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Benzing et al.

[11] **3,830,194**

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[54] **SUSCEPTOR SUPPORT STRUCTURE AND DOCKING ASSEMBLY**

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[52] **U.S. Cl.** .... **118/9,** 198/222, 214/23, 214/310, 266/5 R

[51] **Int. Cl.** **C23c 13/08**

[58] **Field of Search** .... 118/5, 9, 48–49.5, 118/47, 500–503; 269/13, 14; 266/4, 5, 5 R; 214/310, 16.6, 23; 432/50; 198/222; 219/388

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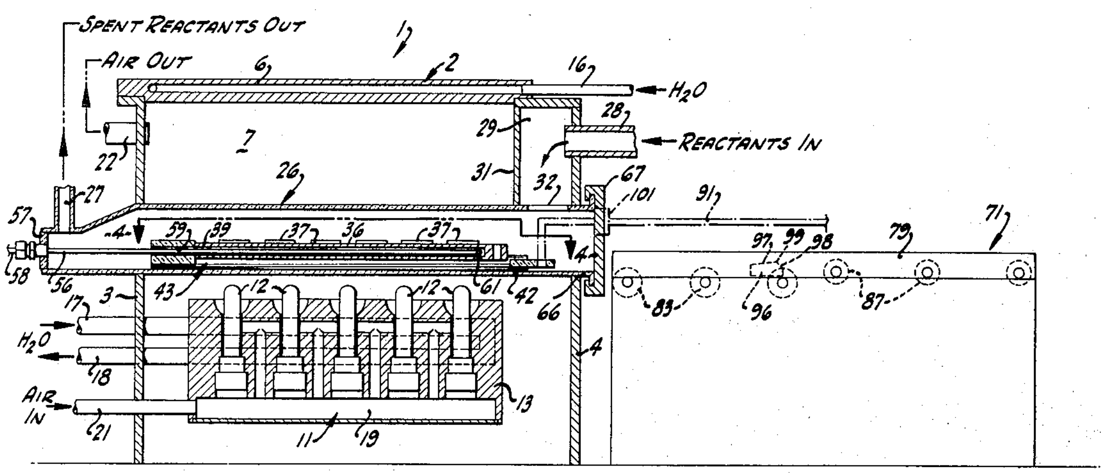
[57] **ABSTRACT**

A chemical vapor deposition reactor or like apparatus including means for accurately sensing the temperature of a susceptor upon which substrates to be coated are positioned. Means for facilitating insertion and removal of the sensing means relative to the susceptor, and for facilitating movement of the susceptor from a reaction chamber to permit expedited loading or unloading of the susceptor, are included with the apparatus. A support structure is provided upon which the susceptor is movable relative to the reaction chamber. Externally of the reaction chamber a docking assembly is provided to receive the susceptor supporting structure and the susceptor during substrate loading and unloading. The temperature sensing means comprises a sheathed thermocouple, which is automatically and accurately positioned in the susceptor following each loading or unloading cycle.

