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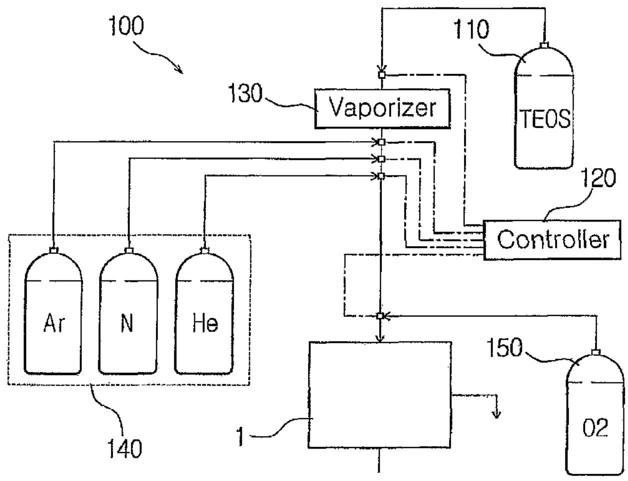
(54) Title: THERMAL OXIDE FORMATION APPARATUS AND THE METHOD BY CHEMICAL VAPOR DEPOSITION IN WAFER



(57) Abstract: There is provided an apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition, the apparatus having a chamber that includes a gas inlet line to which a reaction gas flows, a shower head for spraying the received reaction gas, a heater in which a wafer is settled, a heater supporting unit for supporting the heater, and a vacuum port for exhausting the reaction gas. The apparatus includes a TEOS gas storage unit connected to the gas inlet line to supply TEOS gas to the chamber, a controller for controlling the TEOS gas stored in the TEOS gas storage unit to be supplied by a predetermined amount when required and to be maintained at predetermined temperature, a vaporizer for vaporizing the TEOS gas supplied from theTEOS gas storage unit to be no less than predetermined temperature, a carrier gas storage unit connected to the outlet of the vaporizer to supply an inert gas to the chambertogether with the vaporized TEOS gas, and a second reaction gas storage unit connected to the inlet of the chamber to supply O2 gas that is a second reaction gas.

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Description

THERMAL OXIDE FORMATION APPARATUS AND THE METHOD BY CHEMICAL VAPOR DEPOSITION IN WAFER

Technical Field

[1] The present invention relates to an apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition and a method thereof, and more particularly to, an apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition and a method thereof, in which an apparatus for manufacturing a thermal oxide film and conditions under which the thermal oxide film is deposited using TEOS gas are provided in processes of depositing the thermal oxide film where it is necessary that pattern regions have uniform thickness in a state where step differences are formed so that the thickness of the pattern regions are uniform in processes where devices are highly integrated and metal wiring lines are used.

Background Art

[2] In general, pattern regions such as a device isolation barrier, an interlayer insulating film, a conductive film, and a contact are formed on a semiconductor substrate to complete a semiconductor device.

[3] The device isolation barrier is formed of oxide film by a local oxidation of silicon (LOCOS) method or a trench device isolation method using ion implantationmask with spacers. The interlayer insulating film is formed of a silicon oxide film such as phosphorus silicon glass (PSG), boron phosphorus silicon glass (BPSG), and undoped silicon glass (USG) or a nitride film such as SixNy. The conductive film and the contact are formed of polycrystalline silicon with conductivity, silicide, or metal.

Disclosure of Invention

Technical Problem

[4] The most important factors in forming the oxide film are reaction source gas and equipment. A bell-type furnace is commonly used for forming the oxide film. However, high temperature and long time are required and metal wiring lines formed under the oxide film are transformed due to excessive exposure to heat so that electrical characteristic deteriorates and implanted impurities are re-diffused and that the thickness of the thermal oxide film becomes non-uniform due to difference in partial pressure of gas between regions of the same wafer or between wafers in large capacity wafer processes. Therefore, difference in threshold voltage is caused in a spacer process of a transistor process so that the electrical characteristic of a device deteriorates.

[5] In particular, when the thermal oxide film is formed using silane (SiH4) or dichloro silane (SiH2Cl2) gas or N2O gas as the reaction source gas, high temperature is required and, in particular, in a silane process, the deposition thickness of the thermal oxide film becomes non-uniform due to the influence of pattern surface areas.

