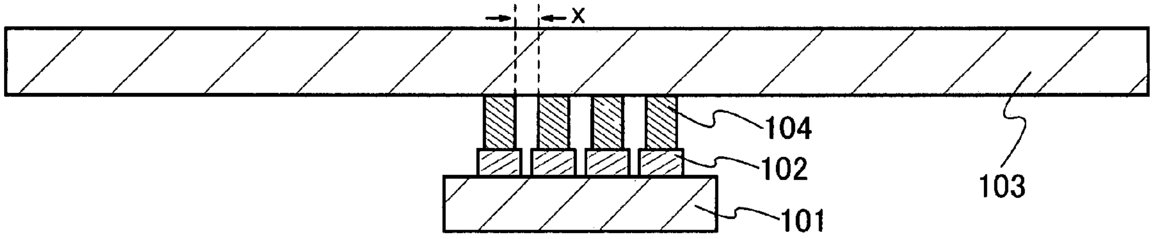

FIG. 1B

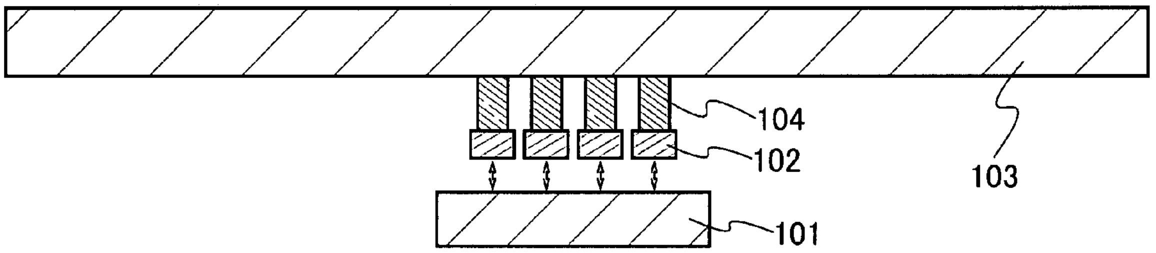

FIG. 1C

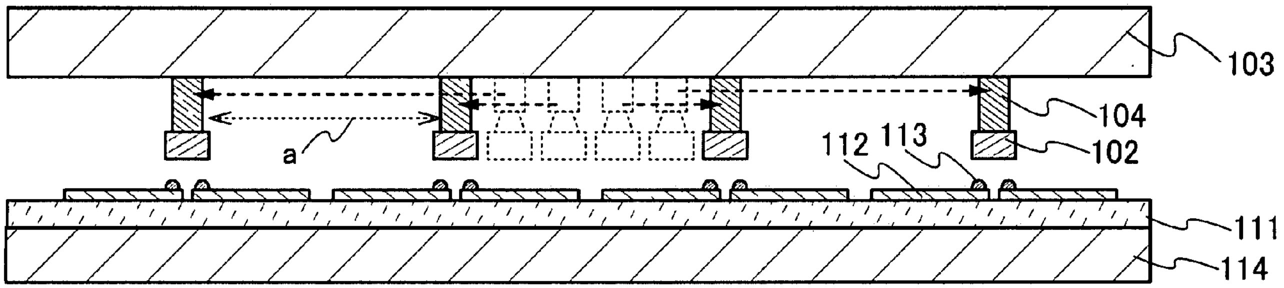

FIG. 1D

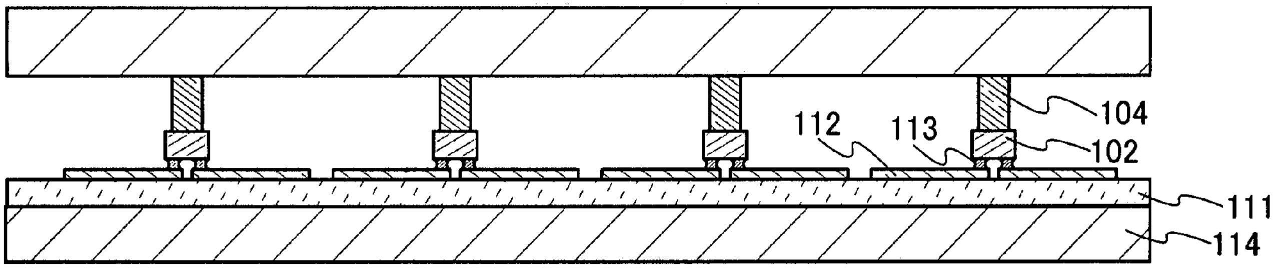

FIG. 2A

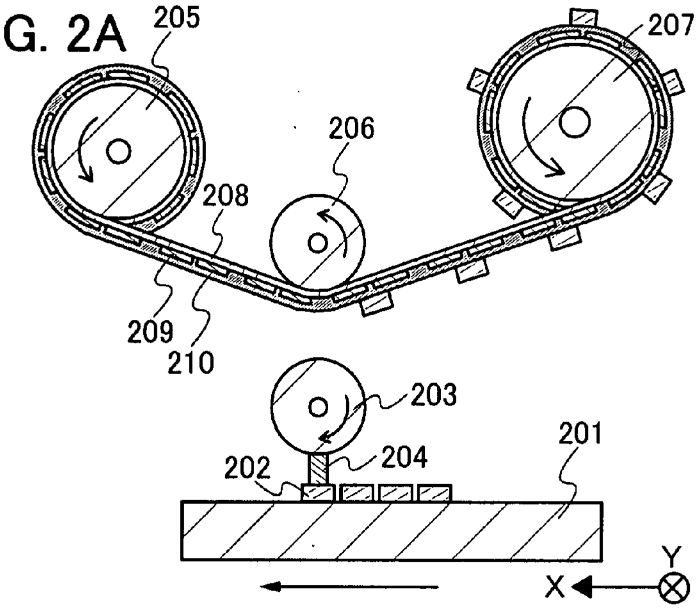

FIG. 2B

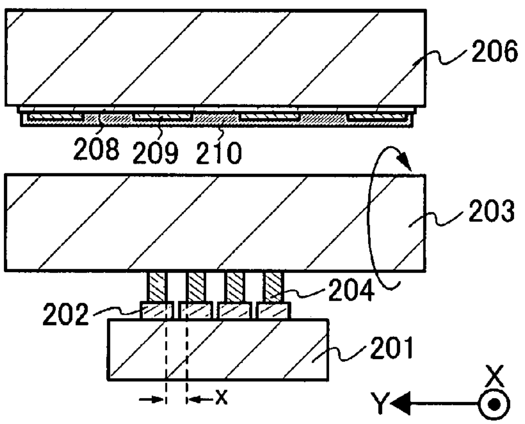

FIG. 2C

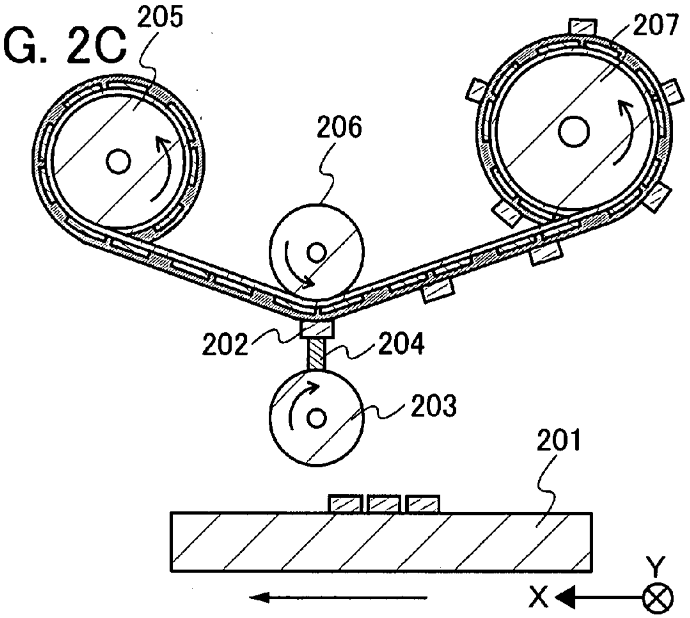

FIG. 2D

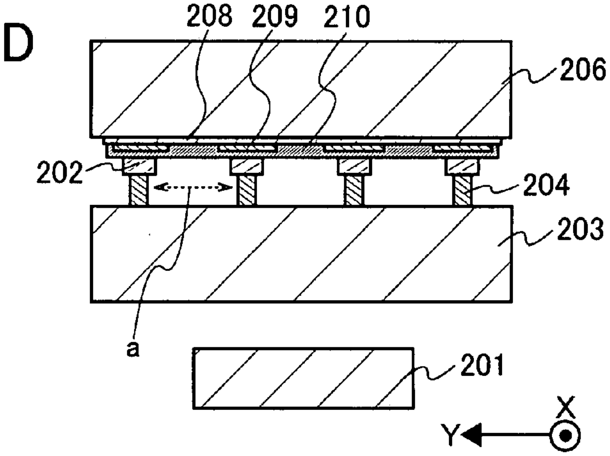

FIG. 3A

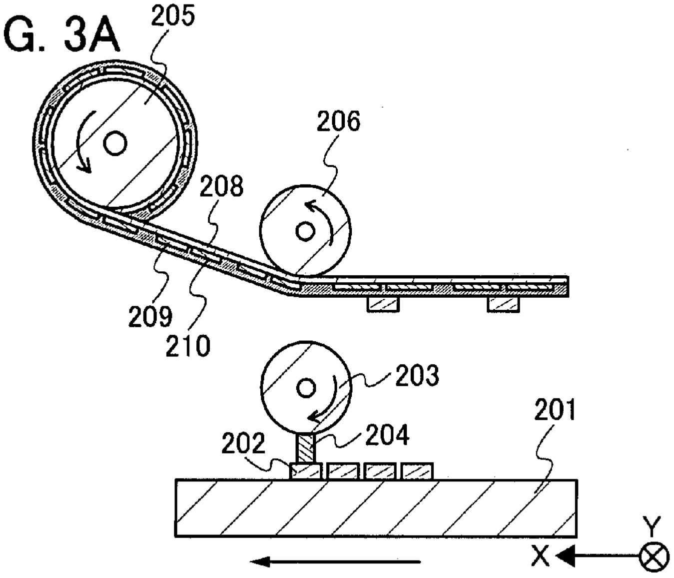

FIG. 3B

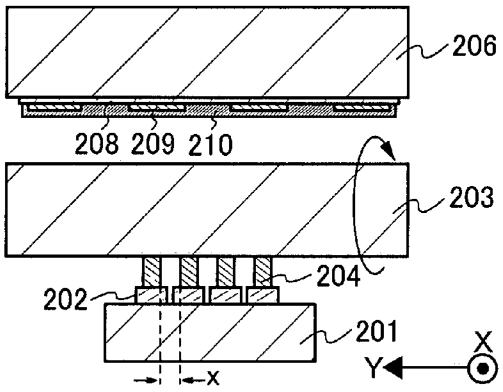

FIG. 3C

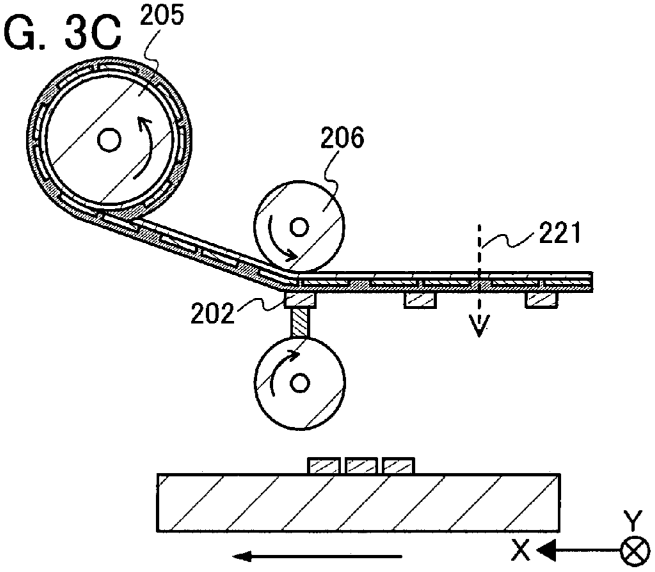

FIG. 3D

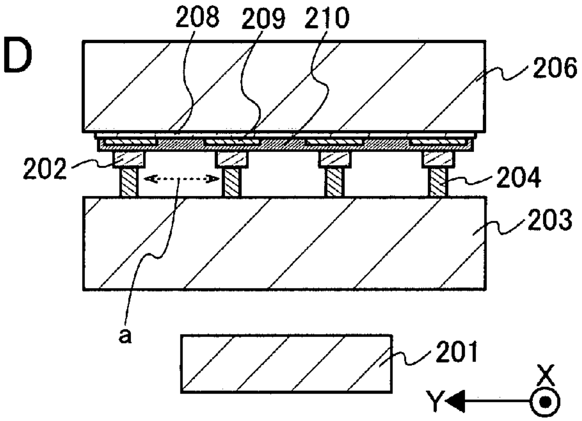

FIG. 4A

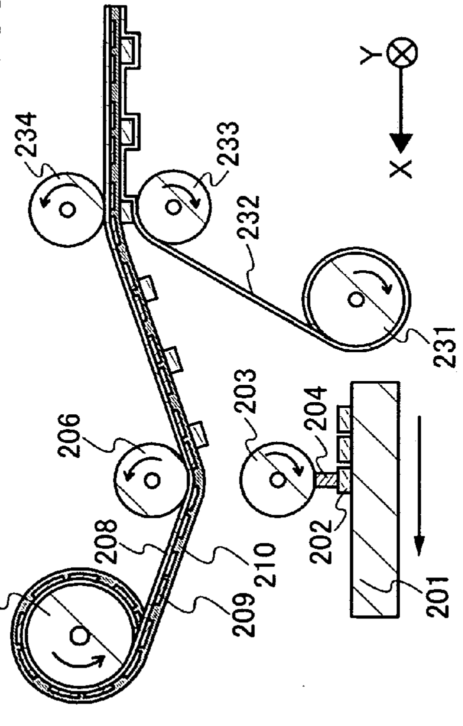

FIG. 4C

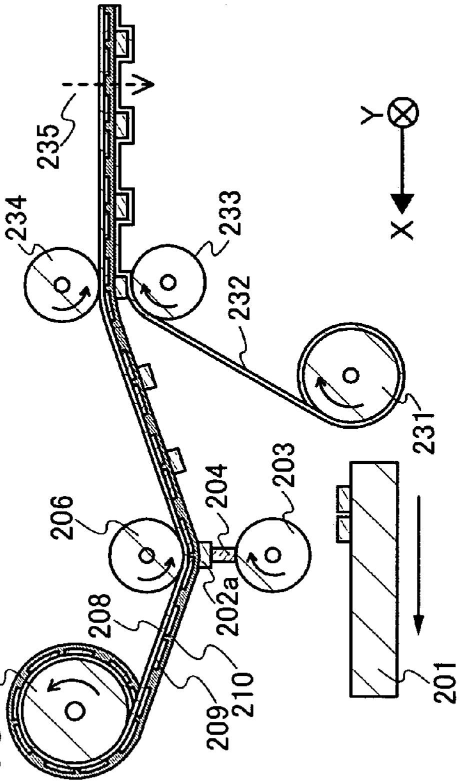

FIG. 4B

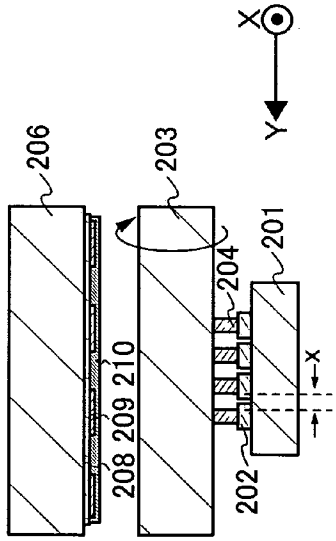

FIG. 4D

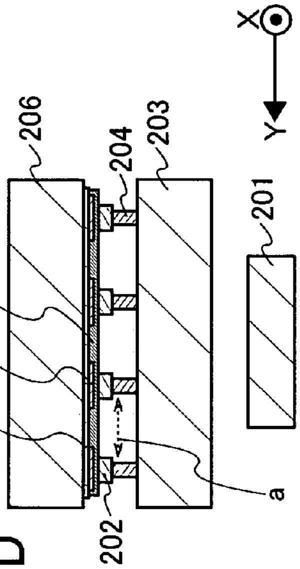

FIG. 5A

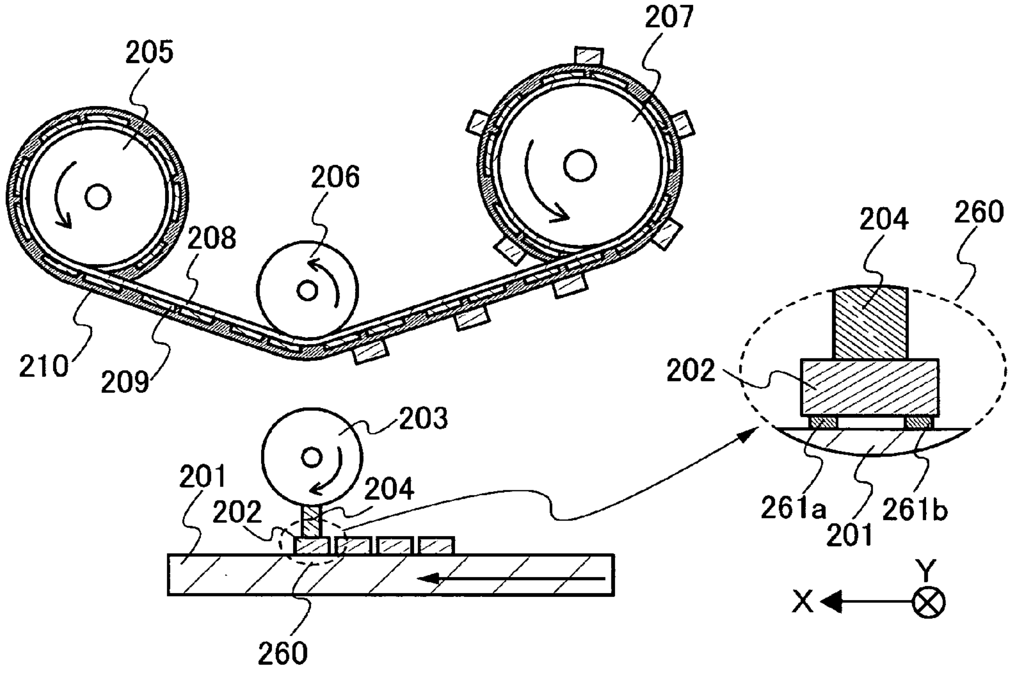
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FIG. 5B

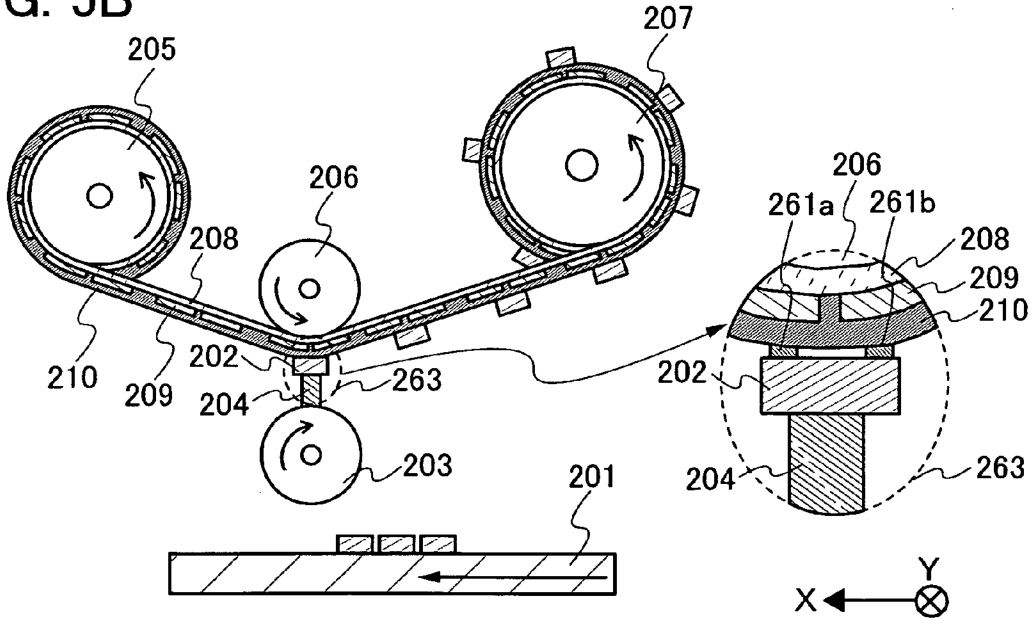
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FIG. 6A