15 Claims, 6 Drawing Figures



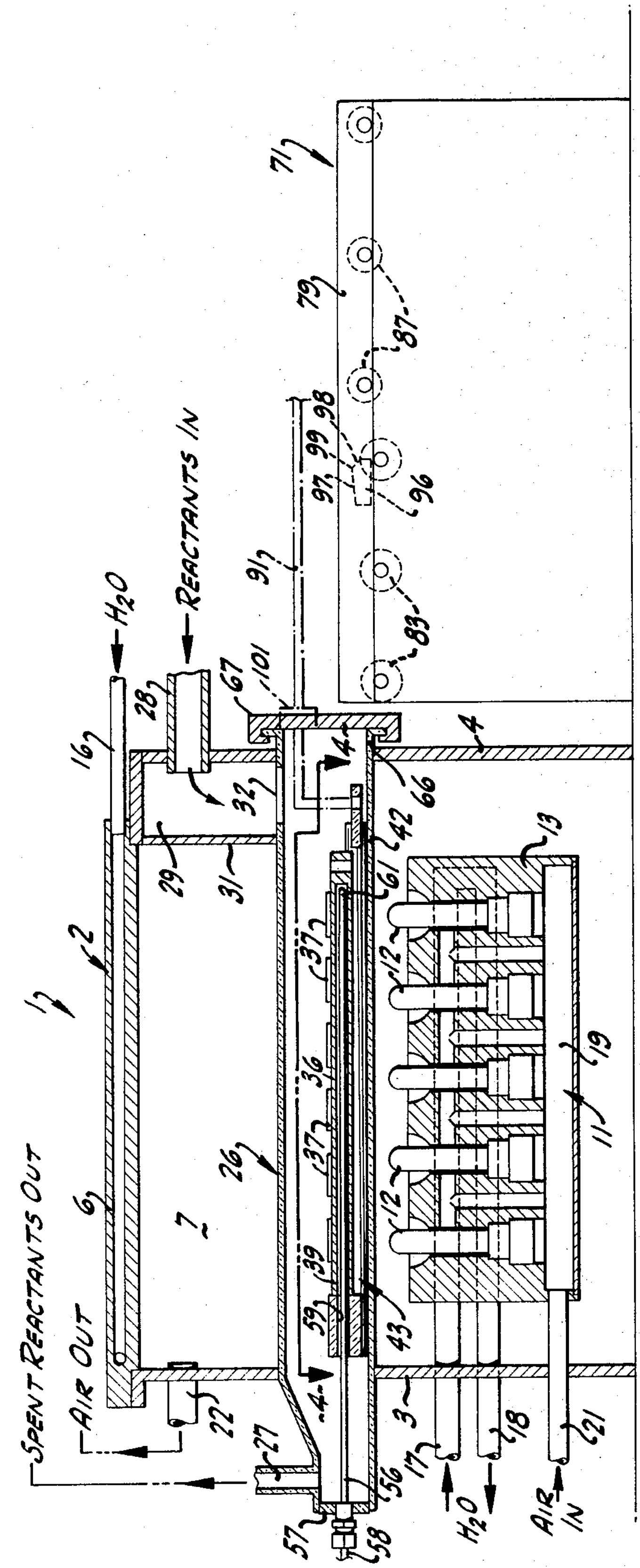


FIG. 1

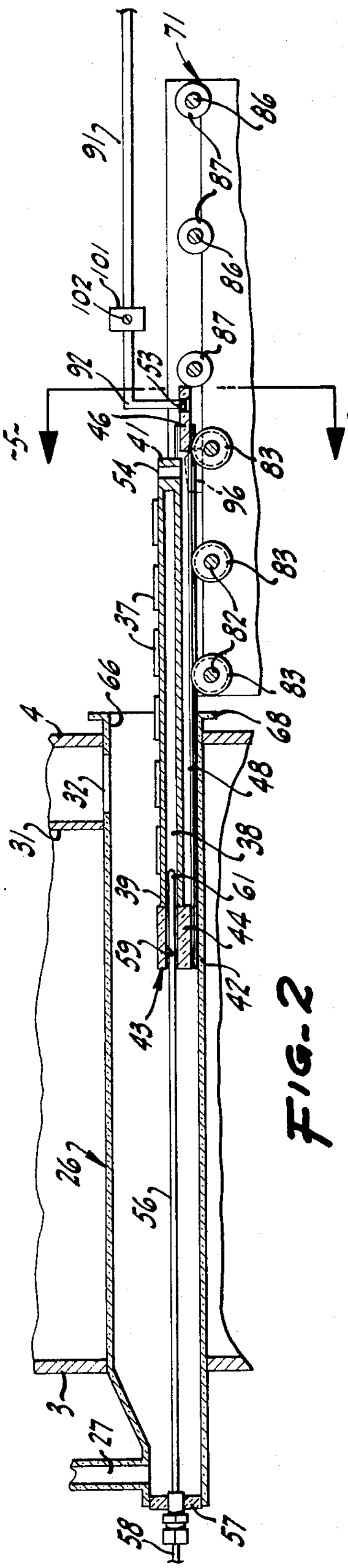


FIG-2

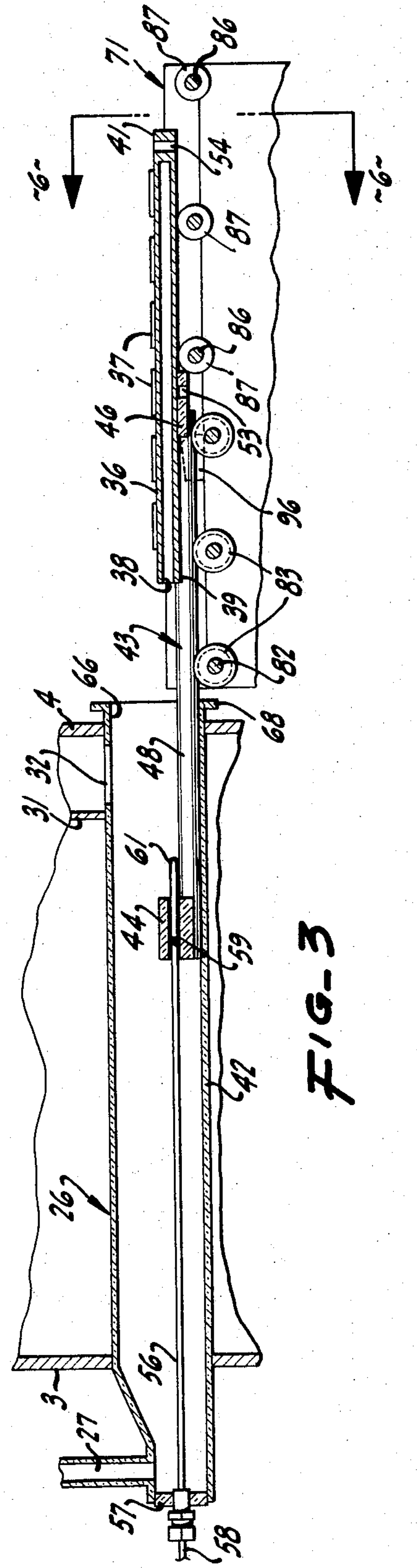


FIG-3

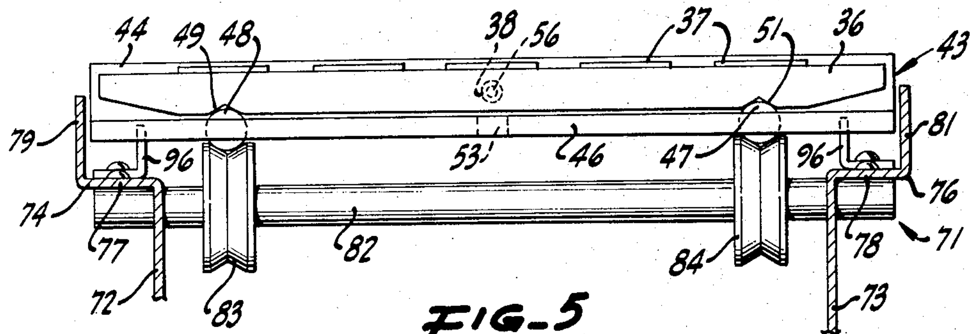


FIG_5

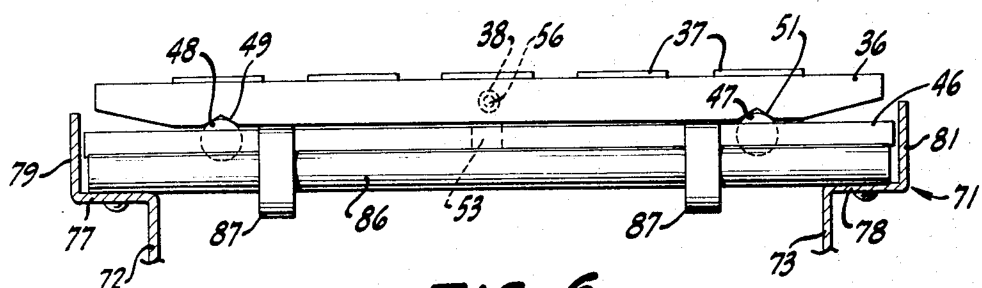


FIG_6

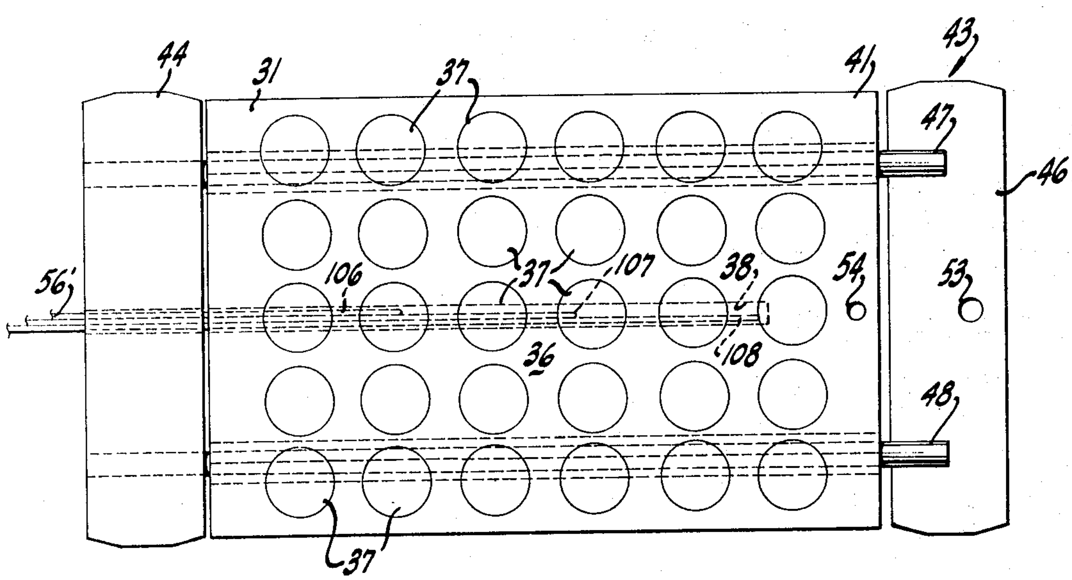


FIG_4

SUSCEPTOR SUPPORT STRUCTURE AND DOCKING ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of deposition of chemical films on substrates. More particularly, the field of this invention involves the vapor deposition of epitaxial or like chemically deposited films on exposed surfaces of articles, such as silicon wafer substrates commonly used in the electronics industry in the production of semiconductors and other devices. Still more particularly, the field of this invention involves apparatus, such as gaseous chemical vapor deposition reactors, in which gaseous reactants are brought into contact with a heated substrate supported by a susceptor within a cold wall reaction chamber to effect deposition of a desired film on the substrate.

This invention also relates specifically to the field of accurately sensing the temperature of a susceptor during such a chemical deposition reaction, within a cold wall reaction chamber. This invention further relates to the field of facilitating movement of a susceptor (during loading and unloading of substrates thereon) relative to a temperature sensor positioned within a reaction chamber in which film deposition is effected.

2. Description of the Prior Art

Substrates, such a silicon and like wafers, have been coated heretofore with epitaxial and other chemically deposited films, such as silicon dioxide or like films. However, so far as is known, the specific and improved procedure for sensing accurately the temperature of a susceptor on which substrates are supported during chemical vapor deposition has been unknown heretofore. Furthermore, so far as is known, the particular support structure and docking assembly disclosed herein for facilitating loading and unloading of substrates on a susceptor prior to and following a chemical vapor deposition (CVD) reaction within a reactor chamber also have been unknown heretofore.

Heretofore the temperature of a susceptor during a cool wall CVD reaction was sensed by utilizing an optical instrument, such as a non-contact optical pyrometer through which the substrate was viewed from outside the reaction chamber. Such optical temperature sensing procedures produce less than desirable results because film deposits, which interfere with accurate temperature sensing, frequently form on the transparent walls of the reaction chamber. Furthermore, film deposits which may form on the susceptor also tend to defeat accurate temperature sensing by changing the emissivity of the susceptor surface or as a result of optical interference effects in the case of deposited transparent films. Additionally, other operating conditions encountered in conjunction with a cool wall CVD reaction make optical pyrometric sensing methods less accurate than direct sensing using a thermocouple sensing device.