Technical Solution

[6] In orderto solve the above problems, according to the method of depositing the thermal oxide film using the TEOS gas, the bell-type furnace is used. However, the concentration of the source gas used when forming the oxide film becomes non-uniform due to the large capacity wafer processes so that difference in the thickness of the oxide film is generated between the regions of the wafer and between the wafers. Therefore, process reproducibility deteriorates and vulnerability increases according as high integration is performed.

[7] In the case of a plasma enhanced CVD type using the TEOS gas, an insulating layer is commonly used between electrode wiring lines. In the plasma process, it is possible to perform deposition with FR power density and at the low temperature of 300 to 500C. However, in the oxide film deposition process where it is necessary that the thickness of the patterns is uniform in a state where the step differences are formed, deposition characteristic (such as loading effect and step coverage) efficiency dependent on the influence of the patterns deteriorates so thatthe above process conditions cannot be applied.

[8] Also, a low temperature oxide film process using the TEOS gas and ozone gas is commonly used. The low temperature oxide film process is performed at the temperature of 300 to 500C, which is a process condition that cannot be applied to the oxide film deposition process in which it is necessary that the thickness of the patterns is uniform in the state where the step differences are formed likein the plasma enhanced CVD type since the deposition characteristic (such as the loading effect and the step coverage) efficiencydeteriorates.

[9] According to the present invention, there is provides a technology of depositing the thermal oxide film on the semiconductor substrate using the TEOS gas and a single chamber manufacturing apparatus in a semiconductor device isolation process.

[10] Accordingly, it is an object of the present invention to provide an apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition and a method thereof, in which an apparatus for manufacturing a thermal oxide film and conditions under which the thermal oxide film is deposited using TEOS gas are provided in processes of depositing the thermal oxide film where deposition condition (such as loading effect and step coverage) efficiency dependent on the influence of patterns is required and it is necessary that pattern

regions have uniform thickness in a state where step differences are formed so that the thickness of the pattern regions are uniform in processes where devices are highly integrated and metal wiring lines are used.

[11] In order to achieve the above object, there is provided an apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition, the apparatus having a chamber that includes a gas inlet line to which a reaction gas flows, a shower head for spraying the received reaction gas, a heater in which a wafer is settled, a heater supporting unit for supporting the heater, and a vacuum port for exhausting the reaction gas. The apparatus comprises a TEOS gas storage unit connected to the gas inlet line to supply TEOS gas to the chamber, a controller for controlling the TEOS gas stored in theTEOS gas storage unit to be supplied by a predetermined amount when required and to be maintained at predetermined temperature, a vaporizer for vaporizing the TEOS gas supplied from the TEOS gas storage unit to be no less than predetermined temperature, a carrier gas storage unit connected to the outlet of the vaporizer to supply an inert gas to the chamber together with the vaporized TEOS gas, and a second reaction gas storage unit connected to the inlet of the chamber to supply O2 gas that is a second reaction gas.

Advantageous Effects

[12] According to the present invention, the apparatus for manufacturing the thermal oxide film and the conditions under which the thermal oxide film is deposited using the TEOS gas are provided in the processes of depositing the thermal oxide film where it is necessary that the pattern regions have uniform thickness in the state where the step differences are formed so that the thickness of the pattern regions are uniform in the processes where the devices are highly integrated and the metal wiring lines are used.

Brief Description of the Drawings

[13] These and/or other objects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

[14] FIG. 1 schematically illustrates the structure of a chamber according to the present invention;

[15] FIG. 2 illustrates the structure of an apparatus according to the present invention;

[16] FIG. 3 is a graph illustrating deposition speed in accordance with change in flux of TEOS gas according to the present invention;

[17] FIG. 4 is a graph illustrating deposition speed in accordance with change in pressure in the chamber according to the present invention;

[18] FIG. 5 is a graph illustrating deposition speed of an oxide film in accordance with change in process temperature according to the present invention;

[19] FIG. 6 is a graph illustrating deposition speed in accordance with change in the amount ofhelium used as a carrier gas when liquid TEOS gas is vaporized in a vaporizer according to the present invention; and

[20] FIG. 7 is a graph illustrating deposition speed of an oxide film in accordance with change in distance according to the present invention.

