(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 December 2012 (27.12.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/176965 A1

(51) International Patent Classification:
H01L 21/205 (2006.01)

(21) International Application Number:
PCT/KR2012/000204

(22) International Filing Date:
9 January 2012 (09.01.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10-2011-0059858 20 June 2011 (20.06.2011) KR

(71) Applicant *(for all designated States except US)*: **LG INNOTEK CO., LTD.** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **JO, Yeong Deuk** [KR/KR]; Seoul Square, 541,Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **KIM, Moo Seong** [KR/KR]; Seoul Square, 541,Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **KANG, Seok Min** [KR/KR]; Seoul Square, 541,Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(74) Agent: **SEO, Kyo Jun**; 9th Fl. Hyun Juk Bldg., 832-41,Yeoksam-dong, Gangnam-gu, Seoul 135-080 (KR).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

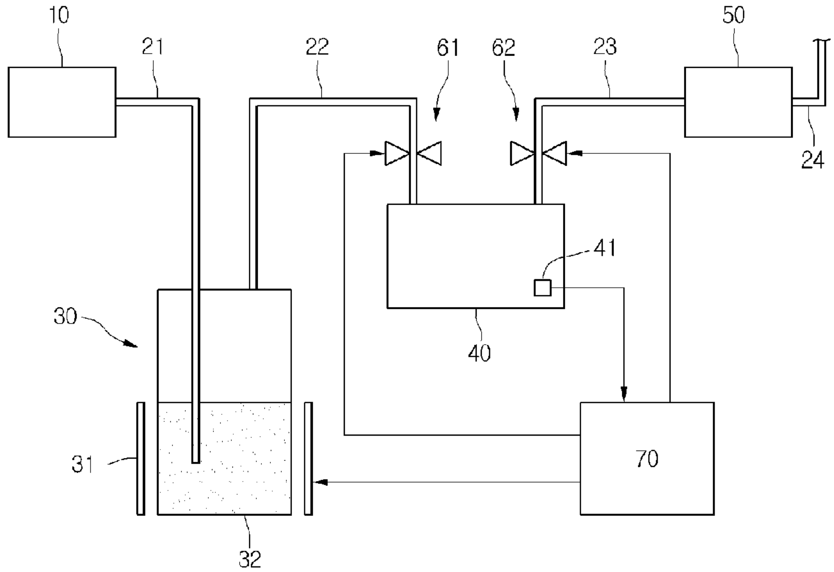
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: DEPOSITION APPARATUS AND METHOD OF FORMING THIN FILM

[Fig. 1]



(57) **Abstract**: A deposition apparatus and a method of forming a thin film are provided. The deposition apparatus includes a reaction gas supply unit supplying a reaction gas, a buffer unit temporarily storing the reaction gas supplied from the reaction gas supply unit, and a deposition unit forming a thin film by using the reaction gas supplied from the buffer unit.

WO 2012/176965 A1

Description

Title of Invention: DEPOSITION APPARATUS AND METHOD OF FORMING THIN FILM

Technical Field

[1] The present disclosure relates to a deposition apparatus and a method of forming a thin film.

Background Art

[2] In general, a chemical vapor deposition (CVD) method is frequently used among the techniques of forming various thin films on a substrate or a wafer. The CVD method is a deposition technique accompanying a chemical reaction and forms a semiconductor thin film or an insulation layer on the surface of a wafer by using the chemical reaction of a source material.

[3] The CVD method and the deposition apparatus receive attention as very important techniques among thin film forming techniques according to the recent miniaturization of semiconductor devices and development of a high efficiency and high power light-emitting diode (LED). Currently, the CVD method is used for depositing various thin films, such as a silicon layer, an oxide layer, a silicon nitride layer or a silicon oxynitride layer, or a tungsten layer, on a wafer.

Disclosure of Invention

Technical Problem

[4] Embodiments provide a deposition apparatus for forming a thin film having improved quality at an improved rate through precise flow control and a method of forming the thin film.