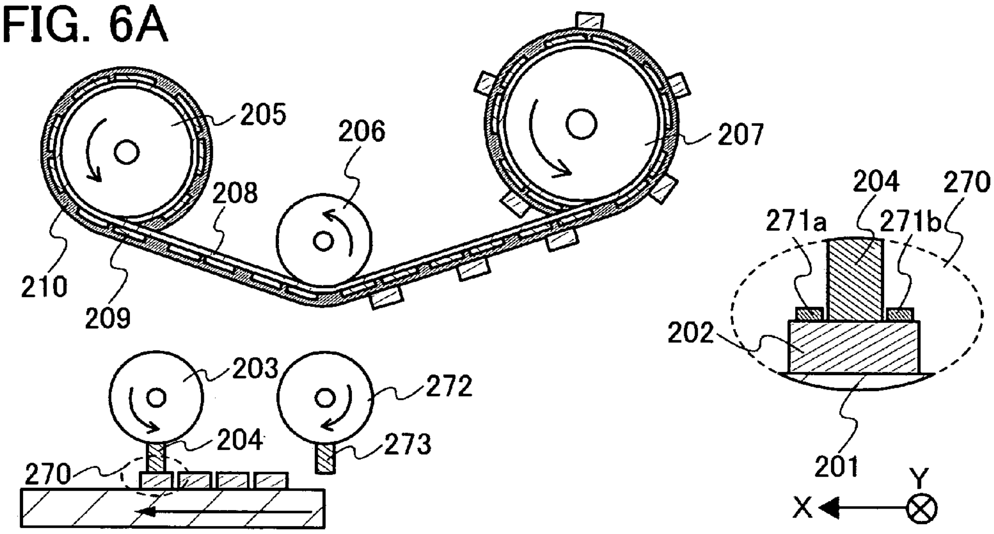

FIG. 6B

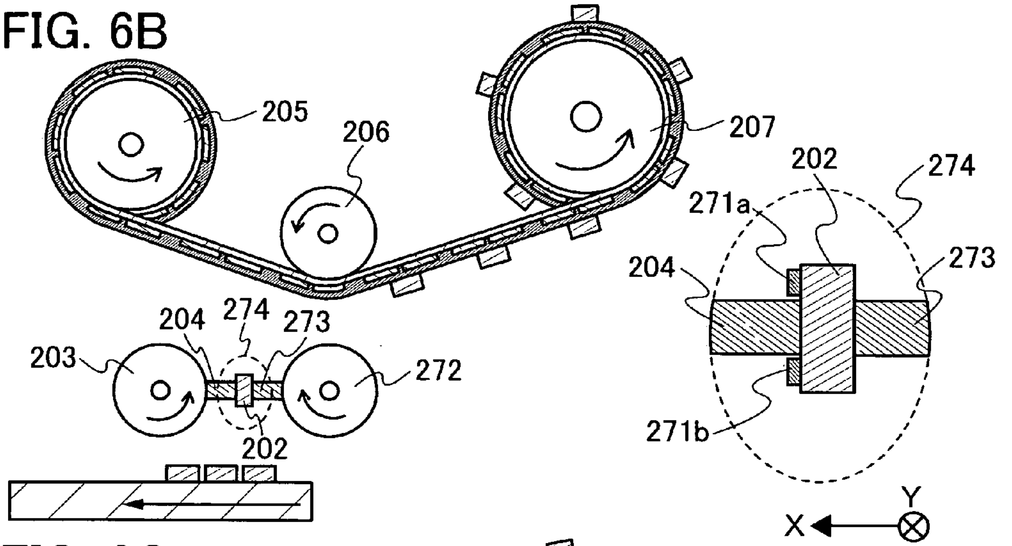

FIG. 6C

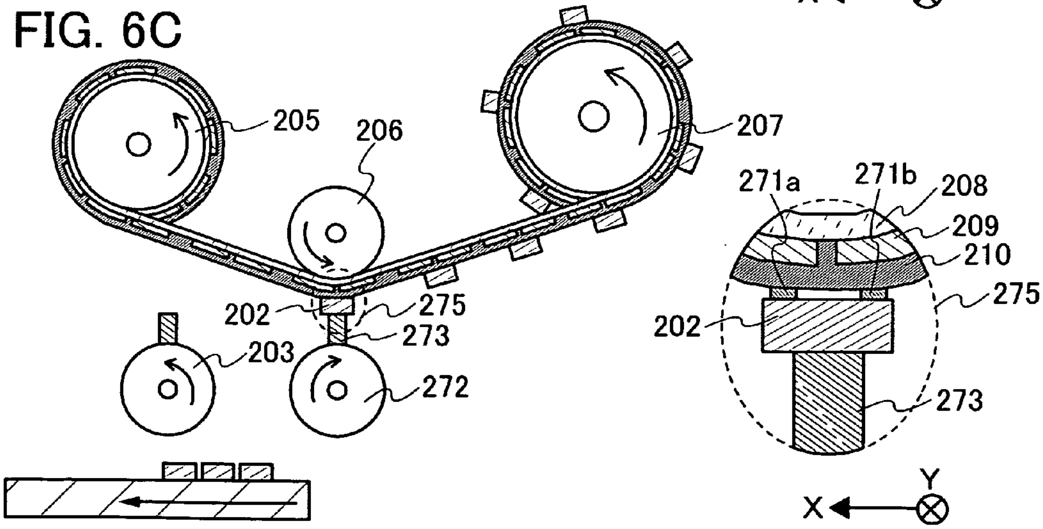

FIG. 7A

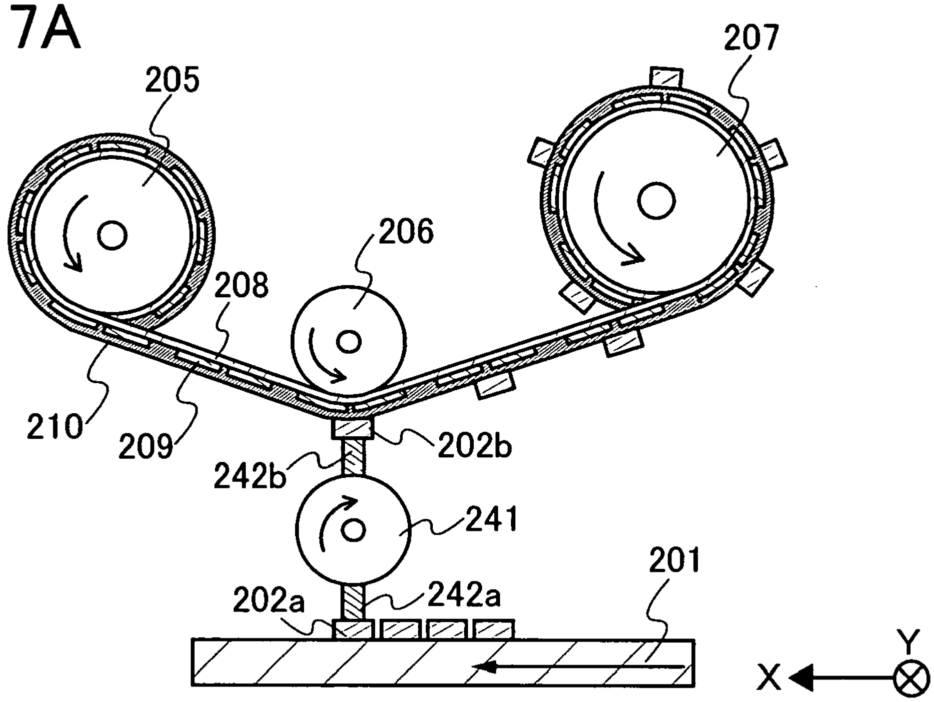
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FIG. 7B

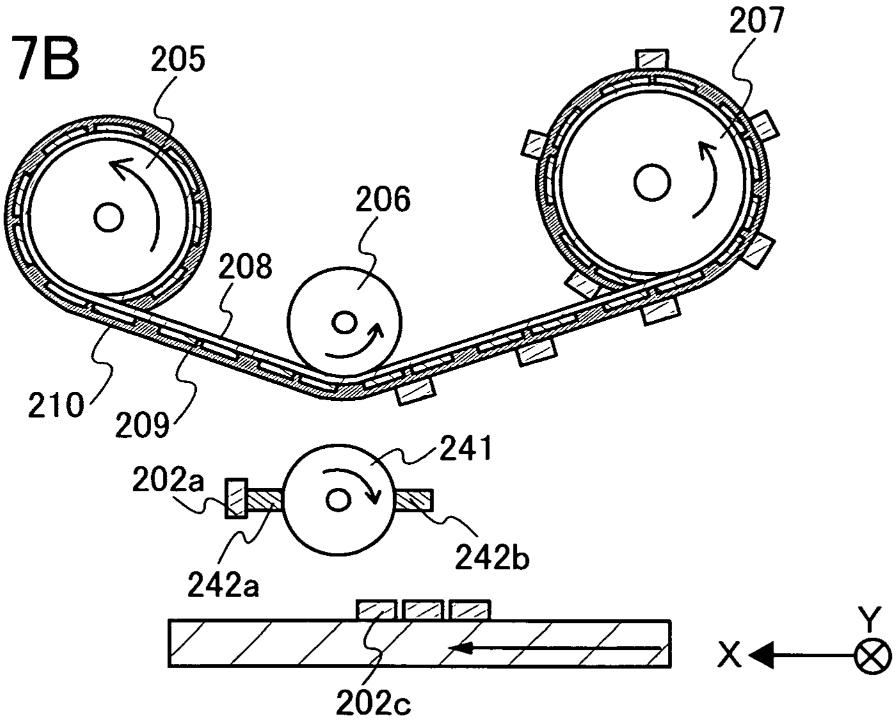
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FIG. 8A

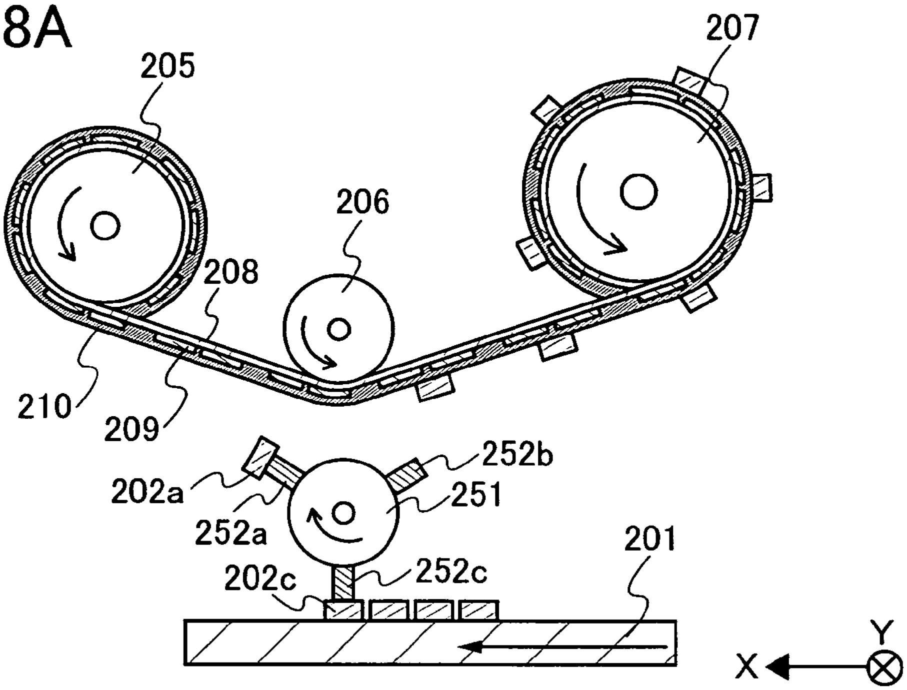
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FIG. 8B

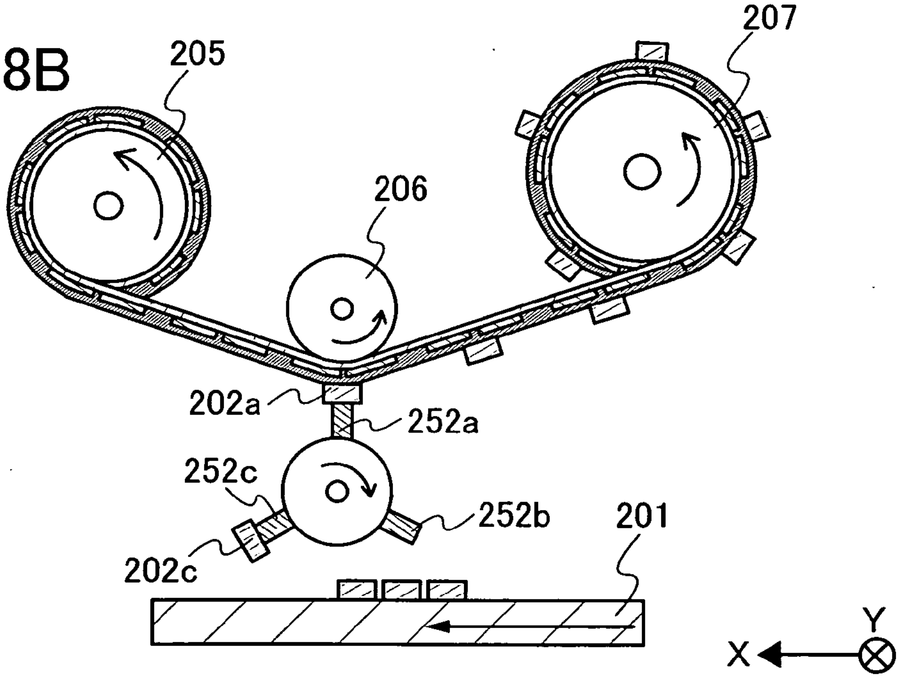
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FIG. 9A

