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(54) **SEMICONDUCTOR MODULE, SEMICONDUCTOR MEMBER, AND METHOD FOR MANUFACTURING THE SAME**

(71) Applicant: **UltraMemory Inc.**, Tokyo (JP)

(72) Inventors: **Fumitake OKUTSU**, Tokyo (JP); **Takao ADACHI**, Tokyo (JP)

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(57) **ABSTRACT**

The present invention provides a semiconductor module, a semiconductor member, and a method for manufacturing the same that make it possible to improve heat dissipation efficiency. This semiconductor module **1** comprises: a power supply unit **40**; a RAM unit **50**, which is a RAM module having a facing surface disposed so as to face an exposed surface of a logic chip **20** and an exposed surface of the power supply unit **40**, the RAM module being disposed across some of a plurality of logic chip signal terminals **22** and some of a plurality of power supply unit power supply terminals **41**; and a support substrate **10** having a power feeding circuit capable of feeding electrical power to the logic chip and to the power supply unit **40**, one main surface of the support substrate **10** being disposed adjacent to a heat dissipation surface of the RAM unit **50**, which is the surface of the RAM unit **50** opposite the facing surface. The support substrate **10** is electrically connected, using the power feeding circuit **12**, to at least some of logic chip power supply terminals **21** and the other power supply unit power supply terminals **41**. The support substrate **10** has, at positions overlapping the RAM unit **50**, heat dissipation vias **11** that penetrate in the thickness direction and come into contact with the heat dissipation surface of the RAM unit **50**.

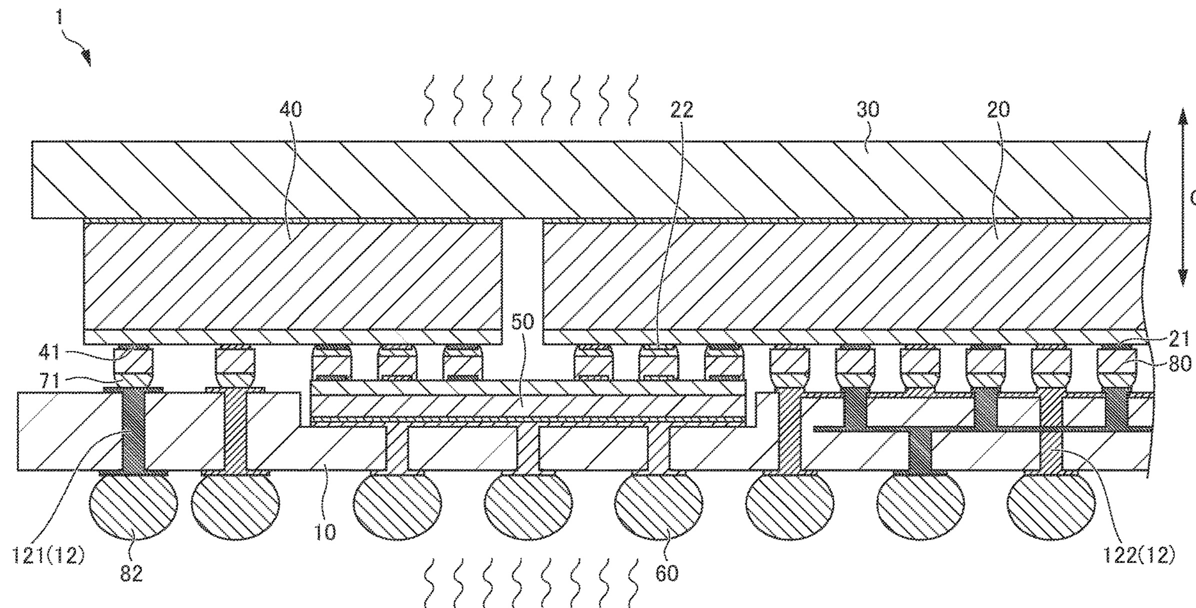


FIG. 1

FIG. 2

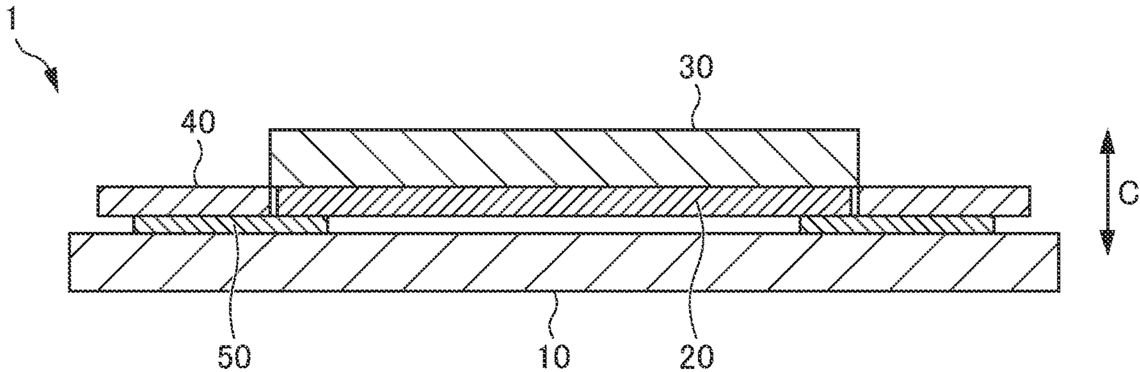


FIG. 3

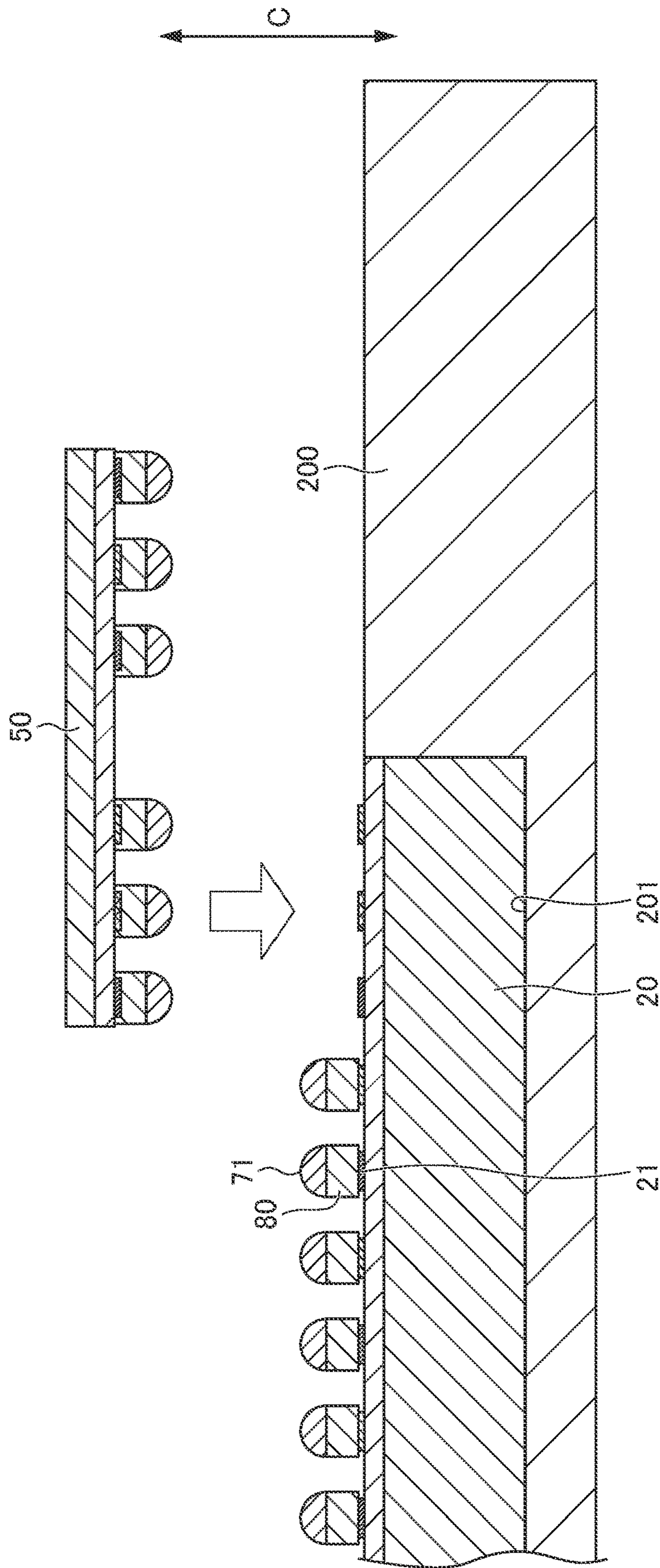


FIG. 4
C
200
50
201
20
71
21
80

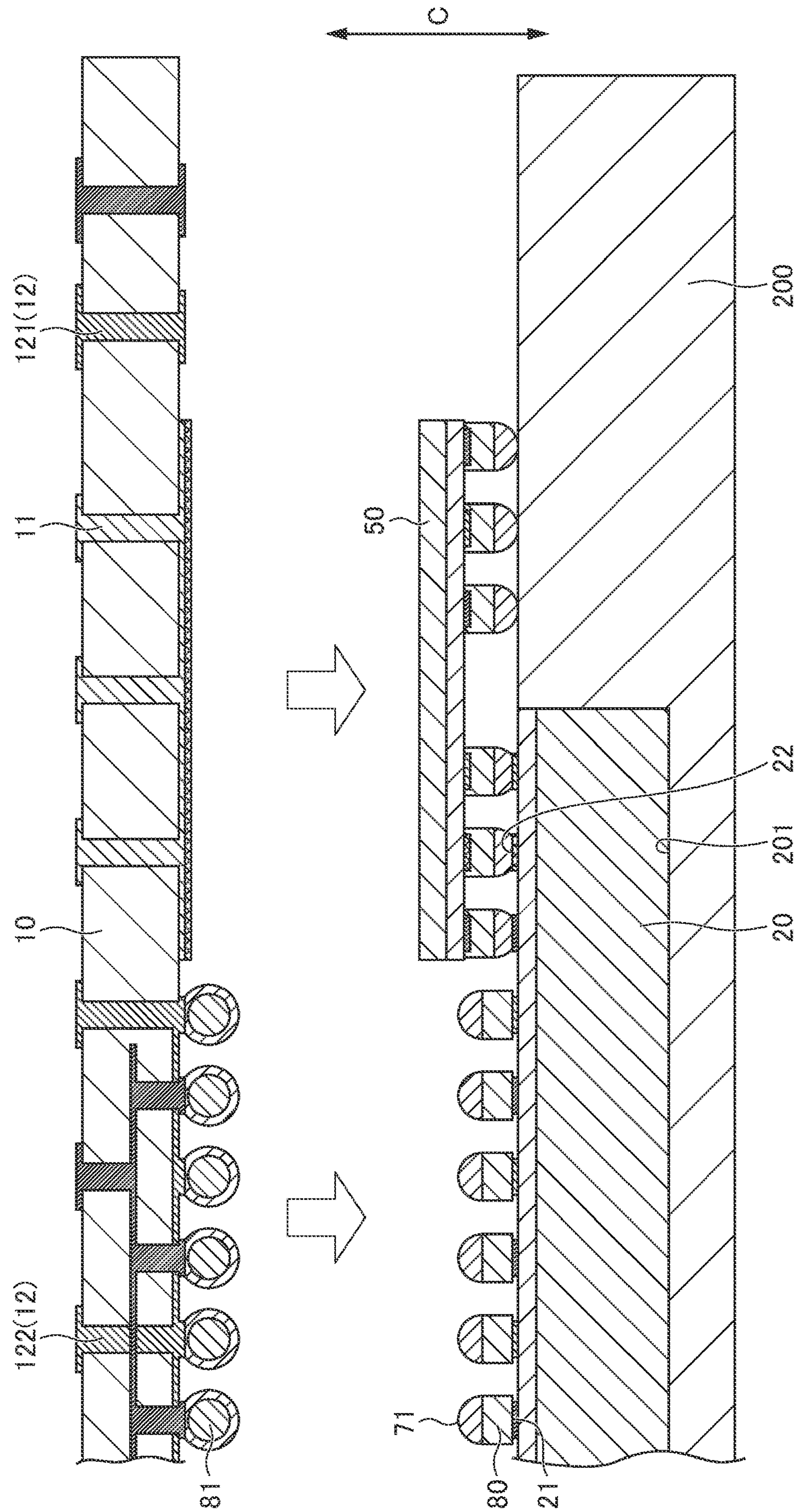
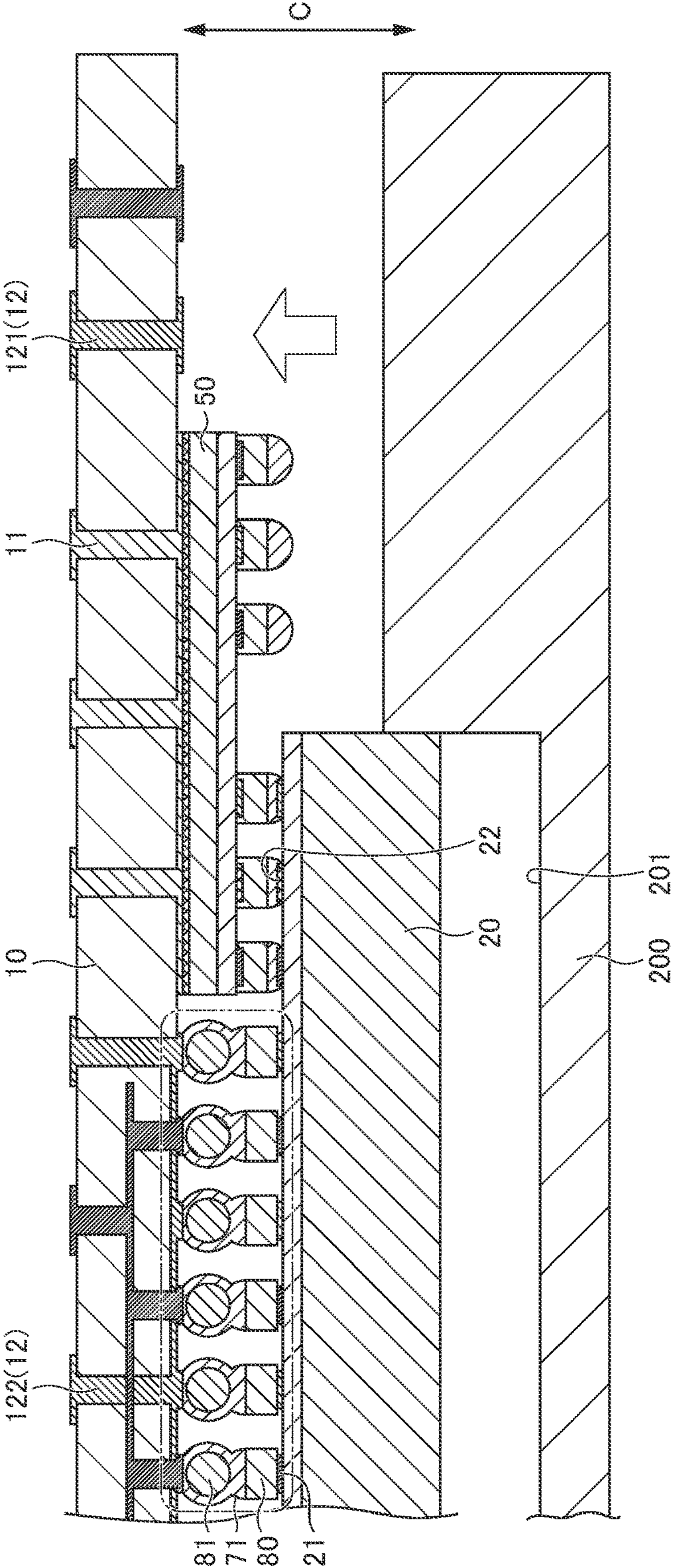


