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[54] **CRUCIBLE FOR HOLDING MOLTEN
SEMICONDUCTOR MATERIALS**
12 Claims, 1 Drawing Fig.

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13/31; 118/49.5; 165/169; 219/420, 343; 266/39

[51] Int. Cl. **F27b 14/10**

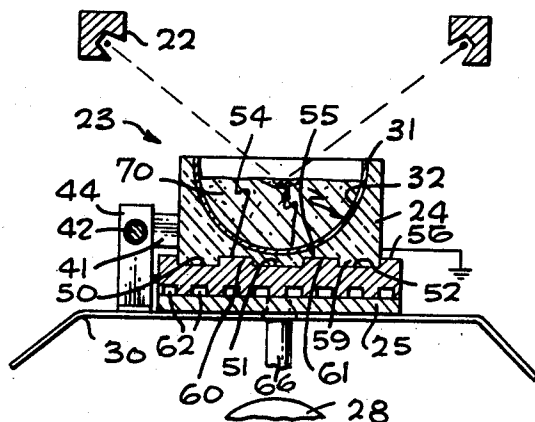
[50] Field of Search 219/420,
121, 421—2—8, 347—3, 121; 13/31, 25;
118/49.5; 263/48; 165/168, 169; 126/284, 343.5;
22/79; 75; 266/39, 34

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ABSTRACT: A crucible is disclosed herein for holding a source material in which a portion thereof is to be melted including a crucible body forming a heat sink composed of material having sufficient electrical and thermal conductivity adapted for operation as an element of an electrical circuit and being formed with a hemispherical recess for confining the source material. Means are provided for recirculating a coolant through the body which is slidably mounted on a base by a mating ribbed and grooved construction therebetween so as to form a thermal transmission path for dissipating maximum heat into the base constituting a portion of the total heat sink.