Mode for the Invention

[21] Hereinafter, preferred embodiments of the present invention will be described with reference to the attached drawings.

[22] FIG. 1 schematically illustrates the structure of a chamber according to the present invention. FIG. 2 illustrates the structure of an apparatus according to the present invention. FIG. 3 is a graph illustrating deposition speed in accordance with change in flux of TEOS gas according to the present invention. FIG. 4 is a graph illustrating deposition speed in accordance with change in pressure in the chamber according to the present invention. FIG. 5 is a graph illustrating deposition speed of an oxide film in accordance with change in process temperature according to the present invention. Reference numeral 100 denotes a thermal oxide film depositing apparatus according to the present invention.

[23] As illustrated in FIGs. 1 and 2, a single chamber thermal oxide film depositing apparatus having a chamber 1 that includes a gas inlet line 2 to whicha reaction gas flows, a shower head 3 for spraying the received reaction gas, a heater 4 in which a wafer 5 is settled, a heater supporting unit 6 for supporting the heater 4, and a vacuum port 7 for exhausting the reaction gas includes a TEOS gas storage unit 110 connected to the gas inlet line 2 to supply TEOS gas to the chamber 1, a controller 120 for controlling the TEOS gas stored in the TEOS gas storage unit 110 to be supplied by a predetermined amount when required and to be maintained at predetermined temperature, a vaporizer 130 for vaporizing the TEOS gas supplied from theTEOS gas storage unit 110 to be no less than predetermined temperature, a carrier gas storage unit 140 connected to the outlet of the vaporizer 130 to supply an inert gas to thechamber 1 together with the vaporized TEOS gas, and a second reaction gas storage unit 150 connected to the inlet of the chamber 1 to supply O2 gas that is a second reaction gas.

[24] The gas storage units are tanks having valves whose operations are controlled by the controller 120.

[25] The controller 120 controls the operation of the apparatus by a control panel that determines the supply times and amounts of the gases and the temperatures of the gases and a control device that has logic and circuit structure by the manipulation of the control panel in accordance with the determined values.

[26] The vaporizer 130 vaporizes liquid material to have predetermined temperature.

[27] Helium (He), nitrogen (N), or argon (Ar) that is an inert gas stored in the carrier gas storage unit 140 is supplied and the partial pressure of the vaporized gas is determined in order to supply the gas vaporized by the vaporizer 130 by a uniform amount.

[28] The O2 gas stored in the second reaction gas storage unit 150 reacts to carbon that is a byproduct of the TEOS gas that is an organic compoundto form CO2 so that it is possible to prevent carbon contamination that deteriorates electrical characteristic and that increases film stress.

[29] When the thermal oxide film is formed using the TEOS gas, the reaction speed and the deposition characteristics (such as loading effect and step coverage) are determined by the flux of the TEOS gas that is a first reaction gas, the flux of the inert carrier gas, the process temperature, and the process pressure. According to the present invention, proper process conditions are selected among the above conditions, which will be described hereinafter.

[30] In processes of determining the fluxes of the first reaction gas and the inert carrier gas supplied to the single chamber, the process temperature, and the process pressure to deposit the thermal oxide film on a wafer, the TEOS gas is used as the first reaction gas for forming the oxide film, the helium (He) gas is used as the carrier gas that determines the partial pressure of the vaporized gas in order to supply the vaporized gas by a uniform amount, and the O2 gas is used as the second reaction gas that reacts to carbon that is the byproduct of the TEOS gas to form CO2 and to thus prevent carbon contamination that deteriorates the electrical characteristic and that increases the film stress. The above gases are sprayed into the chamber 1 so that the thermal oxide film is formed by pyrolysis.

[31] The amount of liquid TEOS is 100 to 10,000 mgram and the amount of vaporized TEOS is 10 to 1,000 SCCM.

[32] The amount of the helium (He) gas that is the carrier gas is 100 to 5,000 SCCM.

[33] The amount of the O2 gas that is the second reaction gas is 0 to 500 SCCM.

[34] Also, the process temperature, that is, the pyrolysis temperature in the chamber 1 is 600 to 750C and the process pressure, that is, the pressure in the chamber 1 is 5 to 200 Torr.