FIG. 5
C
121(12)
11
10
122(12)
81
50
200
22
201
20
71
80
21

FIG. 6



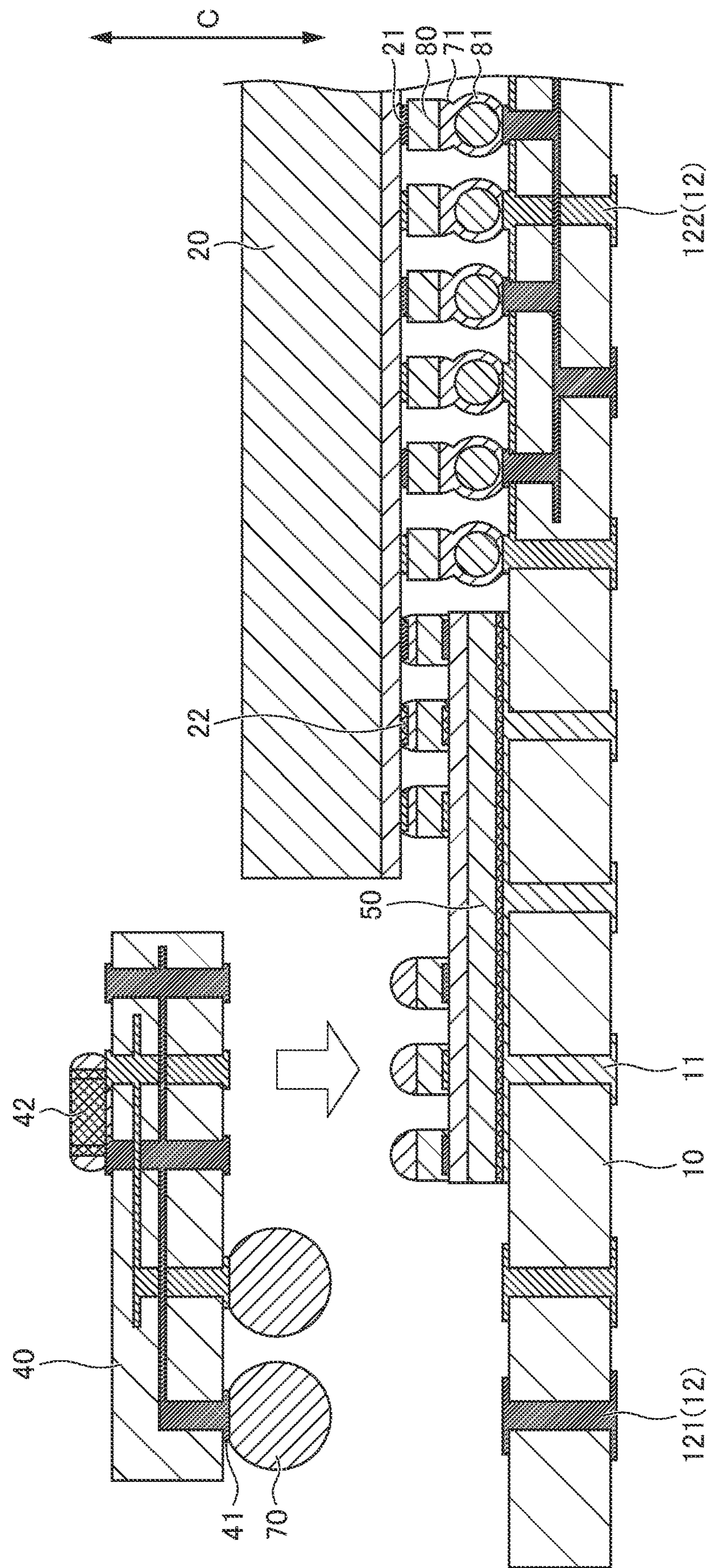
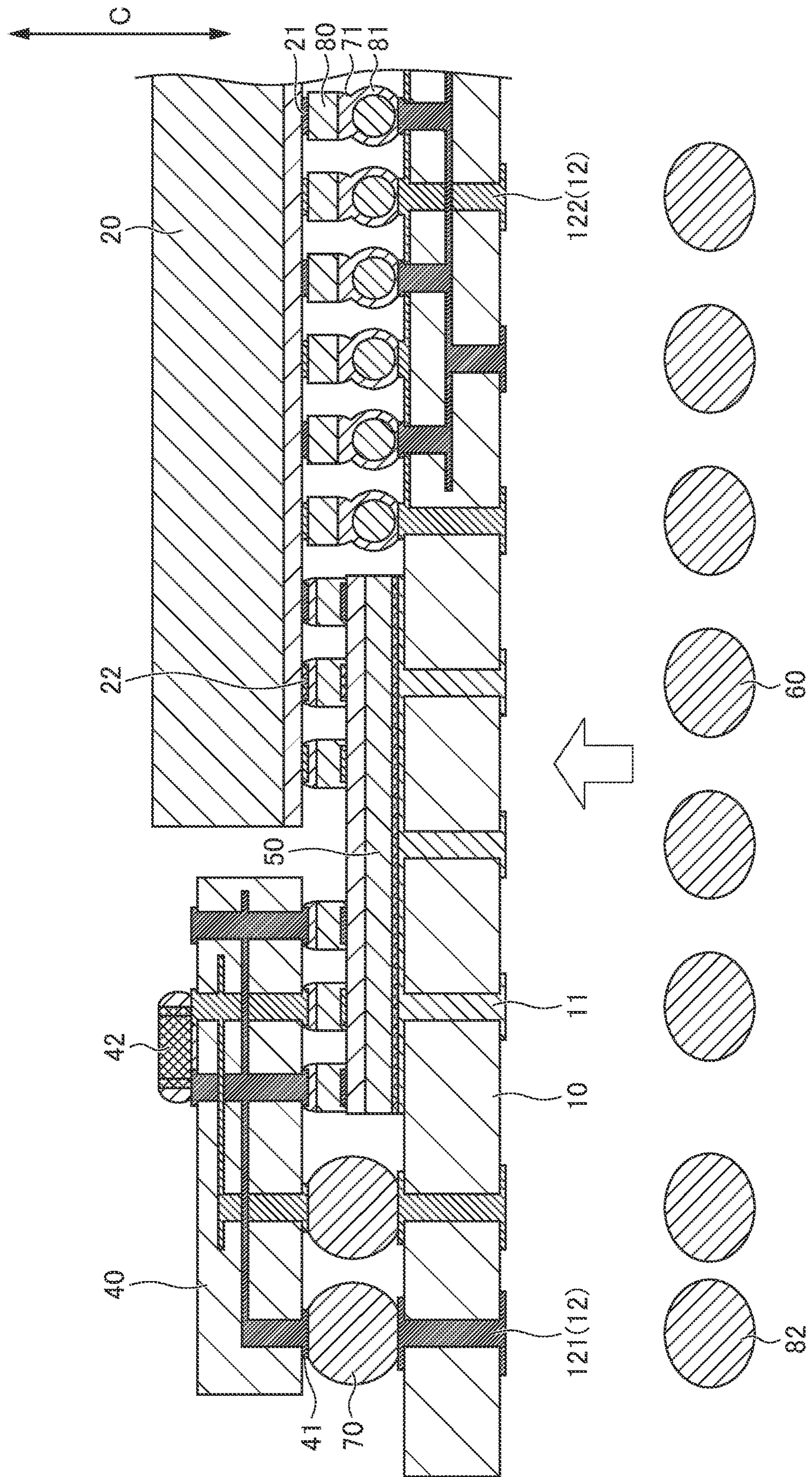


