Fig. 1

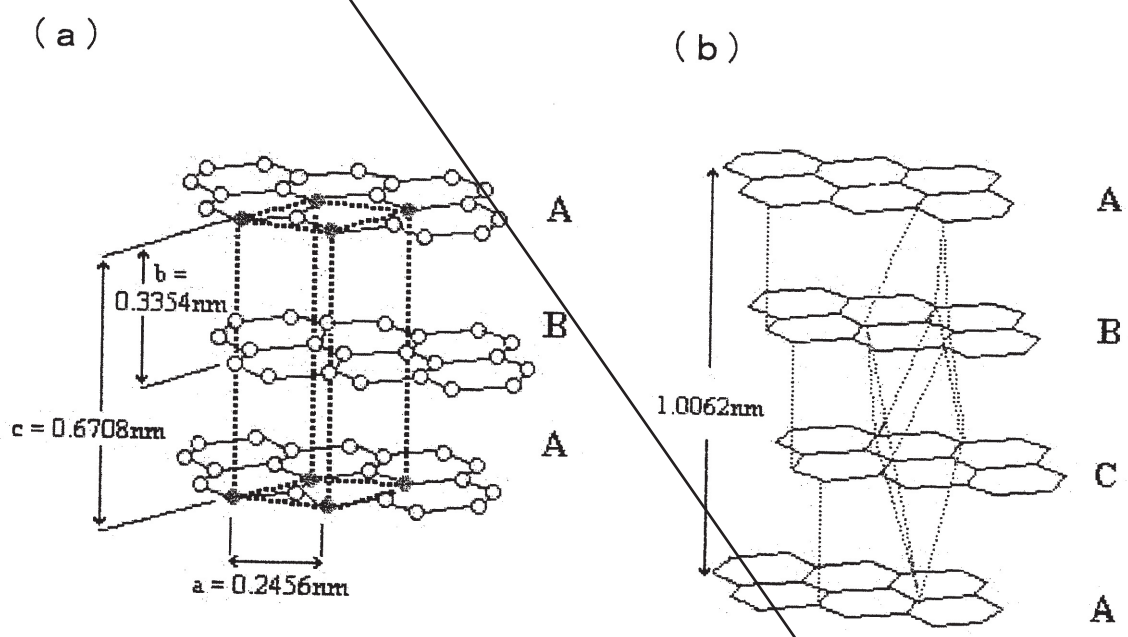


Fig. 2

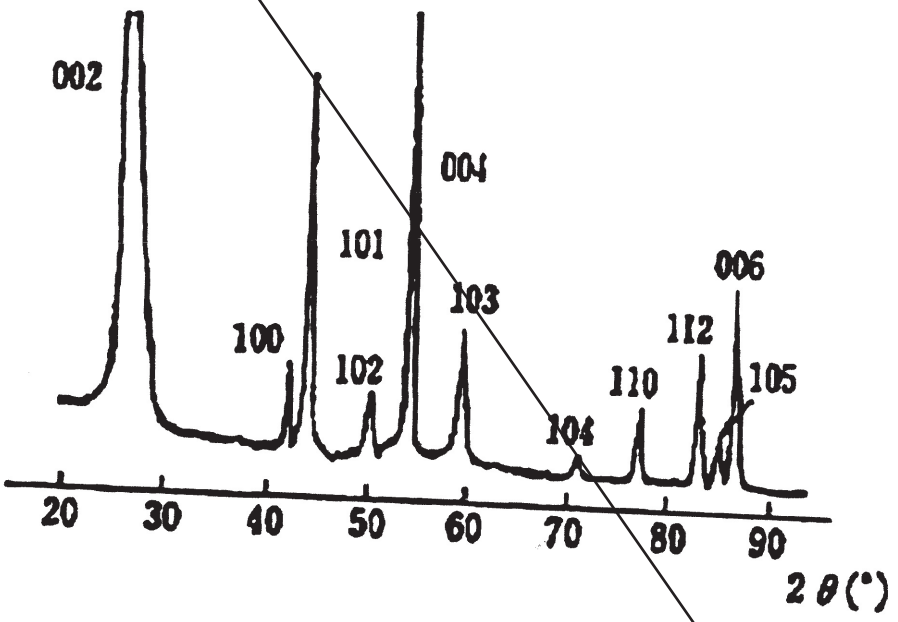

002
100
101
102
004
103
104
110
112
006
105
20
30
40
50
60
70
80
90
2θ(°)

