

[54] **VAPOR GROWTH DEVICE**

[72] Inventors: **Tsuyoshi Murai**, Kokubunji; **Tatsuo Toi**, Koganei, both of Japan

[73] Assignee: **Kokusai Denki Kabushiki Kaisha**, Tokyo-To, Japan

[22] Filed: **Dec. 21, 1970**

[21] Appl. No.: **100,115**

[30] **Foreign Application Priority Data**

Dec. 29, 1969 Japan 45/1599

[52] U.S. Cl.....118/48

[51] Int. Cl.....C23c 11/08

[58] Field of Search.....118/48-49.5;
117/107.1

[56] **References Cited**

UNITED STATES PATENTS

2,953,483	9/1960	Torok.....	118/48 X
3,408,982	11/1968	Capita.....	118/49.5
3,424,628	1/1969	Winings.....	118/49.5 X
3,456,616	7/1969	Gleim et al.....	118/49.5
3,460,510	8/1969	Curran.....	118/48

3,472,684	10/1969	Walther.....	118/48 X
3,473,954	10/1969	Mattson.....	118/48 X

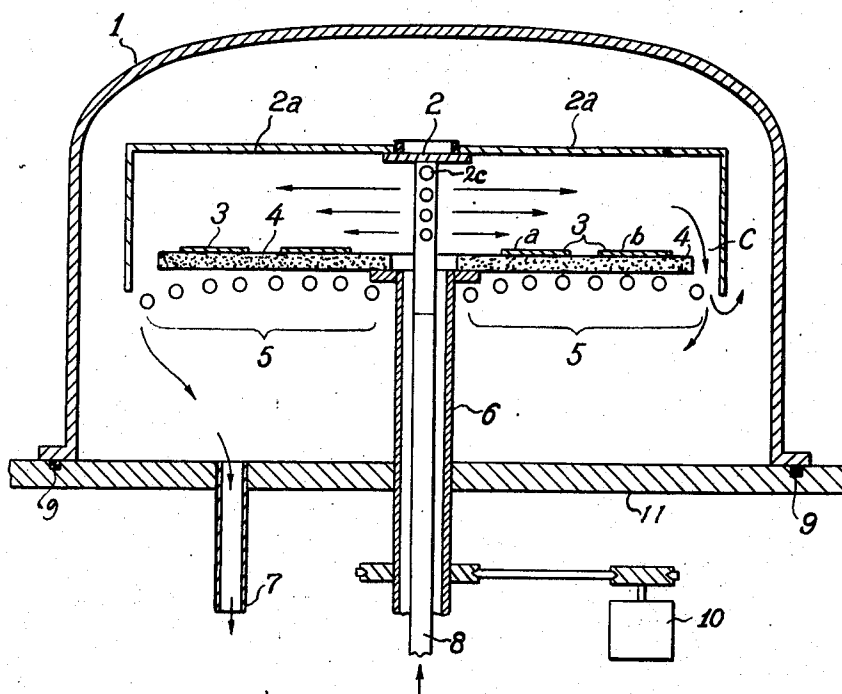
Primary Examiner—Morris Kaplan

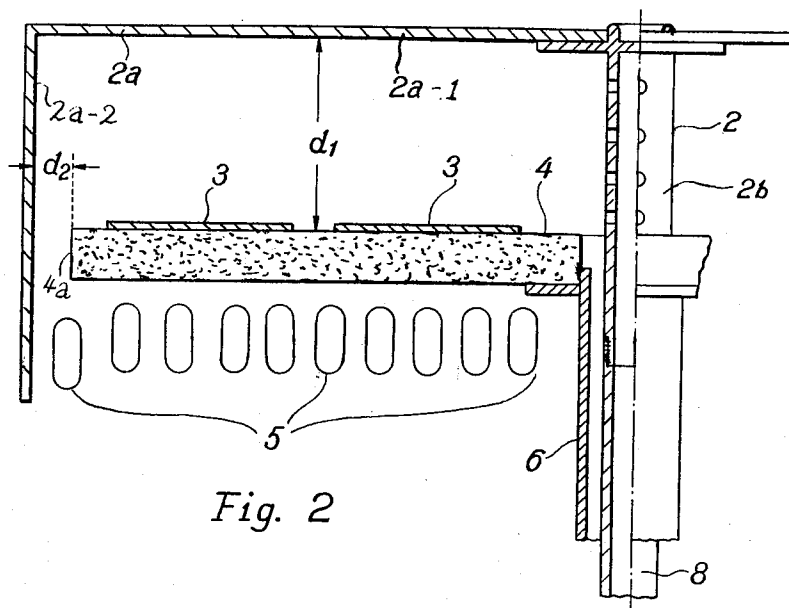
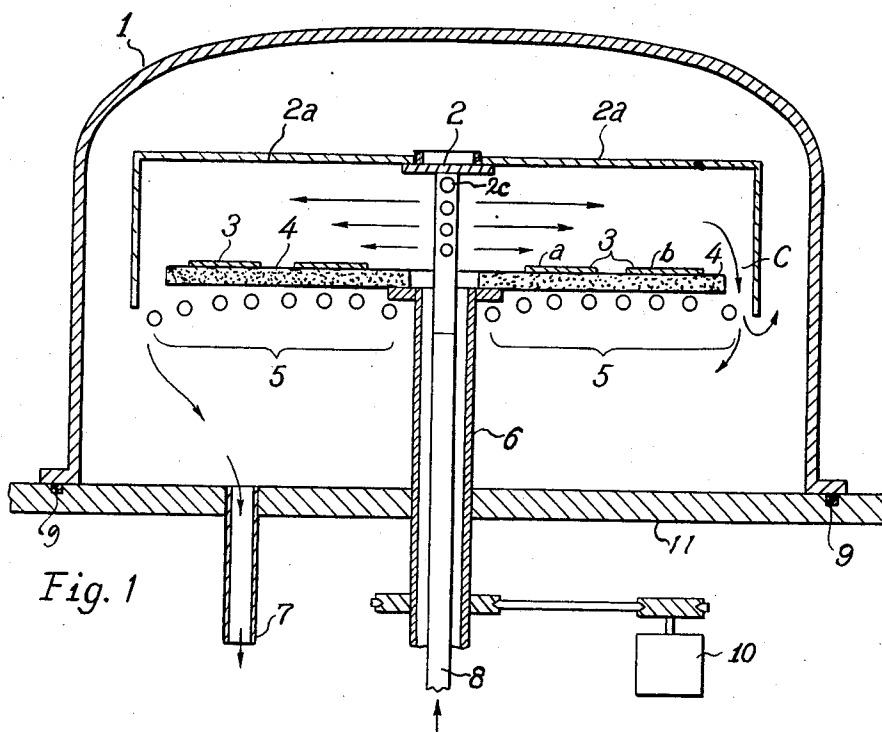
Attorney—Robert E. Burns and Emmanuel J. Lobato

[57] **ABSTRACT**

A vapor growth device for vapor-growing semiconductor crystal films on a plurality of semiconductor crystal wafers arranged on a flat susceptor by injecting a reaction gas of semiconductor compound comprises a metal chamber, a nozzle pipe extending into the chamber and having at the top portion thereof a plurality of holes to inject the reaction gas along directions parallel with the flat susceptor; and a nozzle cover having a flat part and a cylindrical part provided at the edge of the flat part connected to the top of the nozzle pipe at the flat part so that the nozzle cover and the susceptor provide a reaction chamber having a gap between the cylindrical part and the edge of the susceptor, whereby the reaction gas injected in the reaction chamber from the nozzle pipe flows through the gap in the form of a gas curtain and then out an exhaust hole of the metal chamber.