While some use of thermocouple sensing means has been tried heretofore, the particular thermocouple arrangement illustrated herein (and the docking assembly which makes utilization of such a thermocouple arrangement feasible) has been unknown heretofore. Prior thermocouple utilizations were limited because of the inability to easily and uniformly relocate the thermocouple sheath relative to the susceptor, the temperature of which was being sensed during a CVD operation.

Thus, to the extent that thermocouples have been utilized heretofore to sense a susceptor temperature during a CVD reaction, the particular thermocouple positioning arrangement illustrated herein, combined with the docking assembly provided to facilitate susceptor loading and unloading relative to the reaction chamber, have been unknown heretofore.

SUMMARY OF THE INVENTION

This invention relates generally to an improved apparatus and arrangement for sensing the temperature of a susceptor upon which substrates are supported during a chemical vapor deposition or like reaction in a reaction chamber. More particularly, this invention relates to means for positively and accurately orienting a thermocouple sensor in conjunction with a substrate supporting susceptor in a CVD reaction chamber.

Still more particularly, this invention relates to improved means for facilitating loading and unloading of substrates relative to a reactor by simplifying the positioning of a substrate supporting susceptor within a reaction chamber. Still more particularly, this invention relates to docking means provided in conjunction with a reactor utilized during chemical vapor deposition film coating of substrates in the production of semiconductor devices.

Heretofore, temperatures of the susceptor upon which substrates are frequently supported during a CVD reaction have been sensed visually through the utilization of optical pyrometric devices. Such optical devices do not give uniform or accurate temperature sensing results due to the factors set out herein previously. Attempts heretofore to position a thermocouple sensor in conjunction with a susceptor to obtain more accurate temperature readings than are possible with an optical sensing device have encountered difficulty because of prior inability to easily and accurately relocate the thermocouple sensing head in the same orientation relative to the susceptor which is to be sensed.