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3,554,512

Fig. 1

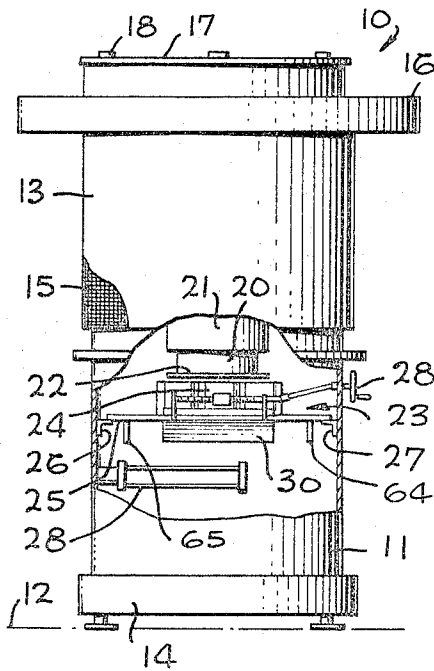


Fig. 2

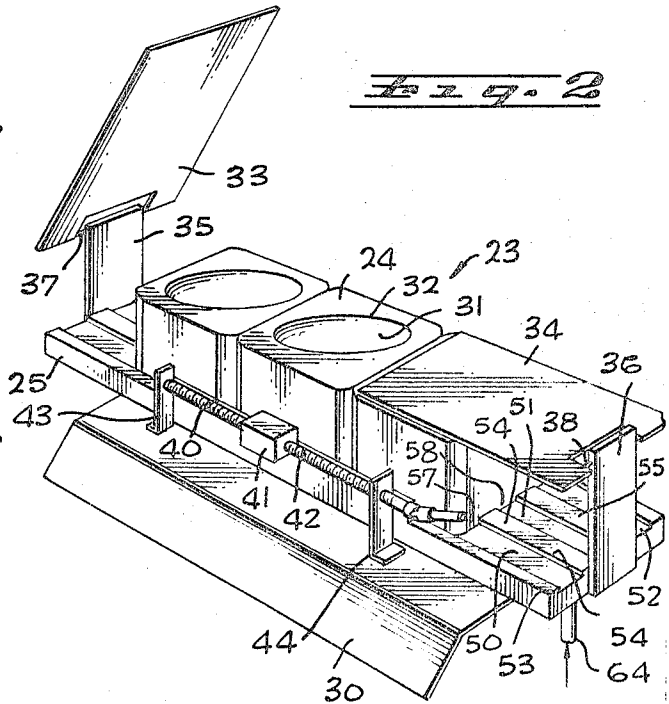


Fig. 3

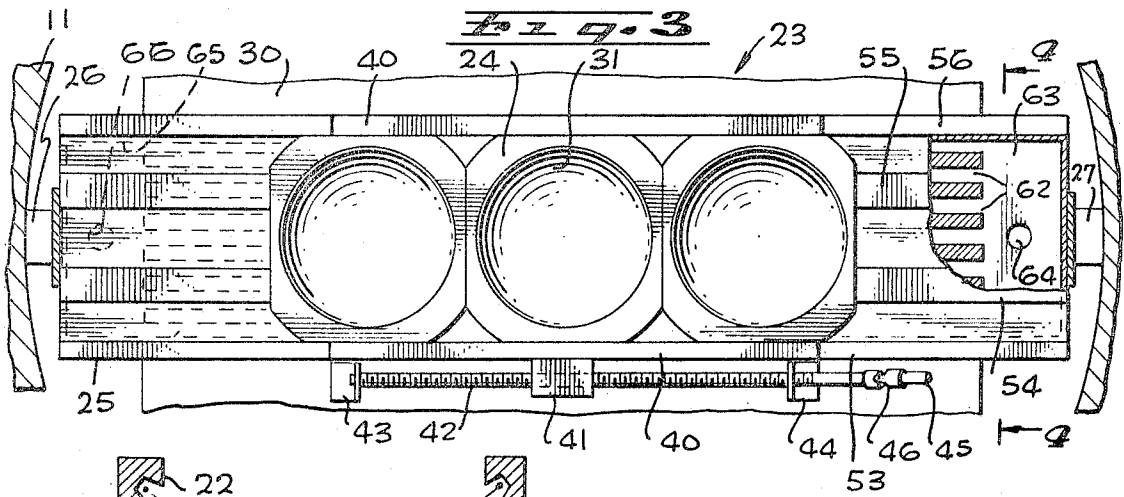
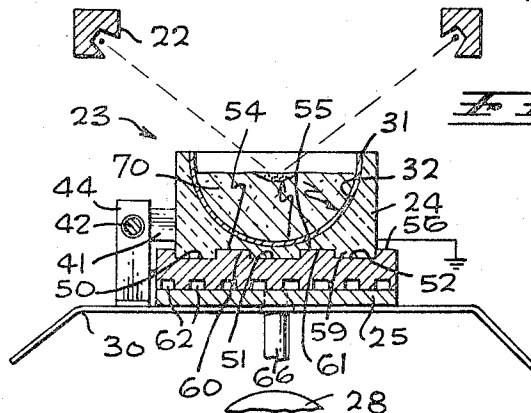


Fig. 4



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CRUCIBLE FOR HOLDING MOLTEN SEMICONDUCTOR MATERIALS

CROSS REFERENCE TO RELATED APPLICATION

In order to best explain some of the prior art in connection with examples of usage employing the present invention, some of the disclosure is reproduced herein from copending application for U.S. Pat. identified by application entitled "Apparatus and Method for Effecting the Restructuring of Materials" having Ser. No. 559,198, filed June 21, 1966, now Pat. No. 3,437,734, by Leonard F. Roman and George H. Elliott. The present application is considered to be copending with the former application and is hereby cross-referenced therewith.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to apparatus and methods for restructuring materials and, more particularly, to a crucible for holding molten semiconductor materials of highest purity having liquid and mechanical means for effecting heat dissipation so that the molten portion of the semiconductor material is positively controlled in its confinement.

