

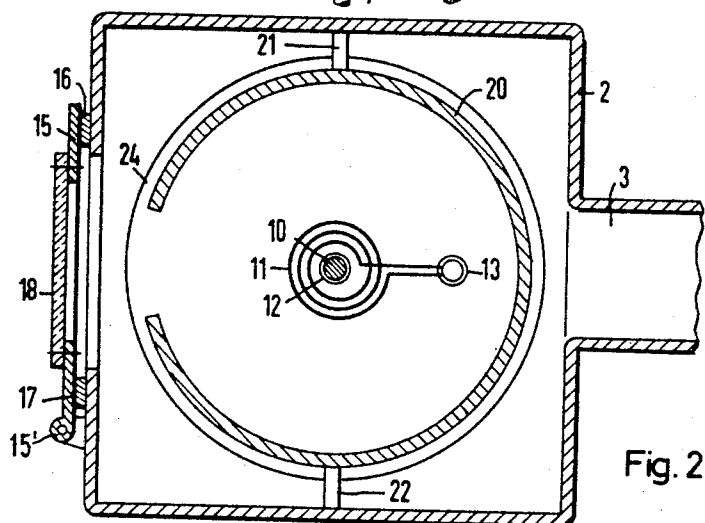
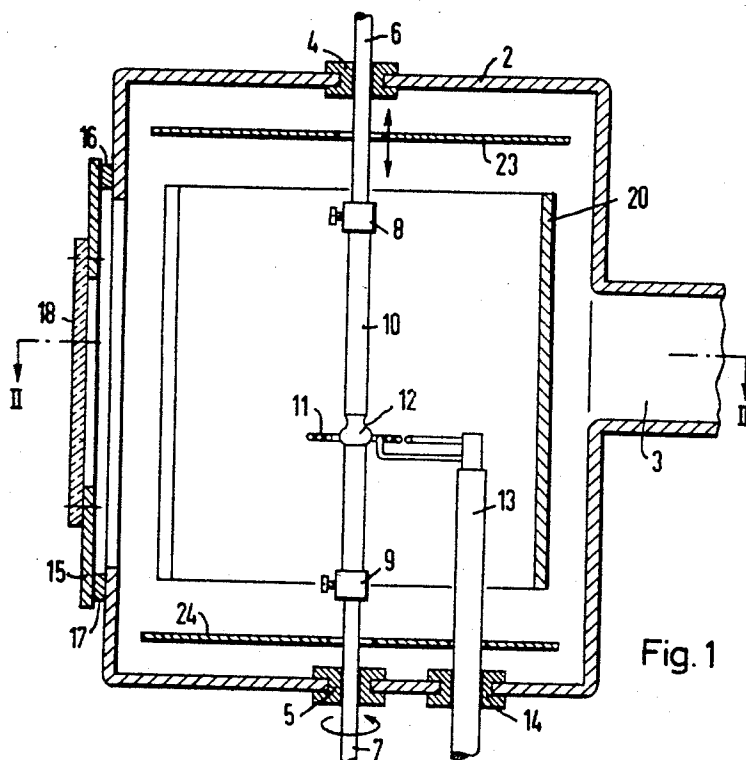
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ROUGHENED SURFACE ALUMINUM CYLINDER IN ZONE REFINING

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5 Claims

ABSTRACT OF THE DISCLOSURE

Device for zone-melting a workpiece in vacuum includes a vacuum chamber wherein the workpiece and heating means for forming a melting zone in the workpiece are located, and a secondary uncooled wall mounted in the interior of the vacuum chamber. The vacuum chamber is defined by cool walls, and the secondary uncooled wall consists of aluminum having a roughened surface, is spaced from the cool walls and is located at a relatively great distance from the melting zone when compared to the diameter of the melting zone.

My invention relates to apparatus for zone melting in vacuum.