[35] The distance between the shower head 3 and the wafer 5 is 10 to 30 mm.

[36] When the heater temperature in the chamber 1, the distance between the shower head and the wafer, the pressures of the reaction gases, and the pressure in the reaction chamber are determined as described above, the loading effect, the step coverage, and the oxide film deposition speed are improved by the fluxes and the flux ratios of the reaction gases.

[37] According to the present invention, helium (He) is used as the carrier gas. However,

nitrogen (N) may be used as the carrier gas and the amount of the carrier gas is 100 to 5,000 SCCM. Argon (Ar) may be used as the carrier gas and the amount of the carrier gas is 100 to 5,000 SCCM.

[38] Reaction states in accordance with change in conditions will be described hereinafter.

[39] In the case of common chemical vapor deposition, when the partial pressure of the reaction source gas increases, thin film deposition speed increases and the amount of increase is determined with the other conditions fixed.

[40] First, FIG. 3 illustrates the deposition speed in accordance with change in the flux of the TEOS gas. When the flux of the TEOS gas that is required for forming the oxide film increases, the thin film deposition speed linearly increases as illustrated in the graph of FIG. 3.

[41] FIG. 4 illustrates the deposition speed in accordance with change in the pressure of the chamber under the condition that the amount of the reaction source gas is fixed. According as the process pressure increases, the deposition speed increases. When thedeposition pressure increases, a byproduct is formed so that it is necessary to prevent the generation of particles and to determine proper pressure.

[42] FIG. 5 illustrates the deposition speed of the oxide film in accordance with change in the process temperature. When the process temperature increases, the oxide film deposition speed that is a main process factor that determines the physical characteristic of the deposition film increases.

[43] FIG. 6 illustrates the deposition speed in accordance with change in the amount of the helium (He) gas used as the carrier gas while liquid TEOS is vaporized by the vaporizer. Liquid TEOS that is vaporized by thevaporizer flows to the reaction chamber together with the carrier gas. The deposition speed of the oxide film is reduced when the concentration of the carrier gas increases.

[44] The amountof the carrier gas is no less than a predetermined level and is determined considering the flux of the TEOS gas.

[45] Finally, FIG. 7 illustrates the deposition speed in accordance with change in the distance between the wafer 5 and the shower head 3 in the single chamber CVD deposition method. According as the distance between the wafer 5 and the shower head 3 increases, the deposition speed increases. This is because the distribution of the reactiongas increases according as the distance between the shower head 3 and the wafer 5 increases.

Claims

[1] An apparatus for depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition, the apparatus having a chamber that includes a gas inlet line to which a reaction gas flows, a shower head for spraying the received reaction gas, a heater in which a wafer is settled, a heater supporting unit for supporting the heater, and a vacuum port for exhausting the reaction gas comprises:
a TEOS gas storage unit connected to the gas inlet line to supply TEOS gas to the chamber;
a controller for controlling the TEOS gas stored in the TEOS gas storage unit to be supplied by a predetermined amount when required and to be maintained at predetermined temperature;
a vaporizer for vaporizing the TEOS gas supplied from the TEOS gas storage unit to be no less than predetermined temperature
a carrier gas storage unit connected to the outlet of the vaporizer to supply an inert gas to the chamber together with the vaporized TEOS gas; and
a second reaction gas storage unit connected to the inlet of the chamber to supply O2 gas that is a second reaction gas.

[2] The apparatus as claimed in claim 1, wherein the controller controls the operation of the apparatus by a control panel that determines the supply times and amounts of the gases and the temperatures of the gases and a control device that has logic and circuit structure by the manipulation of the control panel in accordance with the determined values.

[3] A method of depositing a thermal oxide film on a semiconductor substrate using single chamber chemical vapor deposition, wherein, in processes of determining the fluxes of the first reaction gas and the inert carrier gas supplied to the single chamber, the process temperature, and the process pressure to deposit the thermal oxide film on a wafer,the TEOS gas is used as the first reaction gas for forming the oxide film, the helium (He) gas is used as the carrier gas that determines the partial pressure of the vaporized gas in order to supply the vaporized gas by a uniform amount, and the O2 gas isused as the second reaction gas that reacts to carbon that is the byproduct of the TEOS gas to form CO2 and to thus prevent carbon contamination that deteriorates the electrical characteristic and that increases the film stress so that the above gases are sprayed into the chamber to form the thermal oxide film by pyrolysis.

