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APPARATUS FOR PRODUCING ELECTRIC SEMICONDUCTOR DEVICES BY JOINING AREA ELECTRODES WITH SEMICONDUCTOR BODIES

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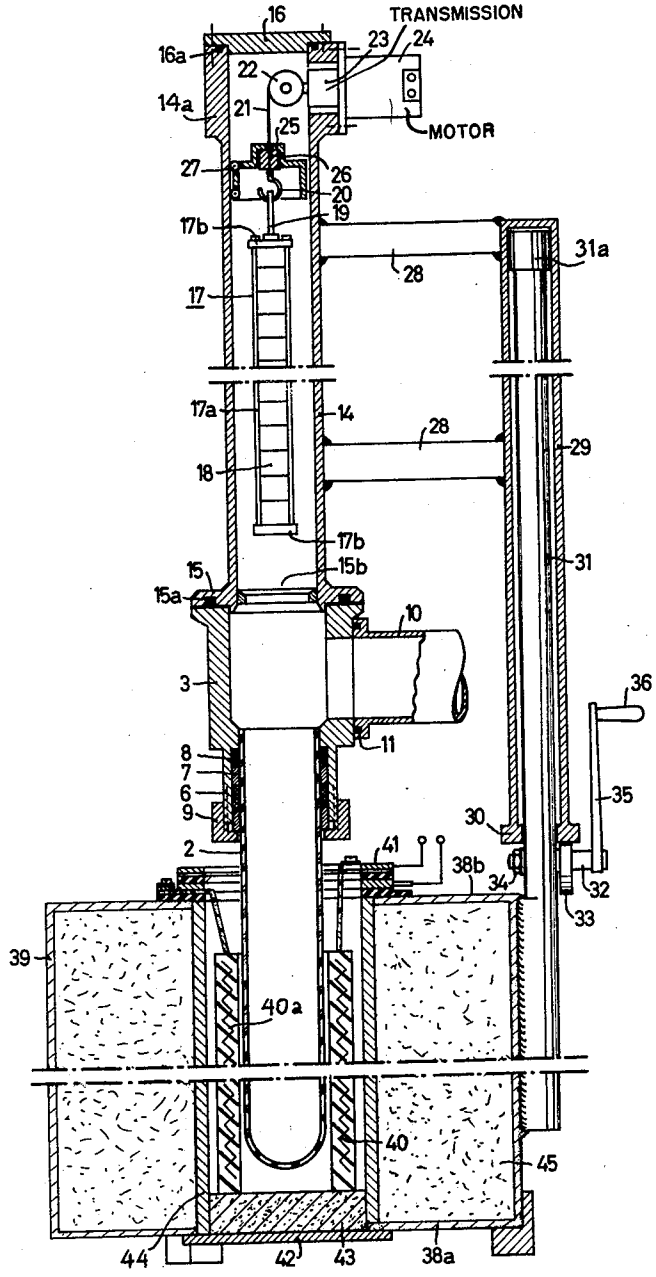

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APPARATUS FOR PRODUCING ELECTRIC SEMICONDUCTOR DEVICES BY JOINING AREA ELECTRODES WITH SEMICONDUCTOR BODIES

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My invention relates to apparatus for producing electric semiconductor devices such as silicon rectifiers or transistors, by alloying or fusing area electrodes of metal together with a silicon or other crystalline semiconductor material. The invention particularly relates to apparatus for performing an alloying or fusion method in which the semiconductor bodies and electrodes are accommodated in molds wherein they are heated to the fusion or alloying temperature, with the mutually contacting surface areas to be joined extending horizontally. Molds of this type are described in my copending application Serial No. 637,029, filed January 29, 1957, now U.S. Patent No. 2,960,419.

My invention is further related to the one disclosed and claimed in my copending application Serial No. 61,541, filed October 10, 1960, for Alloying Apparatus and Method for Attaching Area Electrodes to Semiconductor Bodies. The latter application describes an apparatus for simultaneously accommodating a number of the above-mentioned molds in a cage structure which is pendulously suspended in an alloying furnace. During furnace operation the cage structure and the molds contained therein are surrounded by a tubular container of quartz whose lower end is closed and whose upper end is suspended from a head structure to which a vacuum pump is connected.

It is an object of my present invention to improve such semiconductor production apparatus toward greatly reducing the time required for processing a charge of molds, and facilitating and expediting the charging and discharging of the furnace apparatus.

To this end, and in accordance with a feature of my invention, I provide the evacuatable tubular container structure of the furnace with a tubular extension that extends upwardly and is coaxially aligned with the container structure to form a single vacuum chamber together therewith. I further provide the tubular extension with a vacuum-tight closure at the top and mount a hoisting device in the top portion of the extension, the mold-carrying cage structure being pendulously suspended from the hoisting device so that it can be lifted out of the heating area of the furnace into the evacuated tubular extension. This has the advantage that the alloying molds, upon completion of the alloying process, can be rapidly cooled outside of the furnace shaft proper and independently of the temperature obtaining within the alloying furnace itself, while the molds are still located in vacuum.

The foregoing and other objects, advantages and features of my invention will be apparent from the embodiment illustrated by way of example and shown in vertical section on the accompanying drawing.

The apparatus comprises a tubular, elongated container 2 of refractory material, preferably a quartz tube, whose lower end is completely closed. The upper end of the tubular container 2 is secured in a holding device 3 which serves as a head structure for connection to a vacuum pump. The head structure 3 has a neck portion 6 in which the top of the quartz container 2 is coaxially held by means of a stuffing box 7, squeeze gaskets 8 and a cap nut 9 so as to be vacuum-tightly sealed from the ambient atmosphere. A lateral pipe 10 is fastened and

sealed to the head structure by means of a flange 11 surrounding a lateral opening of the head structure 3. The pipe 10 can be connected to a high-vacuum pump of any suitable type (not illustrated).

An elongated vertical extension tube 14 is mounted on top of the head structure 3 by means of a flange 15 which is provided with a rubber gasket 15*a* and which is thus vacuum-tightly joined with the processing space within the tubular container 2 due to the weight of the extension 14 and of the component mounted thereon. The upper portion 14*a* of the extension tube 14 has a square outer cross section and is vacuum-tightly closed at the top by a cover 16 and a gasket 16*a*, the cover 16 being fastened by screw bolts (not shown).

A cage-like frame structure 17 is suspended by means of an eye 19 and a hook 20 from a steel tape 21. The cage structure 17 is composed of longitudinal rods 17*a* which are connected with one another by square top and bottom plates 17*b*. The cage structure serves for accommodating a number of the above-mentioned alloying molds 18 which are simply piled on top of each other into the cage. The molds are not further described herein because they may be identical with those according to the above-mentioned copending application Serial No. 637,029, and because their particular design is not essential to the present invention.

The steel tape 21 forms part of a hoisting device which comprises a pulley or winch 22, a step-down transmission 23 and an electric motor 24. The winch 22 is mounted inside the extension tube 14. The motor 24 is preferably mounted on the extension tube but on the outside thereof. By means of this hoisting device the cage 17 with the molds 18 can be lifted and lowered. The steel tape 21 is guided in the extension tube 14 by means of a bell-shaped slider 25 to prevent excessive pendulous motion of the cage during hoisting and lowering operation. The slider 25 is supported by a weight 26 fastened to the steel tape 21. The slider can glide along the inner wall of the extension tube 14 and may be provided with guide rollers 27. Preferably, three pairs of such rollers angularly spaced 120° about the slider periphery are used, with the two rollers of each pair located vertically above one another. When the frame 17 is lowered, the slider 25 ultimately reaches a shoulder ring 15*b* welded together with the tube 14 at the lower end thereof. As soon as the slider thus becomes seated on shoulder ring 15*b*, the slider commences guiding the steel tape 21 during continuing lowering operation, the tape then passing through a corresponding slot in the top of the slider 25.

The extension tube 14 is rigidly attached by two arms 28 with an upwardly closed tube structure 29 whose axis is parallel to that of the extension tube 14 and the tubular container 2. The lower portion of the tubular structure 29 is reinforced by a welded flange 30. The tube 29 is concentrically placed over a tubular carrier column 31 of smaller diameter on whose upper end the tube structure 29 is revolvably supported. For this purpose, the upper end of the column 31 is closed by a supporting plate 31*a*. Journalled in a bore of the column 31 is a shaft 32 with an eccentric 33. The shaft is held in proper position by a nut 34 and carries a crank arm 35 with a handle 36 by means of which the eccentric 33 can be turned. With the aid of the eccentric 33 the tube structure 29 together with the extension tube 14 can be lifted off the head structure 3 and can thereafter be swung by hand about the axis of the tube 31 in order to remove the extension tube 14 from the rest of the apparatus.

The lower portion of the column 31 is rigidly secured to the jacket structure 38 of an alloying furnace 39, for example by welding. The furnace has an upwardly open, vertical shaft in which a tubular body 40 of relatively large wall thickness is located. The body 40 consists of

refractory material, for example sintered aluminum oxide and has an electric heater 40*a*, such as a resistance heater, embedded in its wall. Located above the upper end of the tubular heater body 40 are the terminal pieces 41 for connection to the source of electric heating current. The terminal pieces 41 are insulated from each other and from the furnace jacket. The bottom of the furnace shaft, formed by a closure plate 42, carries a layer of aluminum oxide powder. The inner wall 44 of the furnace consists of refractory ceramic material, for example, the space between wall 44 and the outer jacket 39, is filled with heat-insulating material 45. Top and bottom of the furnace jacket are closed by sheets 38*a* and 38*b*.

For charging the alloying furnace, the extension tube 14 is first swung laterally away from the axis of the furnace shaft. The frame 17 with the molds 18 is hung into the hook 20 and is then lifted into the extension tube 14 by means of the hoisting device. Thereafter the extension tube is turned back so as to be located coaxially above the head structure 3. Then the tube 14 is lowered by operating the eccentric 33 so that it becomes heated and sealed in proper position on the head structure 3. Now the container 2, the head structure 3 and the extension tube 14, forming jointly a single vacuum chamber, are evacuated and the frame 17 is lowered into the furnace. The heating current for the furnace can be switched on already during evacuation.

After termination of the alloying process, the frame structure can be immediately lifted out of the furnace so that it will rapidy cool in the relatively cold extension tube 14. This renders the rate and period of cooling independent of the temperature obtaining in the furnace shaft and affords again re-charging the furnace with another assembly of molds before the furnace has completely cooled down. As a result, a considerable saving in time is achieved particularly when the alloying process proper requires a short interval of time. This is the case, for example, when the carrier plates of the semiconductor elements are to be alloyed together with a metal housing for encapsulating the semiconductor body. It is then sufficient to heat the alloying mold only up to the alloying temperature, whereafter the mold can be permitted to cool immediately. However even with processes requiring a predetermined temperature to be kept constant for a prolonged period of time, the rapid cooling afforded by the present invention secures considerable advantages. This is because the furnace is provided with a sufficiently good heat insulation to obtain best possible electrical efficiency so that, after terminating the heating period, the temperature in the furnace will decline only slowly. Since the apparatus according to the invention permits cooling the mold independently of the period of time required for cooling of the alloying furnace, a considerable reduction in overall processing time is again secured.

It will be understood by those skilled in the art, upon studying this disclosure, that with respect to structural details my invention permits of a variety of modifications and can be given embodiments other than particularly illustrated and described herein, without departing from the essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. Apparatus for producing electric semiconductor devices by alloying area electrodes onto semiconductor bodies, comprising an upwardly open furnace structure, a vertically elongated tubular container of refractory material closed at its lower end, said container having a lower portion located in said furnace to be heated therein and having an upper portion upwardly protruding out of said furnace, vacuum duct means communicating with said upper portion for evacuating said container, an extension tube joined with said container at the top thereof and in coaxial vertical alignment therewith so as to form a single vacuum space together with said container, said extension tube being sealed at the top, a vertically elongated cage structure for receiving a column of alloying molds piled on top of each other, said cage structure being movable in said extension tube and downwardly into said lower portion of said tubular container, and a hoisting device disposed in the upper portion of said tubular extension, said cage structure being pendulously suspended from said device.

2. Apparatus for producing electric semiconductor devices by alloying area electrodes onto semiconductor bodies, comprising an upwardly open furnace structure, a vertically elongated tubular container of quartz closed at its lower end, said container having a lower portion within said furnace to be heated therein and having an upper portion upwardly protruding out of said furnace, a fixed head structure to which said upper portion is attached, said head structure comprising a duct vertically and coaxially aligned with said container, said head structure having attached a pump-connection duct for evacuating said container, a vertical extension tube removably seated on top of said head structure in coaxially aligned communication with said container and sealed relative to said head structure when in operation so as to form a single vacuum space together with said container, said extension tube being sealed at the top, a vertically elongated cage structure for receiving a column of alloying molds piled on top of each other, said cage structure being movable in said extension tube and downwardly into said lower portion of said tubular container, and a hoisting device disposed in the upper portion of said tubular extension, said cage structure being pendulously suspended from said device.

3. Apparatus for producing electric semiconductor devices by alloying area electrodes onto semiconductor bodies, comprising an upwardly open furnace structure, a vertically elongated tubular container of refractory material closed at its lower end, said container having a lower portion within said furnace to be heated therein and having an upper portion upwardly protruding out of said furnace, a fixed head structure to which said upper portion is attached, the interior of said head structure forming a duct vertically and coaxially aligned with said container, said head structure having attached a pump-connection duct for evacuating said container, a vertical extension tube removably seated on top of said head structure in coaxially aligned communication with said container and sealed relative to said head structure when in operation so as to form a single vacuum space together with said container, said extension tube being sealed at the top, a vertically elongated cage structure for receiving a column of alloying molds piled on top of each other, said cage structure being movable downwardly into said lower portion of said tubular container, a hoisting device disposed in the upper portion of said tubular extension, said cage structure being pendulously suspended from said device, and a supporting structure vertically movable and laterally displaceable relative to said furnace, said tubular extension being firmly secured to said supporting structure.

4. Apparatus for producing electric semiconductor devices by alloying area electrodes onto semiconductor bodies, comprising an upwardly open furnace structure, a vertically elongated tubular container of quartz closed at its lower end, said container having a lower portion within said furnace to be heated therein and having an upper portion upwardly protruding out of said furnace, a fixed head structure to which said upper portion is attached, said head structure comprising a duct vertically and coaxially aligned with said container and having, a flange a pump-connection duct is attached to said flange for evacuating said container, a vertical extension tube removably seated on top of said head structure in coaxially aligned communication with said container and sealed relative to said head structure when in operation so as to form a single vacuum space together with said container, said extension tube being sealed at the top, a vertically elongated cage structure for receiving a column

of alloying molds piled on top of each other, said cage structure being movable downwardly into said lower portion of said tubular container, and a hoisting device disposed in the upper portion of said tubular extension, said cage structure being pendulously suspended from said device, said hoisting device having a guide member vertically displaceable in said extension tube, a winch journalled in said tube and provided with a hoisting rope member to which said member is attached, and a motor mounted on said extension tube and in driving connection with said winch.

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