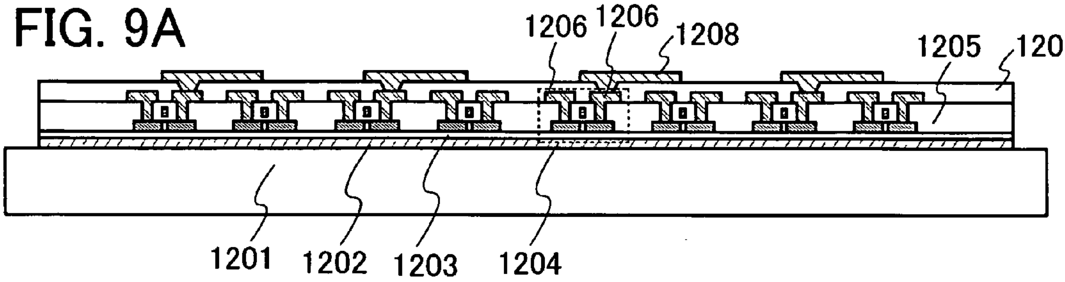


FIG. 9B

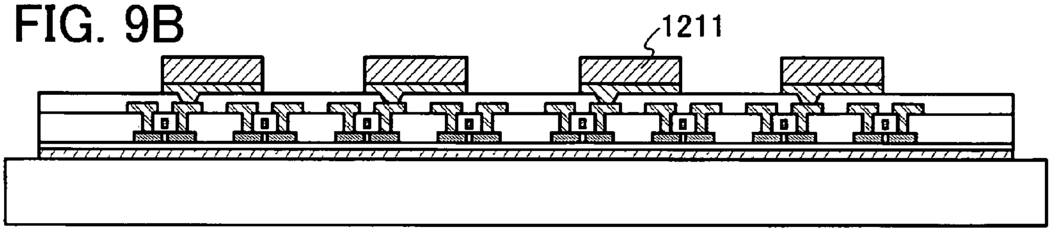


FIG. 9C

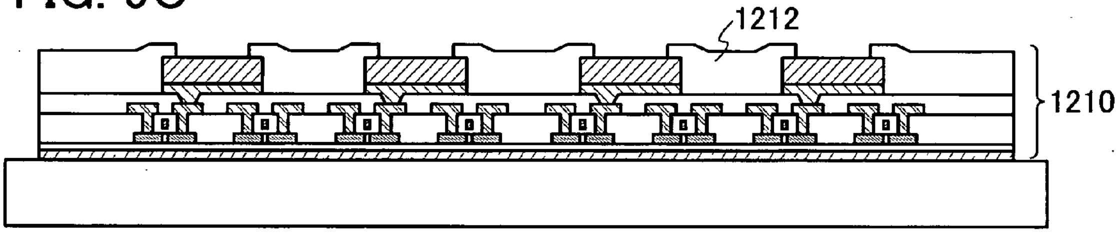


FIG. 9D

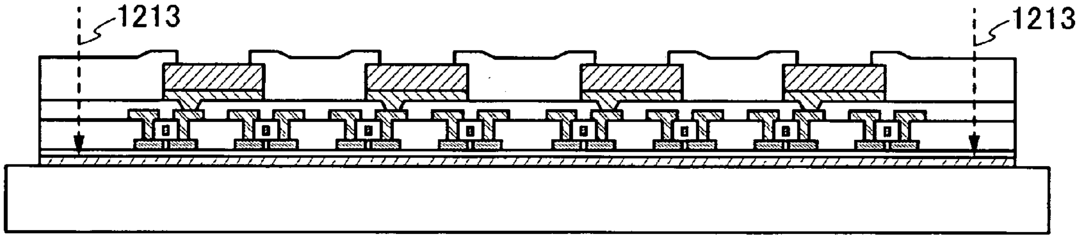


FIG. 9E

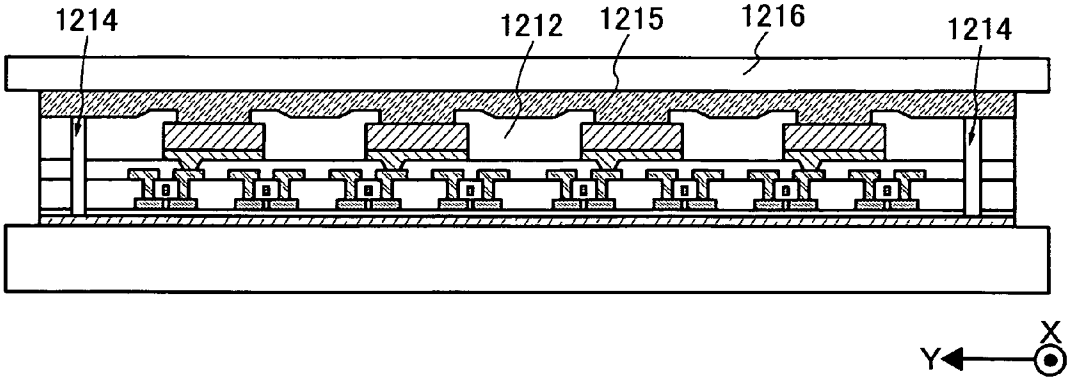


FIG. 10A

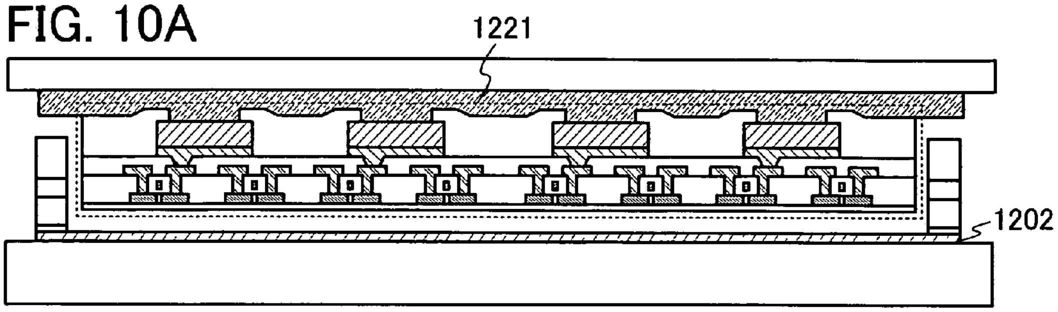


FIG. 10B

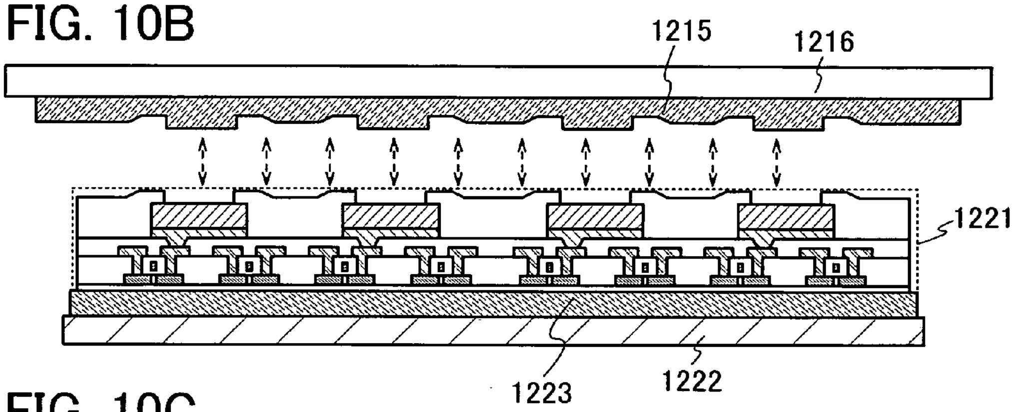


FIG. 10C

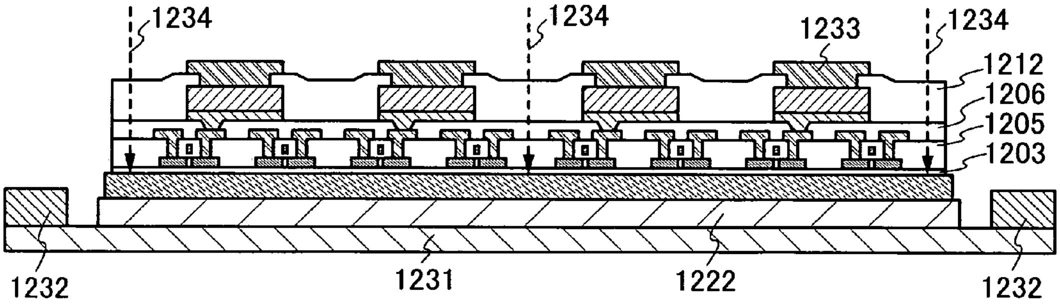


FIG. 10D

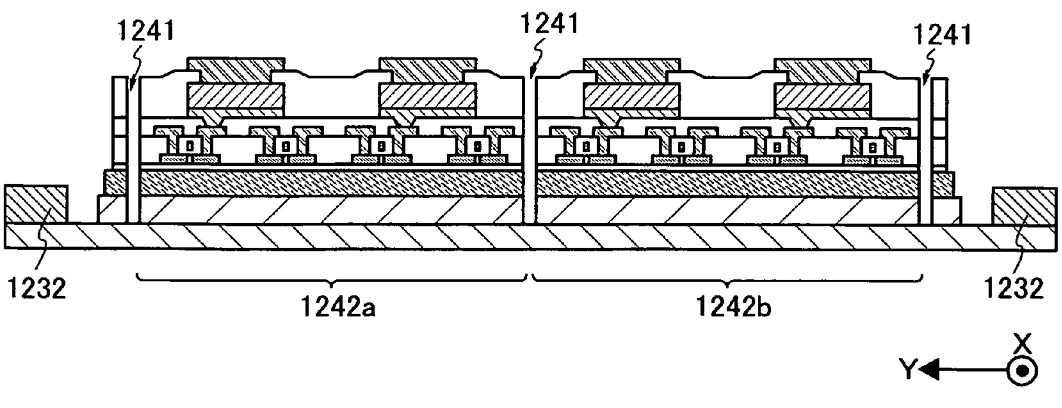


FIG. 11A

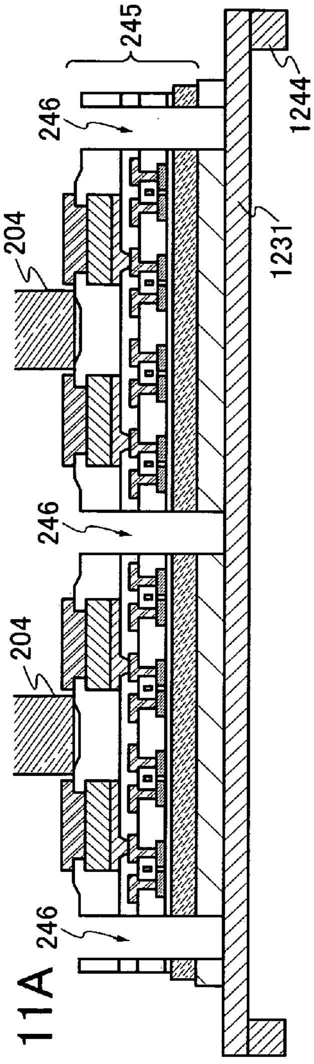


FIG. 11B

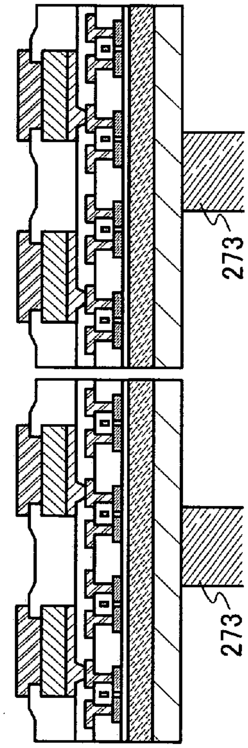


FIG. 11C

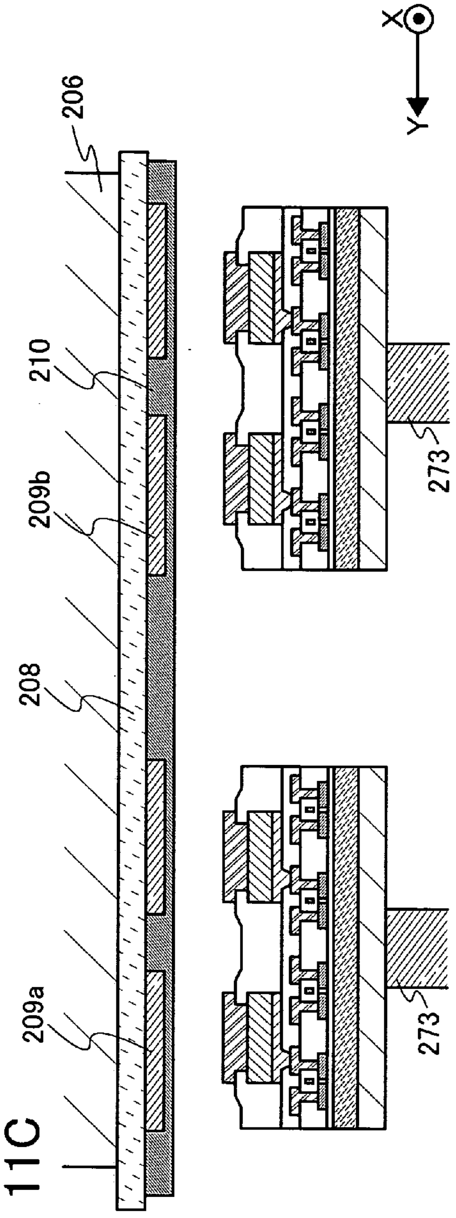


FIG. 12A

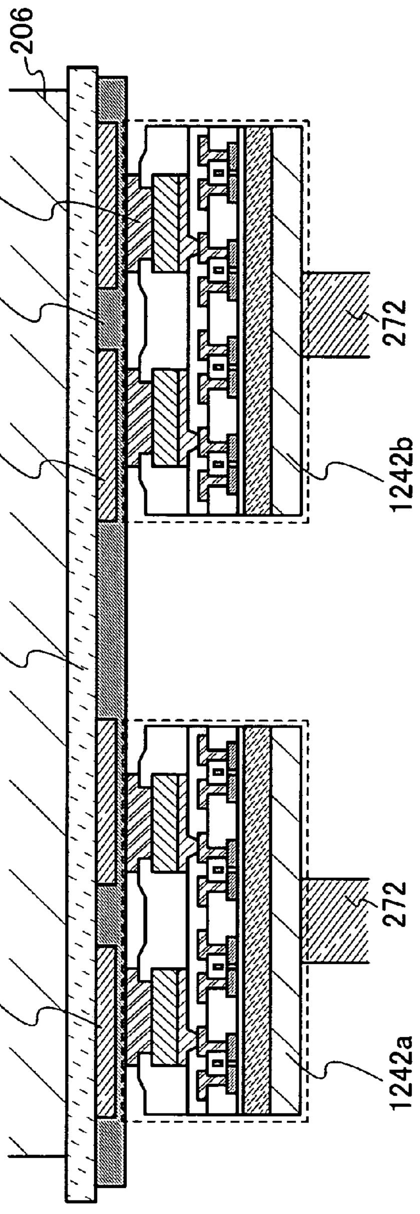


FIG. 12B

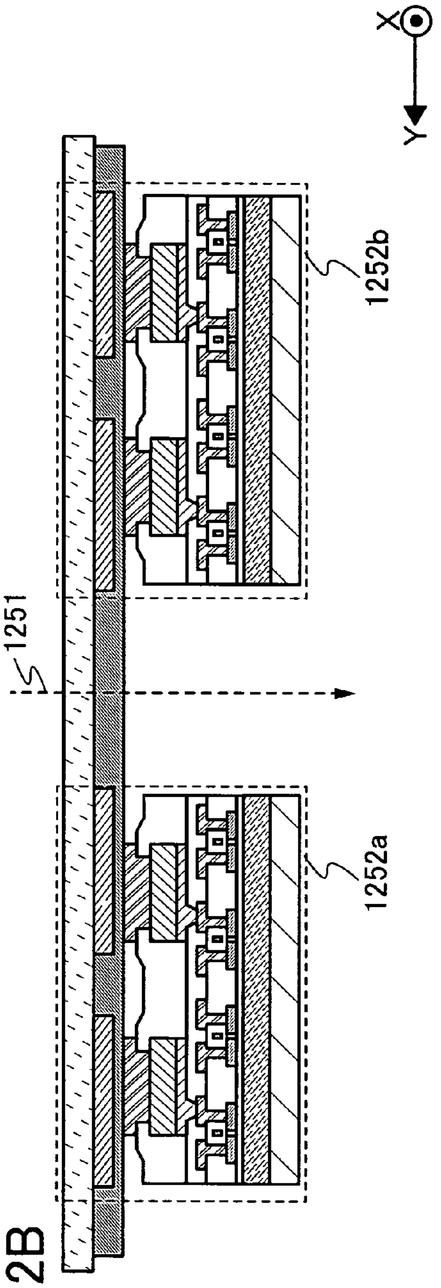


FIG. 13A

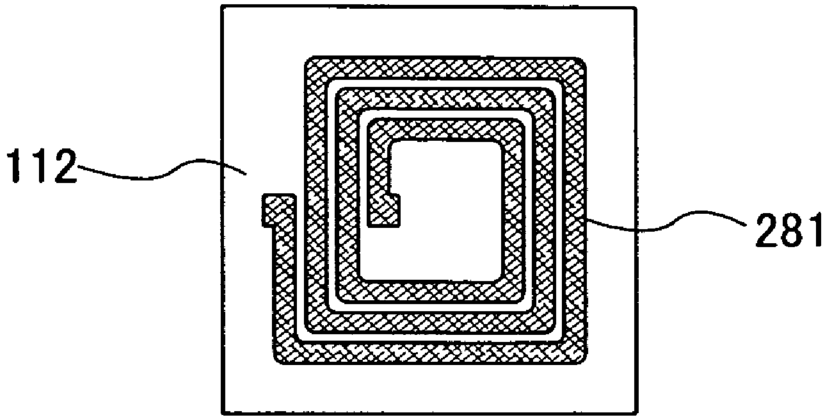


FIG. 13B

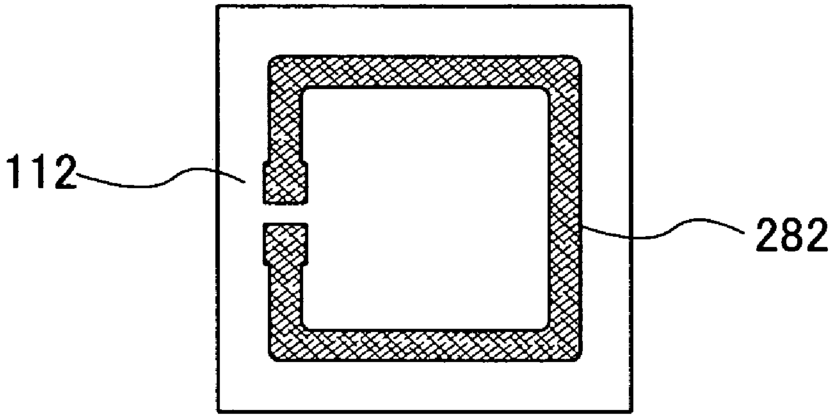


FIG. 13C

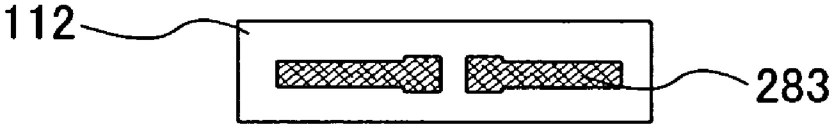


FIG. 14

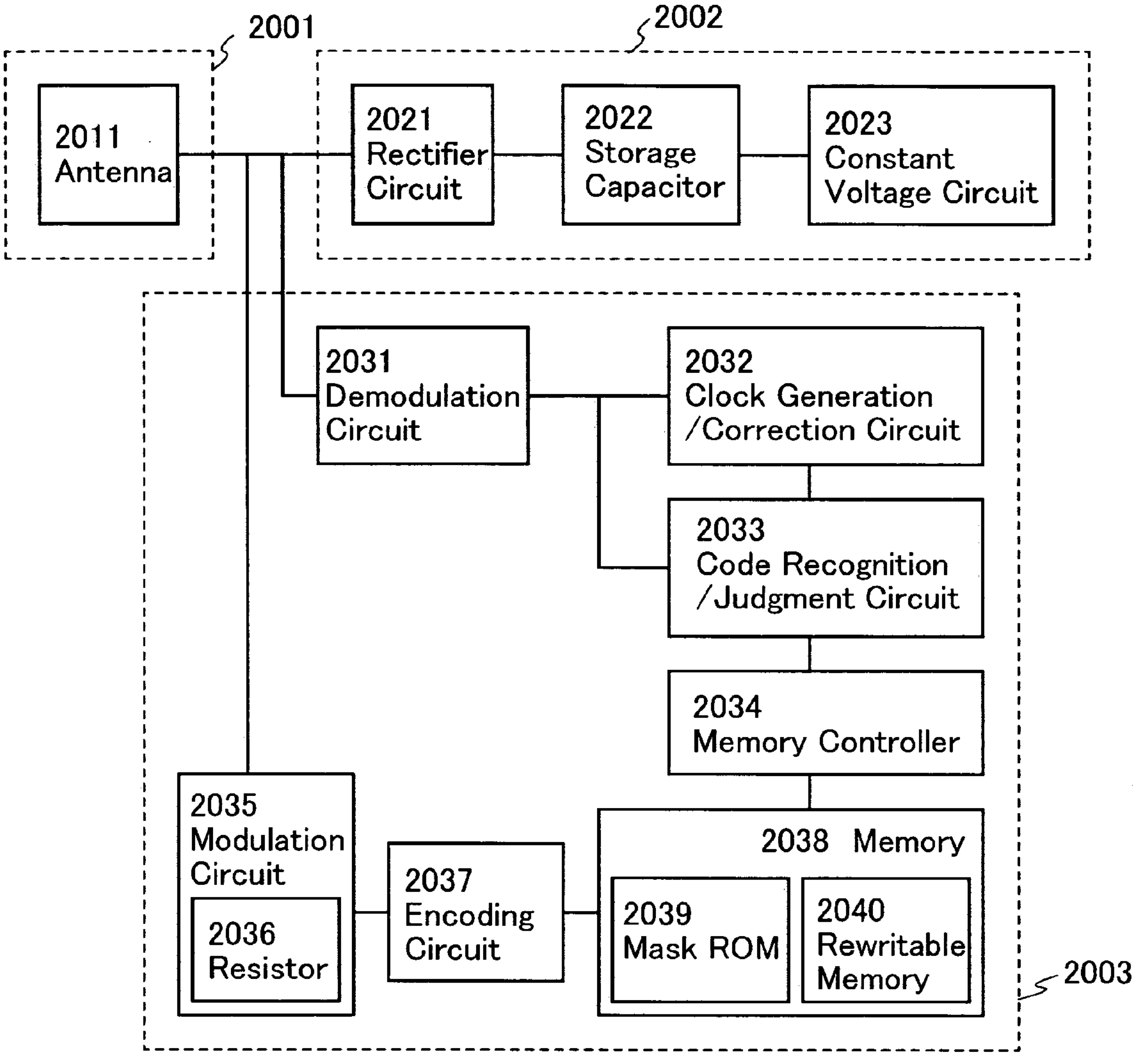

2001
2002
2011 Antenna
2021 Rectifier Circuit
2022 Storage Capacitor
2023 Constant Voltage Circuit
2031 Demodulation Circuit
2032 Clock Generation /Correction Circuit
2033 Code Recognition /Judgment Circuit
2034 Memory Controller
2035 Modulation Circuit
2036 Resistor
2037 Encoding Circuit
2038 Memory
2039 Mask ROM
2040 Rewritable Memory
2003