With the present arrangement, a thermocouple sensor is utilized which may be repeatedly, accurately and easily positioned in exactly the same orientation relative to the susceptor being sensed so that accurate temperature readings are insured. With the present invention, the susceptor to be sensed is provided with a longitudinal bore in which a thermocouple sensor is oriented when the susceptor is operatively positioned within a reaction chamber. In that connection, the susceptor is supported upon support means which facilitates insertion and removal of the susceptor relative to the reaction chamber and which insures accurate positioning of the thermocouple sensor utilized therewith.

In that regard, the support means and the susceptor are movable as a unit relative to the reaction chamber interior and, when withdrawn from the reaction chamber, are positionable upon an improved docking assembly provided adjacent the reaction chamber. Such docking assembly includes guide means for facilitating movement of the support means from the reactor, with the susceptor thereon. Such docking assembly further include stop means for facilitating at least partial separation of the susceptor from the support means during loading and unloading of substrates from the susceptor.

Upon separating the susceptor from the support means therefor, such support means remains at least partially positioned within the reaction chamber and in engagement with the thermocouple sensor to facilitate reinsertion of the sensor into the susceptor following loading of substrates on the susceptor. By permitting separation of the susceptor onto a separate portion of the docking assembly, unloading and loading of substrates may be effected at a more convenient location spaced somewhat from the reaction chamber.

From the foregoing, it should be understood that objects of this invention include the provision of an improved arrangement for accurately sensing the temperature of an element, such as a susceptor utilized in a chemical vapor deposition reaction; the provision of improved thermocouple sensing means which may be repeatedly positioned in a predetermined location for accurate sensing temperature of a susceptor movable relative thereto during loading and unloading of a reaction chamber in which a CVD reaction is to be effected; the provision of improved support means for a susceptor; the provision of improved docking means and a docking assembly adjacent a reaction chamber to facilitate handling of a susceptor and support means therefor during loading and unloading of substrates therefrom; and the provision of improved means for sensing the temperature of a susceptor in a CVD reaction chamber during epitaxial and like film coating of substrates positioned thereon. These and other objects of this invention will become apparent from a study of the following disclosure in which reference is directed to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view, largely schematic in nature, through a chemical vapor deposition reactor and the docking assembly of this invention positioned adjacent thereto.

FIG. 2 is a partial longitudinal sectional view of a portion of the reactor and docking assembly shown in FIG. 1 and illustrating a susceptor and support means therefor partially removed from the reaction chamber of the reactor.

FIG. 3 is a longitudinal sectional view corresponding generally to FIG. 2 showing the susceptor fully removed from the reaction chamber.

FIG. 4 is a plan view, taken in the plane of line **4—4** of FIG. **1**, illustrating details of construction of the susceptor and support means therefor.

FIGS. **5** and **6** are vertical sectional views through the docking assembly illustrating the cooperation between the susceptor, the support means therefor, and the docking assembly, taken in the planes of lines **5—5** and **6—6**, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As noted previously, the subject invention and its various aspects preferably are utilized with chemical vapor deposition (CVD) reactors in which epitaxial and like thin films are deposited chemically at elevated temperatures in conjunction with known procedures. In that regard, such reactions are carried out in high temperature reactors which are operable at temperatures of, for example, 750° to 1,300° C., as well as in lower temperature reactors which are operable at temperatures of 350° to 750° C. In such reactors, thin chemical films of known types are deposited on substrates, such as silicon wafers, commonly utilized in the electronics industry in the manufacture of semiconductor devices. The exact type of reaction chamber utilized and the heat source employed to heat the substrates to be coated therein may be of any known type.

In that connection, described by way of illustration hereinafter is a CVD reactor in which the heat source comprises a bank of high intensity radiant heat lamps positioned to heat a horizontally oriented reaction chamber and substrates positioned therein in the fashion disclosed in McNeilly et al. U.S. Pat. 3,623,712, "Epitaxial Radiation Heated Reactor and Process," dated Nov. 30, 1971. However, it should be understood that such reference herein to the radiant heat source disclosed in said McNeilly et al. patent is by way of illustration only and that other power sources, such as radio frequency (RF) induction heating coils also may be utilized.

Irrespective of the heat source employed, CVD reactions heretofore have been accompanied by difficulty in accurately sensing the temperature of the graphite or like susceptor commonly utilized to support substrates during thin film coating. The present invention has been designed to permit accurate temperature sensing of such a supporting susceptor without utilizing optical pyrometric devices as was the common practice heretofore.

Additionally, the apparatus of the present invention utilizes improved means in conjunction with the reaction chamber to facilitate insertion of the susceptor into and removal thereof from the reaction chamber to facilitate positioning and removal of substrates from the susceptor when the same is located externally of the reaction chamber.

While the improved features of this invention, such as the temperature sensor arrangement and the docking assembly to be described, have particular utility in conjunction with CVD reactions and reactors therefor, it should be understood that the utility of this invention is not limited to that particular field and that the same is utilizable in other installations in which accurate sensing of high temperature bodies within a chamber, plus the need to facilitate loading and unloading of a body to be heated in a chamber, is required. Thus, it should be understood that reference specifically herein to CVD reactors and reactions is by way of illustration, rather than by way of limitation.

With the foregoing general comments in mind, reference is directed to the appended drawings, taken in conjunction with the following description, for an understanding of the novel features incorporated into this invention.

Referring first to FIG. **1**, the overall CVD apparatus with which the subject inventive features are employed will be described. In that connection, the reactor illustrated in FIG. **1** employs a heat source which comprises a plurality of high intensity radiant heat lamps, such as tungsten filament lamps each of which includes a transparent quartz envelope and a halogen gas contained therein, preferably iodine, as will be described in greater detail hereinafter. The radiation heated reactor shown is generally designated **1** and comprises an elongated housing, generally designated **2**, defined by opposed end walls **3** and **4**, opposed side walls (not specifically seen in FIG. 1) and a removable top closure **6**, the latter being slidable along or otherwise separable from the upper margins of the side walls and end walls to permit access to the hollow interior **7** of the housing.