[4] The method as claimed in claim 3, wherein the amount of liquid TEOS is 100 to 10,000 mgram and the amount of vaporized TEOS is 10 to 1,000 SCCM.

[5] The method as claimed in claim 3, wherein the amount of the helium (He) gas that is the carrier gas is 100 to 5,000 SCCM.

[6] The method as claimed in claim 3, wherein nitrogen (N) is used as a carrier gas.

[7] The method as claimed in claim 6, wherein the amount of nitrogen (N) is 100 to 5,000 SCCM.

[8] The method as claimed in claim 3, wherein argon (Ar) is used as a carrier gas.

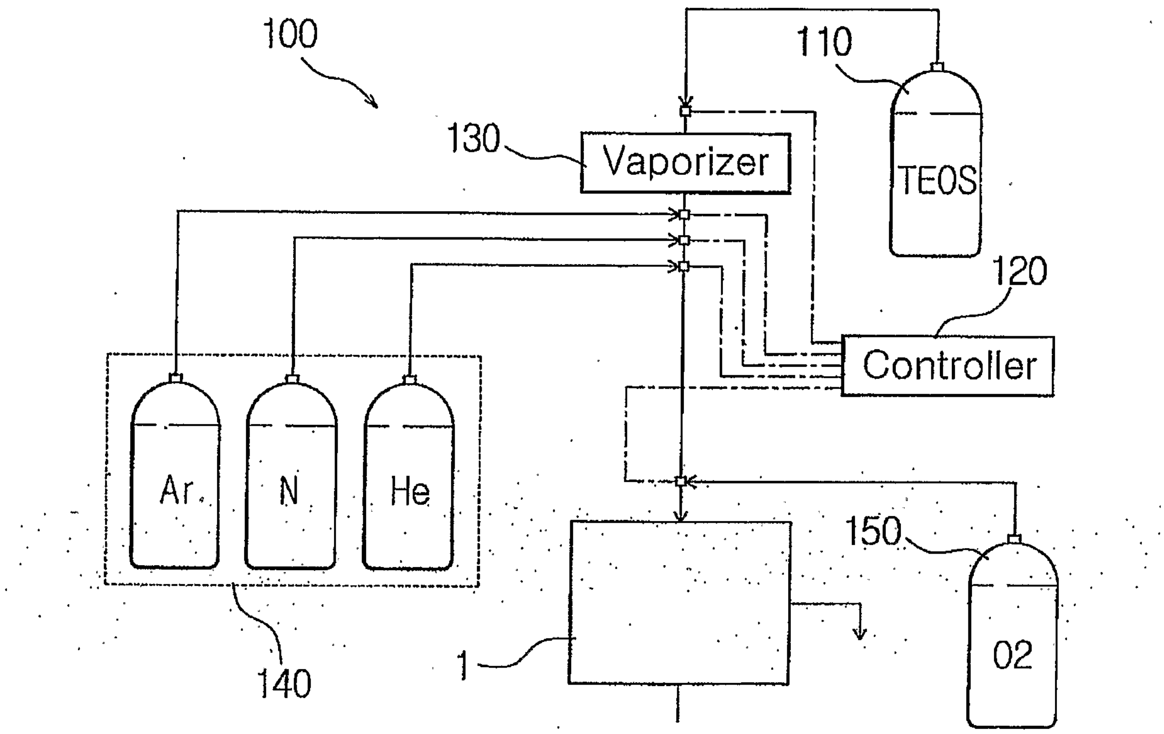
[9] The method as claimed in claim 8, wherein the amount of argon (Ar) is 100 to 5,000 SCCM.

[10] The method as claimed in claim 3, wherein process temperature, that is, pyrolysis temperature in the chamber is 600 to 750C.

