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Bishop

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[54] **STEAM GENERATOR AND GAS INSERTION DEVICE**

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[52] **U.S. Cl.** **118/48,** 118/49.5, 122/40, 60/39.3

[51] **Int. Cl.** **B44d 1/00**

[58] **Field of Search** ..... 60/39.3, 39.55; 122/40; 118/48, 49.5; 148/175; 23/277, 273 SP, 182 X

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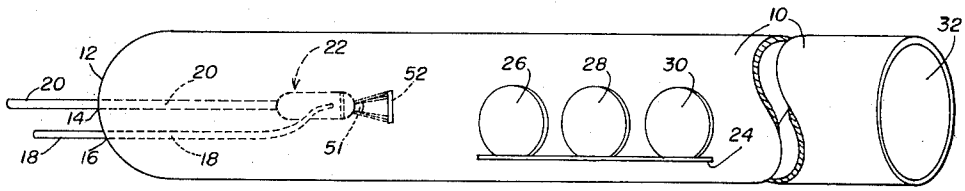
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[57] **ABSTRACT**

A device for inserting steam, steam saturated gases, or dry gases into a heated furnace tube may be located in the tube and selectively connected to gas and water sources by an automated valve system. The device includes a container having an outlet and a first opening through which a water conducting pipe is inserted. A porous filter, for converting water from the pipe into steam, is arranged in the interior of the container intermediate an end of the pipe and the outlet. A blocking plate is positioned external the container and near the outlet to prevent liquid water from reaching a work object within the tube. A second pipe may be inserted through a second opening into the interior of the container for introducing either steam saturated or dry gases into the furnace tube.

9 Claims, 4 Drawing Figures



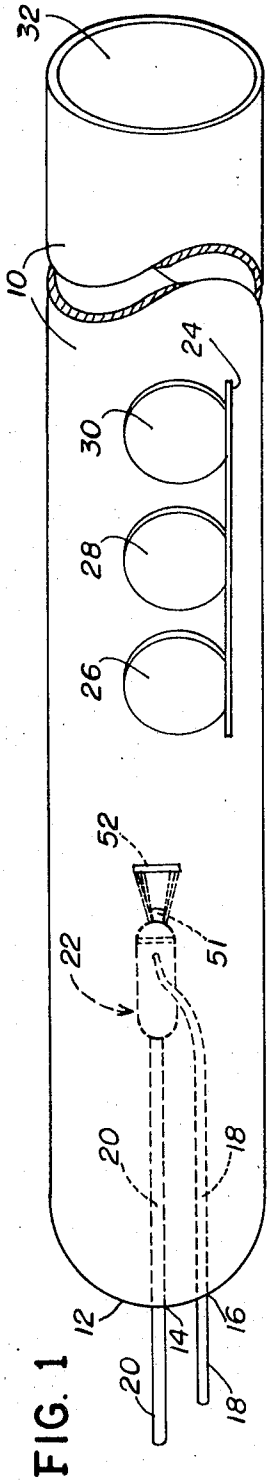


FIG. 1

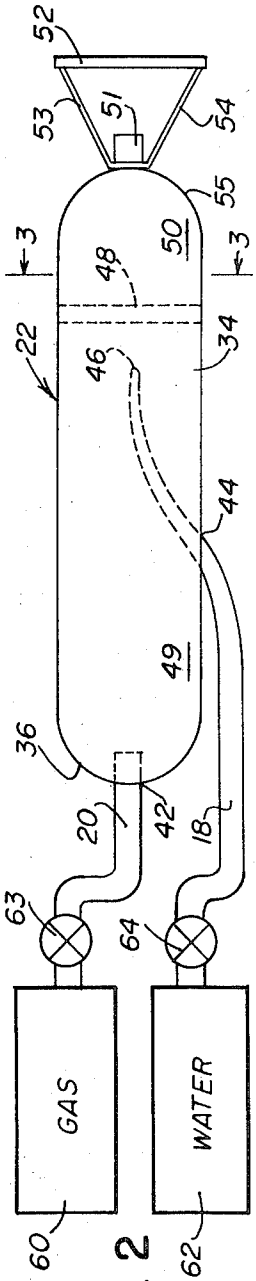


FIG. 2

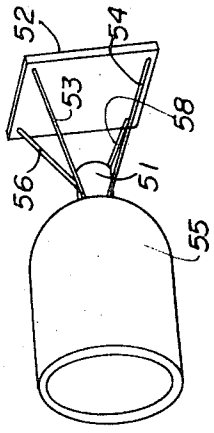


FIG. 3

FIG. 4

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STEAM GENERATOR AND GAS INSERTION DEVICE

