FIG. 1

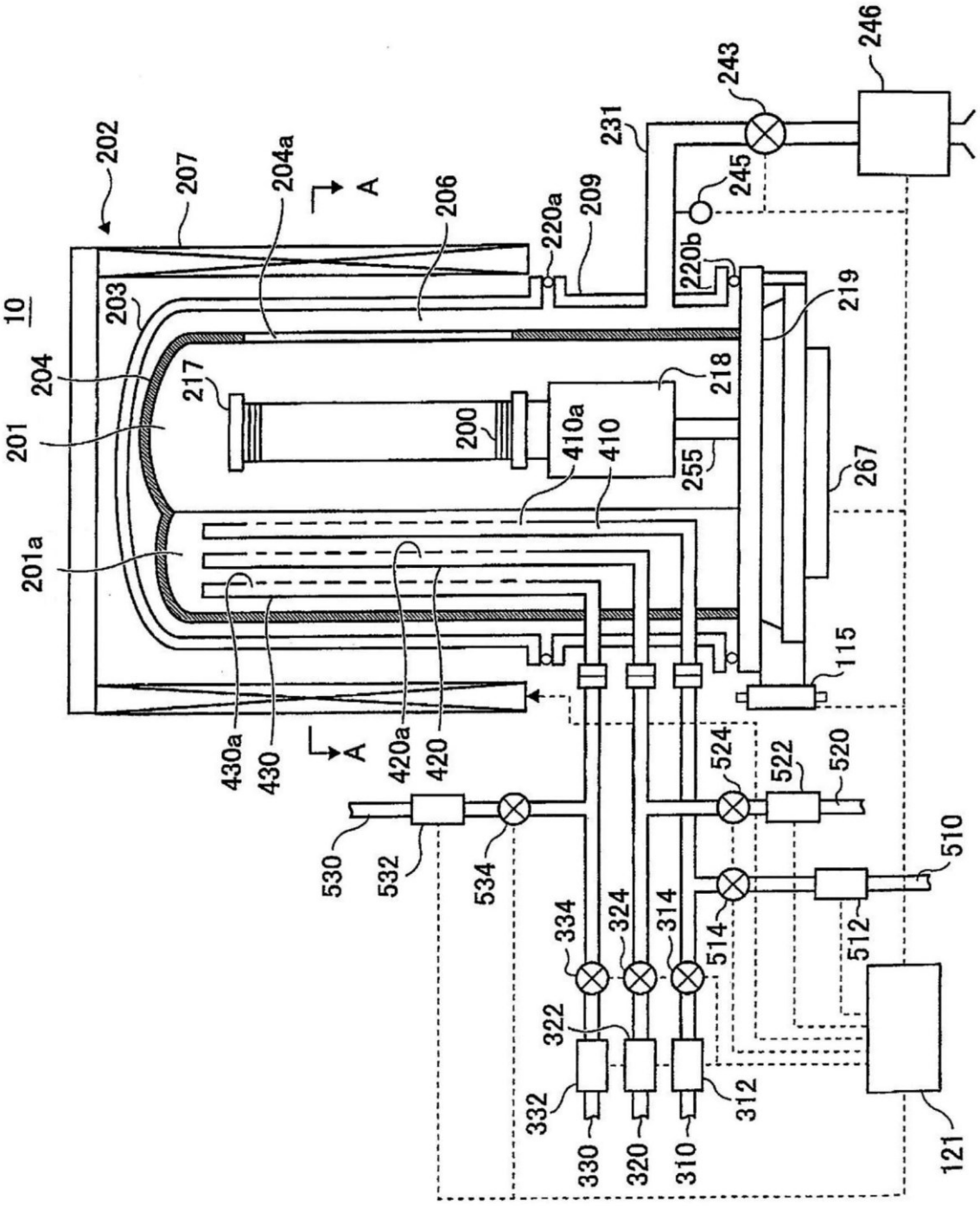
10
201
201a
202
203
204
204a
206
207
209
217
218
219
220a
220b
231
243
245
246
255
267
115
200
410
410a
420
420a
430
430a
A
A
310
312
314
320
322
324
330
332
334
510
512
514
520
522
524
530
532
534
121

FIG. 2

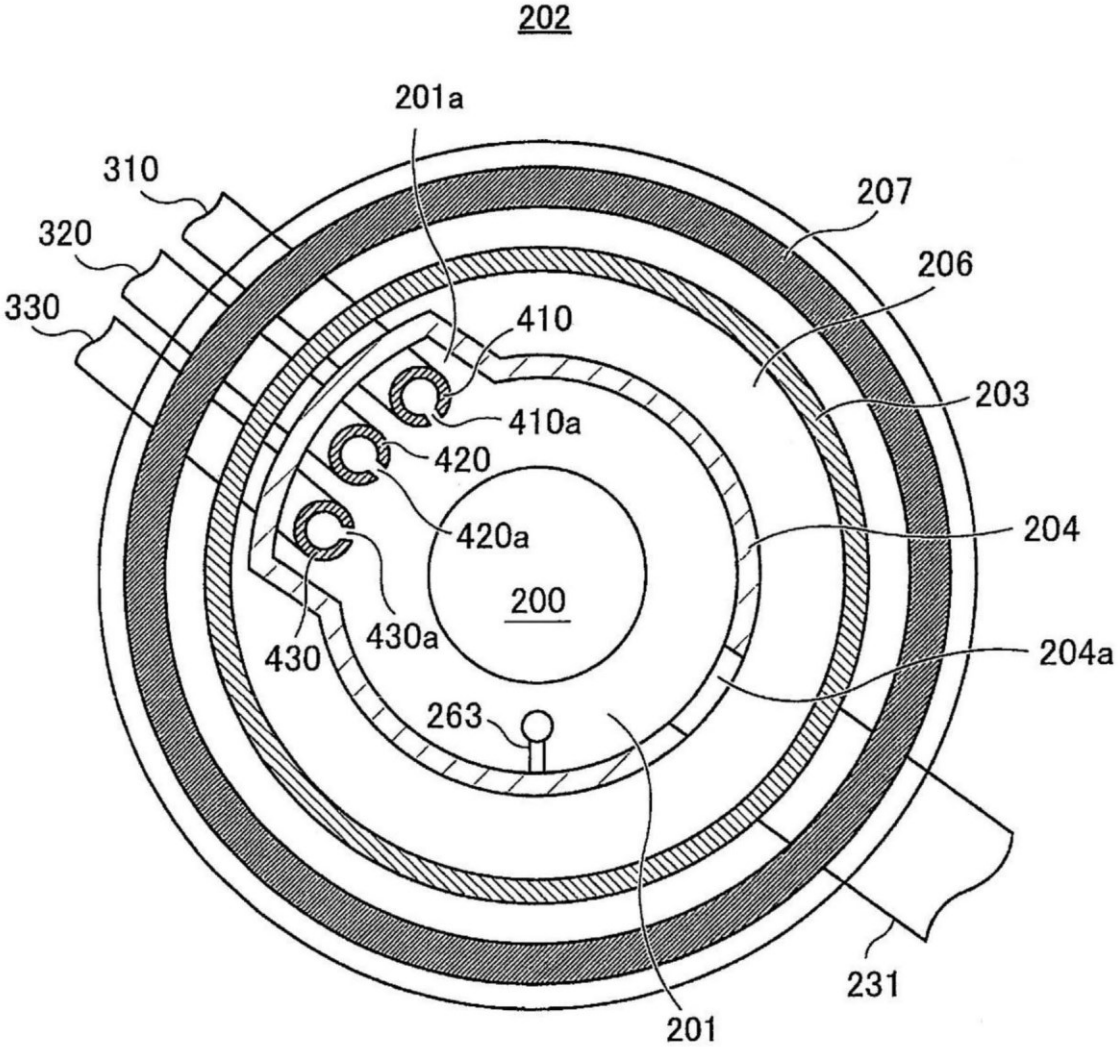
202
201a
310
320
330
207
206
410
410a
203
420
420a
204
200
430
430a
204a
263
231
201

