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[54] **APPARATUS FOR PRODUCING EPITAXIAL LAYERS**

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[51] **Int. Cl.** **B05c 3/18**

[58] **Field of Search** 118/421, 415, 506, 400; 148/171, 172; 117/113

[56] **References Cited**

UNITED STATES PATENTS

3,522,792	8/1970	Delfel	118/415
3,664,294	5/1972	Solomon	118/415 X
3,692,592	9/1972	Marinelli	148/171 X
3,697,330	10/1972	Minden et al.	148/171 X
3,707,137	12/1972	Jaworek	118/415
3,791,344	2/1974	Gramann	118/421

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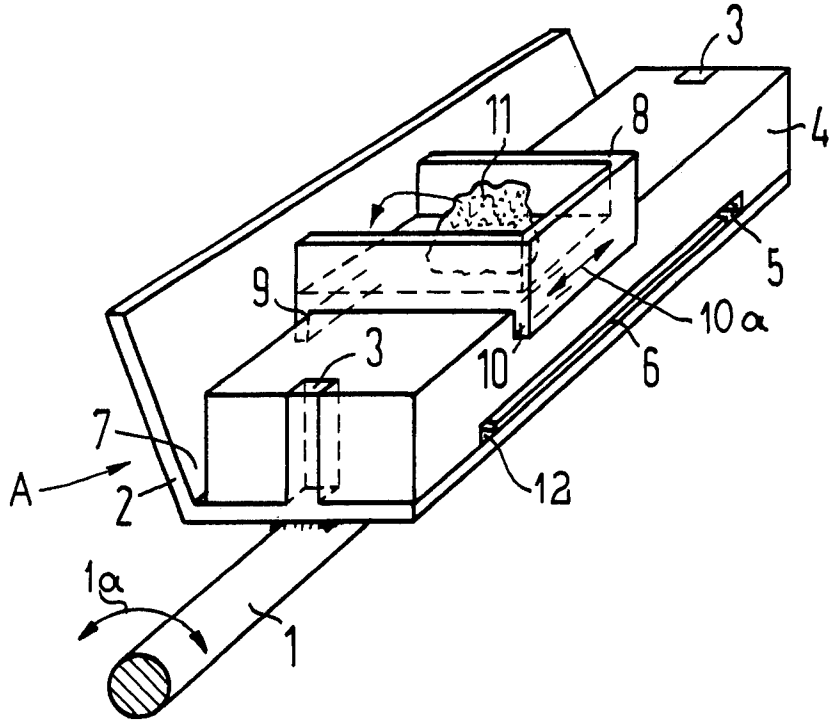
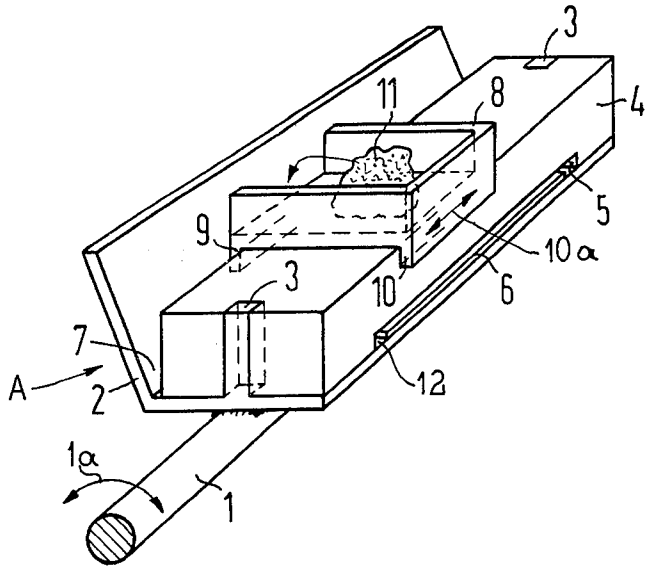
[57] **ABSTRACT**

An epitaxy apparatus is provided wherein molten material is directed via a wedge-shaped slot into a gap located opposite below the slot and between a substrate carrier and an adjacent high-heat capacity body so that a uniform epitaxial layer of a desired thickness is produced on the substrate within the gap.

8 Claims, 1 Drawing Figure

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APPARATUS FOR PRODUCING EPITAXIAL LAYERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an apparatus for producing epitaxial layers on substrates comprised of compound semiconductor materials.

2. Prior Art

During the production of semiconductor components, such as for example, luminescence diodes from compound semiconductor materials, epitaxial layers are produced by a so-called melt epitaxy. In this process, a starting body, i.e. a substrate, composed of gallium arsenide of one conductivity type may be used, onto which a layer of gallium arsenide of the other conductivity type is epitaxially deposited.

A melt which contains a saturated amount of the material to be epitaxially deposited is applied to a substrate surface at the starting temperature for deposition and the substrate is then cooled, as a result of which the material to be deposited is caused to crystallize. As a result of the cooling, the molten solution becomes super-saturated or super-cooled and this process is referred to as "constitutional super-cooling" or crystallization via growth cooling. During such constitutional super-cooling, crystallization initially takes place on the substrate, which functions as a crystallization seed. If the constitutional super-cooling is too fast, seeds will also form within the melt itself, i.e. the melt becomes encrusted and undesirable and uneven epitaxial layers are formed.

