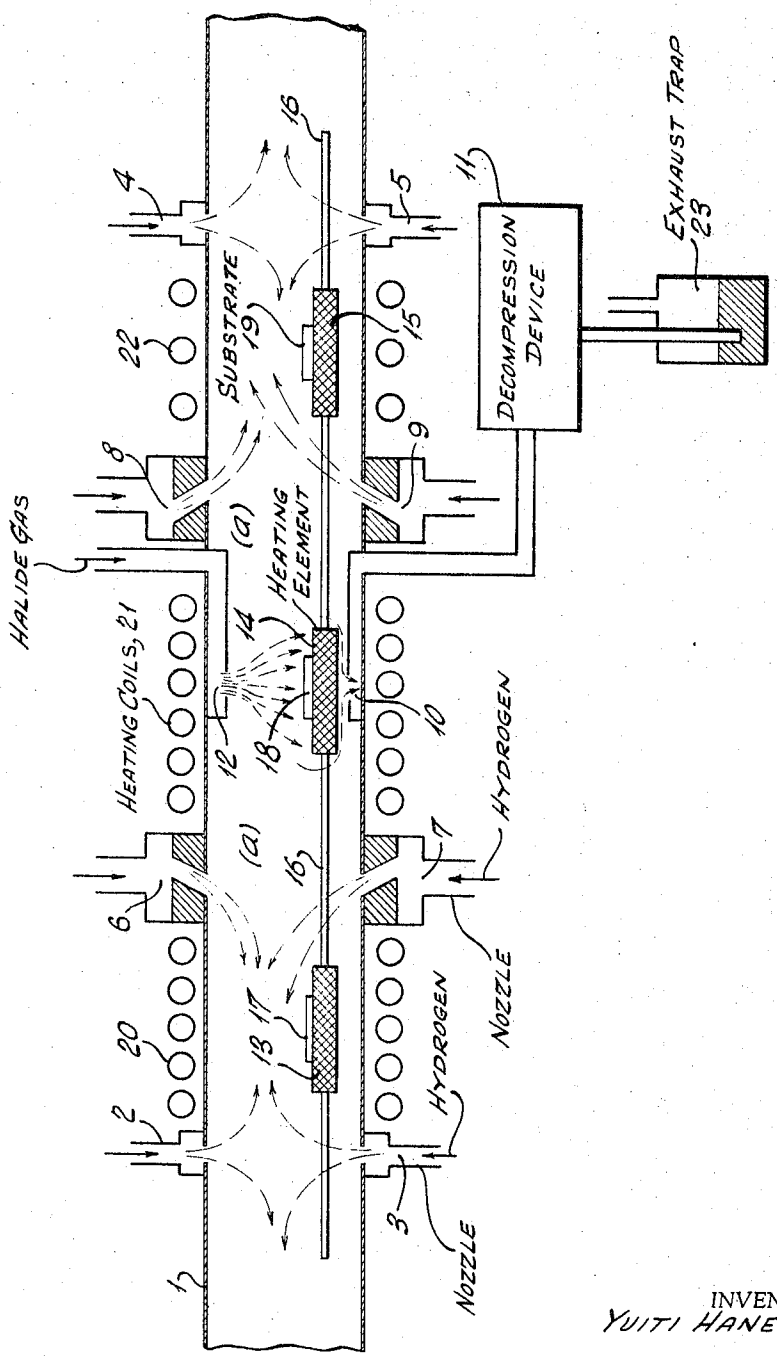
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VAPOR DEPOSITION DEVICE

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VAPOR DEPOSITION DEVICE

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This invention relates to the continuous manufacture of thin film crystals of germanium, silicon, etc., suitable for multilayer semiconductor devices, and particularly such manufacture by means of the epitaxial vapor growth method.

Although there are two conventional methods for manufacturing thin film semiconductor single crystals on a semiconductor substrate, by means of the epitaxial vapor growth method, one being the open tube method and the other the closed tube method, neither of them can operate continuously. Moreover, it has been impossible to freely control the gas flow pattern in the chemical reacting region on the substrate.

Hence it is the object of this invention to provide apparatus which may be utilized for the continuous manufacture of thin film semiconductor single crystals and which completely controls the atmosphere of the semiconductor substrate region where thin film semiconductor materials are grown.

Briefly, it will be seen that the functional prerequisites for the thin film growth are accomplished and the object satisfied by the employment of dual gas curtains in conjunction with a decompression region in the vicinity of the substrate.

The above mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will best be understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawing wherein the single figure illustrates a sectional view of the apparatus designed, according to the invention, for the continuous manufacture of semiconductor thin film single crystals.

Turning now to the figure, a quartz tube **1** is provided with nozzles **2**, **3**, **4** and **5** at both open ends thereof. These nozzles are for injecting hydrogen gas, and are positioned at several mm. intervals on the circumference of the tube for intercepting the air at the open ends; the hydrogen gas flowing inwardly and outwardly as indicated by the arrows. Additional nozzles **6**, **7**, **8** and **9** are also provided for the injection of hydrogen gas. These nozzles, also disposed about the circumference of the tube are inclined outwardly at about 60 degrees with respect to the perpendicular surface of the tube. The diameters of the hydrogen gas injecting nozzles are each several mm. The flow of hydrogen gas injected from the inclined nozzles intercepts the hydrogen gas injected from nozzles **2**, **3**, **4** and **5** and prevents hydrogen from entering the region *a* at the center portion of the tube. Thus the internal pressure of region *a* is freely controlled by the discharge outlet **10**, in communication with the region, and by the decompression device **11** connected thereto. A gas outlet **12** disposed at the central portion of the quartz tube injects a semiconductor halide gas, such as germanium tetrachloride, silicon tetrachloride, etc. The flow pattern of this injection gas can be freely controlled via the exhaust function of the aforementioned decompression device.