Fig. 3

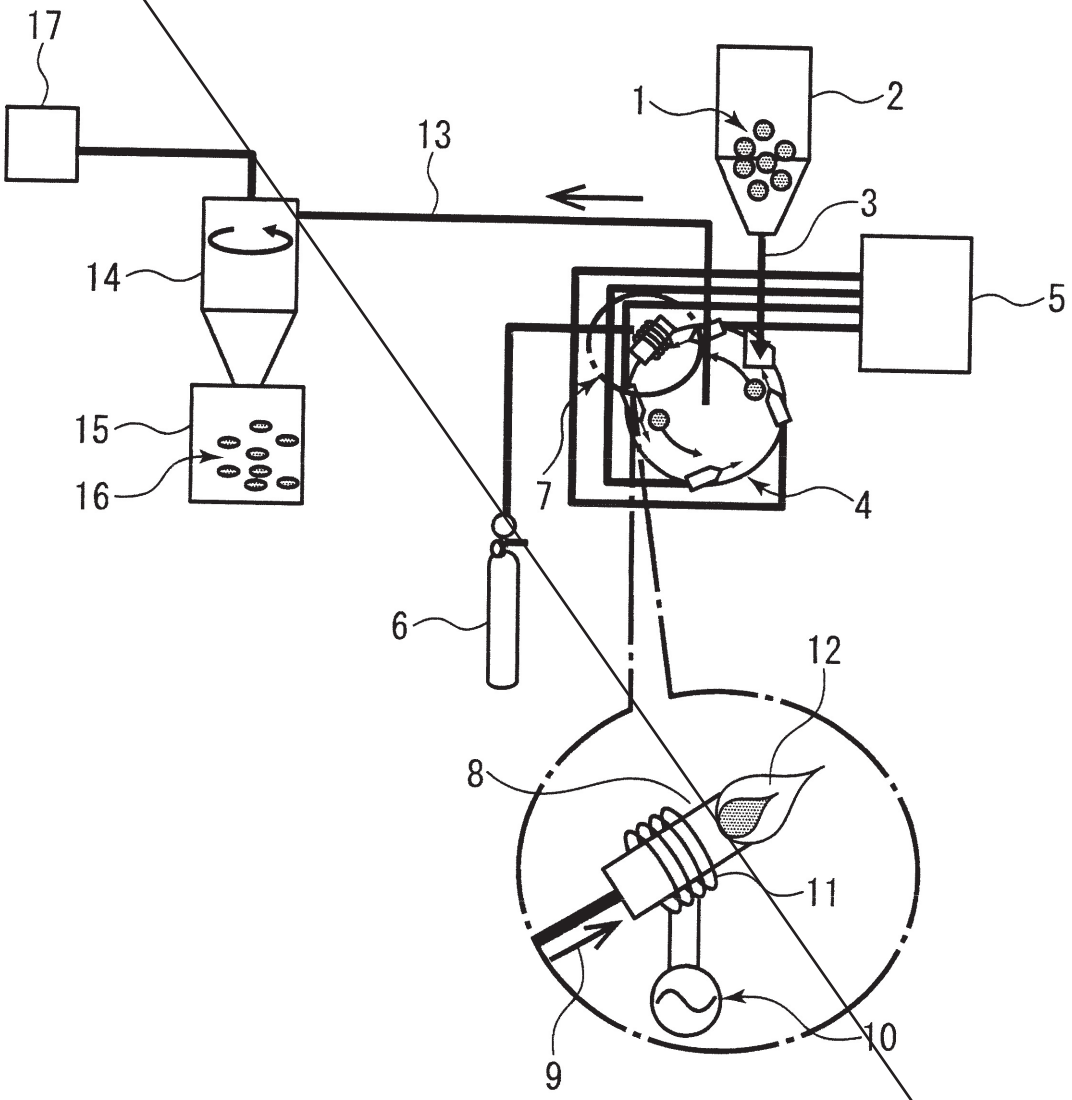
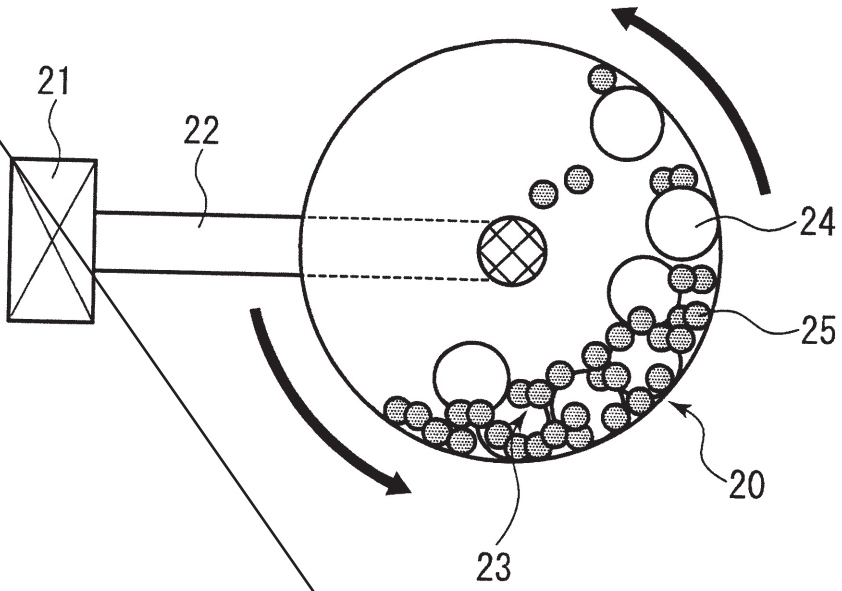