Opposite ends of housing **2** are defined by the end walls **3** and **4** so that the interior **7** of the housing is completely enclosed in known fashion. However, access into the hollow interior may be had through at least one end of the housing as may be necessary. A suitable door (not shown) may be provided in either of the end walls **3** and **4** at any suitable location so that access may be had to the housing interior as noted.

Preferably the inner surfaces of the confining end walls and side walls of the housing, and of the top closure, are formed of a highly polished reflecting material, such as polished sheet aluminum. Such reflecting surfaces are provided to permit maximum utilization of the heat generated by the heat source to be described.

Such heat source in the illustrated embodiment is generally designated **11** and extends longitudinally and laterally of the housing as seen in FIG. **1.** The heat source is secured and positioned in place by fastening the same to suitable portions of the housing side walls in known fashion. As noted, the heat source may be selected from one of several available types but it is preferred that the same be defined by a radiant energy heat source which permits cool wall operation of the reactor in the manner described in said McNeilly et al., patent.

In that regard, the radiant heat source illustrated comprises a bank of high intensity lamps capable of producing and transmitting radiant heat energy at a short wave length, such as approximately **1** micron or less. In the embodiment illustrated, such heat source comprises a plurality of such lamps arranged in a bank, each lamp being designated **12.** In that connection, reference is directed to the aforementioned McNeilly et al., patent for an understanding of the construction and function of such a bank of radiant heat lamps and the manner in which radiant heat energy is produced thereby. Such lamps are commercially available from sources such as the Aerometrics division of Aerojet General Corporation and from the General Electric Corporation.

As noted in the aforementioned patent, such lamps, as shown in FIG. **1** hereof, are constructed to be mounted upright in their sockets in mounting block **13**, but in other embodiments, also as shown in such patent, the lamps may be oriented in other orientations by utilizing other mounting block constructions and other lamp configurations. Such radiant heat lamps operate at very high temperatures, for example 5,000° to 6,000° F. and means are provided in conjunction with the housing and with the lamp mounting block **13** to cool the same.

In that regard, cooling arrangements of the type described in said McNeilly et al., patent may be employed, including cooling fluid conduits (not shown) through which water or like cooling medium may be circulated in conjunction with the side walls of the housing. Such conduits may be operatively connected with any suitable supply of cooling fluid and a disposal system therefor in known fashion. Similarly, cooling water conduits **16** may be provided in conjunction with the top closure **6** of the housing as seen in FIG. **1.**

Additionally, means for cooling the mounting block for the bank of lamps also may be provided including entry and exit fluid conduits **17** and **18** which communicate with fluid passages formed in the lamp mounting block. To further assist cooling of the lamps and the mounting block, as well as the remainder of the reactor apparatus, a plenum chamber **19** is provided in the base of the lamp mounting block which communicates with the sockets in which the lamps are mounted in the block **13** in the fashion described in the aforementioned McNeilly et al., patent. Such plenum is operatively connected with an inlet conduit **21** for cooling air. Thus, by introducing air through conduit **21** into plenum chamber **19**, the same may pass upwardly through the sockets in which the lamps are mounted and into the open interior **7** of the housing for subsequent removal through an exhaust conduit **22** positioned adjacent the top closure **6** of the housing.

In that regard, in applicants' assignee's Anderson et al., application Ser. No. 237,698 entitled "Improved Radiant Heat Energy Lamp Assembly," filed Mar. 24, 1972, improved reflector means for effecting cooling of high intensity radiant heat lampsare lamps are as well as an improved lamp mounting block and lamp assembly used in conjunction therewith. If preferred, the radiant heat source shown in said Anderson et al. application may be utilized in place of the heat source illustrated herein.

Positioned within the hollow interior of housing **7** is the structure which defines the reaction zone in which thin film chemical vapor deposition may be effected on substrates positioned therein. Such reaction zone is defined by and comprises a reaction chamber delimited by an elongated horizontally extending tubular structure **26** formed from a material which is transparent to heat energy generated by the heat source **11.** In its preferred form, such reaction chamber structure is rectangular in transverse cross section and has its four integral walls formed from quartz which is transparent to radiant energy transmitted at the short wave length noted previously. Such quartz tube may vary in dimensions according to particular production needs. However, one such tube having dimensions of 2 inches by 6 inches, with the length being determined in accordance with production requirements, may be employed.

As seen in FIG. **1**, one end of the reactor tube **26** is operatively connected at **27** with exhaust means in the form of a conduit which is fused or otherwise secured to the main body of the tube in known fashion. Such exhaust conduit in turn is connected with an exhaust system provided for the reactor apparatus in known fashion.

At its opposite end, gaseous reactants to be employed in the film coating procedure are introduced into the reaction chamber tube through inlet means which, in the embodiment illustrat ed, comprises an inlet conduit **28** which is connected any suitable source of gaeous reactants to be introduced into the reaction zone in known fashion. In that regard, conduit **28** introduces gaseous reactants into a chamber **29** defined by a baffle wall **31** secured to the housing to overlie the tube **26** in any suitable fashion, and positioned in sealing contact therewith.

An inlet aperture 32 is provided in the upper wall of the quartz tube in alignment with chamber 29 so that gaseous reactants introduced into the chamber may pass therefrom into the reaction zone without escaping into the hollow interior of the housing. Thus, gaseous reactants passing into the reaction zone may perform their intended chemical vapor deposition function on heated substrates positioned in the reaction zone. The spent reactants pass from the reaction zone through conduit 27 mentioned previously. The nature of the chemical reaction effected in the reaction zone is well known in the CVD art and need not be discussed here.

Substrates to be coated in the reactor are supported within the reaction chamber on an elongated support defined by a slab-like susceptor 36 defined by a body of graphite or like opaque heat absorbing material. Such substrates, as noted previously, normally comprise a series of thin silicon or like wafers 37 arranged in one or more parallel rows along the upper surface of the susceptor as seen in FIGS. 4 through 6. The size of the susceptor is correlated to the size of the quartz tube reaction chamber 26 and may vary to meet particular commercial needs.