Solution to Problem

[5] In one embodiment, a deposition apparatus includes: a reaction gas supply unit supplying a reaction gas; a buffer unit temporarily storing the reaction gas supplied from the reaction gas supply unit; and a deposition unit forming a thin film by using the reaction gas supplied from the buffer unit.

[6] In another embodiment, a method of forming a thin film includes: evaporating a liquid to form a reaction gas; temporarily storing the reaction gas in a buffer unit; supplying the reaction gas temporarily stored in the buffer unit to a deposition unit; and forming a thin film by using the reaction gas supplied from the buffer unit.

[7] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

Advantageous Effects of Invention

[8] The deposition apparatus according to an embodiment of the present invention may accurately control the amount of the reaction gas supplied to a deposition unit by using a buffer unit. Therefore, the deposition apparatus according to the embodiment of the present invention may form a thin film on a wafer at a uniform and constant rate by using the buffer unit.

[9] In particular, the deposition apparatus according to the embodiment of the present invention may supply the reaction gas in an amount for growing the thin film at an optimum rate to the deposition unit. Therefore, the deposition apparatus according to the embodiment of the present invention may form the thin film at an improved rate.

Brief Description of Drawings

[10] Fig. 1 illustrates an apparatus for growing a silicon carbide epitaxial layer according to an embodiment of the present invention;

[11] Fig. 2 is a perspective view illustrating a buffer unit;

[12] Fig. 3 is a perspective view illustrating a deposition unit; and

[13] Fig. 4 is a cross-sectional view illustrating a cross-section of the deposition unit.

Best Mode for Carrying out the Invention

[14] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.

[15] In the description of embodiments, it will be understood that when a layer (or film), region, pattern or structure is referred to as being ‘on’ another layer (or film), region, pad or pattern, the terminology of ‘on’ and ‘under’ includes both the meanings of ‘directly’ and ‘indirectly’. Further, the reference about ‘on’ and ‘under’ each layer will be made on the basis of drawings.

[16] Since the thickness or size of each layer (or film), region, pattern or structure in the drawings may be modified for convenience in description and clarity, the size of each element does not entirely reflect an actual size.

[17] Hereinafter, an embodiment of the present invention is described in detail.

[18] Fig. 1 illustrates an apparatus for growing a silicon carbide epitaxial layer according to an embodiment of the present invention. Fig. 2 is a perspective view illustrating a buffer unit. Fig. 3 is a perspective view illustrating a deposition unit. Fig. 4 is a cross-sectional view illustrating a cross-section of the deposition unit.

[19] Referring to FIGS. 1 to 4, the apparatus for growing a silicon carbide epitaxial layer according to an embodiment of the present invention includes a carrier gas supply unit 10, a reaction gas supply unit 30, a buffer unit 40, a deposition unit 50, a first flow control unit 61, a second flow control unit 62, a sensor unit 41, and a control unit 70.

[20] The carrier gas supply unit 10 supplies a carrier gas to the reaction gas supply unit

30. The carrier gas has a very low reactivity. Examples of the carrier gas may be nitrogen or inert gas. In particular, the carrier gas supply unit 10 may supply the carrier gas to the reaction gas supply unit 30 through a first supply line 21.

[21] The reaction gas supply unit 30 generates the reaction gas. Also, the reaction gas supply unit 30 stores a liquid 32 for generating the reaction gas. For example, the reaction gas may be formed by evaporation of the liquid 32.

[22] An end of the first supply line 21 may be immersed in the liquid 32. As a result, the carrier gas is supplied into the liquid 32 through the first supply line 21. Thus, bubbles including the carrier gas may be formed in the liquid 32.

[23] The liquid 32 and the reaction gas may include a compound containing silicon and carbon. For example, the liquid 32 and the reaction gas may include methyl-trichlorosilane (MTS).

[24] The reaction gas supply unit 30 includes a heat generating unit 31 that applies heat to the liquid 32. The heat generating unit 31 may evaporate the liquid 32 by applying heat to the liquid 32. An amount of evaporated reaction gas may be appropriately adjusted according to the amount of heat applied by the heat generating unit 31.

