

[54] **DEVICE FOR THE EPITAXIAL DEPOSITION OF SEMICONDUCTOR MATERIAL**

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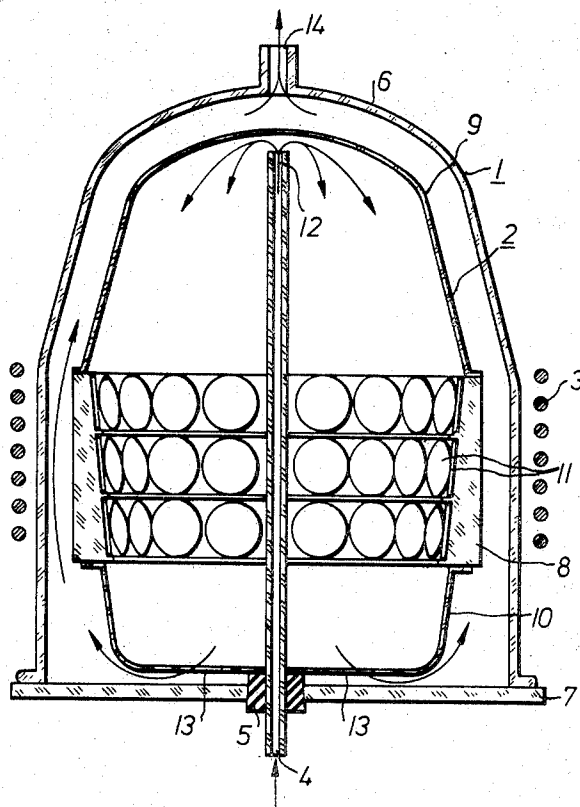
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[57] **ABSTRACT**

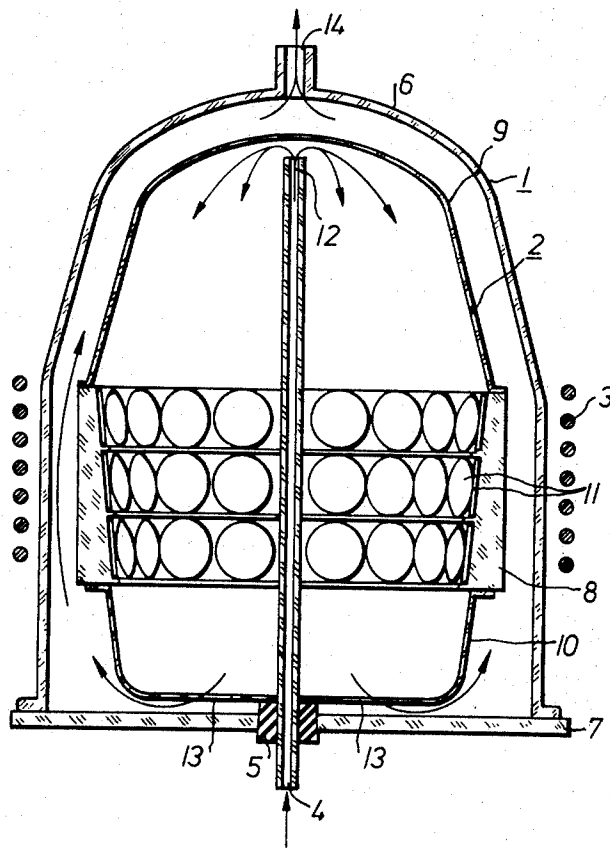
A device for the epitaxial deposition of semiconductor material on a substrate, which device comprises two containers one located inside the other, the substrate being provided inside one of the containers and gas necessary for the epitaxial deposition being introduced into the containers in such a manner that a substantially vertical flow of gas is formed in each of the containers but the direction of flow of the gas in one container is opposite to the direction of flow of the gas in the other container.

12 Claims, 1 Drawing Figure



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DEVICE FOR THE EPITAXIAL DEPOSITION OF SEMICONDUCTOR MATERIAL

BACKGROUND OF THE INVENTION

It is known that in the production of semiconductor devices such as diodes, transistors and integrated switching circuits in the modern semiconductor art, so-called epitaxy is being used to an ever increasing extent, which enables semiconductor regions to be produced on a basic semiconductor body as a substrate, which are difficult or impossible to produce by other methods. Epitaxy is understood to mean a method whereby a material is deposited on a substrate by thermal decomposition of a compound.