As noted, the susceptor 36 comprises an elongated body which is opaque to radiant heat energy at the wave length transmitted by the radiant heat source 11. The susceptor illustrated includes means to accommodate at least one temperature sensor in conjunction therewith. Such means comprises a longitudinal recess or base 38 extending from one end 39 thereof towards the opposite end 41 thereof. In that regard, it should be noted bore 38 enters the susceptor body from the downstream or exit end of reaction chamber so that gaseous reactants do not flow directly into the bore as they travel toward exhaust conduit 27.

It will be noted from FIGS. 2 and 3 that bore 38 extends substantially the full length of the susceptor body but terminates short of end 41 thereof. It is in such bore that the temperature sensor utilized with this invention is positioned when the susceptor is operatively located within the reaction chamber. Bore 38 preferably is positioned to extend longitudinally of the susceptor along the longitudinal axis thereof, as best seen in FIG. 6. It should be understood, however, that, while one such bore to accommodate a single thermocouple sensor device has been illustrated, if desired, plural bores and plural sensors (arranged in parallel relationship) may be utilized, depending upon the nature and number of the temperature readings to be obtained.

Susceptor 36 is supported in spaced relationship above the bottom wall 42 of the reaction chamber tube 26 by support means defined by a support structure of particular illustrated, construction. In that regard, such support structure comprises with any slidable sled member, gaseous designated 43, which is formed from quartz which is transparent to the radiant heat energy emitted by the heat source described.

As best seen in FIG. 4 the support sled 43 is defined by two quartz plates 44 and 46 which define the opposite ends of the sled. Extending between the end plates are a pair of generally circular cylindrical elongated rails 47 and 48 which are fused or otherwise joined in spaced parallel relationship to the plates 44 and 46.

As seen from FIGS. 1 through 3, plate 44 at one end of the sled is of substantially greater thickness than plate 46 at the other end. The rails 47 and 48 are fused to the underside of plate 44 and extend into receiving slots provided therefor in plate 46 as best seen in FIG. 4. Also, as noted from FIGS. 2 and 3, the rails 47 and 48 are of greater thickness than plate 46. As a result, the plates are spaced slightly above the bottom wall 42 of the reaction chamber. Thus, as the sled is moved longitudinally of the reaction chamber between the positions shown in FIGS. 1, 2 and 3, only the rails contact the bottom wall of the reaction chamber to obviate undue wear and damage thereto during repeated movement of the sled in and out of the reaction chamber.

As noted from FIGS. 4 and 6, susceptor 36 is provided with a pair of laterally spaced parallel generally V-shaped grooves 49 and 51 in its under surface. The lateral spacing of the axes of grooves 49 and 51 corresponds to the lateral spacing of the axes of rails 47 and 48 of the sled and the susceptor is thus longitudinally slidable on the sled rails as will be described. In that connection it should be noted from FIG. 5 that rails 47 and 48 also project above the upper surface of end plate 46 of the sled so that the susceptor 36 may move longitudinally over plate 46 without interference therefrom.

As seen in FIG. 4, the sled is provided with an opening 53 in plate 46 and susceptor 36 is provided with an opening 54 adjacent end 41 thereof. Such openings are provided so that the susceptor and sled may be moved relative to the reaction chamber and relative to each other during loading and unloading operations. A tool is utilized for that purpose as will be described.

Referring to FIG. 1 taken in conjunction with FIGS. 2 and 3, it will be noted that a temperature sensor in the form of an elongated sheathed thermocouple device generally designated 56, extends through and it mounted in a gas tight seal 57 provided at the discharge end of the quartz tube 26. The thermocouple sensor is connected in known fashion by lead wire 58 with any suitable temperature sensing and indicating apparatus (not shown).

The thermocouple device is of elongated construction and immovably extends the major portion of the length of the reaction chamber tube as seen. In that regard, the thermocouple extends through a guide bore 59 provided in plate 44 of the sled into bore 36 in susceptor. Thus, during movement of the sled relative to the reaction chamber and relative to the thermocouple, the thermocouple will slidably move through bore 59 and will be at least partially supported thereby to the extent that support is necessary to preclude damage of the thermocouple. As will be noted from FIG. 3, when the susceptor is fully removed from the reaction chamber as will be described, at least a portion of the sled remains within the reaction chamber so that the sensing end 61 of the thermocouple remains in bore 59 of the sled plate 44 and is supported thereby.

In that connection, it will be noted from FIG. 2 that when the susceptor is operatively positioned on the sled within the reaction chamber, the end 39 of the susceptor abuts against a shoulder formed by the enlarged plate 44 of the sled. Thus, by moving the susceptor over the rails 47 and 48 until end 39 of the susceptor strikes the shoulder of plate 44, proper positioning of the susceptor on the sled is effected. Thereafter, by sliding the sled, with the susceptor thereon as a unit, to a predetermined orientation within the reaction chamber, the thermocouple sensing end 61 maybe positioned at the desired location within the susceptor to provide the precise temperature sensing function sought.

In the manner to be described, repeated removal and reintroduction of the susceptor relative to the reaction chamber during sequential batch operations of the reaction chamber results in the thermocouple being precisely oriented in the exact location desired each time so that effective and uniform temperature sensing is insured.

As noted previously, an important aspect of this invention is incorporated into docking means defined by an assembly positioned adjacent to one end **66** of the reaction chamber. Access to the reaction chamber of the illustrated reactor is obtained by slidably removing a closure plate **67** which is movable laterally over enlarged flanges **68** formed integral with the upper and bottom walls of the reaction chamber. With the closure plate **67** removed as seen in FIGS. **2** and **3**, the sled and susceptor carried thereon may be removed from or returned to their operative position within the reaction chamber.

In that regard, the docking assembly, generally designated **71**, is operatively positioned adjacent the end **66** of the reaction chamber in any suitable fashion. Such docking assembly may be self-supporting or may be supported upon another supporting surface in any suitable fashion. In the embodiment illustrated, such docking assembly is schematically illustrated as being generally self-sustaining with the upper operative surface thereof generally in alignment with the bottom wall **42** of the reaction chamber tube **26**.