[25] The reaction gas supply unit 30 supplies the reaction gas to the buffer unit 40 through the second supply line 22. That is, the reaction gas is supplied to the buffer unit 40 by means of the reaction gas supply unit 30, the flow of the carrier gas, and the evaporation of the liquid 32.

[26] The buffer unit 40 is connected to the second supply line 22. The buffer unit 40 is supplied with the reaction gas from the reaction gas supply unit 30 through the second supply line 22. The buffer unit 40 temporarily stores the reaction gas. That is, the buffer unit 40 temporarily stores the reaction gas, and then supplies the reaction gas to the deposition unit 50.

[27] Referring to FIG. 2, the buffer unit 40 includes a container 42 for containing the reaction gas, an inlet 43 introducing the reaction gas, and an outlet 44 discharging the reaction gas.

[28] Also, a volume of the container 42 may be in a range of about 5 ℓ to about 20 ℓ. The second supply line 22 is connected to the inlet 43. A third supply line 23 is connected to the outlet 44. Further, both of the inlet 43 and the outlet 44 may be formed at an upper portion of the container 42.

[29] The deposition unit 50 contains a wafer 80 or a substrate for forming an epitaxial layer 81. The deposition unit 50 forms the epitaxial layer 81 by using the reaction gas. That is, the deposition unit 50 forms a thin film 81 on the wafer 80 or the substrate by using the reaction gas.

[30] Referring to FIGS. 3 and 4, the deposition unit 50 includes an induction heat generating unit 100 and a susceptor 200. Also, the deposition unit 50 may further

include a chamber containing the susceptor 200, a heat insulating unit, and a wafer holder.

[31] The induction heat generating unit 100 encloses the susceptor 100. The induction heat generating unit 100 may generate heat by induction heating. The heat generated by the induction heat generating unit 100 may be transferred to the inside of the susceptor 200.

[32] Examples of the material used for the induction heat generating unit 100 may be graphite or the like. The induction heat generating unit 100 may have a tube shape. The induction heat generating unit 100 may enclose the susceptor 200.

[33] The susceptor 200 contains the wafer 80 or the substrate. Also, the reaction gas is introduced from the buffer unit 40 into the susceptor 200.

[34] As illustrated in FIGS. 3 and 4, the susceptor 200 may include an upper susceptor plate 210, a lower susceptor plate 220, and side susceptor plates 230 and 240. Also, the upper susceptor plate 210 and the lower susceptor plate 220 are disposed to face to each other.

[35] The upper susceptor plate 210 and the lower susceptor plate 220 are disposed and the side susceptor plates 230 and 240 are disposed at both sides thereof, and then the susceptor 200 may be manufactured by bonding one another.

[36] However, the embodiment of the present invention is not limited thereto, and the susceptor 200 may be manufactured by making a space for gas passage in a rectangular susceptor 200.

[37] A wafer holder, which may fix a deposition subject, the wafer 80 or the substrate, may further be disposed on the lower susceptor plate 220.

[38] A deposition process may be performed while air flows in the space between the upper susceptor plate 210 and the lower susceptor plate 220. The side susceptor plates 230 and 240 act to prevent the reaction gas from flowing out when the air flows inside the susceptor 200.

[39] The susceptor 200 may include graphite having high heat resistance and good machinability in order to endure under conditions of high temperatures or the like. Also, the susceptor 200 may have a structure in which a graphite body is coated with silicon carbide. Further, the susceptor 200 itself may be inductively heated.

[40] The reaction gas supplied to the susceptor 200 is decomposed into radicals by means of heat and may be deposited on the wafer 80 in the above-mentioned state. For example, MTS is decomposed into radicals including silicon or carbon and a silicon carbide epitaxial layer may be grown on the wafer 80. More particularly, the radicals may be CH3?, CH4, SiCl3?, or SiCl2?.

[41] The gas remaining after forming the silicon carbide epitaxial layer may be discharged outside through an exhaust line 24 disposed at the end of the susceptor 200.