6 Claims, 2 Drawing Figures





VAPOR GROWTH DEVICE

This invention relates to a vapor growth device for vapor-growing semiconductor films, such as a single silicon crystal, from a semiconductor compound.

In a vapor growth device, the following criteria must be satisfied in order to have an acceptable device: (i) uniformity of specific resistance and thickness of the semiconductor films produced by vapor growth; and (ii) good crystal structure of the films produced by vapor growth. Since the quantity of silicon crystal wafer is small in a conventional vapor growth device, the above-mentioned criteria can be satisfied by effecting adjustment of the flow rate of a gas of the semiconductor compound and by effecting adjustment of the position of a nozzle used for delivering the gas of the semiconductor compound to the silicon wafer. Moreover, since the size of the device is relatively small, quartz parts used in the vapor growth device are easy to obtain at relatively low prices. The size of the vapor growth device has recently grown in proportion to the increase in the required manufacturing capacity of semiconductor in the vapor growth device. In this case, the flow of the gas of the semiconductor compound in vapor growth device becomes irregular in accordance with the rise of the size of the vapor growth. Moreover, since quartz parts of large size cannot be readily obtained at low prices, such quartz parts of the vapor growth device must be replaced by stainless-steel parts which are inexpensive and readily producible in a large size. However, some impurity is usually included in the stainless steel and therefore the uniformity of the specific resistances and thickness of the semiconductor films is accordingly reduced in a conventional device of large capacity.

An object of this invention is to provide a vapor growth device having a large manufacturing capacity and capable of producing semiconductor crystal films having uniform specific resistance and thickness and a good crystal structure.

The principle, construction and operation of the vapor growth device of this invention will be clearly understood from the following detailed discussion in conjunction with the accompanying drawings, in which the same or equivalent parts are designated by the same reference numerals, characters and symbols, and in which:

FIG. 1 is an elevational view including a section illustrating an embodiment of the vapor growth device according to this invention; and

FIG. 2 is an elevational view including a section illustrating, in an enlarged size, a reaction chamber provided in the embodiment shown in FIG. 1.

With reference to FIG. 1, an embodiment of this invention comprises a metal (e.g.; SUS 32) chamber 1 containing therein a gas injection nozzle 2 of quartz pipe having a plurality of small holes or dispensing apertures 2c extending perpendicular to axis of the nozzle 2 and a nozzle cover member 2a detachably held at the top of the nozzle 2. A plurality of wafers 3 are arranged on a support member comprising a carbon susceptor 4 which is a flat disc enlarged in comparison with a conventional one and heating means comprising high frequency coils 5 are positioned beneath the susceptor for heating the wafers. A susceptor holder 6 rotatably supports the susceptor 4 and a gas exhaust hole 7, a gas injecting pipe 8, and a motor 10 for driving

the susceptor holder 6 are also provided. The metal chamber 1 is supported on a supporting plate 11 by the use of a gas-sealing packing 9. The nozzle 2 is extended into the chamber 1 through the center of the flat susceptor 4 so that all of the holes 2c are above the susceptor.

During operation of the device for performing vapor growth of single crystal films in accordance with the hydrogen reduction method of silicon tetrachloride (SiCl_4), a reaction gas, obtained by mixing silicon tetrachloride with hydrogen, is injected through the gas injecting pipe 8 in the auxiliary reaction chamber 1 while the silicon wafers 3 are heated by the high frequency coils 5 up to a temperature of 1,100°C to 1,200°C, so that films of single silicon crystal are grown on the silicon wafers 3. In the device of this invention, the nozzle cover member 2a has a concave configuration and completely covers the carbon susceptor 4 and therefore also covers the silicon wafers. The cover member is disposed in a working position within the main chamber and defines with the flat surface of the carbon susceptor the auxiliary reaction chamber and the reaction gas injected from the holes 2c of the nozzle 2 travels into the auxiliary reaction chamber along radial directions of the circular susceptor 4 as shown by arrows extending parallel to the nozzle cover member 2a and the carbon susceptor 4 and the reaction gas passes through a gap c between respective ends of the nozzle cover member 2a and the carbon susceptor 4 and is exhausted from the exhaust hole 7.