In order to reduce the rate of constitutional super-cooling, the melt must have a higher temperature than the substrate, i.e., a temperature gradient must exist between the melt and the substrate.

German Offenlegungsschrift Pat. No. 2,028,108 suggests that in order to improve the surface quality of epitaxial layers, the substrate should be arranged within a gap and the epitaxial deposition process take place in such a gap. The concept of this suggestion is to arrange the substrate surface relatively close to an adjacent solid wall of the epitaxy device. However, the required temperature gradient between the melt and the substrate is produced by means of a special relative spatial arrangement of the substrate, the melt and a heating means. The apparatus thus provided renders it difficult, if not impossible, to realize steep temperature gradients. Further, because of the surface tension of the melt, it is not possible to narrow the gap as desired, since once a certain lower limit of the gap width is reached, the melt fails to flow within the gap.

On the other hand, if a gap is too wide, there is a tendency for the melt to form a crust so that with such an apparatus, the surface properties of the produced epitaxial layer are no better than those produced with epitaxy devices without a gap.

SUMMARY OF THE INVENTION

The invention provides an epitaxy apparatus which substantially eliminates the aforementioned disadvantages of prior art epitaxy devices.

In accordance with the principles of the invention, uniform epitaxial layers of a desired thickness are deposited on a substrate composed of compound semiconductor material and which is positioned within a gap so that the melt, which contains the material to be epitaxially deposited, is guided to the gap via a wedge-shaped slot.

In accordance with the invention, the epitaxy apparatus comprises a selectively movable substrate carrier member having at least two adjoining surfaces which define an obtuse angle with one another, a parallelepiped high-heat capacity body associated with the carrier member so as to define a gap for the substrate between the carrier member and the body along a pair of adjacent surfaces thereof and so as to define a wedge-shaped slot in communication with the gap along another pair of adjacent surfaces thereof, and a selectively movable container mounted on the high-heat capacity body for holding a melt so that by inserting a substrate into the gap and placing a melt within the container and selectively moving the substrate carrier in a first direction, the melt will flow through the wedge-shaped slot to the gap and onto a substrate surface. Then by super-cooling the apparatus, an epitaxial layer is deposited on the substrate surface.

BRIEF DESCRIPTION OF THE DRAWING

For a better understanding of the invention as well as other features and further objects thereof, the reader is referred to the following detailed description which is to be read in conjunction with the accompanying drawing, whose single FIGURE shows, in a perspective view, an exemplary embodiment of an apparatus constructed and operable in accordance with the principles of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention provides an apparatus for producing uniform epitaxial layers on a substrate wherein a substrate is positioned in a gap, a melt containing the material which is to be epitaxially deposited is flown to the substrate surface in the gap via a wedge-shaped slot and the material within the melt is deposited on the substrate surface by super-cooling the melt.

In accordance with the principles of the invention, a gap is defined between adjacent surfaces of a substrate carrier and a high-heat capacity body and a wedge-shaped slot is provided in communication with the gap and is defined by other adjacent surfaces of the substrate carrier and the high-heat capacity body. A container for the melt is provided on the high-heat capacity body and is associated with the wedge-shaped slot so that the melt may be guided from the container via the slot to the gap and onto the substrate surface.

Apparatus constructed in accordance with the principles of the invention features a temperature gradient, which is required for constitutional super-cooling, which is determined solely by the gap boundaries. Since the gap boundaries on the side of the melt are in fact formed by the high-heat capacity body, the temperature gradient can readily be made very steep by maintaining a small gap width and a high cooling rate. This arrangement always insures that the melt is hotter than the substrate and avoids a crust from forming on the melt.

On the other hand, the gap width in an epitaxy apparatus constructed in accordance with the principles of the invention may be made very narrow since the melt is guided from a container on the high-heat capacity body through a wedge-shaped slot onto the substrate

surface so that the surface tension of the melt is overcome by kinetic energy developed in passing through the wedge-shaped slot.

Apparatuses constructed in accordance with the invention not only provide a saving in the quantity of melt required, as a result of the narrowness of the gap, but also enable deposition of very thick layers since the entire amount of material dissolved within the melt may be deposited without any crust formation, i.e. exclusively on the substrate. Further, apparatus in accordance with the invention also provides a saving of space since a plurality of wafers or substrates may be epitaxially processed by arranging such plurality directly next to one another on the substrate carrier without any auxiliary means.