An important feature of the docking assembly is the fact that the same can selectively handle both the sled and the susceptor even though the sled and susceptor generally lie in different horizontal planes. That is, the docking assembly is provided with stop means designed to cooperate with the susceptor and the sled to selectively position each of those components as the sled-susceptor combination is removed from the reaction chamber.

In that regard, referring to FIGS. **5** and **6**, it will be noted that the docking assembly comprises a pair of laterally spaced metal structural panel members **72** and **73** which are supported in any suitable fashion by a supporting framework. Such structural members **72** and **73** comprises longitudinally extending oppositely bent rail section **74** and **76** respectively which extend the length of the assembly. Such rail sections include horizontal portions **77** and **78**, respectively, and integral upright or vertical portions **79** and **81**, respectively. The rail portions **79** and **81** define lateral margins of the docking assembly and prevent lateral separation of the sled therefrom as seen in FIGS. **5** and **6**.

Extending between structural members **72** and **73** are first and second series of spaced roller members. The first series of rollers if positioned most closely adjacent the reaction tube end **66** and is defined by a plurality of pivot shafts **82** rotatably mounted in bearings (not shown) in the opposed structural members **72** and **73**. Mounted adjacent opposite ends of each of the shafts **82** (as seen in FIG. **5**) are a pair of grooved circular guide rollers **83** and **84** respectively. Spacing of rollers **83** and **84** from each other corresponds to the lateral spacing of the aforementioned rails **47** and **48** of the sled. Thus, when the sled is withdrawn from the reactor from the position shown in FIG. **1** to the position shown in FIG. **2**, rails **47** and **48** are engaged with the rollers **83** and **84** and are guided thereby during movement of the sled relative to the reaction chamber.

Such sled movement may continue until leading end plate **46** of the sled strikes stop means on the docking assembly defined by the second series of rollers, as seen in FIG. **2**. In that regard, the second set of rollers is defined by a plurality of spaced pivot shafts **86** which are rotatably mounted in bearings (not shown) on the opposite structural members **72** and **73** of the docking assembly. The shafts **86**, as seen from FIGS. **2** and **3**, are mounted in a slightly elevated plane compared to the plane in which shafts **82** of the first series of rollers are positioned.

As seen in FIG. **6**, a pair of laterally spaced rollers **87** are provided on each of the shafts **86**. Such rollers have a smooth periphery as compared to the grooved periphery of the aforementioned rollers **83** and **84**. The rollers **87** have their upper peripheries lying on a higher vertical lever relative to the upper peripheries of the grooved rollers **83** and **84**. The difference in vertical spacing is effected so that susceptor **36** may be slidably moved from rails **47** and **48** of the sled over plate **46** onto the rollers **87**, as seen in FIG. **3**. Thus, for all intents and purposes, the susceptor may be slidably separated from the sled to facilitate loading and unloading of substrates therefrom.

It will be noted that the docking assembly includes the aforementioned stop means to limit longitudinal movement of the sled (with the susceptor thereon) as the sled is moved onto the docking assembly. In that regard, the second series of rollers **86, 87** define such stop means in that the first rollers of that series are engaged by the plate **46** of the sled as the sled is withdrawn. When such engagement is effected, movement of the sled terminates and thereafter the susceptor may be slidably moved longitudinally over rails **47** and **48** onto the rollers **87** as seen in the position of FIG. **3**.

When the susceptor is pulled to the position seen in FIG. **3**, it is entirely free of the reaction chamber and the substrates which had been coated in the reaction chamber may be removed from the susceptor, and a subsequent quantity of substrates may be loaded out of the susceptor. The susceptor is then ready for reinsertion into the reaction chamber for a repetition of the CVD cycle.

It should be noted that the different elevations in which the rollers of the first and second series are mounted insure that the susceptor may be slidably moved directly from the sled onto the rollers **87**.

It will be understood as seen in FIG. **2** that a suitable tool, in the form of an elongated rod **91** having a bent end **92** thereon, may be utilized to withdraw and reinsert the sled from the reaction chamber, and to move the susceptor relative to the sled. Such rod has its end **92** inserted into the respective openings **53** and **54** of the sled and susceptor as noted previously to effect such movement in either direction.

While stop means for the susceptor on the assembly are not specifically required, if desired, the free ends of the guide rails **79** and **81** may have tabs (not shown) bent inwardly therefrom into the path of the susceptor to prevent inadvertent removal of the susceptor from the end of the docking assembly by an inattentive apparatus operator.

Also, preferably provided in conjunction with the docking assembly are means to temporarily limit reverse movement of the sled into the reaction chamber as the susceptor is moved over the sled from the position of FIG. 3 back to the position of FIG. 2. That is, because of the frictional engagement between the susceptor and the rails of the sled, movement of the susceptor over such rails normally tends to move the sled with the susceptor. Because movement of the sled is not desired until the susceptor comes into engagement with the positioning shoulder of the plate **44** of the sled as seen in FIG. 2, it is desired to provide means to temporarily hold the sled in the position seen in FIG. 3 until the susceptor is moved to the position seen in FIG. 2.

Such means comprises a stop lug **96** provided on each of the guide rail portions of the docking assembly. Each stop lug is secured in place by screws or rivets as seen in FIG. 5. Each stop lug is positioned in the path of movement of plate **46** of the sled and each lug is provided with a pair of tapered edge portions **97** and **98**, which lie on opposite sides of a generally flat upper edge portion **99**.

Thus, when the sled comes in contact with the respective stop lugs, plate **46** will ride upwards over the inclined edge portion **97** and over the straight edge portion **99** until the plate clears the other tapered edge portion **98**. At that time, the plate will then drop behind the tapered portion **98** to the position seen in FIG. 2. Thus, reverse movement of the sled toward the reaction chamber is temporarily precluded by the lugs **96**. However, once the susceptor is in place on the sled as seen in FIG. 2, movement of the sled with the susceptor thereon may be easily effected by continuing to push the susceptor with tool **91** so that the sled rides over the inclined edge **98** and subsequently frees itself of engagement with the stop lugs **96**.