Apparatus for zone melting in vacuum have already become known and comprise a vacuum chamber in which the workpiece to be processed with a melting zone is located. The walls of the vacuum chamber which tend to become heated by heat radiation from the melting zone are generally cooled by suitable means such as coolant coils. If they were not cooled there would be a great danger that impurities would emerge from the wall of the vacuum chamber and contaminate the workpiece of semiconductor material, such as silicon for example, which is being processed. Difficulties are consequently encountered in that material is deposited on the cooled walls of the vacuum chamber which may scale off again in solid form and cause disturbances of the growth of the monocrystals during the course of the zone-melting process. This is caused by the flaked-off portions falling into the melt and acting there as secondary seeds which introduce an undesired crystal growth. Because impurities preferably are the first to vaporize from the workpiece being processed, the danger also arises of local doping due to scaled-off material.

It is accordingly an object of my invention to provide apparatus for zone melting in vacuum which avoids the foregoing disadvantages of the heretofore known apparatus.

With the foregoing and other objects in view, I provide apparatus for zone melting in vacuum with a vacuum chamber in which the workpiece which is to be processed with a melting zone is located, the vacuum chamber being further provided with cooled walls. My invention is characterized by the fact that there is located within the vacuum chamber, an inner uncooled wall, spaced a relatively great distance from the melting zone as compared to the diameter of the melting zone and spaced from the cooled wall of the vacuum chamber.

In accordance with another feature of my invention, the side of the uncooled wall facing the melting zone has a roughened surface.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein embodied in apparatus for zone melting in a vacuum, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes

may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof, will be best understood from the following description of a specific embodiment when read in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal section through the vacuum chamber constructed in accordance with my invention; and

FIG. 2 is a cross-sectional view of FIG. 1 taken along the line II—II in the direction of the arrows.

Referring now to the drawings, there is shown a housing 2 consisting for example of thick sheet steel. The vacuum chamber is connected by a connecting conduit 3 with a vacuum pump (not shown) which can produce a vacuum of for example 10^{-4} to 10^{-6} torr in the vacuum chamber. The apparatus shown in the figures is adapted for performing a crucible-free zone melting process. However, this apparatus is also adapted for a zone melting process which employs an elongated boat or crucible because the same problems exist with such apparatus and can be solved in accordance with the invention of this application.

Apertured fittings 4 and 5 are located in the wall 2 of the vacuum chamber and maintain a vacuum seal thereof. Two shafts 6 and 7 extend respectively through the fittings 4 and 5 and are provided with holders 8 and 9 respectively for supporting the rod-shaped workpiece 10 at the respective ends thereof. The material of the workpiece 10 can consist for example of semiconductor material such as silicon or germanium or of a metal melting at high temperatures such as tungsten, for example.

A melting zone 12 is produced in the workpiece 10 with the aid of an induction heating coil 11. The induction heating coil is mounted on a guide 13 extending through an apertured fitting 14 similar to fittings 4 and 5 located in the wall 2 of the vacuum chamber. The guide 13 and the induction heating coil 11 supported thereon can be actuated from the outside by a movement vertically upward and downward as viewed in FIG. 1 whereby the melting zone 12 can be passed through the rod-shaped member 10 along the longitudinal axis thereof. The guide 13 contains the electrical leads (not shown) to the heating coil 11 as well as a coolant loop (not shown) if desired for cooling the induction heating coil 11 which is preferably formed of tubular windings. For a more detailed disclosure of such construction, reference may be had to the copending application Ser. No. 363,339 of W. Keller et al., filed Apr. 24, 1964 now abandoned.

One holder 9 can be rotatably mounted for example whereas the other holder 8 can be mounted on a shaft 6 which is displaceable vertically upward and downward as shown by the double-headed arrow in FIG. 1, whereby variations in the diameter of the workpiece being processed can be equalized or compensated, or the diameter of this workpiece can be varied.

At the front side of the vacuum chamber as viewed on the left-hand side of FIGS. 1 and 2, a very large opening is provided through which necessary manipulations can be carried out within the vacuum vessel. The opening is closed by a door 15 which can also be formed of steel. The door 15 is advantageously mounted at one edge on hinges 15'. The door 15 is automatically kept closed by pressure thereof against the seals 16 and 17 due to the pressure differential between the vacuum within the vacuum chamber and the ambient air pressure on the outside thereof. An opening is also provided in the door 15 which is vacuum-tightly closed by a viewing window 18 which can consist for example of glass or quartz glass and more specifically and advantageously of so-called bullet-proof glass. For the protection of personnel supervising

or observing the zone-melting operation, an additional transparent pane (not shown) for example of a transparent plastic material can be located in front of i.e. to the left-hand side of the viewing window pane 18 as viewed in the figures, which protects against flying fragments of the glass pane 18 in the event of an implosion.