2. Description of the Prior Art

As the usefulness of electronic components, circuits and systems having extremely small or minute orders of magnitude has expanded from strictly component oriented problems to problems of microminiaturization incorporating function oriented approaches in which semiconductor material is restructured to obtain desired functions, and with the widening demand, both militarily and commercially, for system and component microminiaturization capable of dealing with problems of heat dissipation, interconnections and signal interactions, the need for economic production of high density electronic packaging has become of increasing importance. A concomitant of this trend is the need for actual producibility of wider classes of function which, while providing the requisite component density, maintains both system reliability and servability. Under the thrust of this expanding use, it has become an economic necessity to provide a minimum number of circuit interconnections for microminiaturized components and systems which both minimizes the possibility of error under operating conditions and reduces overall system complexity.

With increase in component density, the reliability of circuit interconnecting means has become of paramount significance. Particularly, this is true with regard to the design, construction and interconnection of circuit components and assemblages which carry out the basic work function of complex electronics equipment such as data processing systems. Conventionally, the electrical circuit network employed in such systems generally comprise a plurality of logic circuits such as "gates" and "flip-flops" interconnected to form an electronic complex designed to carry out the various arithmetical and logical functions for which the equipment is programmed. These aforementioned components and basic circuits lend themselves to compact arrangement by placing circuits, sub-circuits or functioning stages on a single wafer or substrate. Many efforts have been expended in performing this approach by employing thin-film where there is usually a one-to-one correlation between the components in the thin-film manufacture by reactive deposition, evaporation, sputtering, photolithographic techniques, etching and many combinations of passive components.

A particularly new approach to building solid-state circuits resides in the contiguous deposition of single crystal silicon layers on a single crystal silicon substrate by employing epitaxial vapor-growth methods. Laminar layers formed in this process can be controlled in conductivity type, resistivity and thickness. By combining this technique with oxide masking, diffusion and alloying techniques, these deposited configurations can be made into microcircuits. Although vapor deposited semiconductor films are old in the prior art, most

methods involve a volatile compound of the coating material which is reduced or decomposed on a heated substrate. Obviously, the disassociation must take place at the substrate only and at a temperature below the melting point of film and substrate. Current interests in the electronics industry employing vapor deposition processes are generally divided into two techniques which have been explored for carrying the volatile compound to the substrate. One technique is generally referred to as the "close-open tube process" which utilizes a carrier gas which streams through the system with a constant flow rate. On the other hand, another technique is referred to as a "closed system" in which the vapor transport is caused by convection currents between the cooler portion of the system containing source material, and the hotter section which supports the substrate.

The only known process for producing thin layers of silicon material suitable for active device application on insulating substrates is the vapor decomposition of silicon tetrachloride at high temperature directly on sapphire substrates which involves several chemical steps between the silicon and the aluminum oxide surface. The cost of sapphire and the ability to obtain a true crystalline surface has kept this process from finding wide acceptance.

Other vacuum methods used to deposit silicon which, however, are not suitable for active device application include the sputtering process which is a method of glow discharge bombardment of a source of material in an inert gas atmosphere effective to sputter dislodged material on a target. Many close proximity techniques have been tried for evaporative processes in order to minimize contamination levels; however, very limited results have been obtained.

Ion plating, which is a form of the evaporative process utilizes a directed transport technique and has been used for inactive metals such as iron, aluminum etc. This plating process can deposit, on occasion, extremely coherent films; however, the ionization techniques used for these processes will generally not function in the ultrahigh vacuum range and they are thereby rendered useless for silicon deposition. Essentially, the ion plating process includes a source of ions which performs the function of reducing the base source material to a gas or cloud, putting it in such condition that it can be transported, further includes a so-called crystallization or target region with or without associated orientation equipment, and finally includes a transport means for transporting the material from the ionizer to a substrate located within or at the crystallization region.