FIG. 3

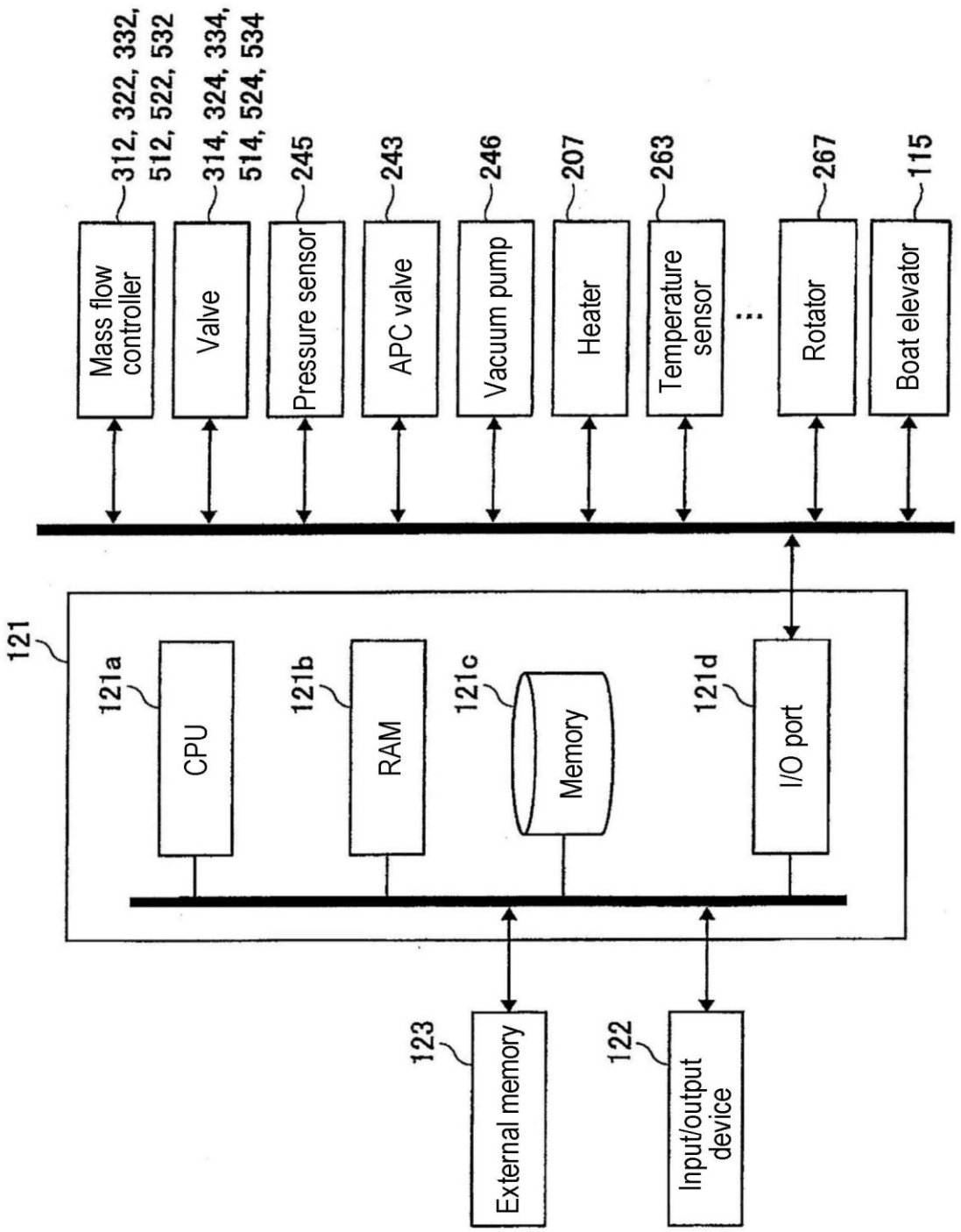
312, 322, 332, 512, 522, 532
314, 324, 334, 514, 524, 534
245
243
246
207
263
267
115
Mass flow controller
Valve
Pressure sensor
APC valve
Vacuum pump
Heater
Temperature sensor
Rotator
Boat elevator
121
121a
CPU
121b
RAM
121c
Memory
121d
I/O port
123
External memory
122
Input/output device

FIG. 4

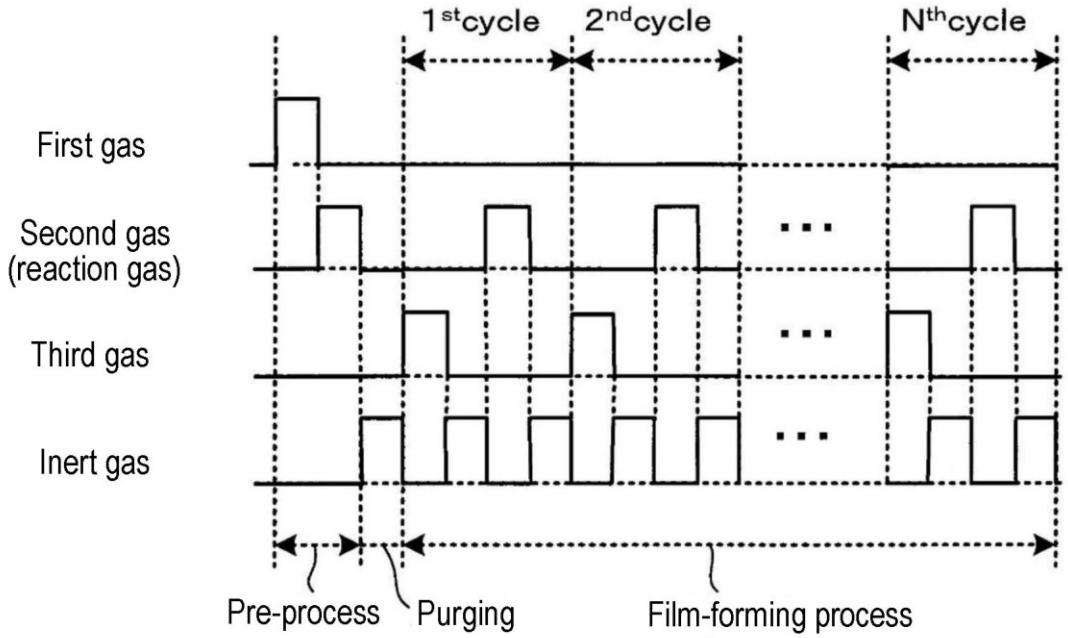
1st cycle
2nd cycle
Nth cycle
First gas
Second gas
(reaction gas)
Third gas
Inert gas
Pre-process
Purging
Film-forming process