The aforescribed difficulties of the material vaporizing from the melting zone, for example, depositing on the cooled walls, scaling off therefrom again and falling into the melting zone, for example by rebounding from the walls, to form secondary seed crystals, occurs in the course of carrying out the zone-melting process in vacuum, especially the crucible-free zone-melting process. The cooling of the walls of the vacuum chamber at least by means of the outer air and if necessary, however, by an additionally mounted cooling fan, or by means of cooling coils which are soldered or welded to the walls and are traversed by coolant liquid, is absolutely necessary and cannot be avoided because otherwise the seals necessary for the production of a high vacuum cannot remain secure if temperature variations were to occur.

The solution in accordance with my invention is to provide a second and inner uncooled wall which is located within the vacuum vessel, out of engagement with the cooled wall and surrounding the melting zone at a relatively great distance therefrom. This inner wall can for example be heated by radiation heating from the melting zone to a small extent whereby danger of scaling off is markedly reduced. In addition, the side of this uncooled wall which faces the melting zone can be provided with a roughened surface which additionally prevents scaling off of the deposited material. Furthermore, this additionally installed wall can, if necessary, be shaped so that it is easily removable and replaceable by a new clean wall during any pause or lull in the zone-melting operation.

As is shown in FIGS. 1 and 2, the additional uncooled wall 20 consists of a cylindrically bent or curved metal sheet. A wide slot is formed in the cylindrical sheet facing the door 15 so that the movement of the melting zone can be observed therethrough. Practically all metals can be used as the material for the wall 20 and if desired also other materials such as for example quartz, ceramic or graphite can also be used therefor. Aluminum is preferably employed because the surface of this material can be roughened relatively easily by sand blasting and, after such roughening, has a surface so formed as to prevent flaking off of material deposited thereon better than for other metals or the aforementioned other materials.

The wall 20 can be held in place within the vacuum chamber by spacer members 21 and 22 consisting for ex-

ample of ceramic. The wall 20 is expediently located with such great clearance from the melting zone 10 that for example a coupling of the wall 20, when consisting of metal, to the magnetic field of the induction heating coil 11, can be safely avoided. If desired, cover members 23 and 24, complementing the cylindrical wall 20 at the top and bottom thereof as shown in FIG. 1, can also be provided in addition. Attention must be given, however, to the fact that sufficiently large clearances and sufficiently large openings are provided so that necessarily free pathways are thereby afforded for producing a high vacuum.

I claim:

1. Device for zone-melting a workpiece in vacuum comprising a vacuum chamber wherein the workpiece and heating means for forming a melting zone in the workpiece are located, said vacuum chamber being defined by cooled walls, and a secondary uncooled wall mounted in the interior of said vacuum chamber spaced from the cooled walls thereof and located at a relatively great distance from the melting zone when compared to the diameter of the melting zone, said secondary uncooled wall consisting of aluminum and having a roughened surface facing the melting zone.

2. Device according to claim 1 wherein the uncooled wall has a surface facing the melting zone, and said surface is roughened.

3. Device according to claim 1 wherein the uncooled wall is substantially cylindrical and surrounds the workpiece.

4. Device according to claim 3 wherein the cooled wall of said vacuum chamber is provided with a viewing window, and said substantially cylindrical uncooled wall is formed with a slot aligned with said viewing window, whereby the workpiece within said uncooled wall can be viewed through said window.

5. Device according to claim 3 including a cover member located at the ends of said uncooled cylindrical wall.

References Cited

UNITED STATES PATENTS

2,890,139	6/1959	Shockley	23—273
2,904,512	9/1959	Horn	23—301
2,912,321	11/1959	Brennan	23—301
3,173,765	3/1965	Gobat	23—273
3,211,881	10/1965	Jablonski	23—273
3,261,671	7/1966	DeJonge	23—273
3,282,654	11/1966	Hutcheson	23—273

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