BACKGROUND OF THE INVENTION

Some processes such as those utilized in the manufacture of semiconductor devices, require that a work object be subjected to controlled ambients comprised of steam and other gases at selected temperatures and for predetermined periods of time. For example, thermally grown silicon dioxide, which is used for passivating and masking silicon wafers, used in the manufacture of semiconductors, is normally grown by heat treating the silicon wafer in an atmosphere comprised of either steam or oxygen saturated with steam. The growth rate of the silicon dioxide is a function of the amount of time the wafers are exposed to the oxidizing gases and the temperature of the oxidizing gases. After the oxidation cycle has been completed, dry oxygen and nitrogen are commonly used to stabilize the oxide or to perform other functions in the diffusion process. Sometimes the exposure time of the wafers to various gases in each phase of a process must be controlled within a few seconds.

In the past, most oxidation and stabilization operations have been performed manually. For instance, the prior art oxidation operation for semiconductor wafers requires a steam generator to be set up in proximity to a standard diffusion furnace in which the operation is to be effectuated. This steam generator is comprised of a heat source which is external to the furnace and a closed container having an inlet connected to a first valve and an outlet connected to a second valve. An "on-off" valve is placed in the line running between gas sources or supplies and the first valve. The second valve is connected to a pipe running to a heated furnace tube or enclosure in which the wafers are placed.

The operator is required to fill the container of the steam generator with water and adjust the heat source to make the water boil. Then the first and the "on-off" valves are operated to allow oxygen or some other gas, which is to be saturated, to flow through the boiling water. Next the second valve is opened to allow the saturated gas to flow for a critical time period into the furnace tube containing the wafers. Finally, at the end of the time period, the first and second valves may be manipulated by the operator to apply other gases either through the steam generator or directly into the furnace.

The foregoing prior art method of oxidizing semiconductor wafers has been found to have many disadvantages. Under some conditions, the steam tends to condense in the tube or pipe leading from the steam generator to the furnace enclosure thereby causing water to be formed which spots the wafers. Another problem is that the operator cannot tell whether the water in the steam generator is boiling when oxygen, nitrogen, argon or some other gas is being bubbled therethrough. Thus, if the external heat source for the steam generator is inadvertently turned down or not turned up high enough at the beginning of a cycle, steam is not generated during some part of the oxidization cycle thereby resulting in a defective oxidation. Furthermore, operator error with respect to timing of the various processes and manipulation of the valves also results in defective process and sometimes creates danger of an explosion.

SUMMARY OF THE INVENTION

One object of this invention is to provide an improved apparatus for facilitating the exposure of articles to a controlled ambient which includes steam.

Another object of this invention is to provide a structure for use in a tube of standard semiconductor diffusion furnace to facilitate the selective exposure of semiconductor materials in the tube to steam, steam saturated gases, and dry gases.

Still another object of the invention is to provide a reliable steam generating and gas insertion device which is suitable for inclusion in an automated system employing a furnace.

In brief, the steam generator is suitable for being located in a heated enclosure to facilitate the transformation of liquid water delivered thereto under pressure into steam to be applied to a work object which, likewise, is located in the enclosure. The generator is also adapted to apply either dry or steam saturated gases to the work object. The generator includes a container having a first portion with a first opening therein, a second portion with an outlet therein and an interior region. A first pipe extends through the first opening in the first portion and has an end which is located in the interior region of the container. The end has a reduced diameter with respect to the rest of the pipe. A filter, which is positioned between the end of the first pipe and the outlet, is adapted to be raised to a sufficiently high temperature by heat from the enclosure to change liquid water, passing from the first pipe and impinging thereon, into steam. The steam then flows out of the container outlet and onto the work object. A second pipe, which extends through a second opening in the container, facilitates injection of other gases into the interior region thereof. A blocking plate is located adjacent the outlet of the steam generator to prevent any liquid water passing out of the outlet from striking the work object.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a removable enclosure or tube for a semi-conductor furnace which includes a steam generator and gas insertion device of one embodiment of the invention;

FIG. 2 is an approximately full scale drawing of the steam generator and gas insertion device of FIG. 1;

FIG. 3 is a perspective view of the outlet end of the device of FIG. 2 which shows a water blocking plate fastened thereto; and

FIG. 4 is a schematic diagram of an automated system including the steam generator and gas insertion device of FIG. 2.

DETAILED DESCRIPTION

In FIG. 1, a quartz tube or enclosure 10 is shown which may be inserted in a standard semiconductor diffusion furnace. This tube is in the form of a hollow cylinder having a wall thickness of about one-eighth of an inch, a length on the order of 5 feet and a circular cross-sectional diameter on the order of 5 inches. End 12 of the tube is closed except for apertures 14 and 16 through which hollow, cylindrical quartz water conducting tube or pipe 18 and gas conducting tube or pipe 20 are respectively inserted. Steam generator and gas insertion device 22, which will later be explained in greater detail, develops steam and steam saturated

gases. It also inserts either the foregoing gases or dry gases into the tube **10.** Carrier **24,** which may be of conventional design, supports work objects or wafers **26, 28** and **30.** These wafers which may be formed from semiconductor materials such as germanium or silicon, are selectively exposed to gases exiting from device **22.** Carrier **24** is inserted through opening **32** and selectively placed near the center of diffusion tube **10** so that the wafers are in a constant temperature zone created by the furnace

FIG. **2** is another view of steam generator and gas insertion device **22** of FIG. **1.** Corresponding parts of the various figures have the same reference numbers. All parts of device **22** and its associated pipes are formed from quartz or some other material which is capable of withstanding high temperatures and thermal shock resulting from rapid change in temperature. Device **22,** which is drawn at approximately full scale in FIG. **2,** is comprised of a hollow cylindrical body or container **34** having a partially closed end **36** with an aperture **42** through which gas inlet tube **20** is inserted. A second aperture **44** is provided through the side wall of the container through which water inlet tube **18** is inserted into the interior region **45** thereof. Body **34** is about 4½ inches long and **1** inch in diameter; however, its dimensions can be modified to meet particular applications.

Water inlet tube **18** "necks down" from a diameter of approximately two-tenths of an inch to a diameter of one-sixteenth inch to form a jet which has an open end **46.** Filter baffle **48,** which may be comprised of No. 1 fritted quartz, has the shape of a short cylinder having an outside diameter approximately equal to the inside diameter of body **34.** The baffle is fused around its entire circumference to the inside surface of body **34,** so that the interior region is divided into chambers **49** and **50.** The baffle is located between open end **46** of the jet and outlet **51.** The degree of porosity or density of the baffle is selectively chosen to prevent liquid water from passing therethrough while allowing the passage of steam and other gases.

Positioned in front of the outlet **51** is a rectangular blocking plate **52** which may be formed from solid quartz. Quartz rods **53, 54, 56,** and **58,** of FIG. **3,** attach the corners of plate **52** to end **55** of body **34.** Plate **52** forms a blocking shield to prevent liquid water, which somehow passes fritted quartz baffle **48,** from spotting or otherwise damaging wafers or other work objects located in proximity to outlet **51.** Blocking plate **52** could have a shape other than the shape shown in FIG. **3.**

As illustrated in FIG. **2,** water pipe **18** may be connected to a supply **62** of "ultra-pure" water, which is commonly found in semiconductor processing facilities and which is capable of providing a flow rate of about 7 milliliters per minute under a pressure of about 2 lbs. per square inch. Gas pipe **20** is connected to gas supply **60** which might provide oxygen, nitrogen or argon at a flow rate, for example, of 300 cubic centimeters per minute at pressure of 10 lbs. per square inch. The pressure and flow rate of the gas or water may be varied within broad limits to meet requirements of a particular application. If the water flow rate is substantially changed, the degree of porosity of the fritted baffle may have to be changed accordingly. Valves **63** and **64** may be manually operated to respectively control the flow from gas supply **60** and water supply source **62.**