Fig. 4

(a)



(b)

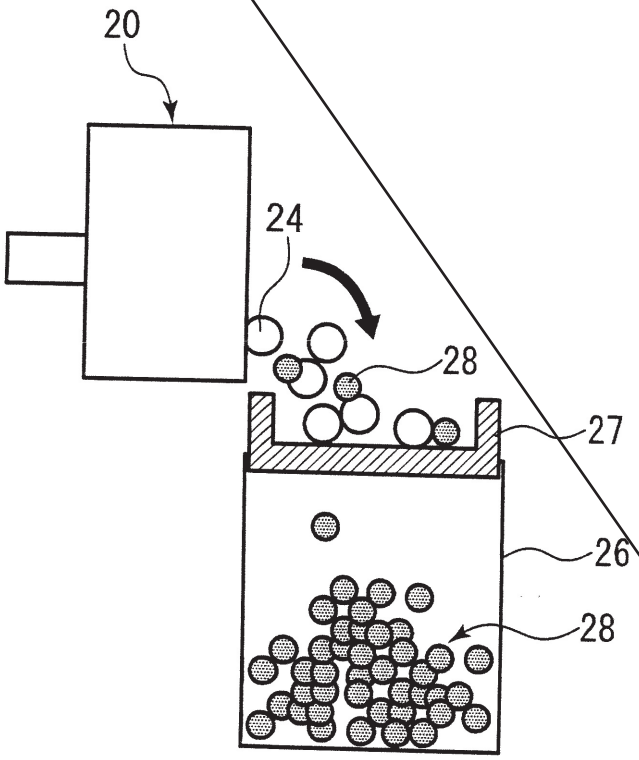


Fig. 5

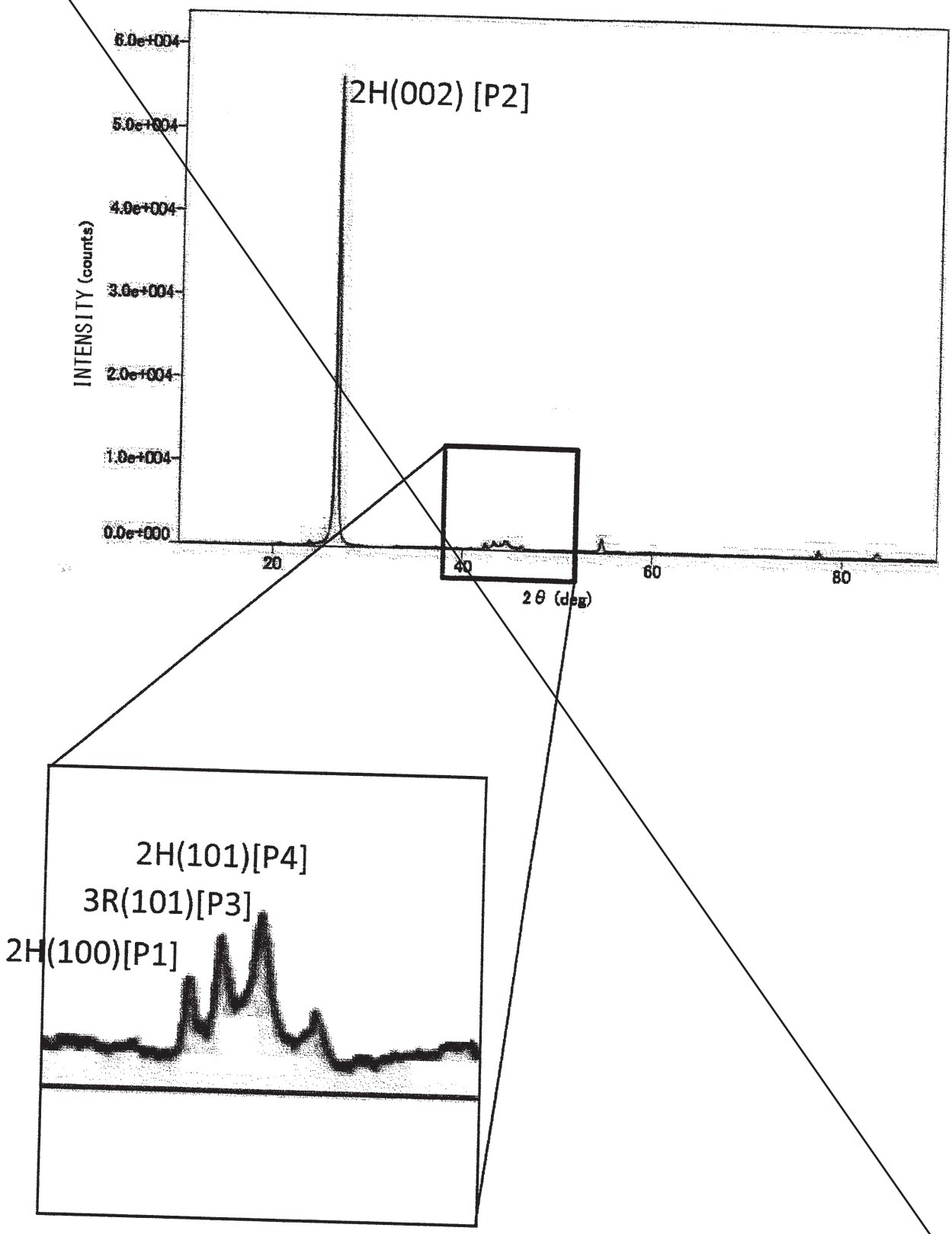

2H(002) [P2]
6.0e+004
5.0e+004
4.0e+004
3.0e+004
2.0e+004
1.0e+004
0.0e+000
INTENSITY (counts)
20
40
60
80
2θ (deg)
2H(101)[P4]
3R(101)[P3]
2H(100)[P1]