[42] The first flow control unit 61 is disposed between the reaction gas supply unit 30 and the buffer unit 40. More particularly, as shown in FIG. 2, the first flow control unit 61 is included in the second supply line 22. More particularly, the first flow control unit 61 may be disposed near the buffer unit 40.

[43] The first flow control unit 61 may adjust the flow of the reaction gas supplied from the reaction gas supply unit 30 to the buffer unit 40. More particularly, the first flow control unit 61 may adjust the amounts of the reaction and carrier gases supplied from the reaction gas supply unit 30 to the buffer unit 40. Also, the first flow control unit 61 may be controlled by the control unit 70.

[44] The second flow control unit 62 is disposed between the buffer unit 40 and the deposition unit 50. More particularly, the second flow control unit 62 is included in the third supply line 23. Also, a shown in FIG. 2, the second flow control unit 62 may be disposed near the buffer unit 40.

[45] The second flow control unit 62 may adjust the flow of the reaction gas supplied from the buffer unit 40 to the deposition unit 50. More particularly, the second flow control unit 62 may adjust the amounts of the reaction and carrier gases supplied from the buffer unit 40 to the deposition unit 50. Also, the second flow control unit 62 may be controlled by the control unit 70.

[46] The sensor unit 41 measures a concentration of the reaction gas in the buffer unit 40. The sensor unit 41 supplies the measured concentration to the control unit 70. The sensor unit 41 may measure the concentration of the reaction gas by using an absorption spectrum with respect to infrared rays. For example, the sensor unit 41 may include a non-dispersive infrared absorption (NDIR) sensor. In addition, the sensor unit 41 may measure the concentration of the reaction gas with various methods.

[47] The control unit 70 controls the first flow control unit 61, the second flow control unit 62, and the heat generating unit 31 based on the concentration of the reaction gas input from the sensor unit 41. For example, when the concentration of the reaction gas in the buffer unit 40 is lower than a reference value, the control unit 70 may increase the amount of the reaction gas supplied to the deposition unit 50 by controlling the first flow control unit 61 and the second flow control unit 62. Also, the control unit 70 may increase the evaporation amount of the liquid 32 by increasing the heat generation amount of the heat generating unit 31 when the concentration of the reaction gas in the buffer unit 40 is lower than the reference value.

[48] Further, when the concentration of the reaction gas in the buffer unit 40 is higher than the reference value, the control unit 70 may decrease the amount of the reaction gas supplied to the deposition unit 50 by controlling the first flow control unit 61 and the second flow control unit 62. Also, the control unit 70 may decrease the evaporation amount of the liquid 32 by decreasing the heat generation amount of the heat

generating unit 31 when the concentration of the reaction gas in the buffer unit 40 is higher than the reference value.

[49] Thus, the apparatus for growing a silicon carbide epitaxial layer according to an embodiment of the present invention may effectively form a silicon carbide epitaxial layer by using the buffer unit 40. That is, the reaction gas supply unit 30 evaporates the liquid 32 to form the reaction gas. The reaction gas is temporarily stored in the buffer unit 40, and then is supplied to the deposition unit 50. The reaction gas thus supplied is decomposed into radicals to form an epitaxial layer on the wafer 80.

[50] Also, the concentration of the reaction gas in the buffer unit 40 is measured through the sensor unit 41 and the amount of the reaction gas supplied into the deposition unit 50 may easily be adjusted by the control unit 70, the first flow control unit 61, the second flow control unit 62, and the heat generating unit 31.

[51] Therefore, the apparatus for growing a silicon carbide epitaxial layer according to the embodiment of the present invention may form a thin film 81 such as the silicon carbide epitaxial layer on the wafer 80 at a uniform and constant rate by using the buffer unit 40.

[52] In particular, the apparatus for growing a silicon carbide epitaxial layer according to the embodiment of the present invention may supply the reaction gas in an amount for growing the thin film 81 at an optimum rate to the deposition unit 50. Therefore, the apparatus for growing a silicon carbide epitaxial layer according to the embodiment of the present invention may form the thin film 81 at an improved rate.

[53] The foregoing apparatus for growing a silicon carbide epitaxial layer may correspond to a deposition apparatus for forming the thin film 81 on the wafer 80.