However, difficulties and problems have been encountered when employing conventional vapor deposition equipment and methods since such conventional equipment cannot provide a clean environment and maintain the purity of the vaporized material to the degree that is required for active semiconductor thin-film work because the ion plating techniques will not function in the ultrahigh vacuum range. An additional problem encountered with the conventional practice resides in the fact that some source materials, such as silicon for example, are extremely difficult to confine in a molten or liquid condition. Unless the source material can be held in such a condition, it is difficult, if not impossible, to create a vapor cloud capable of performing the process. Extreme purity of the melt is a basic requirement in the handling of silicon, especially for the restructuring of semiconductor crystals. An ancillary problem resides in the fact that the use of crucibles introduces the danger of contamination entering into the melt from the material of the crucible due to an insufficiency of thermoenergy transfer. Considerable technical expenditure has been employed to develop so-called "crucible-free" methods in an effort to circumvent this danger. Thus, for example, crucibles for melting silicon of highest purity have been tried that were made of SiO_2 , BeO , Al_2O_3 , or made of similar high-melting material indifferent to silicon, such as carbides of titanium or zirconium and the like, which are lined on the inside of these materials. However, completely satisfactory results could not be achieved, because these materials al-

ways caused contamination of the melt, however slight such contamination might be.

SUMMARY OF THE INVENTION

Accordingly, these difficulties and problems encountered with conventional crucibles are obviated by the present invention which provides a novel crucible for confining molten source material at elevated temperatures, such as at 1,700° C. for example, without effecting diffusion between the source material and the crucible material or contaminating the source material per se. The crucible is adapted to hold a plurality of different semiconductor source materials and is particularly suitable for melting silicon of highest purity which completely excludes the danger of contamination resulting from the crucible material. The crucibles may be used when a method is employed for heating the source in which the required heat is not transmitted to the melt by conduction of the crucible wall but in the melt itself, by radiation or by high frequency thermal energy.

Accordingly, the present invention may be used for the melting of highly pure silicon or other semiconductor material, preferably for electrical purposes, for example, electronic components represented by diodes, rectifiers or transistors, wherein the crucible is made of thermally conductive material with a melting point under that of the source material. The crucible body is formed with a hemispherical recess in which a layer of the semiconductor source material is seated and which is sufficiently thick so that the melt of the source material is held by the layer. The crucible body is cooled by means of a cooling agent to such an extent that the temperature in the material of the crucible recess and the contacting layer of source material will be under the melting temperature of the source material and of the material of the crucible body. The crucible body is slidably mounted on a base and interconnection is made by means of alternate elongated ribs and grooves so that thermal pressure contact is produced over the complete groove side area even in the presence of anomalies existing in the parts such as may be represented by minor dents, warps or contamination not visible to the eye. These anomalies sometimes cause high pressure points which reduce the probability of achieving thermal energy transfer at the interface of the body and base surfaces.

Therefore, it is a primary object of the present invention to provide a novel crucible for melting semiconductor material of highest purity which obviates the danger of contamination resulting from the crucible material.

Another object of the present invention is to provide a novel crucible having a plurality of recesses adapted to hold semiconductor material of different conductivity characteristics whereby a selected source material of the plurality may be selectively heated to the exclusion of the other source material.

Another object of the present invention is to provide a novel crucible having improved thermal energy transferring characteristics such that source materials requiring extremely elevated melting temperatures can be readily handled without adverse reaction of the crucible material upon the source material.

BRIEF DESCRIPTION OF THE DRAWINGS

It should be noted that the following detailed description and the accompanying drawings are merely intended as being illustrative of the invention and not as a limitation thereon. Furthermore, in the following drawings, reference numerals shall be carried forward where applicable to designate like parts of the invention. The invention itself will be best understood when read in connection with the accompanying drawings in which:

FIG. 1 is a front elevational view of a vacuum chamber partially broken away to expose the novel crucible of the present invention;

FIG. 2 is an enlarged perspective view of the crucible shown in FIG. 1;

FIG. 3 is an enlarged top plan view of the crucible illustrated in FIG. 2 partially broken away to show ribbed and grooved interface construction; and

FIG. 4 is a cross-sectional view of the crucible illustrated in FIG. 3 as taken in the direction of arrows 4-4 thereof.

