FIG.1 RELATED ART

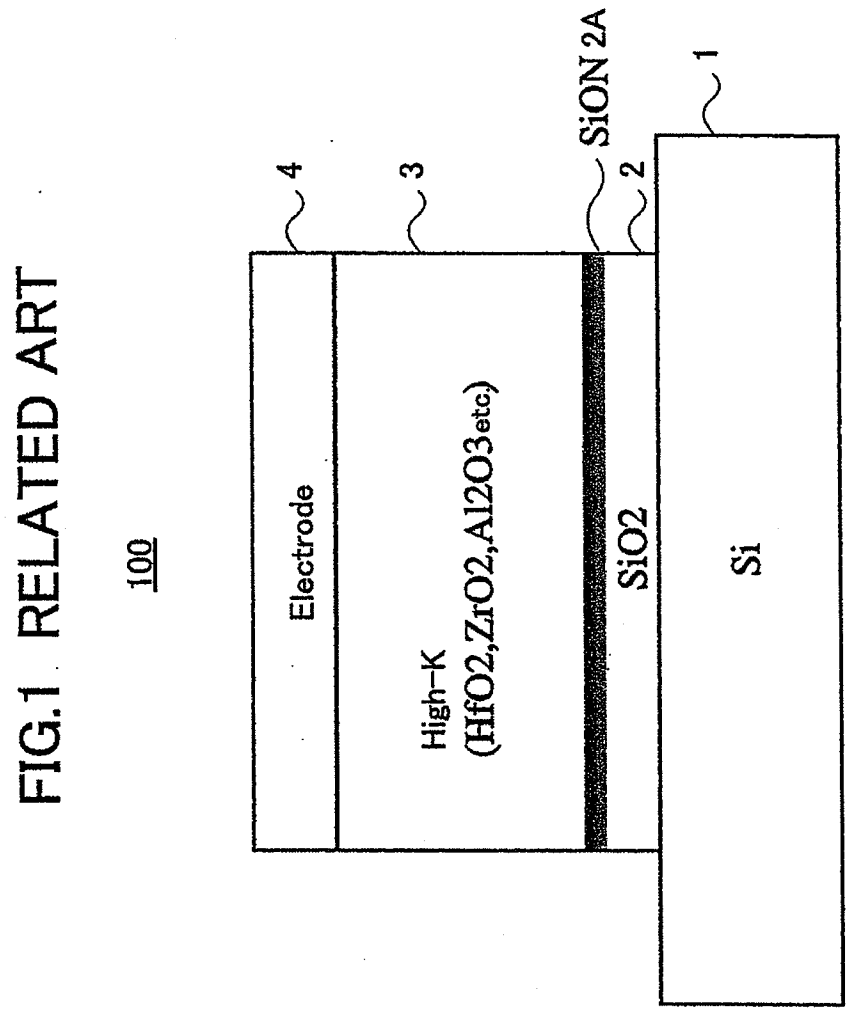


FIG.2 RELATED ART

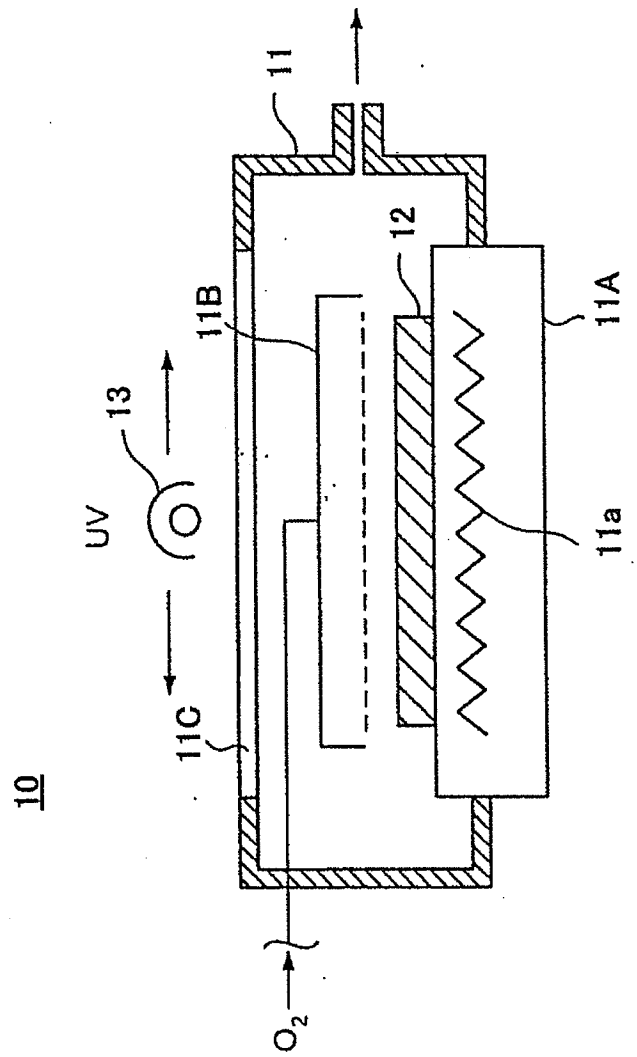
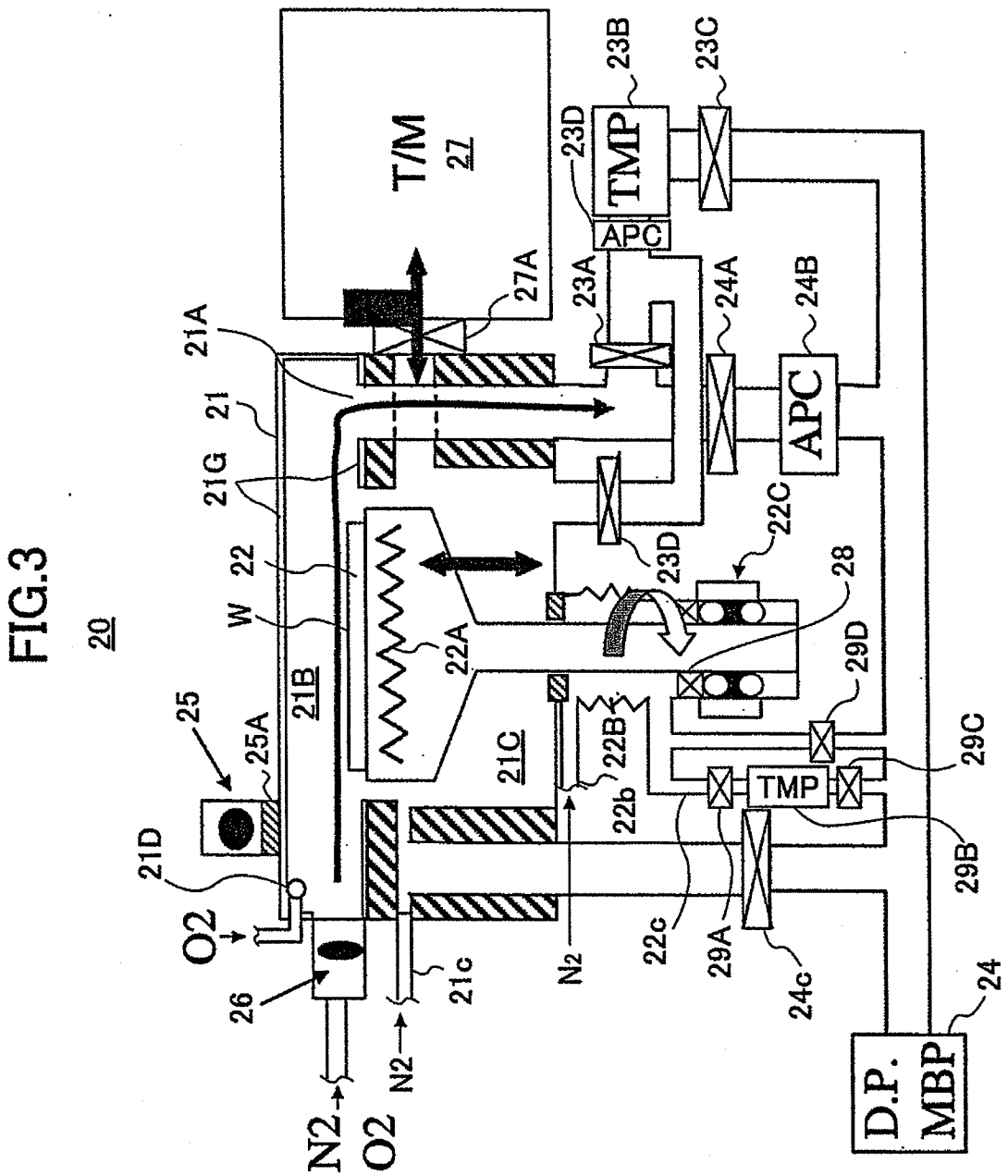


FIG.3


20
T/M
27
TMP
APC
23B
23C
23D
23A
24A
24B
27A
21A
21
21G
22
W
22A
21B
21C
25
25A
21D
O2
26
N2
21c
N2
22B
22b
22C
28
29D
29C
TMP
29B
22c
29A
24c
24
D.P.
MBP

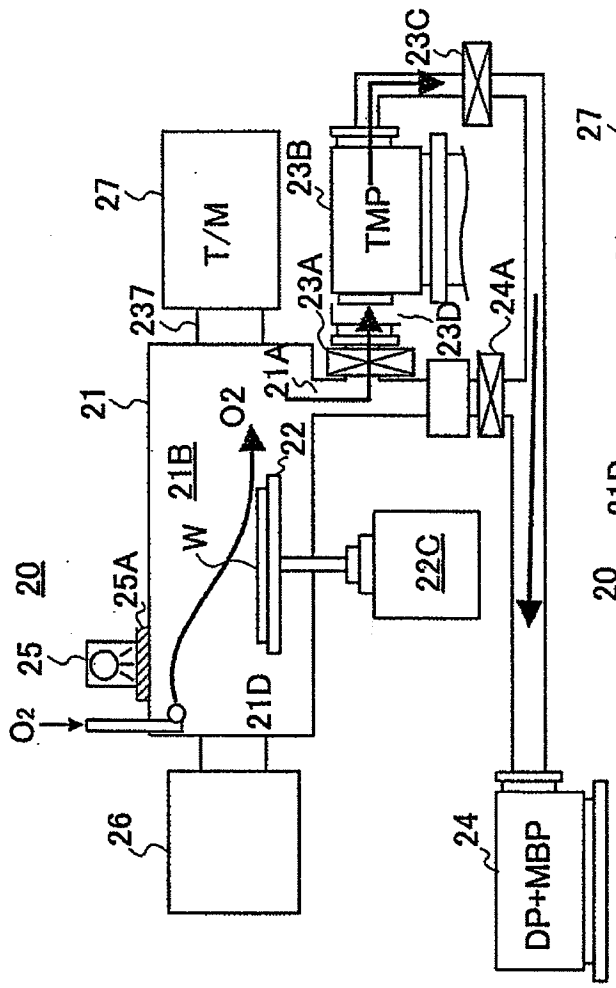

O2
25
20
25A
W
21B
21
O2
22
21A
23A
23B
TMP
23C
23D
24A
27
T/M
237
21D
22C
26
24
DP+MBP

FIG.4A

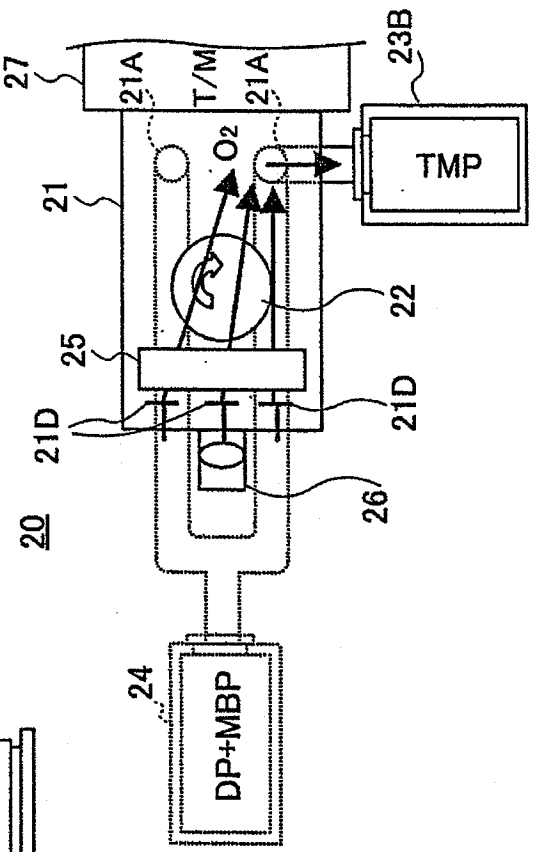

27
21A
T/M
21A
23B
TMP
O2
21
22
25
21D
21D
20
26
24
DP+MBP

FIG.4B

FIG.5

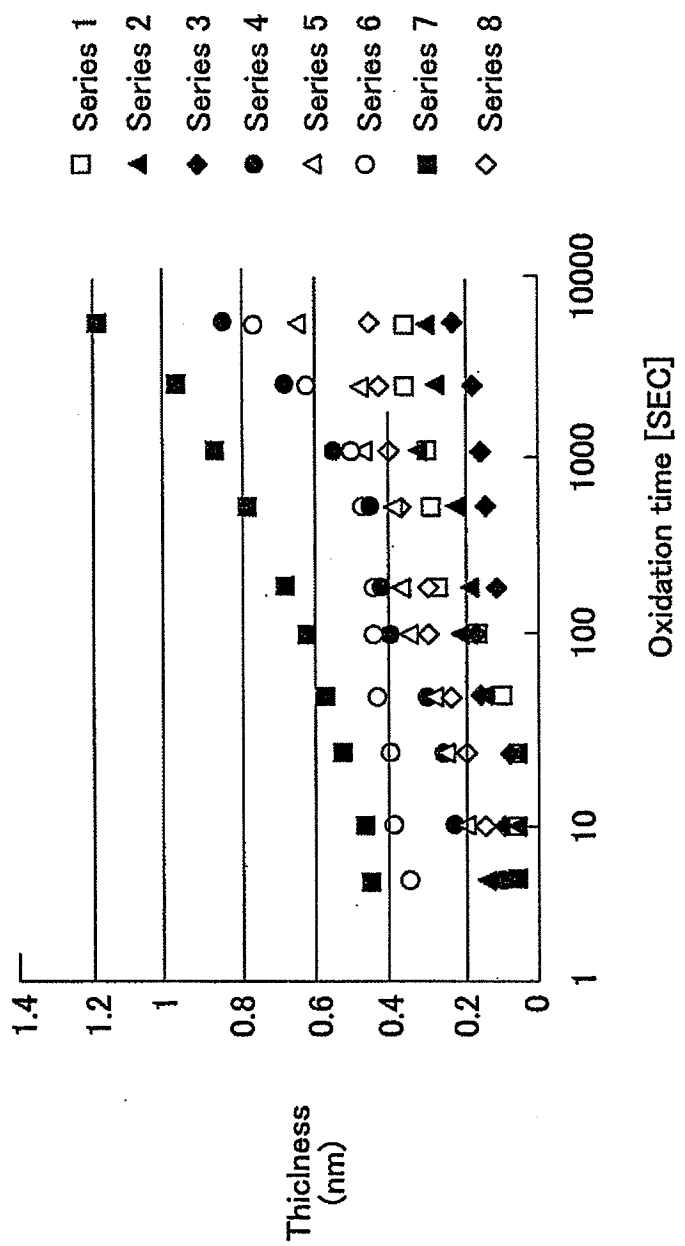

Series 1
Series 2
Series 3
Series 4
Series 5
Series 6
Series 7
Series 8
Thickness (nm)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
10
100
1000
10000
Oxidation time [SEC]

FIG.6

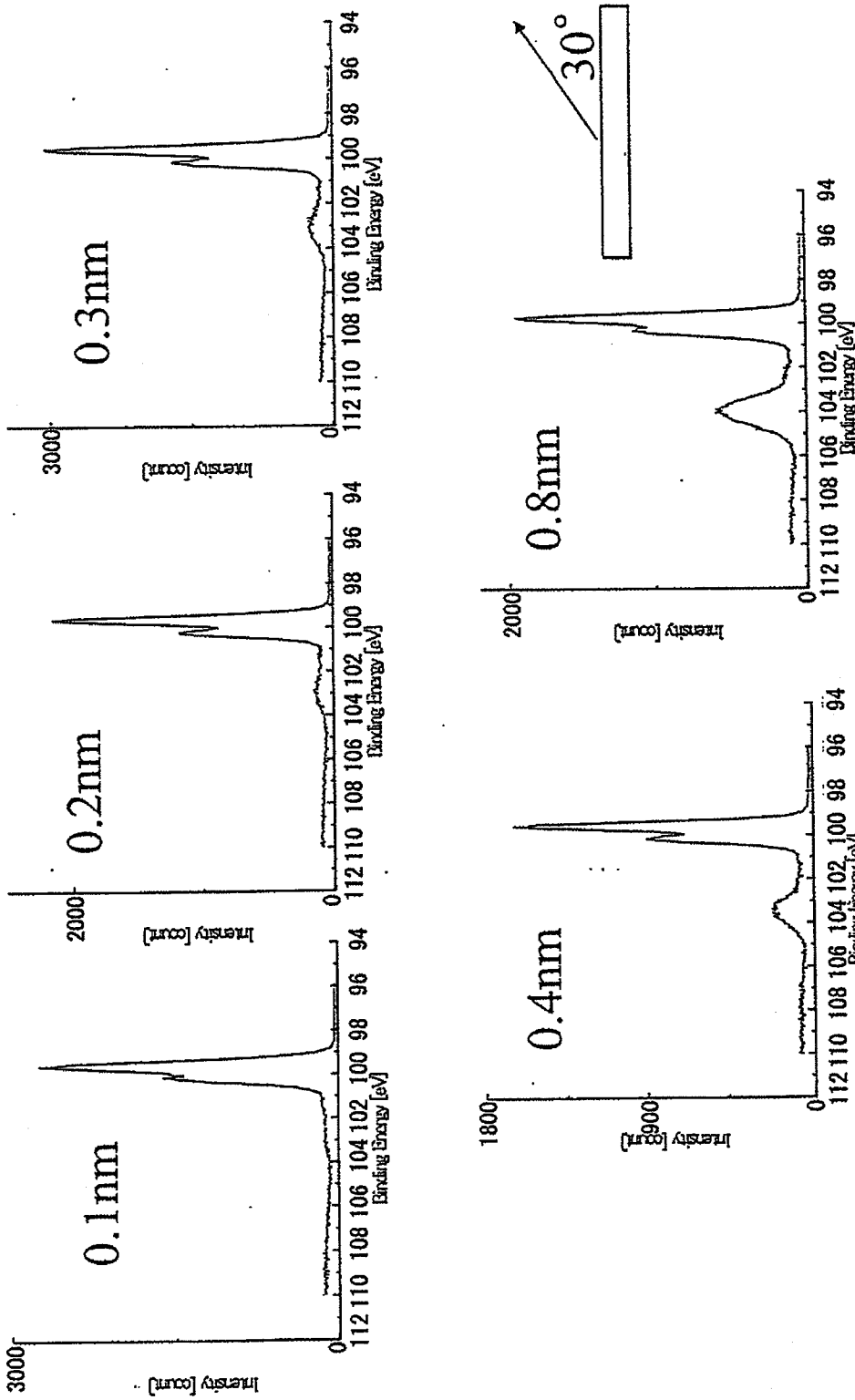

0.1nm
0.2nm
0.3nm
0.4nm
0.8nm
30°
Intensity [count]
Binding Energy [eV]
112 110 108 106 104 102 100 98 96 94
0
1800
2000
3000

FIG.7

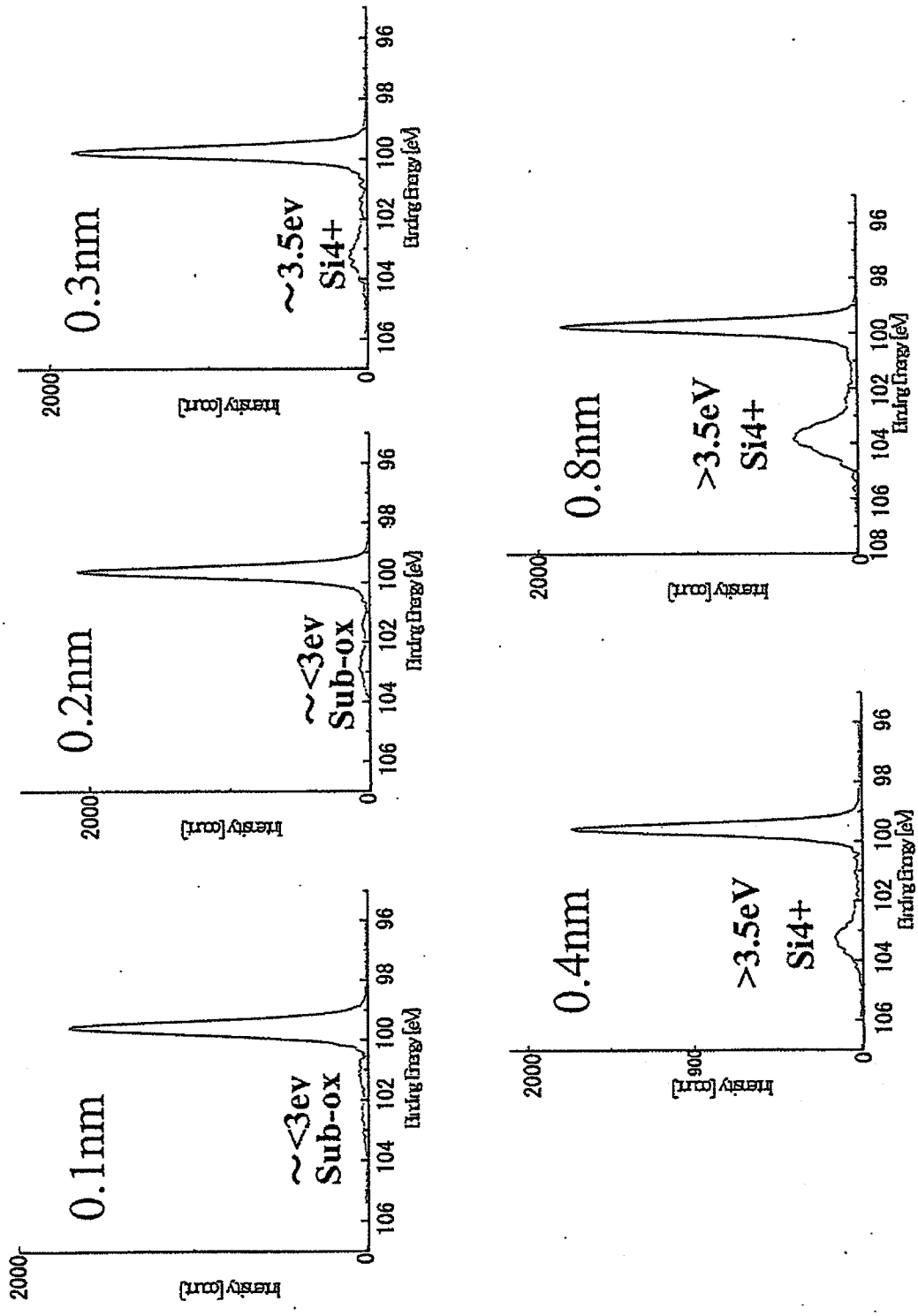
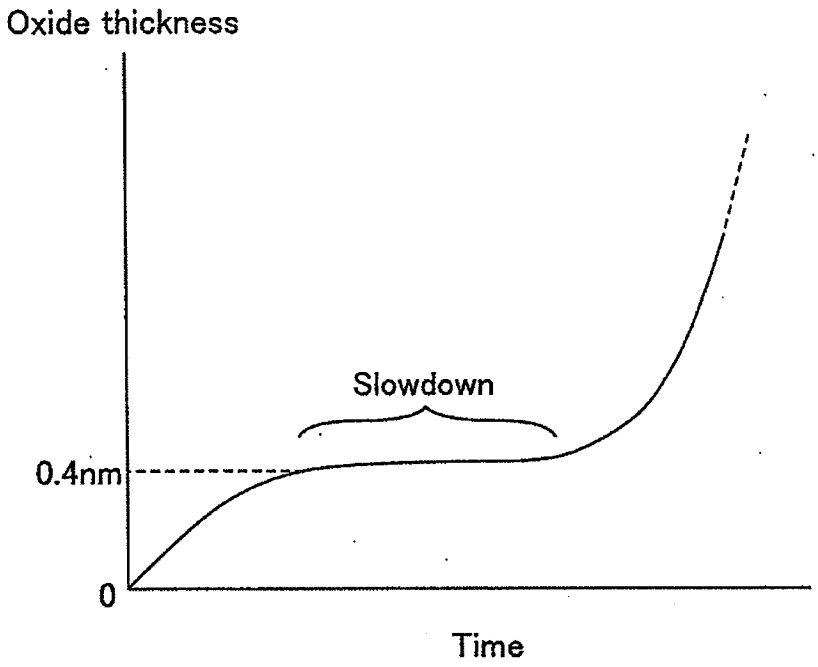

0.1nm
~<3ev
Sub-ox
0.2nm
~<3ev
Sub-ox
0.3nm
~3.5ev
Si4+
0.4nm
>3.5eV
Si4+
0.8nm
>3.5eV
Si4+
Intensity [count]
Binding Energy [eV]

FIG.8



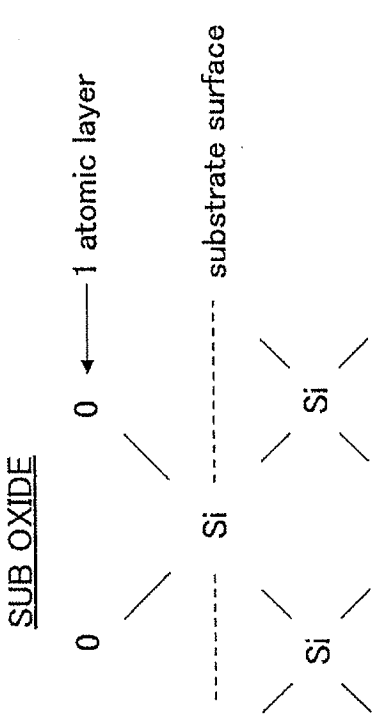
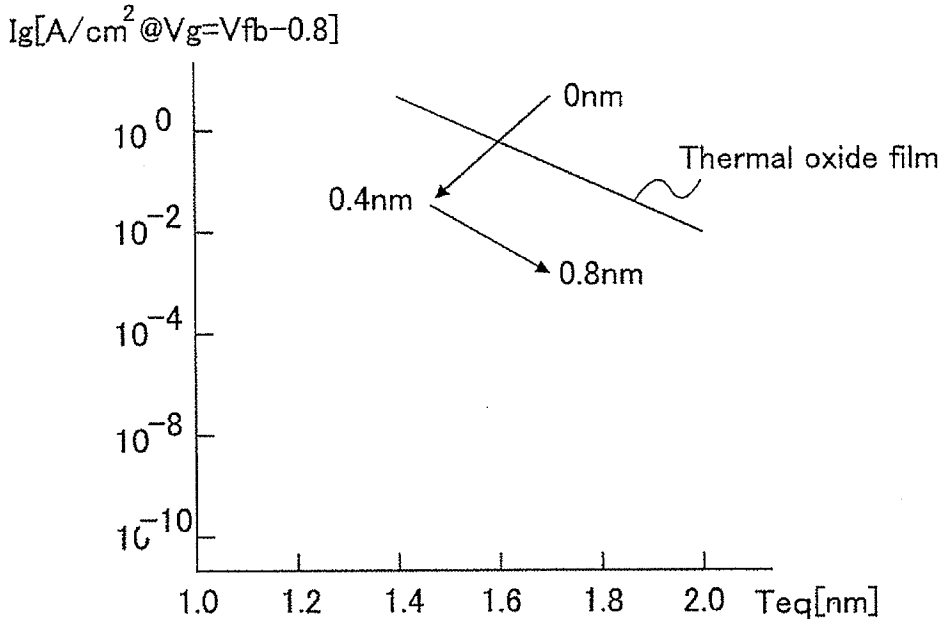

SUB OXIDE
1 atomic layer
substrate surface
O
O
Si
Si
Si

FIG.9A

OXIDE
2nd atomic layer
1st atomic layer
substrate surface
0.4nm
O
Si

FIG.9B

FIG.10


Ig[A/cm2@Vg=Vfb-0.8]
10 0
10 -2
10 -4
10 -8
10 -10
1.0
1.2
1.4
1.6
1.8
2.0
Teq[nm]
0nm
Thermal oxide film
0.4nm
0.8nm

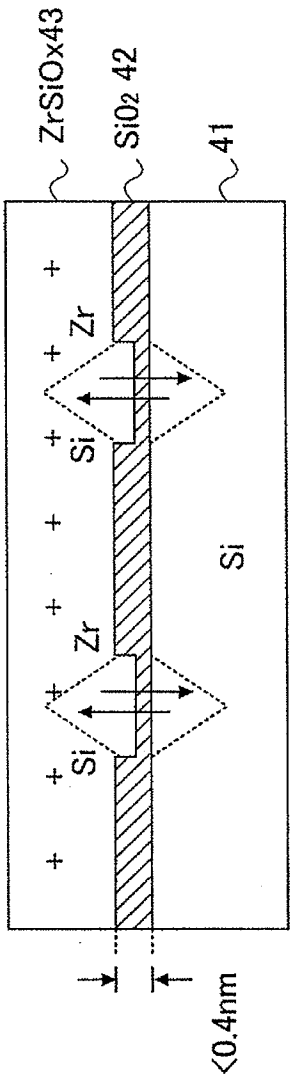


FIG.11A

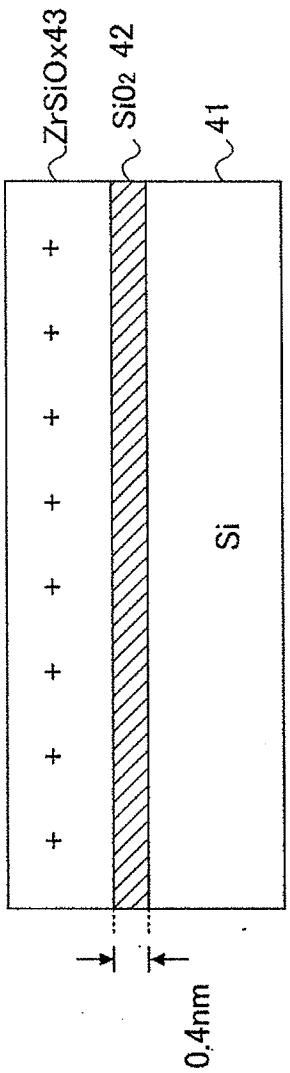


FIG.11B

FIG.12A

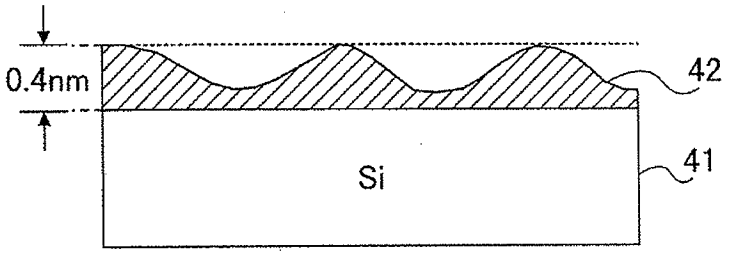


FIG.12B

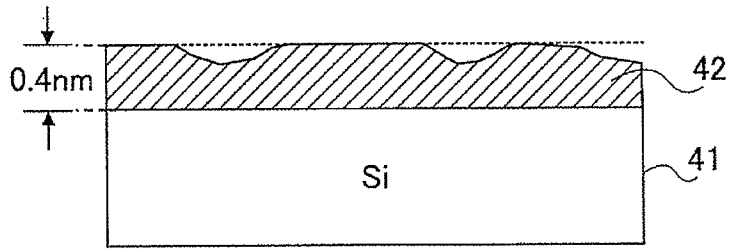


FIG.12C

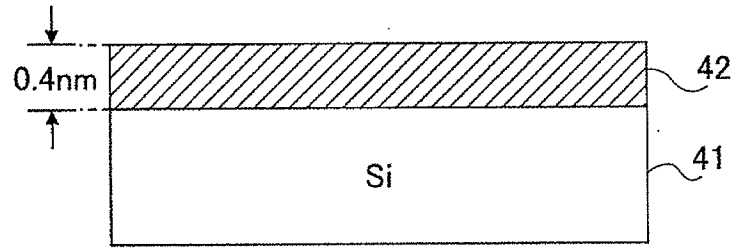
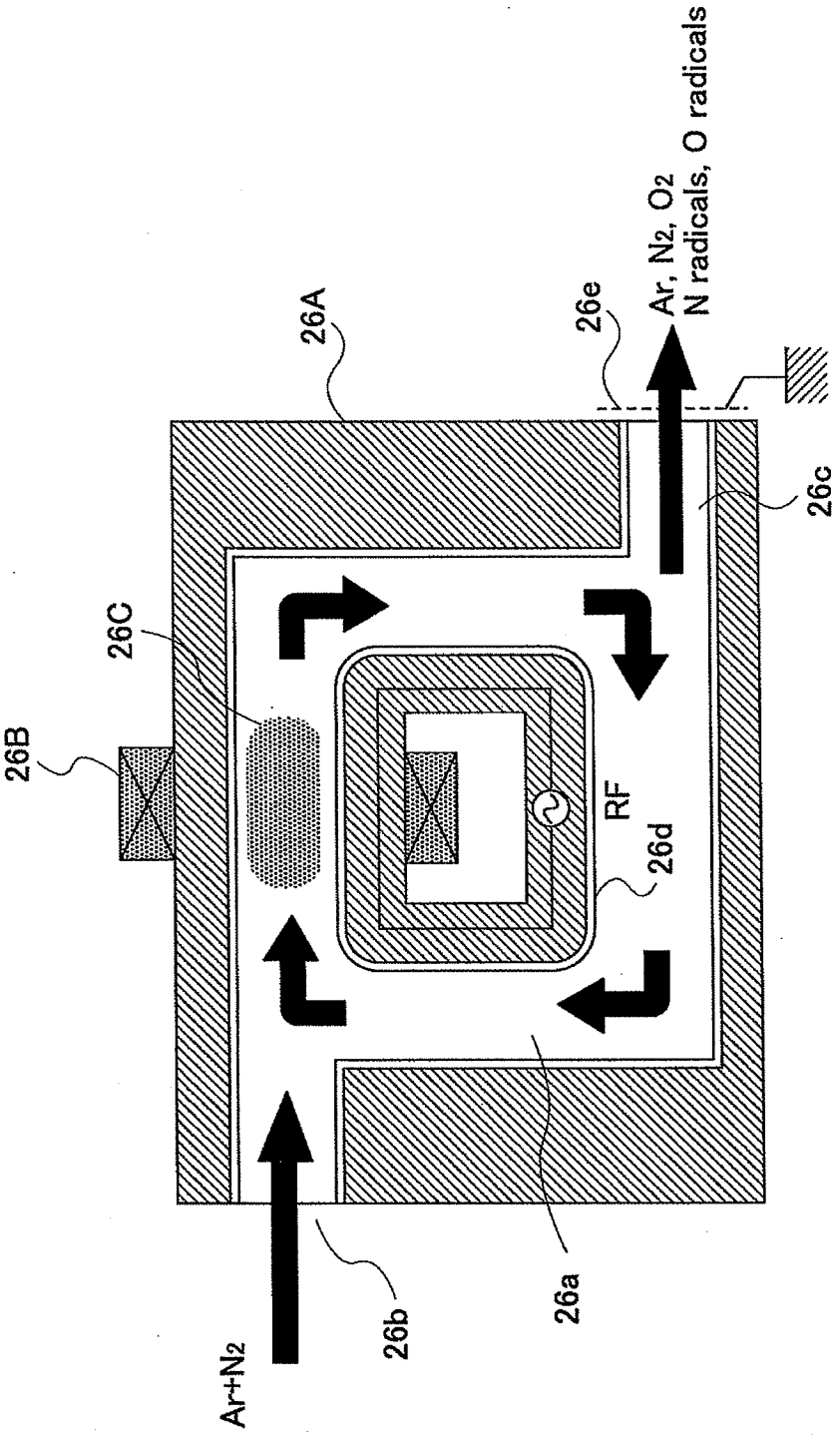


FIG.13


26
26A
26e
Ar, N2, O2
N radicals, O radicals
26c
26C
26B
RF
26d
Ar+N2
26b
26a

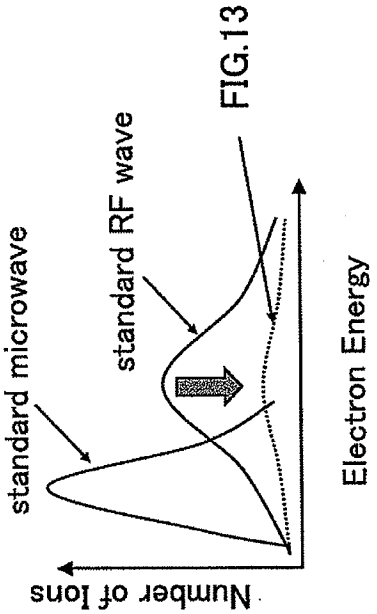


FIG.14A

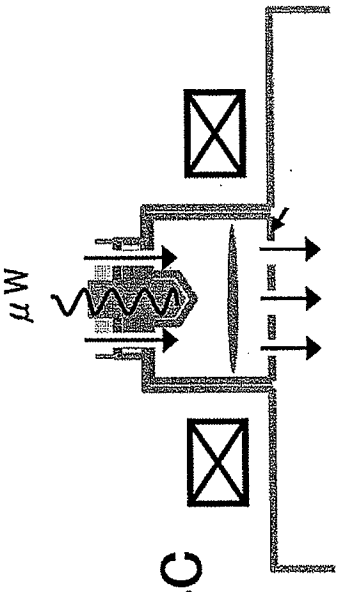


FIG.14C

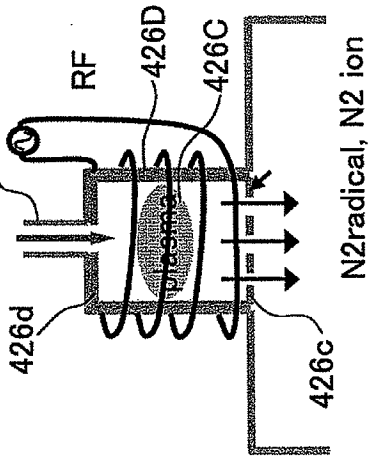
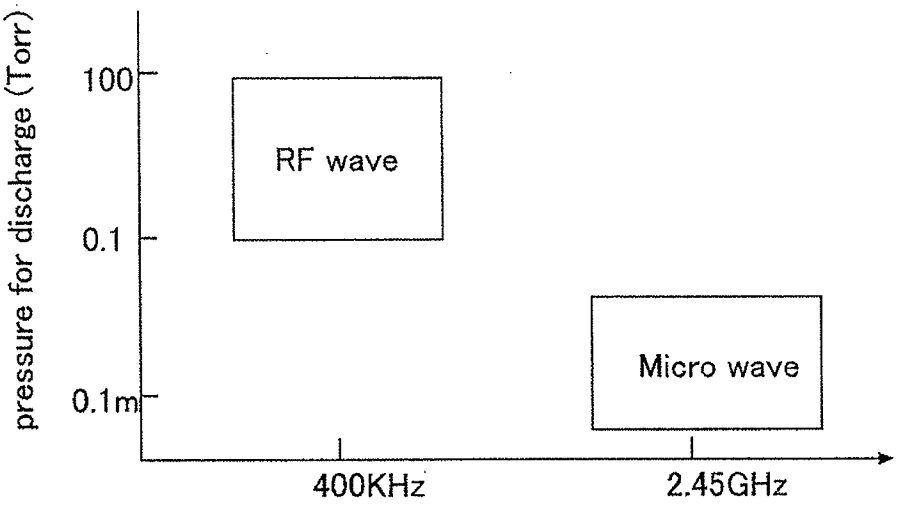


FIG.14B

FIG.15


pressure for discharge (Torr)
100
0.1
0.1m
RF wave
Micro wave
400KHz
2.45GHz

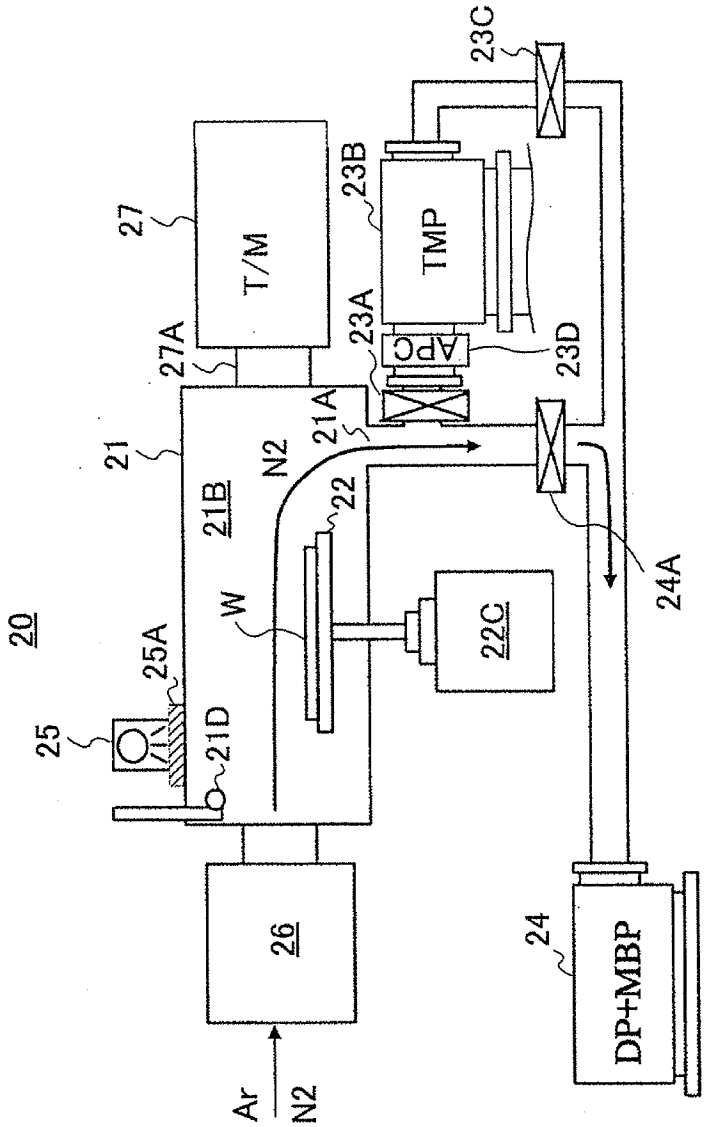

20
25
25A
21D
W
21B
21
N2
21A
22
22C
27
T/M
27A
23B
TMP
23A
APC
23C
23D
24A
24
DP+MBP
26
Ar
N2

FIG.16A

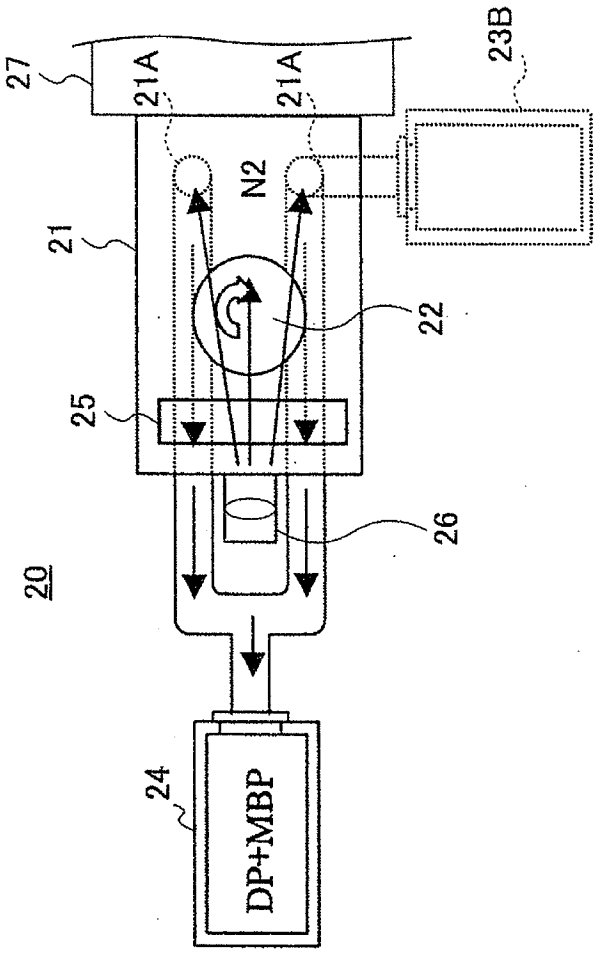


FIG.16B

FIG.17A

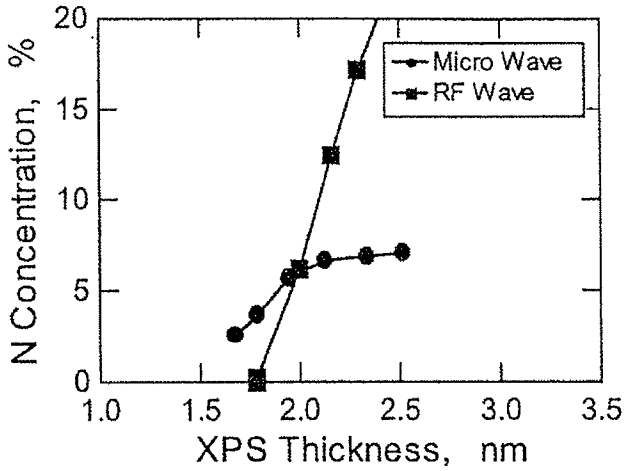


FIG.17B

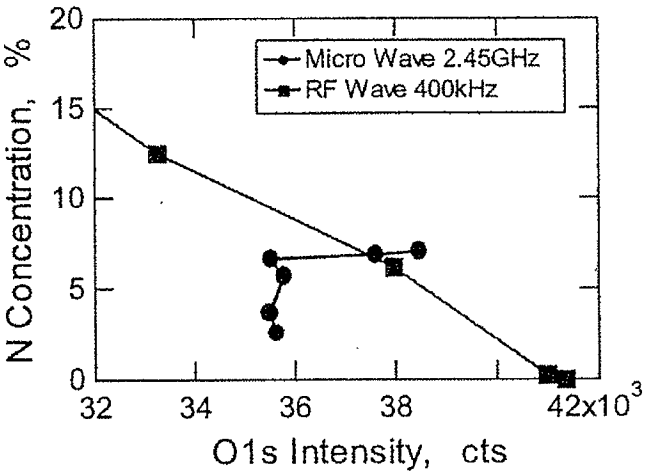


FIG.18

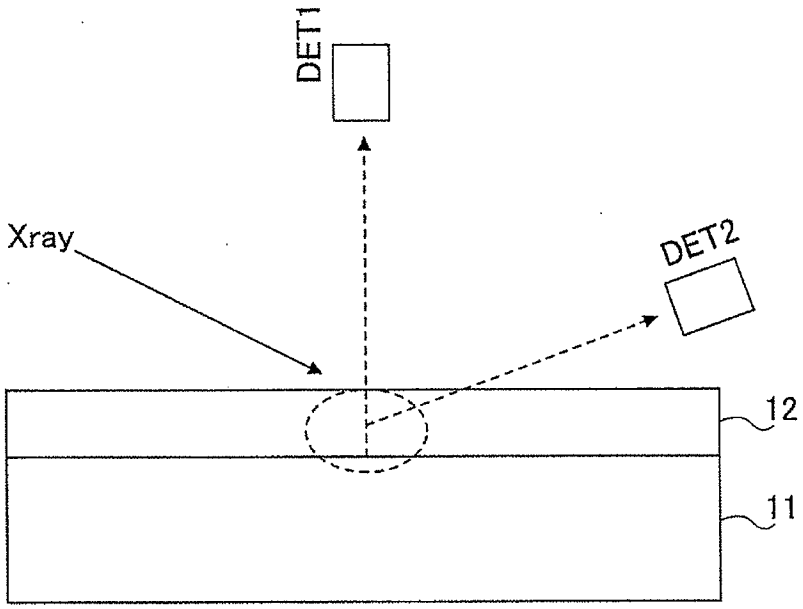


FIG.19

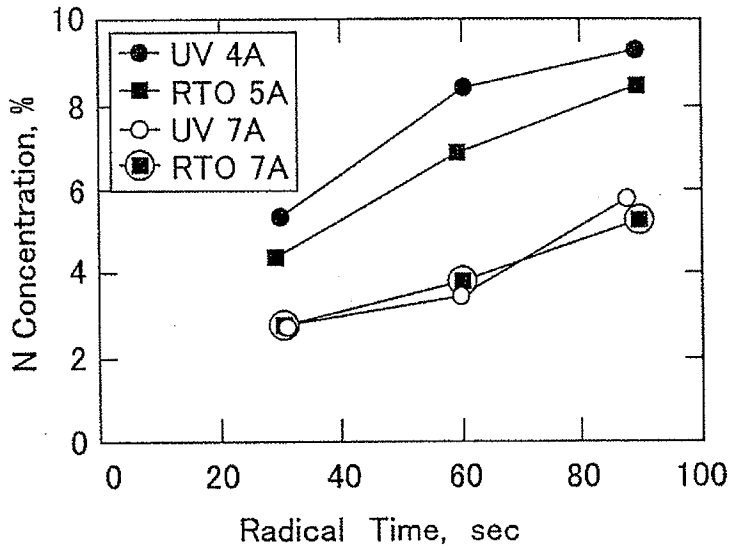

UV 4A
RTO 5A
UV 7A
RTO 7A
N Concentration, %
0
2
4
6
8
10
0
20
40
60
80
100
Radical Time, sec

FIG.20

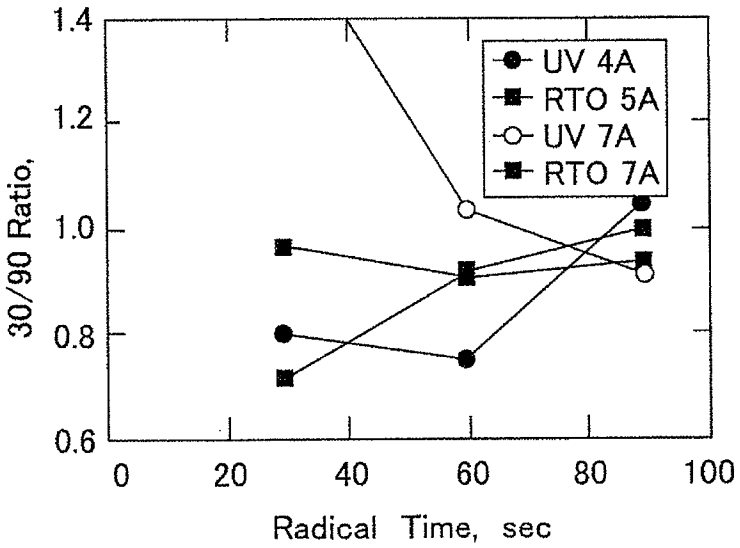

UV 4A
RTO 5A
UV 7A
RTO 7A
30/90 Ratio,
0.6
0.8
1.0
1.2
1.4
0
20
40
60
80
100
Radical Time, sec

FIG.21

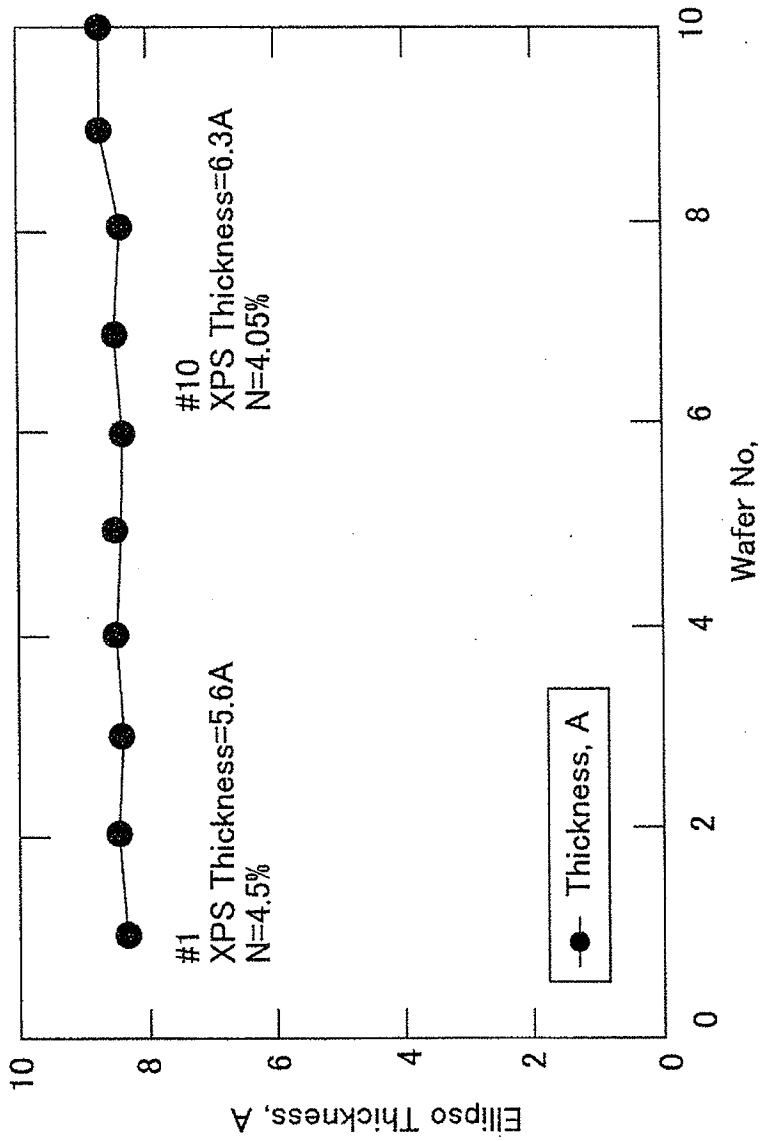

Ellipso Thickness, A
Wafer No,
Thickness, A
#1
XPS Thickness=5.6A
N=4.5%
#10
XPS Thickness=6.3A
N=4.05%
0
2
4
6
8
10

FIG.22

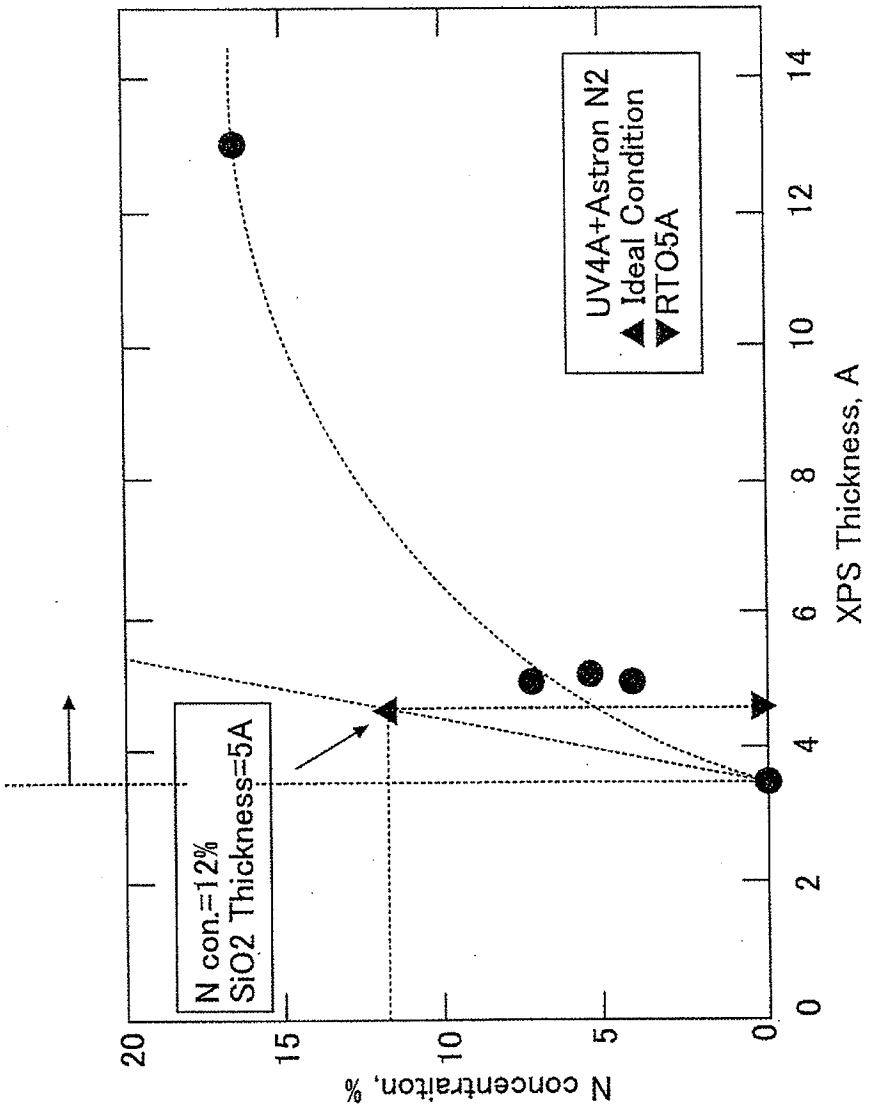

N concentration, %
XPS Thickness, A
UV4A+Astron N2
▲ Ideal Condition
▼RTO5A
N con.=12%
SiO2 Thickness=5A
0
5
10
15
20
0
2
4
6
8
10
12
14

FIG.23A

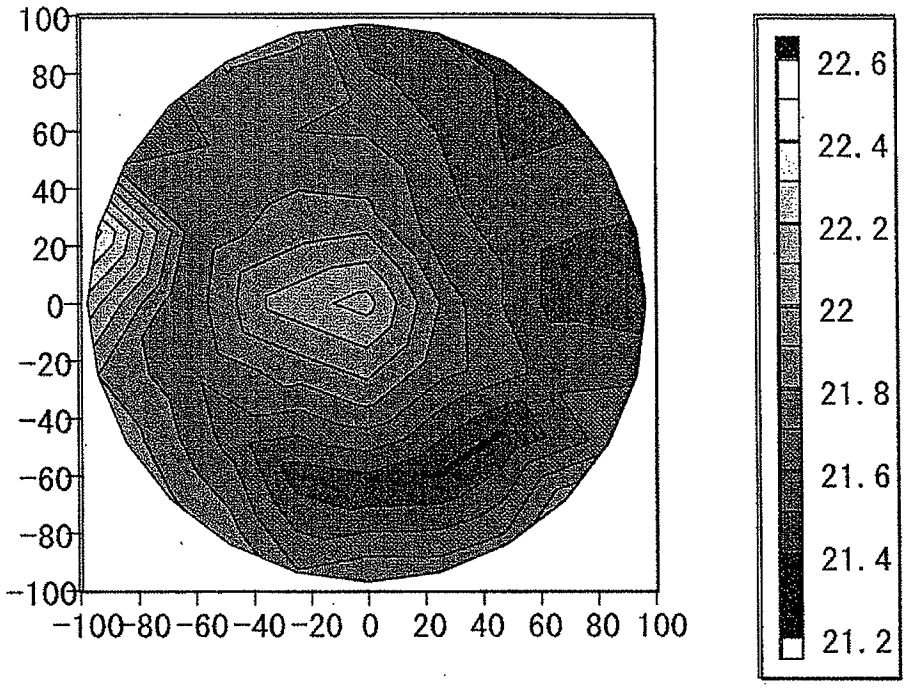


FIG.23B

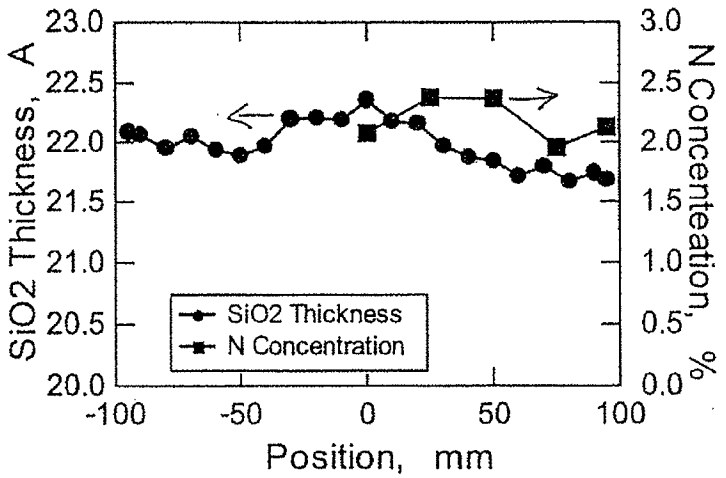


FIG.24

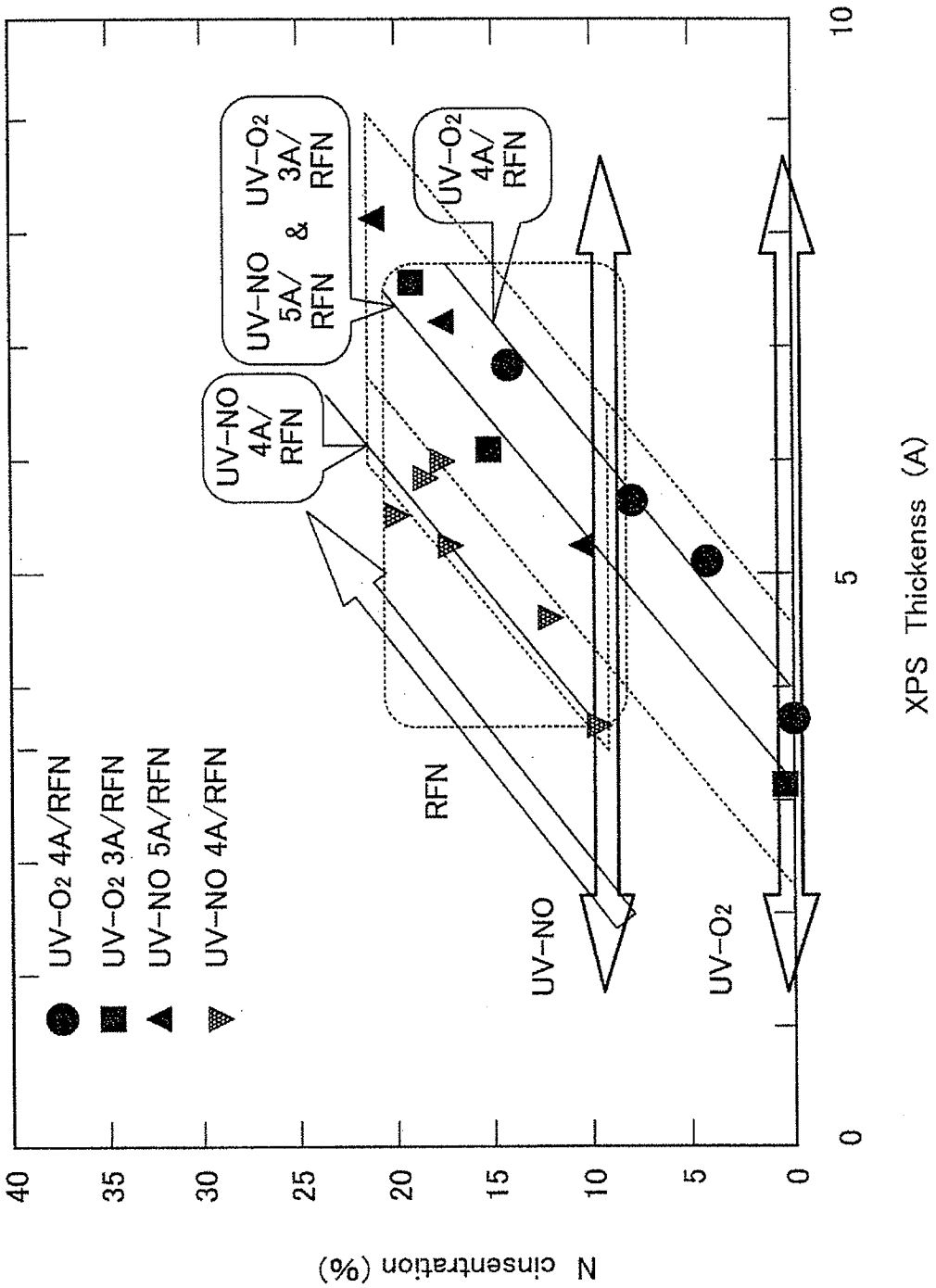

UV–O2 4A/RFN
UV–O2 3A/RFN
UV–NO 5A/RFN
UV–NO 4A/RFN
UV–NO 4A/ RFN
UV–NO 5A/ RFN & UV–O2 3A/ RFN
UV–O2 4A/ RFN
RFN
UV–NO
UV–O2
N cinsentration (%)
XPS Thickenss (A)
0
5
10
15
20
25
30
35
40

FIG.25

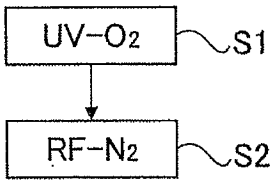


FIG.26A

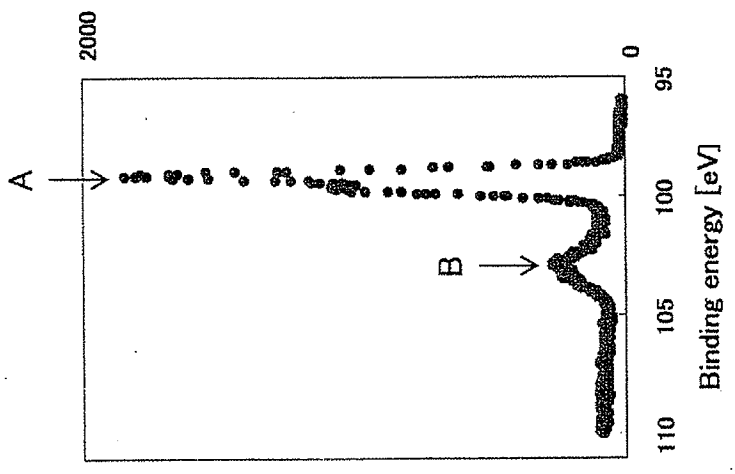


FIG.26B

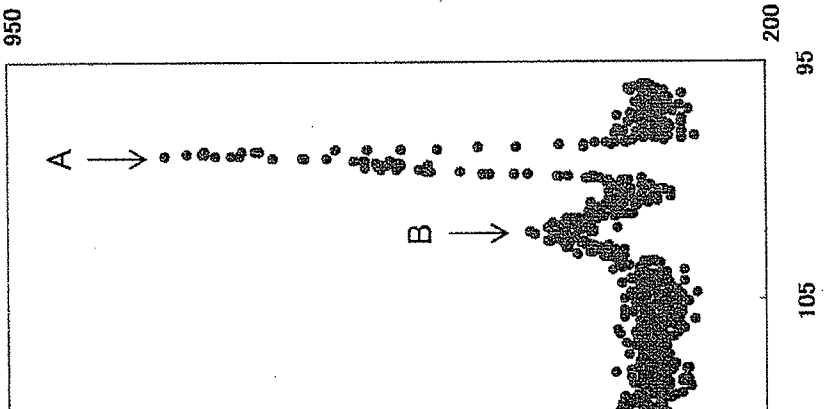


FIG.26C

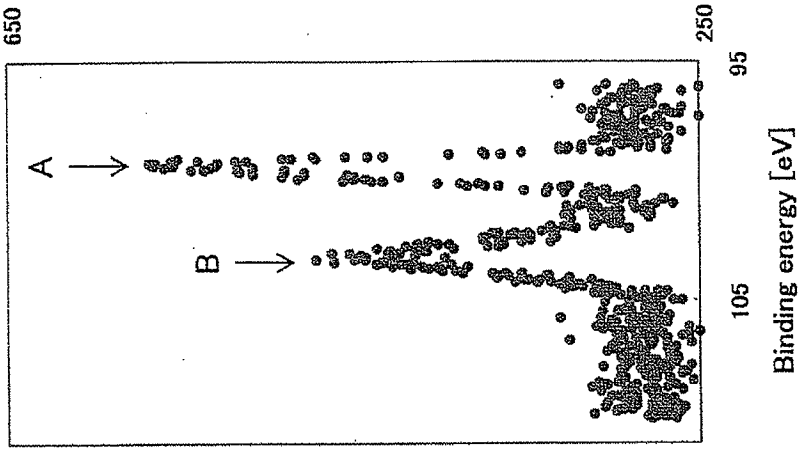


FIG.27

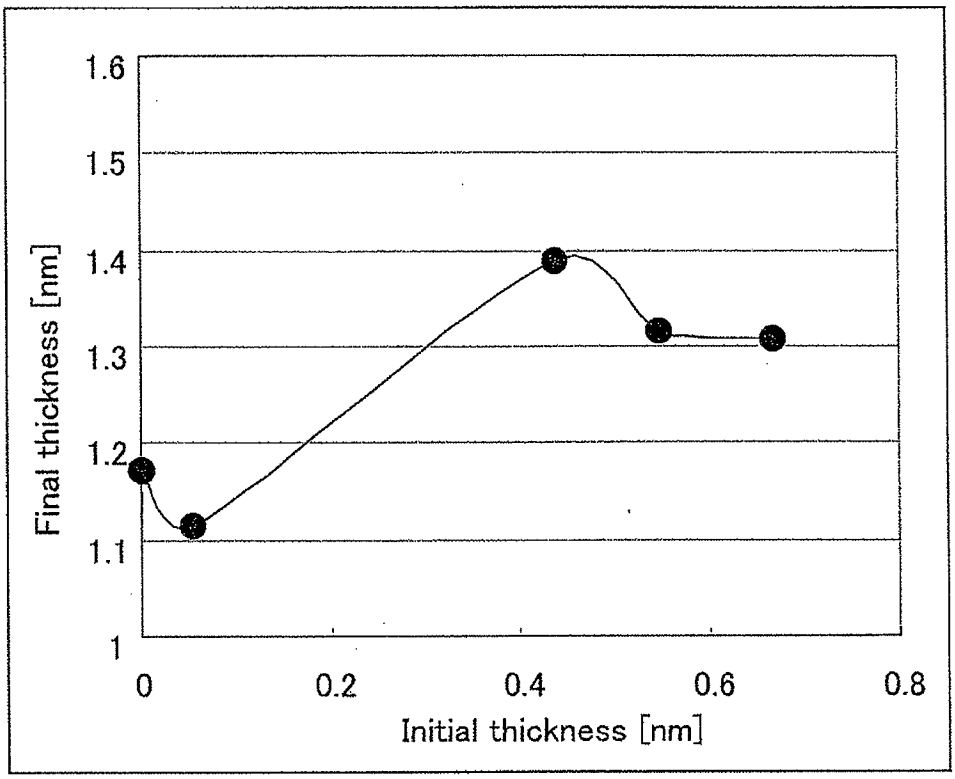

1.6
1.5
1.4
1.3
1.2
1.1
1
Final thickness [nm]
0
0.2
0.4
0.6
0.8
Initial thickness [nm]

FIG.28A

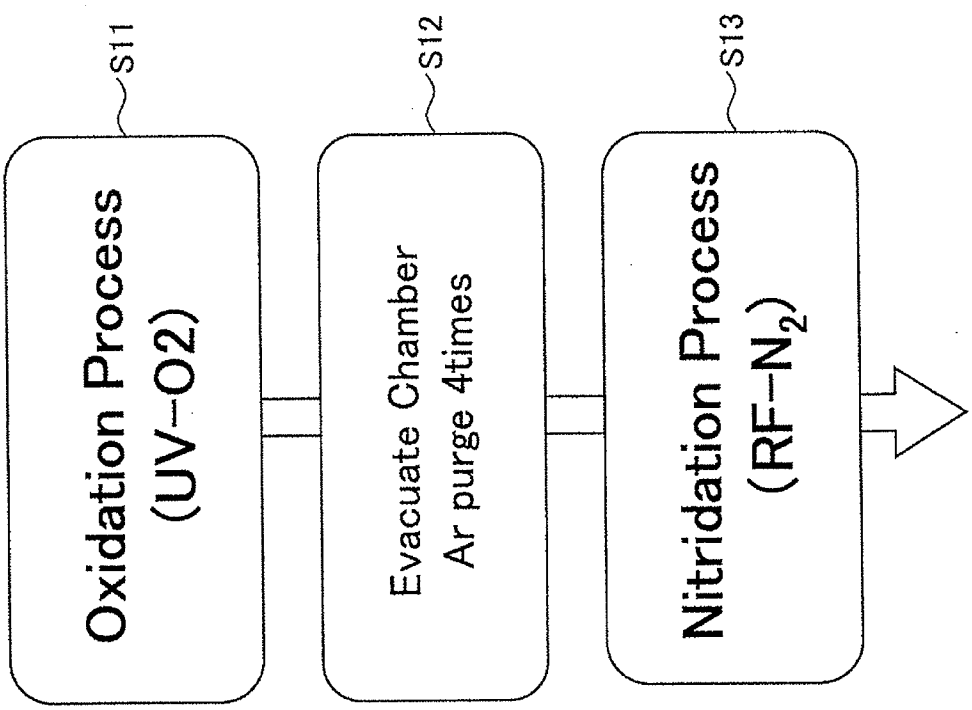


FIG.28B

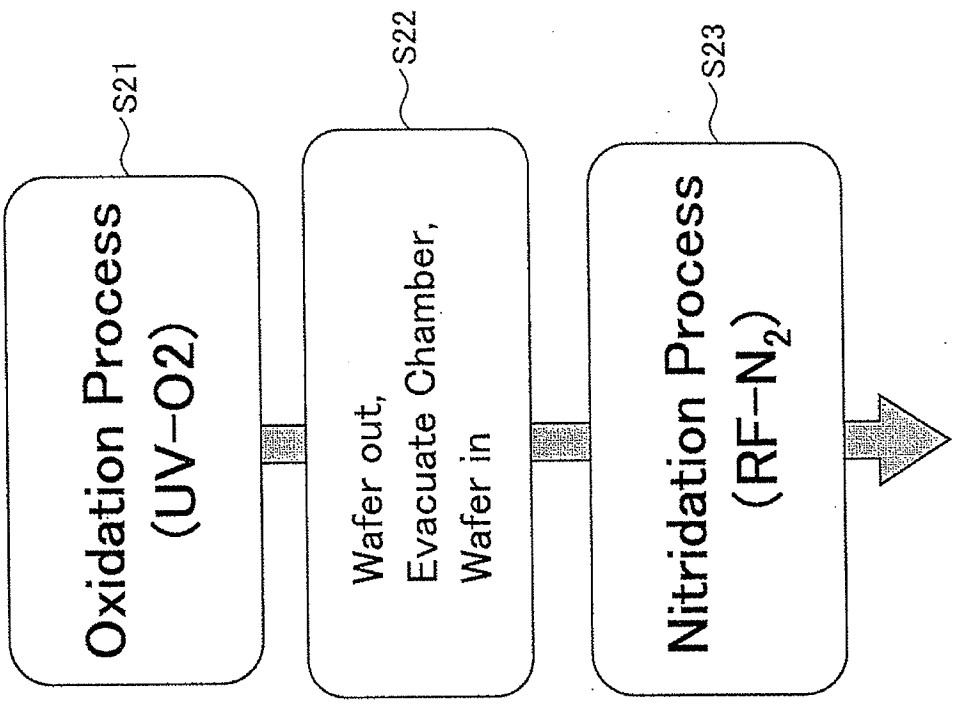


FIG.29A

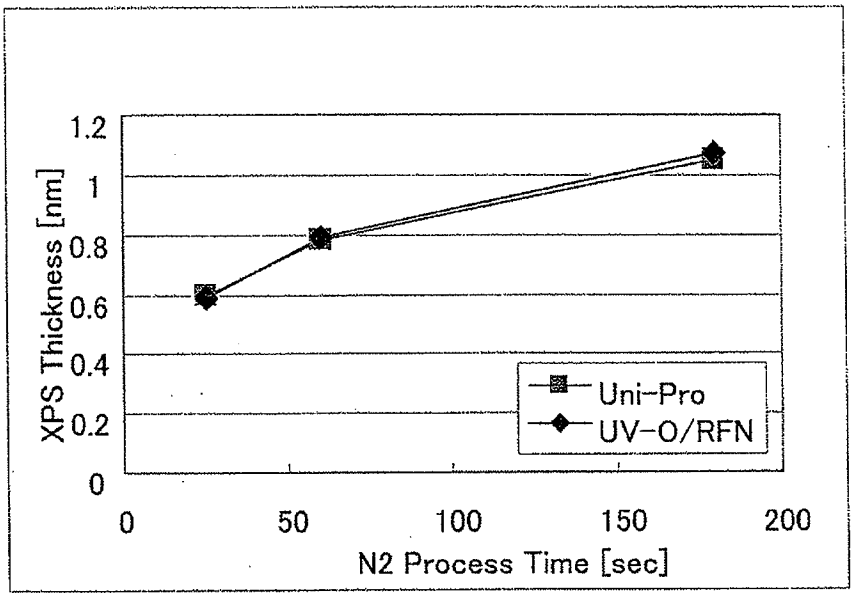


FIG.29B

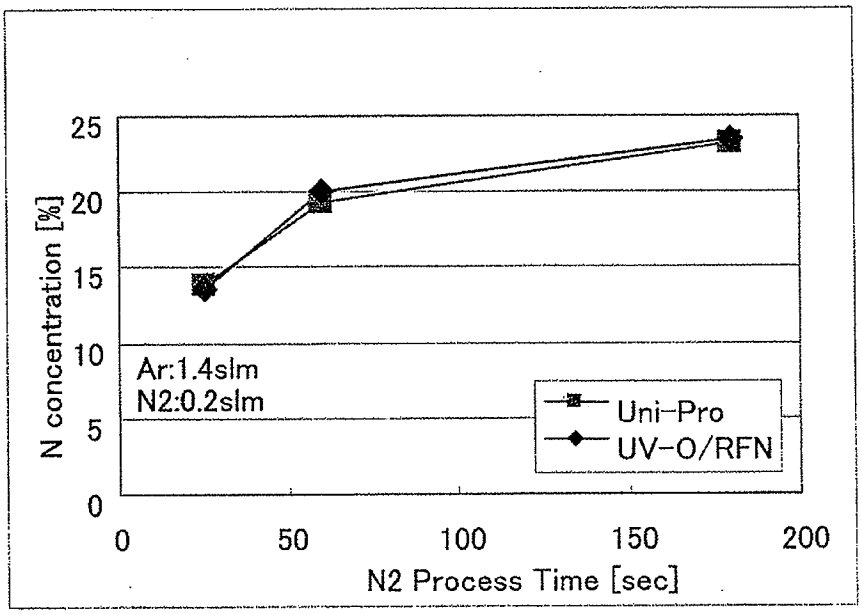


FIG.30A

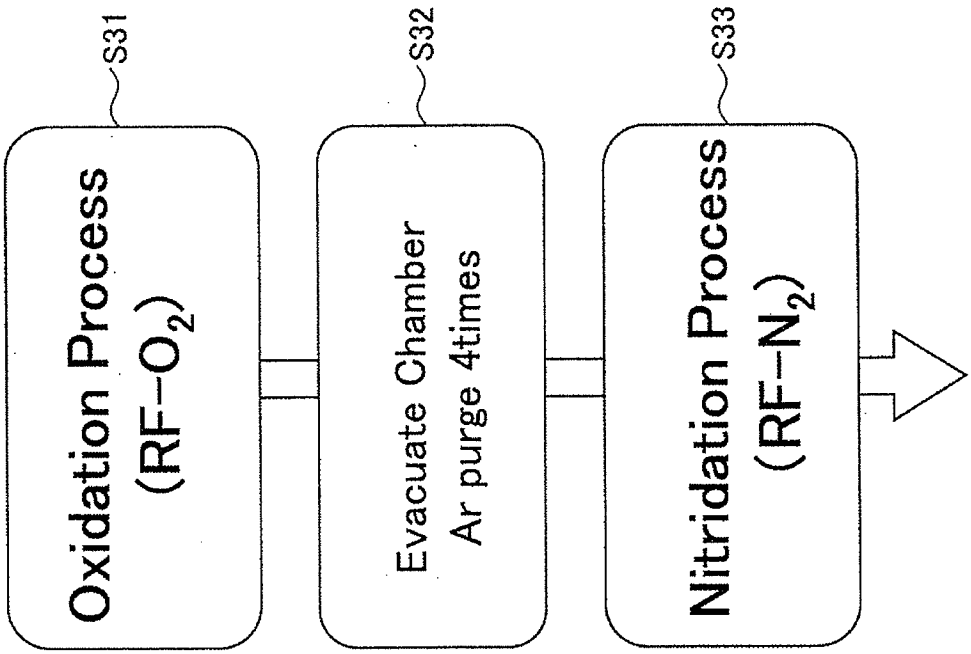


FIG.30B

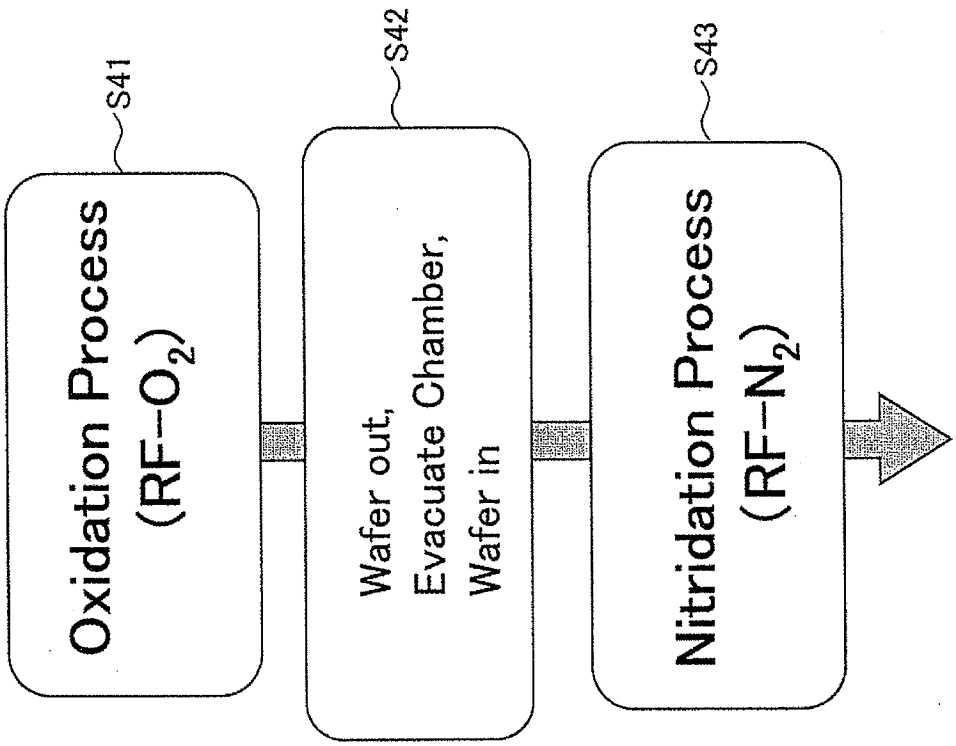


FIG.31A

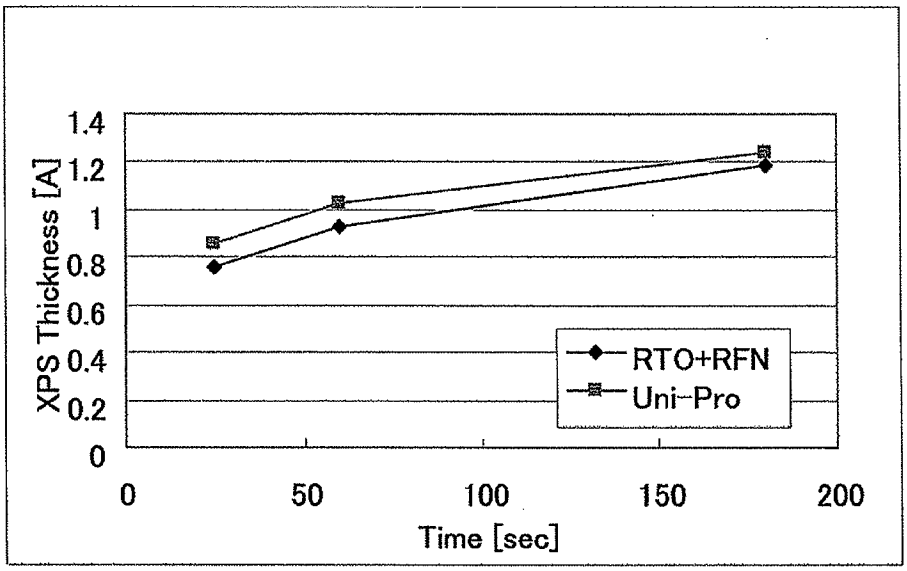


FIG.31B

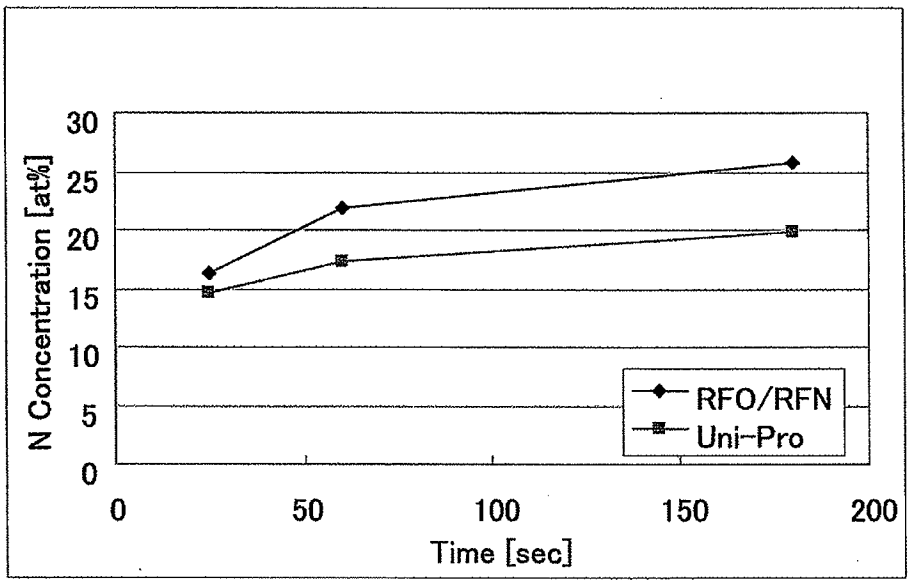


FIG.32

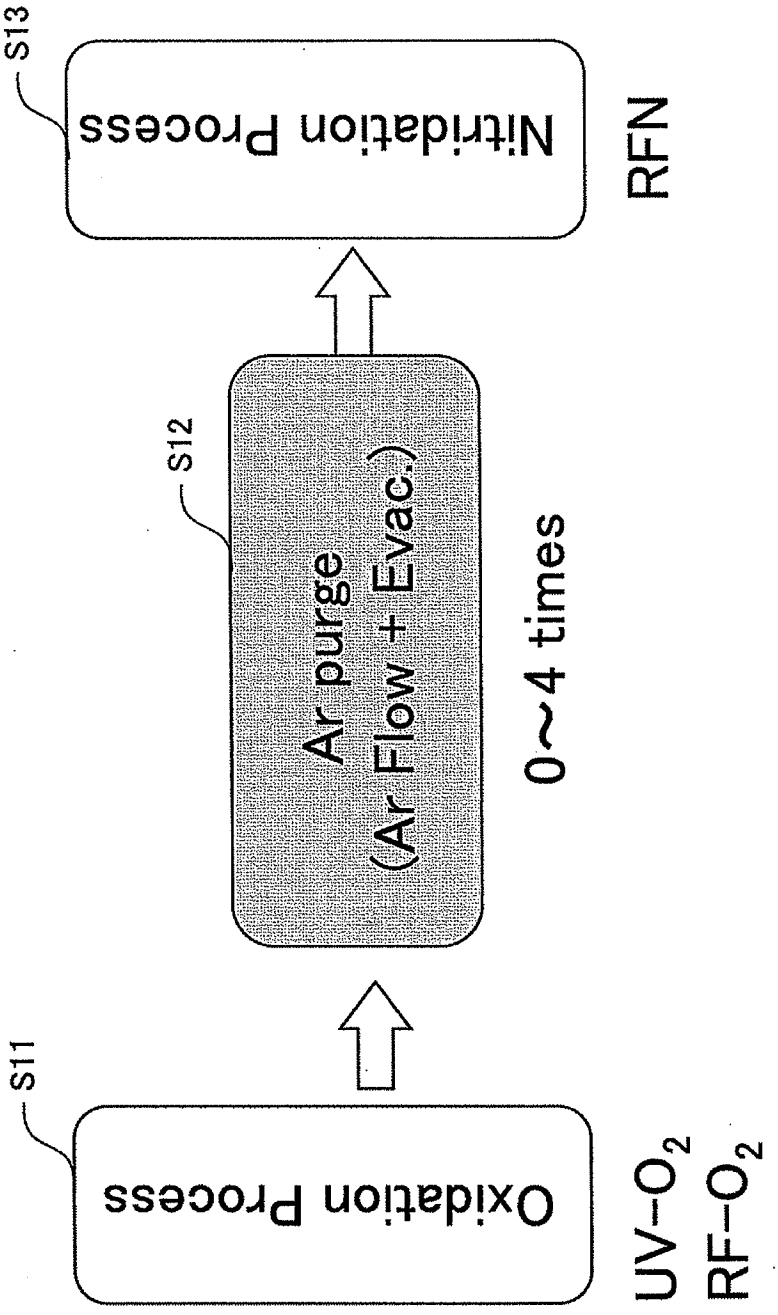

S11
Oxidation Process
UV–O2
RF–O2
S12
Ar purge
(Ar Flow + Evac.)
0~4 times
S13
Nitridation Process
RFN

FIG.33A

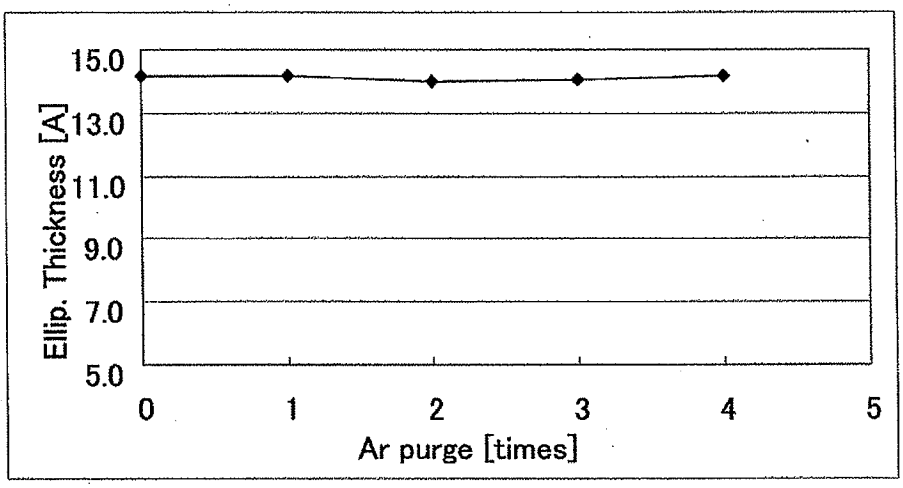


FIG.33B

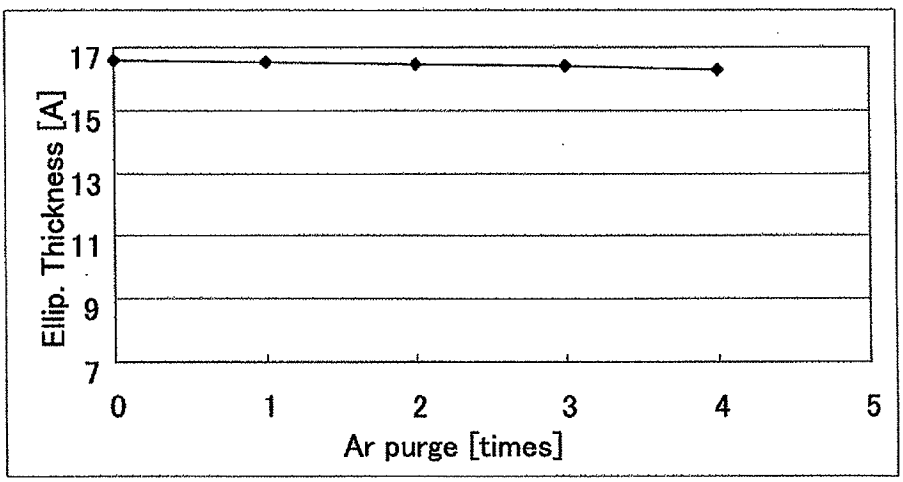


FIG.34

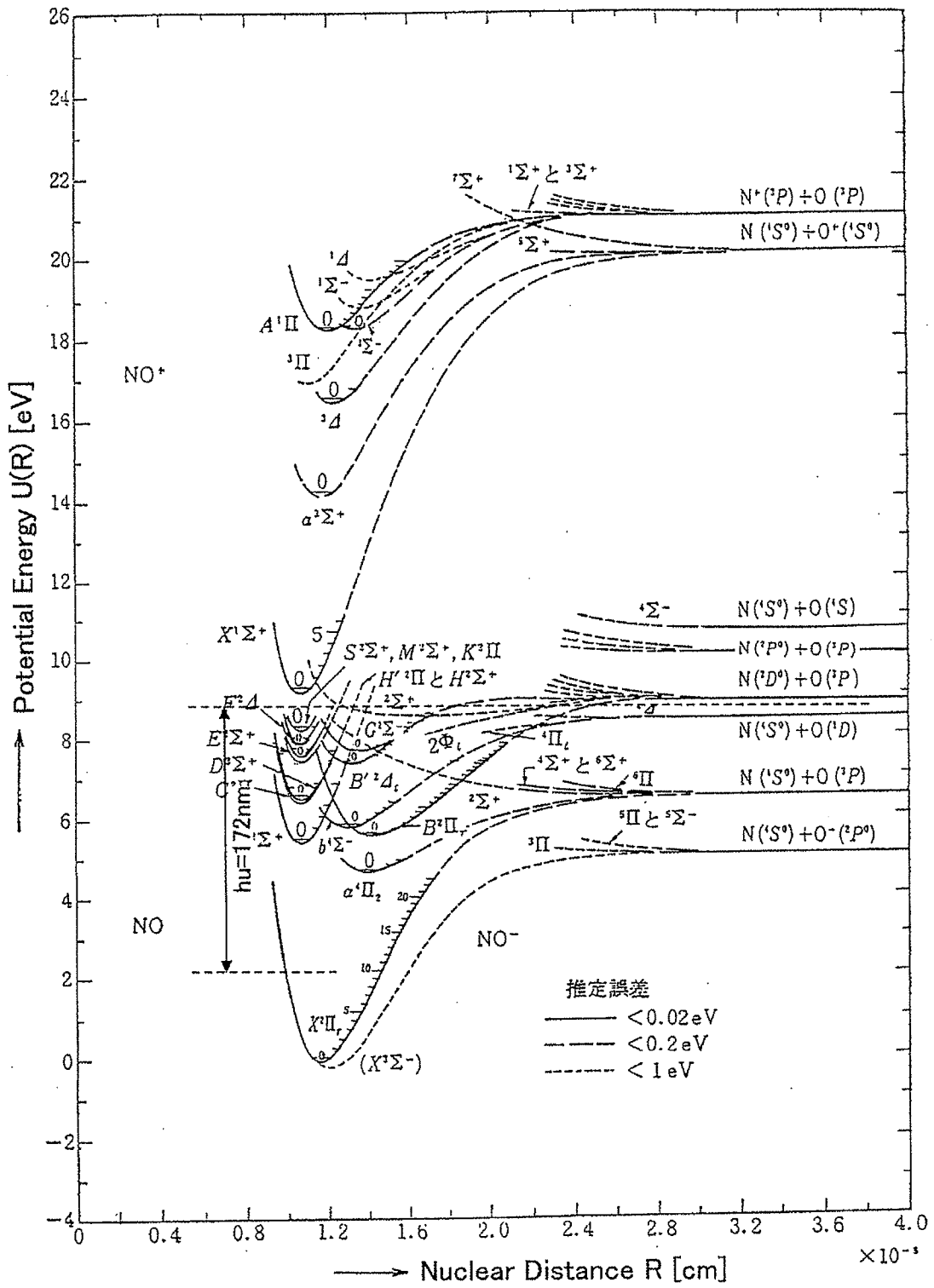

Potential Energy U(R) [eV]
Nuclear Distance R [cm]
×10⁻⁸
NO⁺
NO
NO⁻
hu=172nm
N⁺(³P)+O(³P)
N(⁴S°)+O⁺(⁴S°)
N(⁴S°)+O(¹S)
N(²P°)+O(³P)
N(²D°)+O(³P)
N(⁴S°)+O(¹D)
N(⁴S°)+O(³P)
N(⁴S°)+O⁻(²P°)
推定誤差
<0.02eV
<0.2eV
<1eV

FIG.35

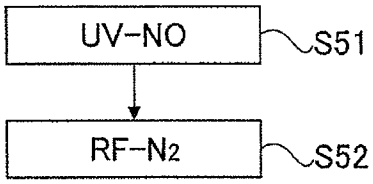


FIG.36

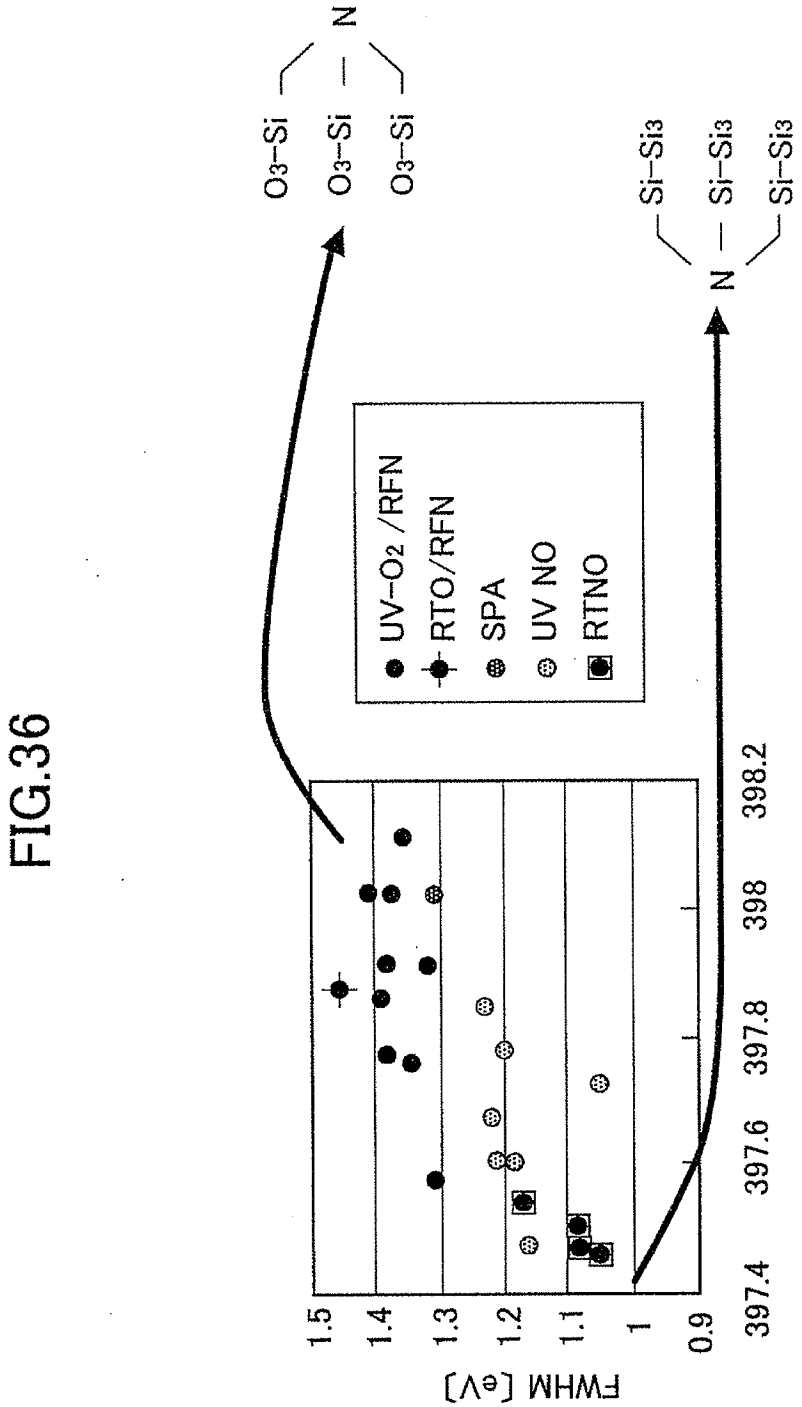

O3–Si
O3–Si
N
O3–Si
Si–Si3
Si–Si3
N
Si–Si3
UV–O2 /RFN
RTO/RFN
SPA
UV NO
RTNO
FWHM [eV]
1.5
1.4
1.3
1.2
1.1
1
0.9
397.4
397.6
397.8
398
398.2
N1s binding energy [eV]

FIG.37A

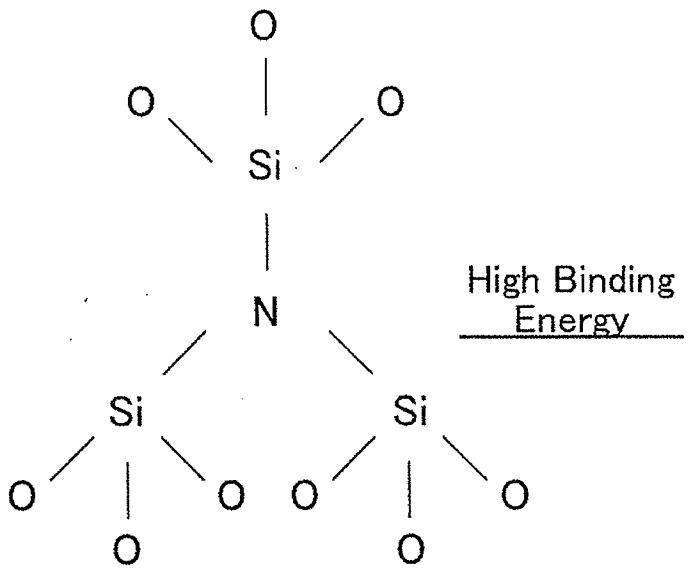


FIG.37B

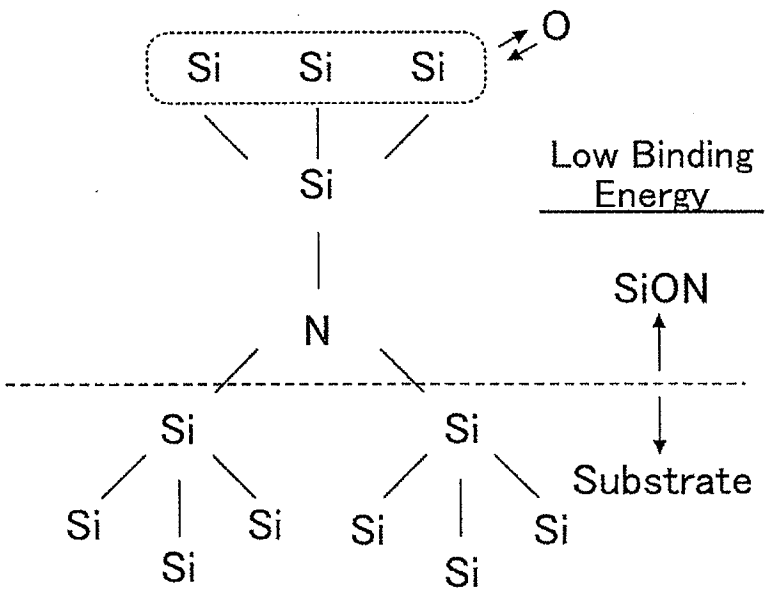
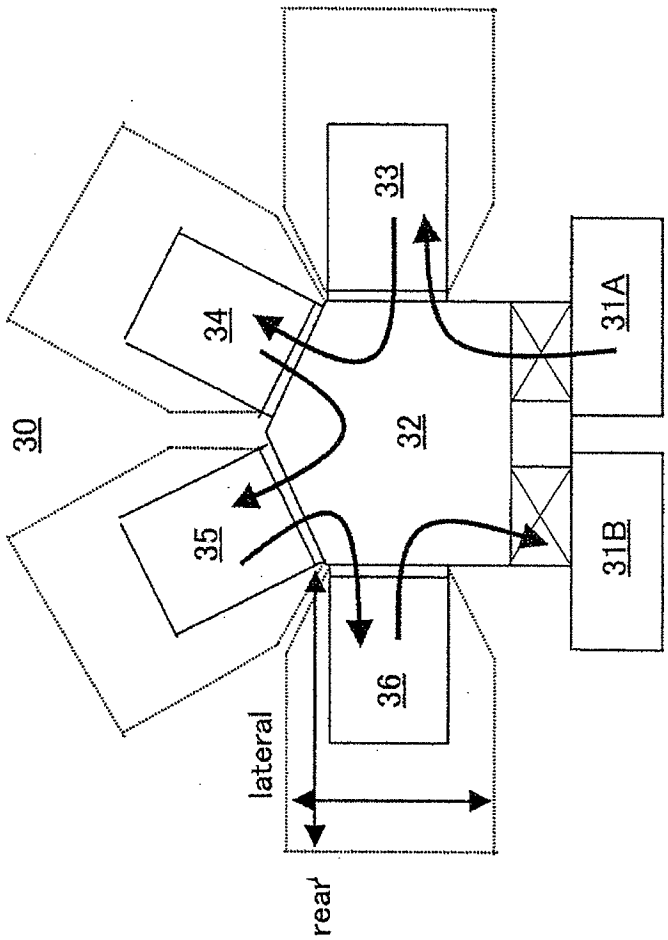


FIG.38



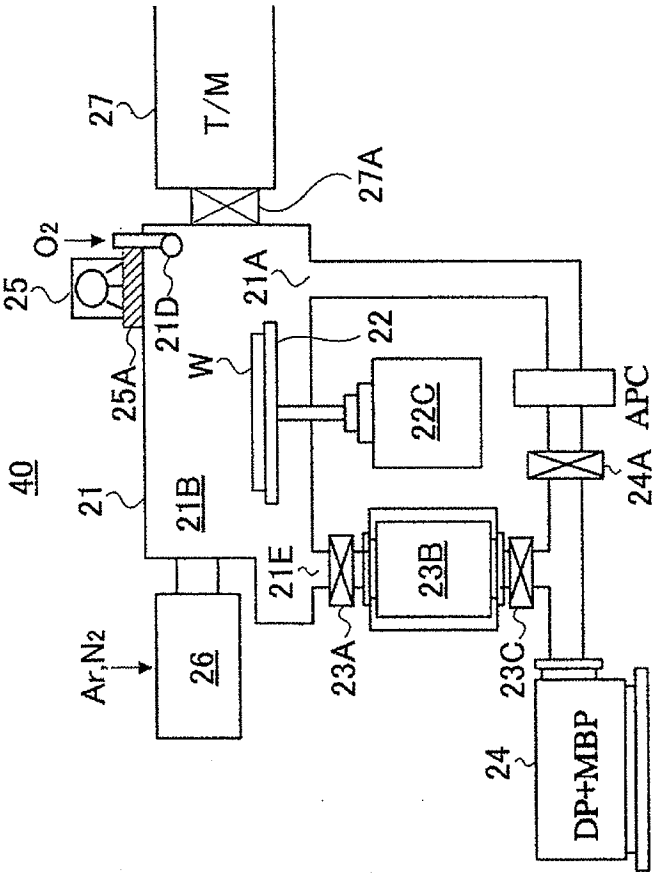


FIG.39A

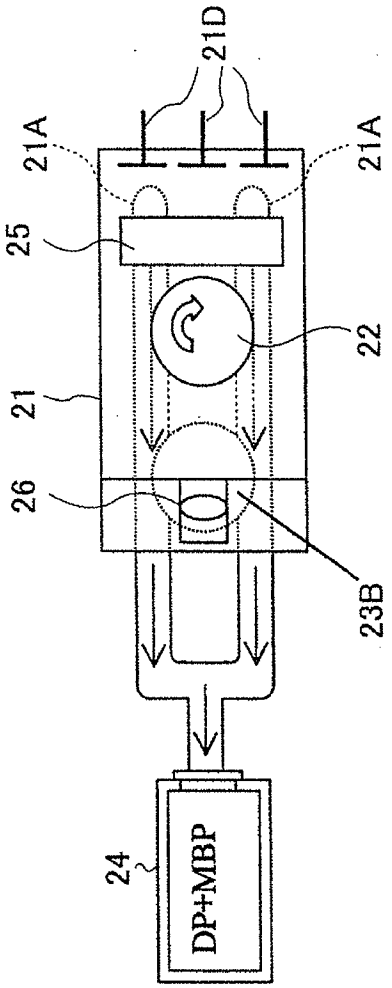


FIG.39B

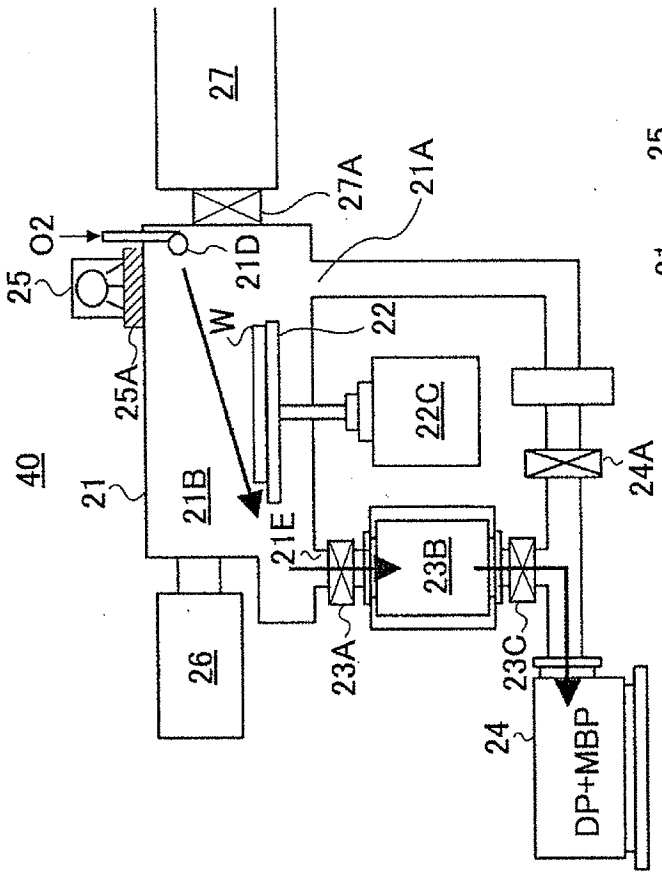


FIG.40A

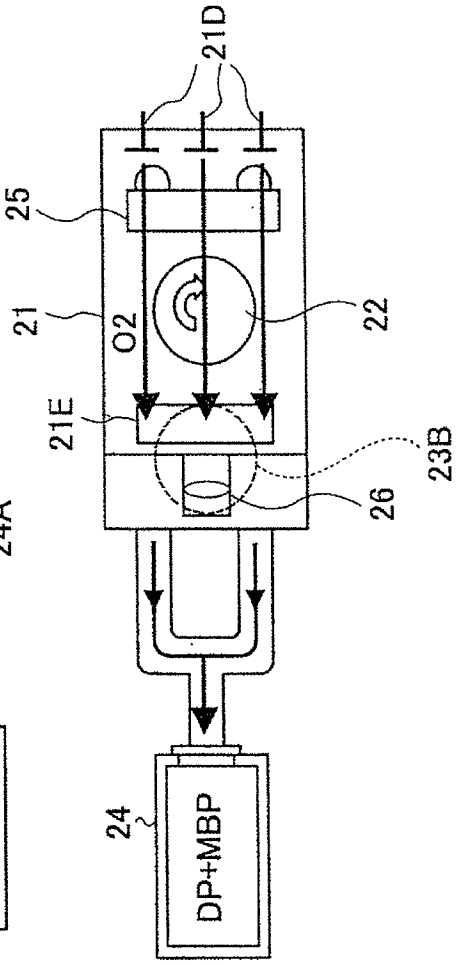


FIG.40B

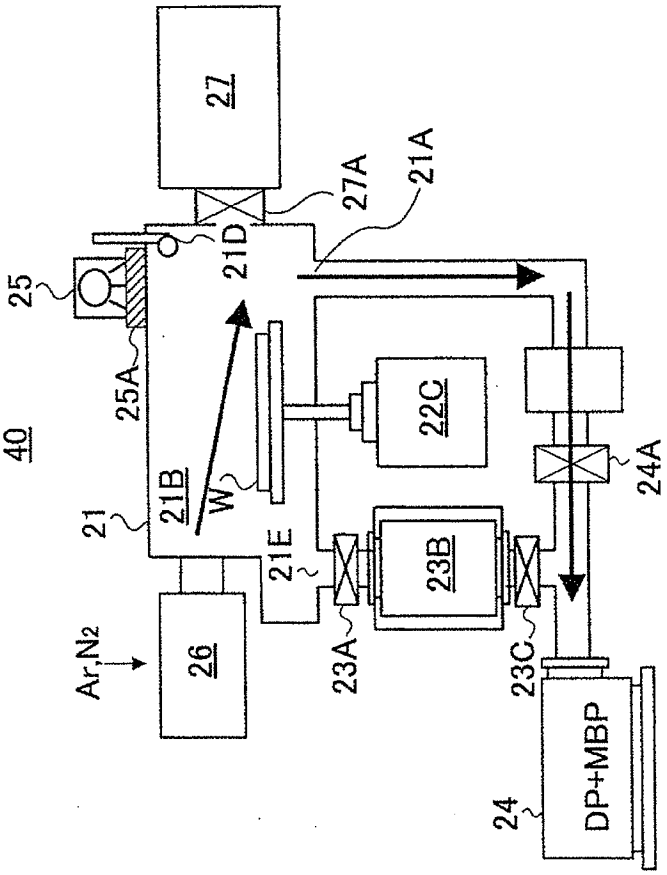


FIG.41A

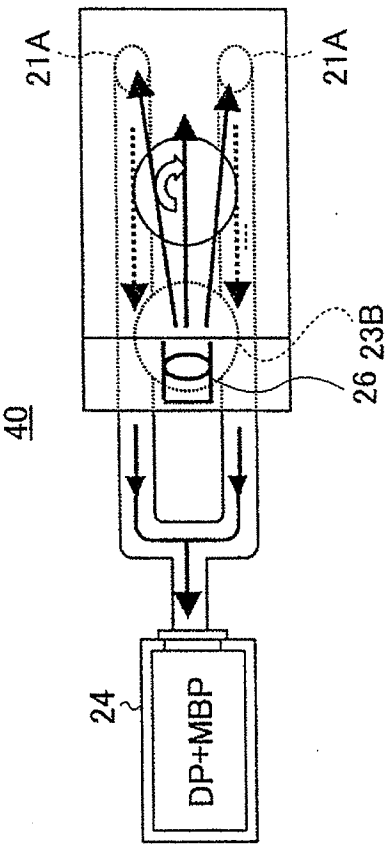


FIG.41B

FIG.42

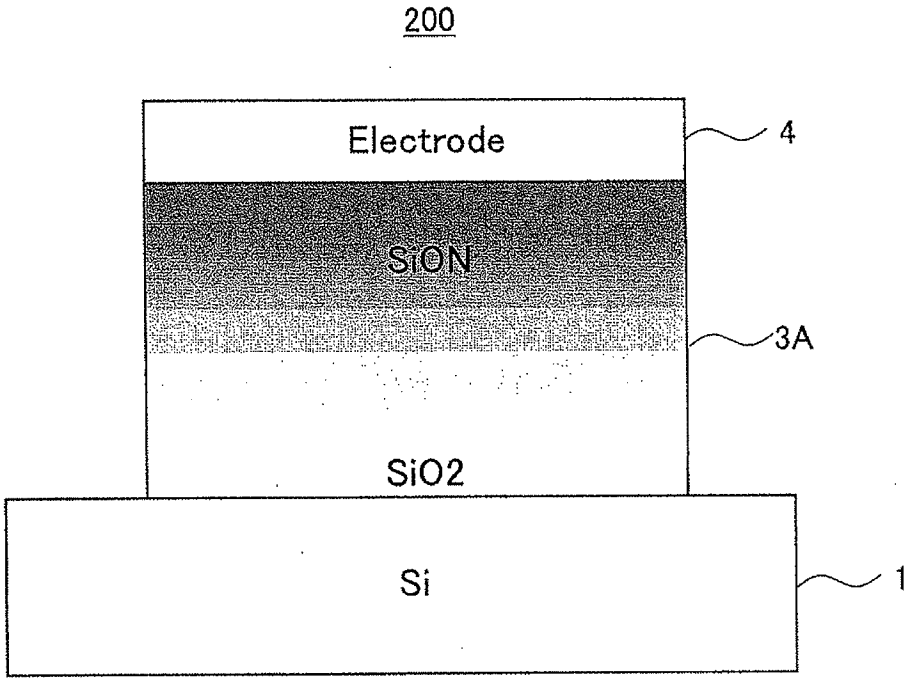


FIG.43

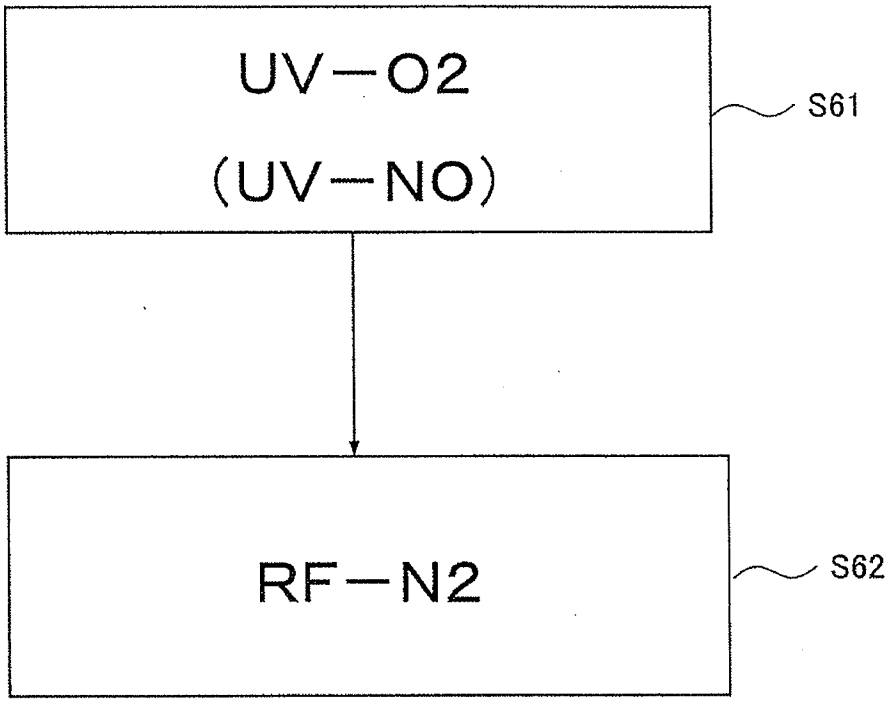
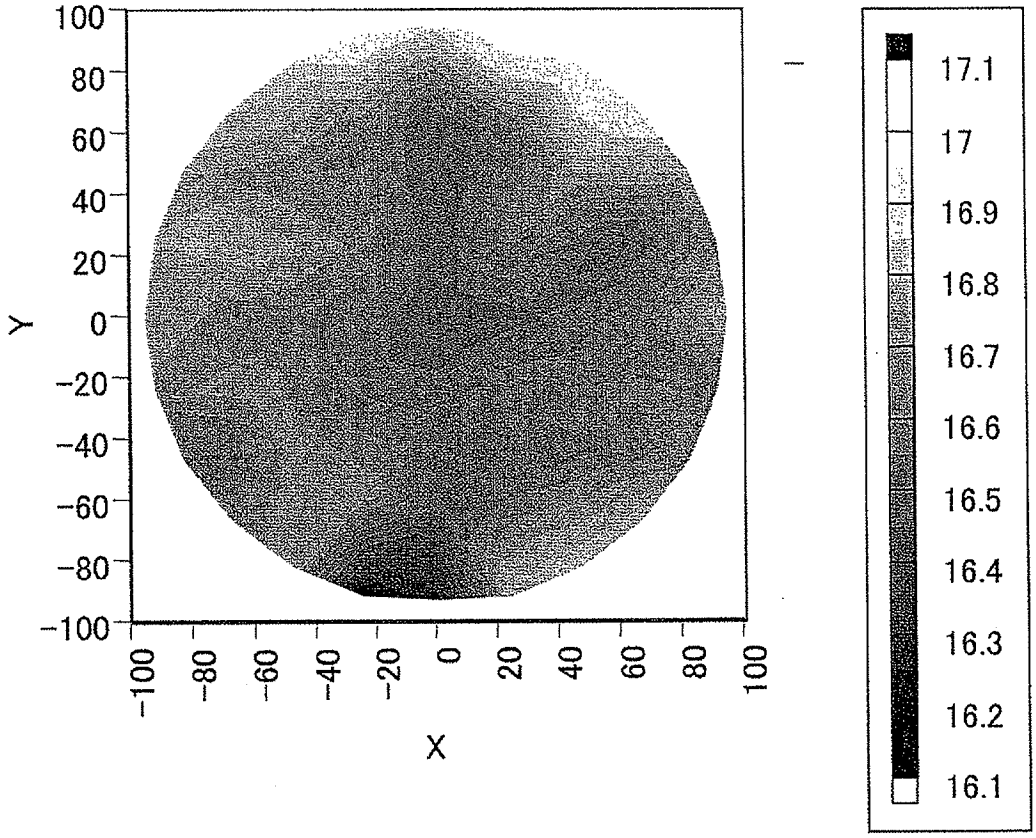


FIG.44



σ Unif.=0.72%

FIG.45A

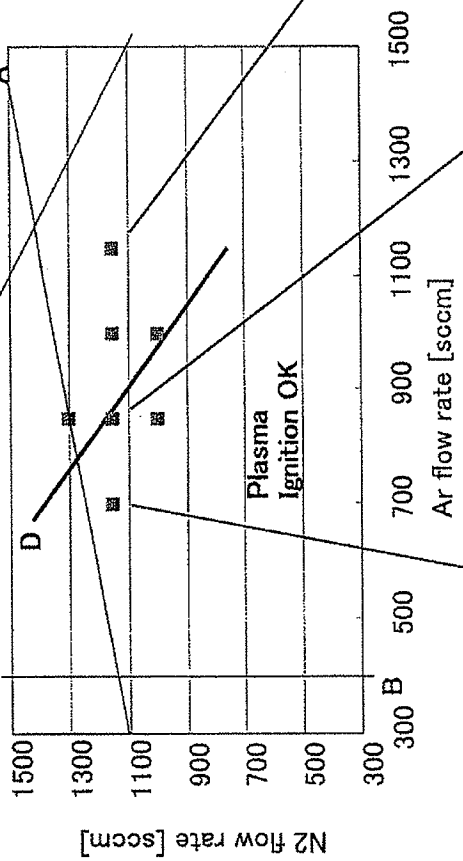


FIG.45C

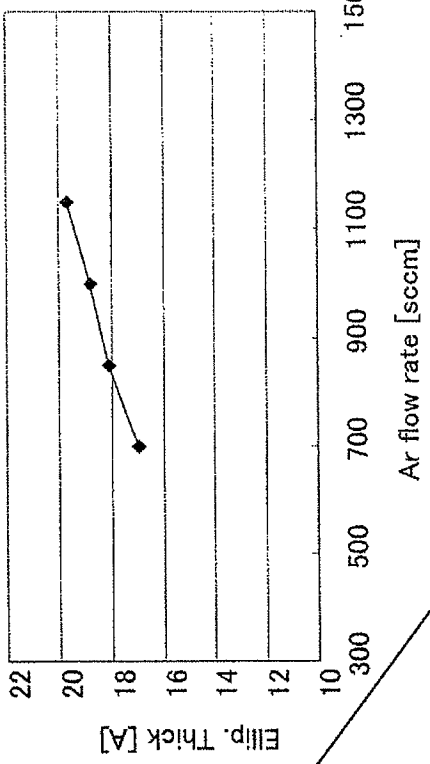


FIG.45B

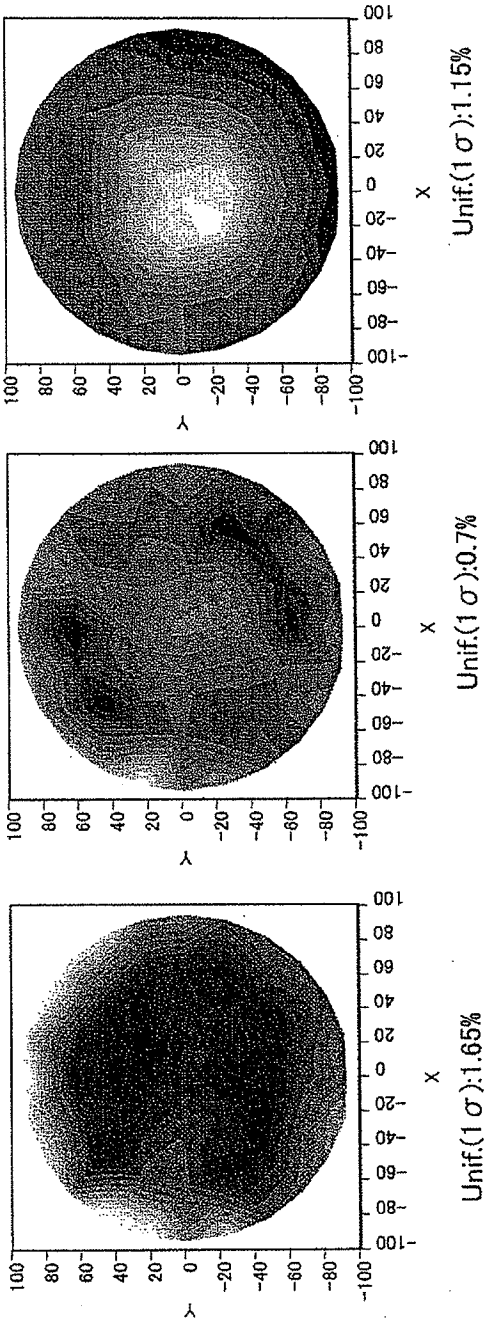


FIG.46A

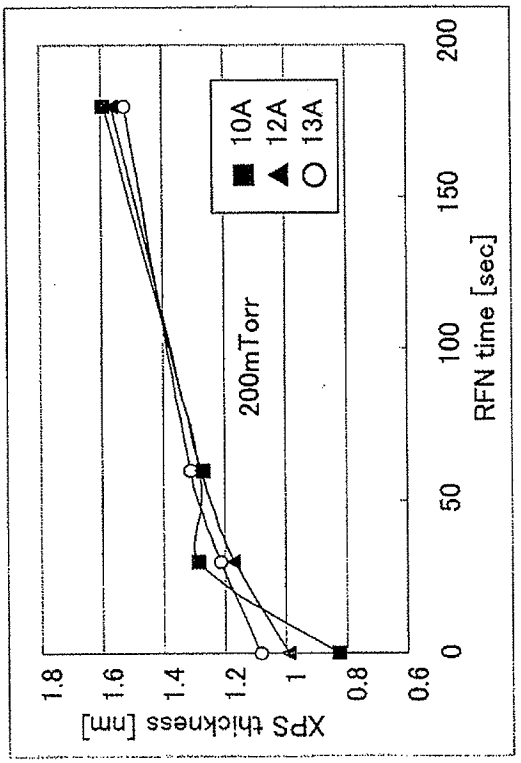


FIG.46B

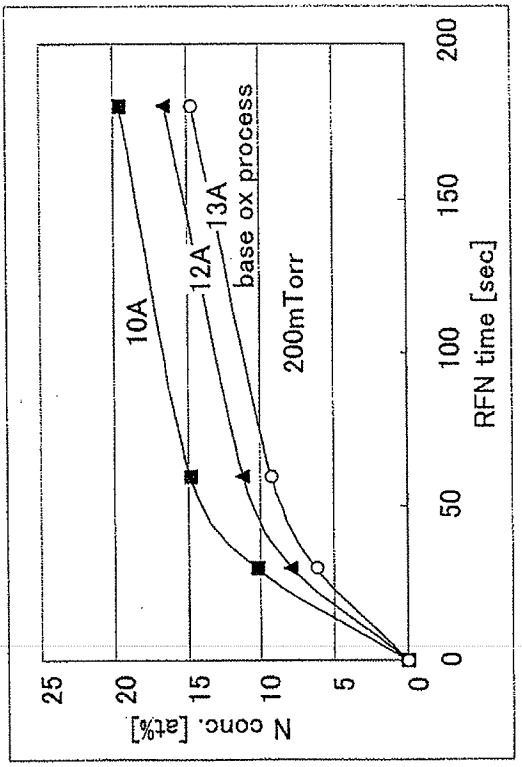


FIG.46C

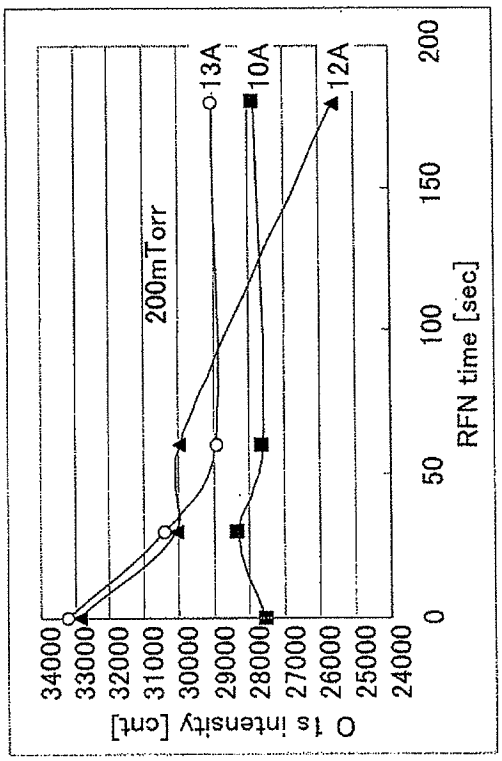


FIG.46D

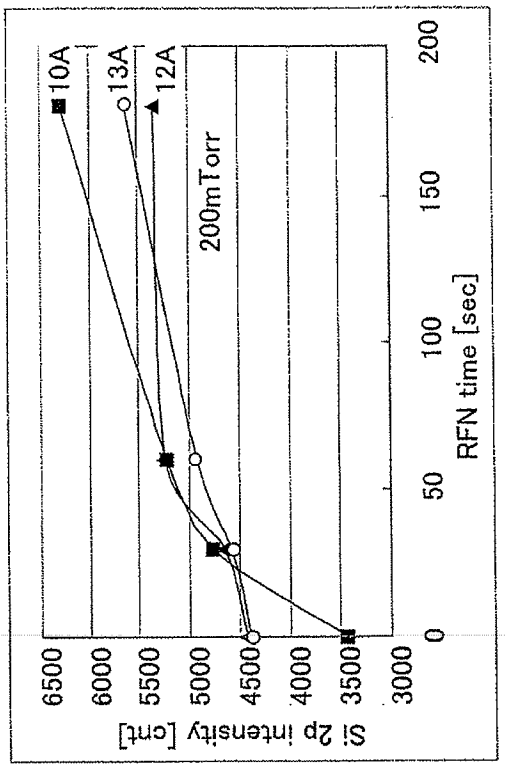


FIG.47A

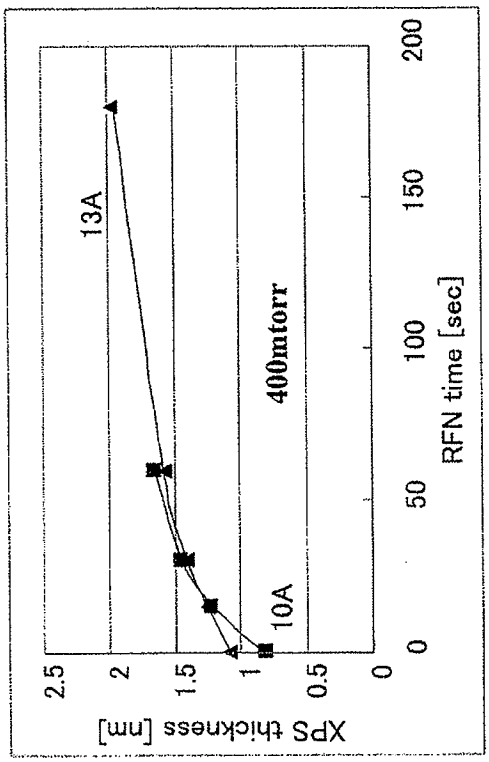


FIG.47B

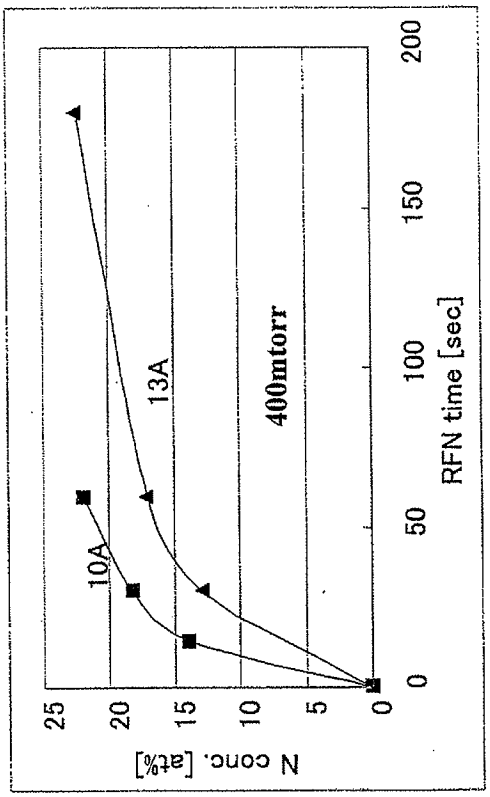


FIG.47C

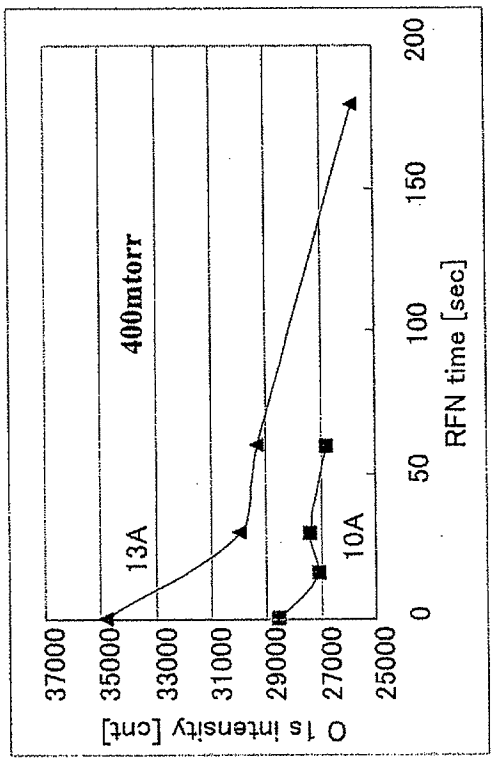


FIG.47D

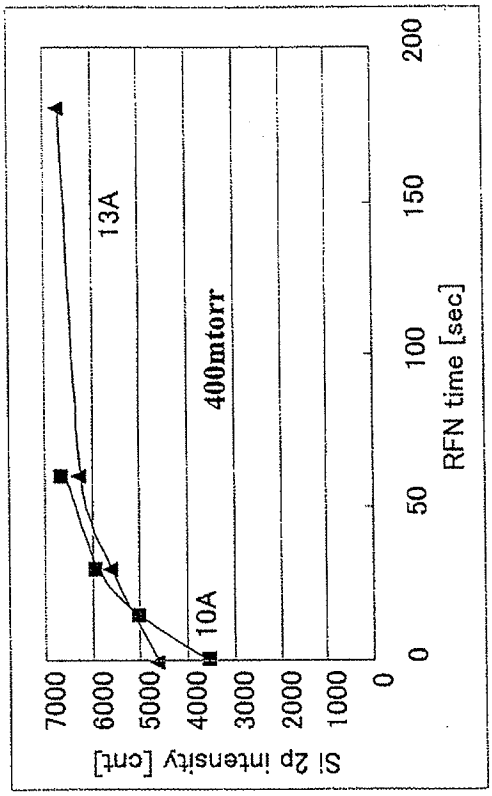


FIG.48A

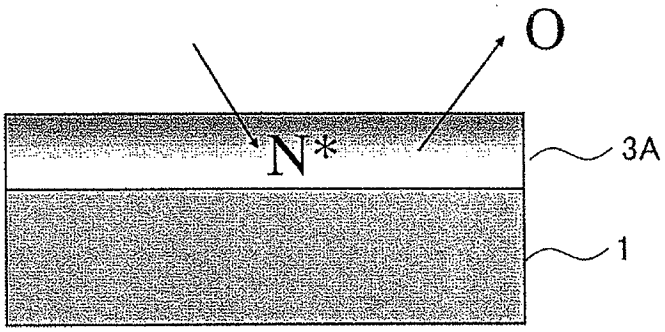


FIG.48B

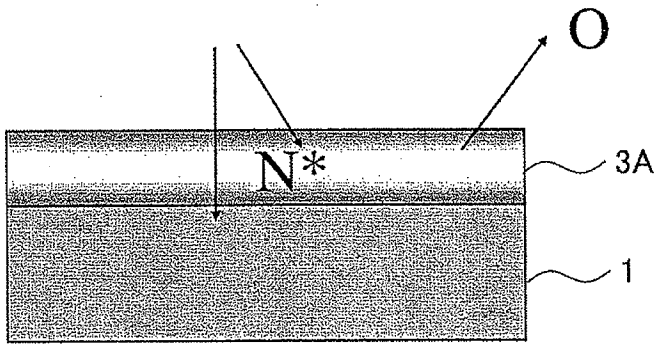


FIG.49A

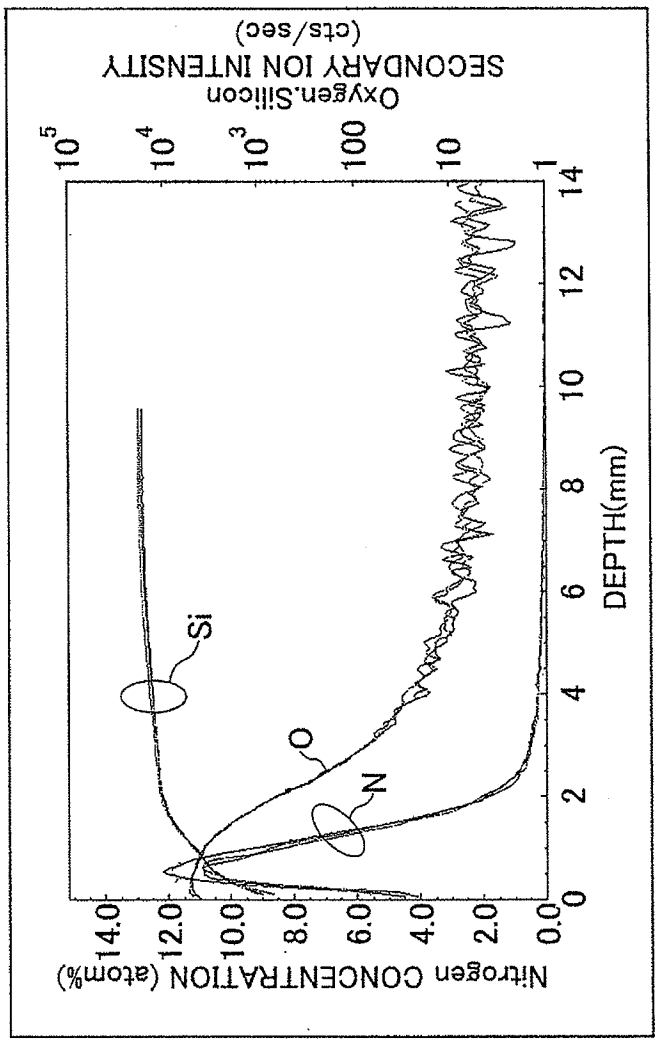


FIG.49B

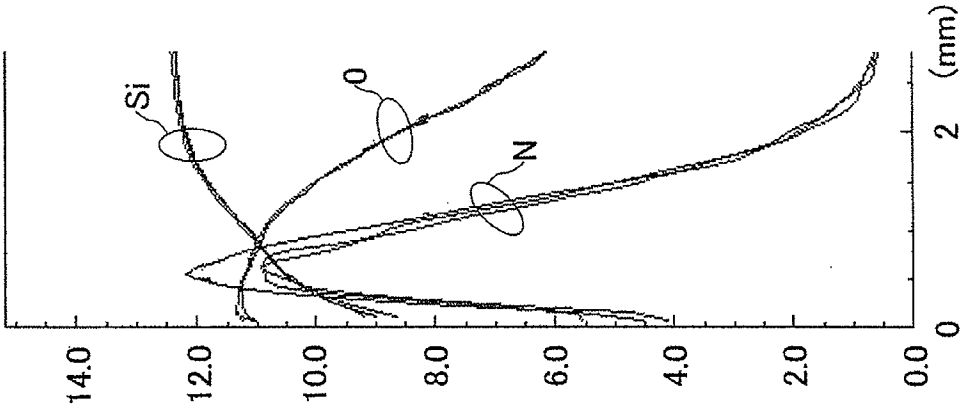


FIG.50A

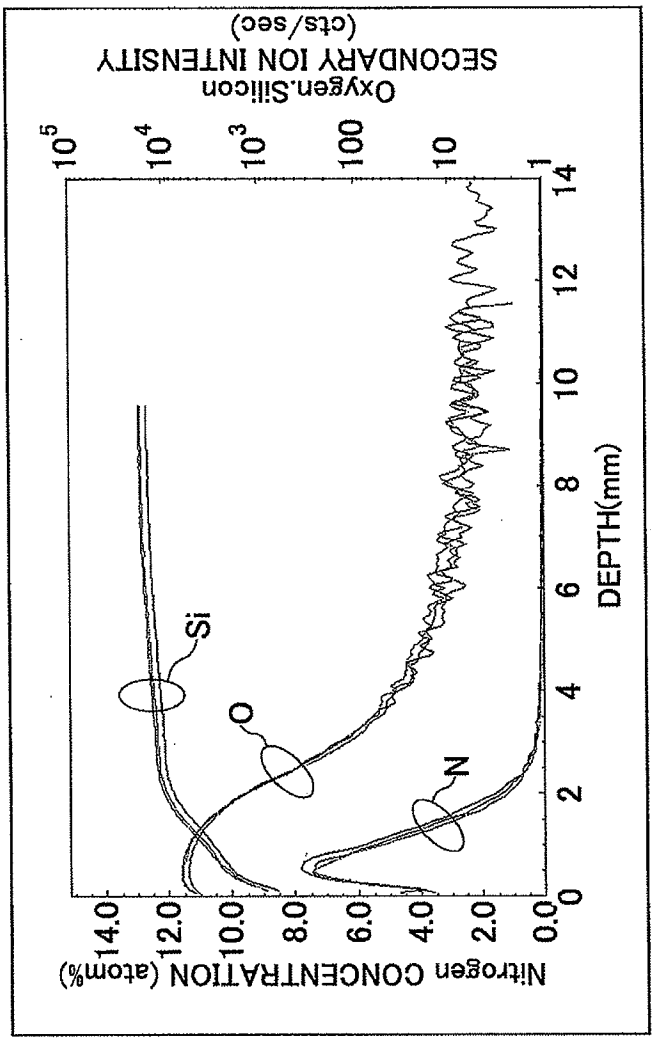


FIG.50B

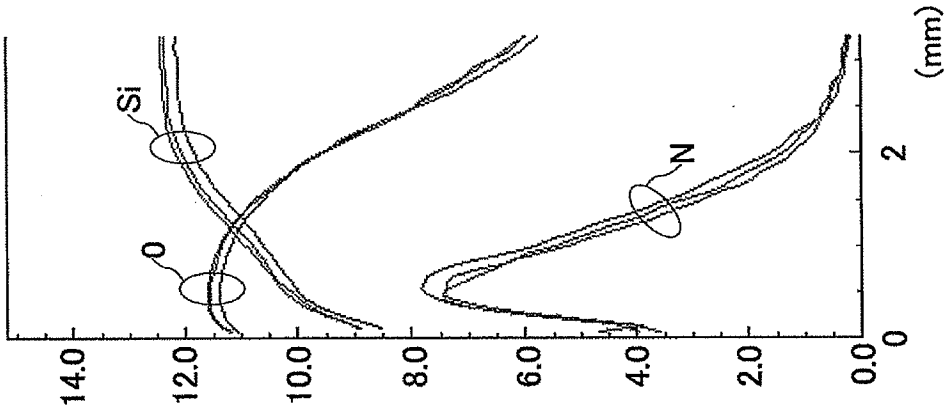


FIG.51

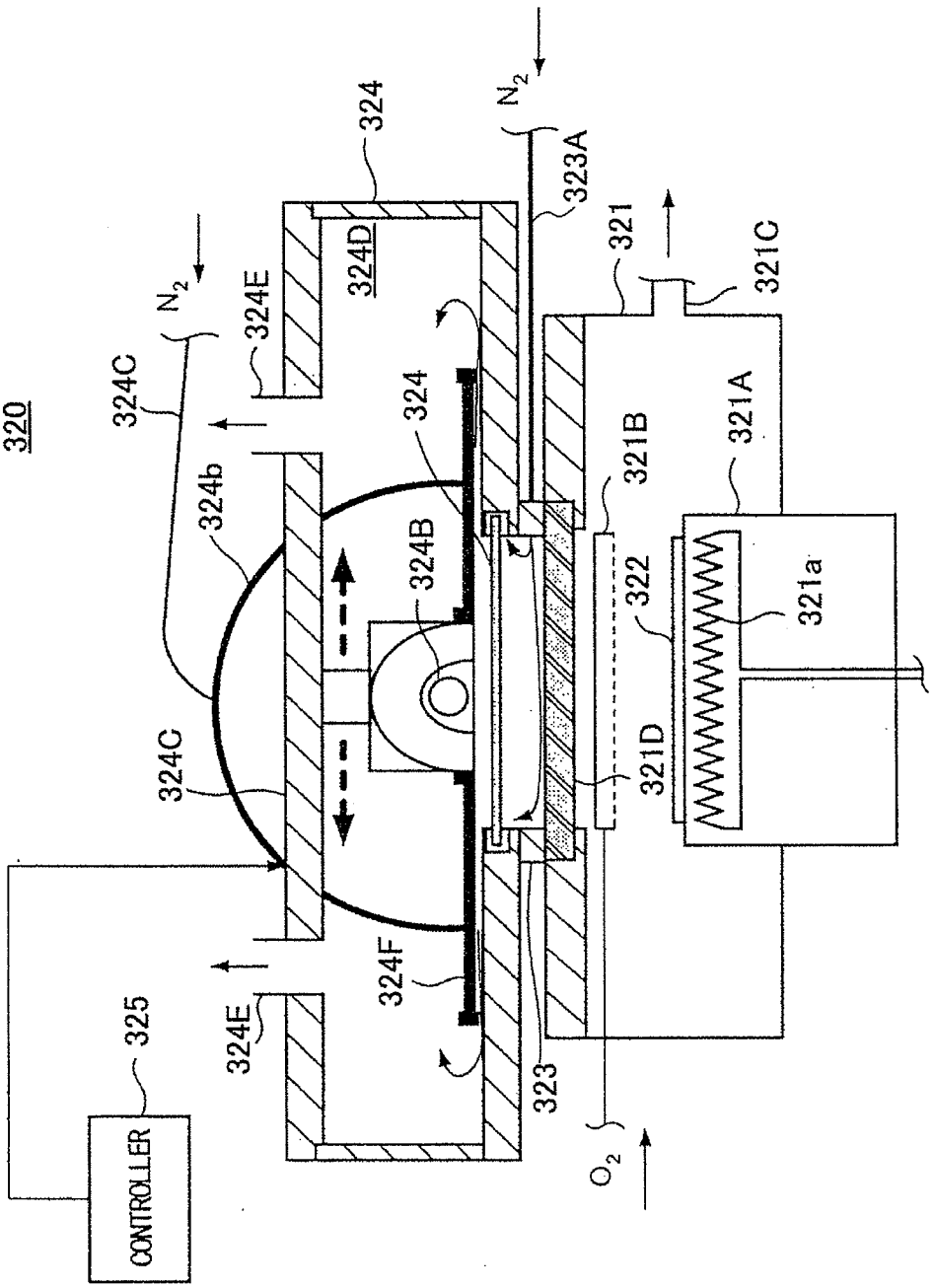

320
324
N_2
323A
321
321C
324D
324E
324C
324b
324
321B
321A
324B
322
321a
321D
324C
324F
325
CONTROLLER
324E
323
O_2

FIG.52A

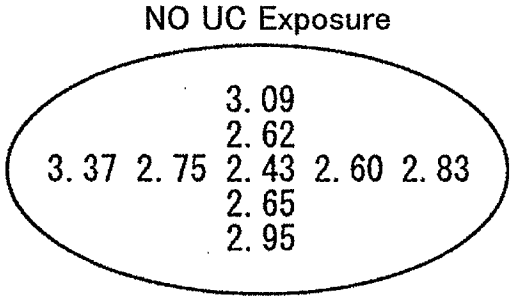


FIG.52B

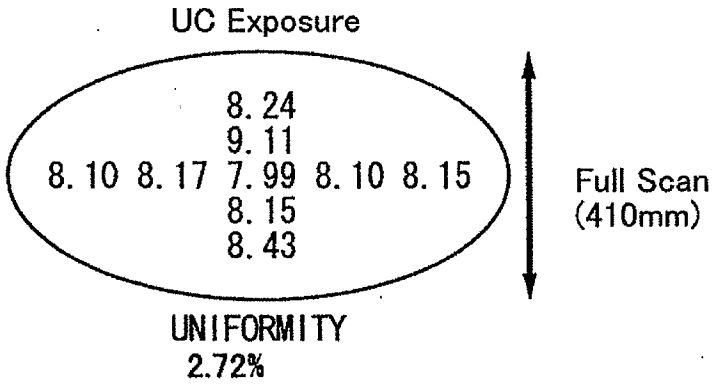


FIG.52C

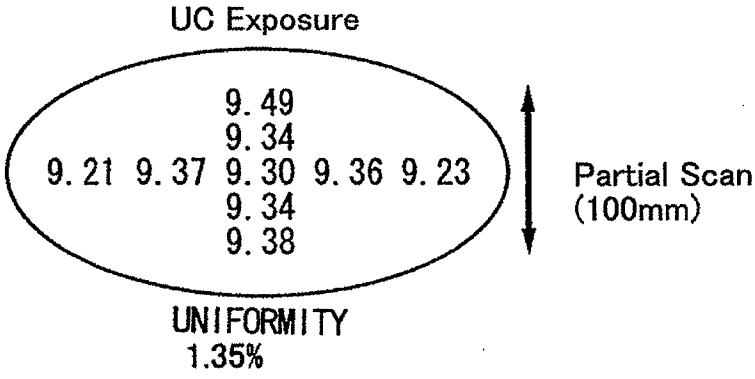


FIG.53

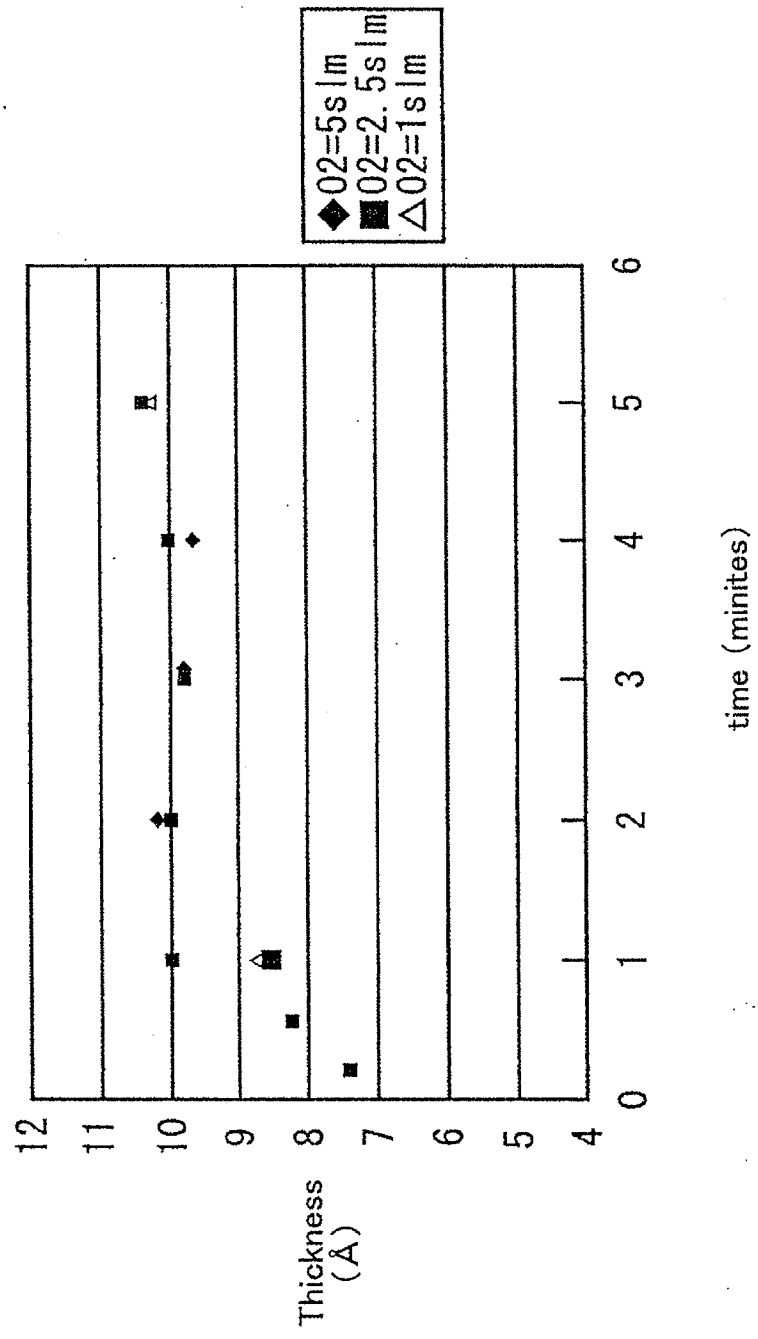
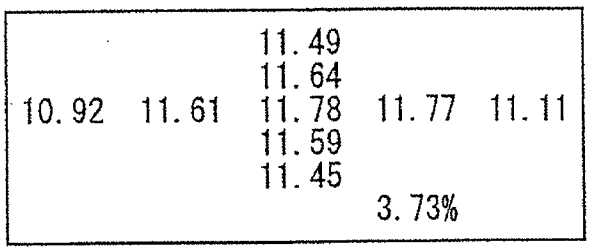
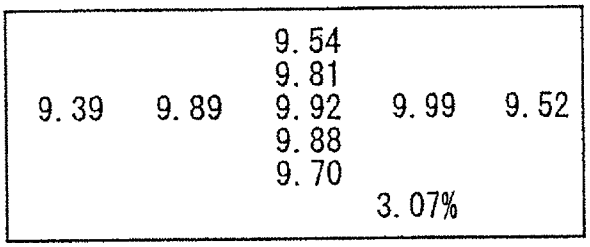

◆O2=5slm
■O2=2.5slm
△O2=1slm
Thickness (Å)
12
11
10
9
8
7
6
5
4
0
1
2
3
4
5
6
time (minites)

FIG.54A



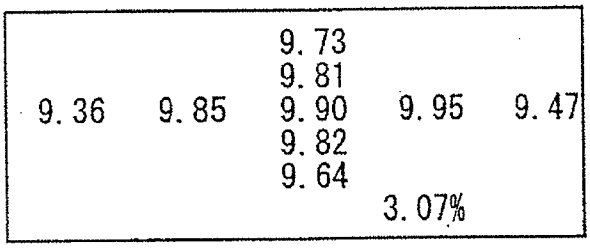
Δ y =0.0mm

FIG.54B



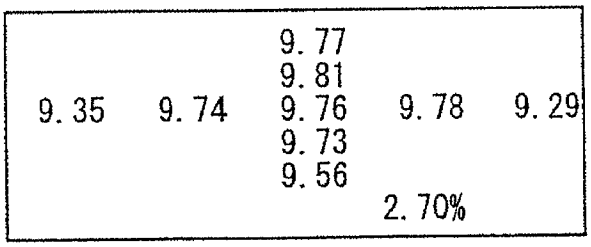
Δ y =12.5mm

FIG.54C



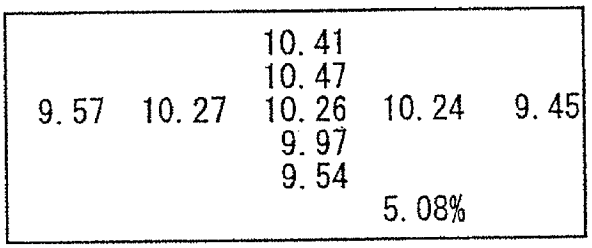
Δ y =25.0mm

FIG.54D



Δ y =37.5mm

FIG.54E



Δ y =50.0mm

FIG.55A

6.70	6.72	6.81 6.75 6.78 6.72 6.84 1.08%	6.82	6.83

FIG.55B

7.86	7.91	7.87 7.96 8.04 7.93 7.87 1.30%	8.03	8.07

FIG.55C

8.54	8.66	8.51 8.63 8.66 8.60 8.48 1.11%	8.67	8.49

FIG.55D

8.92	9.04	8.92 9.01 9.06 9.05 8.86 1.21%	9.08	9.94

FIG.55E

9.85	10.42	10.21 10.41 10.40 10.34 9.61 4.57%	10.54	10.1

FIG.56A

		5.10 4.75			NO UV
4.95	4.79	4.72 4.86 5.11	4.79	4.99	
			4.03%		

FIG.56B

		8.81 8.63			RTO
8.06	8.50	8.46 8.43 8.15	8.43	8.04	
			4.57%		

FIG.57

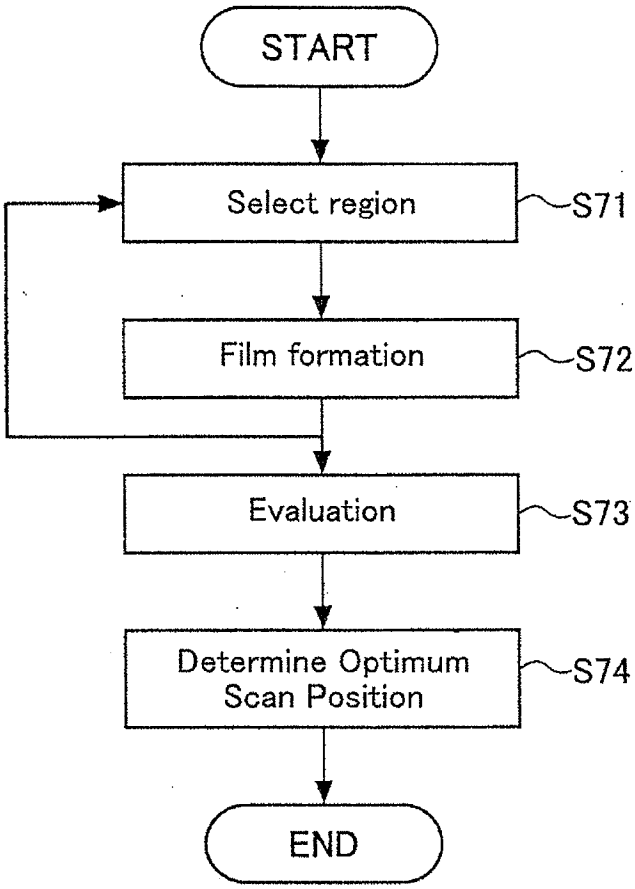

START
Select region
S71
Film formation
S72
Evaluation
S73
Determine Optimum Scan Position
S74
END

FIG.58

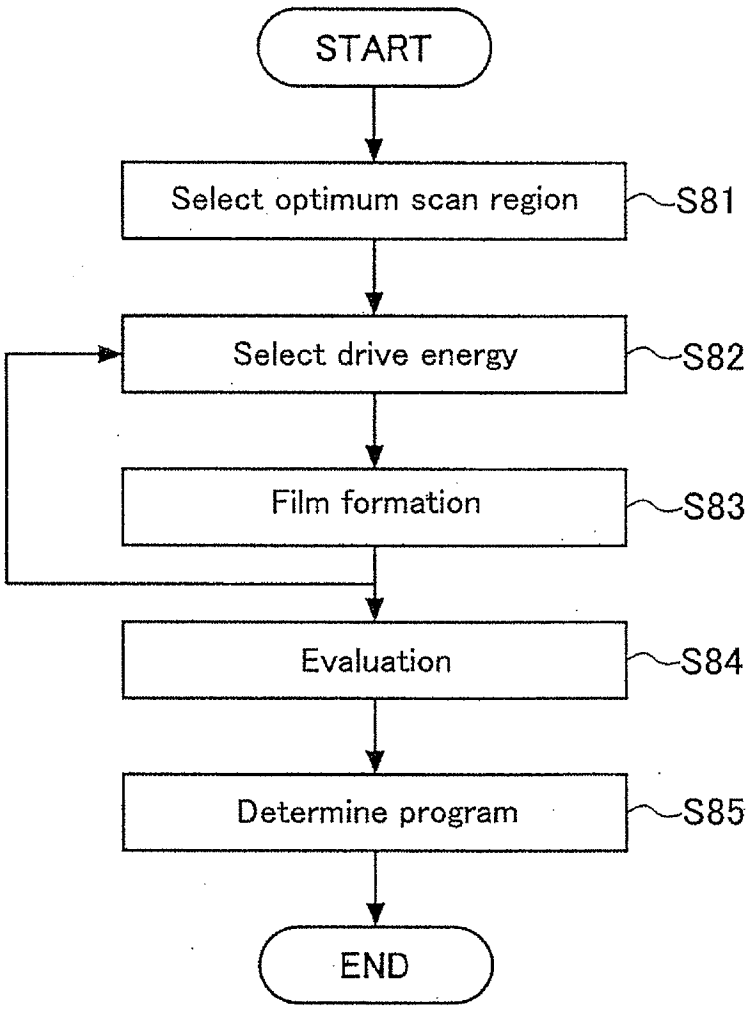

START
Select optimum scan region
S81
Select drive energy
S82
Film formation
S83
Evaluation
S84
Determine program
S85
END

FIG.59

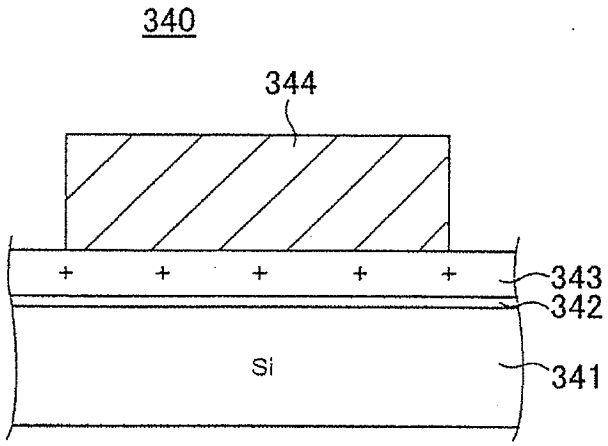


FIG.60

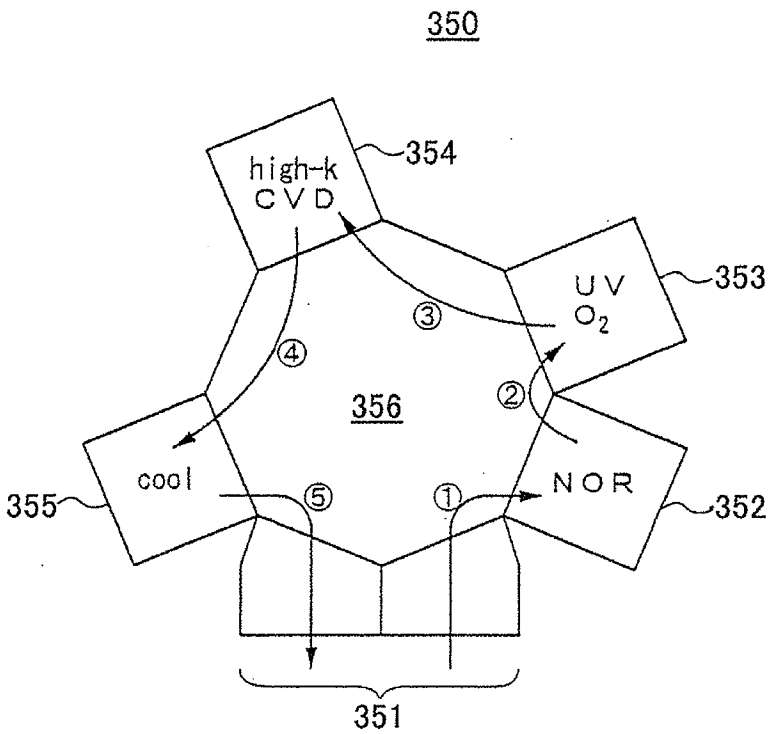


FIG.61

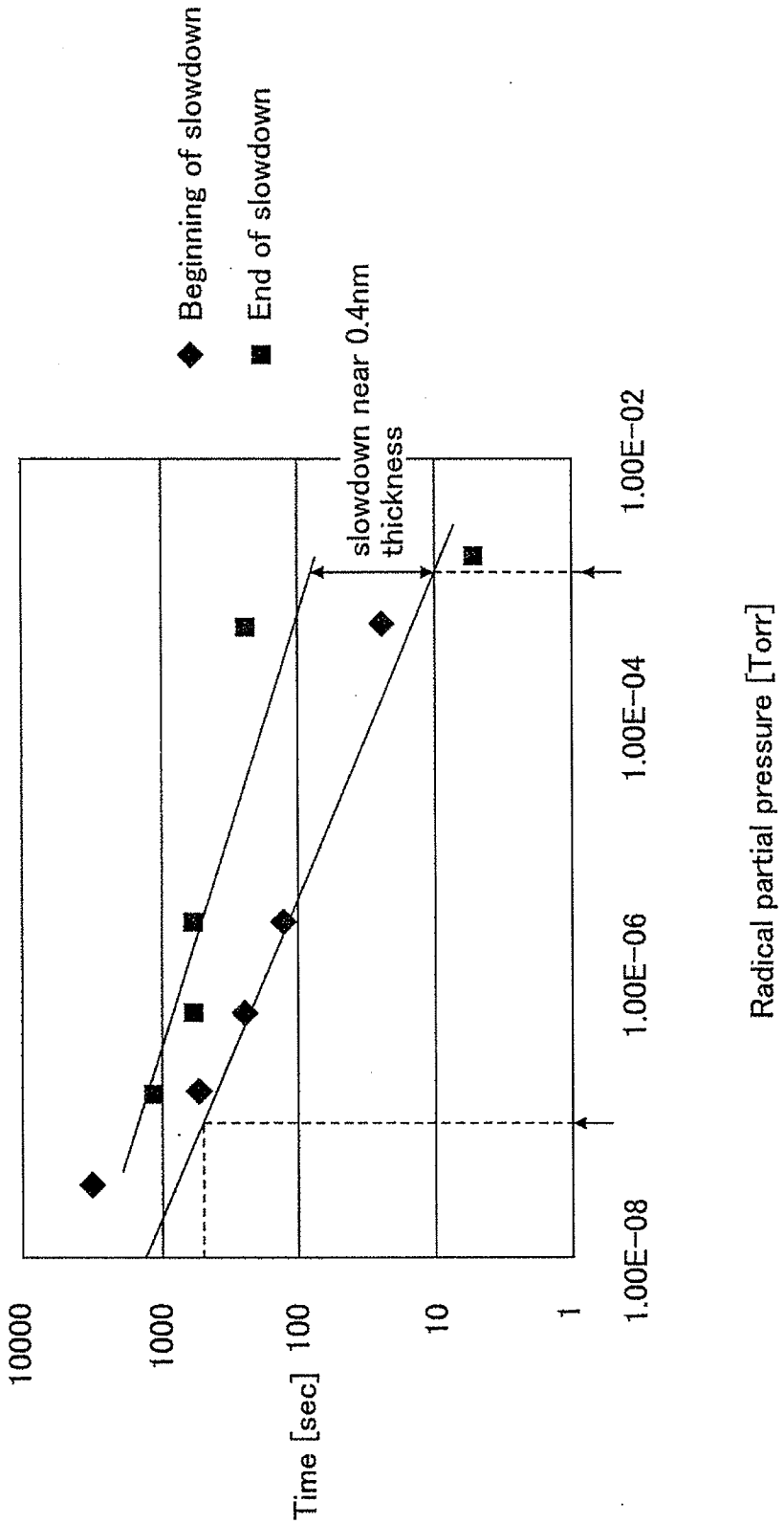
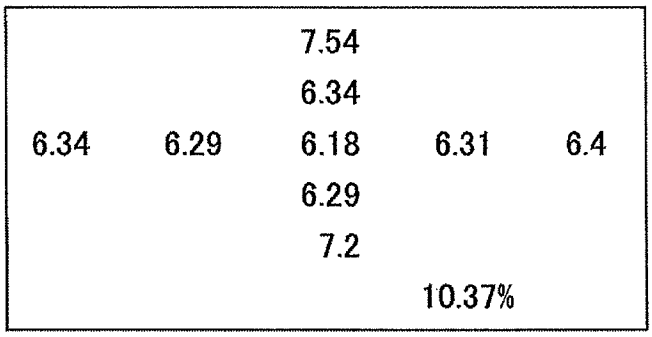
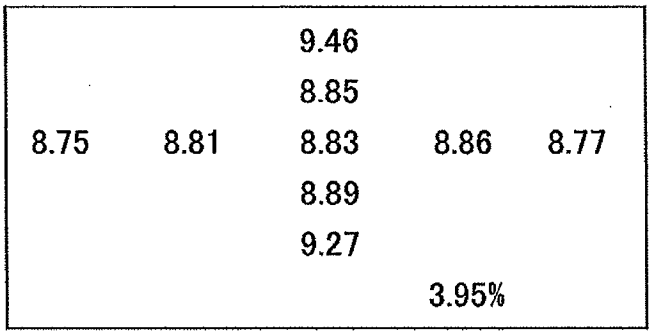

Beginning of slowdown
End of slowdown
slowdown near 0.4nm thickness
Time [sec]
10000
1000
100
10
1
1.00E−08
1.00E−06
1.00E−04
1.00E−02
Radical partial pressure [Torr]

FIG.62A



Avg.6.549

FIG.62B



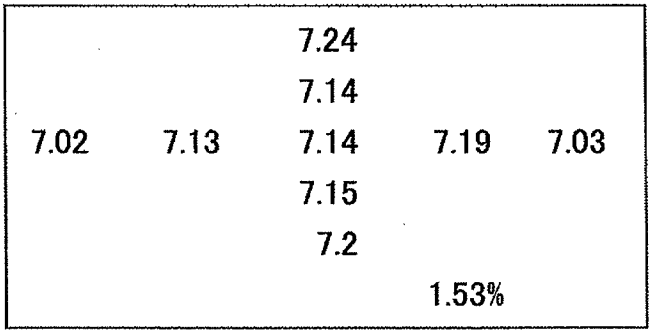
Avg.8.947

FIG.63A



Avg.6.848

FIG.63B



Avg.7.141

FIG.64A

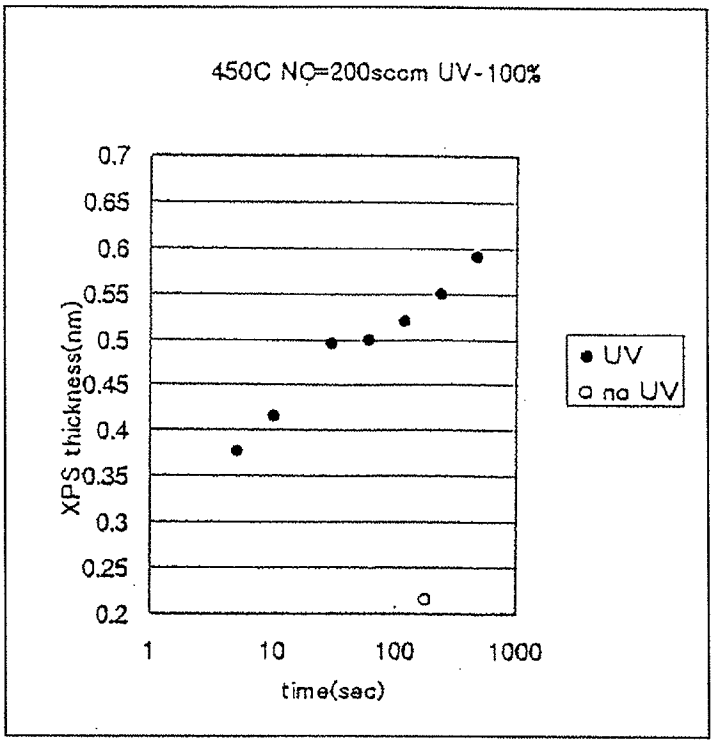


FIG.64B

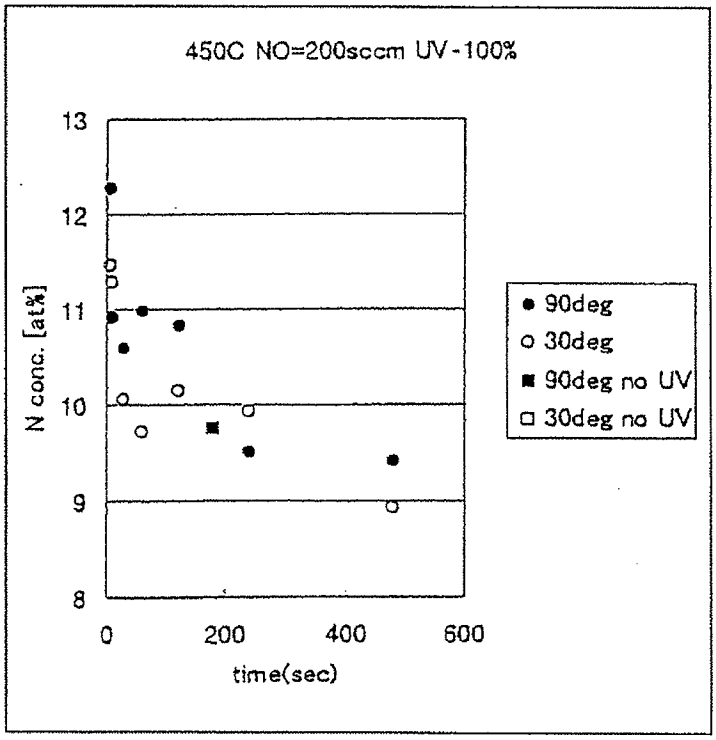


FIG.65A

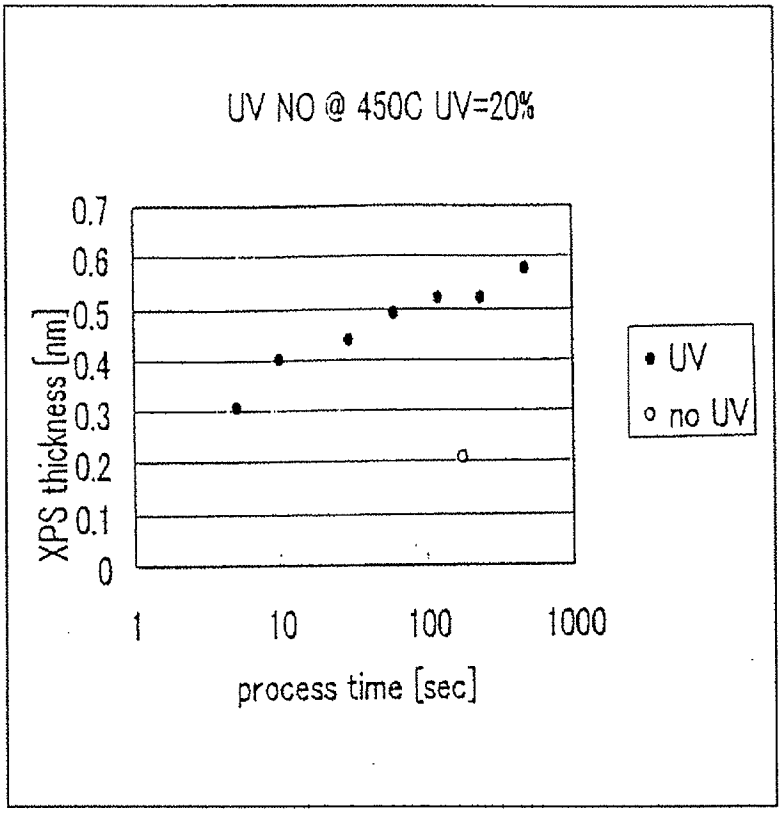


FIG.65B

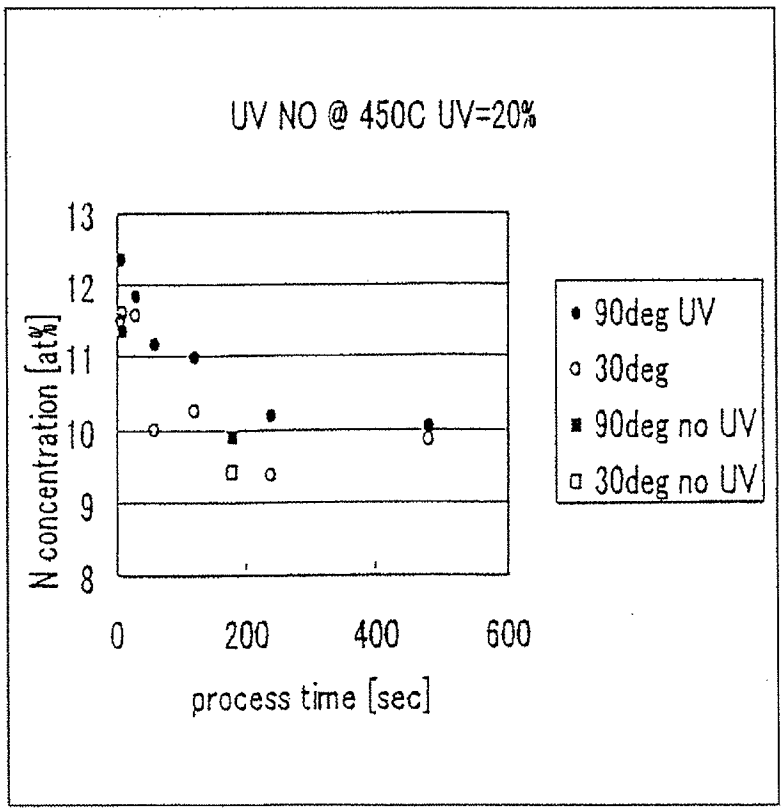


FIG.66A

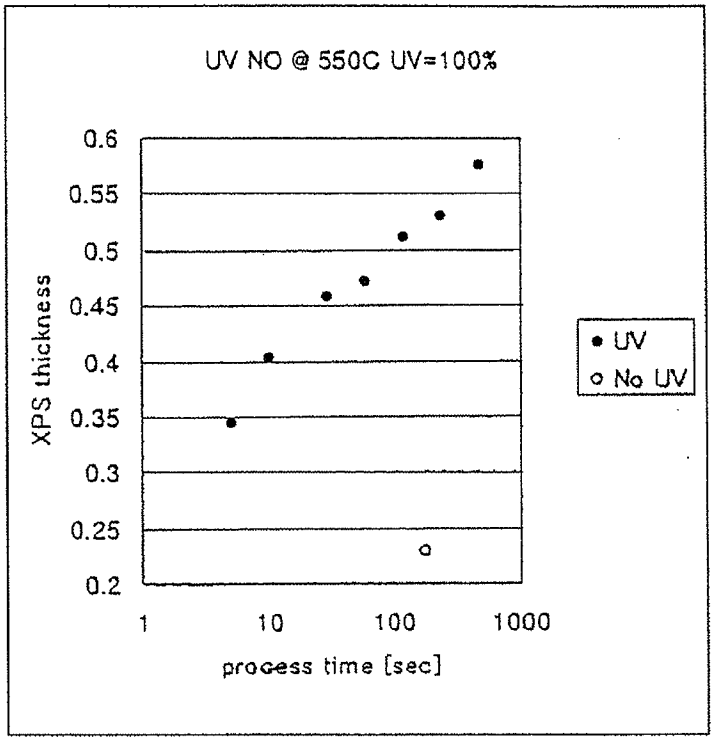


FIG.66B

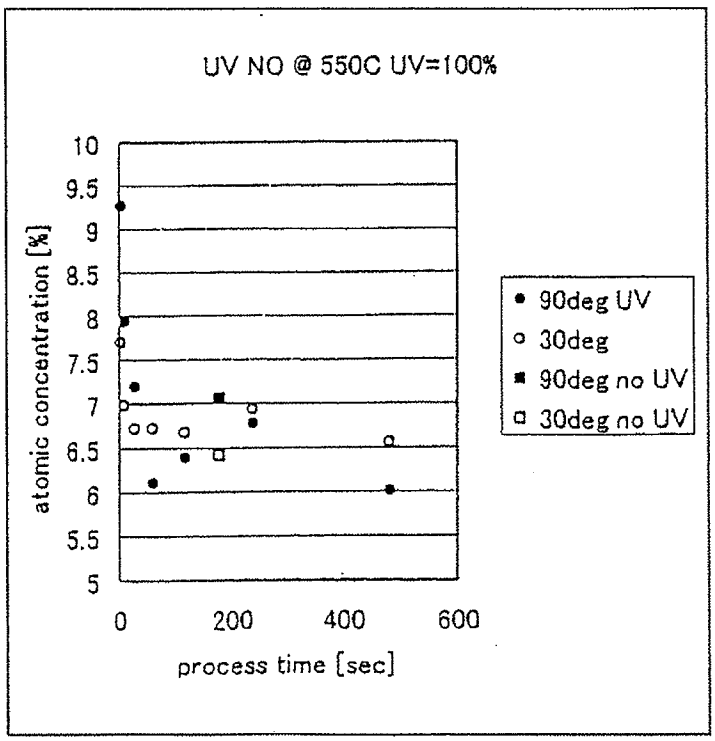


FIG.67

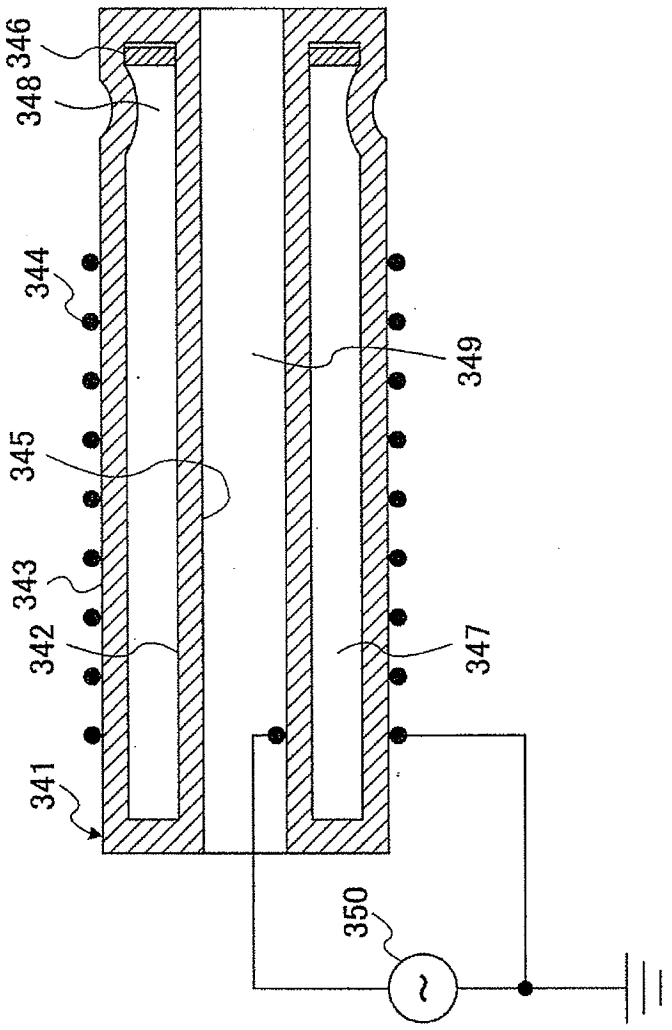


FIG.68A

7.09		7.88		7.05
	7.28	7.27	7.31	
7.05	7.35	7.09	7.35	7.03
	7.38	7.32	7.32	
8.15		7.72		8.2
			7.90%	

Avg.7.402

FIG.68B

7.26		7.56		7.22
	7.24	7.35	7.24	
7.31	7.39	7.13	7.37	7.23
	7.29	7.35	7.24	
7.53		7.54		7.56
			2.93%	

Avg.7.342

FIG.69B

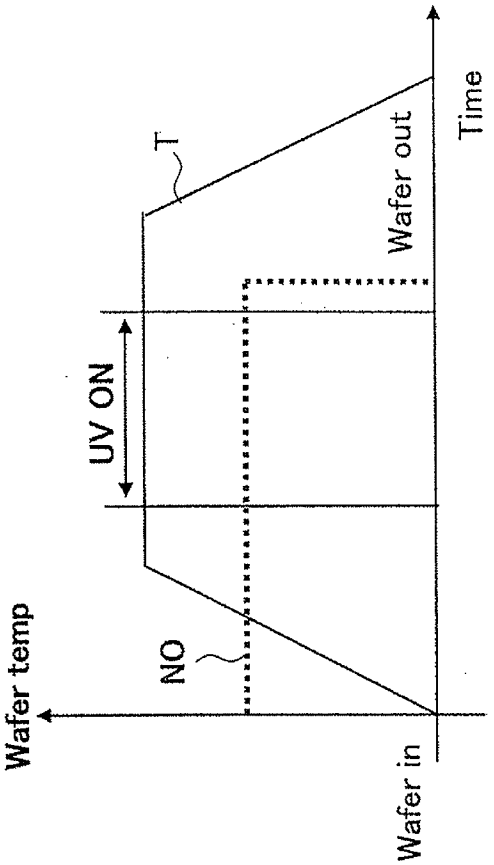
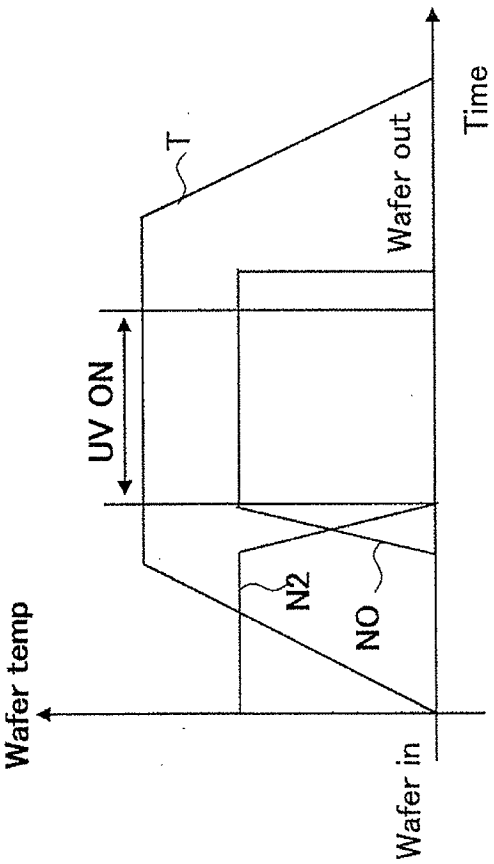


FIG.69A



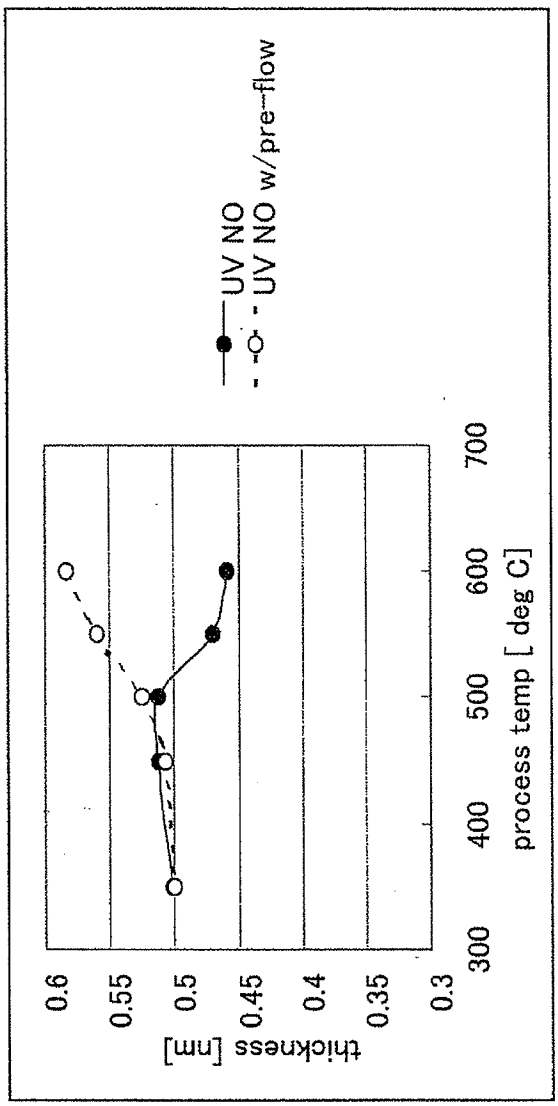


FIG.70A

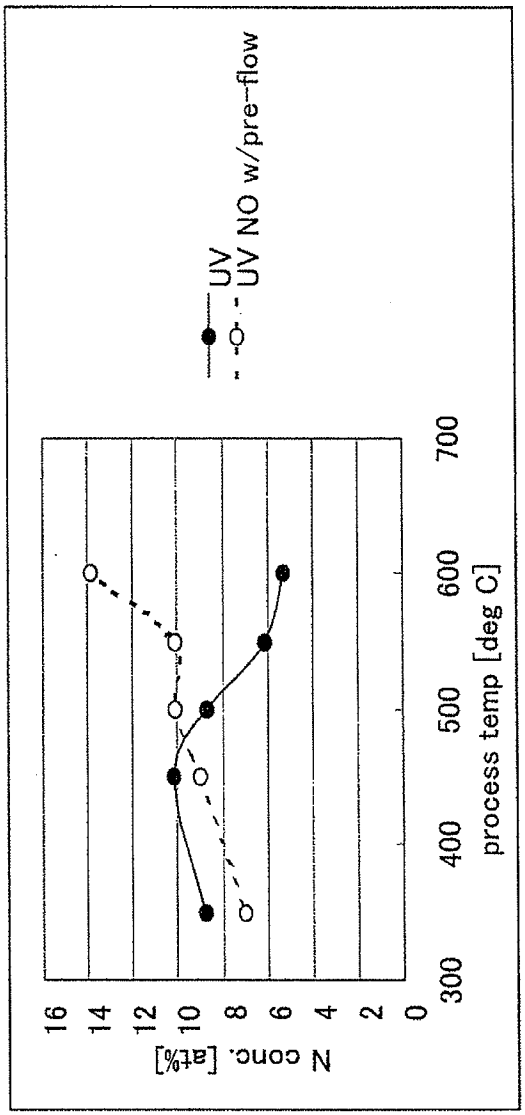


FIG.70B

FIG.71A

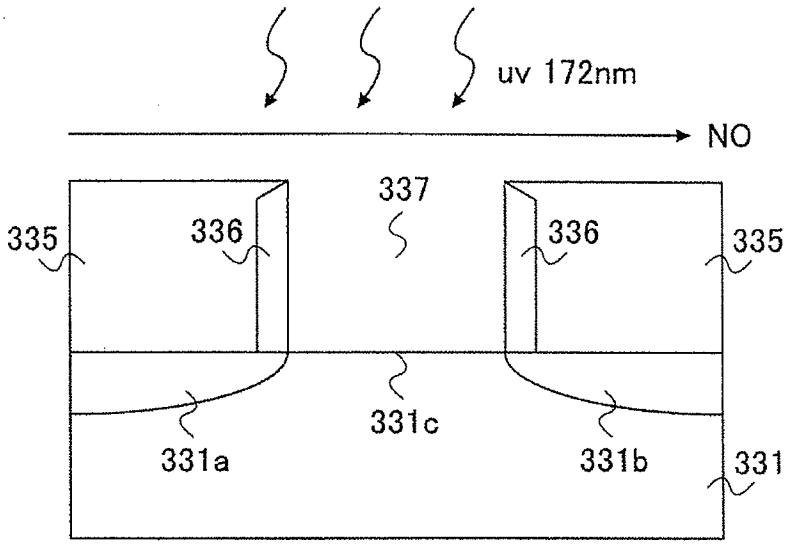


FIG.71B

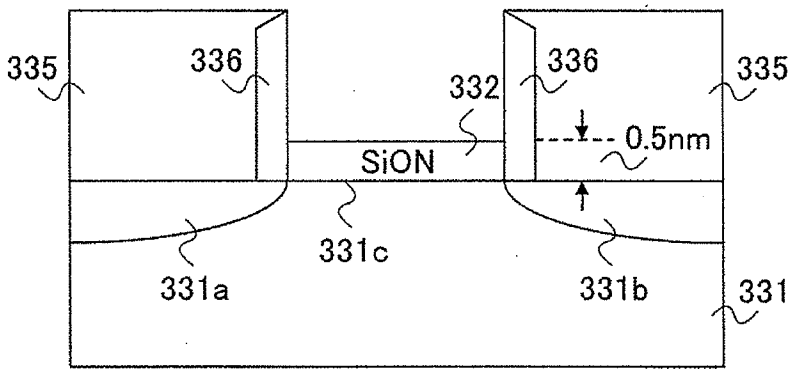


FIG.71C

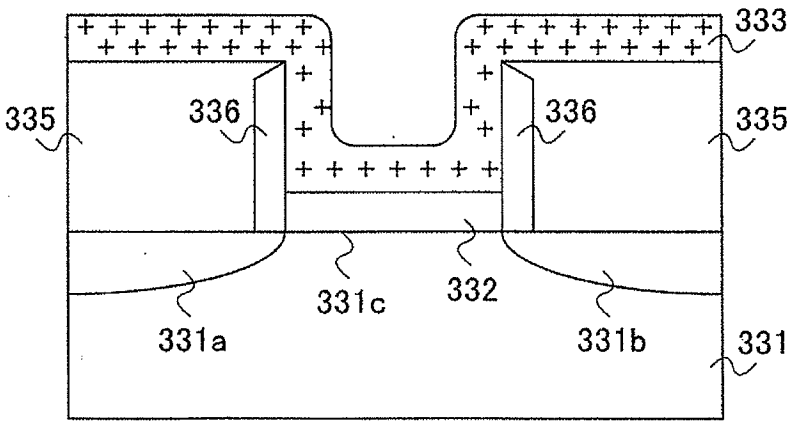


FIG.71D

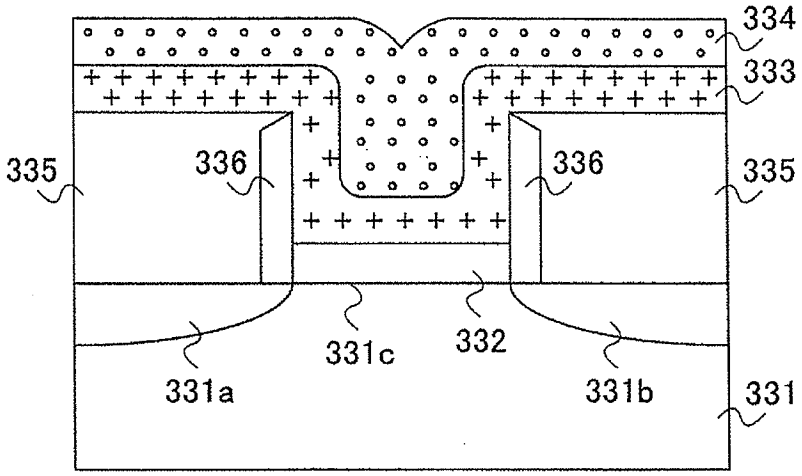


FIG.71E

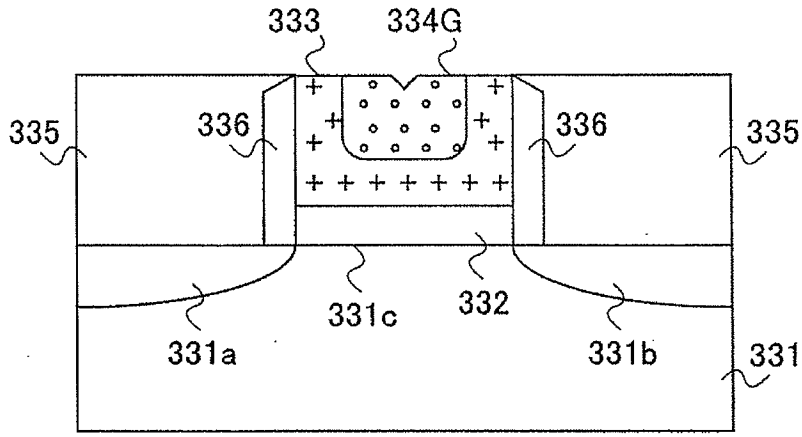


FIG.72

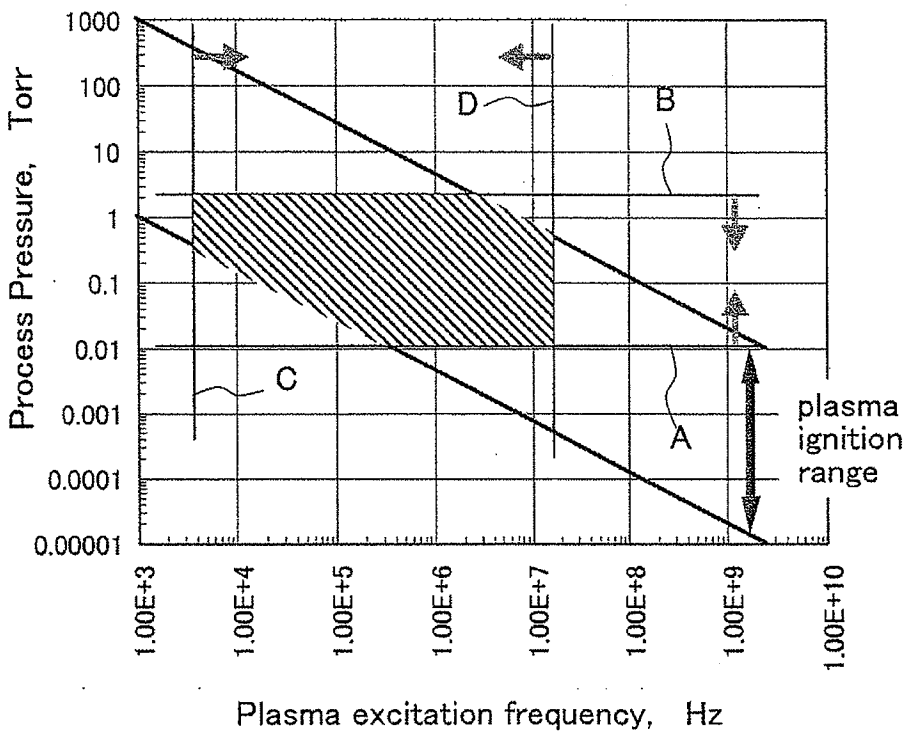

Process Pressure, Torr
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
D
B
C
A
plasma
ignition
range
1.00E+3
1.00E+4
1.00E+5
1.00E+6
1.00E+7
1.00E+8
1.00E+9
1.00E+10
Plasma excitation frequency, Hz

FIG.73

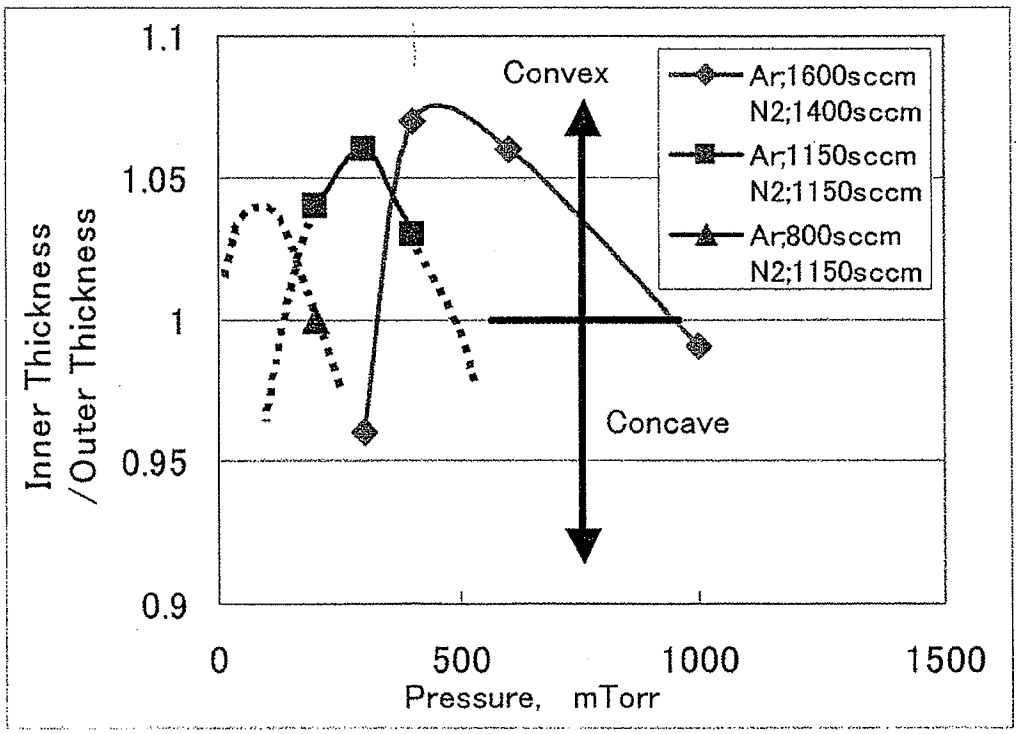

Inner Thickness
/Outer Thickness
1.1
1.05
1
0.95
0.9
Convex
Concave
Ar;1600sccm
N2;1400sccm
Ar;1150sccm
N2;1150sccm
Ar;800sccm
N2;1150sccm
0
500
1000
1500
Pressure, mTorr

FIG.74A

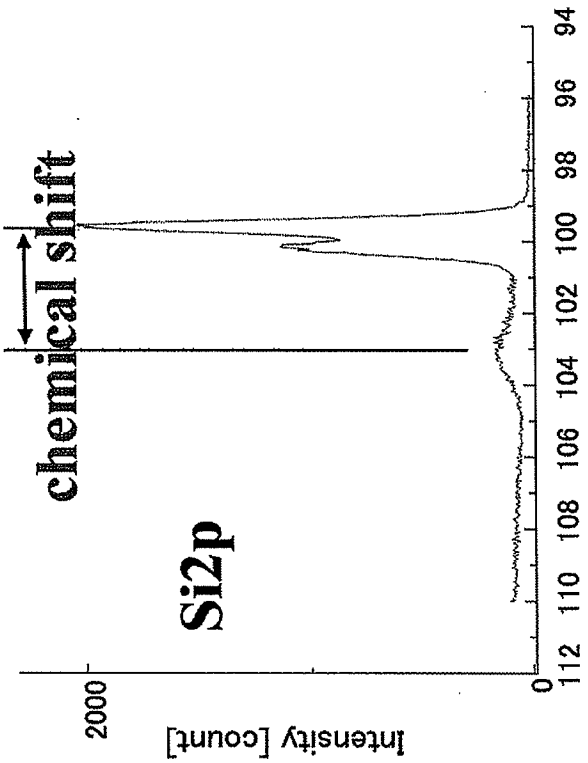


FIG.74B

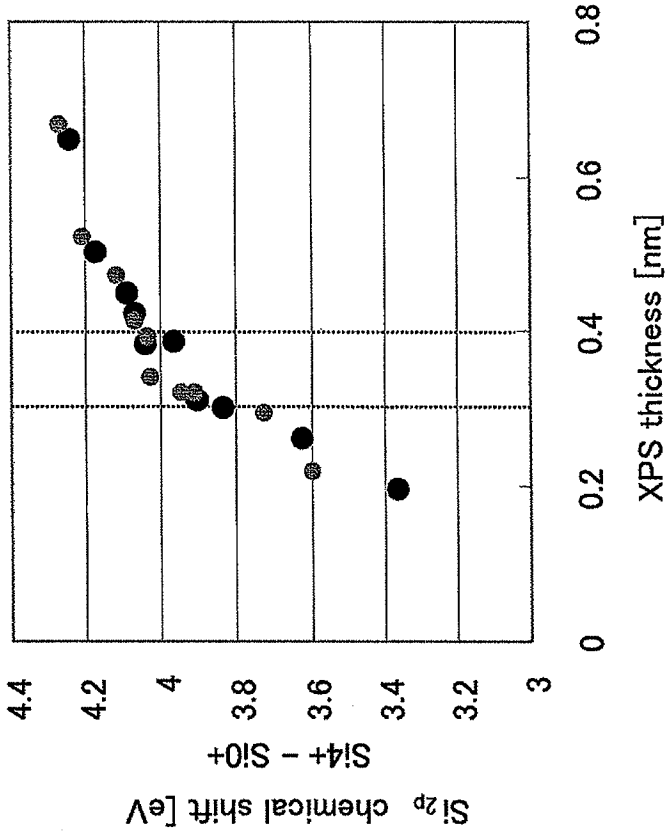
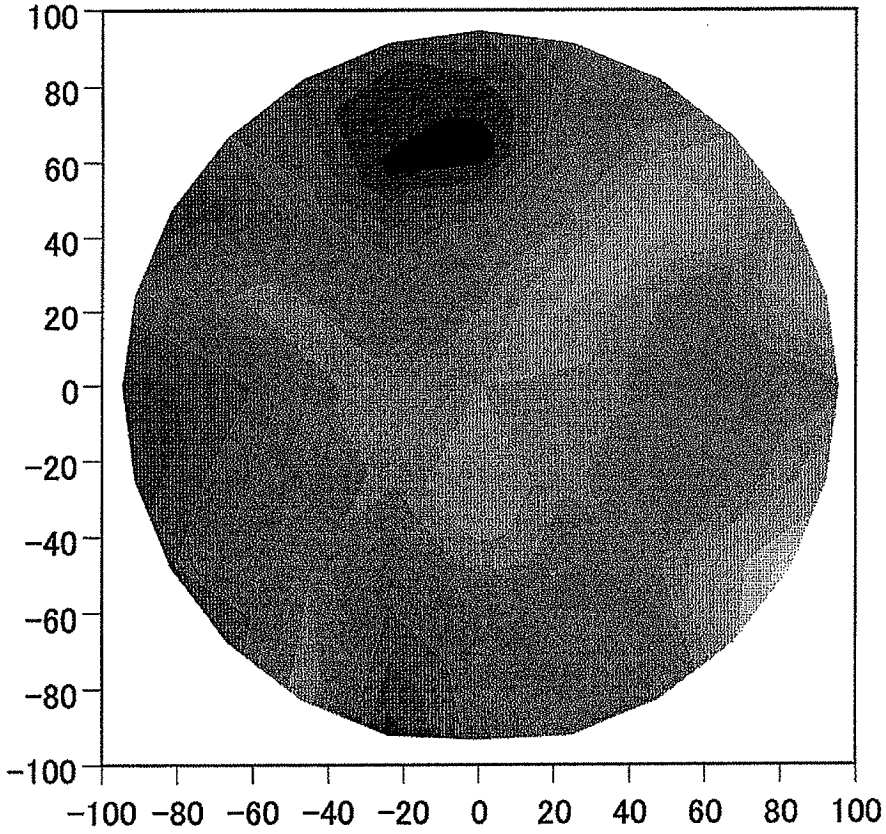
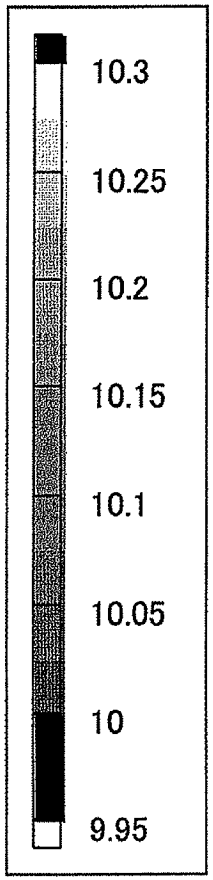


FIG.75

UV NO XPS THICKNESS 0.5nm 200mmWAFER





$\sigma = 0.65\%$