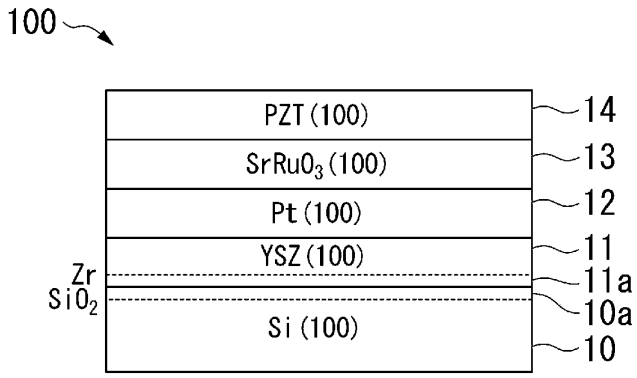
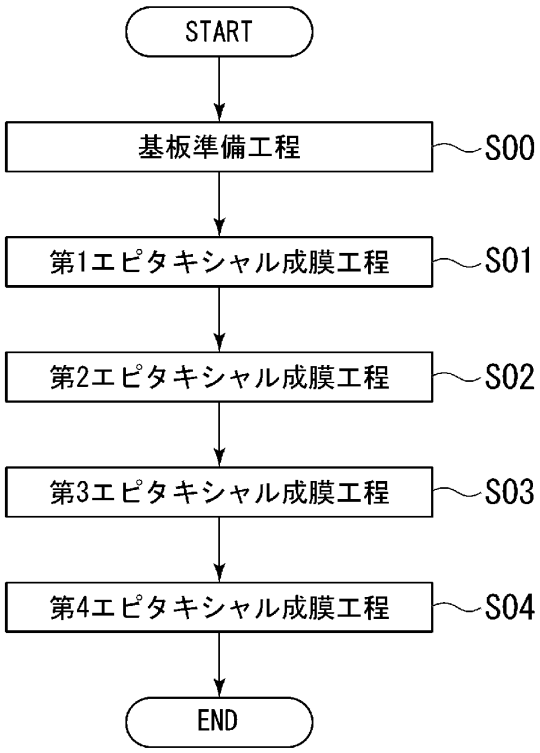
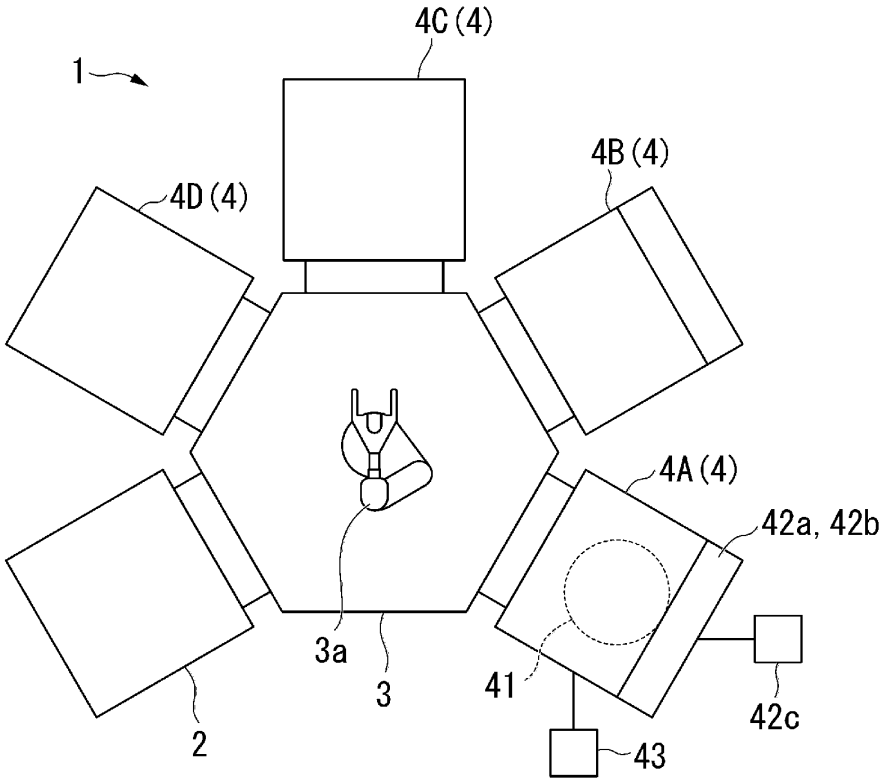
[図1]


100
PZT(100)
14
SrRuO3(100)
13
Pt(100)
12
YSZ(100)
11
Zr
11a
SiO2
10a
Si(100)
10

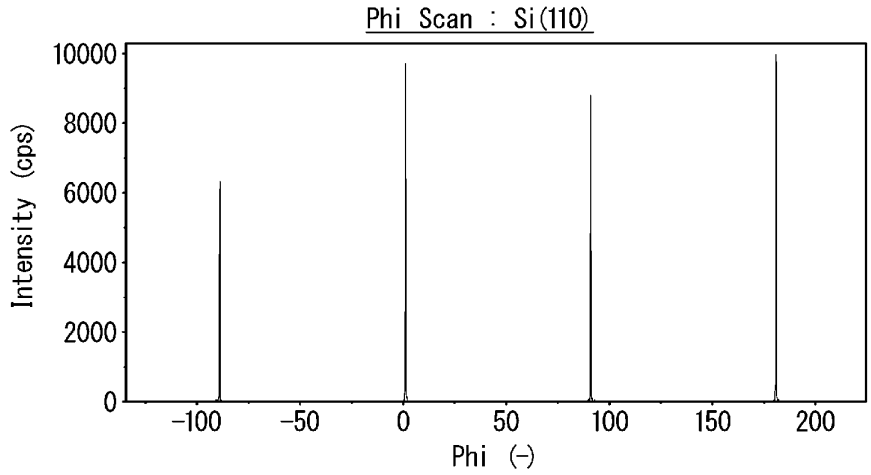
[図2]


START
基板準備工程
S00
第1エピタキシャル成膜工程
S01
第2エピタキシャル成膜工程
S02
第3エピタキシャル成膜工程
S03
第4エピタキシャル成膜工程
S04
END

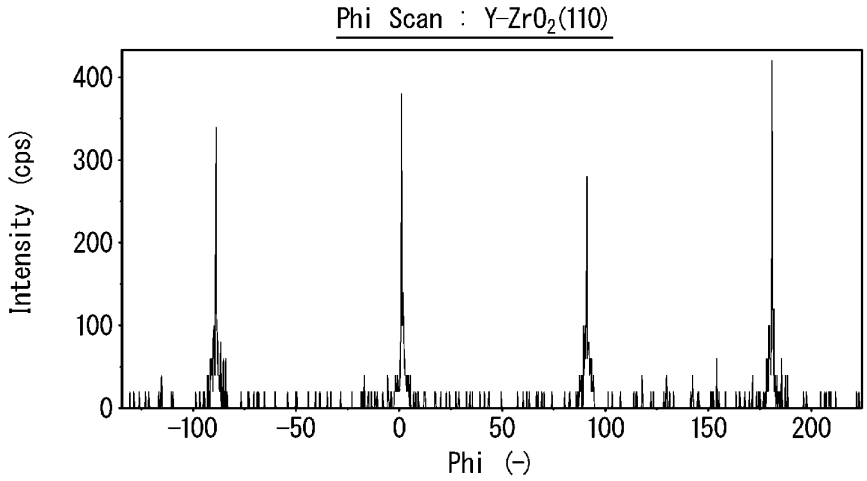
[図3]


4C (4)
1
4B (4)
4D (4)
4A (4)
42a, 42b
3a
3
41
42c
2
43

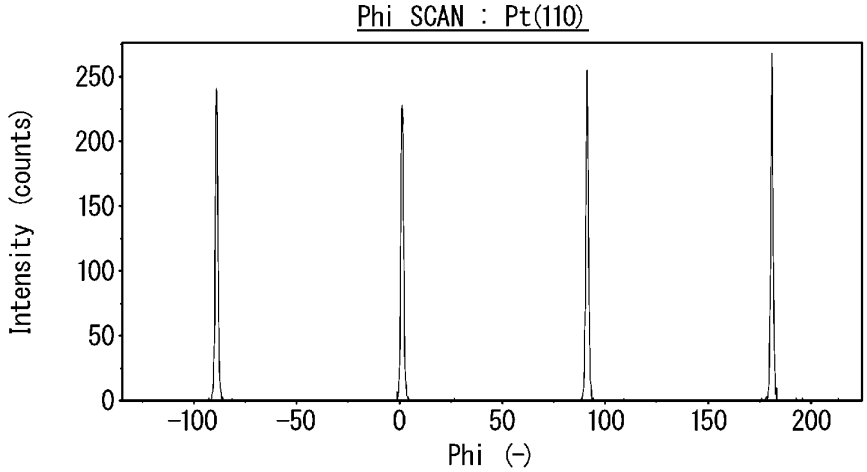
[図4A]