With the arrangement shown, uniform positioning of the sensing end **61** of the thermocouple may be easily and accurately effected following each loading and unloading cycle of the susceptor. In that regard, preferably tool **91** is provided with indexing means thereon so that a visual determination can be made to insure that the sled, with the susceptor thereon, is properly oriented. In the embodiment illustrated, the tool is provided with a slidable indicating collar **101** held in place thereon by a set screw **102**, as seen in FIGS. 1 and 2. By utilizing the tool to push the susceptor/sled combination back into the reaction chamber, proper positioning of the sled, and therefore of the susceptor also, may be visually determined by bringing the collar into alignment with the outer edge of the reactor chamber tube end **66**. When thus properly oriented, the sensing end **61** of the thermocouple **56** is properly positioned within the bore **36** in the susceptor body. Such proper orientation may be repeated easily and readily following each load-unload cycle of movement of the sled and susceptor.

In that connection, when the sled is moved from the position shown in FIG. 3 to the position shown in FIG. 1, proper longitudinal orientation of the sled witin the tube is insured because of the rails **47** and **48** of the sled are in contact with the guide rollers **83** of the docking assembly until the time when the sled passes from engagement with the guide rollers. Thus, lateral misalignment of the sled in the reactor tube **26** is precluded until the sled is properly positioned within the reaction chamber.

In the embodiment illustrated in FIGS. 1 through 3, a single temperature sensing thermocouple is illustrated, that is, one which senses temperatures at only one location namely, at the sensing end **61** thereof. By way of illustration, reference is directed to FIG. 4 in which a modified thermocouple configuration is illustrated, designated **56'**. Such thermocouple is capable of sensing temperatures at more than one location and, in that regard, comprises a multiple thermocouple structure, preferably encased in a single thermocouple sheath. The modified thermocouple contructuion **56'** includes plural sensing ends, (three in number) designated **106, 107** and **108** respectively. Such sensing ends are oriented when the susceptor is operatively positioned so that temperature readings adjacent opposite ends of the susceptor and generally centrally thereof may be determined simultaneously. Thus, thermocouple structures of known constructions may be utilized to provide multiple readings in a structural arrangement of the type shown in FIG. 4.

Having thus made a full disclosure of a preferred embodiment of the subject invention, reference is directed to the appended claims for the scope of protection to be afforded thereto.

We claim:

1. In a chemical vapor deposition reactor or like apparatus, the combination comprising

A. a reaction chamber in which chemical vapor deposition is to be effected on substrates,

B. a supporting structure movably positioned within said chamber and being selectively removable therefrom,

C. a susceptor positioned on, supported by, and movable with said supporting structure on which said substrates are positionable,

1. a recess extending longitudinally of said susceptor from an end thereof,

D. a temperature sensor projecting into said susceptor recess when said supporting structure and said susceptor thereon are operatively positioned within said chamber, and

E. means supporting said temperature sensor in a predetermined fixed orientation within said chamber and maintaining said sensor in such orientation as said supporting structure and said susceptor are moved relative to said chamber during loading or unloading of substrates relative to said susceptor.

2. The apparatus of claim **1** which further includes

F. means between said supporting structure and said susceptor for maintaining said susceptor properly aligned with said supporting structure during relative movement therebetween.

3. The apparatus of claim **2** in which said means comprises interfitting longitudinal rails and grooves between said supporting structure and said susceptor which permit longitudinal sliding movement therebetween and preclude lateral movement therebetween.

4. The apparatus of claim **3** in which said rails are provided on said supporting structure and said grooves are formed in the undersurface of said susceptor.

5. The apparatus of claim **1** which further includes

F. stop shoulder means on said supporting structure against which said susceptor is engagable to properly position said susceptor thereon when said supporting structure with said susceptor thereon are operatively positioned within said chamber.

6. The apparatus of claim 5 in which said stop shoulder means comprises an enlarged shoulder against which an end of said susceptor is engagable, said shoulder having a guide opening therethrough through which said temperature sensor extends into said susceptor recess.

7. The apparatus of claim 1 which further includes

F. reactant gas inlet means and spent reactant gas outlet means in operative communication with said chamber,

G. said susceptor being oriented in said chamber so that said susceptor recess therein opens in a direction facing away from said gas inlet means so that reactant gases do not flow directly into said susceptor recess.

8. The apparatus of claim 1 which further includes

F. a docking rack assembly adjacent said reaction chamber for receiving said supporting structure and said susceptor thereon when removed from said chamber for substrate loading or unloading.

9. The apparatus of claim 8 in which said docking rack includes two spaced docking surfaces for receiving said supporting structure and said susceptor separately thereon.

10. The apparatus of claim 9 in which said docking rack further includes guide rollers on each of said surfaces to facilitate movement of said supporting structure and said susceptor thereover.

11. The apparatus of claim 10 in which said rollers on one of said surfaces are grooved to interfit with rails provided on said supporting structure.

12. The apparatus of claim 8 in which said docking rack assembly further includes stop lug means to temporarily preclude movement of said supporting structure over said docking rack assembly as said susceptor is being moved over said supporting structure.

13. The apparatus of claim 9 in which one of said spaced docking surfaces defines stop means to limit movement of said supporting structure over said other docking surface.

14. The apparatus of claim 1 in which said supporting structure comprises a slidable sled having a plate at one end thereof through which said temperature sensor extends, said plate maintaining an end of said sensor properly oriented when such end is removed from said susceptor recess in response to movement of said susceptor over said sled.

15. The apparatus of claim 1 in which said supporting structure comprises a slidable sled defined by a pair of spaced plates having a pair of laterally spaced rails extending therebetween over which said susceptor slides during relative movement between said sled and said susceptor.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,830,194 Dated October 9, 1974

Inventor(s) Walter C. Benzing & James McDiarmid

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title Page, [73], "Santa Clare" should be --Santa Clara--.

Column 6, Line 25, "lampsare lamps" should be --lamps are illustrated--.

Column 6, Line 60, "illustrat ed" should be --illustrated--.

Column 7, Line 54, "illustrated," should be --configu~~a~~ration and--.

Column 7, Line 57, "gaseous" should be --generally--.

Column 8, Line 67, "maybe" should be --may be--.

Column 10, Line 20, "lever" should be --level--.

Signed and sealed this 11th day of February 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks