

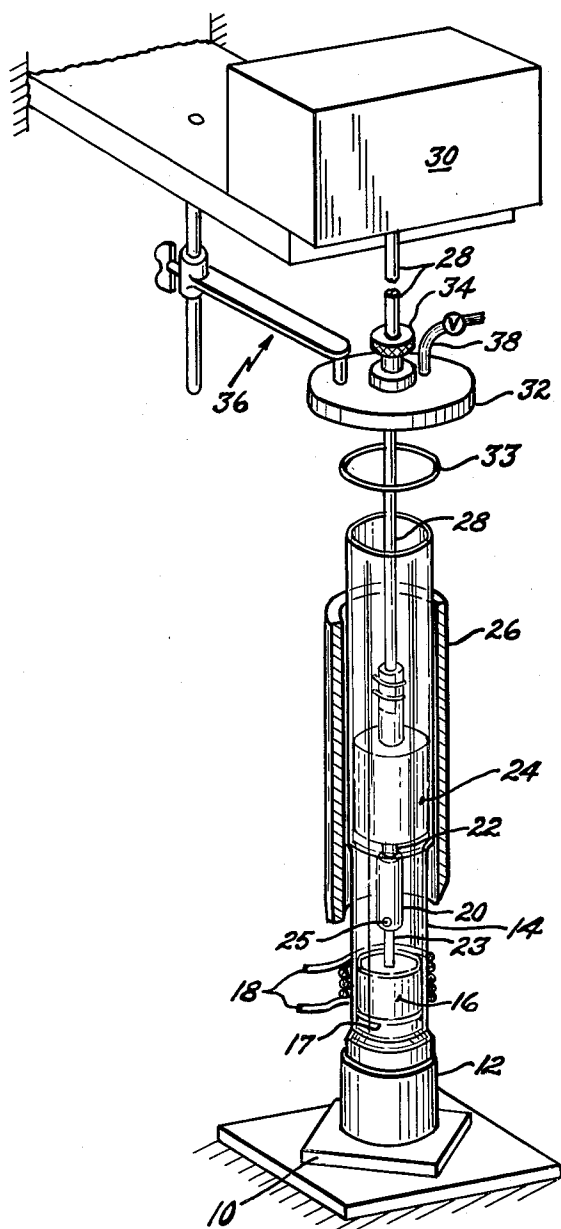
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SYRINGE-TYPE SINGLE-CRYSTAL FURNACE

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## SYRINGE-TYPE SINGLE-CRYSTAL FURNACE

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6 Claims. (Cl. 23—273)

This invention relates generally to furnaces and more particularly to a single-crystal furnace of the syringe type for materials containing a volatile constituent.

The furnace of this invention is of the type wherein a seed is pulled from a melt to form single-crystals of compounds such as InAs, GaAs, InP, etc. By utilizing a quartz tube having a closely fitted piston therein and a seed pulling shaft integral with said piston, sealing problems inherent in conventional furnaces for preventing the escape of volatile constituents are eliminated.

The preparation of single-crystal semiconductors and rectifying cells for the electronics industry has been the source of much research; however, prior art methods for the manufacture of these items heretofore have utilized cumbersome external magnetic pulling systems or an elaborate method of sealing the system from the atmosphere.

The syringe-type crystal puller of this invention with a clearance at operating temperatures of approximately 0.0005 inch provides a substantially vacuum tight syringe which fills the need of the industry for a device to grow high purity crystals.

Accordingly, it is an object of this invention to provide a single crystal furnace capable of use with volatile constituents.

It is another object of this invention to provide a syringe-type crystal puller.

It is still another object of this invention to provide a single-crystal furnace capable of operation under a vacuum or inert atmosphere.

It is a further object of this invention to provide a syringe-type single-crystal furnace which is easy and economical to produce of currently available materials which lend themselves to mass production manufacturing techniques.

These and other advantages, features and objects of the invention will become more apparent from the following description taken in connection with the illustrative embodiment in the accompanying drawing wherein the figure is an isometric view partly in section of the novel furnace.

In the figure a base portion 10 having a right circular cylindrical section 12 affixed thereto provides the support for the base portion of a quartz tube or housing 14. A crucible 16, which may be of quartz integral with the tube or of graphite construction sealed from the base by means of a quartz false base 17, is suspended in tube 14 to hold the melt which is heated by a standard R.F. induction coil of tubing 18 connected to a suitable source of energy and a water cooling system (not shown).

The method of utilization of this invention involves the projecting of a crystal seed or germ into contact with the melt and then withdrawing while rotating the crystal seed in accordance with the rate of growth of the crystal.

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The seed holder of this invention is shown at 20 and is affixed at one end to shaft 22 while the opposite end is hollow to engage the seed 23, for example, by means of set screws 25. A ground quartz or graphite piston or plunger 24 is affixed to the shaft 22 and is provided with a clearance in the order of 0.0005 inch with the ground quartz tube 14. The escape of the volatile constituent of the melt is prevented by the close fit between the precision ground surfaces of the tube 14 and plunger 24. In order to provide an equilibrium atmosphere over the melt, a heating unit 26 is provided around the quartz tube 14 to maintain the walls of said tube above the condensation temperature of the volatile element.

The piston 24 is connected to a driving shaft 28 which is capable of rotation and reciprocation by means of a mechanism 30 which may be of the type disclosed in application Serial No. 610,693 to J. R. O'Connor and R. P. Dolan, Jr., filed September 18, 1956.

A cap assembly shown as an exploded view, is provided to prevent the leakage of any toxic gases which might possibly escape by the piston. The cap assembly comprises a plate 32 having a groove in its lower surface to house a silicone rubber gasket 33 for sealing engagement with ground quartz tube 14.

A Wilson-type seal or conventional packing gland 34 is provided on the cover plate 32 to seal the shaft 28 to plate 32 while allowing a reciprocating and rotating action of the shaft. A linkage 36 is provided from a fixed support to the cover plate 32 such that a downward force may be exerted on said cover plate to maintain the sealing relationship.

A valved tubular member 38 is connected with the interior of tube 14 through plate 32 for connection with either a vacuum pump or an inert gas supply. A slight pressure above the piston helps to seal any molecules from escaping by the piston 24 thus forming a gate against the atmospheric escape of toxic gases.

Thus it should be apparent that a syringe type unit capable of use with a melt having a volatile constituent has been provided, and, with the cover plate arrangement is capable of operating under vacuum conditions or with a gate comprising an inert atmosphere.

Although the invention has been described with reference to a particular embodiment, it will be understood to those skilled in the art that the invention is capable of a variety of alternative embodiments within the spirit and scope of the appended claims:

We claim:

1. A syringe-type single-crystal furnace comprising a tubular housing, a crucible adjacent one end of said housing, means for heating said crucible for melting constituents therein, a piston fitted in a substantially gas tight relationship with said housing for movement therein, a seed holder secured to the end of said piston adjacent said crucible, and a shaft affixed to the other end of said piston for operating said piston.

2. A device as defined in claim 1 including means for imparting a rotative and longitudinal motion to said shaft.

3. A device as defined in claim 1 including means for heating said tube to prevent condensation of volatile elements thereon.

4. A device as defined in claim 3 including means for

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sealing said shaft and the end of said housing opposite said crucible.

5. A device as defined in claim 4 including means for applying a vacuum or a gaseous atmosphere to the interior of said tubular housing.

6. A single-crystal furnace for use with a volatile constituent comprising a cylindrical housing, a plunger in a substantially gas tight relationship within said housing for longitudinal movement therein, a crucible mounted within said housing, means for heating constituents within said crucible, and a seed holder on said plunger for inserting a seed into contact with a melt in said

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crucible and withdrawing it in accordance with movement of said plunger in timed relationship to the rate of crystal growth of said seed.

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