Phi Scan : Si(110)
Intensity (cps)
10000
8000
6000
4000
2000
0
-100
-50
0
50
100
150
200
Phi (-)

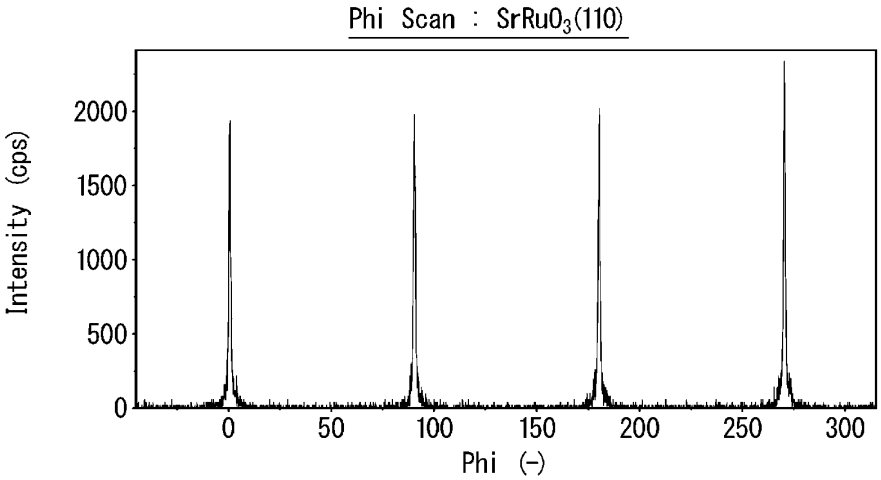
[図4B]


Phi Scan : Y-ZrO2(110)
Intensity (cps)
400
300
200
100
0
-100
-50
0
50
100
150
200
Phi (-)

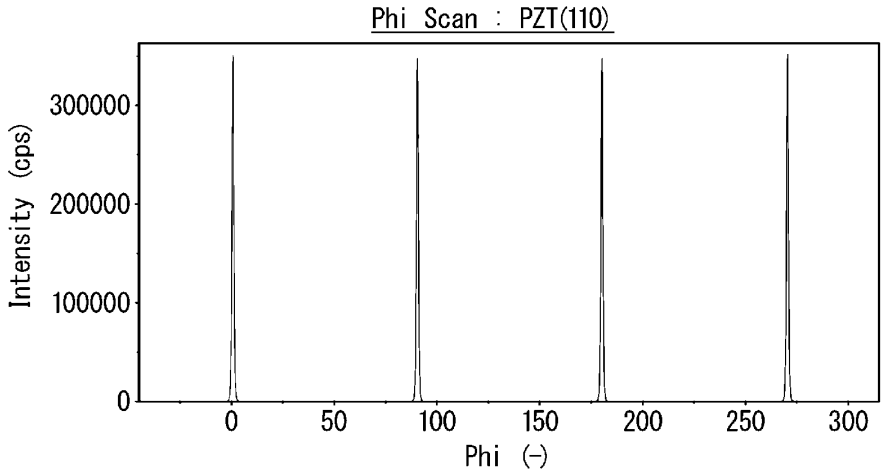
[図4C]


Phi SCAN : Pt(110)
Intensity (counts)
250
200
150
100
50
0
-100
-50
0
50
100
150
200
Phi (-)

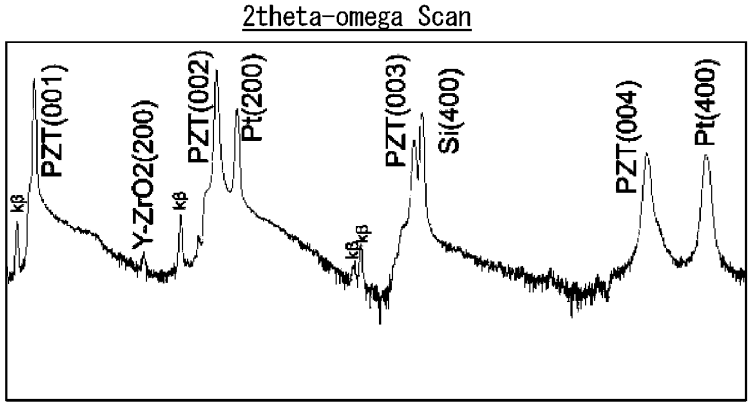
[図5A]


Phi Scan : SrRuO3(110)
Intensity (cps)
2000
1500
1000
500
0
0
50
100
150
200
250
300
Phi (-)

[図5B]



[図5C]



[図6]

YSZ膜厚200-500nm

Etching	Seed layer	600℃	650℃	700℃
YES	NO	×YSZ(111)大	△YSZ(111)小	◎YSZ(111)なし
NO	NO	×YSZ(111)大	◎YSZ(111)なし	◎YSZ(111)なし
NO	YES		◎YSZ(111)なし	

[図7]

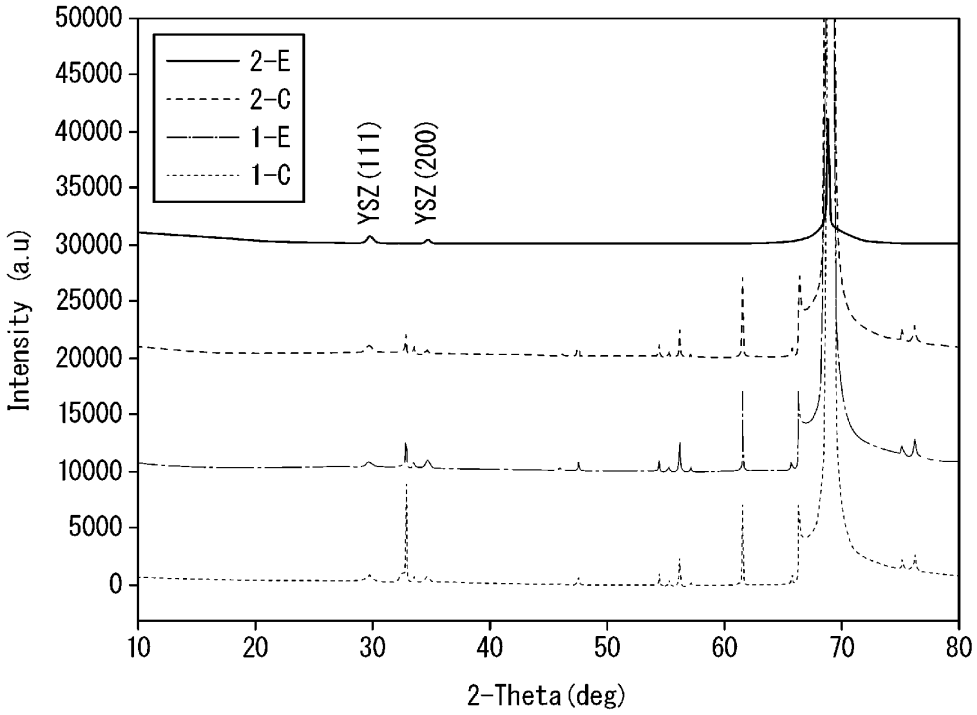
YSZ膜厚60nm以下

Etching	Seed layer	600℃	650℃	700℃
NO	NO		×YSZ(111)大	△YSZ(111)小
NO	YES	×YSZ(111)大	◎YSZ(111)なし	◎YSZ(111)なし

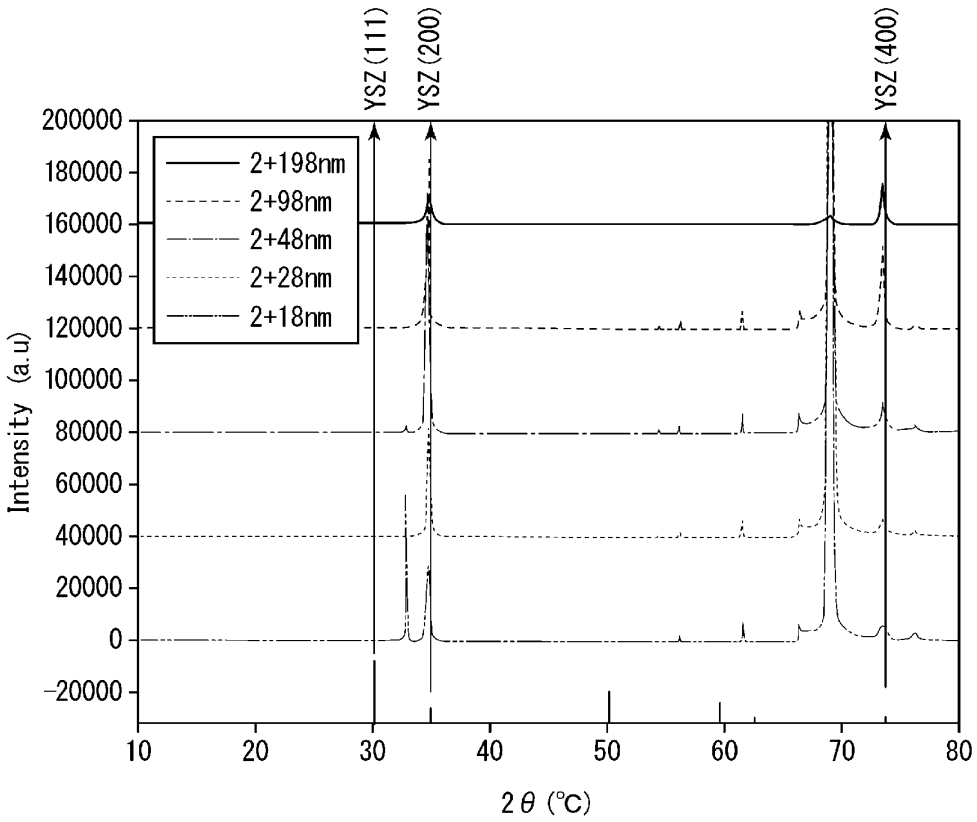
[図8]

Pt成膜温度	YSZ膜厚					
	20nm	25nm	30nm	40nm	50nm	60nm
400℃	111		111&200	111&200		
500℃	111	200	200	200	200	111
600℃	111	200	200	200	200	111

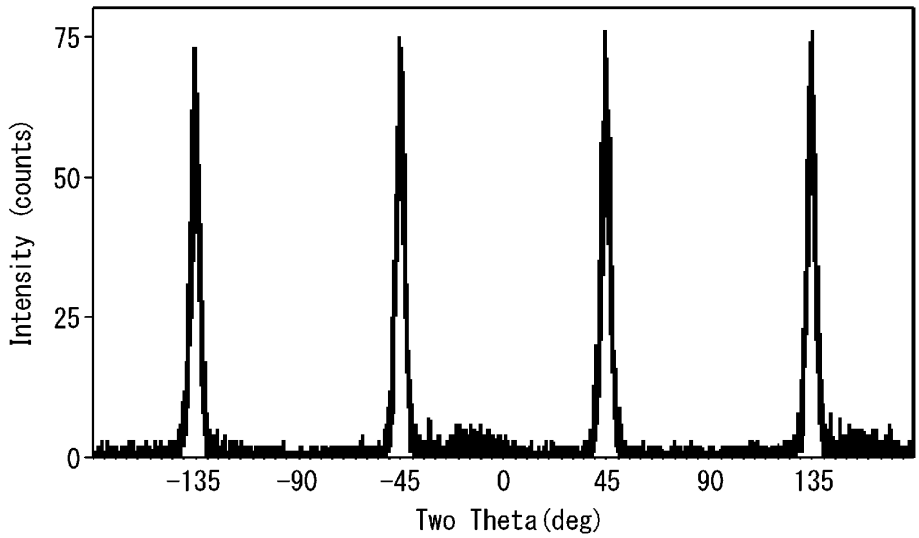
[図9]



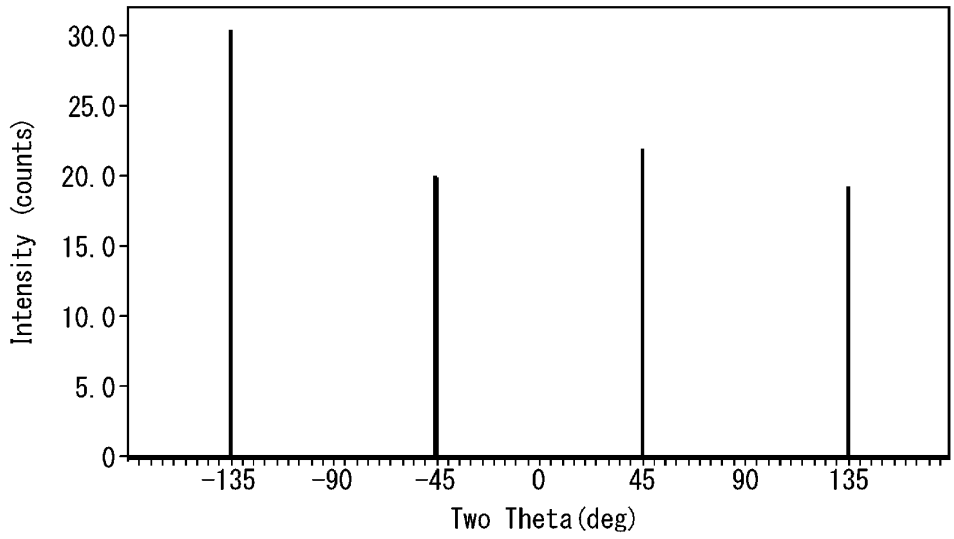
[図10]


YSZ(111)
YSZ(200)
YSZ(400)
2+198nm
2+98nm
2+48nm
2+28nm
2+18nm
Intensity (a.u)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
10
20
30
40
50
60
70
80
2θ (℃)

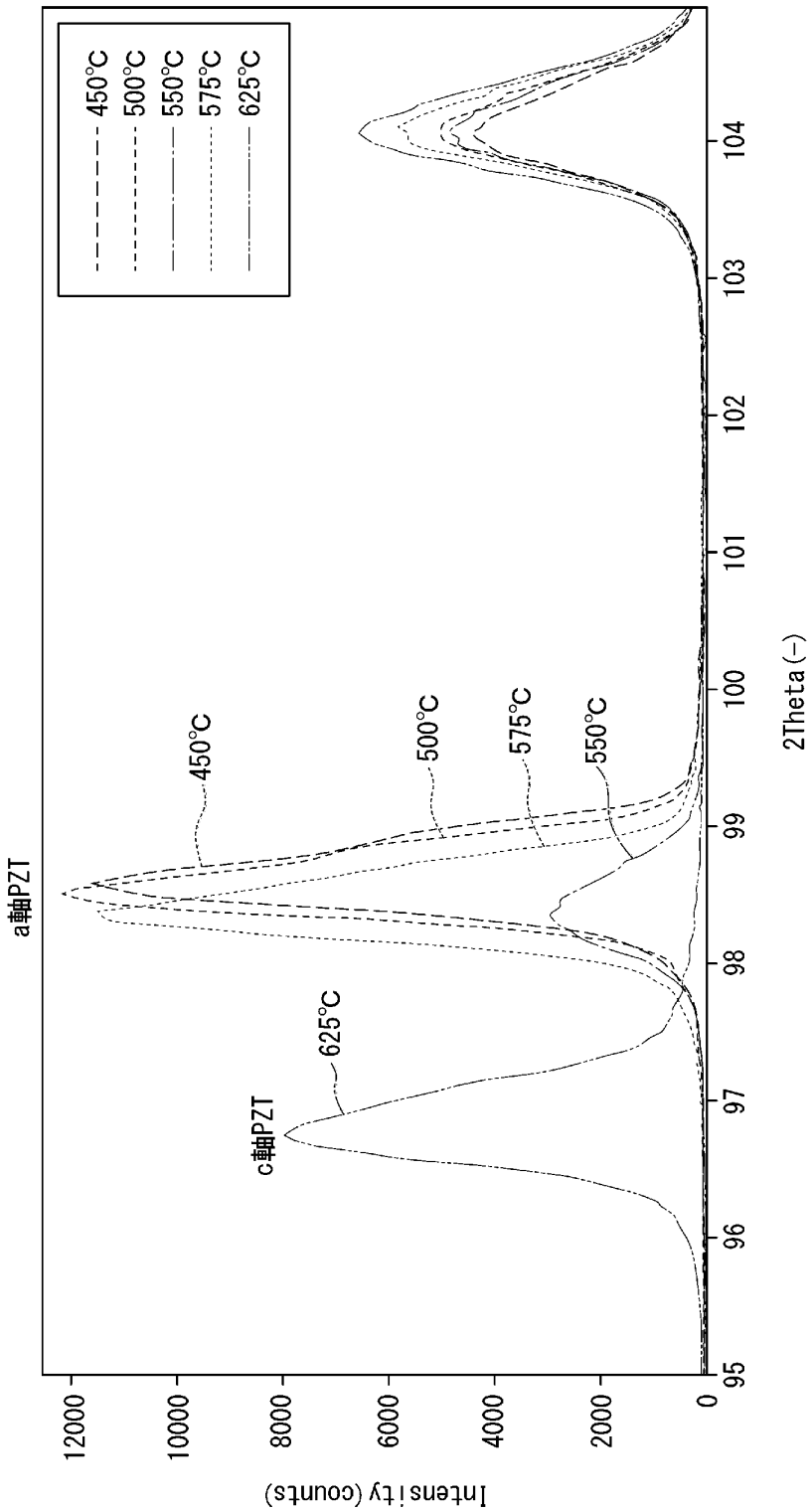
[図11]


Intensity (counts)
75
50
25
0
-135
-90
-45
0
45
90
135
Two Theta(deg)

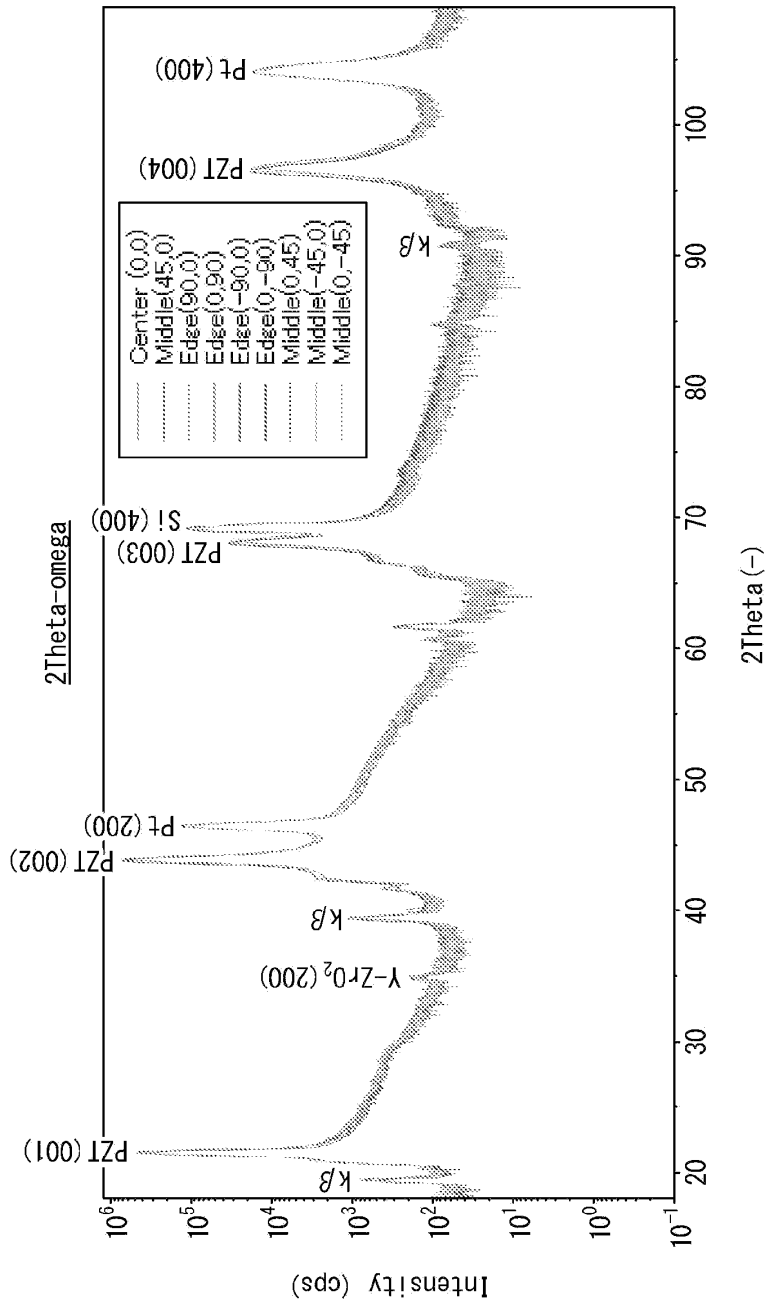
[図12]


30.0
25.0
20.0
15.0
10.0
5.0
0
Intensity (counts)
-135
-90
-45
0
45
90
135
Two Theta(deg)

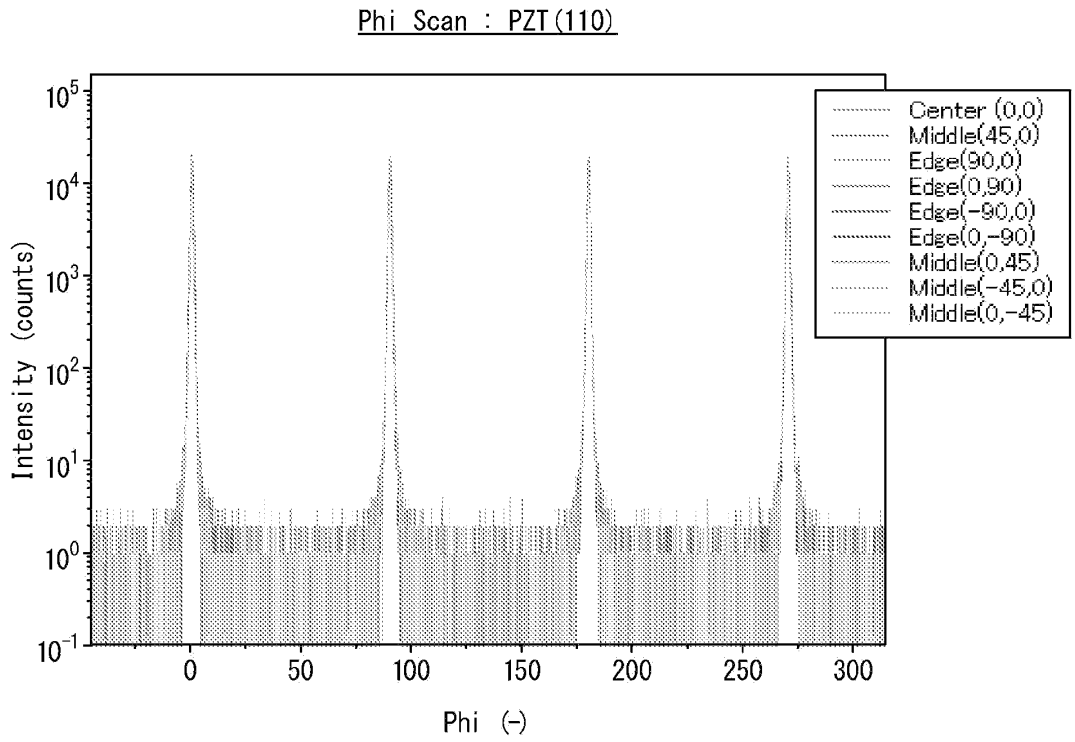
[図13]


450℃
500℃
550℃
575℃
625℃
a軸PZT
c軸PZT
Intensity (counts)
2Theta (-)
0
2000
4000
6000
8000
10000
12000
95
96
97
98
99
100
101
102
103
104

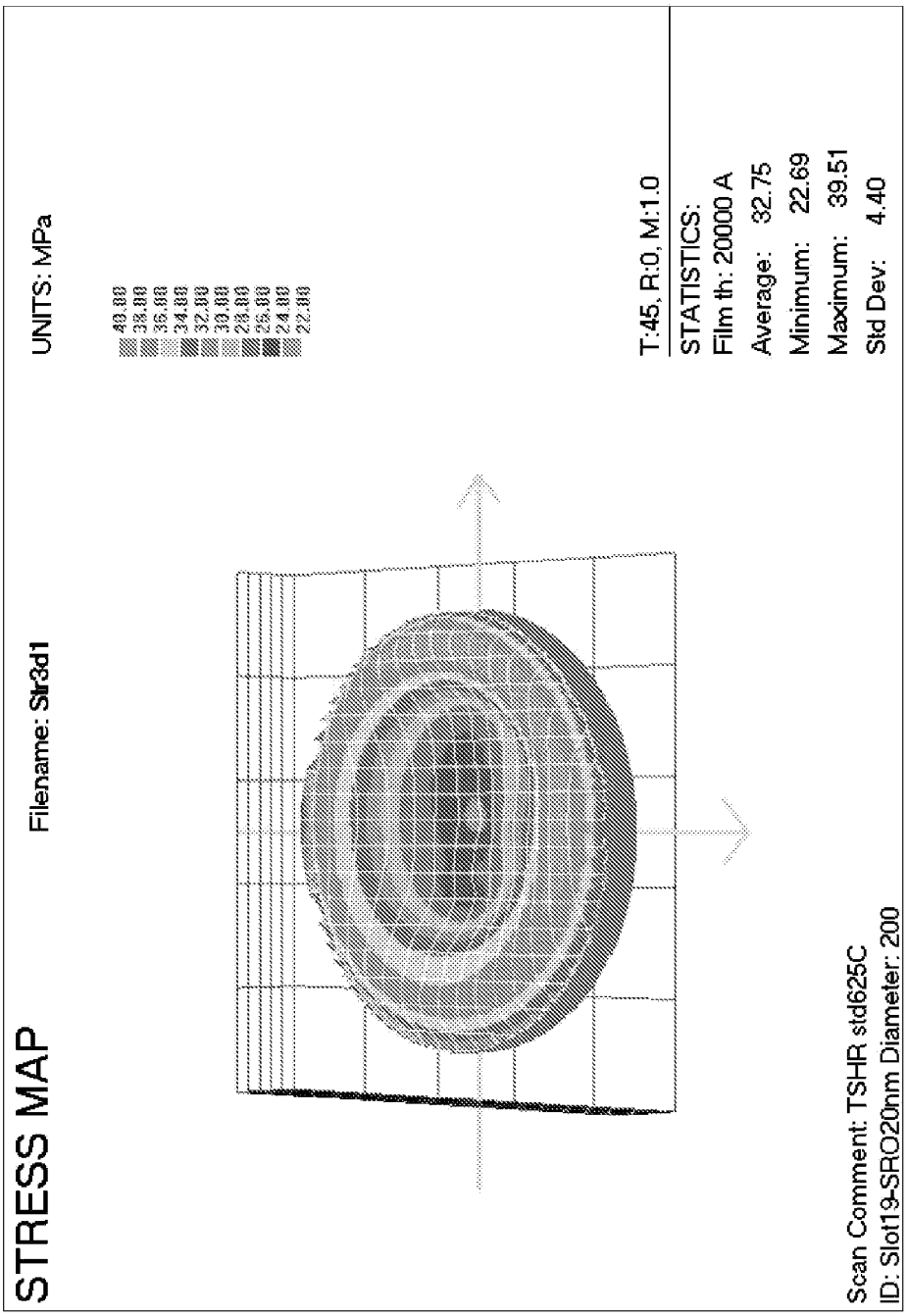
[図14]


2Theta-omega
Intensity (cps)
2Theta (-)
Center (0,0)
Middle(45,0)
Edge(90,0)
Edge(0,90)
Edge(-90,0)
Edge(0,-90)
Middle(0,45)
Middle(-45,0)
Middle(0,-45)
PZT (001)
Kβ
Y-ZrO2 (200)
Kβ
PZT (002)
Pt (200)
PZT (003)
Si (400)
Kβ
PZT (004)
Pt (400)

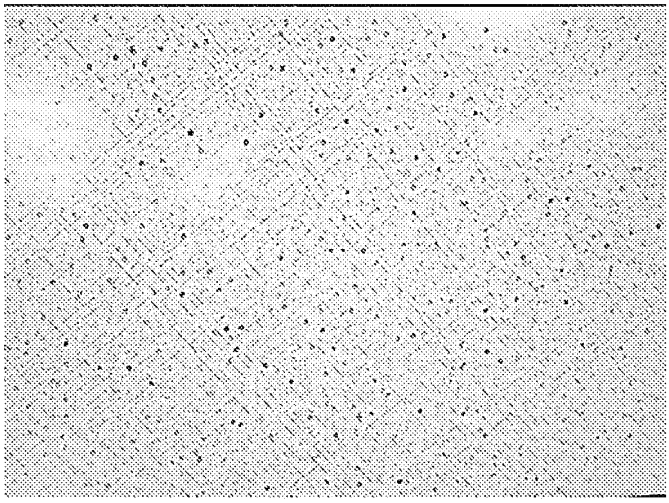
[図15]


Phi Scan : PZT(110)
Intensity (counts)
Phi (-)
Center (0,0)
Middle(45,0)
Edge(90,0)
Edge(0,90)
Edge(-90,0)
Edge(0,-90)
Middle(0,45)
Middle(-45,0)
Middle(0,-45)

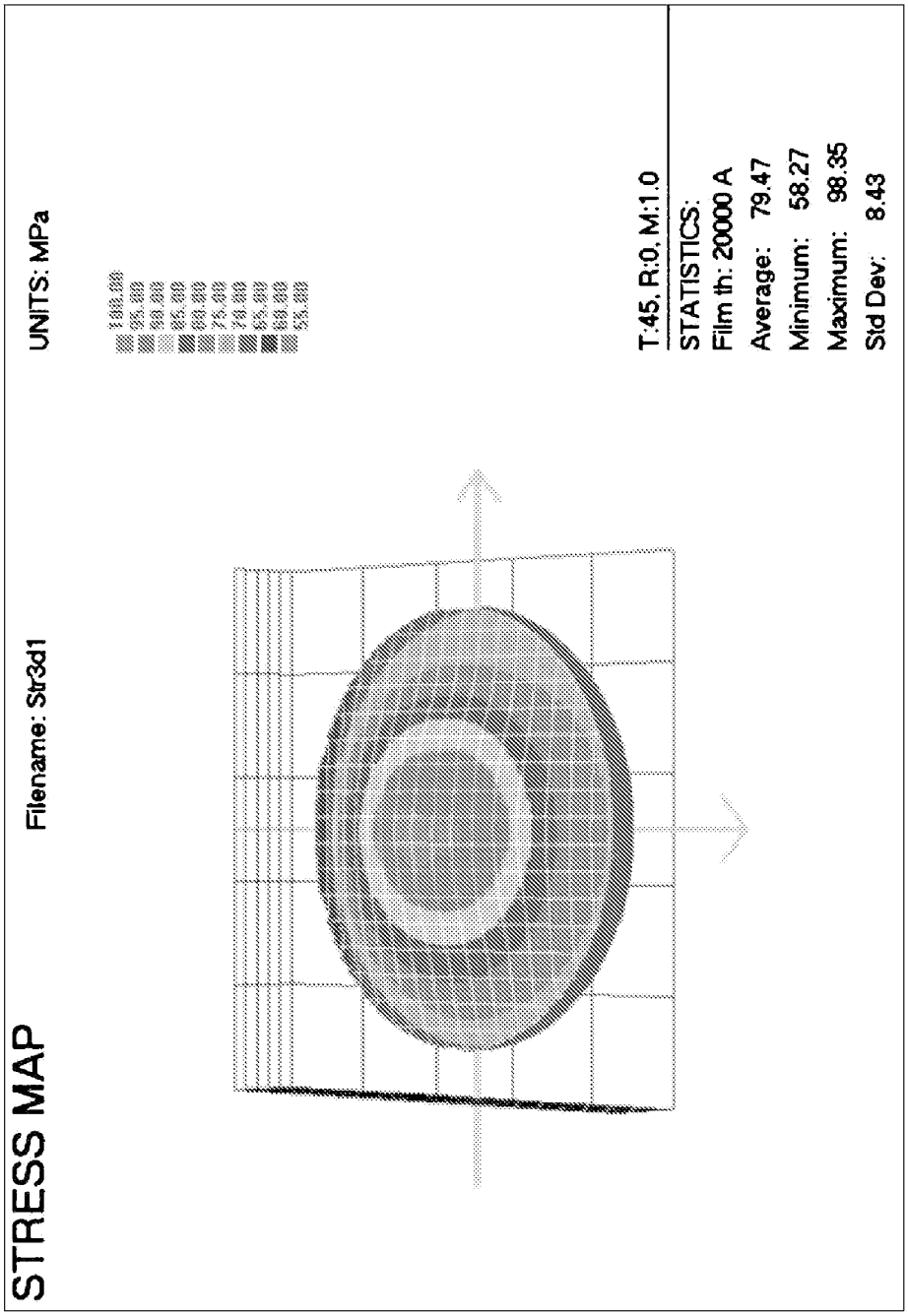
[図16]


STRESS MAP
Filename: Str3d1
UNITS: MPa
40.00
38.00
36.00
34.00
32.00
30.00
28.00
26.00
24.00
22.00
T:45, R:0, M:1.0
STATISTICS:
Film th: 20000 A
Average: 32.75
Minimum: 22.69
Maximum: 39.51
Std Dev: 4.40
Scan Comment: TSHR std625C
ID: Slot19-SRO20nm Diameter: 200

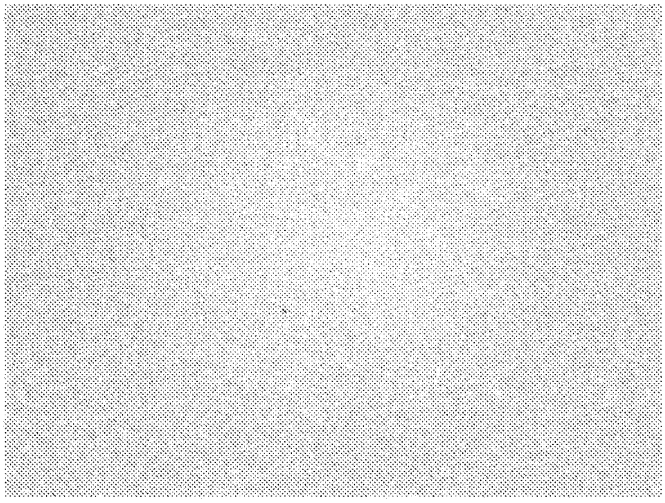
[図17]



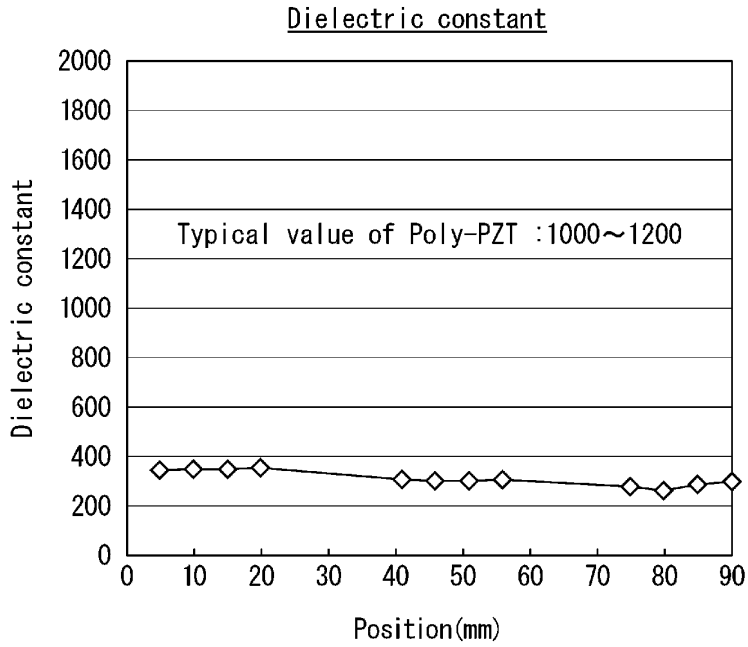
[図18]


STRESS MAP
Filename: Str3d1
UNITS: MPa
T:45, R:0, M:1.0
STATISTICS:
Film th: 20000 A
Average: 79.47
Minimum: 58.27
Maximum: 98.35
Std Dev: 8.43

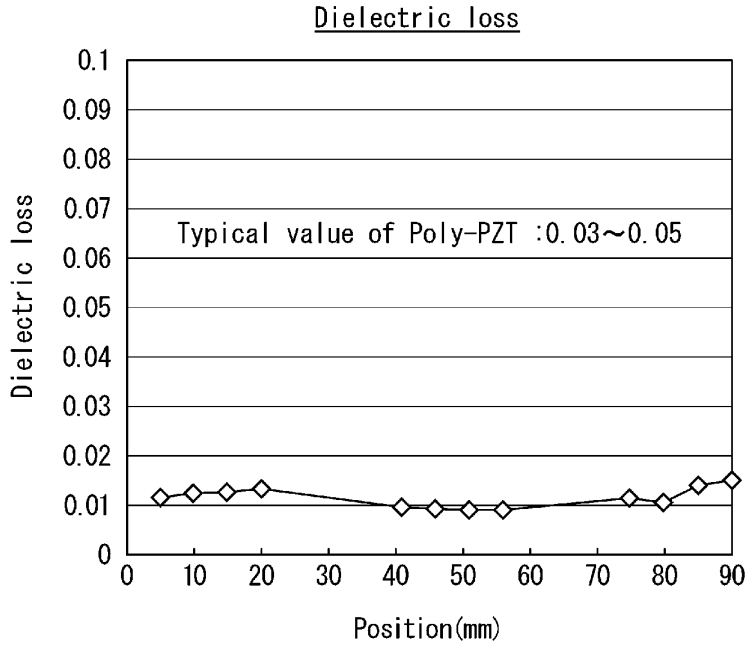
[図19]



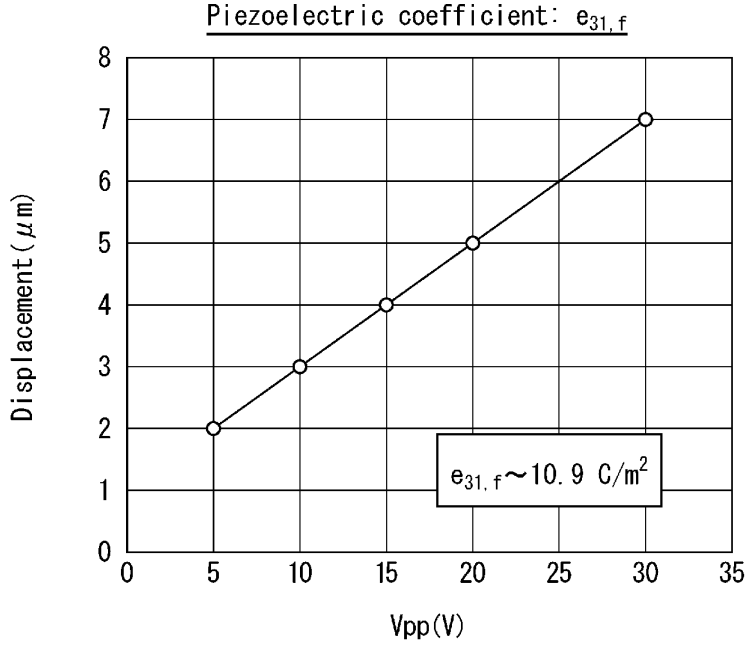
[図20]


Dielectric constant
Dielectric constant
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Typical value of Poly-PZT :1000～1200
0
10
20
30
40
50
60
70
80
90
Position(mm)

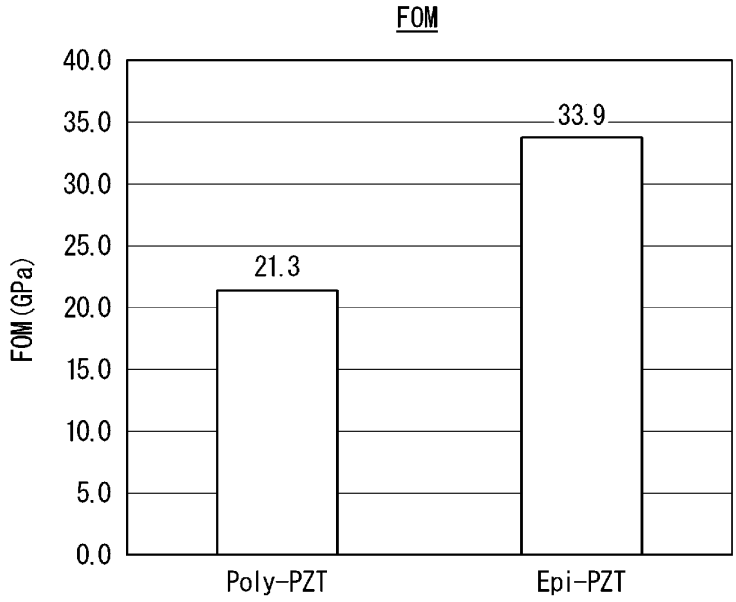
[図21]


Dielectric loss
Typical value of Poly-PZT :0.03～0.05
Dielectric loss
Position(mm)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
70
80
90

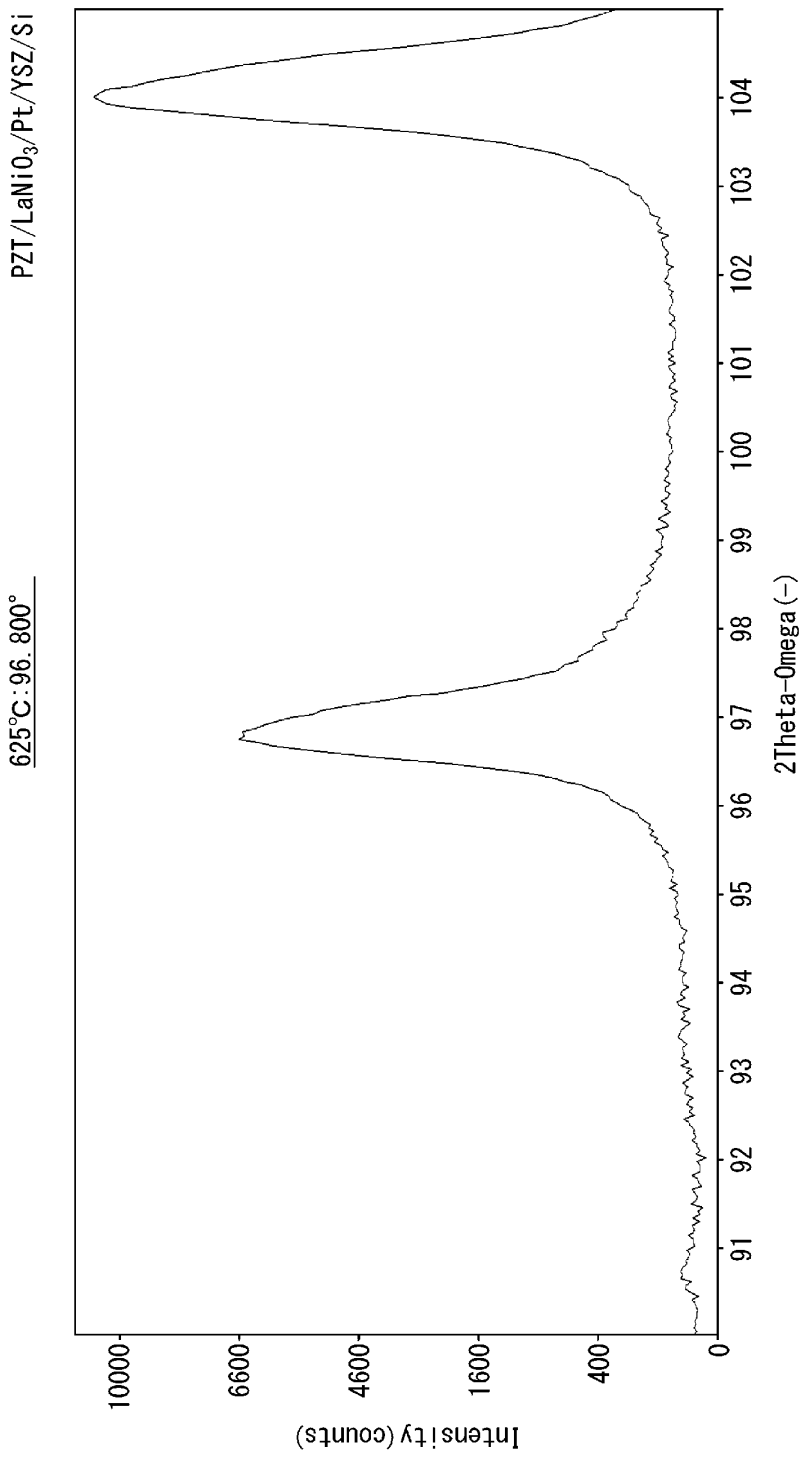
[図22]


Piezoelectric coefficient: $e_{31,f}$
$e_{31,f}$～10.9 C/m^2
Displacement(μm)
Vpp(V)
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
30
35

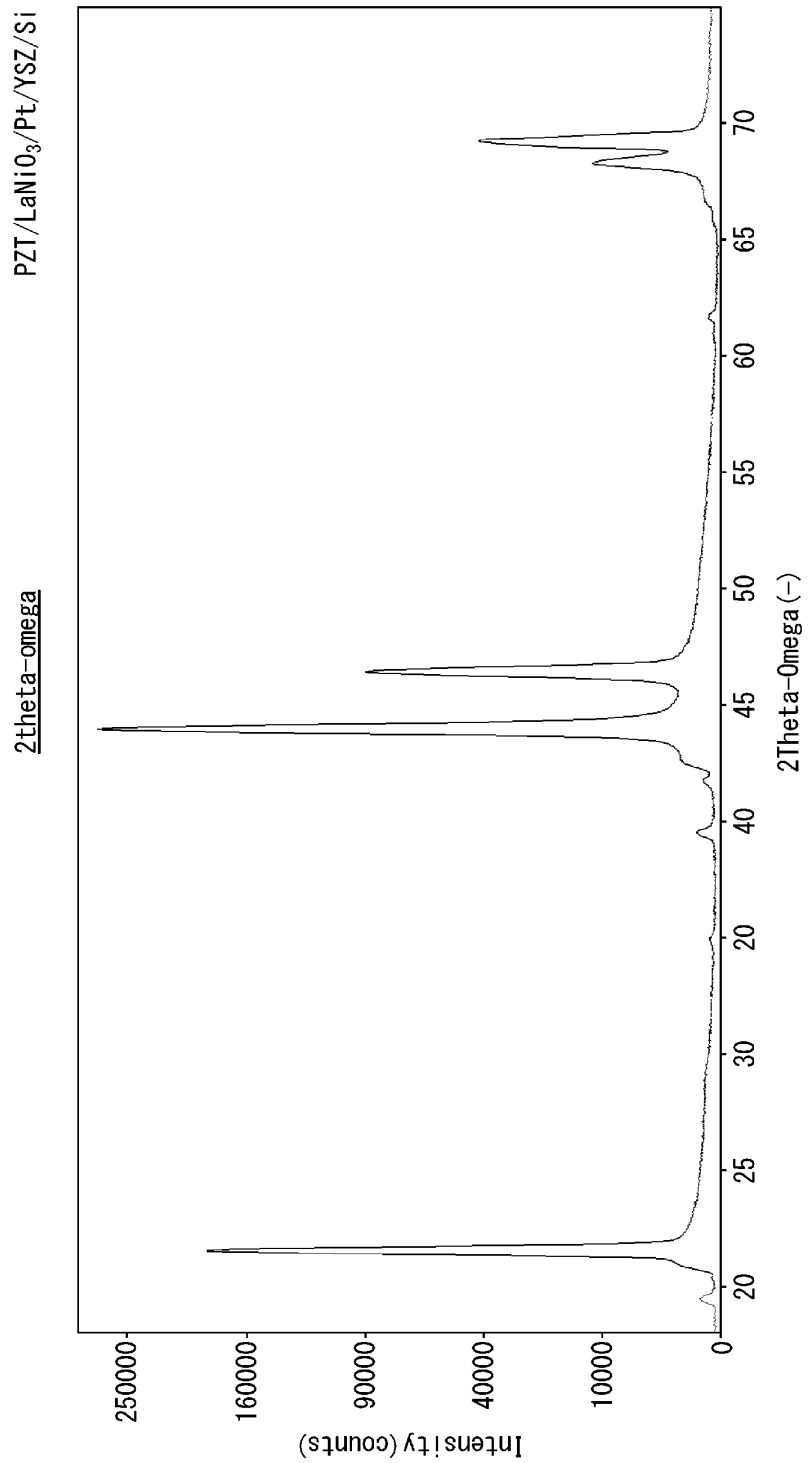
[図23]


FOM
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
FOM(GPa)
21.3
33.9
Poly-PZT
Epi-PZT

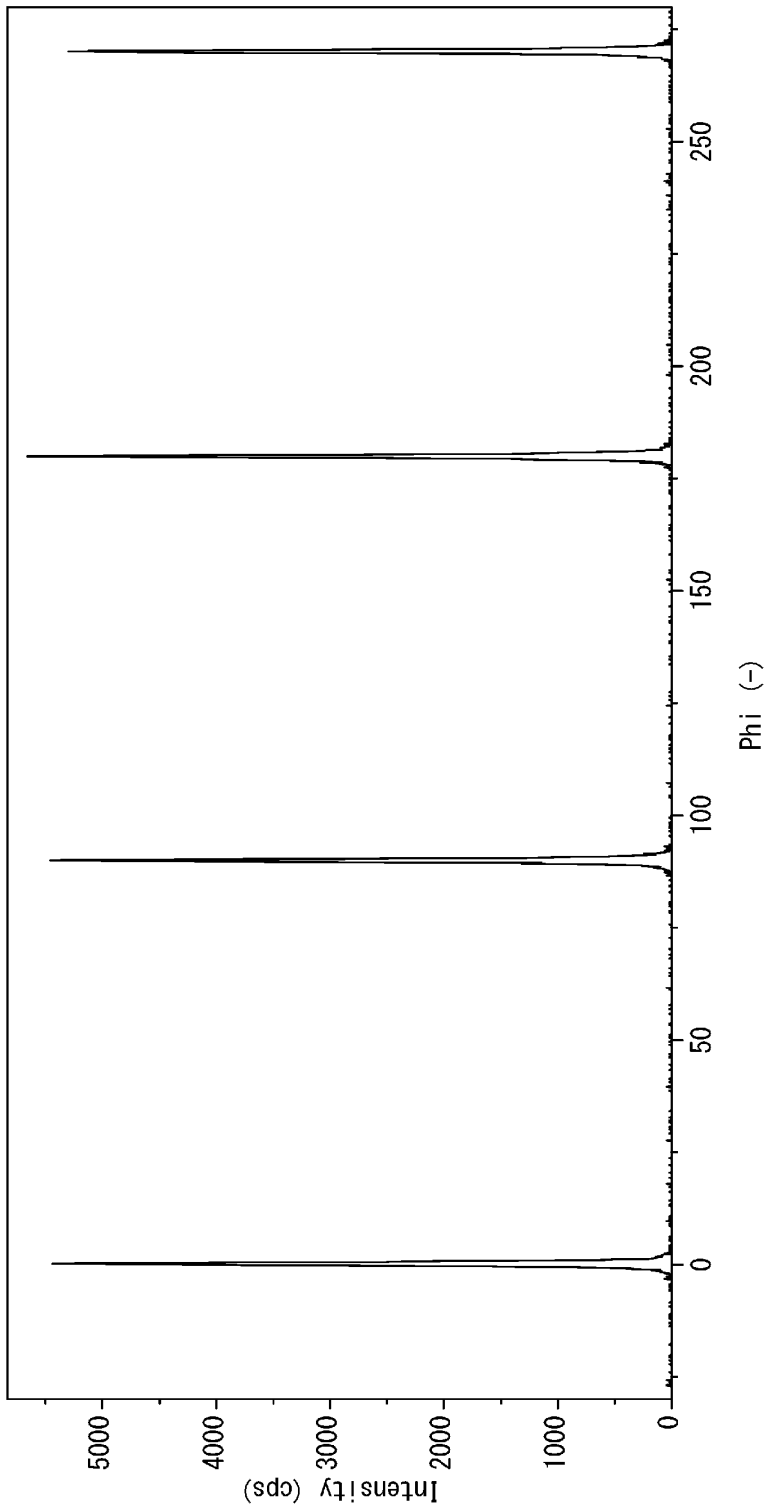
[図24]


PZT/LaNiO3/Pt/YSZ/Si
625℃:96.800°
Intensity (counts)
10000
6600
4600
1600
400
0
91
92
93
94
95
96
97
98
99
100
101
102
103
104
2Theta-Omega(-)

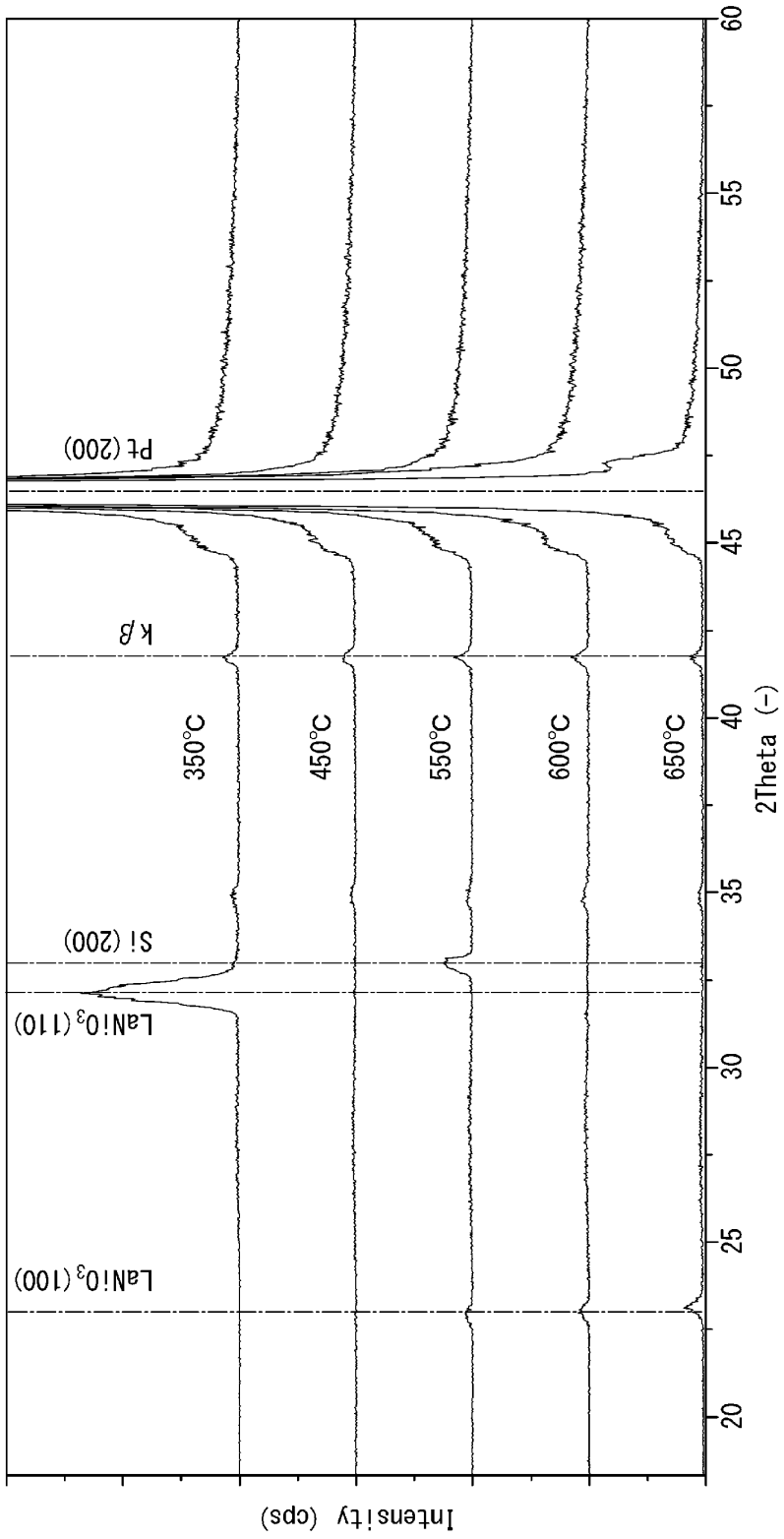
[図25]


PZT/LaNiO3/Pt/YSZ/Si
2theta-omega
Intensity (counts)
250000
160000
90000
40000
10000
0
20
25
30
20
40
45
50
55
60
65
70
2Theta-Omega (-)

[図26]


Intensity (cps)
0
1000
2000
3000
4000
5000
0
50
100
150
200
250
Phi (-)

[図27]


Intensity (cps)
2Theta (-)
20
25
30
35
40
45
50
55
60
350℃
450℃
550℃
600℃
650℃
kβ
Pt(200)
LaNiO3(100)
LaNiO3(110)
Si(200)