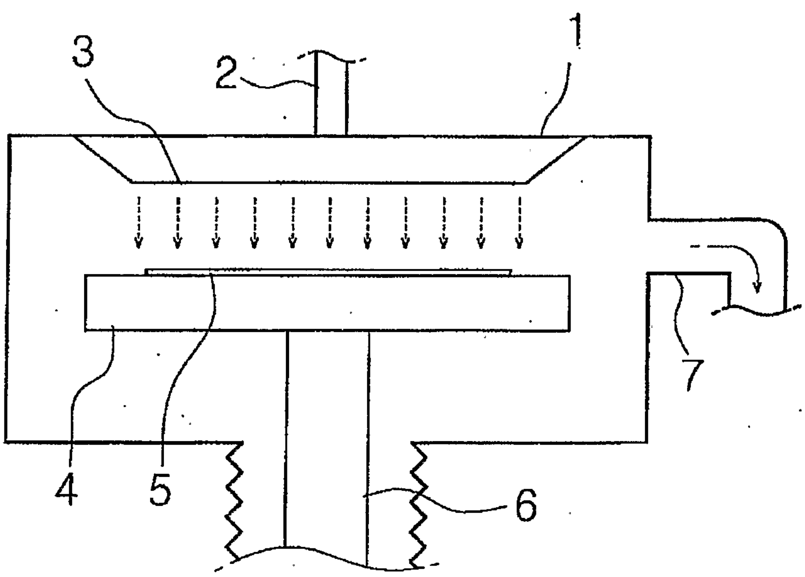
[11] The method as claimed in claim 3, wherein process pressure, that is, pressure in the chamber is 5 to 200 Torr.

[12] The method as claimed in claim 3, wherein the distance between the shower head and the wafer is 10 to 30 mm.

[Fig. 1]



[Fig. 2]