[54] Features, structures, or effects described in the foregoing embodiment are included in at least one embodiment of the present invention, and are not necessarily limited to only one embodiment thereof. Further, the features, structures, or effects exemplified in each embodiment may be combined or modified by those skilled in the art and implemented to other embodiments thereof. Therefore, descriptions related to such combinations and modifications will be construed as being included in the scope of the present invention.

[55] Also, while this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The preferred embodiments should be considered in descriptive sense only and not for purposes of limitation. Therefore, the scope of the invention is defined not by the detailed description of the invention but by the appended claims, and all differences within the scope will be construed as being included in the present invention.

[56]

[57]

Claims

[Claim 1] A deposition apparatus comprising:
a reaction gas supply unit supplying a reaction gas;
a buffer unit temporarily storing the reaction gas supplied from the reaction gas supply unit; and
a deposition unit forming a thin film by using the reaction gas supplied from the buffer unit.

[Claim 2] The deposition apparatus according to claim 1, wherein the deposition apparatus comprises a first flow control unit controlling a flow of the reaction gas supplied from the reaction gas supply unit to the buffer unit.

[Claim 3] The deposition apparatus according to claim 2, wherein the deposition apparatus comprises a sensor unit measuring a concentration of the reaction gas in the buffer unit.

[Claim 4] The deposition apparatus according to claim 3, wherein the deposition apparatus comprises a control unit controlling the first flow control unit, and the concentration of the reaction gas measured by the sensor unit is input to the control unit.

[Claim 5] The deposition apparatus according to claim 1, wherein the reaction gas comprises methyltrichlorosilane (MTS), and the thin film comprises silicon carbide.

[Claim 6] The deposition apparatus according to claim 1, wherein a carrier gas is supplied to the reaction gas supply unit, and the reaction gas and the carrier gas are supplied to the buffer unit at the same time.

[Claim 7] The deposition apparatus according to claim 1, wherein the deposition apparatus comprises a second flow control unit controlling a flow of the reaction gas supplied from the buffer unit to the deposition unit.

[Claim 8] The deposition apparatus according to claim 7, wherein the deposition apparatus comprises a sensor unit measuring a concentration of the reaction gas in the buffer unit.

[Claim 9] The deposition apparatus according to claim 8, wherein the deposition apparatus comprises a control unit controlling the second flow control unit, and the concentration of the reaction gas measured by the sensor unit is input to the control unit.

[Claim 10] A method of forming a thin film, the method comprising:
evaporating a liquid to form a reaction gas;
temporarily storing the reaction gas in a buffer unit;

supplying the reaction gas temporarily stored in the buffer unit to a deposition unit; and
forming a thin film by using the reaction gas supplied from the buffer unit.

[Claim 11] The method according to claim 10, wherein the liquid and the reaction gas comprise methyltrichlorosilane, and the thin film comprises silicon carbide.

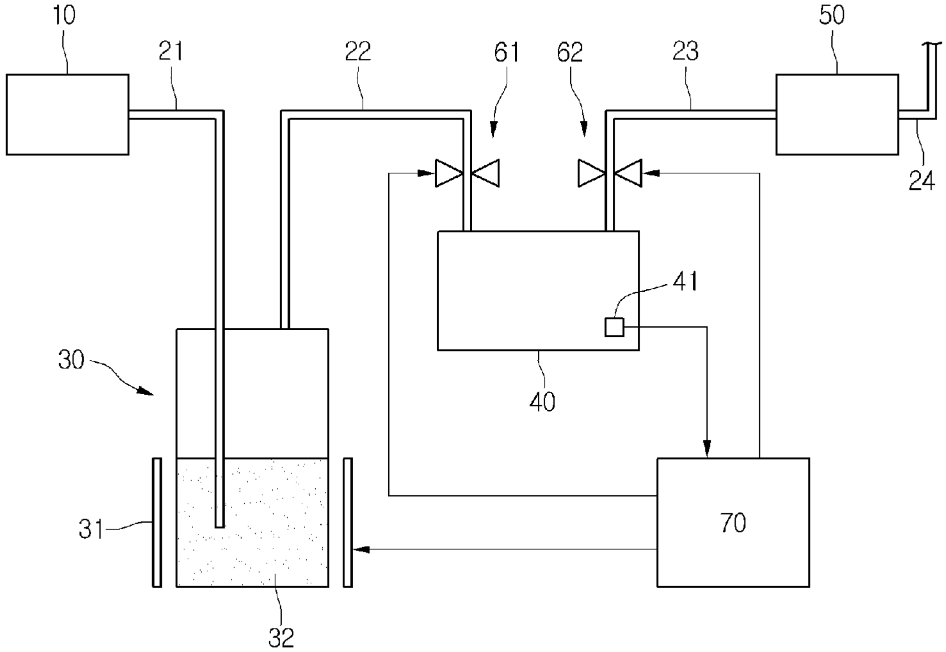
[Claim 12] The method according to claim 10, further comprising:
measuring a concentration of the reaction gas in the buffer unit; and
controlling a flow of the reaction gas stored in the buffer unit based on the measured concentration.