In operation, the area inside of enclosure **10** is first heated to a selected temperature. Next, carrier **24** which includes wafers **26, 28** and **30** is inserted in the heated enclosure. If the wafers are to be oxidized by steam, then valve **64** is operated to allow liquid water from supply **62** to flow through pipe **18** and to squirt out end **46** thereof. Fritted quartz baffle **48,** which has been heated by the furnace, converts substantially all of the liquid water impinging thereon into steam which flows through outlet **51,** around blocking plate **52** and operates on the wafers. Liquid water droplets, if any, which succeed in inadvertently passing through baffle **48** also may pass through opening **51.** Because of their momentum, the droplets tend to strike plate **52,** which also has been heated by the furnace, where they are changed into steam. Thus, blocking plate **52** protects the work object from adverse affects which might otherwise be caused by liquid water.

Alternatively, if steam saturated oxygen is desired as an oxidizing agent, for instance, valve **63** is also operated to its open position. Then oxygen from gas source **60** progressively flows through pipe **20** into chamber **49,** through baffle **48,** and into chamber **50** where the gas is saturated by steam. The steam saturated gas then flows through outlet **51** and operates on the work object. Moreover, if only dry gas is desired, then valve **63** is opened and valve **64** is closed. The path followed by the dry gas is similar to the aforementioned path followed by the gas to be saturated.

FIG. **4** is a diagramatical view of an automated system employing device **22** which may be utilized to effectuate a process which requires that a work object be exposed to steam, steam saturated gases, and dry gases. Water supply **65** is connected through pipe **66** to inlet terminal **68** of electrically controlled valve **70.** Outlet **72** of valve **70** is connected to water inlet pipe **18** of steam and gas insertion device **22** as shown in FIG. **2.** Nitrogen supply **74** is connected through pipe **76** to first inlet **78** of valve **80.** Oxygen supply **82** is connected through pipe **84** to second inlet **86** of valve **80.** Outlet **88** of valve **80** is connected to gas inlet pipe **20.** Valve **80** is arranged to connect either supply **74,** supply **82,** or neither supply **74** nor **82** to pipe **20** depending upon the electrical signals applied to control terminal **84.**

Control circuit **89,** which selectively operates valves **70** and **80,** includes series connected first, second and third timing circuits or devices which are respectively designated by reference numbers **92, 94** and **96.** The output of device **96** is connected to buzzer or indicator **97.** Manually operated start circuit **98** is connected to the input of timing device **92.** A first output **99** of timer **92** is connected to control terminal **100** of water control valve **70.** A second output **102** of timer **92,** and output **104** of timer **94,** are connected to control terminal **84** of valve **80.**

The above described automated system is suitable for effectuating a standard oxidation cycle wherein a work object is first subjected to an ambient comprised of steam saturated oxygen for a first predetermined period of time, then to a dry oxygen ambient for a second predetermined period of time and finally to a nitrogen ambient for a third predetermined period of time. The steps of the foregoing process are executed as follows: Wafers are inserted in the heated diffusion enclosure which normally contains a nitrogen ambient because valve **80** is normally positioned to allow nitrogen to flow through pipe **20.** Then the operator activates start circuit **98** which applies control signals which initiate

the runing of timing circuit **92**, which in turn opens normally closed valve **70** to allow water flow and repositions valve **80** to allow oxygen to flow while shutting off the flow of nitrogen. Steam saturated oxygen is generated in the previously described manner, while the first timing circuit runs. After the first timing circuit **92** has run for the first predetermined period of time, it generates signals which turn valve **70** off and start timing circuit **94** running for the second predetermined period of time during which the dry oxygen ambient is created in the heated enclosure to stabilize the oxide formed during the previous step. At the end of the second predetermined period of time, timing circuit **94** applies simultaneous control signals, to terminal **84** of valve **80** which then automatically repositions to shut off the oxygen flow and allow nitrogen flow, and to the input of timing circuit **96** to initiate the operation thereof. After the third predetermined period of time, circuit **96** applies a control signal to buzzer **97** which provides an audio indication that the oxidation process has been completed.