FIG. 15A

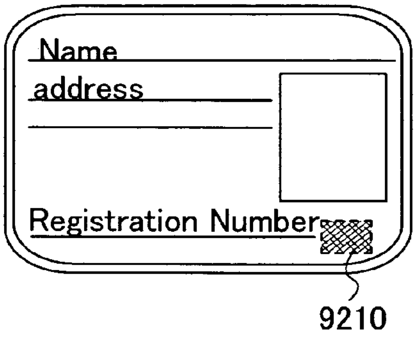


FIG. 15B

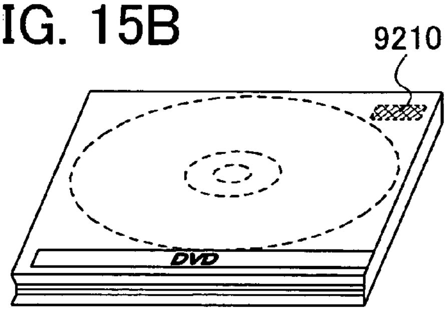


FIG. 15C

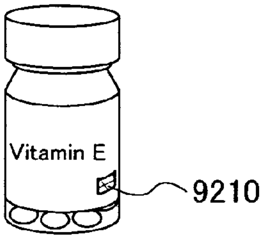


FIG. 15D

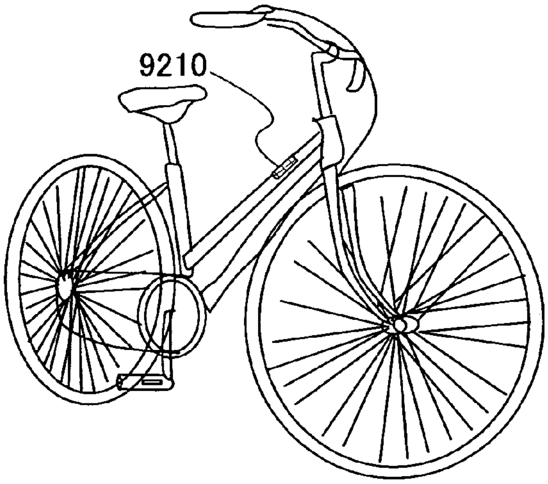


FIG. 15E

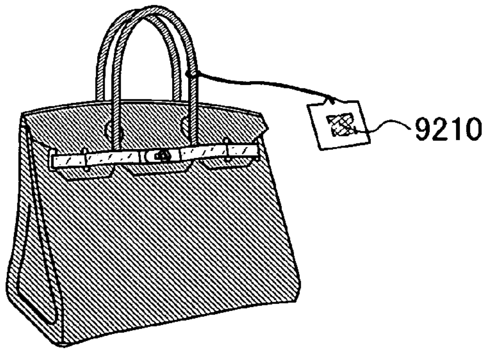


FIG. 15F

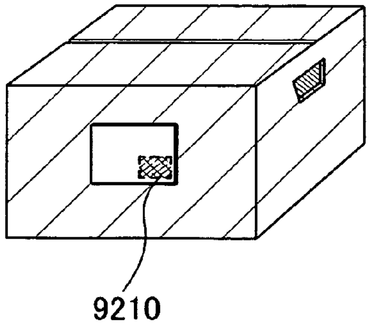


FIG. 16A

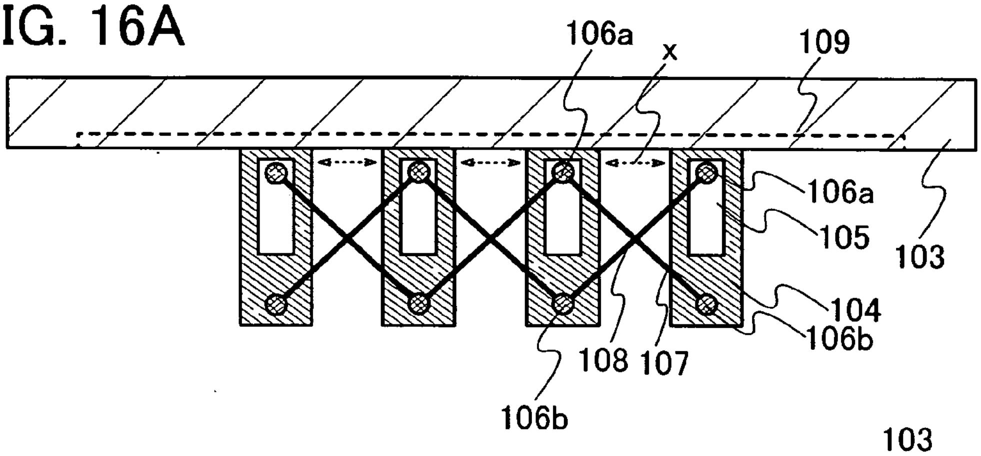


FIG. 16B

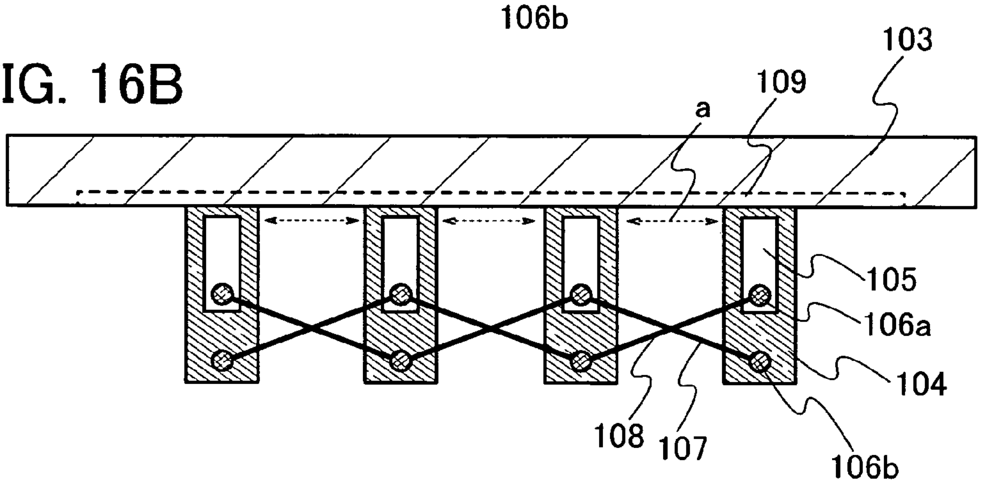


FIG. 17A

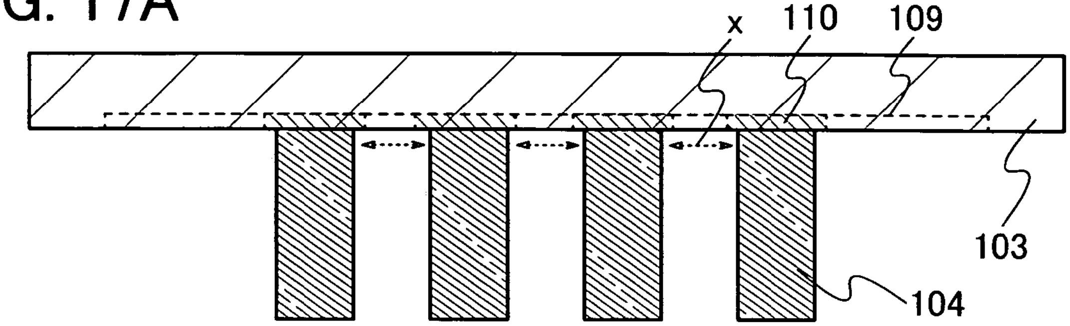


FIG. 17B

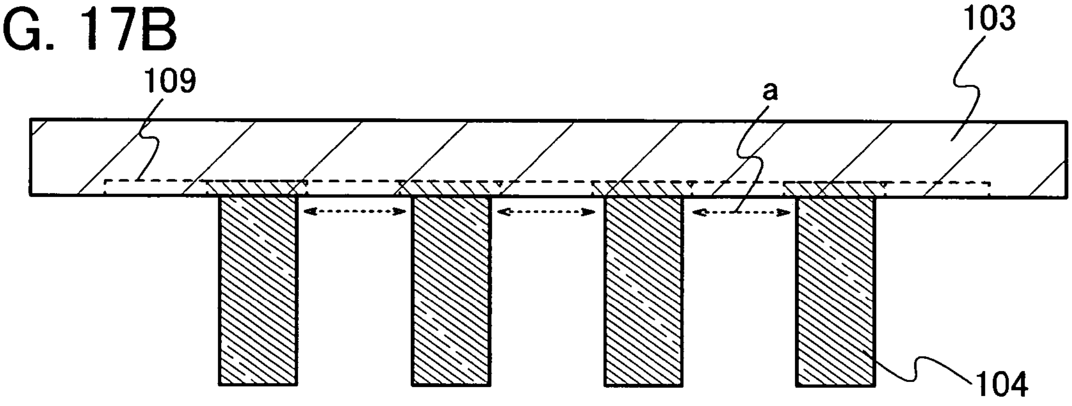


FIG. 18

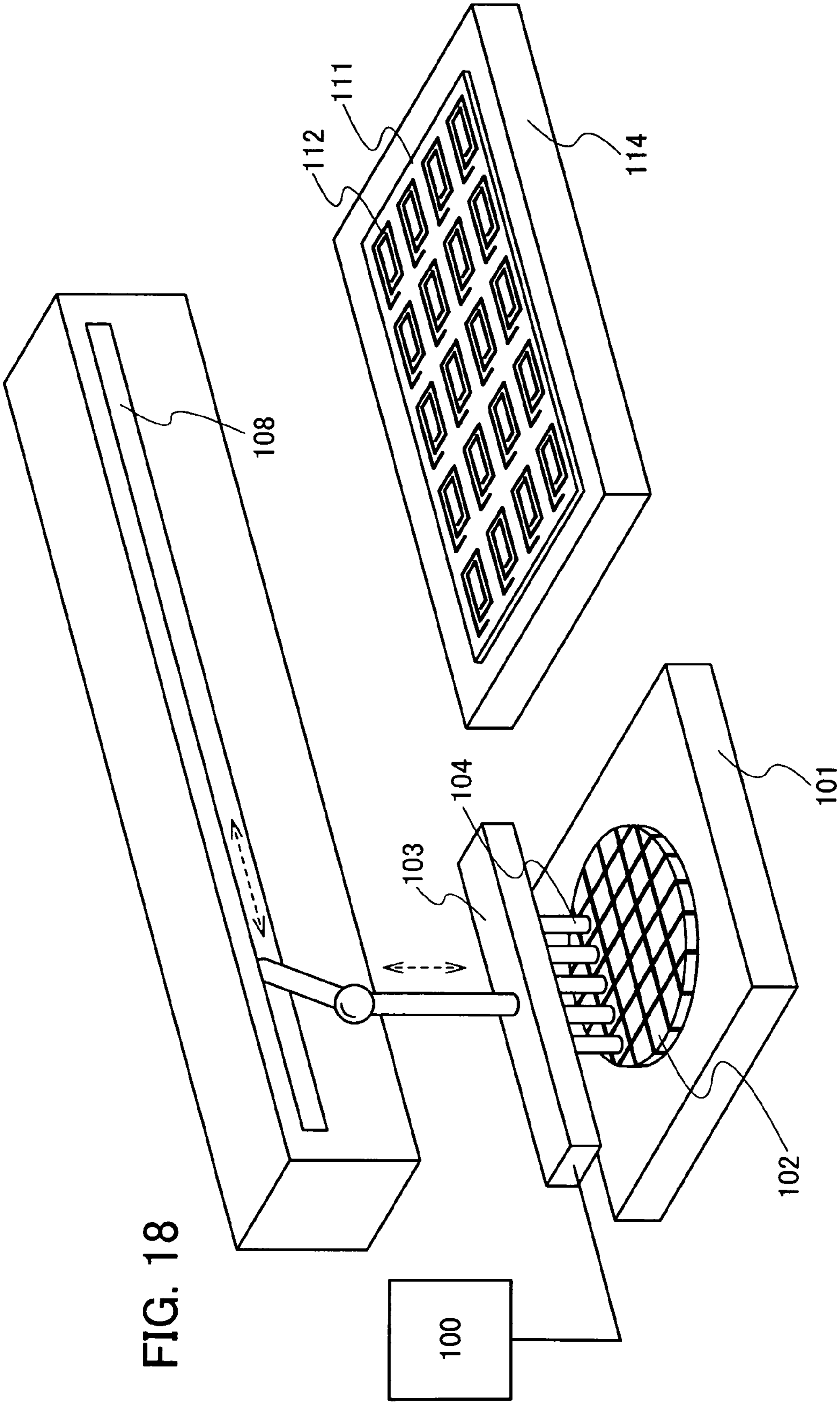
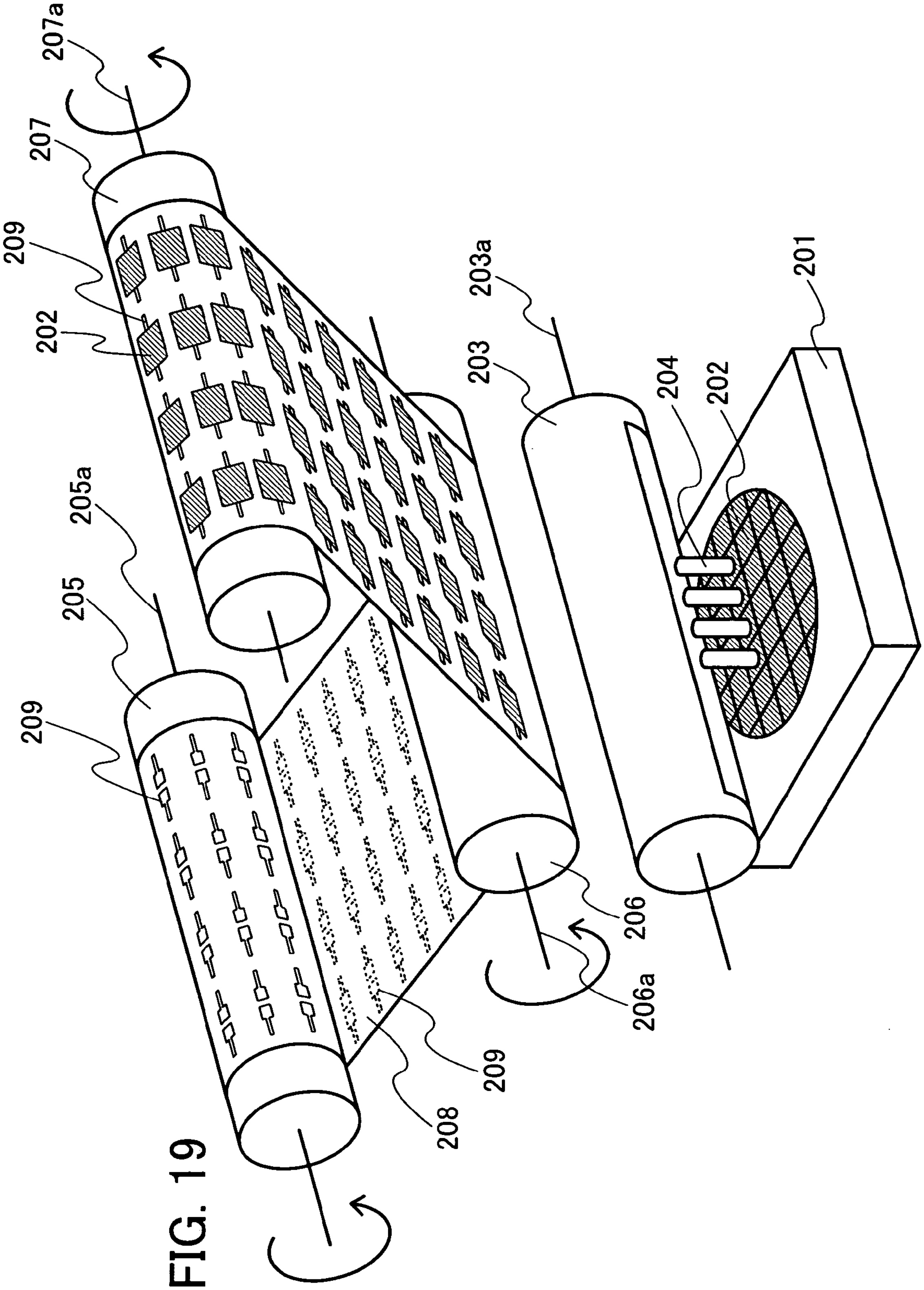


FIG. 19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APPARATUS AND METHOD FOR MANUFACTURING SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a manufacturing apparatus of a semiconductor device. In addition, the invention relates to a manufacturing method of a semiconductor device by which a semiconductor integrated circuit is electrically connected to a circuit (or an element) provided over a substrate (or a flexible substrate). In particular, the invention relates to a manufacturing method of a semiconductor device which performs data input/output by wireless communication via an antenna.

[0003] 2. Description of the Related Art

[0004] A semiconductor device which includes an antenna and a semiconductor integrated circuit electrically connected to the antenna has been drawing attention as an RFID tag. An RFID tag is also called an IC tag, an ID tag, a transponder, an IC chip, or an ID chip. A manufacturing method of an RFID tag is proposed, which includes the steps of providing a plurality of antennas over a flexible substrate, and electrically connecting semiconductor integrated circuits to the plurality of antennas one by one (see Reference 1: Japanese Published Patent Application No. 2005-115646).

[0005] In addition, a method which includes the steps of forming a plurality of semiconductor integrated circuits over one substrate (hereinafter also called an element substrate), taking out the plurality of semiconductor integrated circuits one by one, and mounting each semiconductor integrated circuit on a substrate which is different from the element substrate, is proposed (see Reference 2: Japanese Published Patent Application No. 2000-299598).

SUMMARY OF THE INVENTION

[0006] In order to reduce cost, it is preferable to form a plurality of semiconductor integrated circuits over an element substrate with high integration density. Meanwhile, an antenna should be formed to have a predetermined shape and size in order to receive electromagnetic waves with a predetermined frequency. Therefore, the pitch of a plurality of semiconductor integrated circuits formed over an element substrate tends to be narrower than that of a plurality of antennas over a flexible substrate. In that case, it has been impossible to electrically connect the plurality of semiconductor integrated circuits formed over the element substrate to the plurality of antennas over the flexible substrate at the same time. Therefore, it has been necessary to repeat the operation of connecting each of the plurality of semiconductor integrated circuits formed over the element substrate to one of the plurality of antennas over the flexible substrate, one by one. Thus, a long tact time is required, which results in high manufacturing cost of the semiconductor device.

[0007] In view of the foregoing, it is an object of the invention to provide a manufacturing method of a low-cost semiconductor device, and a manufacturing apparatus capable of manufacturing a semiconductor device at low cost.

[0008] It is the gist of the invention to provide a manufacturing apparatus of a semiconductor device, which includes a jig having a plurality of holders arranged in a row; a controller for controlling the pitch of the plurality of holders arranged in a row; a support means provided with a plurality of semiconductor integrated circuits; and a support means provided with a substrate having a plurality of elements. By mounting the semiconductor integrated circuits on the respective elements using the jig having the plurality of holders arranged in a row, semiconductor devices are manufactured.

[0009] It is also the gist of the invention to provide a manufacturing apparatus of a semiconductor device, which includes a support means provided with a plurality of semiconductor integrated circuits; a jig having a plurality of holders which are arranged in a row with a pitch of x ($0 \leqq x$) so as to be positioned opposite the respective semiconductor integrated circuits; a controller for controlling the pitch of the plurality of holders arranged in a row; a substrate having a plurality of elements where the pitch of connection terminals of the adjacent elements is a; and a support means for supporting the substrate. The controller changes the pitch of the holders from x to a ($a>x$) so that the semiconductor integrated circuits picked up by the holders can be positioned opposite the respective elements. Then, the semiconductor integrated circuits are mounted on the respective elements by using the jig, thereby semiconductor devices are manufactured.

[0010] It is also the gist of the invention to provide a manufacturing method of a semiconductor device, which includes the steps of picking up a plurality of semiconductor integrated circuits by using a jig having a plurality of holders arranged in a row; controlling the pitch of the plurality of holders arranged in a row by a controller for controlling the pitch of the plurality of holders arranged in a row so that connection terminals of the semiconductor integrated circuits can be positioned opposite respective connection terminals of elements; and connecting the connection terminals of the semiconductor integrated circuits to the respective connection terminals of the opposed elements.

[0011] It is also the gist of the invention to provide a manufacturing method of a semiconductor device, which includes the steps of picking up a plurality of semiconductor integrated circuits by using a jig having a plurality of holders which are arranged in a row with a pitch of x; changing the pitch of the plurality of holders arranged in a row, from x to a by a controller for controlling the pitch of the plurality holders arranged in a row; and connecting connection terminals of the semiconductor integrated circuits to respective connection terminals of the opposed elements where the pitch of the connection terminals of the adjacent elements is a.

[0012] Note that a semiconductor integrated circuit is a circuit including a plurality of semiconductor elements. Typical examples of the semiconductor integrated circuit are a silicon chip on which a plurality of semiconductor elements are formed, a chip having thin film semiconductor elements, and the like. In addition, typical examples of the element are an antenna, a semiconductor integrated circuit, a sensor, a battery, a wiring board, and a display device.

[0013] In addition, the invention includes the following.

[0014] One aspect of the invention is a manufacturing apparatus of a semiconductor device, which includes a first support means provided with a plurality of semiconductor integrated circuits; a plurality of holders for catching and holding the plurality of semiconductor integrated circuits; a jig having the plurality of holders arranged in a row; a controller for controlling the pitch of the plurality of holders;

and a second support means provided with a substrate having a plurality of elements. The jig picks up the plurality of semiconductor integrated circuits provided over the first support means by using the plurality of holders, and mounts the plurality of semiconductor integrated circuits on the plurality of respective elements over the substrate which are provided over the second support means.

[0015] Note that the controller moves the plurality of holders arranged in a row so that connection terminals of the plurality of semiconductor integrated circuits can be positioned opposite respective connection terminals of the plurality of elements.

[0016] Each of the first support means and the second support means may be a stage, a belt conveyor, or a robot arm.

[0017] Alternatively, the first support means may be a stage, a belt conveyor, or a robot arm, while the second support means may be a set of a roller for supplying a flexible substrate having a plurality of elements and a roller for winding up the flexible substrate having the plurality of elements.

[0018] One aspect of the invention is a manufacturing apparatus of a semiconductor device, which includes a support means provided with a plurality of semiconductor integrated circuits; a plurality of holders for catching and holding the plurality of semiconductor integrated circuits; a first roller on which the plurality of holders are arranged in a row; a controller for controlling the pitch of the plurality of holders; a second roller for supplying a flexible substrate having a plurality of elements; a third roller for controlling the movement of the flexible substrate having the plurality of elements; and a fourth roller for winding up the flexible substrate having the plurality of elements. The first roller picks up the plurality of semiconductor integrated circuits provided over the support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller.

[0019] One aspect of the invention is a manufacturing apparatus of a semiconductor device, which includes a support means provided with a plurality of semiconductor integrated circuits; a plurality of holders for catching and holding the plurality of semiconductor integrated circuits; a first roller on which the plurality of holders are arranged in a row; a controller for controlling the pitch of the plurality of holders; a second roller for supplying a flexible substrate having a plurality of elements; a third roller for controlling the movement of the flexible substrate having the plurality of elements; and a cutter for cutting the flexible substrate having the plurality of elements. The first roller picks up the plurality of semiconductor integrated circuits provided over the support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller. Then, the cutter cuts the flexible substrate having the plurality of elements on which the plurality of semiconductor integrated circuits are mounted.

[0020] One aspect of the invention is a manufacturing apparatus of a semiconductor device, which includes a support means provided with a plurality of semiconductor integrated circuits; a plurality of holders for catching and holding the plurality of semiconductor integrated circuits; a first roller on which the plurality of holders are arranged in a row; a controller for controlling the pitch of the plurality of holders; a second roller for supplying a first flexible substrate having a plurality of elements; a third roller for controlling the movement of the first flexible substrate having the plurality of elements; a fourth roller for supplying a second flexible substrate; and a pair of a fifth roller and a sixth roller which attach the first flexible substrate having the plurality of elements, the plurality of semiconductor integrated circuits, and the second flexible substrate, to each other. The first roller picks up the plurality of semiconductor integrated circuits provided over the support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller. Then, the pair of the fifth roller and the sixth roller attach the second flexible substrate to the first flexible substrate having the plurality of elements on which the plurality of semiconductor integrated circuits are mounted.

[0021] Note that the first roller, on which the plurality of holders are arranged in a row, has 2n sets of holders or (2n+1) sets of holders.

[0022] One aspect of the invention is a manufacturing apparatus of a semiconductor device, which includes a support means provided with a plurality of semiconductor integrated circuits; a plurality of first holders for catching and holding the plurality of semiconductor integrated circuits; a first roller on which the plurality of first holders are arranged in a row; a controller for controlling the pitch of the plurality of first holders; a plurality of second holders for catching and holding the plurality of semiconductor integrated circuits from the plurality of first holders; a second roller on which the plurality of second holders are arranged in a row; a third roller for supplying a flexible substrate having a plurality of elements; a fourth roller for controlling the movement of the flexible substrate having the plurality of elements; and a fifth roller for winding up the flexible substrate having the plurality of elements. The second roller catches and holds the plurality of semiconductor integrated circuits which have been caught and held by the plurality of first holders, by using the plurality of second holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the fourth roller.

[0023] Note that each of the first roller and the second roller may have 2n sets of first holders and 2n sets of second holders. Alternatively, each of the first roller and the second roller may have (2n+1) sets of first holders and (2n+1) sets of second holders.

[0024] One aspect of the invention is a manufacturing method of a semiconductor device, which includes the steps of setting a plurality of semiconductor integrated circuits on a first support means; picking up the plurality of semiconductor integrated circuits by using a plurality of holders arranged in a row on a jig; controlling the pitch of the plurality of holders by a controller for controlling the pitch of the plurality of holders so that connection terminals of the plurality of semiconductor integrated circuits can be positioned opposite respective connection terminals of a plurality of elements over a substrate which is provided over a second support means; and connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements.

[0025] One aspect of the invention is a manufacturing method of a semiconductor device, which includes the steps of setting a plurality of semiconductor integrated circuits on a support means; picking up the plurality of semiconductor integrated circuits by using a plurality of holders arranged in a row on a roller; rotating a roller for supplying a flexible substrate having a plurality of elements, a roller for controlling the movement of the flexible substrate having the plurality of elements, and a roller for collecting the flexible substrate having the plurality of elements, thereby moving the flexible substrate having the plurality of elements; rotating the roller on which the plurality of holders are arranged in a row, so that the plurality of semiconductor integrated circuits can be positioned opposite the flexible substrate having the plurality of elements; controlling the pitch of the plurality of holders by a controller for controlling the pitch of the plurality of holders so that connection terminals of the plurality of semiconductor integrated circuits can be positioned opposite respective connection terminals of the plurality of elements over the flexible substrate; and connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row.

[0026] Note that after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row, the flexible substrate may be cut by a cutter.

[0027] Alternatively, after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row, another flexible substrate may be attached to surfaces of the plurality of semiconductor integrated circuits and the plurality of elements by using a pair of rollers.

[0028] As a further alternative, after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row, another flexible substrate may be attached to surfaces of the plurality of semiconductor integrated circuits and the plurality of elements by using a pair of rollers. Then, the flexible substrate having the plurality of elements and the other flexible substrate may be cut by a cutter.

[0029] By the manufacturing method of a semiconductor device of the invention, a semiconductor device can be manufactured through the steps of picking up a plurality of semiconductor integrated circuits by a plurality of holders; controlling the pitch of the plurality of holders so that connection terminals of the semiconductor integrated circuits can be positioned opposite respective connection terminals of elements; and connecting the semiconductor integrated circuits to the respective elements. Therefore, even when the pitch of the connection terminals of the adjacent semiconductor integrated circuits is different from the pitch of the connection terminals of the adjacent elements, it is possible to attach the semiconductor integrated circuits to the respective elements only by controlling the pitch of the plurality of holders while picking up the semiconductor integrated circuits from an element substrate and positioning them to be opposite the respective elements. Furthermore, by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of elements through a sequence of steps, a plurality of semiconductor devices can be manufactured. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing method of a low-cost semiconductor device can be provided.

[0030] A manufacturing apparatus of a semiconductor device of the invention includes a jig which has a plurality of holders arranged in a row, a controller for controlling the pitch of the plurality of holders arranged in a row, a support means provided with a plurality of semiconductor integrated circuits, and a support means provided with a flexible substrate having a plurality of elements. The jig includes a plurality of holders arranged in a row and a controller for controlling the pitch of the holders. Therefore, even when the pitch of the connection terminals of the adjacent semiconductor integrated circuits is different from the pitch of the connection terminals of the adjacent elements, the semiconductor integrated circuits can be attached to the elements only by controlling the pitch of the plurality of holders while picking up the semiconductor integrated circuits from an element substrate and positioning them to be opposite the respective elements. Furthermore, by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of elements through a sequence of steps, a plurality of semiconductor devices can be manufactured. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing apparatus capable of manufacturing a semiconductor device at low cost can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] In the accompanying drawings:

[0032] FIGS. **1**A to **1**D are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0033] FIGS. **2**A to **2**D are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0034] FIGS. **3**A to **3**D are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0035] FIGS. **4**A to **4**D are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0036] FIGS. **5**A and **5**B are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0037] FIGS. **6**A to **6**C are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0038] FIGS. **7**A and **7**B are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0039] FIGS. **8**A and **8**B are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0040] FIGS. **9**A to **9**E are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0041] FIGS. **10**A to **10**D are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0042] FIGS. **11**A to **11**C are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0043] FIGS. **12**A and **12**B are cross-sectional diagrams illustrating a manufacturing method of a semiconductor device of the invention;

[0044] FIGS. **13**A to **13**C are top views illustrating shapes of an antenna which are applicable to the invention;

[0045] FIG. **14** is a diagram illustrating a semiconductor device of the invention;

[0046] FIGS. **15**A to **15**F are diagrams illustrating application examples of a semiconductor device of the invention;

[0047] FIGS. **16**A and **16**B are cross-sectional diagrams which partially illustrate a controller of a manufacturing apparatus of a semiconductor device of the invention;

[0048] FIGS. **17**A and **17**B are cross-sectional diagrams which partially illustrate a controller of a manufacturing apparatus of a semiconductor device of the invention;

[0049] FIG. **18** is a perspective view illustrating a manufacturing apparatus of a semiconductor device of the invention; and

[0050] FIG. **19** is a perspective view illustrating a manufacturing apparatus of a semiconductor device of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0051] Embodiment modes and embodiments of the invention will be described in detail below with reference to the accompanying drawings. Note that the invention is not limited to the following description, and it is to be easily understood by those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention. Therefore, the invention should be construed without limitation to the description in the embodiment modes and embodiments described below. In the structure of the invention described below, like reference numerals are used to designate identical portions in different drawings.

Embodiment 1

[0052] An apparatus and a method for manufacturing a semiconductor device in this embodiment mode will be described, with reference to FIGS. **1**A to **1**D, **16**A and **16**B, **17**A and **17**B, and **18**.

[0053] A manufacturing apparatus of a semiconductor device in this embodiment mode includes, as shown in the example in FIG. **18**, a plurality of holders **104** arranged in a row, which pick up semiconductor integrated circuits **102** from a support means **101**, a jig **103** having the plurality of holders **104**, a controller **100** for controlling the plurality of holders **104**, and a support means **114** mounting a substrate **111** which has a plurality of elements. The semiconductor integrated circuits **102** which are picked up by the holders **104** arranged in a row are mounted on the respective elements formed over the substrate **111**. Note that in the following embodiment modes, antennas **112** are illustrated as the elements, and a device in which a semiconductor integrated circuit is mounted on an antenna is illustrated as a semiconductor device. However, the element is not limited to the antenna. In addition, the semiconductor device means a device in which a semiconductor integrated circuit is mounted on an element.

[0054] As the holders **104** arranged in a row, holding tools typified by absorbing nozzles, collets, tweezers, or pincers can be used. Here, absorbing nozzles are used as holding jigs. In addition, the holders **104** may be provided with heaters. By providing the holders **104** with heaters, it becomes possible, after the semiconductor integrated circuits **102** provided over the support means **101** are picked up by the holders **104** and moved to the substrate **111** having the antennas **112**, to mount the semiconductor integrated circuits **102** on the respective antennas **112** by thermocompression bonding by heating the heaters provided for the holders. Note that the heaters are preferably capable of heating at temperatures in the range from a room temperature to 500° C. In the case of connecting the semiconductor integrated circuits to the antennas by pressure bonding with the holders **104**, it is preferable that each holder can withstand a load of 10 g to 100 kg, or preferably 50 g to 50 kg. Furthermore, by providing the holders **104** with drivers such as motors, the direction (θ direction) of the semiconductor integrated circuits can be rotated, which can facilitate an alignment process for mounting the semiconductor integrated circuits on the substrates having the antennas.

[0055] The jig **103** is a moving device such as a robot arm, a head, or a roller, which can freely move up and down and horizontally (in x-y-z directions). The jig **103** may be connected to a driver **108** such as a rail or a motor. After the semiconductor integrated circuits **102** over the support means **101** are picked up by the holders **104** using the jig **103** or the driver **108**, the semiconductor integrated circuits **102** are moved to the vicinity of the antennas **112** over the support means **114**, thereby the semiconductor integrated circuits **102** can be mounted on the respective antennas **112**.

[0056] The controller **100** for controlling the holders **104** arranged in a row is a means for, after the semiconductor integrated circuits **102** are picked up from the support means **101**, moving the holders **104** arranged in a row so that connection terminals of the semiconductor integrated circuits **102** can be positioned opposite respective connection terminals of the antennas **112** formed over the substrate **111**. The controller **100** includes a detection element which detects that the semiconductor integrated circuits **102** are picked up by the holders **104** arranged in a row, a detector which detects that the holders **104** arranged in a row are moved to a position opposite the antennas, and a driver for changing the pitch of the holders **104** arranged in a row. Further, the controller **100** may include a detection element for detecting the pitch of the connection terminals of the adjacent antennas. As the detection element which detects that the semiconductor integrated circuits **102** are picked up by holders **104** arranged in a row, or the detection element for detecting the pitch of the connection terminals of the adjacent antennas, a CCD camera or the like can be employed. By processing image data which is detected by the detection element, the positions of the connection terminals of the semiconductor integrated circuits and the antennas, and alignment thereof are detected.

[0057] Typical examples of the driver which is included in the controller **100** for controlling the holders **104** arranged in a row is described, with reference to FIGS. **16**A and **16**B, and **17**A and **17**B. As shown in FIG. **16**A, each of the holders **104** arranged in a row includes a rail **105**, a support **106***a* which moves within the rail **105**, a support **106***b* which is fixed to the holder **104**, and axes **107** and **108** which are provided between the adjacent supports **106***a* and **106***b*. In addition, a rail **109** is provided in the jig **103** to allow the movement of the holders **104**.

[0058] In the case of picking up the semiconductor integrated circuits over the support means, as shown in FIG. **16**A, the support **106***a* which moves within the rail **105** is positioned away from the support **106***b* which is fixed. The pitch of the adjacent holders **104** at this time is represented by x.

[0059] In the case of positioning the semiconductor integrated circuits to be opposite the respective antennas, as shown in FIG. **16**B, the support **106***a* moves within the rail **105**, so that the distance between the support **106***a* and the support **106***b* which is fixed becomes shorter. At this time, the axes **107** and **108** move in conjunction so that the pitch of the adjacent holders **104** can be widened from x to a.

[0060] As another example, as shown in FIG. **17**A, the rail **109** is provided within the jig **103**, and each holder **104** is provided with a power system **110** such as a motor which travels within the rail **109**.

[0061] In the case of picking up the semiconductor integrated circuits over the support means, the pitch of the holders **104** is x as shown in FIG. **17**A.

[0062] In the case of positioning the semiconductor integrated circuits to be opposite the respective antennas, as shown in FIG. **17**B, the power system provided for each holder **104** travels within the rail **109**, so that the pitch of the holders **104** can be widened from x to a.

[0063] The support means **101** is a means for supporting a plurality of semiconductor integrated circuits, and the support means **114** is a means for supporting a flexible substrate having a plurality of antennas, each of which may typically be a stage, a belt conveyor, a robot arm, or the like. In addition, the stage may be provided on a moving apparatus which can move up and down (in z direction) and horizontally (in x-y directions). In the case of using a stage or a belt conveyor as the support means, the plurality of semiconductor integrated circuits are set on a sheet or a substrate. Meanwhile, in the case of using a robot arm as the support means, the plurality of semiconductor integrated circuits may be set on an adhesive film which is fixed on a frame. In that case, the robot arm supports the frame. Examples of the adhesive film include a UV curing adhesive film (also called a UV film, a UV tape, or a UV sheet), a pressure-sensitive film whose adhesion changes with pressure applied (also called a pressure-sensitive tape or a pressure-sensitive sheet), a thermal curing adhesive film (also called a thermal curing adhesive tape or a thermal curing adhesive sheet), and the like. Further, the adhesive film may be an expand-type film which is elastic.

[0064] The semiconductor integrated circuit **102** is a circuit including a plurality of semiconductor elements. As typical examples of the semiconductor integrated circuit, a silicon chip on which a plurality of semiconductor elements are formed, a chip including thin film semiconductor elements, and the like can be given.

[0065] As a typical example of a manufacturing method of a silicon chip on which a plurality of semiconductor elements are formed, the following steps are performed: forming a MOS transistor, a capacitor, a resistor, a diode, and the like on the surface of a silicon wafer, conducting polishing treatment called a back-grind process to the rear surface of the silicon wafer so that the silicon wafer has a thickness of 30 to 250 μm, or preferably 50 to 100 μm, and cutting the silicon wafer into rectangular chips with a dicer.

[0066] As a typical example of a chip including thin film semiconductor elements, a layer including a thin film transistor, a capacitor, a resistor, a thin film diode, and the like can be given. As a typical example of a manufacturing method of a chip having thin film semiconductor elements, the following steps are performed: forming a layer including a thin film transistor, a capacitor, a resistor, a thin film diode, and the like over a substrate; peeling the layer off the substrate, and cutting the layer into rectangular chips.

[0067] The antenna **112** can be formed using a conductive layer which is formed over a flexible substrate, by using a printing method, a method of etching a conductive thin film, a plating method, or the like. The antenna **112** can be formed with a conductive layer containing one or more elements of Ag, Au, Cu, Ni, Pt, Pd, Ir, Rh, W, Al, Ta, Mo, Cd, Zn, Fe, Ti, Zr, and Ba.

[0068] FIGS. **13**A to **13**C are top views of antennas which are applicable to the invention. When adopting an electromagnetic coupling method or an electromagnetic induction method (e.g., 13.56 MHz) as the signal transmission method of the semiconductor device, the shape of a conductive layer functioning as an antenna can be a rectangular coil shape **281** as shown in FIG. **13**A or a circular coil shape (e.g., a spiral antenna), in order to utilize electromagnetic induction which occurs due to a change in magnetic flux density. Alternatively, a rectangular loop shape **282** as shown in FIG. **13**B or a circular loop shape can be employed.

[0069] When adopting a microwave method (e.g., UHF bands (860 to 960 MHz) or 2.45 GHz), the shape (e.g., length) of a conductive layer functioning as an antenna may be appropriately set in consideration of the wavelength of an electromagnetic wave used for signal transmission, and a linear dipole shape **283** as shown in FIG. **13**C, a curved dipole shape, or a plane shape (e.g., a patch antenna) can be used.

[0070] In this embodiment mode, although the antenna **112** is illustrated as a typical example of the element, the invention is not limited to this. For example, a semiconductor integrated circuit, a sensor, a battery, a wiring board, a display device, or the like can be used as appropriate.

[0071] The substrate **111** can be formed by stacking a substrate made of PET (polyethylene terephthalate), PEN (polyethylene naphthalate), PES (polyethersulfone), polypropylene, polypropylene sulfide, polycarbonate, polyetherimide, polyphenylene sulfide, polyphenylene oxide, polysulfone, polyphthalamide, or the like, and an adhesive organic resin (e.g., acrylic resin, epoxy resin, or silicone resin) as a layer made of a thermoplastic material. Alternatively, the substrate **111** can be formed by stacking paper made of a fibrous material and the above adhesive organic resin. In addition, the substrate may be a flexible substrate. Furthermore, a glass substrate, a quartz substrate, a metal substrate, or the like can be employed.

[0072] A manufacturing method of a semiconductor device shown in this embodiment mode is described below.

[0073] As shown in FIG. **1**A, the plurality of semiconductor integrated circuits **102** which are provided over the support means **101** are caught and held by the plurality of holders **104** arranged in a row. The pitch of the holders **104** at this time is represented by x ($0 \leqq x$).

[0074] Next, as shown in FIG. 1B, the semiconductor integrated circuits **102** are picked up from the support means **101**. At this time, the jig **103** is moved in a direction away from the support means **101**. Alternatively, the support means **101** is moved in a direction away from the jig **103**. As a further alternative, both the jig **103** and the support means **101** are moved in directions in which the holders **104** and the support means **101** are positioned away from each other. In the case of providing a means for controlling the telescopic movement of the holders **104**, the holders **104** are shrunk. Accordingly, the semiconductor integrated circuits **102** can be picked up from the support means **101**.

[0075] Next, as shown in FIG. 1C, the substrate **111** having the antennas **112** are mounted on the support means **114**. Next, conductive pastes **113** are applied to connection terminals (not shown) of the antennas **112**. Note that instead of the conductive pastes **113**, anisotropic conductive agents or anisotropic conductive films may be provided on the connection terminals of the antennas **112**. In addition, parts of the antennas **112** may be used as the connection terminals of the antennas **112**.

[0076] Next, the jig **103** is moved to be positioned above the substrate **111** having the antennas **112**. At this time, the pitch of the holders **104** is widened by the controller so that the connection terminals of the semiconductor integrated circuits **102** can be positioned opposite the respective connection terminals of the antennas **112**. Typically, when the pitch of the connection terminals of the adjacent antennas **112** is a, the pitch of the holders **104** arranged in a row is also set to be a by the controller. Note that instead of moving the jig **103** to be positioned above the substrate **111** having the antennas **112**, it is also possible to move the support means **114** which supports the substrate **111** having the antennas **112** to be positioned below the jig **103**.

[0077] Next, as shown in FIG. 1D, the semiconductor integrated circuits **102** are mounted on the conductive pastes **113**. After that, the semiconductor integrated circuits **102** are connected to the respective antennas **112** with the conductive pastes **113** therebetween though a reflow process or the like.

[0078] Alternatively, bonding means may be provided. In that case, after mounting (temporally attaching) the semiconductor integrated circuits **102** which have been picked up by the jig **103** having the holders **104** onto the respective antennas **112**, the semiconductor integrated circuits **102** and the conductive pastes **113** can be attached to each other by pressure bonding, so that the semiconductor integrated circuits **102** can be mounted (attached) onto the respective antennas **112**. As examples of such bonding means, there are means using a thermocompression bonding method, an ultrasonic bonding method, or the like. Typically, a jig having a heater or an ultrasonic horn can be used.

[0079] Through the above steps, a substrate having a plurality of semiconductor devices each of which includes a semiconductor integrated circuit and an antenna can be manufactured. After that, a protective layer may be formed so as to cover the semiconductor integrated circuits and the antennas. Alternatively, another substrate may be attached to the substrate **111** so as to cover the semiconductor integrated circuits and the antennas. As such a substrate, a flexible substrate which has been described for the substrate **111** can be used as appropriate.

[0080] Furthermore, by cutting the flexible substrate, semiconductor devices each of which includes a semiconductor integrated circuit and an antenna can be manufactured.

[0081] By the manufacturing method of a semiconductor device in this embodiment mode, a semiconductor device can be manufactured through the steps of picking up semiconductor integrated circuits by holders, controlling the pitch of the holders so that connection terminals of the semiconductor integrated circuits can be positioned opposite respective connection terminals of antennas; and connecting the semiconductor integrated circuits to the respective antennas. Therefore, even when the pitch of the connection terminals of the adjacent semiconductor integrated circuits is different from the pitch of the connection terminals of the adjacent antennas, it is possible to attach the semiconductor integrated circuits to the respective antennas only by controlling the pitch of the holders while picking up the semiconductor integrated circuits and positioning them to be opposite the respective antennas. Furthermore, by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of antennas through a sequence of steps, a plurality of semiconductor devices can be manufactured. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing method of a low-cost semiconductor device can be provided.

[0082] The manufacturing apparatus of a semiconductor device in this embodiment mode includes a jig which has a plurality of holders arranged in a row, a controller for controlling the pitch of the holders arranged in a row, a support means provided with a plurality of semiconductor integrated circuits, and a support means provided with a flexible substrate having a plurality of antennas. The jig includes a plurality of holders arranged in a row and a controller for controlling the pitch of the holders arranged in a row. Therefore, even when the pitch of the connection terminals of the adjacent semiconductor integrated circuits is different from the pitch of the connection terminals of the adjacent antennas, it is possible to attach the semiconductor integrated circuits to the respective antennas only by controlling the pitch of the holders while picking up the semiconductor integrated circuits and positioning them to be opposite the respective antennas. Furthermore, by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of antennas through a sequence of steps, a plurality of semiconductor devices can be manufactured. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing apparatus capable of manufacturing a semiconductor device at low cost can be provided.

Embodiment Mode 2

[0083] In this embodiment mode, an apparatus and a method for manufacturing a semiconductor device which employs a roll-to-roll system is described, with reference to FIGS. **2**A to **2**D, **3**A to **3**D, **4**A to **4**D and **19**.

[0084] As shown in FIG. **19**, a manufacturing apparatus of a semiconductor device in this embodiment mode includes a supply roller **205** around which a flexible substrate **208** having antennas **209** is wound, a roller **206** which controls the movement of the flexible substrate **208** and mounts semiconductor integrated circuits **202** on the respective antennas **209**, and a collecting roller **207** for winding up the flexible substrate **208** having the antennas **209** on which the semiconductor integrated circuits **202** are mounted. The manufacturing apparatus also includes a support means **201** for supporting the semiconductor integrated circuits **202** and a roller **203** having holders **204** for catching and holding the semiconductor integrated circuits **202**. Note that the holders **204** are arranged in a row on the side surface of the roller **203**. In addition, the surface of the flexible substrate **208** having the antennas **209** may be provided with an anisotropic conductive film. The rollers **203**, **205**, **206**, and **207** may be provided with moving means for moving their respective rotation axes **203***a*, **205***a*, **206***a*, and **207***a*. By the moving means for moving the rotation axes **203***a*, **205***a*, **206***a*, and **207***a*, the rollers **203**, **205**, **206**, and **207** can be moved up and down, and thus the positions of the rollers **203**, **205**, **206**, and **207** can be controlled. Furthermore, the holders **204** may be provided with means for controlling the telescopic movement of the holders **204**.

[0085] For the semiconductor integrated circuits **202**, the holders **204**, the antennas **209**, and the flexible substrate **208** having the antennas **209** in this embodiment mode, the semiconductor integrated circuits **102**, the holders **104**, the antennas **112**, and the substrate **111** having the antennas **112** shown in Embodiment Mode 1 can be used as appropriate.

[0086] The roller **206**, which controls the movement of the flexible substrate **208** and mounts the semiconductor integrated circuits **202** on the respective antennas **209**, is provided between the supply roller **205** and the collecting roller **207**. In addition, the roller **206**, which controls the movement of the flexible substrate **208** and mounts the semiconductor integrated circuits **202** on the respective antennas **209**, is provided in a position opposite the roller **203** having the holders **204**, with the flexible substrate **208** having the antennas **209** therebetween.

[0087] Each of the rollers **203**, **205**, **206**, and **207** is a cylindrical rotating body, which typically corresponds to a cylindrical cast having a polished surface, or the like. Each of the rollers **203**, **205**, **206**, and **207** rotates at a predetermined speed. The rollers **205**, **206**, and **207** rotate in the same direction, while the roller **203** rotates in the opposite direction to or the same direction as the roller **206**.

[0088] Now, the structure of the holders **204** which are arranged in a row on the roller **203** is described. FIG. **2**A shows a cross section of a manufacturing apparatus of a semiconductor device in the x-axis direction, and FIG. **2**B shows a cross section of the manufacturing apparatus of a semiconductor device in FIG. **2**A in the y-axis direction. FIG. **2**C shows a cross section of the manufacturing apparatus of a semiconductor device in the x-axis direction, and FIG. **2**D shows a cross section of the manufacturing apparatus of a semiconductor device in FIG. **2**C in the y-axis direction. In FIGS. **2**A and **2**B, the plurality of holders **204** are arranged in a row in the y-axis direction of the roller **203**. The pitch of the holders **204** arranged in a row at this time is x. Note that although FIGS. **2**A to **2**D show the structures where the plurality of holders **204** are arranged in a row in the y-direction, the invention is not limited to this. That is, the plurality of holders **204** may be arranged in a row in the x-axis direction.

[0089] Next, a manufacturing method of a semiconductor device is described.

[0090] As shown in FIGS. **2**A and **2**B, when the roller **205** rotates, the flexible substrate **208** having the antennas **209** is transferred. The flexible substrate **208** is delivered to the roller **207** through the roller **206**. In addition, by rotation of the rollers **205** to **207**, the flexible substrate **208** is wound up around the roller **207**. That is, the flexible substrate **208** is collected by the roller **207**.

[0091] The roller **203** rotates in the opposite direction to or the same direction as the moving direction of the support means **201**. By appropriately controlling the pressure of the roller **203**, the distance between the holders **204** and the semiconductor integrated circuits **202**, the rotation speed of the roller **203**, and the moving speed of the support means **201**, the semiconductor integrated circuits **202** provided over the support means **201** can be caught and held by the holders **204** on the roller **203**.

[0092] Next, by rotating the roller **203** in the opposite direction to or the same direction as the roller **206**, the semiconductor integrated circuits **202** are peeled off the support means **201**.

[0093] Alternatively, the following method can be used instead of the above method to pick up the semiconductor integrated circuits **202** from the support means **201**. Under the condition that the roller **203** does not rotate, the roller **203** is moved to the side of the semiconductor integrated circuits **202** by a moving means for moving the rotation axis of the roller **203**. Next, after catching and holding the semiconductor integrated circuits **202** from the support means **201** by using the holders **204**, the roller **203** is moved to the roller **206** side by the moving means for moving the rotation axis of the roller **203**. Accordingly, the semiconductor integrated circuits **202** are picked up from the support means **201** by the holders **204**. After that, the roller **203** is rotated. By such moving of the roller **203**, the semiconductor integrated circuits **202** can be surely peeled off the support means **201**.

[0094] As a further alternative, the following method can be used instead of the above methods to pick up the semiconductor integrated circuits **202** from the support means **201**. Under the condition that the roller **203** does not rotate, the holders **204** are stretched to the side of the semiconductor integrated circuits **202** by a means for controlling the telescopic movement of the holders **204**. Next, after catching and holding the semiconductor integrated circuits **202** from the support means **201** by using the holders **204**, the holders **204** are shrunk by the means for controlling the telescopic movement of the holders **204**. Accordingly, the semiconductor integrated circuits **202** are picked up from the support means **201** by the holders **204**. After that, the roller **203** is rotated. By such telescopic movement of the holders **204**, the semiconductor integrated circuits **202** can be surely peeled off the support means **201**.

[0095] Next, as shown in FIGS. **2**C and **2**D, while rotating the roller **203**, the pitch of the holders **204** is widened by a controller so that connection terminals of the semiconductor integrated circuits **202** can be positioned opposite respective connection terminals of the antennas **209**. The pitch of the holders **204** arranged in a row at this time is represented by a.

[0096] Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the roller **206** and the holders **204**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. By appropriately controlling the distance between the roller **206** and the holders **204** and the rotation speed of a pair of the rollers **203** and **206**, the semiconductor integrated circuits **202** can be mounted on the respective antennas **209** over the flexible substrate **208**.

[0097] As a further alternative, the following method can be used instead of the above methods to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **203**, the rotation of the rollers **203**, **205**, **206**, and **207** is stopped. Next, the pitch of the holders **204** is widened by a controller so that connection terminals of the semiconductor integrated circuits **202** can be positioned opposite respective connection terminals of the antennas **209**. The pitch of the holders **204** arranged in a row at this time is represented by a. Next, the roller **203** is moved to the roller **206** side by a moving means for moving the rotation axis of the roller **203**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the roller **206** and the holders **204**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0098] Next, by moving the roller **203** to the support means **201** side by the moving means for moving the rotation axis of the roller **203**, the semiconductor integrated circuits **202** can be mounted on the respective antennas **209** over the flexible substrate **208**. After that, the rollers **203**, **205**, **206**, and **207** are rotated.

[0099] As a further alternative, the following method can be used instead of the above methods to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **203**, the rotation of the rollers **203**, **205**, **206**, and **207** is stopped. Next, the pitch of the holders **204** is widened by a controller so that connection terminals of the semiconductor integrated circuits **202** can be positioned opposite respective connection terminals of the antennas **209**. The pitch of the holders **204** arranged in a row at this time is represented by a. Next, under the condition that the rollers **203**, **205**, **206**, and **207** do not rotate, the rollers **205** to **207** are moved to the holders **204** side by moving means for moving the rotation axes of the rollers **205** to **207**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the holders **204** and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0100] Next, after moving the roller **206** away from the support means **201** by the moving means for moving the rotation axes of the rollers **205** to **207**, the rollers **203**, **205**, **206**, and **207** are rotated.

[0101] As a further alternative, the following method can be used instead of the above methods to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **203**, the rotation of the rollers **203**, **205**, **206**, and **207** is stopped. Next, the pitch of the holders **204** is widened by a controller so that connection terminals of the semiconductor integrated circuits **202** can be positioned opposite respective connection terminals of the antennas **209**. The pitch of the holders **204** arranged in a row at this time is represented by a. Next, under the condition that the rollers **203**, **205**, **206**, and **207** do not rotate, the holders **204** are stretched to the roller **206** side by a means for controlling the telescopic movement of the holders **204**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the holders **204** and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, after shrinking the holders **204** by the means for controlling the telescopic movement of the holders **204**, the rollers **203**, **205**, **206**, and **207** are rotated.

[0102] Note that the manufacturing apparatus of a semiconductor device in this embodiment mode may also be provided with a pair of rollers having a heating means such as a heater, in addition to the roller **203** having the holders **204**. In that case, after mounting (temporally attaching) the semiconductor integrated circuits **202** which have been picked up by the roller **203** having the holders **204** onto the respective antennas **209**, the semiconductor integrated circuits **202** and the anisotropic conductive film **210** may be attached to each other by thermocompression bonding using the pair of rollers having a heating means such as a heater, so that the semiconductor integrated circuits **202** can be mounted (attached) onto the respective antennas **209**.

[0103] Note that in FIGS. **2**A to **2**D, the connection terminal of each antenna is disposed in a direction parallel to the rotation direction of the roller **206** (i.e., in the x-axis direction). However, the invention is not limited to this, and the connection terminal of each antenna may be disposed in a direction perpendicular to the rotation direction of the roller **206** (i.e., in the y-axis direction). In that case, similarly to the structures shown in FIGS. **2**A to **2**D, the semiconductor integrated circuits can be mounted on the respective antennas only by once holding the antennas and the semiconductor integrated circuits between the roller **206** and the holders **204**, which can improve the yield.

[0104] After that, the flexible substrate **208** having the antennas **209** and the semiconductor integrated circuits **202** connected to the respective antennas **209** are collected by the roller **207**. Through the above steps, a sheet having a plurality of semiconductor devices where semiconductor integrated circuits are mounted on antennas can be formed.

[0105] Furthermore, a cutter **221** may be provided as shown in FIG. **3**C, instead of the collecting roller **207** which winds up the flexible substrate **208** having the attached antennas **209** and the semiconductor integrated circuits **202** mounted on the respective antennas **209**. As a result, semiconductor devices each of which includes the flexible substrate **208** having the antenna **209** and the semiconductor integrated circuit **202** connected thereto can be cut into individual chips. As the cutter **221**, a dicing machine, a scribing machine, a laser irradiation apparatus, and the like can be used as appropriate.

[0106] In addition, the sheet having the semiconductor devices shown in FIGS. **2**A to **2**D and **3**A to **3**D can be sealed by using a flexible substrate. Here, modified examples of FIGS. **3**A to **3**D are described with reference to

FIGS. **4**A and **4**D. FIGS. **4**A and **4**C show cross sections of the manufacturing apparatus of a semiconductor device in the x-axis direction, and FIGS. **4**B and **4**D show cross sections of the manufacturing apparatus of a semiconductor device in FIGS. **4**A and **4**C respectively, in the y-axis direction.

[0107] As shown in FIGS. **4**A and **4**C, in addition to the manufacturing apparatus of a semiconductor device shown in FIGS. **3**A to **3**D, a supply roller **231** around which a flexible substrate **232** is wound, and a pair of rollers **233** and **234** which control the movement of the flexible substrate **232** and attaches the flexible substrate **232** to the flexible substrate **208** having the semiconductor integrated circuits **202** and the antennas **209** may be provided.

[0108] Similarly to FIGS. **2**A to **2**D and **3**A to **3**D, the semiconductor integrated circuits **202** provided over the support means **201** can be caught and held by the holders **204** which are arranged in a row on the roller **203**, by appropriately controlling the pressure of the roller **203**, the distance between the holders **204** and the semiconductor integrated circuits **202**, the rotation speed of the roller **203**, and the moving speed of the support means **201**. The pitch of the holders **204** arranged in a row at this time is represented by x.

[0109] Next, by rotating the roller **203** in the opposite direction to or the same direction as the roller **206**, the semiconductor integrated circuits **202** are peeled off the support means **201**. Next, as shown in FIGS. **4**C and **4**D, the pitch of the holders **204** is widened by a controller so that the connection terminals of the semiconductor integrated circuits **202** and the antennas **209** can be positioned opposite each other. Here, the pitch of the holders **204** arranged in a row is widened from x to a.

[0110] Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the roller **206** and the holders **204**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. By appropriately controlling the distance between the roller **206** and the holders **204** and the rotation speed of the roller **206** and the roller **203**, the semiconductor integrated circuits **202** can be mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0111] By rotating the roller **231**, the flexible substrate **232** is transferred. The flexible substrate **232** is delivered to the roller **233**. By rotating the pair of the rollers **233** and **234** in opposite directions or in the same direction, the flexible substrate **208** having the semiconductor integrated circuits **202** and the antennas **209** is sealed with the flexible substrate **232**. By appropriately controlling the distance between the rollers **233** and **234** and the rotation speed of the pair of the rollers **233** and **234**, the semiconductor integrated circuits **202** and the antennas **209** can be sealed with the flexible substrates **208** and **232**.

[0112] Through the above steps, a sheet having semiconductor devices can be manufactured.

[0113] After that, portions of the flexible substrate which are exposed between the antennas are cut with a cutter **235**, thereby semiconductor devices each of which includes a semiconductor integrated circuit and an antenna can be manufactured.

[0114] By using the manufacturing apparatus of a semiconductor device in this embodiment mode, a plurality of steps can be continuously performed. Furthermore, by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of antennas, a plurality of semiconductor devices can be manufactured. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing apparatus capable of manufacturing a semiconductor device at low cost can be provided.

Embodiment Mode 3

[0115] In this embodiment mode, examples of a manufacturing method of a semiconductor device is described with reference to FIGS. **5**A and **5**B, and **6**A to **6**C, which vary depending on which surface of the semiconductor integrated circuit over the support means **201** is provided with connection terminals. Note that in this embodiment mode, although description will be made by using the manufacturing apparatus of a semiconductor device shown in FIGS. **2**A to **2**D, the manufacturing apparatuses of a semiconductor device shown in FIGS. **3**A to **4**D can also be used as appropriate.

[0116] FIGS. **5**A and **5**B show cross sections of a manufacturing apparatus of a semiconductor device in the x-axis direction, similarly to FIGS. **2**A and **2**C. Although not shown in FIGS. **5**A and **5**B, a plurality of holders are arranged in a row in the y-axis direction of the roller, similarly to FIGS. **2**B and **2**D. Similarly, FIGS. **6**A to **6**C show cross sections of a manufacturing apparatus of a semiconductor device in the x-axis direction of the roller. Although not shown in FIGS. **6**A to **6**C, a plurality of holders are also arranged in a row in the y-axis direction of the roller.

[0117] As shown in a magnified view **260** in FIG. **5**A, description will be made of an example where connection terminals **261***a* and **261***b* of the semiconductor integrated circuit **202** face the support means **201**, but are not exposed to the holder **204** side. In this manner, the structure where the connection terminals **261***a* and **261***b* of the semiconductor integrated circuit **202** face the support means **201** may be obtained through the steps of: forming through-holes for connecting semiconductor elements in the semiconductor integrated circuit **202**, and filling the through-holes with plugs so that the plugs can be used as the connection terminals **261***a* and **261***b*. Alternatively, after forming connection terminals on the surface of the semiconductor integrated circuit, the semiconductor integrated circuit may be flipped to be provided on the support means **201** so that the connection terminals face the support means **201**.

[0118] Similarly to FIGS. **2**A and **2**B, the semiconductor integrated circuit **202** provided over the support means **201** is caught and held by one of the holders **204** arranged in a row on the roller **203**. As shown in the magnified view **260** of the region where the holder **204** holds the semiconductor integrated circuit **202**, a surface of the semiconductor integrated circuit **202** on which the connection terminals **261***a* and **261***b* are formed faces the support means **201** side, and on the opposite surface thereof, the holder **204** holds the semiconductor integrated circuit **202**.

[0119] Next, by rotating the roller **203** in the opposite direction to or the same direction as the roller **206**, the semiconductor integrated circuits **202** are picked up from the support means **201**. Next, although not shown in the drawing, the pitch of the holders **204** arranged in a row is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202** can be positioned opposite the respective connection terminals of the antennas **209**.

[0120] Next, as shown in FIG. **5**B, when the roller **203** and the holders **204** arranged in a row have moved to a position opposite the flexible substrate **208** and the antennas **209**, one or both of pressure treatment and thermal treatment is/are performed using the roller **206** and the holders **204**, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. By appropriately controlling the distance between the roller **206** and the holders **204** and the rotation speed of the pair of the rollers **203** and **206**, the semiconductor integrated circuits **202** can be mounted on the respective antennas **209** formed over the flexible substrate **208**. As shown in a magnified view **263** of the connection terminals of the semiconductor integrated circuit **202** and the antenna **209**, the antenna **209** and the semiconductor integrated circuit **202** are connected to each other through the anisotropic conductive film **210**.

[0121] After that, the flexible substrate **208** having the antennas **209** and the semiconductor integrated circuits **202** mounted on the respective antennas **209** can be collected by the roller **207**.

[0122] Next, as shown in a magnified view **270** in FIG. **6**A, description will be made of an example where connection terminals **271***a* and **271***b* of the semiconductor integrated circuit **202** face the holder **204** side, but are not exposed to the support means **201** side.

[0123] The semiconductor integrated circuit whose connection terminals **271***a* and **271***b* face the holder **204** is picked up by the holder **204** of the roller **203**. The connection terminals **271***a* and **271***b* do not face the antenna **209** even when the jig is rotated. Therefore, the manufacturing apparatus of a semiconductor device requires a flip-chip means for flipping the semiconductor integrated circuit **202**, in addition to the jig. Here, the flip-chip means is constructed from a roller **272** and holders **273** provided on the roller **272**.

[0124] As the roller **272** which forms the flip-chip means, the one similar to the rollers **203**, **205**, **206**, and **207** can be used. It is preferable that the number of the holders **273** be about equal to that of the holders **204**, and the holders **273** be arranged in a row with a similar pitch to the holders **204**. As a result, all of the semiconductor integrated circuits **202** which are picked up by the holders **204** can be delivered to the holders **273**.

[0125] The roller **272** rotates in the opposite direction to or the same direction as the roller **203**. The roller **272** of the flip-flop means and the roller **206** are provided so that their rotation axes are parallel with each other, with the antennas **209** and the flexible substrate **208** therebetween. As a result, the semiconductor integrated circuits **202** which are picked up from the support means **201** by using the roller **203** and the holders **204** thereon (i.e., jig) are transferred to the roller **272** and the holders **273** thereon (i.e., flip-chip means).

[0126] Next, by rotating the roller **272** which is the flip-chip means, the flexible substrate **208** having the antennas **209** and the semiconductor integrated circuits **202** can be attached to each other by the holders **273** and the roller **206**.

[0127] A manufacturing method of a semiconductor device is described with reference to FIGS. **6**A to **6**C.

[0128] As shown in FIG. **6**A, the semiconductor integrated circuits **202** provided over the support means **201** are picked up by the holders **204** on the roller **203**, similarly to FIGS. **2**A and **2**B. As shown in the magnified view **270** of the region where the holder **204** holds the semiconductor integrated circuit **202**, the connection terminals **271***a* and **271***b* of the semiconductor integrated circuit **202** face the holder **204**. The holder **204** holds the semiconductor integrated circuit **202** in a region where the connection terminals **271** and **271***b* are not formed.

[0129] Next, as shown in FIG. **6**B, by rotating the roller **203** in the opposite direction to the roller **272**, the semiconductor integrated circuits **202** are transferred from the holders **204** of the jig to the holders **273** of the flip-chip means. As shown in a magnified view **274** of a region where the holders **204** and **273** hold the semiconductor integrated circuit **202** therebetween, the semiconductor integrated circuit **202** is held by the holder **273** such that the holder **273** faces a surface opposite to the surface where the connection terminals **271***a* and **271***b* of the semiconductor integrated circuit **202** are formed.

[0130] Note that instead of the above method, one or both of the rollers **203** and **272** may be provided with a moving means for moving the rotation axis (axes) of the roller(s). In that case, the rotation of the rollers **203** and **272** is stopped when the holders **204** of the roller **203** are positioned opposite the holders **273** of the roller **272** with the semiconductor integrated circuits **202** therebetween. Next, by moving one or both of the rollers **203** and **272** so that their rotation axes get close to each other, using the moving means for moving the rotation axis (axes) of one or both of the rollers **203** and **272**, the semiconductor integrated circuits **202** may be transferred from the holders **204** to the holders **273**.

[0131] Next, although not shown in the drawing, the pitch of the holders **273** is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202** and the antennas **209** can be positioned opposite each other.

[0132] Next, as shown in FIG. **6**C, the roller **206** is rotated in the opposite direction to or the same direction as the roller **272**. Thus, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the roller **206** and the holders **273**, one or both of pressure treatment and thermal treatment is/are performed. Thus, the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. As shown in a magnified view **275** of the connection terminals of the semiconductor integrated circuit **202** and the antenna **209**, the antenna **209** and the semiconductor integrated circuit **202** are connected to each other through the anisotropic conductive film **210**.

[0133] Alternatively, the following method can be used instead of the above method to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **272**, the rotation of the rollers **203**, **205** to **207**, and **272** is stopped. Next, although not shown in the drawing, the pitch of the holders **273** is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202** can be positioned opposite the respective connection terminals of the antennas **209**. Next, the roller **272** is moved to the roller **206** side by a moving means for moving the rotation axis of the roller **272**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the holders **273** and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, the roller **272** is moved to the support means **201** side by the moving means for moving the rotation axis of the roller **272**. After that, the rollers **203**, **205** to **207**, and **272** are rotated.

[0134] As a further alternative, the following method can be used instead of the above methods to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **272**, the rotation of the rollers **203**, **205** to **207**, and **272** is stopped. Next, although not shown in the drawing, the pitch of the holders **273** is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202** can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **203**, **205** to **207**, and **272** do not rotate, the rollers **205** to **207** are moved to the holders **273** side by moving means for moving the rotation axes of the rollers **205** to **207**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the roller **206** and the holders **273**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, after moving the rollers **205** to **207** away from the support means **201** by the moving means for moving the rotation axes of the rollers **205** to **207**, the rollers **203**, **205** to **207**, and **272** are rotated.

[0135] As a further alternative, the following method can be used instead of the above methods to mount the semiconductor integrated circuits **202** on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202** have moved to a position opposite the antennas **209** by rotating the roller **272**, the rotation of the rollers **203**, **205** to **207**, and **272** is stopped. Next, although not shown in the drawing, the pitch of the holders **273** is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202** can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **203**, **205** to **207**, and **272** do not rotate, the holders **273** are stretched to the roller **206** side by a means for controlling the telescopic movement of the holders **273**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202** between the holders **273** and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202** are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, after shrinking the holders **273** by the means for controlling the telescopic movement of the holders **273**, the rollers **203**, **205** to **207**, and **272** are rotated.

[0136] After that, the flexible substrate **208** having the antennas **209** with the semiconductor integrated circuits **202** attached is collected by the roller **207**.

[0137] By the above manufacturing method of a semiconductor device, a plurality of semiconductor devices can be manufactured by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of antennas, regardless of a position where the connection terminals of the semiconductor integrated circuits are formed. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing apparatus capable of manufacturing a semiconductor device at low cost can be provided.

Embodiment Mode 4

[0138] In this embodiment mode, a jig which is applicable to Embodiment Mode 2 or 3 is described with reference to FIGS. **7**A, **7**B, **8**A and **8**B.

[0139] A manufacturing apparatus of a semiconductor device shown in FIGS. **7**A and **7**B has a jig in which a roller **241** is provided with 2n (n is natural number) sets of holders. In FIGS. **7**A and **7**B, a jig in which the roller **241** is provided with two sets of holders **242***a* and **242***b* is shown. A pair of the holders **242***a* and **242***b* are preferably provided to be symmetrical about the rotation axis of the roller **241**. As a result, a row of semiconductor integrated circuits over the support means **201** can be picked up, while at the same time another row of semiconductor integrated circuits can be attached to the flexible substrate **208** having antennas during a rotation of 1/2n. Therefore, throughput can be improved.

[0140] Here, by rotating the rollers **206** and **241** in opposite directions or in the same direction, semiconductor integrated circuits **202***a* over the support means **201** can be picked up by the holders **242***a*, while at the same time semiconductor integrated circuits **202***b* can be mounted on the respective antennas **209** by the holders **242***b*.

[0141] Next, as shown in FIG. **7**B, the rollers **205** to **207** are rotated to move the flexible substrate **208** having the antennas **209**. In addition, the roller **241** is also rotated so that the semiconductor integrated circuits **202***a* which have been picked up from the support means **201** by the holders **242***a* are put close to the antennas **209**, while at the same time the holders **242***b* are put close to the support means **201**. After that, the semiconductor integrated circuits **202***a* can be mounted on the respective antennas **209**, while at the same time semiconductor integrated circuits **202***c* over the support means **201** can be picked up by the holders **242***b*.

[0142] Note that although not shown in the drawing, before putting the semiconductor integrated circuits **202***a* close to the antennas **209**, the pitch of the holders **242***a* is widened in the y-axis direction so that the holders **242***a* can be positioned opposite the respective connection terminals of the antennas **209**. On the other hand, before picking up the semiconductor integrated circuits **202***c* by the holders **242***b*, the pitch of the holders **242***b* is shrunk in the y-axis direction so that the holders **242***b* can be positioned opposite the respective connection terminals of the semiconductor integrated circuits **202***c*.

[0143] Alternatively, the following method can be used instead of the above method to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuits on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits

202*b* have moved to a position opposite the antennas **209** and also when the holders **242***a* have moved to a position opposite the semiconductor integrated circuits **202***a* over the support means **201**, by rotating the roller **241**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are stopped. Next, although not shown in the drawing, the pitch of the holders **242***b* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***b* can be positioned opposite the respective connection terminals of the antennas **209**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***b* between the holders **242***b* and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***b* are mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0144] Next, by moving the roller **241** to the support means **201** side by the moving means for moving the rotation axis of the roller **241**, the semiconductor integrated circuits **202***a* over the support means **201** are caught and held by the holders **242***a*. Then, the roller **241** is moved to the roller **206** side by the moving means for moving the rotation axis of the roller **241**, so that the semiconductor integrated circuits **202***a* are picked up, upon which the roller **241** is moved to a position where the holders **242***a* and **242***b* have no contact with the flexible substrate **208**, the antennas **209**, and the anisotropic conductive film **210**. After that, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are resumed.

[0145] As a further alternative, the following method can be used to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuits on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202***b* have moved to a position opposite the antennas **209** by rotating the roller **241**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are stopped. Next, although not shown in the drawing, the pitch of the holders **242***b* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***b* can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **205** to **207** and **241** do not rotate, the rollers **205** to **207** are moved to the holders **242***b* side by moving means for moving the rotation axes of the rollers **205** to **207**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***b* between the roller **206** and the holders **242***b*, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***b* are mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0146] Next, the rollers **205** to **207** are moved away from the roller **241** by the moving means for moving the rotation axes of the rollers **205** to **207**. Next, the roller **241** is moved to the side of the semiconductor integrated circuits **202***a* by a moving means for moving the rotation axis of the roller **241**, so that the semiconductor integrated circuits **202***a* over the support means **201** are caught and held by the holders **242***a*. Then, the roller **241** is moved to the roller **206** side by the moving means for moving the rotation axis of the roller **241**, so that the semiconductor integrated circuits **202***a* are picked up. Then, the roller **241** is moved to a position where the holders **242***a* and **242***b* have no contact with the flexible substrate **208**, the antennas **209**, and the anisotropic conductive film **210**. After that, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are resumed.

[0147] As a further alternative, the following method can be used to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuit on the respective antennas **209** over the flexible substrate **208**. When the semiconductor integrated circuits **202***b* have moved to a position opposite the antennas **209** by rotating the roller **241**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are stopped. Next, although not shown in the drawing, the pitch of the holders **242***b* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***b* can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **205** to **207** and **241** do not rotate, the holders **242***b* are stretched to the roller **206** side by a means for controlling the telescopic movement of the holders **242***b*. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***b* between the holders **242***b* and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***b* are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, the holders **242***b* are shrunk by the means for controlling the telescopic movement of the holders **242***b*.

[0148] Next, the holders **242***a* are stretched to the support means **201** side by a means for controlling the telescopic movement of the holders **242***a*, thereby the semiconductor integrated circuits **202***a* over the support means **201** are caught and held by the holders **242***a*, so that the semiconductor integrated circuits **202***a* are picked up. Next, after shrinking the holders **242***a* by the means for controlling the telescopic movement of the holders **242***a*, the holders **242***a* and **242***b* are set in positions having no contact with the flexible substrate **208**, the antennas **209**, and the anisotropic conductive film **210**. After that, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **241** are resumed.

[0149] Through the above steps, a row of semiconductor integrated circuits can be attached to respective antennas, while at the same time another row of semiconductor integrated circuits over the support means can be picked up by holders, during the period in which the roller **241** rotates by 360 degrees.

[0150] Next, an example of a manufacturing apparatus of a semiconductor device having a jig in which a roller **251** is provided with 2n+1 (n is natural number) sets of holders is described, with reference to FIGS. **8**A and **8**B. In FIGS. **8**A and **8**B, a jig in which the roller **251** is provided with three sets of holders **252***a* to **252***c* is shown. Here, each set of holders is preferably provided at even intervals around the rotation axis of the roller **251** (at 360/(2n+1) degrees). As a result, it becomes possible to perform a step of picking up a row of semiconductor integrated circuits over the support means **201** by holders, and a step of attaching another row of semiconductor integrated circuit to the flexible substrate **208** having the antennas **209** by holders, at different timing, whereby each step can be prevented from interfering with the other step. As a result, each step can be surely performed. Here, each set of holders is disposed at intervals of 120° C. around the rotation axis.

[0151] Here, by rotating the rollers **206** and **251** in opposite directions or in the same direction, the semiconductor integrated circuits **202***c* over the support means **201** can be picked up by the holders **252***c*.

[0152] Next, as shown in FIG. **8**B, the flexible substrate **208** having the antennas **209** is moved by rotating the rollers **205** to **207**. In addition, by rotating the roller **251**, the semiconductor integrated circuits **202***a* which have been picked up from the support means **201** by the holders **252***a* can be attached to the respective antennas **209**.

[0153] Note that although not shown in the drawing, before putting the semiconductor integrated circuits **202***a* close to the antennas **209**, the pitch of the holders **252***a* is widened in the y-axis direction so that the holders **252***a* can be positioned opposite the respective connection terminals of the antennas **209**. On the other hand, before picking up the semiconductor integrated circuits **202***c* by the holders **252***c*, the pitch of the holders **252***c* is narrowed in the y-axis direction so that the holders **252***c* can be positioned opposite the respective connection terminals of the semiconductor integrated circuits **202***c*.

[0154] Alternatively, the following method can be used to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuits on the respective antennas **209** over the flexible substrate **208**. When the holders **252***c* have moved to a position opposite the semiconductor integrated circuits **202***c* by rotating the roller **251**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. Next, the roller **251** is moved to the support means **201** side by a moving means for moving the rotation axis of the roller **251**, thereby the semiconductor integrated circuits **202***c* over the support means **201** are caught and held by the holders **252***c*. Next, by moving the roller **251** to the roller **206** side by the moving means for moving the rotation axis of the roller **251**, the semiconductor integrated circuits **202***c* are picked up. After that, the roller **251** is moved to a position where the holders **252***a* to **252***c* have no contact with the flexible substrate **208**, the antennas **209**, and the anisotropic conductive film **210**. Next, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are resumed.

[0155] Next, as shown in FIG. **8**B, when the semiconductor integrated circuits **202***a* have moved to a position opposite the antennas **209**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. Next, although not shown in the drawing, the pitch of the holders **252***a* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***a* can be positioned opposite the respective connection terminals of the antennas **209**. Next, the roller **251** is moved to the roller **206** side by the moving means for moving the rotation axis of the roller **251**. Then, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***a* between the roller **206** and the holders **252***a*, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***a* can be mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0156] Although not shown in the drawing, after mounting the semiconductor integrated circuits **202***a* on the respective antennas **209**, the pitch of the holders **252***a* is narrowed in the y-axis direction.

[0157] As a further alternative, the following method can be used to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuits on the respective antennas **209** over the flexible substrate **208**. When the holders **252***c* have moved to a position opposite the semiconductor integrated circuits **202***c* by rotating the roller **251**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. Next, the roller **251** is moved to the support means **201** side by a moving means for moving the rotation axis of the roller **251**, thereby the semiconductor integrated circuits **202***c* over the support means **201** are picked up by the holders **252***c*. Next, by moving the roller **251** to the roller **206** side by the moving means for moving the rotation axis of the roller **251**, the holders **252***a* to **252***c* are set in positions having no contact with the flexible substrate **208**, the antenna **209**, and the anisotropic conductive film **210**. After that, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are resumed.

[0158] Next, as shown in FIG. **8**B, when the semiconductor integrated circuits **202***a* have moved to a position opposite the antennas **209**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. Next, although not shown in the drawing, the pitch of the holders **252***a* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***a* can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **205** to **207** and **251** do not rotate, the rollers **205** to **207** are moved to the holders **252***a* side by moving means for moving the rotation axes of the rollers **205** to **207**. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***a* between the roller **206** and the holders **252***a*, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***a* can be mounted on the respective antennas **209** formed over the flexible substrate **208**.

[0159] Next, the roller **206** is moved away from the roller **251** by the moving means for moving the rotation axes of the rollers **205** to **207**.

[0160] Although not shown in the drawing, after mounting the semiconductor integrated circuits **202***a* on the respective antennas **209**, the pitch of the holders **252***a* is narrowed in the y-axis direction.

[0161] As a further alternative, the following method can be used to pick up a row of semiconductor integrated circuits from the support means **201** and also to mount another row of semiconductor integrated circuits on the respective antennas **209** over the flexible substrate **208**. When the holders **252***c* have moved to a position opposite the semiconductor integrated circuits **202***c* by rotating the roller **251**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. The holders **252***c* are stretched to the support means **201** side by a means for controlling the telescopic movement of the holders **252***c*, thereby the semiconductor integrated circuits **202***c* over the support means **201** are caught and held by the holders **252***c*. Next, by shrinking the holders **252***c* by the means for controlling the telescopic movement of the holders **252***c*, and picking up the semiconductor integrated circuits **202***c*, the holders **252***a* to **252***c* are set in positions having no contact with the flexible substrate **208**, the antennas **209**, and the anisotropic conductive film **210**. After that, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are resumed.

[0162] Next, as shown in FIG. **8**B, when the semiconductor integrated circuits **202***a* have moved to a position opposite the antennas **209**, the movement of the support means **201** and the rotation of the rollers **205** to **207** and **251** are stopped. Next, although not shown in the drawing, the pitch of the holders **252***a* is widened in the y-axis direction by a controller so that the connection terminals of the semiconductor integrated circuits **202***a* can be positioned opposite the respective connection terminals of the antennas **209**. Next, with the condition that the rollers **205** to **207** and **251** do not rotate, the holders **252***a* are stretched to the roller **206** side by the means for controlling the telescopic movement of the holders **252***a*. Next, while holding the flexible substrate **208**, the antennas **209**, the anisotropic conductive film **210**, and the semiconductor integrated circuits **202***a* between the holders **252***a* and the roller **206**, one or both of pressure treatment and thermal treatment is/are performed, thereby the semiconductor integrated circuits **202***a* are mounted on the respective antennas **209** formed over the flexible substrate **208**. Next, the holders **252***a* are shrunk by the means for controlling the telescopic movement of the holders **252***a*.

[0163] Through the above steps, a row of semiconductor integrated circuits can be attached to respective antennas, while at the same time another row of semiconductor integrated circuits over a support means can be picked up by holders, during the period in which the roller **251** rotates by 360 degrees. Therefore, a plurality of steps can be performed at the same time. Furthermore, a plurality of semiconductor devices can be manufactured by picking up a plurality of semiconductor integrated circuits and attaching them to a plurality of antennas. Therefore, a tact time can be reduced and mass productivity can be improved. Thus, a manufacturing apparatus capable of manufacturing a semiconductor device at low cost can be provided.

Embodiment 1

[0164] In this embodiment, a manufacturing process of a semiconductor device capable wireless data transmission is described with reference to FIGS. **6**A to **6**C, **9**A to **9**E, **10**A to **10**D, **11**A to **11**C, and **12**A and **12**B. In FIGS. **9**A to **9**E, **10**A to **10**D, **11**A to **11**C, and **12**A and **12**B, cross sections of the semiconductor device shown in FIGS. **6**A to **6**C in the y-axis direction are shown.

[0165] As shown in FIG. **9**A, a peeling layer **1202** is formed over a substrate **1201**; an insulating layer **1203** is formed over the peeling layer **1202**; a thin film transistor **1204** and an interlayer insulating layer **1205** for insulating conductive layers of respective thin film transistors are formed over the insulating layer **1203**; and source and drain electrodes **1206** connected to a semiconductor layer of each thin film transistor are formed. Next, an insulating layer **1207** which covers the thin film transistor **1204**, the interlayer insulating layer **1205**, and the source and drain electrodes **1206** is formed, and a conductive layer **1208** connected to the source or drain electrode **1206** with the insulating layer **1207** interposed therebetween is formed.

[0166] As the substrate **1201**, a glass substrate, a quartz substrate, a metal substrate or a stainless steel substrate having an insulating layer formed on its surface, a plastic substrate which can withstand the treatment temperature of the process in this embodiment, or the like is used. The above substrate **1201** has no limitations on size and shape. Therefore, if a rectangular substrate with one meter or longer on a side is used as the substrate **1201**, productivity can be significantly improved. This is a great advantage as compared with the case of using a circular silicon substrate.

[0167] The peeling layer **1202** is formed to have either a single layer or stacked layers by a sputtering method, a plasma CVD method, a coating method, or a printing method, using an element selected from tungsten (W), molybdenum (Mo), titanium (Ti), tantalum (Ta), niobium (Nb), nickel (Ni), cobalt (Co), zirconium (Zr), zinc (Zn), ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and silicon (Si), or an alloy material or a compound material containing such an element as a main component. When the peeling layer **1202** is a layer containing silicon, any of an amorphous structure, a microcrystalline structure, and a polycrystalline structure can be used.

[0168] When the peeling layer **1202** has a single-layer structure, it is preferable to form a tungsten layer, a molybdenum layer, or a layer containing a compound of tungsten and molybdenum. Alternatively, the peeling layer **1202** is formed using a tungsten oxide layer, a tungsten oxynitride layer, a molybdenum oxide layer, a molybdenum oxynitride layer, or a layer containing oxide or oxynitride of a compound of tungsten and molybdenum. Note that the compound of tungsten and molybdenum corresponds to, for example, an alloy of tungsten and molybdenum.

[0169] When the peeling layer **1202** has a stacked-layer structure, it is preferable to form, as a first layer, a tungsten layer, a molybdenum layer, or a layer containing a compound of tungsten and molybdenum, and form, as a second layer, oxide, nitride, oxynitride, or nitride oxide of tungsten, molybdenum, or a compound of tungsten and molybdenum.

[0170] Note that when the peeing layer **1202** is formed to have a stacked-layer structure of a tungsten layer and a tungsten oxide layer, the tungsten layer may be formed first and an insulating layer made of oxide may be formed thereon so that a tungsten oxide layer is formed in the interface between the tungsten layer and the insulating layer. Furthermore, it is also possible to form a tungsten oxide layer by performing thermal oxidation treatment, oxygen plasma treatment, N_2O plasma treatment, treatment with a solution having strong oxidation power such as ozone water or water containing hydrogen, or the like to the surface of the tungsten layer. The same can be said for the case of forming a tungsten nitride layer, a tungsten oxynitride layer, or a tungsten nitride oxide layer. For example, it is preferable to form a tungsten layer first, and then form a silicon nitride layer, a silicon oxynitride layer, or a silicon nitride oxide layer on the tungsten layer.

[0171] Tungsten oxide is represented by WO_x, where x is in the range of 2 to 3, inclusive. There are cases where x is 2 (WO_2), x is 2.5 (W_2O_5), x is 2.75 (W_4O_{11}), x is 3 (WO_3), and the like.

[0172] Although the peeling layer **1202** is formed so as to contact the substrate **1201** in the above step, the invention is not limited to this step. For example, it is possible to form a base insulating layer to contact the substrate **1201**, and then form the peeling layer **1202** to contact the insulating layer.

[0173] The insulating layer **1203** is formed to have either a single layer or stacked layers by a sputtering method, a plasma CVD method, a coating method, a printing method, or the like, using an inorganic compound. As typical examples of the inorganic compound, silicon oxide and silicon nitride can be given.

[0174] Furthermore, the insulating layer **1203** may have a stacked-layer structure. For example, the insulating layer **1203** may be formed by stacking inorganic compounds, and typically by stacking silicon oxide, silicon nitride oxide, and silicon oxynitride.

[0175] The thin film transistor **1204** includes a semiconductor layer having a source region, a drain region, and a channel formation region; a gate insulating layer; and a gate electrode.

[0176] The semiconductor layer is a layer formed of a semiconductor with a crystalline structure, and either a non-single crystalline semiconductor or a single crystalline semiconductor can be used. In particular, it is preferable to employ a crystalline semiconductor which is crystallized by thermal treatment or a crystalline semiconductor which is crystallized by a combination of thermal treatment and laser light irradiation. For the thermal treatment, a crystallization method can be used, which uses a metal element such as nickel having a function of promoting the crystallization of a silicon semiconductor. Furthermore, by the heating conducted in the crystallization step of the silicon semiconductor, the surface of the peeling layer **1202** is oxidized, so that a metal oxide layer can be formed in the interface between the peeling layer **1202** and the insulating layer **1203**.

[0177] In the case of performing crystallization by laser light irradiation in addition to the thermal treatment, crystallization can be performed by continuously moving the melt zone in which the crystallization semiconductor is melt, along the laser light irradiation direction, while irradiating the semiconductor layer with a continuous wave laser beam or an ultrashort pulsed laser beam having a repetition rate of 10 MHz or higher and a pulse width of 1 nanosecond or shorter, or preferably in the range of 1 to 100 picoseconds, inclusive. By such a crystallization method, a crystalline semiconductor having crystal grains which have a large grain size and have grown in one direction can be obtained. By aligning the carrier moving direction with the direction in which such crystalline grains are grown, electron field-effect mobility of the transistor can be increased. For example, 400 cm 2V-sec or higher can be attained.

[0178] In the case of using the above crystallization step for a crystallization process at a temperature equal to or lower than the allowable temperature limit of a glass substrate (approximately 600° C.), a large-area glass substrate can be used. Therefore, large quantities of semiconductor devices can be manufactured from one substrate, and thus cost reduction can be achieved.

[0179] Alternatively, a semiconductor layer can be formed by performing a crystallization step by heating at a temperature equal to or higher than the allowable temperature limit of a glass substrate. Typically, a quartz substrate is used as the substrate **1201** having an insulating surface, and an amorphous or microcrystalline semiconductor is heated at 700° C. or higher, thereby forming a semiconductor layer. As a result, a highly crystalline semiconductor can be formed. Therefore, a thin film transistor which has excellent properties such as a high response speed and high mobility, and which can operate at high speed can be provided.

[0180] The gate insulating layer is formed using an inorganic insulator such as silicon oxide or silicon oxynitride.

[0181] The gate electrode can be formed using a metal or a polycrystalline semiconductor which is doped with an impurity having one conductivity type. In the case of using a metal, tungsten (W), molybdenum (Mo), titanium (Ti), tantalum (Ta), aluminum (Al), or the like can be used. Further, a metal nitride which is obtained by nitriding a metal can be used. Alternatively, a structure where a first layer made of the metal nitride and a second layer made of the metal are stacked may be employed. In the case of forming a stacked-layer structure, a shape that the edge of the first layer is wider than the edge of the second layer may be formed. In that case, if the first layer is formed of a metal nitride, it can function as a barrier metal. That is, the metal of the second layer can be prevented from diffusing into the gate insulating layer or the semiconductor layer below the gate insulating layer.

[0182] As the thin film transistor which is formed by combining the semiconductor layer, the gate insulating layer, the gate electrode, and the like, various structures can be employed such as a single drain structure, an LDD (Lightly Doped Drain) structure, and a gate overlapped drain structure. Here, a thin film transistor with a single drain structure is shown. Furthermore, a multigate structure where transistors to which the same gate potential is applied are connected in series, a dual gate structure where a semiconductor layer is interposed between gate electrodes, an inversely staggered thin film transistor where a gate electrode is formed over the insulating layer **1203**, and a gate insulating layer and a semiconductor layer are formed over the gate electrode, or the like can be used.

[0183] The source and drain electrodes **1206** are preferably formed by combining a low-resistance material such as aluminum (Al) and a high-melting-point metal material such as titanium (Ti) or molybdenum (Mo), e.g., a stacked-layer structure of titanium (Ti) and aluminum (Al) or a stacked-layer structure of molybdenum (Mo) and aluminum (Al).

[0184] The interlayer insulating layer **1205** and the insulating layer **1207** are formed by using polyimide, acrylic, or siloxane polymers.

[0185] Furthermore, any other semiconductor elements which can function as switching elements can be provided in any structure instead of the thin film transistor **1204**. As typical examples of the switching element, a MIM (Metal-Insulator-Metal), a diode, and the like can be given.

[0186] Next, as shown in FIG. **9**B, a conductive layer **1211** is formed over the conductive layer **1208**. Here, the conductive layer **1211** is formed by printing a composition containing metal particles by a printing method, and then heating and baking the composition at 200° C. for 30 minutes.

[0187] Next, as shown in FIG. **9**C, an insulating layer **1212** which covers the insulating layer **1207** and the edge of the conductive layer **1211** is formed. Here, an epoxy resin is applied by a spin coating method and heated at 160° C. for 30 minutes. Then, a portion of the insulating layer **1212** which covers the conductive layer **1211** is removed to expose the conductive layer **1211**. Here, a stack having the insulating layer **1203** as the bottom layer and the insulating layer **1212** as the top layer serves as an element formation layer **1210**.

[0188] Next, as shown in FIG. **9**D, in order to facilitate the later peeling step, the insulating layers **1203**, **1205**, **1207**, and **1212** are irradiated with laser beams **1213** to form openings **1214** as shown in FIG. **9**E. As the laser beams used for forming the openings **1214**, laser beams having a wavelength which can be absorbed by the insulating layers **1203**, **1205**, **1207**, and **1212** are preferably used. Typically, a laser beam in the UV region, visible region, or infrared region is selected as appropriate for irradiation.

[0189] As a laser oscillator which can produce such laser beams, the following can be used: an excimer laser oscillator such as ArF, KrF, or XeCl; a gas laser oscillator such as He, He—Cd, Ar, He—Ne, HF, or CO_2; a solid-state laser oscillator of crystals, glass, ruby, or the like, in which crystals such as YAG, $GdVO_4$, YVO_4, YLF, or $YAlO_3$ are doped with Cr, Nd, Er, Ho, Ce, Co, Ti, or Tm; or a semiconductor laser oscillator such as GaN, GaAs, GaAlAs, or InGaAsP. Note that in the case of using a solid-state laser oscillator, it is preferable to use the fundamental wave to the fifth harmonic as appropriate. As a result, laser beams are absorbed by the insulating layers **1203**, **1205**, **1207**, and **1212**, and thus openings are formed therein.

[0190] Note that when the step of irradiating the insulating layers **1203**, **1205**, **1207**, and **1212** with laser beams is omitted, throughput can be improved.

[0191] Next, a support base **1216** is attached to the insulating layer **1212** with an adhesive agent **1215**.

[0192] As the adhesive agent **1215**, a peelable adhesive agent can be used, typically such as a UV peelable adhesive agent which can be peeled off by an ultraviolet ray, a heat peelable adhesive agent which can be peeled off by heat, a water-soluble adhesive agent, or a double-sided tape. As a material of the support base **1216**, a glass substrate, a quartz substrate, a metal substrate, a plastic substrate, a flexible substrate (e.g., PET, PES, polycarbonate, or paper made of a fibrous material), or the like can be used as appropriate. Here, synthetic paper is used as the support base **1216**.

[0193] Note that the adhesive strength between the adhesive agent **1215**, the support base **1216**, and the element formation layer **1210** is set higher than the adhesive strength between the peeling layer **1202** and the insulating layer **1203**.

[0194] Next, as shown in FIG. **10**A, the substrate **1201** having the peeling layer **1202** and a part **1221** of the element formation layer are separated from each other by a physical method at the metal oxide layer which is formed in the interface between the peeling layer **1202** and the insulating layer **1203**. A physical method means a mechanical method, i.e., a method of changing certain mechanical energy. Typically, a physical method means an action of applying mechanical force (e.g., peeling with the human hands or with a gripper, or a separation process by rotating a roller as a supporting point).

[0195] The above peeling step is characterized in that a layer which does not contract by thermal treatment, a layer which contracts by thermal treatment, and an intermediate layer between the two layers are formed, and thermal treatment is performed at the completion of the peeling step or during the peeling step, so that excess stress is applied to the intermediate layer or to a region in the vicinity of the intermediate layer, and after that, by applying a stimulus to the intermediate layer, separation occurs at the intermediate layer or in the region in the vicinity of the intermediate layer.

[0196] In this embodiment, the layer which does not contract by thermal treatment is the peeling layer **1202**; the layer which contracts by thermal treatment is the insulating layer **1203** or the insulating layer **1212**; and the intermediate layer between the two layers is a metal oxide layer formed in the interface between the peeling layer **1202** and the insulating layer **1203**. As a typical example, when a tungsten layer is used as the peeling layer **1202**, silicon oxide or silicon nitride is used as the insulating layer **1203**, and an epoxy resin is used as the insulating layer **1212**, the peeling layer **1202** does not contract by the thermal treatment in crystallization, impurity activation, or dehydrogenation of an amorphous silicon film, while the insulating layer **1203** or the insulating layer **1212** contracts, and further, a tungsten oxide layer (WO_x where $2 \leqq x \leqq 3$) is formed at the interface between the peeling layer **1202** and the insulating layer **1203**. Since a tungsten oxide layer is weak, it can easily be separated by the above physical method. As a result, the part **1221** of the element formation layer can be separated from the substrate **1201** by the above physical method.

[0197] Note that when the support base **1216** is a flexible substrate, by providing a pair of rollers at each side in the traveling direction as the supporting points of the support base **1216**, setting the support base **1216** on the element formation layer **1210** with the adhesive agent **1215** interposed therebetween, and pushing the support base **1216** with a pressure bond head, the support base **1216** can be attached to the element formation layer **1210** with the adhesive agent **1215** interposed therebetween. Next, after taking away the pressure bond head, the roller of front side is gradually pulled up so that the pair of the rollers have a difference in elevation. As a result, since the rollers are used as the supporting points of the support base **1216**, the support base **1216** and the element formation layer **1210** can be gradually peeled from the peeling layer.

[0198] Although this embodiment employs a method in which the metal oxide film is formed between the peeling layer and the insulating layer, and the element formation layer **1210** is separated at the metal oxide film by a physical method, the invention is not limited to this. For example, a method can be used in which a light-transmissive substrate is used as the substrate, an amorphous silicon film containing hydrogen is used as the peeling layer, and after the step in FIG. **9**E, the amorphous silicon film is irradiated with a laser beam from a substrate side so that hydrogen contained in the amorphous silicon film is vaporized and separation occurs between the substrate and the peeling layer.

[0199] Alternatively, after the step in FIG. **9**E, a method of removing the substrate by mechanical polishing, or a method of removing the substrate by using a solution such as HF which can dissolve the substrate can be employed. In that case, the peeling layer can be omitted.

[0200] As a further alternative, the following method can be used: before attaching the support base **1216** to the insulating layer **1212** by using the adhesive agent **1215** in FIG. **9**E, a halogen fluoride gas such as NF_3, BrF_3, or ClF_3 is introduced into the openings **1214** so that the peeling layer is etch-removed by the halogen fluoride gas, and the support base **1216** is attached to the insulating layer **1212** by using the adhesive agent **1215**, and then the element formation layer **1210** is separated from the substrate.

[0201] As a further alternative, the following method can be used: before attaching the support base **1216** to the insulating layer **1212** by using the adhesive agent **1215** in FIG. **9**E, a halogen fluoride gas such as NF_3, BrF_3, or ClF_3 is introduced into the openings **1214** so that the peeling layer is partially etch-removed by the halogen fluoride gas, and the support base **1216** is attached to the insulating layer **1212** with the adhesive agent **1215**, and then the element formation layer **1210** is separated from the substrate by a physical method.

[0202] Next, as shown in FIG. **10**B, a flexible substrate **1222** is attached to the insulating layer **1203** in the part **1221** of the element formation layer. As the flexible substrate **1222**, the substrate **111** illustrated in Embodiment Mode 1 can be used as appropriate.

[0203] As a method of attaching the flexible substrate **1222** to the insulating layer **1203**, there are a method of attaching the flexible substrate **1222** to the insulating layer **1203** with an adhesive agent, and a method of attaching the flexible substrate **1222** to the insulating layer **1203** including the steps of heating the flexible substrate **1222** so that it is partially melted, and cooling the flexible substrate **1222**. Note that the adhesive strength between the insulating layer **1203** and the flexible substrate **1222** is set higher than the adhesive strength between the adhesive agent **1215**, the support base **1216**, and the element formation layer **1210**. In the case of attaching the flexible substrate **1222** to the insulating layer **1203** with an adhesive agent, a material having higher adhesive power than the adhesive agent **1215** is selected as appropriate. Here, the flexible substrate **1222** is attached to the insulating layer **1203** with an adhesive agent **1223**. Next, the support base **1216** is peeled off the part **1221** of the element formation layer. Here, the adhesive agent **1215** is peeled off the part **1221** of the element formation layer by applying heat.

[0204] Next, as shown in FIG. **10**C, the flexible substrate **1222** is attached to a UV tape **1231** on a dicing frame **1232**. Since the UV tape **1231** has an adhesive property, the flexible substrate **1222** is fixed on the UV tape **1231**. After that, the conductive layer **1211** may be irradiated with a laser beam so that the adhesion between the conductive layer **1211** and the conductive layer **1208** is increased.

[0205] Next, a connection terminal **1233** is formed on the conductive layer **1211**. Forming the connection terminal **1233** can facilitate the later process of aligning and attaching a conductive layer functioning as an antenna.

[0206] Next, as shown in FIG. **10**D, the part **1221** of the element formation layer, the flexible substrate **1222**, and the second adhesive agent **1223** are cut. Here, the part **1221** of the element formation layer and the flexible substrate **1222** are irradiated with laser beams **1234** to form grooves **1241** as shown in FIG. **10**D, thereby the part **1221** of the element formation layer is divided into a plurality of sections. As the laser beams **1234**, laser beams described for the laser beams **1213** can be used as appropriate. Here, laser beams which can be absorbed by the insulating layers **1203**, **1205**, **1207**, and **1212**, and the flexible substrate **1222** are preferably used. Note that although the part of the element formation layer is cut into a plurality of sections by a laser ablation method, a dicing method, a scribing method, or the like can be used as appropriate instead of the laser ablation method. Note also that in the case of using fibrous paper as the flexible substrate **1222**, it is preferable not to use water in cutting the element formation layer by a dicing method, but to blow gas to the portions to be cut so that dust produced by cutting can be blown away. As a result, the element formation layer and the paper can be prevented from being separated from each other. Furthermore, by conducting dicing while blowing high-humidity gas onto the portions to be cut, the element formation layer can be prevented form being charged with static electricity. The element formation layers obtained after the cutting are denoted by semiconductor integrated circuits **1242***a* and **1242***b*.

[0207] Next, after attaching expander frames **1244** onto the UV sheet **1231**, the dicing frames **1232** are taken off the UV sheet **1231**. At this time, by attaching the expander frames **1244** while stretching the UV tape **1231**, the width of each groove **1241** which is formed between the semiconductor integrated circuits **1242***a* and **1242***b* can be increased.

[0208] Next, the UV tape **1231** on the expander frames **1244** is irradiated with UV light so that the adhesive power of the UV sheet is decreased. Next, using the manufacturing apparatus of a semiconductor device shown in FIGS. **6**A to **6**C, the expander frames **1244** mounting the semiconductor integrated circuits **1242***a* and **1242***b* are fixed with robot arms which are the support means. Next, the semiconductor integrated circuits **1242***a* and **1242***b* are picked up from the UV tape **1231** by the holders **204** of the jig (see FIG. **11**A).

[0209] Next, using the flip-chip means of the manufacturing apparatus of a semiconductor device shown in FIGS. **6**A to **6**C, the semiconductor integrated circuits **1242***a* and **1242***b* are transferred from the holders **204** to the holders **273** of the flip-chip means (see FIG. **11**B).

[0210] Next, as shown in FIG. **11**C, the holders **273** of the flip-chip means are moved by using a controller so that the semiconductor integrated circuits **1242***a* and **1242***b* can be positioned opposite antennas **209***a* and **209***b*, respectively.

[0211] Next, the flip-chip means having the holders **273** and the roller **206** in the manufacturing apparatus of a semiconductor device shown in FIGS. **6**A to **6**C are moved in the opposite direction to one another, so that the flexible substrate **208** having the antennas **209***a* and **209***b* and the semiconductor integrated circuits **1242***a* and **1242***b* are attached to each other with the anisotropic conductive film **210** as shown in FIG. **12**A. At this time, attachment is conducted so that the antennas **209***a* and **209***b* and the connection terminals **1233** of the semiconductor integrated circuits **1242***a* and **1242***b* are connected with conductive particles contained in the anisotropic film **210**.

[0212] Next, as shown in FIG. **12**B, at a region where the antennas **209***a* and **209***b* and the semiconductor integrated circuits **1242***a* and **1242***b* are not formed, the flexible substrate **208** is cut. As a method of cutting, a laser ablation method, a dicing method, a scribing method, or the like can be used as appropriate. Here, cutting is conducted by a laser ablation method by which the anisotropic conductive film **210** and the flexible substrate **208** are irradiated with a laser beam **1251**.

[0213] Though the above steps, semiconductor devices **1252***a* and **1252***b* capable of wireless data transmission can be manufactured.

[0214] Through the above steps, semiconductor devices which are thin and lightweight can be manufactured with high yield.

Embodiment 2

[0215] In this embodiment, the structure of a semiconductor device capable of wireless data transmission is described with reference to FIG. **14**.

[0216] The semiconductor device in this embodiment includes an antenna portion **2001**, a power supply portion **2002**, and a logic portion **2003** as its main components.

[0217] The antenna portion **2001** includes an antenna **2011** which receives external signals and transmits data. The signal transmission method of the semiconductor device can be any of an electromagnetic coupling method, an electromagnetic induction method, and a microwave method.

[0218] The power supply portion **2002** includes a rectifier circuit **2021** which produces power from a signal received from outside through the antenna **2011**, a storage capacitor **2022** which holds the produced power, and a constant voltage circuit **2023** which produces a constant voltage to be supplied to each circuit.

[0219] The logic circuit portion **2003** includes a demodulation circuit **2031** for demodulating received signals, a clock generation/correction circuit **2032** for generating clock signals, a code recognition/judgment circuit **2033**, a memory controller **2034** for generating signals for reading out data from a memory based on the received signals, a modulation circuit **2035** for superposing an encoded signal on the received signal, an encoding circuit **2037** for encoding the data read out, and a memory **2038** for storing data. Note that the modulation circuit **2035** includes a resistor **2036** for modulation.

[0220] As the memory **2038**, a DRAM (Dynamic Random Access Memory), an SRAM (Static Random Access Memory), an FERAM (Ferroelectric Random Access Memory), a mask ROM (Mask Read Only Memory), an EPROM (Electrically Programmable Read Only Memory), an EEPROM (Electrically Erasable and Programmable Read Only Memory), a flash memory, an organic memory, or the like is used as appropriate. Here, a mask ROM **2039** and a rewritable memory **2040** formed from an organic memory are shown as the memory **2038**.

[0221] A code recognized and judged by the code recognition/judgment circuit **2033** is a frame termination signal (EOF, End of Frame), a frame starting signal (SOF, Start of Frame), a flag, a command code, a mask length, a mask value, and the like. The code recognition/judgment circuit **2033** also has a cyclic redundancy check (CRC) function for discriminating send errors.

Embodiment 3

[0222] A semiconductor device capable of wireless data transmission as illustrated in the above embodiments can be applied to various uses, such as bills, coins, securities, bearer securities, documents (e.g., driver's licenses or resident's cards, see FIG. **15**A), packaging containers (e.g., wrapping paper or bottles, see FIG. **15**C), storage media (e.g., DVD software or video tapes, see FIG. **15**B), means of transportation (e.g., bicycles, see FIG. **15**D), personal ornaments and accessories (e.g., shoes or glasses), foods, clothing, everyday articles, or tags on goods such as electronic devices or on bags (see FIGS. **15**E and **15**F). Note that electronic devices include a liquid crystal display device, an EL display device, a television set (also simply called as a TV set, a TV receiver, or a television receiver), a mobile phone, and the like. Furthermore, the semiconductor device can also be applied to plants, animals, human bodies, and the like.

[0223] The semiconductor devices **9210** in this embodiment are fixed on goods by, for example, being mounted on a printed board, attached to a surface, embedded in goods, or the like. For example, the semiconductor device **9210** can be embedded in paper of a book, or embedded in an organic resin of a package. Since the semiconductor device **9210** in this embodiment can realize a compact size, thin shape, and light weight, it can be fixed on goods without spoiling the design thereof. Further, by applying the semiconductor device **9210** in this embodiment to bills, coins, securities, bearer securities, documents, or the like, authentication functions can be provided, with which forgery can be prevented. In addition, by applying the semiconductor device **9210** in this embodiment to packaging containers, storage media, personal belongings, foods, clothing, everyday articles, electronic devices, and the like, efficiency of systems such as an inspection system can be increased.

[0224] The present application is based on Japanese Priority application No. 2006-027737 filed on Feb. 3, 2006 with the Japanese Patent Office, the entire contents of which are hereby incorporated by reference.

What is claimed is:

1. A manufacturing apparatus of a semiconductor device, comprising:

a first support means provided with a plurality of semiconductor integrated circuits;

a second support means provided with a substrate having a plurality of elements, and

a jig comprising:

a plurality of holders arranged in a row for catching and holding the plurality of semiconductor integrated circuits, picking up the plurality of semiconductor integrated circuit provided over the first support means, and mounting the plurality of semiconductor integrated circuit on the plurality of respective elements provided over the second support means; and

a controller for controlling a pitch of the plurality of holders.

2. The manufacturing apparatus of a semiconductor device according to claim **1**, wherein the controller moves the plurality of holders arranged in a row so that connection terminals of the plurality of semiconductor integrated circuits are positioned opposite respective connection terminals of the plurality of elements.

3. The manufacturing apparatus of a semiconductor device according to claim **1**, wherein each of the first support means and the second support means is a stage, a belt conveyor, or a robot arm.

4. The manufacturing apparatus of a semiconductor device according to claim **1**,

wherein the first support means is a stage, a belt conveyor, or a robot arm; and

wherein the second support means is a set of a roller for supplying a flexible substrate having the plurality of elements and a roller for winding up the flexible substrate having the plurality of elements.

5. A manufacturing apparatus of a semiconductor device, comprising:

a support means provided with a plurality of semiconductor integrated circuits;

a plurality of holders for catching and holding the plurality of semiconductor integrated circuits;

a first roller on which the plurality of holders are arranged in a row a controller for controlling a pitch of the plurality of holders;

a second roller for supplying a flexible substrate having a plurality of elements;

a third roller for controlling a movement of the flexible substrate having the plurality of elements; and

a fourth roller for winding up the flexible substrate having the plurality of elements,

wherein the first roller picks up the plurality of semiconductor integrated circuits provided over the first support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller.

6. A manufacturing apparatus of a semiconductor device, comprising:

a support means provided with a plurality of semiconductor integrated circuits;

a plurality of holders for catching and holding the plurality of semiconductor integrated circuits;

a first roller on which the plurality of holders are arranged in a row;

a controller for controlling a pitch of the plurality of holders;

a second roller for supplying a flexible substrate having a plurality of elements;

a third roller for controlling a movement of the flexible substrate having the plurality of elements; and

a cutter for cutting the flexible substrate having the plurality of elements,

wherein the first roller picks up the plurality of semiconductor integrated circuits provided over the support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller; and

wherein the cutter cuts the flexible substrate having the plurality of elements on which the plurality of semiconductor integrated circuits are mounted.

7. A manufacturing apparatus of a semiconductor device, comprising:

a support means provided with a plurality of semiconductor integrated circuits;

a plurality of holders for catching and holding the plurality of semiconductor integrated circuits;

a first roller on which the plurality of holders are arranged in a row;

a controller for controlling a pitch of the plurality of holders;

a second roller for supplying a first flexible substrate having a plurality of elements;

a third roller for controlling a movement of the first flexible substrate having the plurality of elements;

a fourth roller for supplying a second flexible substrate; and

a pair of a fifth roller and a sixth roller which attach the first flexible substrate having the plurality of elements, the plurality of semiconductor integrated circuits, and the second flexible substrate, to each other,

wherein the first roller picks up the plurality of semiconductor integrated circuits provided over the support means by using the plurality of holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the second roller; and

wherein the pair of the fifth roller and the sixth roller attach the second flexible substrate to the first flexible substrate having the plurality of elements on which the plurality of semiconductor integrated circuits are mounted.

8. The manufacturing apparatus of a semiconductor device according claim **5**, wherein the first roller has 2n sets of holders.

9. The manufacturing apparatus of a semiconductor device according to claim **6**, wherein the first roller has 2n sets of holders.

10. The manufacturing apparatus of a semiconductor device according to claim **7**, wherein the first roller has 2n sets of holders.

11. The manufacturing apparatus of a semiconductor device according to claim **5**, wherein the first roller has (2n+1) sets of holders.

12. The manufacturing apparatus of a semiconductor device according to claim **6**, wherein the first roller has (2n+1) sets of holders.

13. The manufacturing apparatus of a semiconductor device according to claim **7**, wherein the first roller has (2n+1) sets of holders.

14. A manufacturing apparatus of a semiconductor device, comprising:

a support means provided with a plurality of semiconductor integrated circuits;

a plurality of first holders for catching and holding the plurality of semiconductor integrated circuits;

a first roller on which the plurality of first holders are arranged in a row;

a controller for controlling a pitch of the plurality of first holders;

a plurality of second holders for catching and holding the plurality of semiconductor integrated circuits from the plurality of first holders;

a second roller on which the plurality of second holders are arranged in a row;

a third roller for supplying a flexible substrate having a plurality of elements;

a fourth roller for controlling a movement of the flexible substrate having the plurality of elements; and

a fifth roller for winding up the flexible substrate having the plurality of elements,

wherein the second roller catches and holds the plurality of semiconductor integrated circuits which have been caught and held by the first holders, by using the plurality of second holders, and then the plurality of semiconductor integrated circuits are mounted on the plurality of respective elements by using the fourth roller.

15. The manufacturing apparatus of a semiconductor device according to claim **14**, wherein each of the first roller and the second roller has 2n sets of first holders and 2n sets of second holders.

16. The manufacturing apparatus of a semiconductor device according to claim **14**, wherein each of the first roller and the second roller has (2n+1) sets of first holders and (2n+1) sets of second holders.

17. The manufacturing apparatus of a semiconductor device according to claim **1**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

18. The manufacturing apparatus of a semiconductor device according to claim **5**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

19. The manufacturing apparatus of a semiconductor device according to claim **6**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

20. The manufacturing apparatus of a semiconductor device according to claim **7**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

21. The manufacturing apparatus of a semiconductor device according to claim **14**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

22. A manufacturing method of a semiconductor device, comprising the steps of:

setting a plurality of semiconductor integrated circuits on a first support means;

picking up the plurality of semiconductor integrated circuits from the first support means by using a plurality of holders arranged in a row on a jig;

controlling a pitch of the plurality of holders by a controller for controlling the pitch of the plurality of holders so that connection terminals of the plurality of semiconductor integrated circuits are positioned opposite respective connection terminals of a plurality of elements over a substrate which is provided over a second support means; and

connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements.

23. A manufacturing method of a semiconductor device, comprising the steps of:

setting a plurality of semiconductor integrated circuits on a support means;

picking up the plurality of semiconductor integrated circuits by using a plurality of holders arranged in a row on a roller;

rotating a roller for supplying a flexible substrate having a plurality of elements, a roller for controlling a movement of the flexible substrate having the plurality of elements, and a roller for collecting the flexible substrate having the plurality of elements, thereby moving the flexible substrate having the plurality of elements;

rotating the roller on which the plurality of holders are arranged in a row, so that the plurality of semiconductor integrated circuits are positioned opposite the flexible substrates having the plurality of elements;

controlling a pitch of the plurality of holders by a controller for controlling the pitch of the plurality of holders so that connection terminals of the plurality of semiconductor integrated circuits are positioned opposite respective connection terminals of the plurality of elements over the flexible substrate; and

connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row.

24. The manufacturing apparatus of a semiconductor device according to claim **23**, further comprising the step of:

cutting the flexible substrate by a cutter, after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row.

25. The manufacturing apparatus of a semiconductor device according to claim **23**, further comprising the step of:

attaching another flexible substrate to surfaces of the plurality of semiconductor integrated circuits and the plurality of elements by using a pair of rollers, after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row.

26. The manufacturing apparatus of a semiconductor device according to claim **23**, further comprising the steps of:

attaching another flexible substrate to surfaces of the plurality of semiconductor integrated circuits and the plurality of elements by using a pair of rollers, after connecting the connection terminals of the plurality of semiconductor integrated circuits to the respective connection terminals of the plurality of elements by using the roller for controlling the movement of the flexible substrate having the plurality of elements and the roller on which the plurality of holders are arranged in a row; and

cutting the flexible substrate having the plurality of elements and the other flexible substrate by a cutter.

27. The manufacturing apparatus of a semiconductor device according to claim **22**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

28. The manufacturing apparatus of a semiconductor device according to claim **23**, wherein the element includes at least one of an antenna, a semiconductor integrated circuit, and a sensor.

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