There are so-called vertical reactors and horizontal reactors for carrying out the epitaxial process. In a vertical reactor, the substrates on which semiconductor material is to be deposited are on a rotating graphite plate or ring under a quartz bell. In the vertical reactor, the reaction mixture flows out centrally and is supplied radially, at a low velocity of flow, over the ring, to the individual substrates. The uniformity in the deposition is obtained by rotating the substrates. Vertical reactors have a low gas consumption, produce satisfactory constancy in the values aimed at, and permit satisfactory reproducibility. It must be regarded as a disadvantage, however, in vertical reactors that they have a relatively low production capacity. In addition, if the induction coil is accommodated inside the reduction chamber, there is the risk of constant contamination.

In contrast to a vertical reactor, a horizontal reactor consists of a quartz tube, which is generally rectangular in shape and is situated horizontally, and in which there is a graphite block which is heated inductively for example and which is adapted to receive the substrate wafers. In the horizontal reactor, the gas flows lengthwise through the quartz tube and hence over the semiconductor wafers. In order that the reaction mixture may not be impoverished during passage over the substrates, higher velocities of flow are necessary in the horizontal reactor. Horizontal reactors have a definite flow of gas and also the advantage that there are no unwanted metal parts present in the reaction chamber. Uniform thickness of layer and layer resistances can only be achieved in horizontal reactors, however, with a very powerful stream of gas. A further disadvantage of horizontal reactors consists in the fact that they only have a low production capacity.

SUMMARY OF THE INVENTION

It is therefore the object of the invention to provide a device for the epitaxial deposition of semiconductor material, also called an epitaxy reactor, wherein the disadvantages of the known vertical and horizontal reactors do not occur. According to the invention, such a device consists of two containers fitted one inside the other, the supply of gas necessary for the epitaxial deposition being so effected in one of the two containers, and apertures being provided in both containers in such a manner that a vertical flow of gas develops in both containers but the direction of flow is opposite in the two containers.

According to a further object of the invention, the containers are so constructed that the gas flowing out is calmed before reaching the substrates so that there is a

uniform flow at the substrates with as low a velocity of flow as possible. This may be achieved, for example, by maintaining the volume of the center portion of the inner container as large as possible.

According to another object of the invention, a gas pipe is taken through the bottom of the inner container and extends as far as the upper end of the inner container where it has one or more outlets, and one or more outlets are provided at the bottom of the inner container as well as at the upper end of the outer container, so that a flow of gas extending from the top downwards develops in the inner container while the gas in the outer container flows conversely from the bottom upwards. As a result of the flow of gas provided according to the invention, the effect is achieved that neither in the reaction chamber nor in the other regions of the containers are there areas which are not covered by the stream of gas. As a result, precisely defined conditions are obtained which guarantee epitaxial layers, the properties of which satisfy all requirements.

According to yet another object of the invention, the substrates may be provided both in the inner and in the outer container, for example on the inner wall or outer wall of the inner container. If the gas pipe extends from the bottom upwards in the inner container, the two containers are preferably disposed concentrically round the gas pipe. The inner container is preferably adapted for rotation. Heating of the device may be effected for example, by means of a heating coil disposed round the two containers or in one of the two containers.

DESCRIPTION OF PREFERRED EMBODIMENT

The invention will now be further described by way of example with reference to the accompanying drawing which shows a preferred embodiment of a device according to the invention.

As shown in the drawing, the reactor includes an outer container 1, an inner container 2 rotatably mounted within the outer container 1, a gas pipe 4, a supporting plate 7, and at least one heating coil 3. The inner container 2 of the epitaxial reactor is formed by a cylindrical portion 8 consisting of quartz glass for example on both sides of which there are mounted the upper bell-shaped housing portion 9 and the lower bell-shaped housing portion 10 likewise consisting of quartz for example. The cylindrical portion 8 is provided with a tapered inner surface 8a which converges in a direction toward the lower bell-shaped housing portion 10. At preferably equal intervals along the inner surface 8a there is situated a plurality of shelf-like compartments 8b for supporting the wafers 11 in a substantially vertical position. The compartments 8b are formed by annular rims 8c formed integrally with the cylindrical portion 8 and extending from the inner surface 8a, and a portion of the inner surface 8a between successive rims. It should be understood, of course, that other and different configurations for the compartments are possible.

The outer container 1 includes a bell-shaped upper portion 6 which preferably conforms to the upper bell-shaped housing portion 9 of the inner container 2. The outer container 1, the inner container 2 and the mounting plate 7 defined therebetween a chamber S through which a gas flow is directed toward an exit aperture 14 in the upper portion 6 of the outer container 1.