To obtain sufficient performance of the vapor growth device of this invention, a distance d_1 between a parallel part 2a-1 of the nozzle cover 2a and the carbon susceptor 4 and a gap d_2 between a vertical side wall part 2a-2 of the nozzle cover 2a and the edge 4a of the carbon susceptor 4 as shown in FIG. 2, as well as the flow rate of the reaction gas are determined in conjunction with the size or volume of the carbon susceptor 4 and so as to obtain an optimum uniform thickness of the grown semiconductor films and uniform specific resistance of the grown semiconductor films. The distance d_1 is selectively adjusted by changing the length of the nozzle head 5b, while the gap d_2 is selectively adjusted by replacing the nozzle cover member 2a with another one having an appropriate size. In order to enable various cover members to be interchanged with one another, the cover member 2a is detachably mounted in its working position so that it may be easily detached and replaced by another cover member when it is desired to vary the volume of the auxiliary reaction chamber. Moreover, since the gap d_2 is very narrow, a gas curtain is established around the carbon susceptor 4 by the reaction gas exhausted through the narrow gap d_2 . This gas curtain completely checks and prevents invasion of an impurity gas in the reaction chamber between the nozzle cover 2a and the susceptor 4. Accordingly, even if an impurity gas absorbed in the material of the metal chamber 1 is expelled into the metal chamber 1, this impurity gas is completely exhausted without invasion into the auxiliary reaction chamber. The head 2b of the nozzle pipe 2 may be replaced by another head having holes 2c of different size to adjust the flow rate of the reaction gas.

Examples of operations of the vapor growth device of this invention are as follows:

EXAMPLE 1

In the conventional vapor growth device having no nozzle cover, a nozzle is provided to inject the reaction gas from the upward portion thereof toward the carbon susceptor along a direction perpendicular to the carbon susceptor. In this example of operation, a nozzle is exchanged from the conventional type to the type of this invention. Employed wafers include arsenic (As) and have a specific resistance of 0.008 ohms/centimeters and a thickness of 220 microns. After etching by hydrogen chloride (HCl), a reaction gas obtained by mixing hydrogen phosphide (PH₃) with silicon tetrachloride (SiCl₄) was injected during a time interval of about 12 minutes. Temperature of the wafers at vapor growing was 1,130°C for the conventional nozzle and 1,170°C for the nozzle of this invention. The specific resistances in a batch of produced films have a deviation of 13 percent for the device of this invention and a deviation of 21 percent for the conventional device. Accordingly, the deviation of the specific resistance is effectively reduced in accordance with this invention. Moreover, a specific resistance of 25 ohms/centimeter is obtained in a case where an impurity gas is not included in the reaction gas in the device of this invention. However, a specific resistance of more than 2 ohms/centimeter cannot be obtained in the conventional device. Accordingly, detrimental effects caused by the impurity gas is effectively reduced in accordance with this invention.

EXAMPLE 2

Twenty-three wafers each having a diameter of 38 millimeters were arranged on a carbon susceptor having a diameter of 220 millimeters coated with silicon carbide (SiC), while silicon tetrachloride (SiCl₄) was employed as the reaction gas. Hydrogen phosphide (PH₃) was mixed with the reaction gas as an impurity gas. As measured results of grown semiconductor films, a deviation of ± 4.8 percent for a standard of thickness of 10 microns and a deviation of ± 2.5 percent for a standard of specific resistance of 0.7 ohms/centimeter were obtained. In a conventional vapor growth device having substantially the same manufacturing capacity as this device, the above-mentioned deviations exceeded respectively 10 percent and 7 percent.