What has been described, therefore, is a steam generator and gas insertion tube for operating in cooperation with a heated tube of a standard diffusion furnace found in semi-conductor processing facilities. The device is simple and inexpensive to construct and suitable for use in an automated system which virtually eliminates the possibility of operator error. Unlike prior art systems, devices of the invention while operated in its steam producing mode does not require an external heat source because it utilizes heat furnished by the diffusion furnace. Moreover, the device includes a protective structure for preventing adverse effects of liquid water on work objects.

I claim:

1. A steam generator adapted to expose a work object to a controlled ambient which includes steam including in combination:

first hollow container means at least partially enclosing a space surrounding a work object;

heater means associated with said first hollow container means for increasing the temperature of the space enclosed therein;

second hollow container means included within said first container means and substantially enclosing an interior region, said second container means having a first portion, a second portion with an outlet therein which is located near the work object and an intermediate portion located between and integral with said first and second portions and having an inlet located therein;

first pipe means extending into said inlet in said intermediate portion of said second container means;

porous filter means fused around its periphery to said intermediate portion and located in said interior region enclosed by said second container means between said first and second portions, said porous means being adapted to be raised to a sufficiently high temperature by heat from said heater means to change liquid water passing into said interior region from said first pipe means into steam; and

said second portion of said second container means being shaped to direct the flow of said steam out of said outlet and onto the work object.

2. The steam generator of claim **1** wherein said first pipe means has a first cross-sectional area and an end portion extending through said intermediate portion of said second container means and into said interior region enclosed by said second container means, said end portion of said first pipe means having a second cross-sectional area which is less than said first cross-sectional area.

3. The steam generator of claim **1** wherein said porous filter means includes a member comprised of number one type fritted quartz.

4. The steam generator of claim **1** further including blocking plate means connected to said second portion of said second container means and having a member located external to said container means and adjacent said outlet, said member extending substantially perpendicular to the steam flow to prevent liquid water passing out of said outlet from striking the work object.

5. The steam generator of claim **4** wherein said member of said blocking plate means is comprised of a quartz plate which is mechanically connected to said second container means.

6. The steam generator of claim **1** further including second pipe means which extends through a second opening in said second container means and which is adapted to inject gases into said interior region thereof.

7. The steam generator of claim **6** further including:

water supply means having an outlet;

first electrically controlled valve means having an inlet connected to said water supply means, an outlet and a control terminal, said outlet of said first valve means being connected to said first pipe means;

gas supply means having an outlet;

second electrically controlled valve means having an inlet connected to said gas supply means, an outlet and a control terminal, said outlet of said second valve means being connected to said second pipe means; and

electric control circuit means including timing circuits having at least one output terminal which is connected to said control terminals of said first and second electrically controlled valve means, said control circuit means selectively supplying control signals to said first and second electrically controlled valve means for controlling the flow of water through said first pipe means and the flow of gas through said second pipe means into said second container.

8. A steam generator and gas mixing device located in a heating chamber of a semiconductor diffusion furnace and which utilizes heat from the furnace to convert water into steam which it mixes with a selected gas to facilitate the thermal growth of oxides on a semiconductor work product also included in the chamber, such device including in combination:

container means having an elongated, cylindrical body which is closed by first and second curved end members, said first and second end members being integrally affixed to said cylindrical body, said first end member having an aperture therein, said second end member having an aperture therein and said cylindrical body having an aperture located about half way between said apertures in said first and second end members;

first pipe means extending from a gas supply through said aperture in said first end member, said first end member being sealed around said first pipe means;

second pipe means extending from a water supply and through said aperture in said cylindrical body, said cylindrical body being sealed around said second pipe means;

filter means selectively located between ends of said first and second pipe means and the aperture in said second end member, said filter means being connected to the inside of said cylindrical body and being adapted to pass gas from said gas source and to be raised to a sufficient temperature to heat water from said water source to provide steam, said filter means facilitating the mixing of said steam with said gas; and

nozzle means connected with said second end member and aligned with said aperture therein for directing said steam and gas mixture onto the work product.

9. The steam generator and gas mixing device of claim **8** wherein said second pipe means has a first cross-sectional area and an end portion extending through said cylindrical body portion and into the interior region of said container, said end portion of said second pipe means having a second cross-sectional area which is less than said first cross-sectional area.

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