FIG. 5A

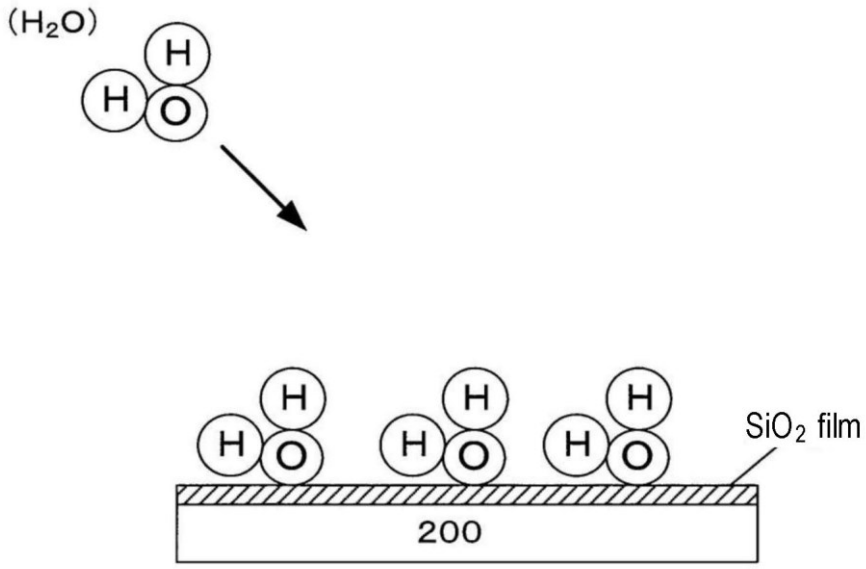

FIG. 5B

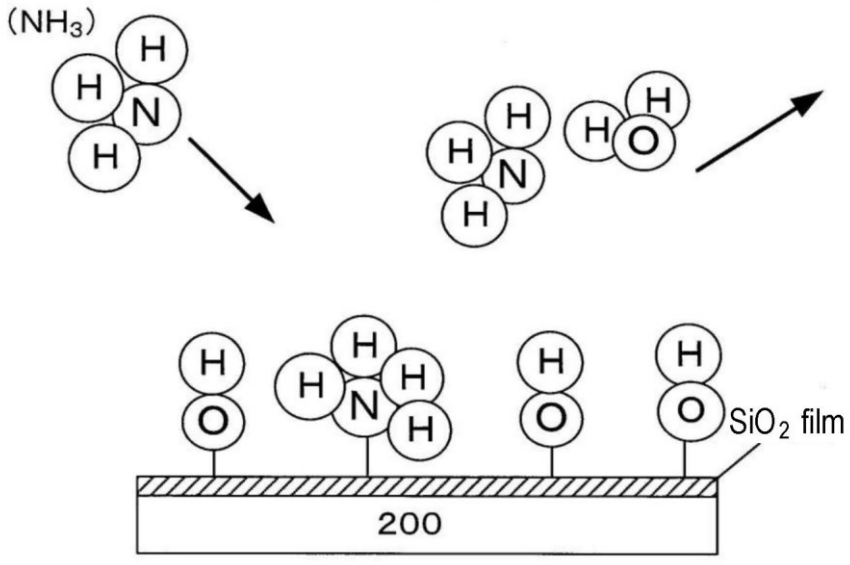

FIG. 5C

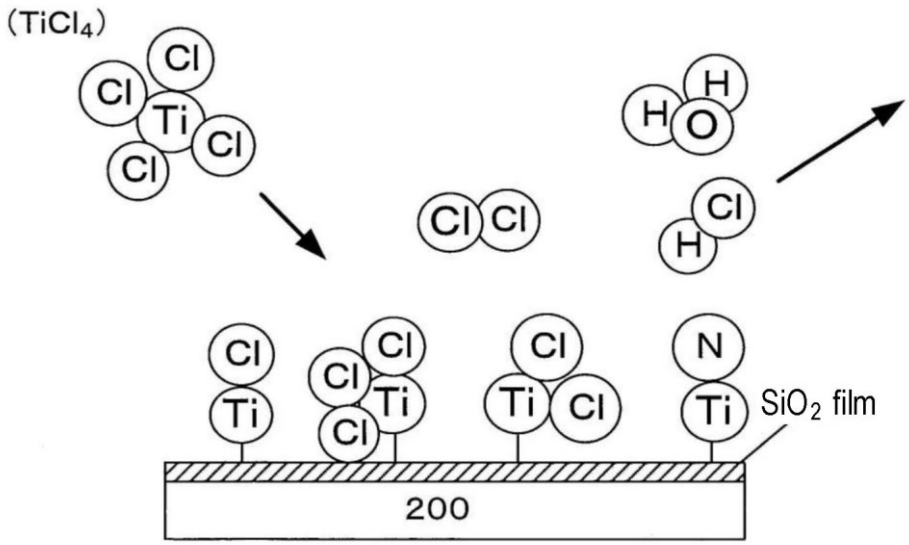
(TiCl4)
Cl
Cl
Ti
Cl
Cl
Cl Cl
H
H O
Cl
H
Cl
Ti
Cl
Cl
Ti
Cl
Ti
Cl
N
Ti
SiO2 film
200

FIG. 5D

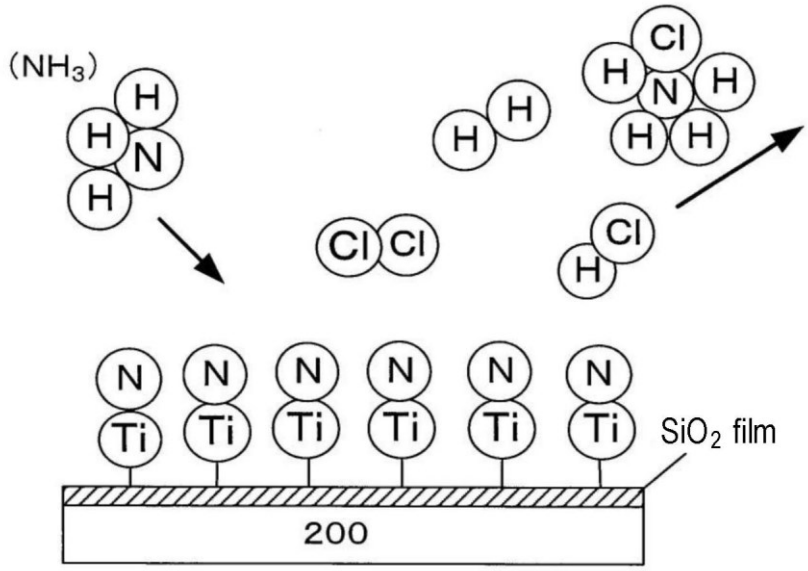
(NH3)
H
H
N
H
H H
Cl
H
N
H
H H
Cl Cl
Cl
H
N N N N N N
Ti Ti Ti Ti Ti Ti
SiO2 film
200