As mentioned above with, the vapor growth device of this invention it is possible to completely avoid the harmful effects of an absorbed gas and stain on the material of the metal chamber 1 even if a metal chamber is used. Moreover, deviations for thickness and specific resistance of crystal films grown on a number of wafers arranged on the susceptor can be effectively reduced, so that the grown crystal films have good and stable characteristics. In a conventional device, if a substrate doped by arsenic (As) is employed, undesirable effects are not avoidable due to insufficient exhaust caused by convection, etc. However, sufficient characteristics of grown crystal films are obtained by the vapor growth device of this invention in the above condition.

What we claim is:

1. A vapor growth device for vapor-growing semiconductor crystal films on a plurality of semiconductor wafers, comprising: a main chamber composed of metal and having means therein defining an exhaust

hole; a flat susceptor supported in the main chamber to hold said semiconductor wafers; means for heating said flat susceptor; a nozzle pipe receptive during use of the device of a reaction gas and extending through the center portion of said flat susceptor into said main chamber and having means therein above the level of said flat susceptor defining a plurality of holes extending perpendicular to the longitudinal axis of said nozzle pipe; means for effecting relative rotational movement between said nozzle pipe and said flat susceptor; a nozzle cover having a flat part and a cylindrical part provided at the edge of said flat part, said flat part being supported on the top of said nozzle pipe and extending parallel to and in spaced-apart relationship from said flat susceptor to substantially cover same, said cylindrical part being spaced-apart from the edge of said flat susceptor to define therebetween a gap, and wherein said flat susceptor and said nozzle cover comprise an auxiliary reaction chamber so that the reaction gas injected into the auxiliary reaction chamber from said nozzle pipe flows through said gap to said exhaust hole while forming a gas curtain around said gap.

2. A vapor growth device according to claim 1, in which said flat susceptor has a circular configuration and said nozzle pipe extends through the center of said flat susceptor so that the reaction gas flows out said plurality of holes and radially outwardly with respect to said flat susceptor.

3. A vapor growth device according to claim 1, in which the head of the nozzle pipe is exchangeable with other heads to effect adjustment of said distance between said flat susceptor and said flat part of said nozzle cover and/or to effect adjustment of the flow rate of the reaction gas.

4. A device for vapor-growing semiconductor crystal films on semiconductor wafers comprising: means defining a main chamber; a support member disposed within said main chamber and having a flat surface for supporting thereon a series of semiconductor wafers; a cover member having a concave configuration disposed in a working position within said main chamber spaced apart from and substantially covering said flat surface to define therewith an auxiliary reaction chamber and spaced a predetermined distance from a peripheral portion of said support member to define therebetween a peripheral gap; means detachably mounting said concave cover member in said working position for detachment and replacement with another concave cover member having a different interior volume than said first-mentioned cover member whereby the volume of said auxiliary reaction chamber may be selectively varied by interchanging concave cover members; heating means for heating the interior of said main chamber; gas injecting means having radially directed dispensing apertures and extending into said auxiliary reaction chamber for injecting a reaction gas during use of the device into said auxiliary reaction chamber above the level of said flat surface and then through said peripheral gap in the form of a gas curtain to effectively prevent ingress of impurities into said auxiliary reaction chamber; and means cooperating with said gas injecting means for exhausting from said main chamber the reaction gas flowing thereinto through said peripheral gap along with any impurities present in said main chamber; whereby the reaction gas

5

reacts with the semiconductor wafers to form thereon crystal films.

5. A device according to claim 4; including means for effecting relative rotation between said support member and said gas injecting means.

6. A device according to claim 5; wherein said gas injecting means comprises a gas inlet pipe connectable to a source of reaction gas and having means therein defining a plurality of holes opening into said auxiliary

6

reaction chamber above the level of said flat surface for injecting the reaction gas into said auxiliary reaction chamber; and wherein said means for effecting relative rotation between said support member and said gas injecting means comprises means mounting said support member for rotational movement, and driving means for rotationally driving said support member.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65