[Claim 13] The method according to claim 12, wherein the method comprises controlling an evaporation rate of the liquid based on the measured concentration.

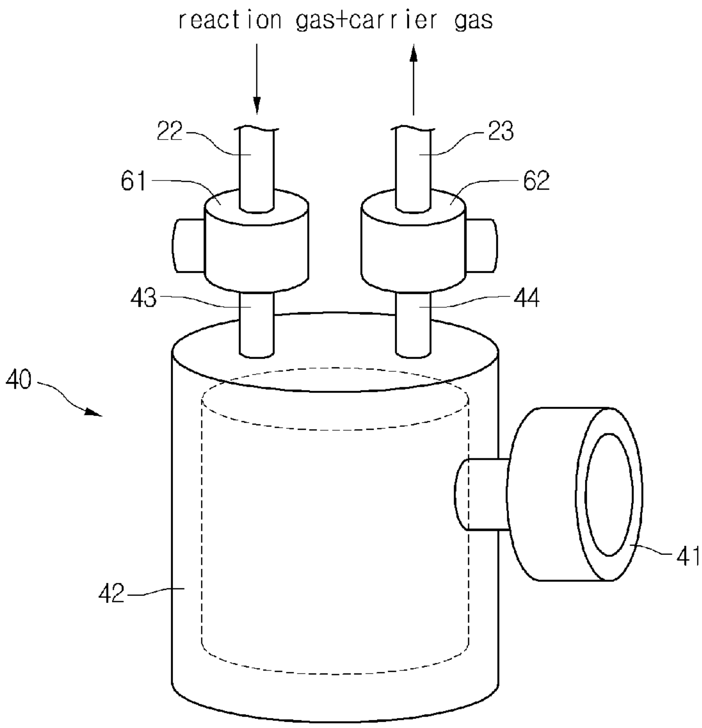
[Claim 14] The method according to claim 10, further comprising:
measuring a concentration of the reaction gas in the buffer unit; and
controlling a flow of the reaction gas supplied to the deposition unit based on the measured concentration.

[Claim 15] The method according to claim 14, wherein the method comprises controlling an evaporation rate of the liquid based on the measured concentration.