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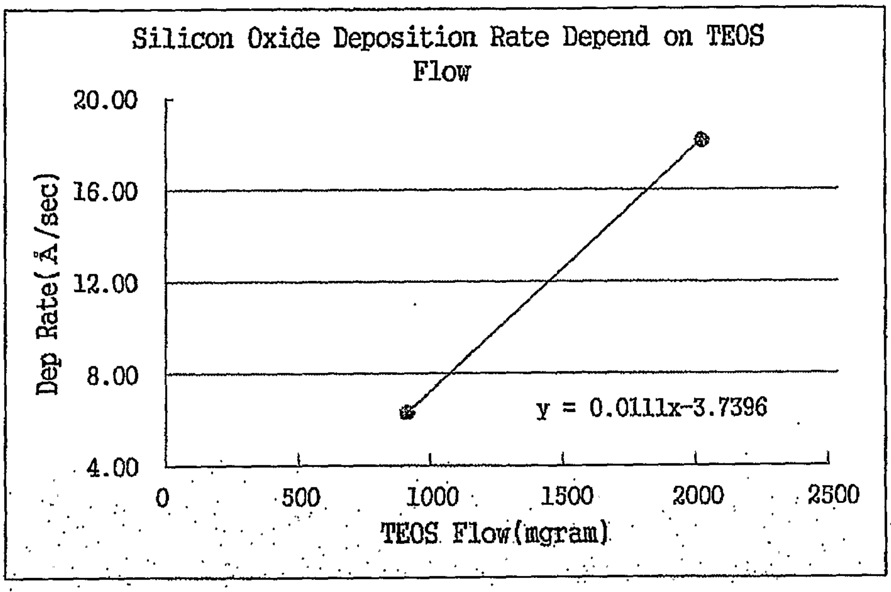
[Fig. 3]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8.00
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1000
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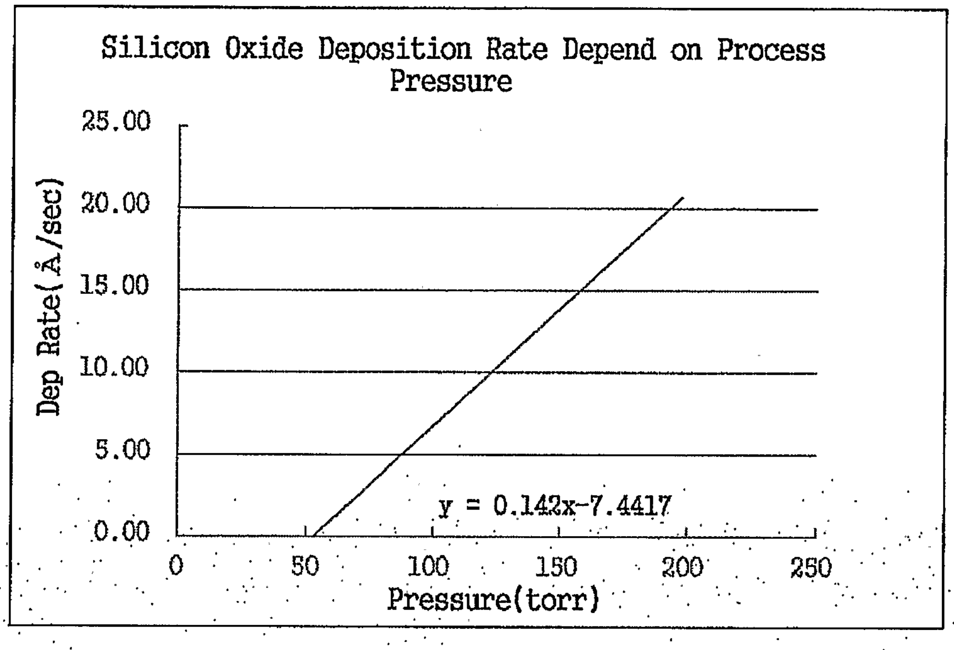
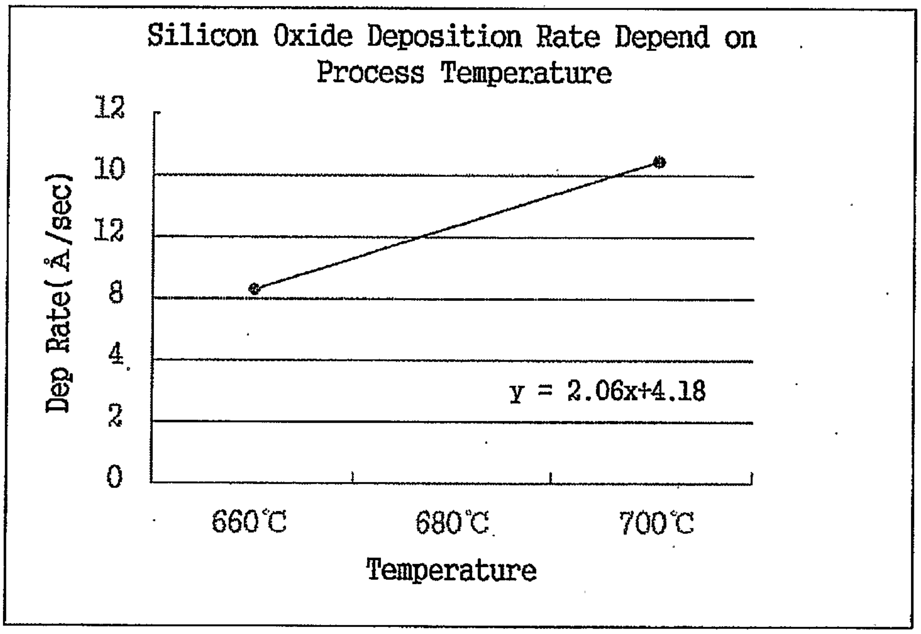
TEOS Flow(mgram)

[Fig. 4]