Referring to FIG. 1, a side elevational view of a vacuum apparatus is illustrated in the general direction of arrow 10 which is mounted on a base 11 supported on a suitable flooring 12. A glass enclosed chamber 13 confines the vacuum area in which the vapor deposition process is practiced and the glass chamber 13 is suitably supported onto the upper edge of base 11. The base 11 is provided with various conduits and plumbing communicating the vacuum chamber exteriorly of the base that are necessary to effect an ultrahigh vacuum within the chamber 13. Located about the lower periphery of the base 11, there is provided a plurality of magnets 14 which are employed in a conventional vacuum system. Suitably carried about the vacuum chamber 13, there is provided a protective screen or grate 15 which offers protection in the event the glass portion of the vacuum chamber should shatter.

Pursuant to the teachings of the above mentioned copending application, a toroidal electromagnet 16 is disposed about the vacuum chamber 13 in a coaxial relationship therewith. A removable flat lid or cover 17 is removably fastened to the upper periphery of the chamber 13. In this manner, the lid 17 may be removed from the supporting annular wall of the chamber so that the various elements and components held within the chamber may be worked upon and so that repair and maintenance may be readily achieved. The lid or cover 17 is provided with a plurality of covered passageways blocked by removable plates 18 which may be employed to mount and hold a variety of work supporting fixtures, if desired.

Within the vacuum chamber 13, there is provided an ionizing means 20 arranged in coaxial relationship with an electrical transport means 21 which are arranged over and in coaxial relationship with an electron heating source 22 which is described in more detail in the above-mentioned copending application.

Still within the vacuum chamber and located immediately below the ionizer means 20 and heating means 22, there is provided a crucible apparatus in the direction of arrow 23 for holding a quantity of source material intended to be restructured onto a substrate or target carried on a support member of fixture (not shown) at the top of the vacuum chamber 13. The electron heating source means 22 supplies a steady stream of electrons focused to strike at the center of the source material carried by a selected crucible 24 so that the electron bombardment of the source material contained within the crucible will cause the rapid melting thereof. The crucible 24 is slidably carried on a base 25 which is supported on the inside of the vacuum chamber by means of brackets 26 and 27. External drive means are provided for manually positioning the crucible 24 on the base 25 in its vacuum environment which include a lead-screw system as one embodiment thereof operable by a handle 28 located exteriorly of the vacuum base 11. To augment the vacuum system, a heater element 28 is illustrated as being cantilevered inwardly from the wall of the base 11 below the crucible apparatus 23. Also, a pan 30 is shown mounted on the underside of the base 25 which may serve as a "getter" in removing contaminants during pumpdown by the vacuum system.

Referring now to FIG. 2, a more detailed description of the source material crucible apparatus 23 will be presented as well as further elaboration on the problem and difficulties encountered with prior art crucibles. Extreme purity of the melt is a basic requirement in the melting of the source material, especially silicon, for the production of semiconductor crystals. The use of crucibles introduces the danger of contamination entering into the melt from the material of the crucible. One method for circumventing this danger is disclosed in U.S. Pat. No. 3,051,555 by providing a crucible made of copper material having a melting point lying under that of the melt. The crucible body is lined on the inside thereof with a layer or coating of purest silicon. A cooling agent is circulated through

the crucible body to cool same. However, completely satisfactory results are not achieved employing this method because of the extremely high temperature required to vaporize silicon as a source material at any appreciable rate. For example, a temperature of approximately 1,700° C. is required to vaporize silicon for any practical applications employing methods for crystalline growth. Under such a condition, it has been found that the body material of the crucible, particularly copper, will diffuse with the edge of the silicon liner. A temperature range of approximately 800° C. to 1000° C. is present at the areas of contact between the silicon and copper which represents the diffusion range for silicon so that slowly, copper will diffuse from the crucible heat sink into the silicon source material being vaporized. Also, under such high temperature conditions, the silicon liner, whether it be pure silicon or a silicon oxide, has a tendency to discolor which adversely affects the concentration of heat at the center of the source material when the source material is held in a crucible. Because silicon is transparent to heat, the heat created at the point of vaporization is transmitted to the surface of the crucible holding the source material where the heat should be reflected back to the melt which complements the creation of heat at the vaporization point. However, the discolored surface or liner separating the crucible from the source material will not efficiently reflect the transmitted heat and therefore a heat loss is encountered at the vaporization point where it is most desirable to create maximum heat. An optically correct shape of the crucible is required to efficiently obtain maximum temperature. Running water through the body of the crucible for cooling purposes necessitates that the crucible itself become a permanent or semipermanent fixture of the process chamber making it difficult to replace, move or shoot multiple materials.

These problems are overcome by the novel crucible of the present invention wherein an embodiment of a crucible for melting a source material 70, such as silicon, is shown represented by numeral 24 which indicates a copper crucible body provided with a plated polished chrome liner 31 disposed within a hemispherical recess 32. The silicon source material is seated within the hemispherical chrome liner 31 and preferably has a relatively flat continuous surface having its center on the major vertical axis of the vacuum chamber.

The crucible 24 is maintained at a relatively cool temperature, preferably under 350° C. by utilizing a novel thermal compression coupling technique allowing the sources to be moved under the electron bombardment source and interchanged with other sources without flexing water lines or elaborate bellows arrangement. The thermal energy is coupled to a large water cooled copper heat sink, which is grooved to match the grooved copper crucibles. Extremely high pressure copper-to-copper contact efficiently transfers the excess thermal energy to the water coolant. The very high pressure contact is achieved by utilizing the thermal expansion of the crucible against the much cooler heat sink grooves. When the crucible cools below 150° C. it can be easily moved from under the electron bombardment source and a new source material put in its place by a simple external drive mechanism. Because of the reflected surface offered by the chrome liner, shown more clearly in FIG. 4, the silicon source material has a thermal gradient extending from the liner to the molten region at the center of material surface. Inasmuch as the crucible is hemispherical, the thermal gradient in all directions will act as the line of focusing toward the center of the sphere in the melting region. Preferably, the hemispherical diameter as illustrated represents 2½ inches. By directing a high intensity electron beam from the heating source 22 at the center of the source material surface, intense local heat at the desired temperature is created to melt the source material for vaporization. The advantage of using the hemispherical heat sink with a correspondingly configured liner resides in the fact that an optical heater is constructed in addition to the electron heater whereby the energy which is radiated toward the polished surface of the chrome liner 31 is reflected back to the local heat

point at the surface center of the source material to aid in creating the intense local heat to effect vaporization of the source material.

The crucible apparatus 23 shown in FIG. 2 includes three crucibles with the center crucible identified by numeral 24; however, it is to be understood that although crucible 24 will be described in detail and is the inner or middle crucible of the three, the other crucibles are identical in construction to crucible 24. As mentioned earlier, the crucibles are slidably mounted on base 25 by means of a novel interconnection means between the bottom of the crucible and the upper surface of the base 25. The interconnection construction will be described later.

The object of movably mounting the crucibles on the base resides in the fact that different semiconductor materials, such as those having different electrical conductivity characteristics, can be held within the respective recesses of each of the crucibles and when the crucibles are moved so that a selected one resides in a coaxial relationship with the heating means 22 along the central vertical axis of the apparatus, the semiconductor material held by the selected crucible will be acted on by the heating means and vaporized for restructuring on the target area by means of ion implantation. To assure that vaporized source material of the selected crucible does not reach the others, pivotal covers 33 and 34 are movably mounted on posts 35 and 36 respectively, which are fixed to the opposite ends of the base 25. By means of pivot hinges 37 and 38, the covers 33 and 34 allow the desired crucible to slide out from underneath with minimum interference. By properly moving the crucibles on the base 25, any one of the three crucibles may be exposed to the heating means while the other two crucibles are protected from contamination. If it is desired to block one outermost and inner crucible so that the other outer crucible is exposed to the heating means, the crucibles are moved to the left and cover 33 pivoted to cover the respective recesses and hence the source material held in the covered crucibles. Cover 34 is raised so that the crucible at the extreme right end of the plurality will be solely exposed to the heating means. On the other hand, when it is desired to expose the source material of the inner crucible to the heating means, both covers 33 and 34 are lowered to block the heating means from reaching the two outermost crucibles. The source material in the crucible which is not being acted upon may be covered with a lid composed of some high refractory material such as molybdenum, tantalum, tungsten or the like, so that the lid will not melt. Therefore, only one source material at a time may be exposed for heating and vaporization by the electron source 22.

In order to move the plurality of the crucibles together as a unit, a member 40 is attached to each side of the plurality of crucibles by any suitable means so that the plurality of crucibles are joined together in a unitary structure. Secured to member 40, is a block 41 through which a lead screw 42 is threadably connected. The opposite ends of lead screw 42 are rotatably mounted on braces 43 and 44 which are fixed by any suitable means to the top surface of pan 30. Lead screw 42 is actuated by means of an extension rod 45 coupled to the end of the lead screw by means of a universal joint 46.

The opposite end of the extension rod 45 from its end coupled to lead screw 42 is connected to another universal joint (not shown) which is operably connected to the hand wheel 28. Therefore, it can be seen that rotation of the hand wheel 28 will effect rectilinear movement of the crucible apparatus 23 so as to selectively position a selected crucible from the plurality into operating position to be heated by the heating means 22.

In view of the foregoing, it can be seen that the crucible apparatus 23 is made up of three independent crucibles, wherein each crucible can contain a different source material. In one case, for example, one crucible can be employed to hold an N type silicon and the other crucible can contain a P type silicon, while the third crucible can contain still another source material having different electrical conductivity charac-

teristics. The crucibles may be slid on base 25 by the reciprocating lead screw 42 so that an operator may change the position of the individual crucible from outside the vacuum chamber without the necessity of breaking vacuum. Therefore, only one source material at a time may be exposed for heating and vaporization by the electron source 22.

Referring now in detail to FIGS. 2, 3 and 4, it is noted that the plurality of crucibles are mounted on the base 25 by means of a ribbed groove arrangement comprising a plurality of ribs and grooves arranged in parallel relationship on the corresponding mating surfaces of the crucibles and the base 25. For example, it is noted in FIG. 2, that the base is provided with grooves 50—52 inclusive which separate raised load bearing portions or ribs 53—56 inclusive. Mated with the respective ribs and grooves on the base 25 are a plurality of ribs and grooves formed in the bottom surface of the crucible and identified by ribs 57—59 and grooves 60 and 61. By the provision of such a grooved and ribbed interconnection construction, the thermal expansion differential between the hot crucible body and the water-cooled base create a thermal compression interlock which physically connects the two parts together and produces very low series thermal resistance to the water coolant. Inasmuch as a greater surface area is provided than with flat planar surfaces, minute surface irregularities which normally cause hot spots and reduce thermal energy transfer are not of critical concern.

To assure that the crucible apparatus and the base 25 effectively functions as a heat sink, a liquid coolant is recirculated through the base 25 through a plurality of passageways identified by numeral 62. Each of the passageways are enclosed by the body of the base 25 and are arranged in parallel spaced apart relationship with respect to each other. However, a chamber 63 is provided in one end of the base into which an inlet conduit 64 terminates so as to supply a quantity of the cooling agent to the passageways. The opposite end of the base is formed with an outlet chamber 65 communicating with an outlet conduit 66 for effecting the removal of the conduit from the base. Conventional pumping apparatus is included in the recirculating system so that a constant flow of the agent is supplied to the passageways in the base. In the operation of a crucible formed according to the present invention, water has been employed as the cooling agent and is recirculated through the base at approximately 50°F.

Therefore, it can be seen that an improved control over the heat gradient in the heat sink at the crucible interface with the base is readily achieved by the incorporation of the plurality of grooves and ribs disposed on the bottom of the crucible heat sink. As the temperature of the crucible increases, expansion occurs and in expanding, the copper edges of the ribs in corresponding grooves form the thermal compression lock therebetween. To further increase the heat gradient of the crucible in the base as a heat sink, it is preferred that the crucibles and the base be formed from a high thermal energy transferring material such as copper, for example. A combined crucible and vaporizing means is provided which augment each other during operation. The heater causes vaporization of the source material and the heated source material conducts heat to the crucible walls which is then transferred back to the melted source material to effect vaporization thereof.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. A crucible apparatus for holding molten source material within a vacuum apparatus comprising:

a crucible body formed of a material which is of sufficient electrical and thermal conductivity so as to be adapted for operation as an element in an electrical circuit and as a heat sink;

said crucible body having a hemispherical recess formed therein for confining a quantity of the source material; a chromium liner disposed on said hemispherical recess separating said crucible body from the source material; means for recirculating a cooling agent through said crucible body during the melting of the source material to maintain the temperature of said crucible body below its melting temperature and below the temperature of the source material melt thereby maintaining said chromium liner in a solidified state and preventing fusion of the melt to said chromium liner; and

said crucible body having a pair of portions movable relative to each other, a first portion formed with said hemispherical recess and a second portion supporting said first portion by a thermal compression interlock that connects said portions together.

2. The invention as defined in claim 1 wherein said chromium liner is operable as an optical heater in response to the presence of heat at the surface center of the source material melt which is reflected back to the surface center so as to augment heating of the source material.

3. The invention as defined in claim 1 wherein said crucible body is additionally formed with at least one other hemispherical recess for holding a quantity of source material of a different conductivity type than the source material confined in said first mentioned hemispherical recess; and

actuating means operably connected to said first portion of said crucible body for selectively locating a selected one of said hemispherical recesses so that the surface center of the source material held therein will lie substantially along the central vertical axis of the vacuum apparatus.

4. The invention as defined in claim 3 wherein said actuating means includes a lead screw mechanism operably coupled between said crucible body and the vacuum apparatus and having means located externally of the vacuum apparatus for manually operating said mechanism so as to locate said selected one of said hemispherical recesses to an alternate position without the necessity of breaking the ultrahigh vacuum created in the vacuum apparatus.

5. The invention as defined in claim 4 wherein said crucible body first portion constitutes a base fixedly supported on the vacuum apparatus and said second portion of said crucible body movably carried on said base and wherein said recirculating means include longitudinal passageways provided in said base for conducting said cooling agent therethrough.

6. The invention as defined in claim 5 wherein said first portion of said crucible body is slidably mounted on said base by correspondingly mated ribs and grooves formed in respective opposing and adjacent surfaces thereof constituting an interconnection construction defining said thermal compression interlock having high thermal energy transfer characteristics so that said base serves as an efficient heat sink.

7. A crucible apparatus for holding molten source material within a vacuum environment comprising:

a crucible body formed of a material which is electrically and thermally conductive so as to be adapted for operation as an element in an electrical circuit and being further formed with a plurality of hemispherical recesses adapted to hold quantities of source materials of different conductivity types;

a fixed base for movably supporting said crucible body so that a selected hemispherical recess can be located in a predetermined position within said vacuum environment; means for recirculating a cooling agent through said base whereby said base and said crucible body cooperate as a heat sink for dissipating heat of the source material; and

an interconnection construction movably coupling said crucible body to said base constituting a thermal energy transmission path therebetween whereby maximum heat gradients are transferred from said crucible body to said base eliminating diffusion of material from said crucible body into the source material.

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8. The invention as defined in claim 7 wherein said inter-connection construction includes a plurality of elongated grooves and ribs formed in each of the opposing and contacting surfaces of adjacent sides of said crucible body and said base and wherein said plurality of grooves and ribs of the respective surfaces are mated together in frictional contact to provide maximum high pressure surface contact therebetween.

9. The invention as defined in claim 8 including means coupled to said crucible body for selectively moving said crucible body with respect to said base without the necessity of breaking the vacuum environment.

10. The invention as defined in claim 9 wherein each of said plurality of recesses are provided with a chromium liner corresponding to the hemispherical contour thereof adapted to

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separate the source material from said crucible body and operable as an optical heater whereby radiant heat from the source material melt at the surface center thereof is reflected back to the surface center to augment heating of the source material.

11. The invention as defined in claim 8 wherein said inter-connection construction forms a thermal compression lock between said mated ribs and grooves.

12. The invention as defined in claim 7 wherein said inter-connection construction provides a thermal expansion differential between said crucible body and said base which creates a thermal compression interlock that physically connects said crucible body and said base together and further provides a low series thermal resistance to said cooling agent.

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