FIG. 6

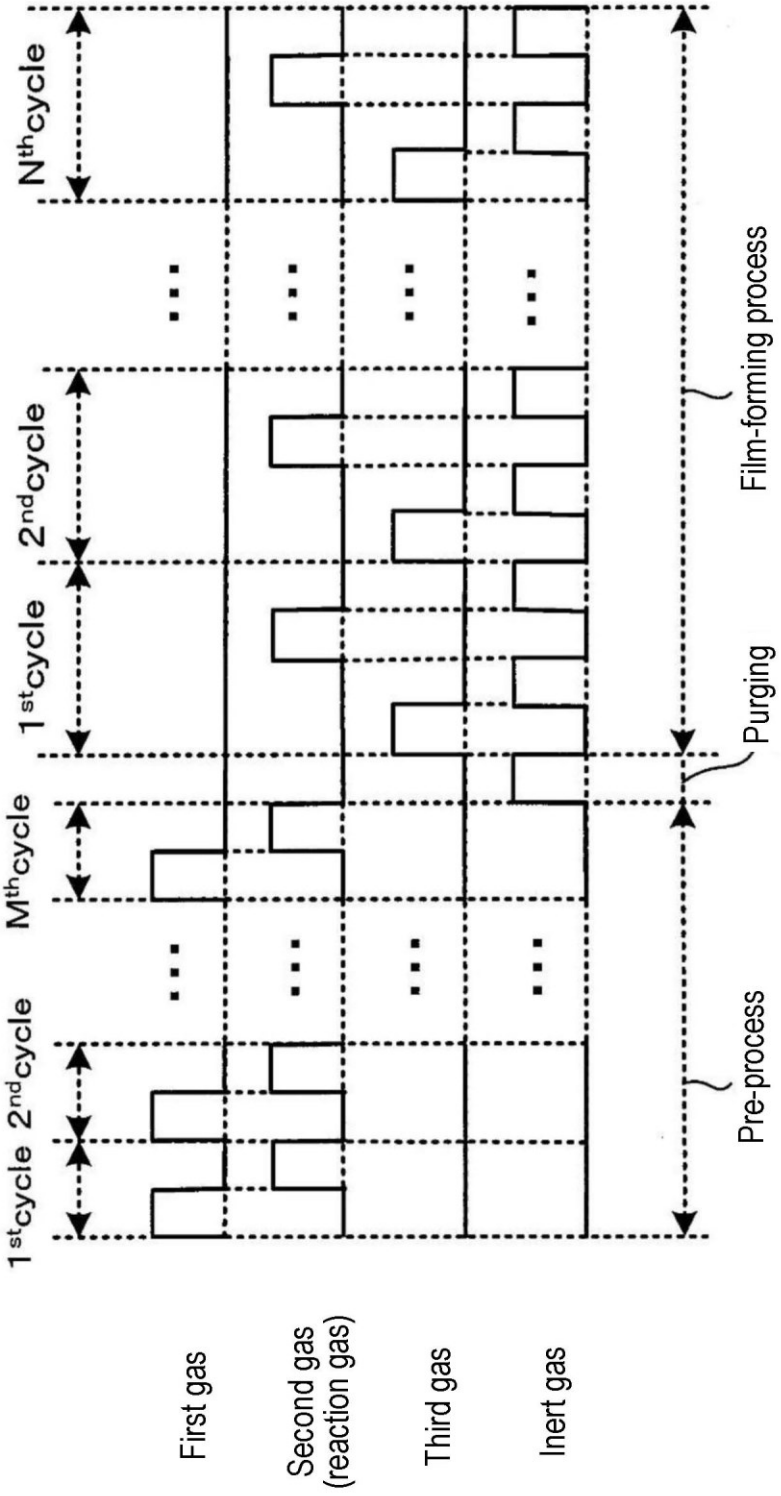
1stcycle
2ndcycle
Mthcycle
1stcycle
2ndcycle
Nthcycle
Pre-process
Purging
Film-forming process
First gas
Second gas (reaction gas)
Third gas
Inert gas

FIG. 7A

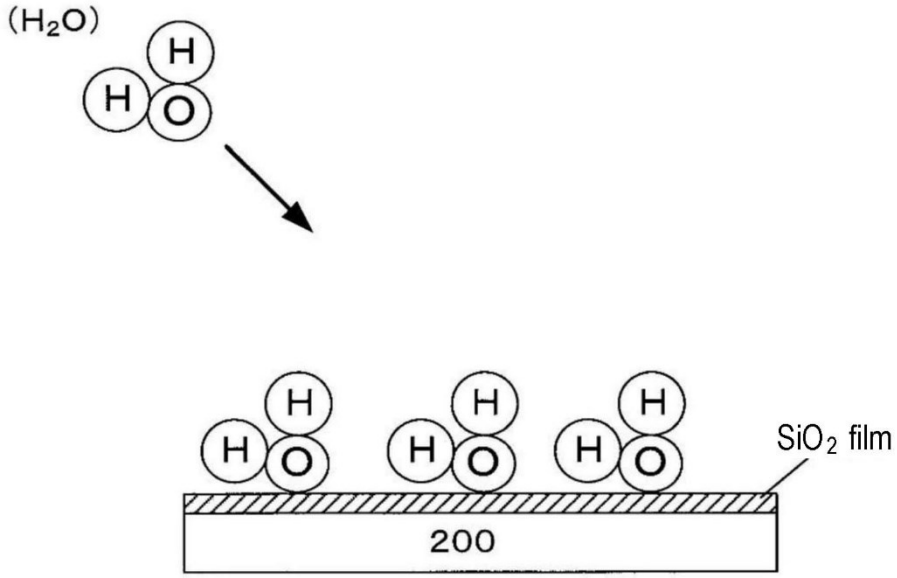
(H2O)
H
H
O
H
O
H
O
H
O
H
O
SiO2 film
200

FIG. 7B

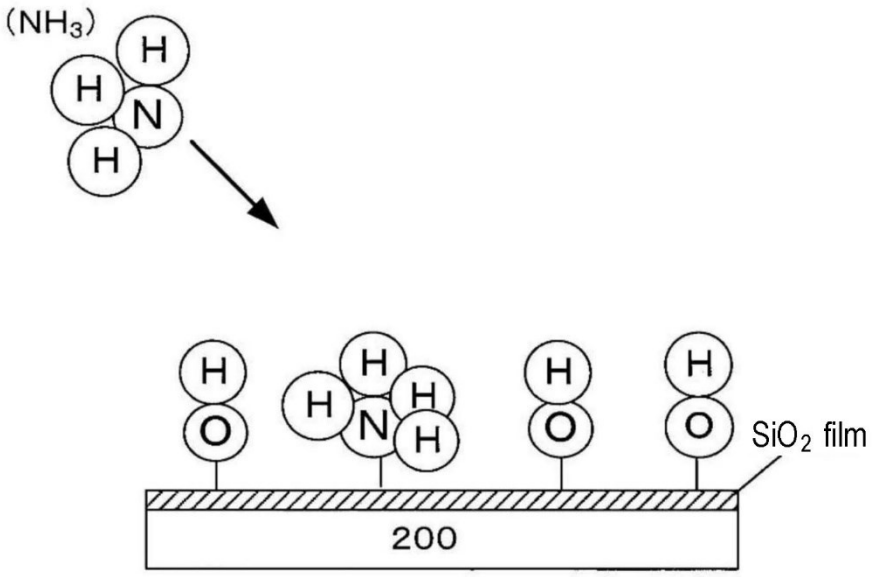
(NH3)
H
H
N
H
H
O
H
N
H
H
H
O
H
O
SiO2 film
200

FIG. 7C

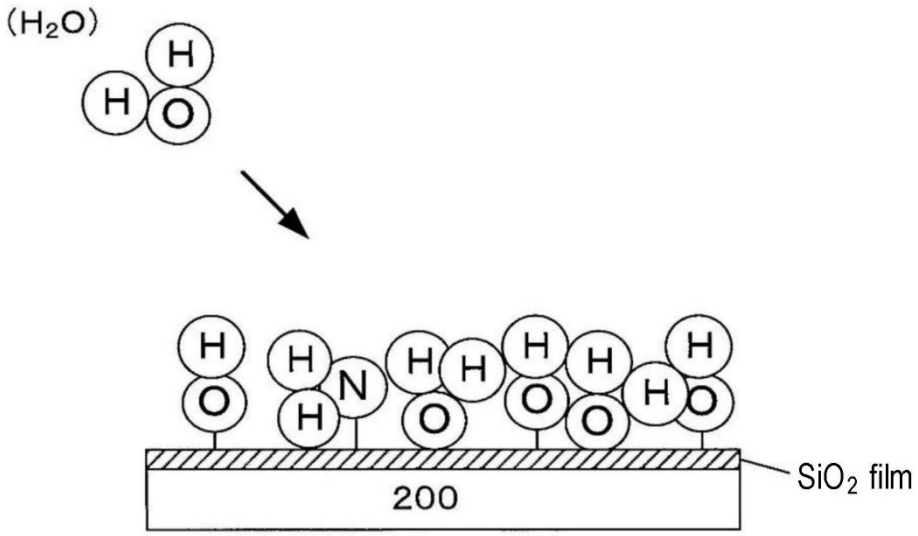
(H2O)
H
H
O
H
O
H
H
N
H
H
O
H
H
O
O
H
H
O
SiO2 film
200