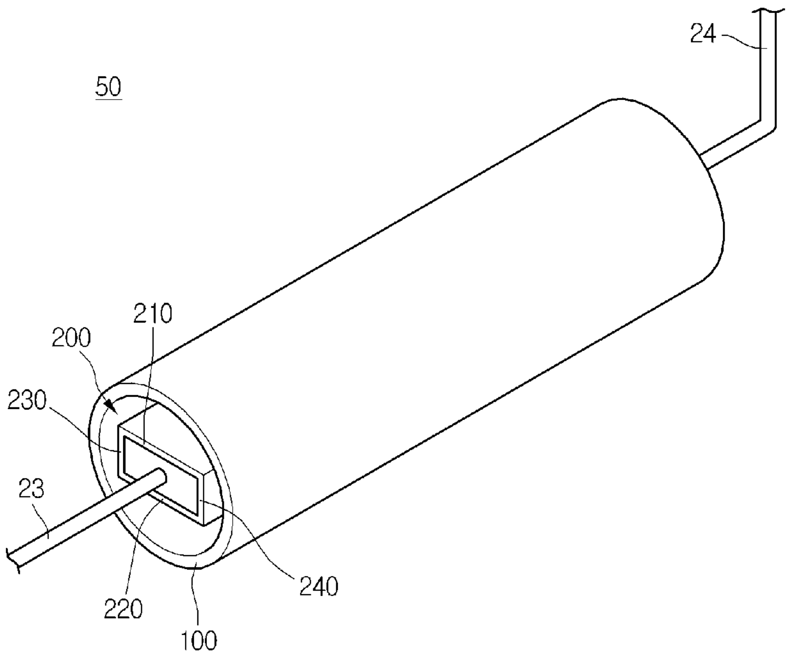
[Fig. 1]


10
21
22
61
62
23
50
24
41
30
40
31
70
32

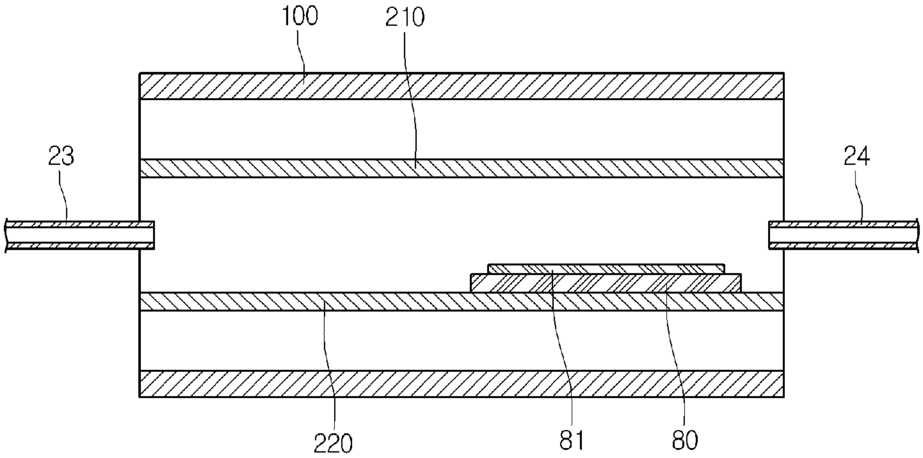
[Fig. 2]


reaction gas+carrier gas
22
23
61
62
43
44
40
41
42

[Fig. 3]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2012/000204

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/205(2006.01)i

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)
H01L 21/205; C01B 31/36; H01L 21/20; C04B 35/565

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: buffer unit, reaction gas supply unit, deposition unit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	KR 10-2004-0103020 A (SAMSUNG ELECTRONICS CO., LTD.) 08 December 2004 See page 2 line 40 - page 3 line 53; and figures 2-4.	1,6,10 2-5,7-9,11-15
Y	KR 20-2000-0016861 U (HYUNDAI MICRO ELECTRONICS CO., LTD.) 25 September 2000 See page 2 line 39 - page 3 line 15; and figures 3-4.	2-4,7-9,12-15
Y	JP 2002-037669 A (KYOCERA CORP.) 06 February 2002 See paragraph [0012] - paragraph [0054]; and figure 2.	5,11
A	KR 10-2010-0099592 A (LG INNOTEK CO., LTD.) 13 September 2010 See paragraph [0013] - paragraph [0056]; and figure 1.	1-15

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
11 SEPTEMBER 2012 (11.09.2012)	**12 SEPTEMBER 2012 (12.09.2012)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
Kim, Han Su
Telephone No. 82-42-481-8683

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2012/000204

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 10-2004-0103020 A	08.12.2004	None	
KR 20-2000-0016861 U	25.09.2000	None	
JP 2002-037669 A	06.02.2002	None	
KR 10-2010-0099592 A	13.09.2010	None	