Heating elements **13**, **14** and **15** which consist of plates of carbon or molybdenum are connected by a coupling rod **16** in such a manner as to allow the simultaneous movement of the plates in one direction. Semiconductor

substrates **17**, **18** and **19** are mounted on the heating elements and are heated by the high frequency heating coils **20**, **21** and **22** (for surface treatment) fitted on the circumference of the tube. An exhaust trap **23** is connected to the decompression device, if necessary.

In order to manufacture the thin film semiconductor single crystals by this device, the steps are as follows: detrimental gas is first prevented from entering the region *a* of the central portion by injecting hydrogen gas from the nozzles **2** through **9**. Next, the semiconductor substrate **17** mounted on the heating element **13** is maintained at a definite temperature, for example about 800° C. for germanium, for removing deoxides from the surface of the semiconductor substrate. The heating element **13** is then moved to the region *a* at the central portion of the tube by means of the coupling rod **16**. Here, it is heated to a proper temperature by the high frequency heating coil **21**, the temperature being sufficient for the forming of a semiconductor single crystal on the surface of the semiconductor substrate by vapor growth. In the case of germanium a temperature of approximately 800° may be used. The semiconductor halide gas being introduced into the quartz tube, through the gas inlet **12** passes over the substrate and discharges as shown by the arrows.

When, for example, germanium tetrachloride is used as the semiconductor halide, vapor germanium, hydrochloric acid and halide germanium are obtained by the hydrogen reduction of the germanium tetrachloride. This vapor germanium deposits on the semiconductor substrate and the other vapors are quickly discharged through the exhaust outlet by the decompression device. By properly adjusting the pressure in the region *a*, by means of the decompression device **11**, it is possible to freely control, the gas flow pattern of the semiconductor halide and there is produced on the semiconductor substrate a gas current which is quite uniform and has high degree of purity; thus resulting in a favorable growing condition for a superior thin film semiconductor single crystal. By raising the temperature at the same time, via the high frequency heating coil **21** and the heating element **14**, up to the point at which hydrogen reduction occurs, a uniform thin film semiconductor single crystal is formed on the semiconductor substrate.

The heating element, with the thin film and substrate thereon is then transferred to the next step. Here, it is heated by the high frequency heating coil **22**. In this case, the temperature is a little lower than that of the previous steps, and is, for the material mentioned, between 500° C.–600° C. to insure a slow cooling of the semiconductor substrate. After a proper length of time, the heating element is transferred by the coupling rod to a point outside the tube and the semiconductor substrate on which the thin film semiconductor single crystal has been grown may be removed.

Thus it may be seen that by the method of this invention, not only is it possible to grow a semiconductor single crystal with a uniform thickness on a semiconductor substrate, but it is also also possible to make the impurity density in the grown layer uniform and one can adjust and control freely the objective impurity and the grown layer; and further, it is possible to continuously manufacture thin film semiconductor single crystals on semiconductor substrates.

While I have described above the principles of my invention is connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

What is claimed is:

1. An apparatus for the continuous manufacture of thin film semiconductor single crystals comprising a cylin-

drical tube open at both ends; means connected to said tube for creating a pair of gas curtains therein; means connected to said tube, intermediate said first mentioned means for creating a second pair of gas curtains in said tube the first pair of gas curtains being substantialy perpendicular to said tube axis and each of the second pair of gas curtain means being inclined with respect to the said tube axis, whereby three distinct tube regions are defined; semiconductor substrate positioning means disposed through said tube and adapted for axial movement with respect thereto; means for heating said regions; decompression means communicating with the central region of said tube; and means for injecting a film growing gas into said central region.

2. An apparatus for the continuous manufacture of thin film semiconductor single crystals as claimed in claim 1 in which the supporting elements of said substrate positioning means are positioned consecutively within each region and heat the substrate supported thereby when so positioned.

3. An apparatus for the continuous manufacture of thin film semiconductor single crystals comprising a cylindrical tube open at both ends; means disposed about said tube at each end thereof for creating a pair of gas curtains therein; means disposed about said tube, intermediate said first mentioned means for creating a second pair of gas curtains in said tube in which said end pair of gas curtains is substantially perpendicular to said tube axis, and each of said second pair of gas curtains is inclined towards its neighboring end curtain, whereby three distinct tube regions are defined; semiconductor substrate positioning means disposed through said tube and adapted for axial movement with respect thereto; means for heating each of said three regions; decompression means communicating with the central region of said tube for adjusting the internal pressure thereof; and means for injecting a film growing gas into said central region.

4. An apparatus for the continuous manufacture of thin films semiconductor single crystals as claimed in claim 3 in which said second pair of curtains are so oriented as to enable independent control of the center of the three regions so formed and simultaneously create the desired atmosphere in each of the end regions.

5. An apparatus for the continuous manufacture of thin film semiconductor single crystals as claimed in claim 3 in which said heating means consists of induction coils, said coils being disposed with relation to said support means as to induce heat therein which is then radiated to the substrate supported thereby.

6. An apparatus for the continuous manufacture of thin film semiconductor single crystals as claimed in claim 3 in which said injecting and decompression means cooperate to control the gaseous atmosphere within said center region.

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