FIG. 7D

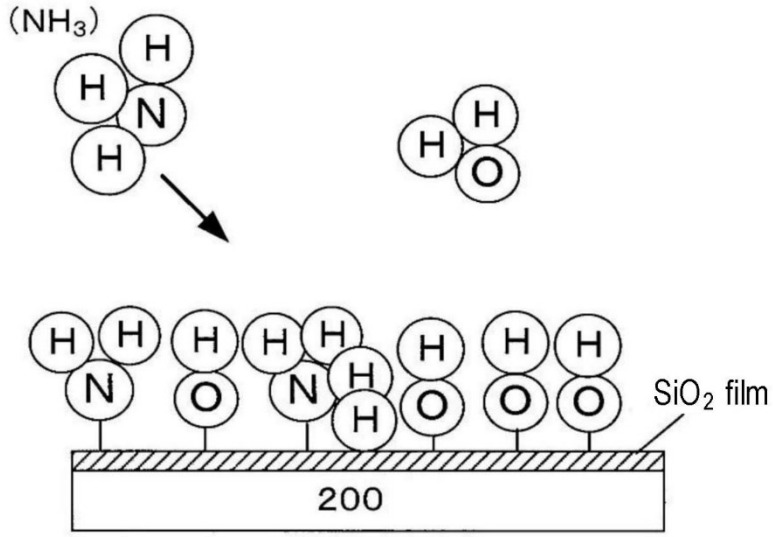
(NH3)
H
H
N
H
H
H
O
H
H
N
H
O
H
H
N
H
H
H
O
H
O
H
O
SiO2 film
200

FIG. 8A

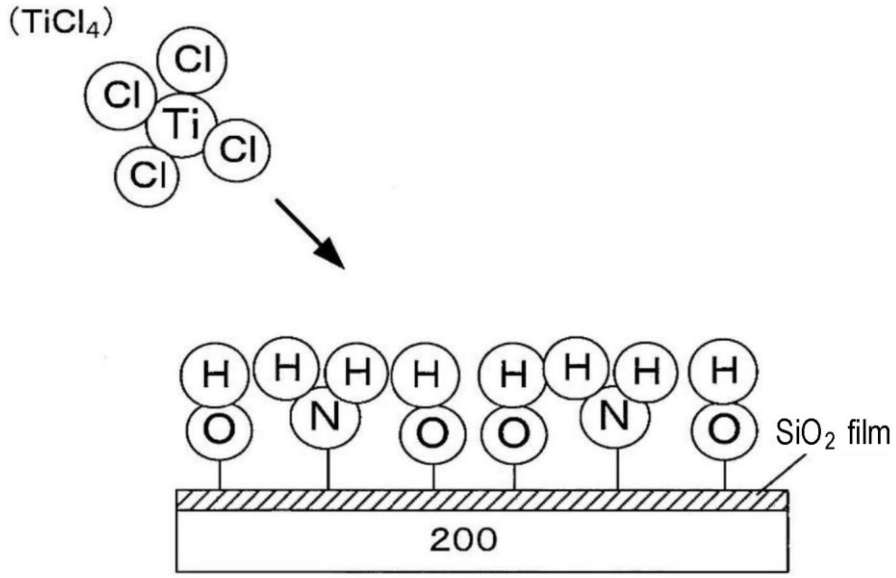
(TiCl4)
Cl
Cl
Ti
Cl
Cl
H
O
N
SiO2 film
200