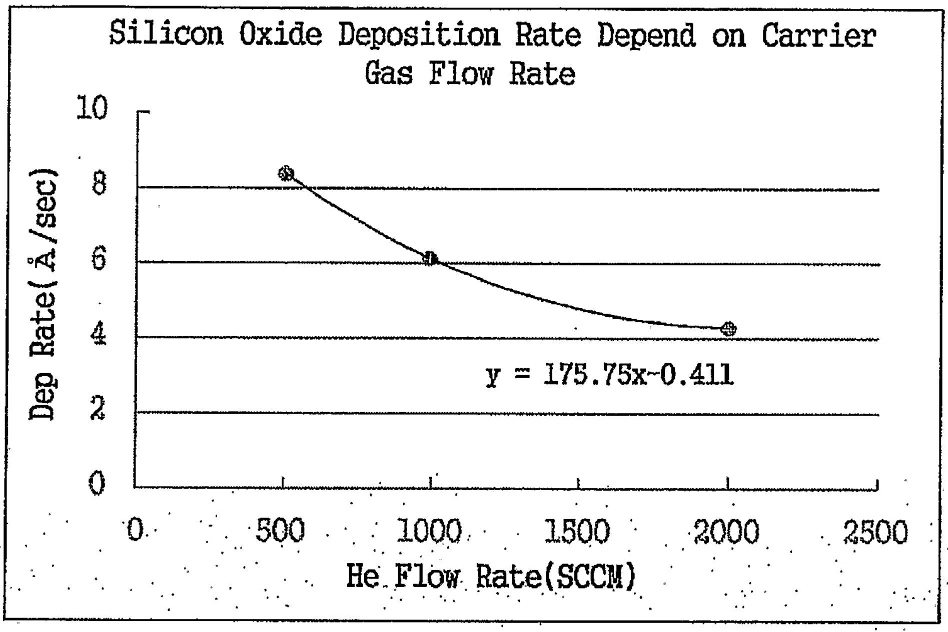


[Fig. 5]



SUBSTITUTE SHEET (RULE 26)

[Fig. 6]


Silicon Oxide Deposition Rate Depend on Carrier Gas Flow Rate
Dep Rate(Å/sec)
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6
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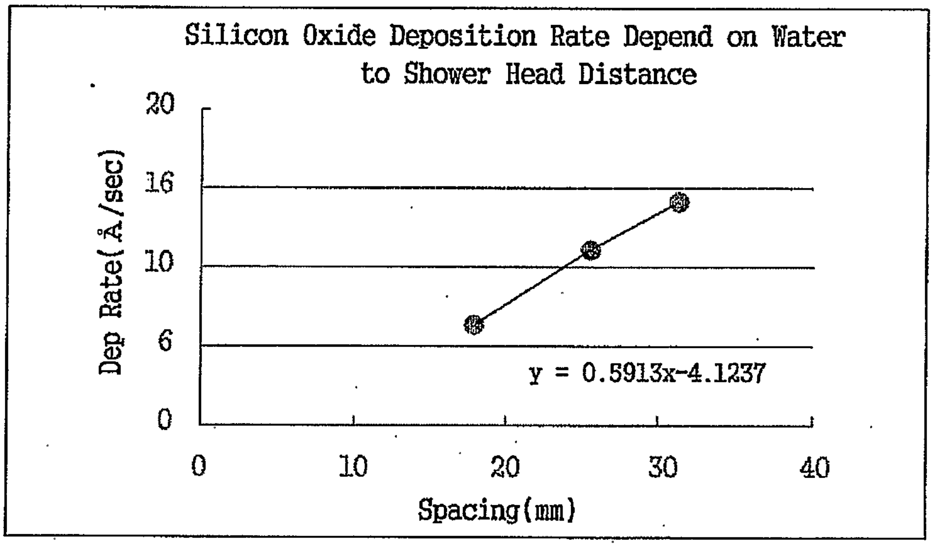
0
500
1000
1500
2000
2500
He Flow Rate(SCCM)

[Fig. 7]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Dep Rate(Å/sec)
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16
10
6
0
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10
20
30
40
Spacing(mm)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/002539

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01L 21/205

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7 C23C 16/46, C23C 16/00, H01L 21/205, H01L 21/316, H01L 21/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
KIPONET

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5000113 A (APPLIED MATERIALS, INC) 19 MARCH 1991 see column 20	1, 3 2, 4-12
Y	US 2003/0138562 A1 (JANARDHANAN ANAND SUBRAMONY ET AL) 24 JULY 2003 see Fig. 4, 7, claims 1, 3, 26, 27	2, 4-12
A	US 6001728 A (APPLIED MATERIALS, INC) 14 DECEMBER 1999 see the whole document	1-12
A	KR 2000-17994 U (ANAM SEMICONDUCTOR, LTD.) 5 OCTOBER 2000 see the whole document	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 NOVEMBER 2005 (30.11.2005)	**30 NOVEMBER 2005 (30.11.2005)**

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Facsimile No. 82-42-472-7140

Authorized officer
LEE, Yoon Jik
Telephone No. 82-42-481-5731

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2005/002539

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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