FIG. 7
C
20
21
80
71
81
122(12)
22
50
42
11
10
40
121(12)
41
70

FIG. 8



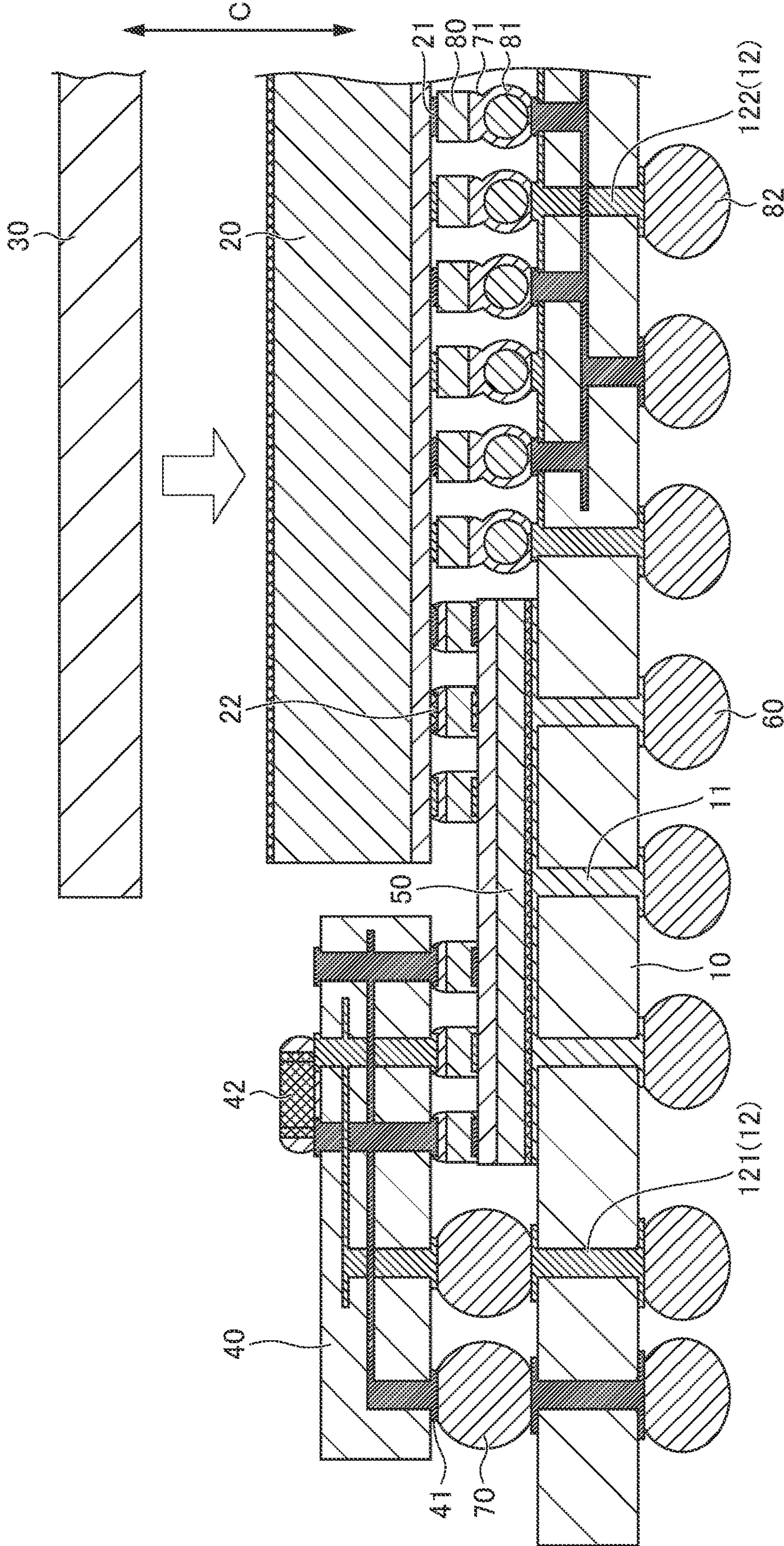
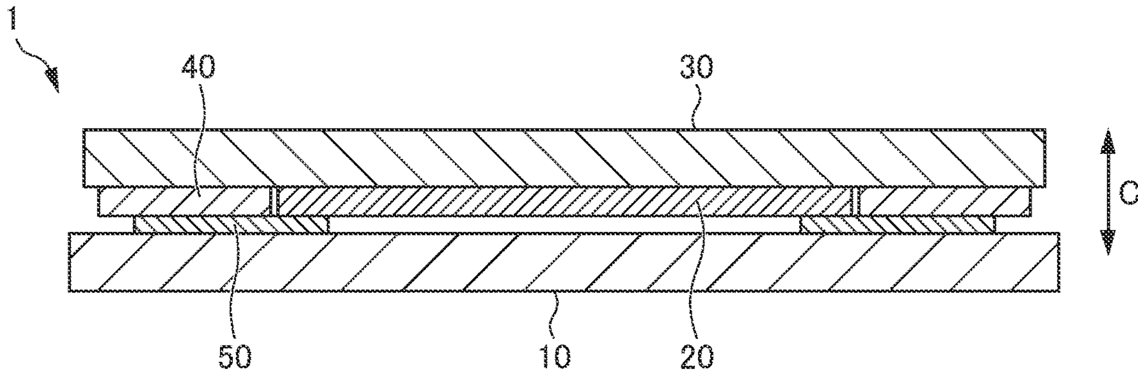


FIG. 9
C
30
20
21
80
71
81
122(12)
82
22
60
11
50
10
42
121(12)
40
41
70

FIG. 10

1
10
20
30
40
50
B
B

FIG. 11



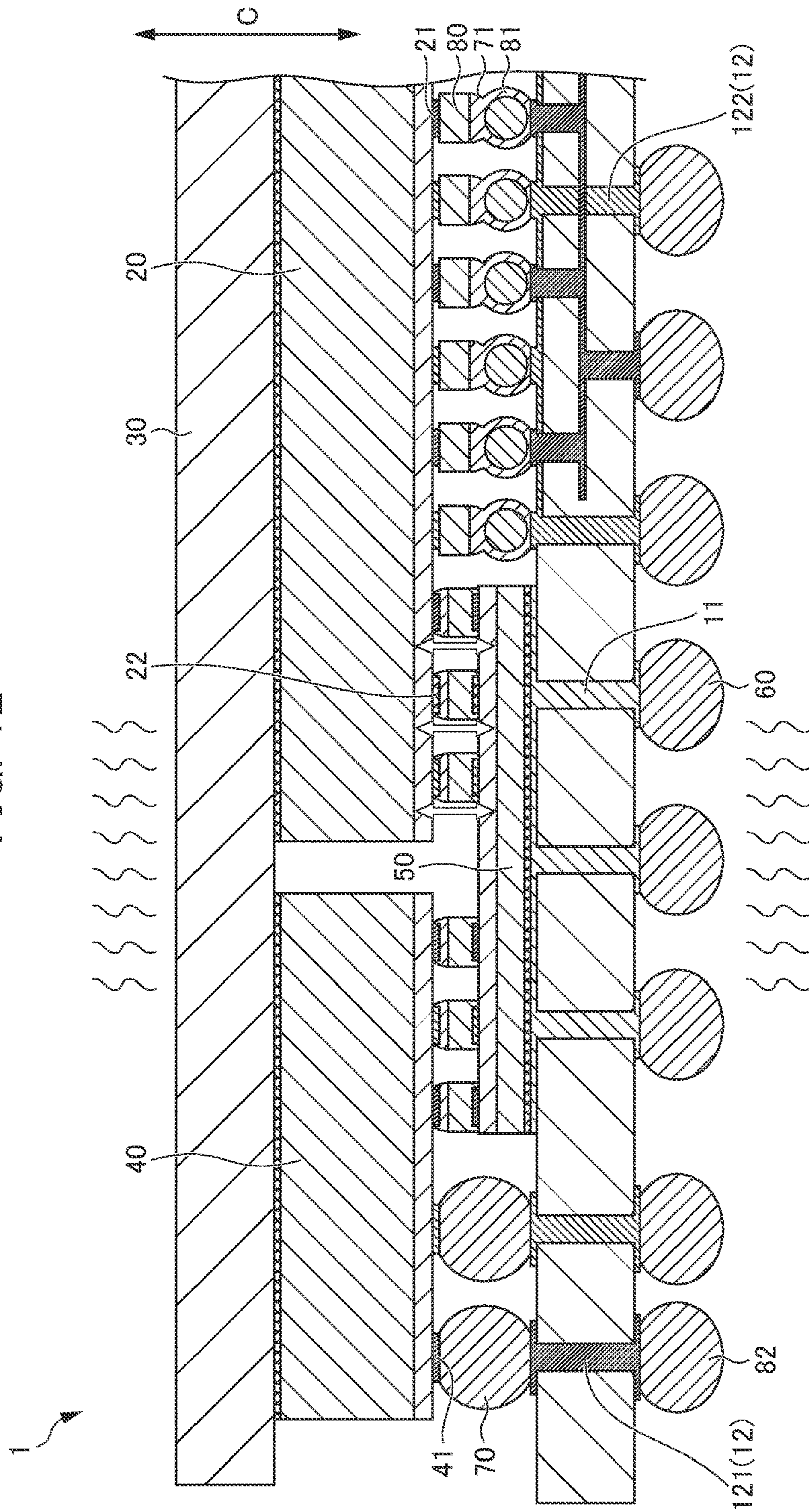


FIG. 12
C
21
80
71
81
122(12)
20
30
22
11
60
50
40
1
41
70
121(12)
82

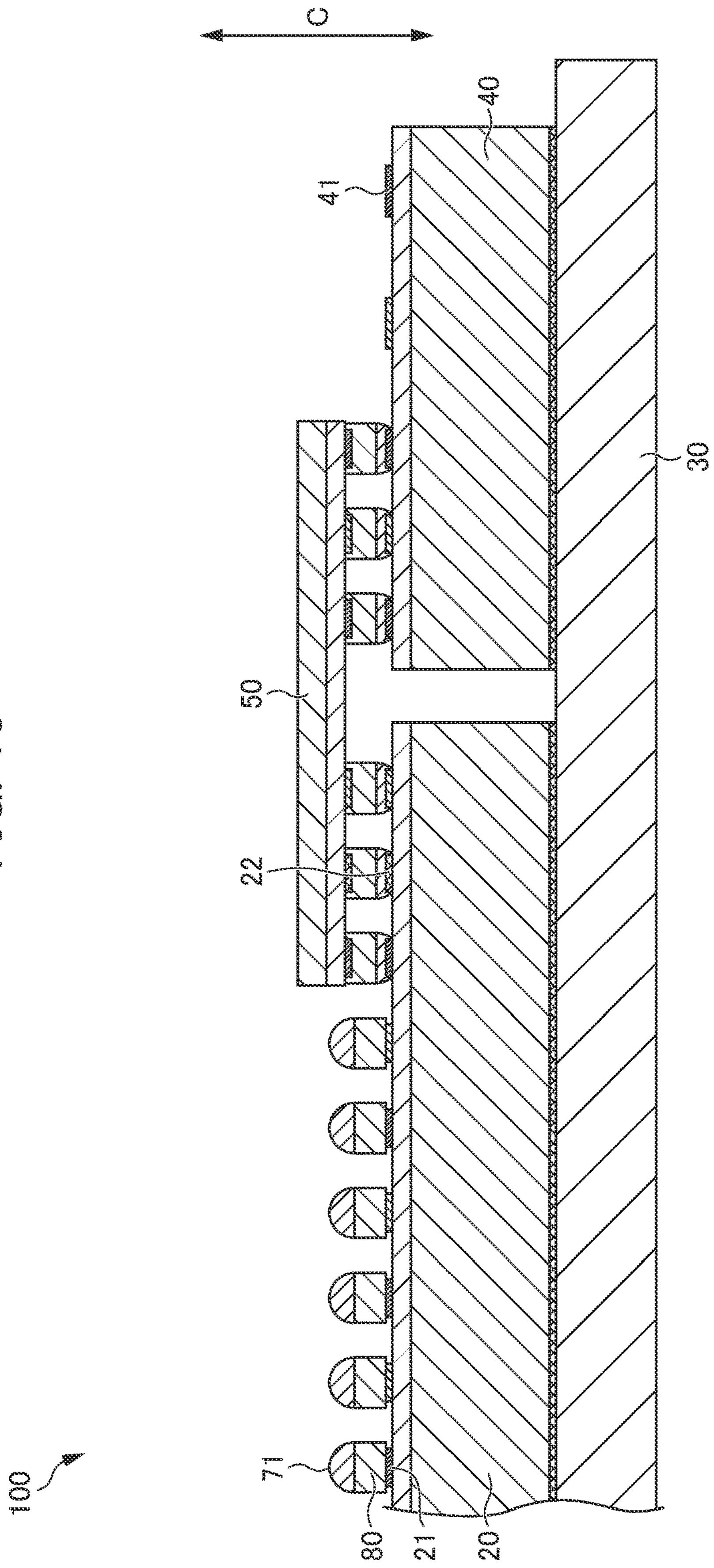


FIG. 13
C
40
41
30
50
22
71
100
80
21
20

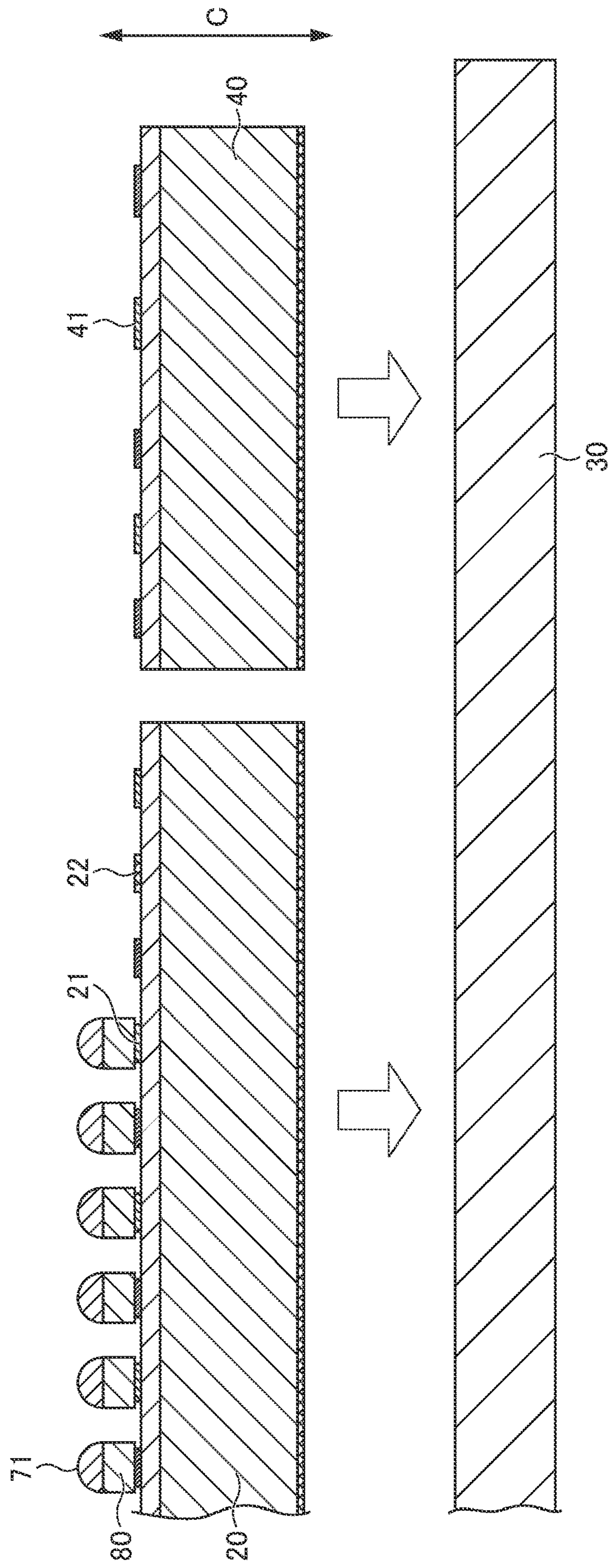


FIG. 14

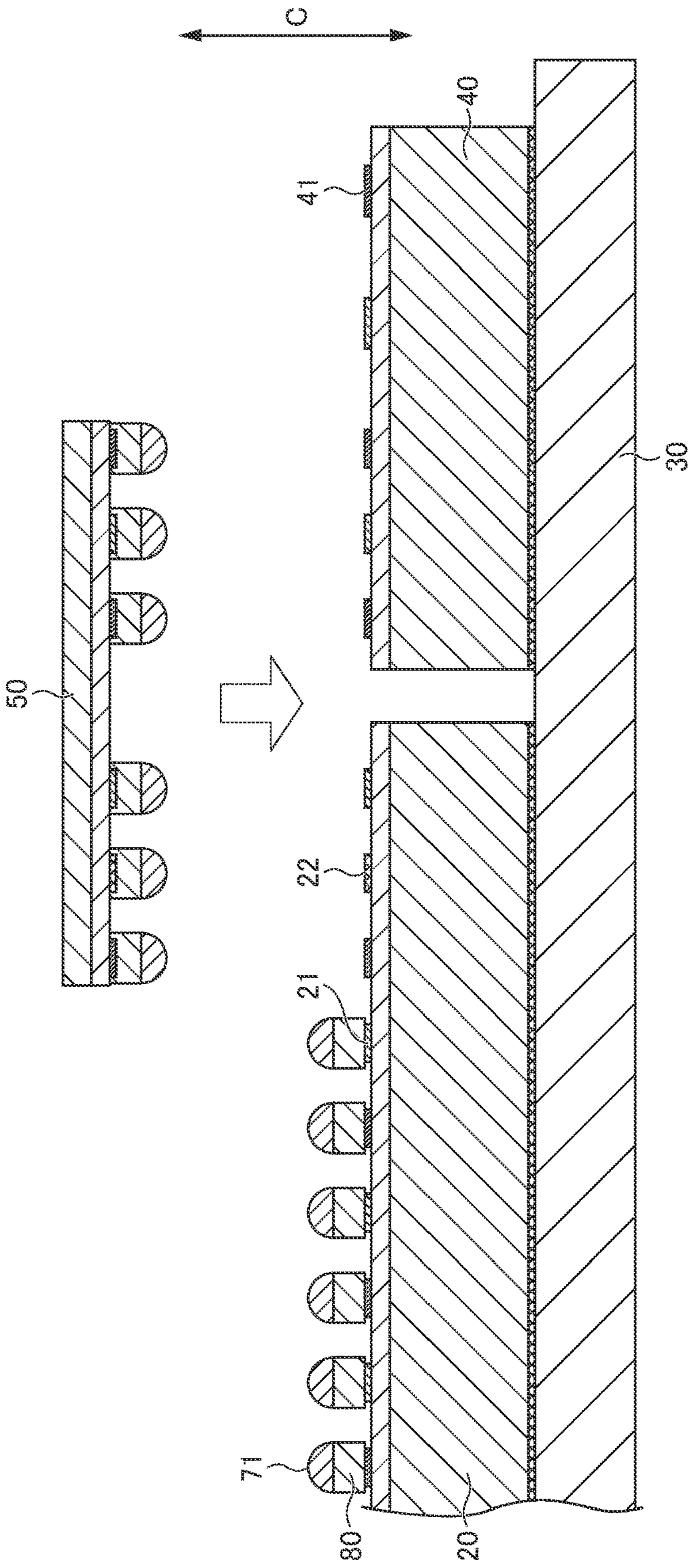


FIG. 15
C
40
41
30
50
22
21
71
80
20

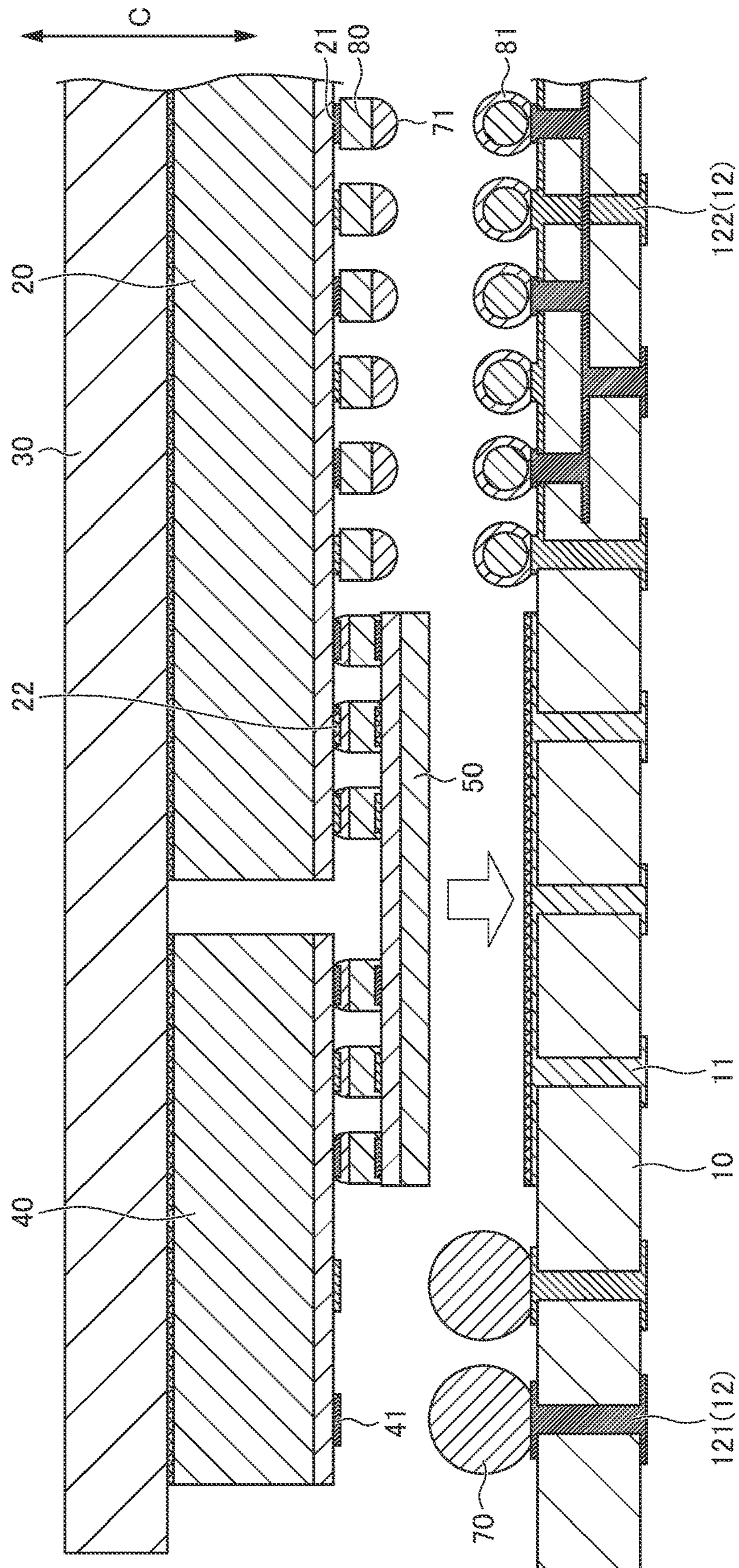


FIG. 16

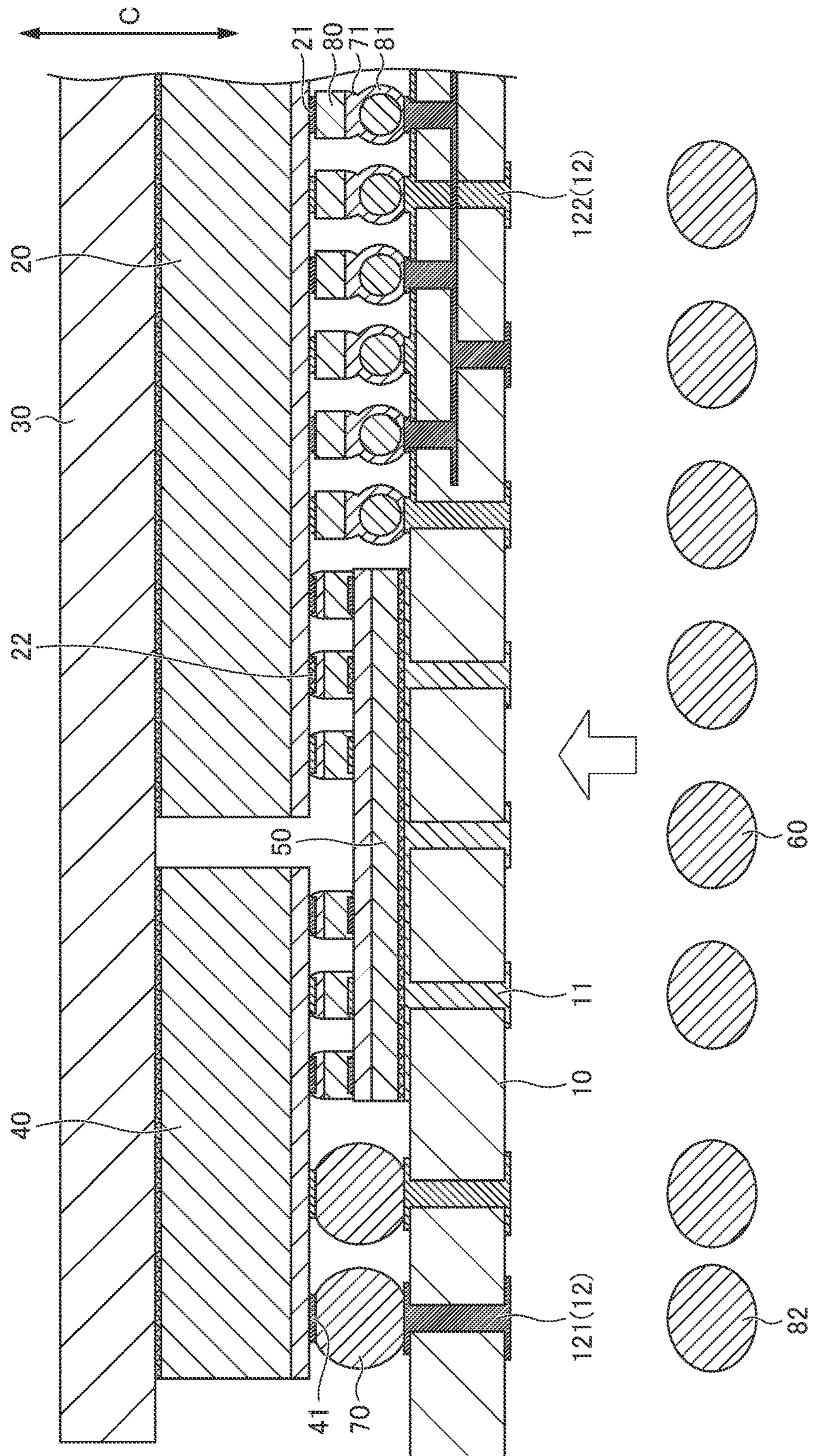
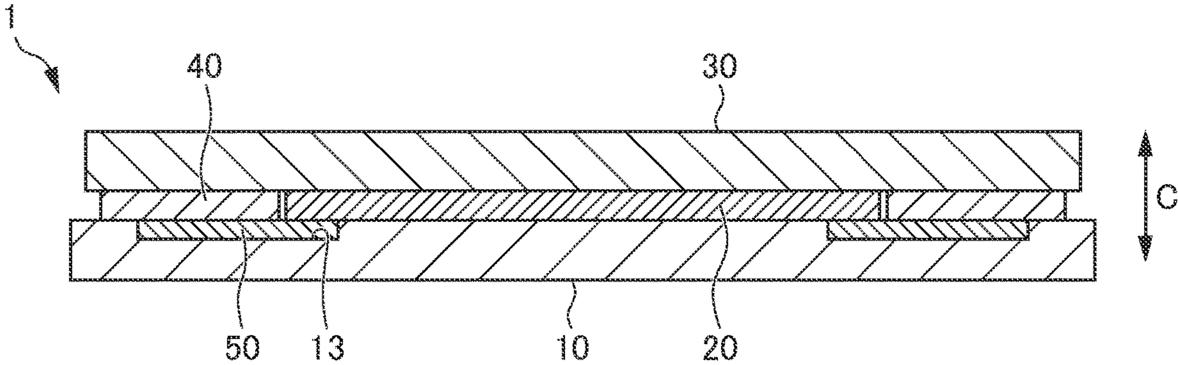


FIG. 17
C
21
80
71
81
20
30
122(12)
22
50
60
11
40
10
121(12)
82
41
70

FIG. 18



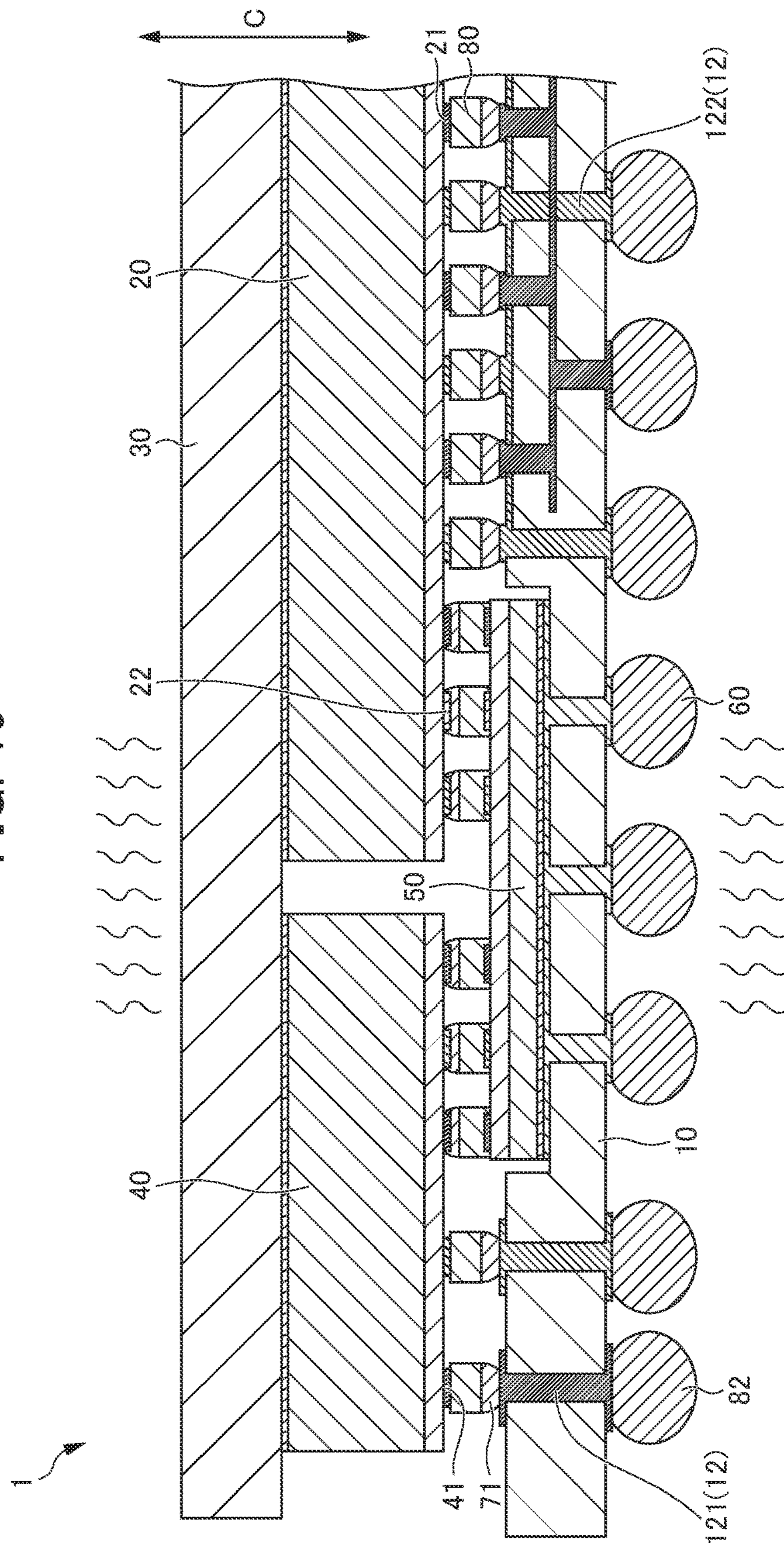
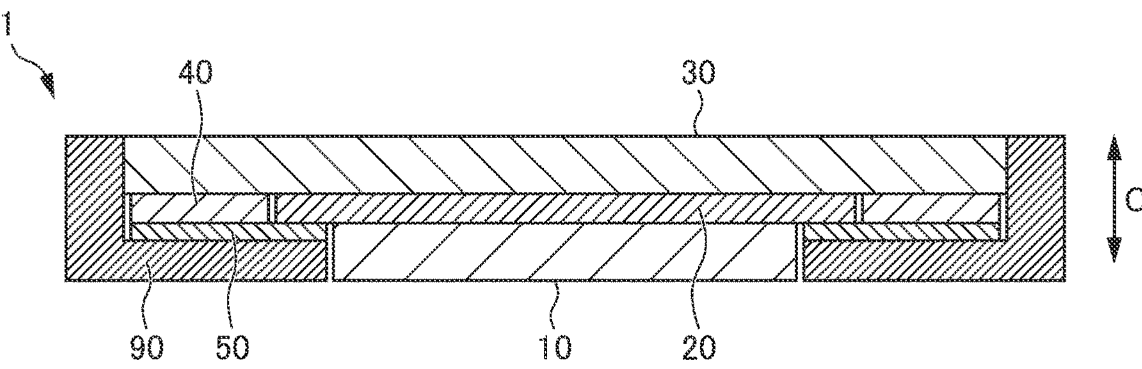


FIG. 19
C
21
80
122(12)
20
30
22
60
50
10
40
82
1
41
71
121(12)

FIG. 20

FIG. 21



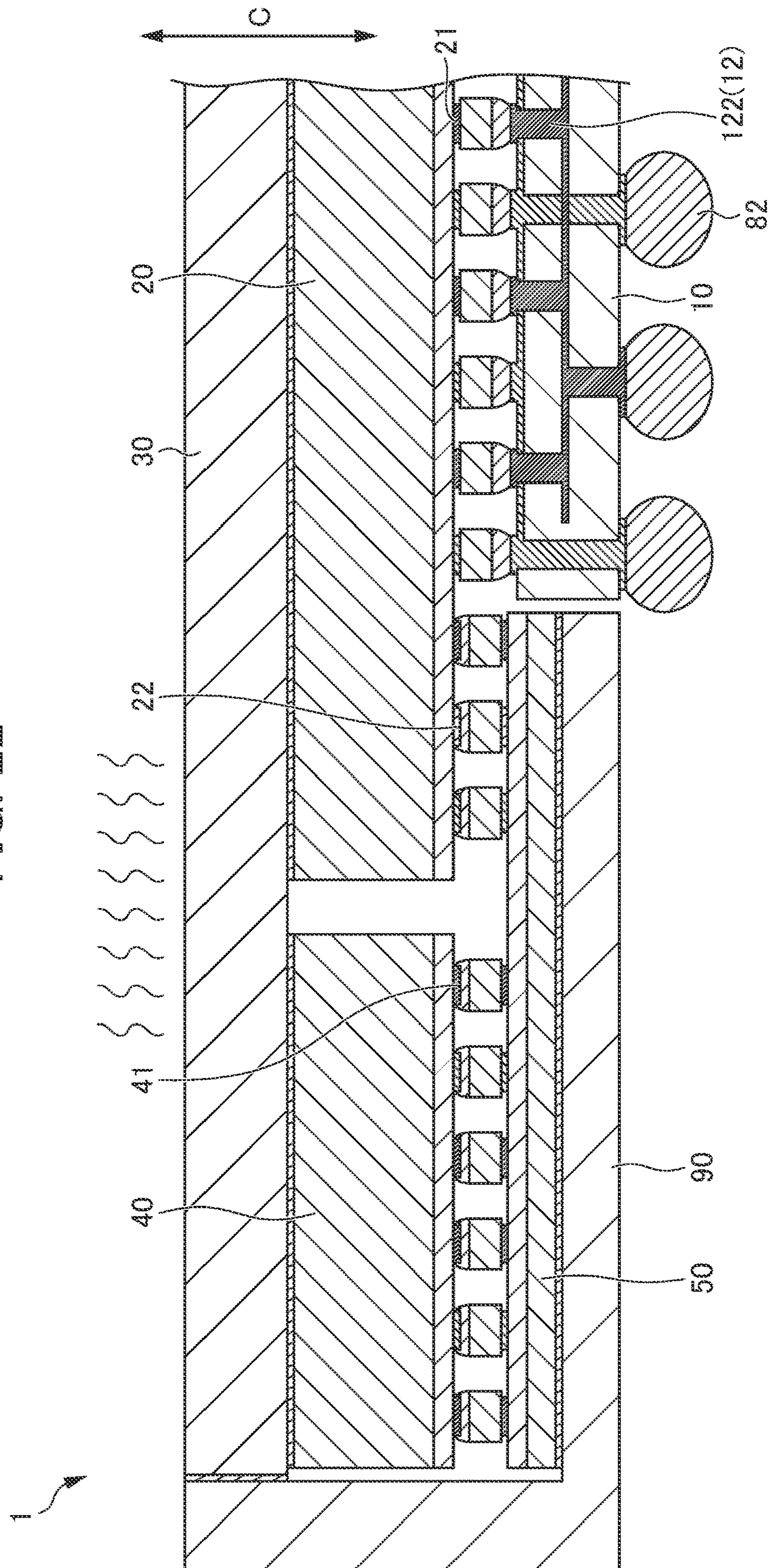


FIG. 22

SEMICONDUCTOR MODULE, SEMICONDUCTOR MEMBER, AND METHOD FOR MANUFACTURING THE SAME

TECHNICAL FIELD

[0001] The present invention relates to a semiconductor module, a semiconductor member, and a method for manufacturing the same.

BACKGROUND ART

[0002] A volatile memory (RAM), such as a dynamic random access memory (DRAM), has been known as a storage device. The DRAM is required to have a large capacity such that it can support high performance of an arithmetic unit (hereinafter referred to as a logic chip) and an increase in an amount of data. To address this, the capacity has been increased by miniaturization of the memory (memory cell array, memory chip) and planar expansion of a cell. On the other hand, this type of increase in capacity is reaching its limit because of the miniaturization resulting in feebleness to noise, an increase in die area, and other factors.

[0003] Therefore, in recent years, a technique for achieving a large capacity by way of a three-dimensional (3D) structure that is formed by stacking a plurality of planar memories has been developed. Further, a semiconductor module has been proposed in which a logic chip and a RAM are superimposed over each other so that an area required for disposing the logic chip and the RAM is reduced (see, for example, Patent Documents 1 to 3).

Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2015-216169

Patent Document 2: U.S. Published Patent Application Publication, No. 2015/255411

Patent Document 3: U.S. Published Patent Application Publication, No. 2018/182744

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0004] As disclosed in Patent Documents 1 to 3, superimposing two chips over each other makes it possible to reduce a distance between the two chips. This reduction in the distance is expected to improve a bandwidth between the two chips. On the other hand, placing the two chips over a substrate means that one of the chips that is disposed closer than the other chip to the substrate is sandwiched between the substrate and the other chip. This configuration may lower heat dissipation efficiency of the chip disposed closer to the substrate. In view of the foregoing, it is favorable to achieve a configuration capable of improving the heat dissipation efficiency.

[0005] It is an object of the present invention to provide a semiconductor module and a semiconductor member that are capable of improving the heat dissipation efficiency, and a method for manufacturing such semiconductor module and member.

Means for Solving the Problems

[0006] The present invention relates to a semiconductor module including: a heat spreader; a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface; a power supply unit juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having an exposed surface facing an identical direction with respect to the exposed surface of the logic chip, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof; a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals; and a support substrate including a power supply circuit capable of supplying electric power to the logic chip and the power supply unit, and having one main surface adjacent to a heat dissipation surface of the RAM unit opposite to the opposing surface. The support substrate is electrically connected to at least part of the logic chip-power supply terminals and another part of the power supply unit-power supply terminals by means of the power supply circuit, and has, in a portion over which the RAM unit is superimposed, a heat dissipation via that is in contact with the heat dissipation surface of the RAM unit and penetrates the support substrate in a thickness direction.

[0007] Preferably, the power supply unit is disposed over the surface of the heat spreader where the logic chip is disposed.

[0008] Preferably, the support substrate has, on the one main surface, a recess that is recessed in the thickness direction, and is formed at a position over which the RAM unit is superimposed.

[0009] Further, the present invention relates to a semiconductor module including: a heat spreader; a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface; a power supply unit disposed juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having an exposed surface facing an identical direction with respect to the exposed surface of the logic chip, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof; a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals; a support substrate including a power supply circuit capable of supplying electric power to the logic chip and the power supply unit, and facing the exposed surface of the logic chip or the exposed surfaces of the power supply unit; and a heat dissipation plate disposed adjacent to a heat dissipation surface of the RAM unit.

[0010] Further, the present invention relates to a semiconductor member for use as a component for manufacturing a semiconductor module. The semiconductor member

includes: a heat spreader; a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface; a power supply unit disposed over the surface of the heat spreader where the logic chip is disposed, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof; and a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals. At least part of the plurality of logic chip-power supply terminals and another part of the plurality of power supply unit-power supply terminals are exposed and connectable to a different module.

[0011] Preferably, the semiconductor module further includes a heat dissipation ball connected to one end of the heat dissipation via, and disposed on a surface of the support substrate opposite to the surface facing the RAM unit.

[0012] Further, the present invention relates to a method for manufacturing a semiconductor module. The method includes: electrically connecting a RAM unit as a RAM module to a logic chip such that a portion of an opposing surface as one surface of the RAM unit faces a portion of an exposed surface as one surface of the logic chip; electrically connecting the RAM unit to a power supply unit such that another portion of the opposing surface of the RAM unit faces a portion of an exposed surface as one surface of the power supply unit; disposing a heat spreader adjacent to another surface of the logic chip opposite to the exposed surface; disposing a support substrate such that one main surface of the support substrate becomes adjacent to a heat dissipation surface of the RAM unit opposite to the opposing surface, while bringing a heat dissipation via penetrating the support substrate in a thickness direction into contact with the heat dissipation surface; and connecting a heat dissipation ball to one end of the heat dissipation via, on another main surface of the support substrate opposite to the surface facing the RAM unit.

[0013] Further, the present invention relates to a method for manufacturing a semiconductor member for use as a component for manufacturing a semiconductor module. The method includes: disposing a logic chip and a power supply unit adjacent to each other over one surface of a heat spreader; and disposing a RAM unit as a RAM module over an exposed surface of the logic chip and an exposed surface of the power supply unit, the exposed surfaces facing away from the heat spreader, so that the RAM unit extends across the logic chip and the power supply chip.

Effects of the Invention

[0014] The present invention provides a semiconductor module and a semiconductor member that are capable of improving heat dissipation efficiency, and a method for manufacturing such semiconductor module and member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a planar view illustrating a semiconductor module according to a first embodiment of the present invention;

[0016] FIG. **2** is a cross-sectional view taken along line A-A in FIG. **1**;

[0017] FIG. **3** is a diagram illustrating a portion of FIG. **2** at an enlarged scale;

[0018] FIG. **4** is a diagram schematically illustrating a step of a process for manufacturing the semiconductor module of the first embodiment;

[0019] FIG. **5** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the first embodiment;

[0020] FIG. **6** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the first embodiment;

[0021] FIG. **7** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the first embodiment;

[0022] FIG. **8** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the first embodiment;

[0023] FIG. **9** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the first embodiment;

[0024] FIG. **10** is a planar view illustrating a semiconductor module according to a second embodiment of the present invention;

[0025] FIG. **11** is a cross-sectional view taken along line B-B in FIG. **10**;

[0026] FIG. **12** is a diagram illustrating a portion of FIG. **11** at an enlarged scale;

[0027] FIG. **13** is a diagram schematically illustrating a step of a process for manufacturing the semiconductor module of the second embodiment;

[0028] FIG. **14** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the second embodiment;

[0029] FIG. **15** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the second embodiment;

[0030] FIG. **16** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the second embodiment;

[0031] FIG. **17** is a diagram schematically illustrating a step of the process for manufacturing the semiconductor module of the second embodiment;

[0032] FIG. **18** is a cross-sectional view of a semiconductor module according to a third embodiment of the present invention;

[0033] FIG. **19** is a diagram illustrating a portion of FIG. **18** at an enlarged scale;

[0034] FIG. **20** is a planar view illustrating a semiconductor module according to a fourth embodiment of the present invention;

[0035] FIG. **21** is a cross-sectional view taken along line C-C in FIG. **20**; and

[0036] FIG. **22** is a diagram illustrating a portion of FIG. **21** at an enlarged scale.

PREFERRED MODE FOR CARRYING OUT THE INVENTION

[0037] A semiconductor module **1** and a semiconductor member **100** according to embodiments of the present invention, and a method for manufacturing the semiconductor module and member will be described with reference to FIGS. **1** to **22**. The semiconductor module **1** according to

each embodiment is, for example, a system in a package (SIP) that includes an arithmetic device (hereinafter, referred to as a logic chip), a RAM unit configured as a RAM module including a single layer or multilayer RAM, and a support substrate **10** over which the SIP and the RAM unit are disposed. The semiconductor module **1** is disposed on a different support substrate (e.g., a motherboard; not illustrated), and is electrically connected to the different substrate using solder balls (e.g., power supply balls). The semiconductor module **1** is supplied with electric power from the different support substrate, and is capable of transmitting and receiving data to and from the different support substrate. In the following embodiments, a MPU **20** will be described as an example of the logic chip. Further, in the following description of the embodiments, a thickness direction (height direction) of the semiconductor module **1** is denoted as the thickness direction C. With respect to the thickness direction C of the semiconductor module **1**, a side where the support substrate **10** is disposed is referred to as the lower side. With respect to the thickness direction C of the semiconductor module **1**, a side where the logic chip is disposed is referred to as the upper side.

First Embodiment

[0038] Next, a semiconductor module **1** according to a first embodiment and a method for manufacturing the semiconductor module **1** will be described with reference to FIGS. **1** to **9**. As illustrated in FIGS. **1** to **3**, the semiconductor module **1** according to the first embodiment includes a heat spreader **30**, a MPU **20**, a power supply unit **40**, a RAM unit **50**, a support substrate **10**, and a heat dissipation ball **60**. In the semiconductor module **1** of the present embodiment, the MPU **20** includes one MPU **20**, the RAM unit **50** includes four RAM units **50**, and the power supply unit **40** includes four power supply units **40**. These components are all disposed over the support substrate **10** including one support substrate **10**.

[0039] The heat spreader **30** is made of, for example, a material having relatively high heat dissipation efficiency, such as a metal. In the present embodiment, the heat spreader **30** has a rectangular plate shape in planar view, as illustrated in FIGS. **1** to **3**. The heat spreader **30** may have, for example, a heat dissipation fin (not illustrated) attached thereto.

[0040] The MPU **20** is a plate-like member having a rectangular shape in planar view. As illustrated in FIGS. **1** to **3**, the MPU **20** is disposed adjacent to one surface (lower surface) of the heat spreader **30**. The MPU **20** has a surface adjacent to the heat spreader **30** and an exposed surface opposite to the surface. The MPU **20** includes a plurality of logic chip-power supply terminals **21** on the exposed surface. Further, the MPU **20** includes, on the exposed surface, a plurality of logic chip-signal terminals **22** through which data can be inputted and outputted.

[0041] The power supply unit **40** is, for example, a power supply plate including a power circuit incorporated therein. In the present embodiment, each power supply unit **40** is juxtaposed with the logic chip in an in-plane direction of the exposed surface of the MPU **20**. Each power supply unit **40** has an exposed surface facing the same direction with respect to the exposed surface of the MPU **20**, and includes a plurality of power supply unit-power supply terminals **41** on the exposed surface. In the present embodiment, each power supply unit **40** has, for example, a bypass capacitor **42**.

[0042] As illustrated in FIG. **1**, each RAM unit **50** is composed of a RAM module having a rectangular shape in planar view. As illustrated in FIGS. **2** and **3**, each RAM unit **50** has an opposing surface that faces the exposed surface of the MPU **20** and the exposed surface of the power supply unit **40**. Specifically, each RAM unit **50** is disposed across part of the plurality of logic chip-power supply terminals **21**, part of the plurality of logic chip-signal terminals **22**, and part of the plurality of power supply unit-power supply terminals **41**. The RAM units **50** are electrically connected to the power supply units **40**, and are supplied with driving electric power from the power supply units **40**. The RAM units **50** are electrically connected to the MPU **20** such that the RAM units **50** can transmit and receive signals to and from the MPU **20** (the plurality of logic chip-signal terminals **22**). As in the present embodiment, it is suitable for the RAM units **50** to supply or receive electric power for interface, to or from the MPU **20**. Note that the signals may be transmitted and received between the RAM units **50** and the MPU **20** in a non-contact manner, such as magnetically coupling communication or capacity coupling communication. In this case, the power for interface does not have to be supplied or received between the RAM units **50** and the MPU **20**.

[0043] As illustrated in FIG. **1**, the support substrate **10** is a plate-like member having a rectangular shape in planar view. The support substrate **10** has, in planar view, an area that allows the MPU **20** and the RAM units **50** to be disposed thereover. The support substrate **10** is disposed such that one main surface of the support substrate **10** is adjacent to a heat dissipation surface of each RAM unit **50** opposite to the opposing surface. The support substrate **10** includes therein a power supply circuit **12** capable of supplying electric power to the MPU **20** and the power supply units **40**. Further, the support substrate **10** has, at a position over which the RAM unit **50** is superimposed, one or more heat dissipation vias **11** that are in contact with the heat dissipation surface of the RAM unit **50** and penetrate the support substrate **10** in the thickness direction C. The heat dissipation via **11** of the support substrate **10** is connected to the heat dissipation surface of the RAM unit **50** by means of, for example, thermally conductive grease or a thermally conductive sheet (not illustrated) provided between the heat dissipation surface of the RAM unit **50** and the heat dissipation via **11**. In the present embodiment, the support substrate **10** includes, as the power supply circuit **12**, a power supply unit-connecting circuit **121** for supplying electric power to the power supply units **40**, and a logic chip-connecting circuit **122** for supplying electric power to the MPU **20**. The support substrate **10** is disposed such that the one main surface thereof is adjacent to the heat dissipation surface of the RAM unit **50** opposite to the opposing surface. The power supply unit-connecting circuit **121** of the support substrate **10** is electrically connected to the power supply units **40** (the power supply unit-power supply terminals **41**) through, for example, solder balls **70**. The logic chip-connecting circuit **122** of the support substrate **10** is electrically connected to the MPU **20** (the plurality of logic chip-power supply terminals **21**) through, for example, Cu pillars **80** and Cu core balls **81**. The support substrate **10** is disposed over a different support substrate (not illustrated).

In the present embodiment, the support substrate **10** is electrically connected to the different support substrate, by means of the power supply circuit **12** exposed from another main surface of the support substrate **10** and power supply balls **82** disposed between the support substrate **10** and the different support substrate. Referring to FIG. **3**, a connection portion between the support substrate **10** and the MPU **20**, a connection portion between the support substrate **10** and the power supply unit **40**, a space between a connection portion between the RAM unit **50** and the MPU **20** and a connection portion between the RAM unit **50** and the power supply unit **40**, and the RAM unit **50** are filled and sealed with an underfill material (not illustrated).

[0044] The heat dissipation balls **60** are made of a material having higher heat dissipation efficiency (a higher thermal conductivity) than the support substrate **10**. The heat dissipation balls **60** are made of, for example, a metal. Specifically, each heat dissipation ball **60** is a solder ball. The heat dissipation balls **60** are disposed on a surface of the support substrate **10** opposite to the one main surface. Each heat dissipation ball **60** is connected to one end of the heat dissipation via **11**. Specifically, the heat dissipation ball **60** is connected to the one end of the heat dissipation via **11**, the one end being exposed from the surface of the support substrate **10** opposite to the one main surface. The heat dissipation ball **60** is disposed while having its surface exposed, except for a connection surface connected to the heat dissipation via **11**. That is, the heat dissipation ball **60** is disposed such that its surface other than the surface in contact with the heat dissipation via **11** is in contact with the external atmosphere or the different support substrate.

[0045] Next, an operation of the semiconductor module **1** according to the present embodiment will be described. First, the support substrate **10** supplies electric power to the MPU **20** through the power supply circuit **12**. Specifically, the support substrate **10** supplies the logic chip-power supply terminals **21** with electric power from the power supply circuit **12**. The support substrate **10** also supplies the MPU **20** with ground (a ground potential) from the power supply circuit **12**. The support substrate **10** supplies electric power to the power supply units **40** through the power supply circuit **12**. Specifically, the support substrate **10** supplies the power supply unit-power supply terminals **41** with electric power from the power supply circuit **12**. Further, the support substrate **10** supplies the power supply units **40** with ground (a ground potential) from the power supply circuit **12**. The power supply units **40** supply electric power and ground to the RAM units **50** through the power supply unit-power supply terminals **41**. In this way, the MPU **20** and the RAM units **50** are electrically driven.

[0046] In a case where signals are transmitted and received between the MPU **20** and the RAM unit **50**, it is suitable that at least one of the MPU **20** or the RAM unit **50** supplies the other with electric power for interface. Further, the MPU **20** or the RAM unit **50** transmits a signal including data to the other. According to the present embodiment, since transmission paths through which the signals are transmitted can be shortened, high-speed and low-power signal transmission can be achieved.

[0047] Heat generated in the MPU **20** due to the operation of the MPU **20** is released across an upper surface of the MPU **20** through the heat spreader **30**. This configuration inhibits the MPU **20** from overheating. On the other hand, heat generated in each RAM unit **50** due to the operation of the RAM unit **50** is released across the other main surface of the support substrate **10** through the heat dissipation vias **11** and the heat dissipation balls **60**. This configuration inhibits the RAM units **50** from overheating.

[0048] Next, a method for manufacturing the semiconductor module **1** will be described. First, as shown in FIG. **4**, a die bonding jig **200** having a receiving portion **201** recessed downward in the thickness direction C is provided. The receiving portion **201** of the die bonding jig **200** has the same or substantially the same depth as the thickness of the MPU **20**. The MPU **20** is received in the receiving portion **201**, while having the exposed surface facing upward.

[0049] Next, each RAM unit **50** is placed such that a portion thereof is superimposed over and connected to a portion of the MPU **20**. For example, an end portion of the RAM unit **50** in an in-plane direction of the opposing surface of the RAM unit **50** is superimposed over and connected to an end portion of the MPU **20** in an in-plane direction of the exposed surface of the MPU **20**. Here, each Cu pillar **80** has, at the tip thereof, a solder bump **71** for solder connection. Thus, each RAM unit **50** and the MPU **20** are electrically connected to each other. In the present embodiment, end portions corresponding to the four sides of the exposed surface of the MPU **20** are each connected to a portion of the opposing surface of the RAM unit **50**. In other words, the four RAM units **50** are respectively connected to positions corresponding to the four sides of the one MPU **20**.

[0050] Next, as illustrated in FIG. **5**, the support substrate **10** is superimposed over the heat dissipation surfaces of the RAM units **50**. Further, the support substrate **10** is electrically connected to the MPU **20**. For example, grease (a thermally conductive material) is applied to a portion of the one main surface of the support substrate **10**, the portion to be superimposed over each RAM unit **50**. Further, on the support substrate **10**, the Cu core balls **81** are disposed at positions to be connected to the MPU **20**. One surface of the support substrate **10** is superimposed over the MPU **20** and the RAM units **50**. Then, as illustrated in FIG. **6**, the support substrate **10**, the MPU **20**, and the RAM units **50** are removed from the die bonding jig **200**.

[0051] Next, as illustrated in FIG. **7**, power supply units **40** are each disposed across a portion of the opposing surface of the RAM unit **50** and the support substrate **10**. Specifically, the power supply unit **40** is connected to an exposed region of the opposing surface of the RAM unit **50**, while having a portion of its exposed surface superimposed over the exposed region. Further, the other portion of the exposed surface of the power supply unit **40** is superimposed over and connected to the one main surface of the support substrate **10**. Thereafter, sealing with the underfill material (not illustrated) is provided, as described above with reference to FIG. **3**.

[0052] Next, as illustrated in FIG. **8**, the power supply balls **82** for connection with a different support substrate are disposed on the other main surface of the support substrate **10**. Further, the heat dissipation balls **60** to be connected to the heat dissipation vias **11** are disposed on the other main surface of the support substrate **10**.

[0053] Next, as illustrated in FIG. **9**, the heat spreader **30** is placed over the upper surface of the MPU **20**. For example, the heat spreader **30** is disposed adjacent to the MPU **20** with the interposition of grease (a thermally conductive material) provided on the upper surface of the MPU **20**.

[0054] The above-described semiconductor module **1** according to the first embodiment and the method for manufacturing the same exert the following effects.

[0055] (1) The semiconductor module **1** includes: the heat spreader **30**; the logic chip disposed adjacent to one surface of the heat spreader **30**, and having the exposed surface opposite to a surface adjacent to the heat spreader **30**, and including the plurality of logic chip-power supply terminals **21** and the plurality of logic chip-signal terminals **22** on the exposed surface; the power supply unit **40** juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having the exposed surface facing the identical direction with respect to the exposed surface of the logic chip, and including the plurality of power supply unit-power supply terminals **41** on the exposed surface; the RAM unit **50** as a RAM module having the opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit **40**, and disposed across part of the plurality of logic chip-power supply terminals **21**, part of the plurality of logic chip-signal terminals **22**, and part of the plurality of power supply unit-power supply terminals **41**; and the support substrate **10** including the power supply circuit **12** capable of supplying electric power to the logic chip and the power supply unit **40**, and having one main surface adjacent to the heat dissipation surface of the RAM unit **50** opposite to the opposing surface. The support substrate **10** is electrically connected to another part of the logic chip-power supply terminals **21** and another part of the power supply unit-power supply terminals **41** by means of the power supply circuit **12**, and has, in a portion over which the RAM unit **50** is superimposed, the heat dissipation via **11** that is in contact with the heat dissipation surface of the RAM unit **50** and penetrates the support substrate **10** in the thickness direction C. This feature provides a heat dissipation path for the RAM unit **50**, and makes it possible to inhibit the RAM unit **50** from overheating, thereby enabling further prolongation of the product life. It is suitable for the RAM unit **50** to include the terminals only on the opposing surface, whereas the heat dissipation surface does not have to be provided with any terminals. This feature eliminates the need to provide the RAM unit **50** with a TSV or the like for power supply, thereby enabling reduction in manufacturing costs of the semiconductor module **1**.

[0056] (2) The semiconductor module **1** further includes the heat dissipation ball **60** that is connected to one end of the heat dissipation via **11** and is disposed on a surface of the support substrate **10** opposite to the surface facing the RAM unit **50**. This feature makes it possible to ensure the heat dissipation path for the RAM unit **50**, thereby enabling enhancement of heat dissipation efficiency.

Second Embodiment

[0057] Next, a semiconductor module **1** and a semiconductor member **100** according to a second embodiment of the present invention, and a method for manufacturing the semiconductor module and member will be described with reference to FIGS. **10** to **17**. In the description of the second embodiment, the same components as those of the above-described embodiment will be denoted by the same reference characters, and a description of the same components will be omitted or simplified. As illustrated in FIGS. **10** to **12**, the semiconductor module **1** according to the second embodiment differs from that of the first embodiment in that in the second embodiment, a heat spreader **30** is adjacent to power supply units **40** in a thickness direction C. Further, the semiconductor module **1** according to the second embodiment differs from that of the first embodiment in that each power supply unit **40** of the second embodiment is configured as a power supply die including therein, for example, a power supply circuit (not illustrated), a capacitor (not illustrated), and an inductor (not illustrated). Moreover, the semiconductor module **1** according to the second embodiment differs from that of the first embodiment in that the semiconductor module **1** of the second embodiment has the semiconductor member **100** as a semi-finished product of the semiconductor module **1**.

[0058] Each power supply unit **40** has the same or substantially the same thickness as that of a MPU **20**. Each power supply unit **40** is juxtaposed with the MPU **20** in an in-plane direction of an exposed surface of the MPU **20**. For example, as illustrated in FIG. **10**, the power supply units **40** are respectively disposed to be adjacent to the four sides of the exposed surfaces of the MPU **20**. In other words, each power supply unit **40** is disposed such that one of its side surfaces faces one of the side surfaces of the MPU **20**.

[0059] As illustrated in FIG. **13**, the semiconductor member **100** is a semi-finished product corresponding to the semiconductor module **1** excluding a support substrate **10**, power supply balls **82**, and heat dissipation balls **60**. Thus, in the semiconductor member **100**, part of a plurality of logic chip-power supply terminals **21**, part of a plurality of logic chip-signal terminals **22**, and part of a plurality of power supply unit-power supply terminals **41** are connected to a RAM unit **50**. On the other hand, another part of the plurality of logic chip-power supply terminals **21** and another part of the plurality of power supply unit-power supply terminals **41** are exposed and connectable to a different module.

[0060] Next, a method for manufacturing the semiconductor module **1** and the semiconductor member **100** of the present embodiment will be described with reference to FIGS. **13** to **17**. First, as illustrated in FIG. **14**, the MPU **20** and the power supply units **40** are disposed adjacent to each other over one surface of the heat spreader **30**. The MPU **20** and the power supply units **40** are disposed over the one surface of heat spreader **30** such that their exposed surfaces face upward. The MPU **20** and the power supply units **40** are disposed over the one surface of the heat spreader **30** with the interposition of grease (a thermally conductive material).

[0061] Next, as illustrated in FIG. **15**, the RAM units **50** are each disposed across the MPU **20** and the power supply unit **40**. Specifically, the RAM unit **50** is disposed while having its opposing surface facing the exposed surface of the MPU **20** and the exposed surface of the power supply unit **40**. The RAM unit **50** is electrically connected to the part of the plurality of logic chip-power supply terminals **21**, the part of the plurality of logic chip-signal terminals **22** of the MPU **20**, and the part of the power supply units **41** of the power supply unit **40**. Due to this configuration, another part of the logic chip-power supply terminals **21** and another part of the power supply units of the power supply unit **40** are maintained exposed. Consequently, as illustrated in FIG. **13**, each RAM unit **50** is electrically connected to the MPU **20** and the power supply unit **40**.

[0062] Next, as illustrated in FIG. **16**, the support substrate **10** is superimposed over the heat dissipation surfaces of the RAM units **50**. Further, the support substrate **10** is electrically connected to the MPU **20** and the power supply units **40**. For example, grease (a thermally conductive material) is

applied to a portion of one main surface of the support substrate **10**, the portion to be superimposed over the RAM unit **50**. Further, on the support substrate **10**, Cu core balls **81** are disposed at positions to be connected to the MPU **20**. On the support substrate **10**, solder balls **70** are disposed at positions to be connected to the power supply units **40**. In this way, the support substrate **10** is electrically connected to the MPU **20**. Further, the support substrate **10** is electrically connected to the power supply units **40**. Thereafter, sealing with an underfill material (not illustrated) is provided, as described above with reference to FIG. **3**.

[0063] Next, as illustrated in FIG. **17**, power supply balls **82** for connection with a different support substrate **10** are disposed on the other main surface of the support substrate **10**. Further, heat dissipation balls **60** to be connected to heat dissipation vias **11** are disposed on the other main surface of the support substrate **10**.

[0064] The above-described semiconductor module **1** and semiconductor member **100** according to the second embodiment, and the method for manufacturing the semiconductor module **1** and the semiconductor member **100** exert the following effects.

[0065] (3) The power supply units **40** are disposed over the surface of the heat spreader **30** where the logic chip is also disposed. This feature makes it possible to dispose the power supply units **40** adjacent to the heat spreader **30**, thereby allowing the power supply units **40** to be cooled more efficiently. Thus, the entire semiconductor module **1** can be cooled with enhanced efficiency, thereby making it possible for the semiconductor module **1** to improve in reliability. Further, since fixing the MPU **20** and the power supply units **40** to the heat spreader **30** is followed by connection to the RAM units **50**, the manufacturing process can be made easy. Moreover, since accuracy of positioning of bumps is increased, the yields can be improved and the manufacturing costs can be reduced.

[0066] (4) The semiconductor member **100** includes: the heat spreader **30**; the logic chip disposed adjacent to one surface of the heat spreader **30**, having the exposed surface opposite to a surface adjacent to the heat spreader **30**, and including the plurality of logic chip-power supply terminals **21** and the plurality of logic chip-signal terminals **22** on the exposed surface; the power supply unit **40** disposed over the surface of the heat spreader **30** where the logic chip is disposed, having the exposed surface opposite to a surface adjacent to the heat spreader **30**, and including the plurality of power supply unit-power supply terminals **41** on the exposed surface; and the RAM unit **50** as a RAM module having the opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit **40**, and disposed across part of the plurality of logic chip-power supply terminals **21**, part of the plurality of logic chip-signal terminals **22**, and part of the plurality of power supply unit-power supply terminals **41**. Another part of the plurality of logic chip-power supply terminals **21** and another part of the plurality of power supply unit-power supply terminals **41** are exposed and connectable to a different module. With this feature, while the semiconductor member **100** has been manufactured, the semiconductor module **1** can be manufactured in a different place. Further, the semiconductor member **100** can be easily disposed on the support substrate **10** together with, for example, other module and component. Thus, the method for manufacturing the semiconductor module **1** can be improved in general versatility.

Third Embodiment

[0067] Next, a semiconductor module **1** according to a third embodiment of the present invention and a method for manufacturing the semiconductor module **1** will be described with reference to FIGS. **18** and **19**. In the description of the third embodiment, the same components as those of the above-described embodiments will be denoted by the same reference characters, and a description of the same components will be omitted or simplified. As illustrated in FIGS. **18** and **19**, the semiconductor module **1** according to the third embodiment differs from that of the second embodiment in that a support substrate **10** of the third embodiment has, on one main surface, recesses **13** that are recessed in a thickness direction C and are formed at positions over which RAM units **50** are superimposed.

[0068] Each recess **13** has a depth that enables connection to the MPU **20** and the power supply unit **40** only by means of Cu pillars **80** and solder bumps **71** provided on one main surface of the support substrate **10**, without having to provide Cu core balls **81** or solder balls **70** on the one main surface of the support substrate **10**. Each recess **13** has a shape and an area that allow the RAM unit **50** to be received in the recess **13**. As described above with reference to FIG. **3**, the connection portions and the RAM units **50** are sealed with an underfill material (not illustrated).

[0069] The above-described semiconductor module **1** and the semiconductor member **100** according to the third embodiment, and the method for manufacturing the same exert the following effects.

[0070] (5) The support substrate **10** has, on the one main surface, the recesses **13** that are recessed in the thickness direction C and are formed at positions over which the RAM units **50** are superimposed. This feature can shorten a distance between the support substrate **10** and the MPU **20** and a distance between the support substrate **10** and the power supply units **40**. Thus, the semiconductor module **1** can be fabricated without using the Cu core balls **81** or the solder balls **70**, whereby the manufacturing costs of the semiconductor module **1** can be reduced.

Fourth Embodiment

[0071] Next, a semiconductor module **1** according to a fourth embodiment of the present invention and a method for manufacturing the semiconductor module **1** will be described with reference to FIGS. **20** to **22**. As illustrated in FIGS. **20** to **22**, the semiconductor module **1** of the fourth embodiment differs from those of the second and third embodiments in that according to the fourth embodiment, with respect to an in-plane direction of an exposed surface of a MPU **20** and an exposed surface of each power supply unit **40**, an outer edge of the exposed surface of the power supply unit **40** is positioned to an outer edge of an opposing surface of a RAM unit **50**, in a direction from the power supply unit **40** to the MPU **20**. The semiconductor module **1** of the fourth embodiment includes a support substrate **10** that has notches in its portions to be superimposed over the RAM units **50**. This feature constitutes another difference from the second and third embodiments. Further, the semiconductor module **1** of the fourth embodiment further

includes heat dissipation plates **90**. This feature constitutes yet another difference from the second and third embodiments. In the present embodiment, each power supply unit **40** has a portion not being superimposed over the RAM unit **50**, the portion extending in a direction along a side facing the MPU **20**. By way of the portion not being superimposed over the RAM unit **50**, the power supply unit **40** is electrically connected to the support substrate **10**. As described above with reference to FIG. **3**, the connection portions and the RAM units **50** are sealed with an underfill material (not illustrated).

[0072] As illustrated in FIG. **20**, the support substrate **10** has, in each of four side portions, the notch **14**. For example, the support substrate **10** has the notches **14** each of which can receive therein the RAM unit **50**. The support substrate **10** of the present embodiment have the notches **14** formed by indenting the four side portions.

[0073] The heat dissipation plate **90** is disposed adjacent to the heat dissipation surface of the RAM unit **50**. For example, the heat dissipation plate **90** is disposed adjacent to the heat dissipation surface of the RAM unit **50** with the interposition of grease (a thermally conductive material). In the present embodiment, the heat dissipation plate **90** has an L-shape composed of two parts, one of which is disposed along the heat dissipation surface of the RAM unit **50** and the other of which rises in a thickness direction C. A leading end of the other part of the heat dissipation plate **90** in a direction in which the other part rises is connected to a side surface of a heat spreader **30** with the interposition of grease (a thermally conductive material).

[0074] The above-described semiconductor module **1** according to the fourth embodiment and the method for manufacturing the semiconductor module **1** exert the following effects.

[0075] (6) The semiconductor module **1** includes: the heat spreader **30**; the logic chip disposed adjacent to one surface of the heat spreader **30**, having the exposed surface opposite to a surface adjacent to the heat spreader **30**, and including a plurality of logic chip-power supply terminals **21** and a plurality of logic chip-signal terminals **22** on the exposed surface; the power supply unit **40** juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having the exposed surface facing an identical direction with respect to the exposed surface of the logic chip, and including a plurality power supply terminals for the power supply unit **40** on the exposed surface thereof; the RAM unit **50** as a multilayer RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit **40**, and disposed across part of the plurality of logic chip-signal terminals **22** and at least part of the plurality of power supply terminals for the power supply unit **40**; the support substrate **10** including a power supply circuit **12** capable of supplying electric power to the logic chip and the power supply unit **40**, and facing the exposed surface of the logic chip or the exposed surfaces of the power supply unit **40**; and the heat dissipation plate **90** disposed adjacent to the heat dissipation surface of the RAM unit **50**. This feature can further enhance heat dissipation efficiency of the RAM unit **50**.

[0076] In the foregoing, preferred embodiments of the semiconductor module, the semiconductor member, and the method for manufacturing the semiconductor module and member of the present invention have been described. Note that the above-described embodiments are not intended to limit the present invention, and various modification can be made to the present invention.

[0077] For example, in the above embodiments, the surface of the heat dissipation ball **60** is exposed, except for the portion connected to the heat dissipation via **11**. However, this is a non-limiting example. The heat dissipation ball **60** may be connected to, for example, ground.

[0078] Further, the arithmetic unit is not limited to the MPU **20**, and may be widely applied to the general logic chips. The memory is not limited to DRAM, and may be widely applied to general RAM (random access memory) including non-volatile RAM (e.g., MRAM, ReRAM, FeRAM, etc.).

EXPLANATION OF REFERENCE NUMERALS

[0079] **1**: Semiconductor Module
[0080] **10**: Support Substrate
[0081] **11**: Heat Dissipation Via
[0082] **12**: Power Supply Circuit
[0083] **13**: Recess
[0084] **20**: MPU
[0085] **21**: Logic Chip-Power Supply Terminal
[0086] **22**: Logic Chip-Signal Terminal
[0087] **30**: Heat Spreader
[0088] **40**: Power Supply Unit
[0089] **41**: Power Supply Unit-Power Supply Terminal
[0090] **42**: Bypass Capacitor
[0091] **50**: RAM Unit
[0092] **60**: Heat Dissipation Ball
[0093] **70**: Solder Ball
[0094] **71**: Solder Bump
[0095] **80**: Cu Pillar
[0096] **81**: Cu Core Ball
[0097] **82**: Power Supply Ball
[0098] **90**: Heat Dissipation Plate
[0099] **100**: Semiconductor Member
[0100] C: Thickness Direction

1. A semiconductor module comprising:

a heat spreader;

a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface;

a power supply unit juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having an exposed surface facing an identical direction with respect to the exposed surface of the logic chip, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof;

a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals; and

a support substrate including a power supply circuit capable of supplying electric power to the logic chip and the power supply unit, and having one main surface adjacent to a heat dissipation surface of the RAM unit opposite to the opposing surface,

wherein the support substrate is electrically connected to at least part of the logic chip-power supply terminals and another part of the power supply unit-power supply terminals by means of the power supply circuit, and has, in a portion over which the RAM unit is superimposed, a heat dissipation via that is in contact with the heat dissipation surface of the RAM unit and penetrates the support substrate in a thickness direction.

2. The semiconductor module according to claim **1**,

wherein the power supply unit is disposed over the surface of the heat spreader where the logic chip is disposed.

3. The semiconductor module according to claim **1**,

wherein the support substrate has, on the one main surface, a recess that is recessed in the thickness direction, and is formed at a position over which the RAM unit is superimposed.

4. A semiconductor module comprising:

a heat spreader;

a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface;

a power supply unit disposed juxtaposed with the logic chip in an in-plane direction of the exposed surface of the logic chip, having an exposed surface facing an identical direction with respect to the exposed surface of the logic chip, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof;

a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals;

a support substrate including a power supply circuit capable of supplying electric power to the logic chip and the power supply unit, and facing the exposed surface of the logic chip or the exposed surfaces of the power supply unit; and

a heat dissipation plate disposed adjacent to a heat dissipation surface of the RAM unit.

5. A semiconductor member for use as a component for manufacturing a semiconductor module, the semiconductor member comprising:

a heat spreader;

a logic chip disposed adjacent to one surface of the heat spreader, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of logic chip-power supply terminals and a plurality of logic chip-signal terminals on the exposed surface;

a power supply unit disposed over the surface of the heat spreader where the logic chip is disposed, having a surface adjacent to the heat spreader and an exposed surface opposite to the surface, and including a plurality of power supply unit-power supply terminals on the exposed surface thereof; and

a RAM unit as a RAM module having an opposing surface facing the exposed surface of the logic chip and the exposed surface of the power supply unit, and disposed across part of the plurality of logic chip-signal terminals and part of the plurality of power supply unit-power supply terminals,

wherein at least part of the plurality of logic chip-power supply terminals and another part of the plurality of power supply unit-power supply terminals are exposed and connectable to a different module.

6. The semiconductor module according to claim **1**, further comprising:

a heat dissipation ball connected to one end of the heat dissipation via, and disposed on a surface of the support substrate opposite to the surface facing the RAM unit.

7. A method for manufacturing a semiconductor module, the method comprising:

electrically connecting a RAM unit as a RAM module to a logic chip such that a portion of an opposing surface as one surface of the RAM unit faces a portion of an exposed surface as one surface of the logic chip;

electrically connecting the RAM unit to a power supply unit such that another portion of the opposing surface of the RAM unit faces a portion of an exposed surface as one surface of the power supply unit;

disposing a heat spreader adjacent to another surface of the logic chip opposite to the exposed surface;

disposing a support substrate such that one main surface of the support substrate becomes adjacent to a heat dissipation surface of the RAM unit opposite to the opposing surface, while bringing a heat dissipation via penetrating the support substrate in a thickness direction into contact with the heat dissipation surface; and

connecting a heat dissipation ball to one end of the heat dissipation via, on another main surface of the support substrate opposite to the surface facing the RAM unit.

8. A method for manufacturing a semiconductor member for use as a component for manufacturing a semiconductor module, the method comprising:

disposing a logic chip and a power supply unit adjacent to each other over one surface of a heat spreader; and

disposing a RAM unit as a RAM module over an exposed surface of the logic chip and an exposed surface of the power supply unit, the exposed surfaces facing away from the heat spreader, so that the RAM unit extends across the logic chip and the power supply chip.

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