FIG. 8B

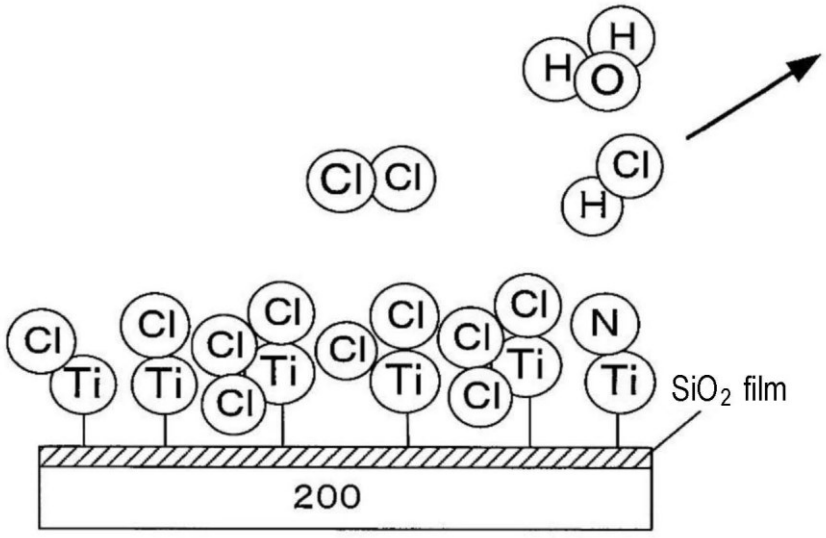
H
H
O
Cl
Cl
Cl
H
Ti
N
SiO2 film
200

FIG. 8C

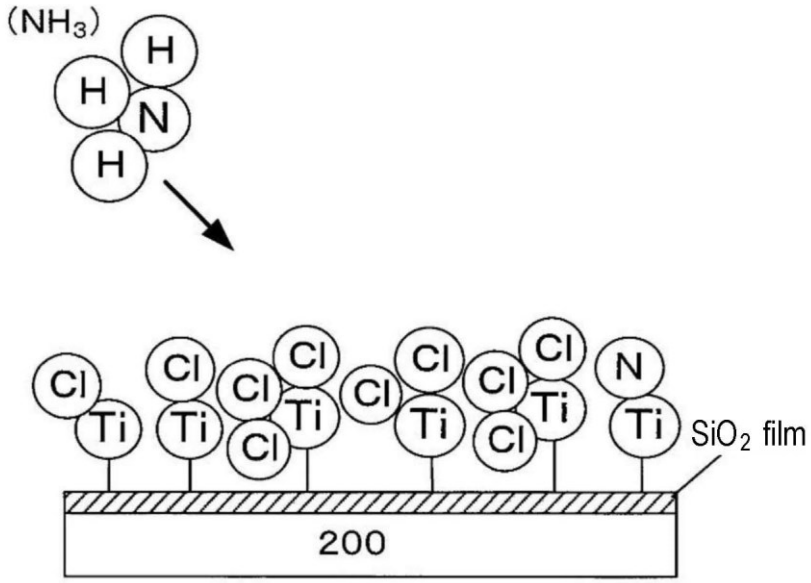

FIG. 8D

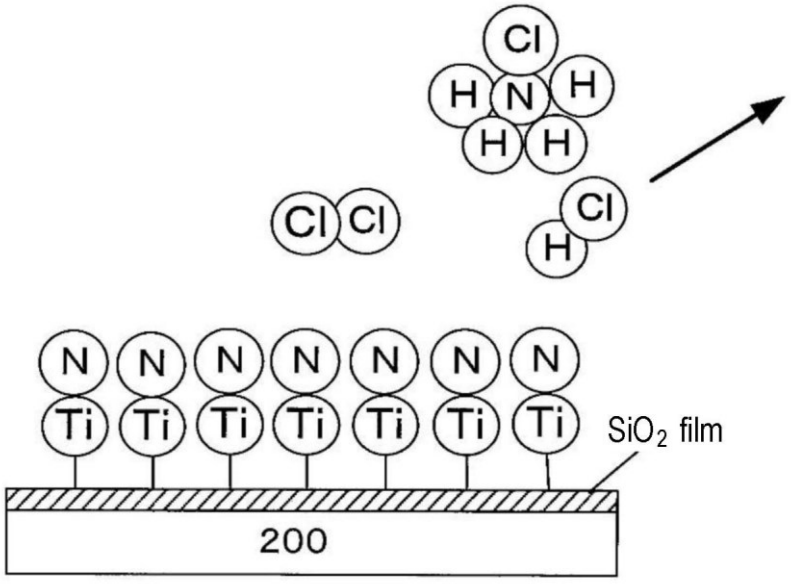

FIG. 9

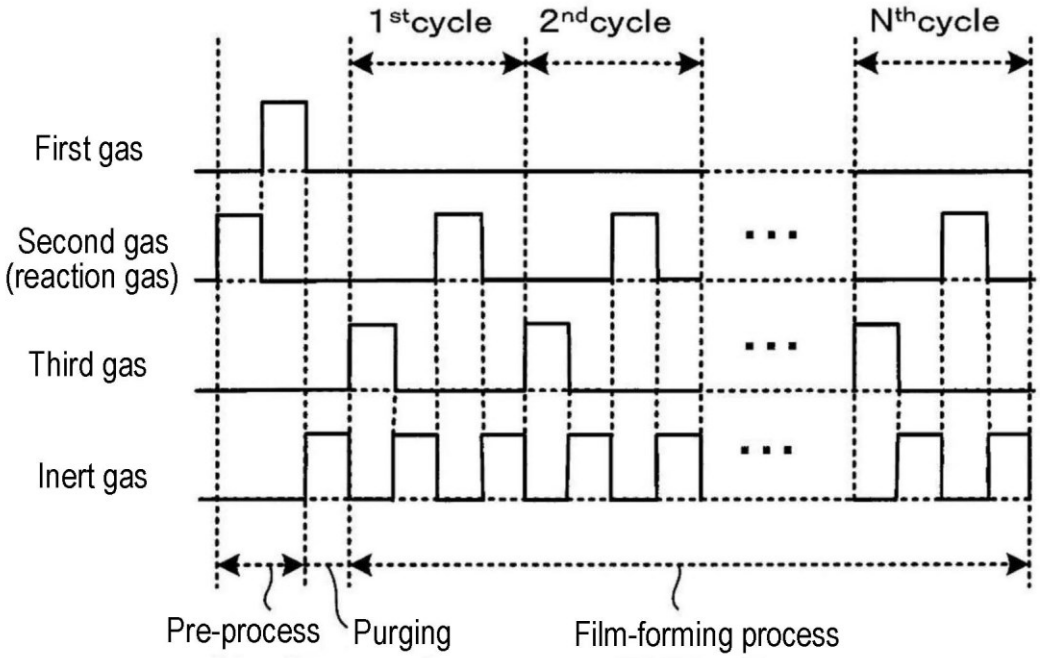
1stcycle
2ndcycle
Nthcycle
First gas
Second gas
(reaction gas)
Third gas
Inert gas
Pre-process
Purging
Film-forming process