Referring now to the drawings, wherein an exemplary embodiment of the essential features of an epitaxy apparatus A constructed and operable in accordance with the principles of the invention is illustrated. Such conventional items as a heating means, a cooling means, a reaction chamber, etc., are omitted for the sake of clarity. As shown, a substrate carrier **2** is attached on a selectively movable shaft **1.** In a preferred embodiment, the substrate carrier **2** takes the form of an angular member having at least two joined side walls which define an obtuse angle with one another. A body **4** composed of a high-heat capacity material is positioned on the substrate carrier **2** and held in place by pins **3.** In preferred embodiments, the body **4** comprises a parallelepiped member which is composed of quartz or aluminum oxide. In the embodiment shown, a recess **5** is provided along the central area of a bottom surface of body **4** so as to define, with the adjacent substrate carrier surface, a gap **12.** The gap **12** may also be defined by spacing the bottom surface of the body **4** a select distance above the substrate carrier. The gap **12** is of a size sufficient to receive at least one substrate **6** therein, upon which an epitaxial layer is to be deposited. A wedge-shaped slot **7,** which is in communication with the gap **12,** is provided between a pair of adjacent walls of the carrier **2** and the high-heat capacity body **4.** A selectively movable vessel or container **8** is positioned on top of the body **4** above each substrate **6** and held in place by flanges **9** and **10.** A melt **11,** which contains the material to be epitaxially deposited onto the substrate **6,** is placed within the container **8.**

During an epitaxial deposition, the entire apparatus A as described above is heated via a suitable heating means to a required temperature in accordance with the material being deposited. Then the apparatus A is selectively moved, for example, about shaft **1** in a direction indicated by arrow **1***a* so that the melt **11** falls or flows into the wedge-shaped slot **7** and runs along the gap **12,** which contains a substrate **6** and onto the up-facing surface of the substrate. If more than one substrate is placed within the gap, accordingly more containers are used and moved along the directions indicated by arrow **10***a* so as to be placed one above each substrate. Thereafter, the apparatus A is moved back to the starting position and an appropriate cooling means is activated to cool the apparatus so that the deposition process proceeds in the manner described earlier.

Since, as mentioned hereinabove, apparatusus constructed in accordance with the invention prevent crust formation on the melt, it becomes advantageously feasible to deposit a plurality of substances in accordance with appropriate phase diagrams in the sequence of their respective solubility within the melt on one or more substrates. Thus, for example, in the formation of gallium arsenide luminescence diodes doped with silicon, a thin layer of silicon may be deposited with the apparatus of the invention so that it is possible to contemporaneously form ohmic contacts for the p-doped layers of gallium arsenide beneath the thin silicon layer. Thus, an additional contact diffusion process may be dispensed with.

Further, since the gap **12** is open for access along a side thereof, it is possible to introduce substances in a gaseous form, such as doping substances, during the epitaxial deposition with the apparatus of the invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope and spirit of the invention as claimed.

I claim as my invention:

1. An apparatus for the production of epitaxial layers on a substrate composed of a compound semiconductor material, comprising:

a substrate carrier having at least two adjoining surfaces;

a high-heat capacity body in contact with one of said surfaces of the substrate carrier and adjacent the other of said surfaces of the substrate carrier;

an area along contacting surfaces of said carrier and body defining a gap for receiving at least one substrate therein;

an area along non-contacting surfaces of said carrier and body defining a wedge-shaped slot in communication with said gap;

a container for holding a melt containing the material to be epitaxially deposited, said container being positioned on said high-heat capacity body and in communication with said slot; and

a selectively movable shaft attached to said substrate carrier so that upon movement of said shaft the melt is guided from said container through said slot to said gap and onto a surface of a substrate within said gap for epitaxial deposition thereon upon super-cooling of said melt.

2. An apparatus as defined in claim **1,** wherein said substrate carrier is an angular member having adjacent side walls which form an obtuse angle with one another.

3. An apparatus as defined in claim **2,** wherein the high-heat capacity body is a parallelepiped member spaced above a wall of the substrate carrier a distance which defines the gap.

4. An apparatus as defined in claim **1,** wherein the high-heat capacity body is composed of quartz.

5. An apparatus as defined in claim **1,** wherein the high-heat capacity body is composed of aluminum oxide.

6. An apparatus as defined in claim **1,** wherein the gap between the substrate carrier and the high-heat capacity body is open at a side thereof for access so that a gaseous dopant may be supplied to said gap.

7. An apparatus for the production of epitaxial layers on a substrate comprising:

a selectively movable substrate carrier member having at least two adjoining walls which define an obtuse angle with one another;

a parallelepiped body composed of a high-heat capacity material and having a bottom surface in contact with one of said adjoining walls of the carrier member so as to define a wedge-shaped slot between adjacent non-contacting surfaces of said carrier member and said body;

a recess formed along a central area of said bottom surface of the parallelepiped body so as to define a gap between said body and said carrier member for receiving at least one substrate therein;

a selectively movable container positioned on said parallelepiped body above said gap and in communication with said slot for maintaining a melt containing the material to be epitaxially deposited therein; and

means for selectively moving said substrate carrier toward the direction of a non-contacted wall of said substrate carrier so that upon movement of said carrier in said direction the melt is guided from said container toward said gap.

8. An apparatus as defined in claim **7** including means for selectively moving said container along said body for directing said melt to selective areas of said gap.

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