The mounting plate 7 and the bottom wall 10' of the lower bell-shaped housing portion 10 include apertures 7' and 10'', respectively. These apertures are preferably aligned when the reactor is assembled and have extending therethrough the gas pipe 4. The apertures 7' of the mounting plate 7 includes therein an elastic bearing 5 through which the gas pipe 4 extends and on which the inner container 2 is supported. The inner surface 7'' on the mounting plate 7 cooperated with apertures 13 formed within the lower wall 10' of the housing portion 10 in a manner to be described hereinafter.

The heating coil 3 is disposed around the outer container 1 and serves to heat the reactor. The heating coil 3 could alternatively be situated within one of the two containers if so desired. In order to achieve uniform rates during the epitaxial deposition on the substrates 11 provided on the inner wall of the quartz cylindrical portion 8 in the example, the volume of the cylindrical portion 8 must be made as large as possible, while the volume of the bell present on the cylindrical portion 8 must be at least half to twice as great as the volume of the cylindrical portion 8.

In the epitaxy reactor illustrated in the drawing, the flow of gas takes place as follows. The gas necessary for the epitaxial deposition first flows vertically upwards through the gas pipe 4 from the bottom and emerges, at its upper end 12, into the inner container 2 of the epitaxial reactor. The pipe 4 thus directs the gas into a flow path toward the generally dome-like upper surface 9' of the housing portion. As the arrows in the drawing indicate, the gas emerging from the upper end 12 of the gas pipe 4, impinges against the surface 9' and flows vertically downwards in the container 2, past the substrates 11, supported on the inner wall of the cylindrical portion 8, toward the apertures 13 in the bottom wall 10' of the housing portion 10. As a result, the semiconductor material is deposited epitaxially on the substrates. The gas leaves the inner container 2 through the apertures 13 and enters the outer container 1 where it impinges against surface 7'' and flows vertically but not from the top downwards as in the container 2 but conversely from the bottom upwards. The apertures 13 and plate 7 thus combine to direct the gas into a flow directed toward the aperture 14 in the upper portion 6. Finally, the gas passes out of the epitaxy reactor to the outside through the aperture 14. The important advantage of such a flow of gas and hence of the invention consists in that all compartments of the epitaxy reactor are covered by the flow of gas and are thoroughly flushed in this manner.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations.

What is claimed is:

1. A device for the epitaxial deposition of semiconductor material on a substrate, said device comprising a first vertical container, a second vertical container inside the first container, means for introducing a gas for epitaxial deposition on the substrate into said second container, said gas introducing means including a gas pipe which passes through the bottom of the second container and extends to adjacent the upper end of said

second container, said gas pipe having an outlet adjacent to said upper end of the second container, first means vertically displaced from said outlet in a downward direction for allowing said gas to pass out of said second container into said first container so that said gas flows in said second container in a substantially vertical direction and toward said first means, second means vertically displaced from said first means in the direction of said outlet for allowing said gas to pass out of said first container so that said gas flows in said first container in a substantially vertical direction opposite to that in said second container, and means for supporting at least one substrate within the path of one of said substantially vertical flows for deposition thereon.

2. A device as claimed in claim 1, in which said second container includes a cylindrical portion and an upper and lower bell-shaped housing portion extending one from each end of said cylindrical portion, said cylindrical portion includes said means for supporting the substrates, and said bell-shaped housing portions have a volume which is at least half to twice as great as the volume of said cylindrical portion, whereby the gas flow is calmed in such manner that a uniform flow with minimum possible velocity is developed at the substrate.

3. A device as claimed in claim 1, in which the second container is rotatable.

4. A device as claimed in claim 1, in which the two containers are arranged concentrically around the gas pipe.

5. A device as claimed in claim 1, in which said second means for allowing said gas to pass out of said first container includes an aperture provided in the upper end of the first container.

6. A device as claimed in claim 1, in which said first means for allowing said gas to pass out of said second container into said first container includes apertures provided in the bottom of the second container.

7. A device as claimed in claim 1, in which the means for supporting the substrate is mounted on the outer wall of the second container.

8. A device as claimed in claim 1, in which the means for supporting the substrate is mounted on the inner wall of the second container.

9. A device as claimed in claim 1, in which the first container is surrounded by a heating coil.

10. A device as claimed in claim 1, in which the second container is surrounded by a heating coil.

11. A device as claimed in claim 4 in which said second means for allowing said gas to pass out of said first container includes an aperture provided in the upper end of said first container, and said first means for allowing said gas to pass out of said second container into said first container includes apertures provided in the bottom of said second container.

12. A device as claimed in claim 11 wherein said second container includes a cylindrical portion and an upper and lower bell-shaped housing portion extending one from each end of said cylindrical portion, said cylindrical portion includes said means for supporting the substrates, and said bell-shaped housing portions have a volume which is at least half to twice as great as the volume of said cylindrical portion.

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