FIG. 10A

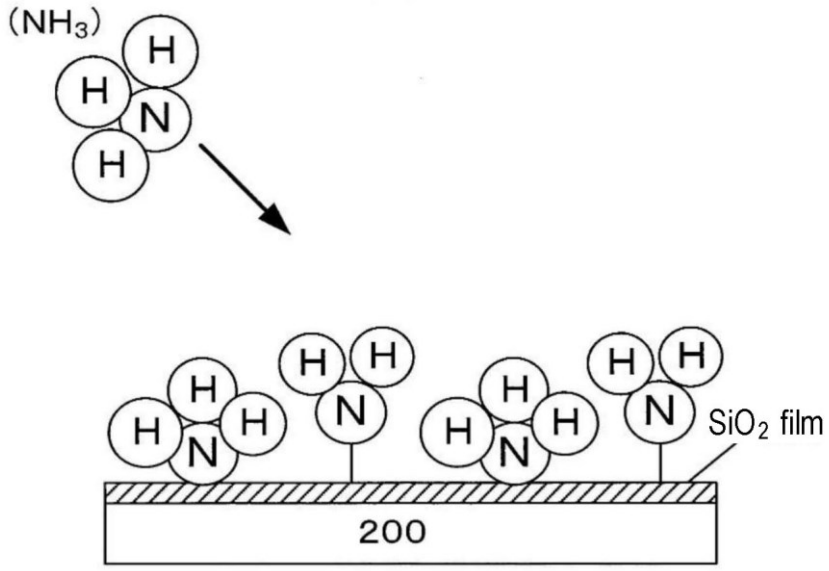

FIG. 10B

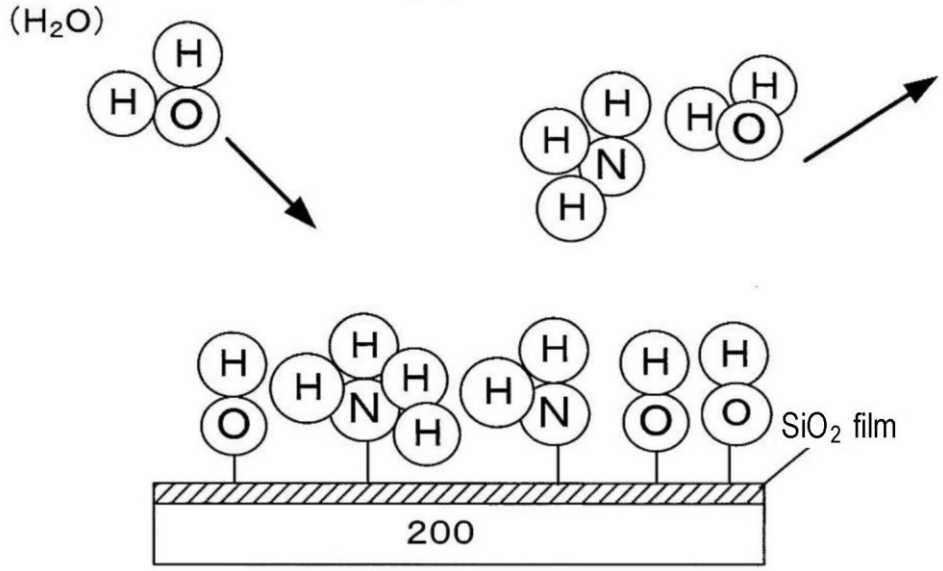

FIG. 10C

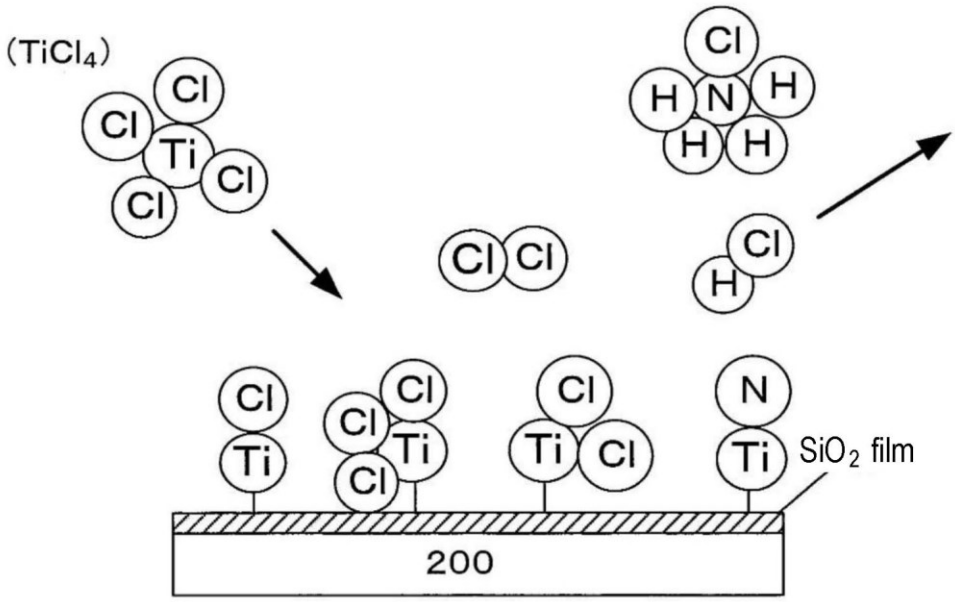

FIG. 10D

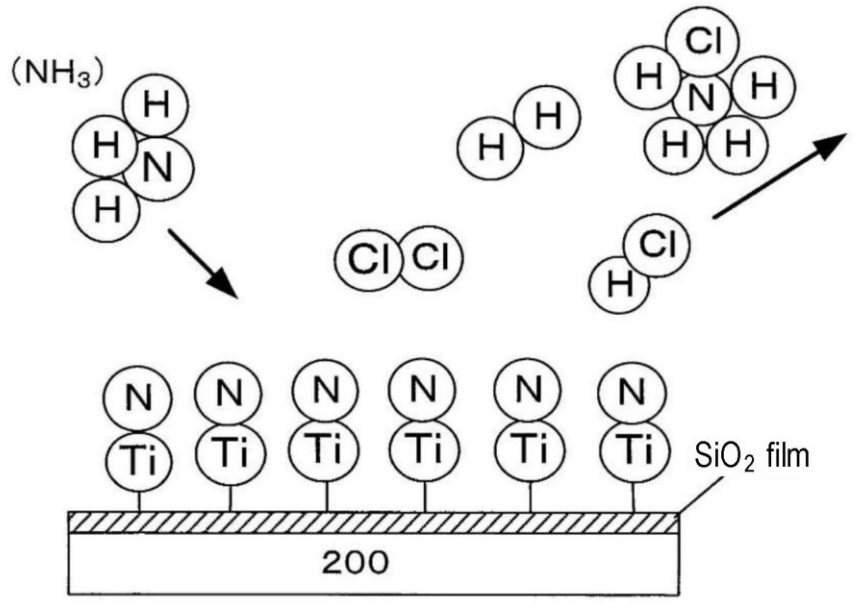

FIG. 11

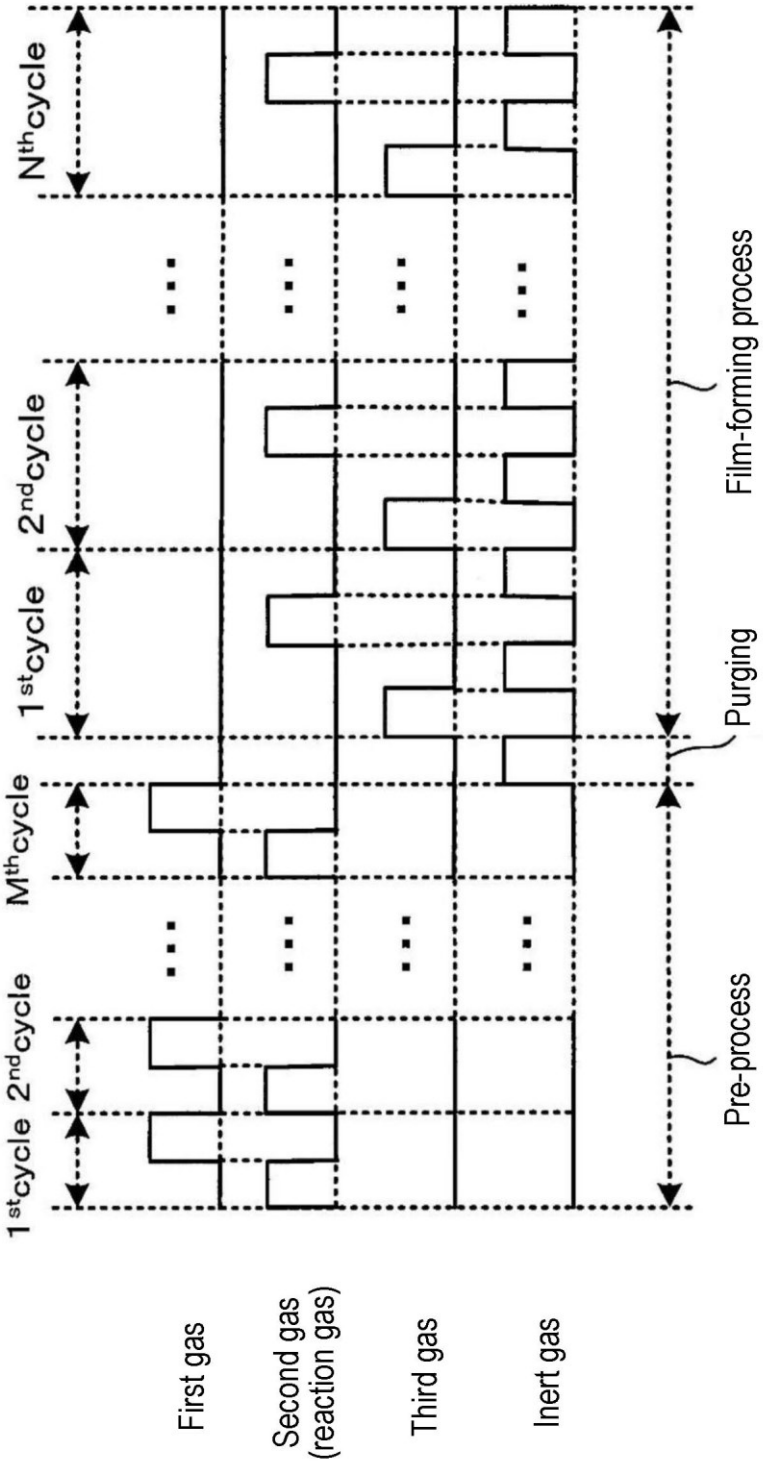
1st cycle
2nd cycle
Mth cycle
1st cycle
2nd cycle
Nth cycle
Pre-process
Purging
Film-forming process
First gas
Second gas (reaction gas)
Third gas
Inert gas

FIG. 12A

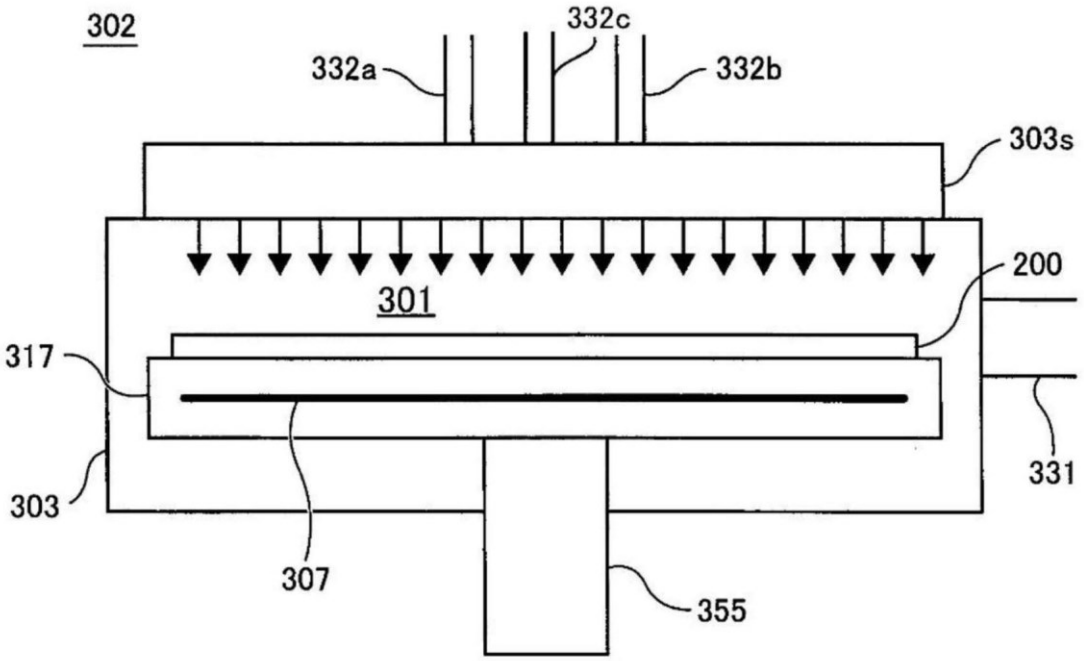

FIG. 12B

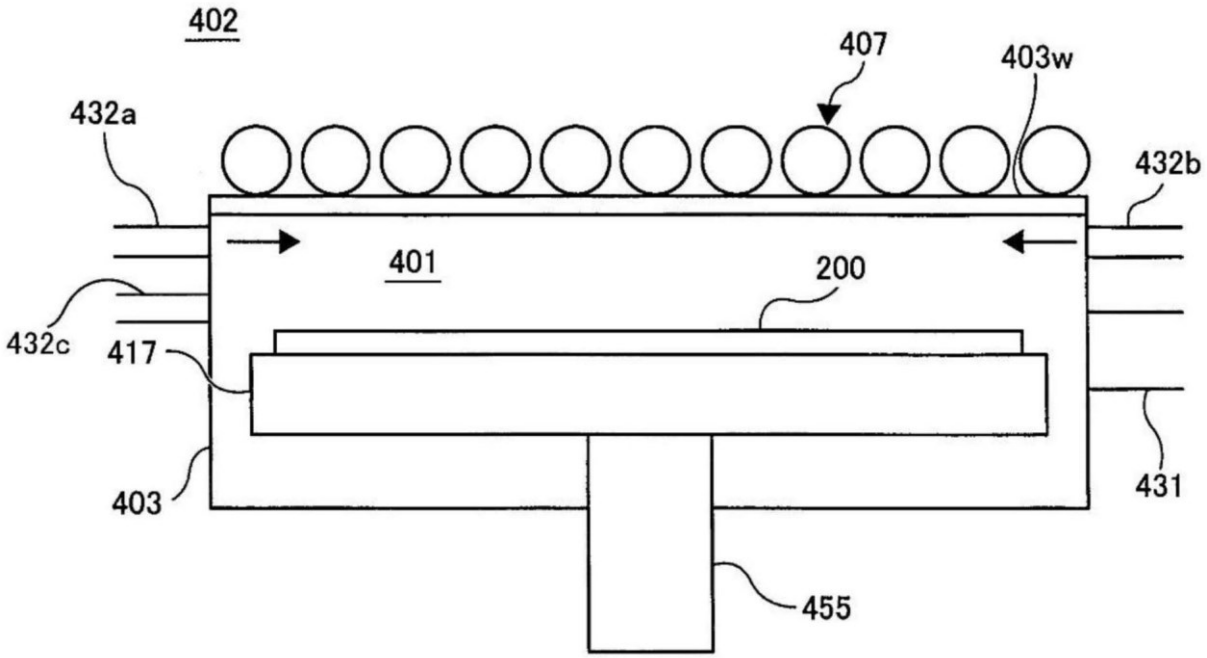

FIG. 13A

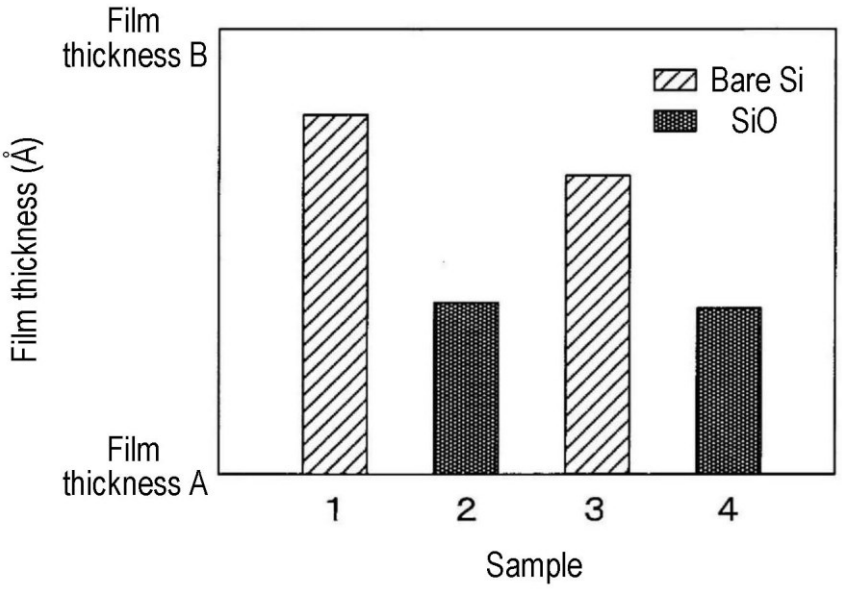

FIG. 13B

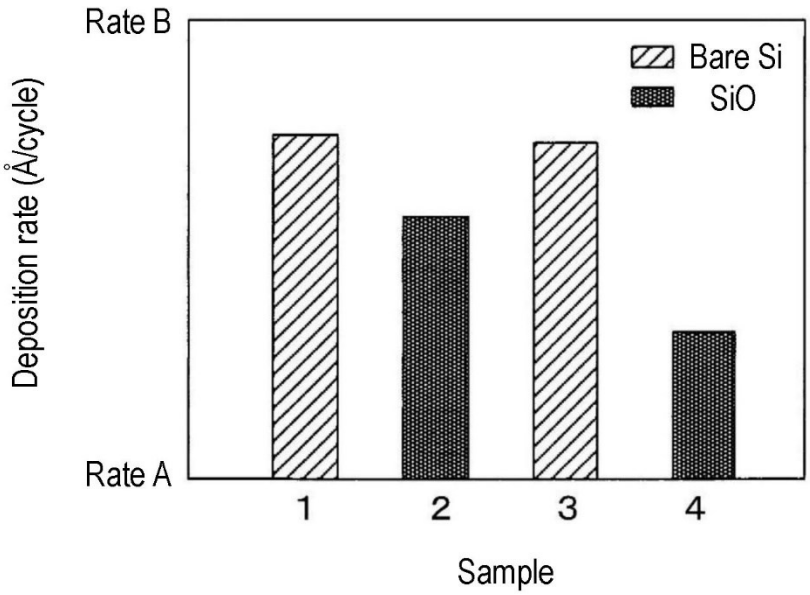

FIG. 14A

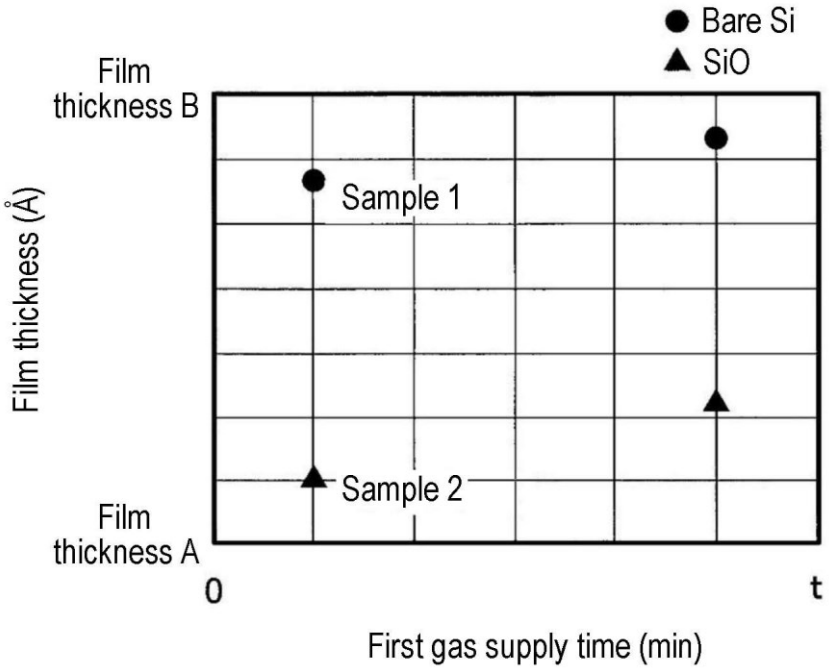

FIG. 14B