Fig. 6

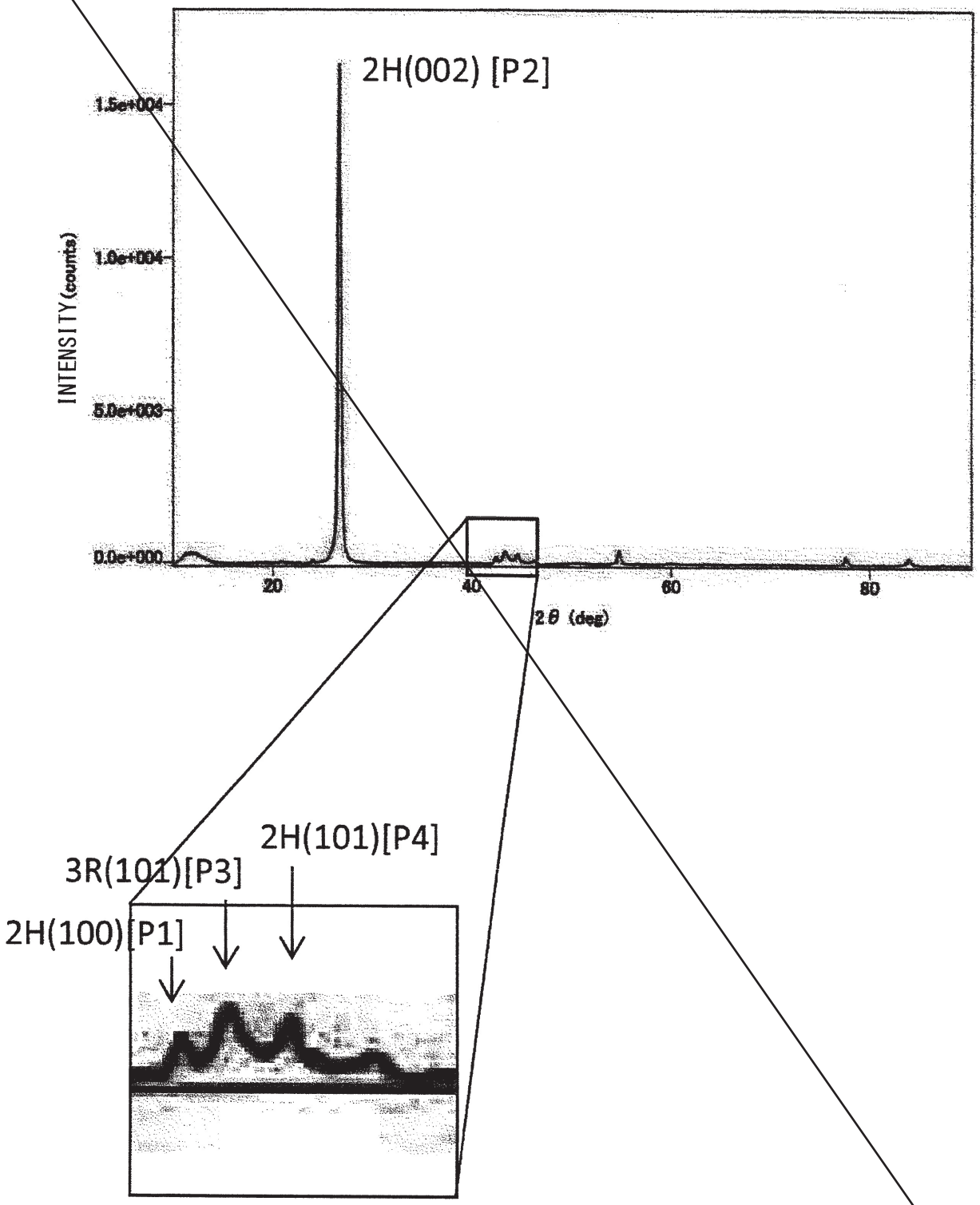

2H(002) [P2]
1.5e+004
1.0e+004
5.0e+003
0.0e+000
INTENSITY (counts)
20
40
60
80
2θ (deg)
2H(101)[P4]
3R(101)[P3]
2H(100)[P1]

Fig. 7

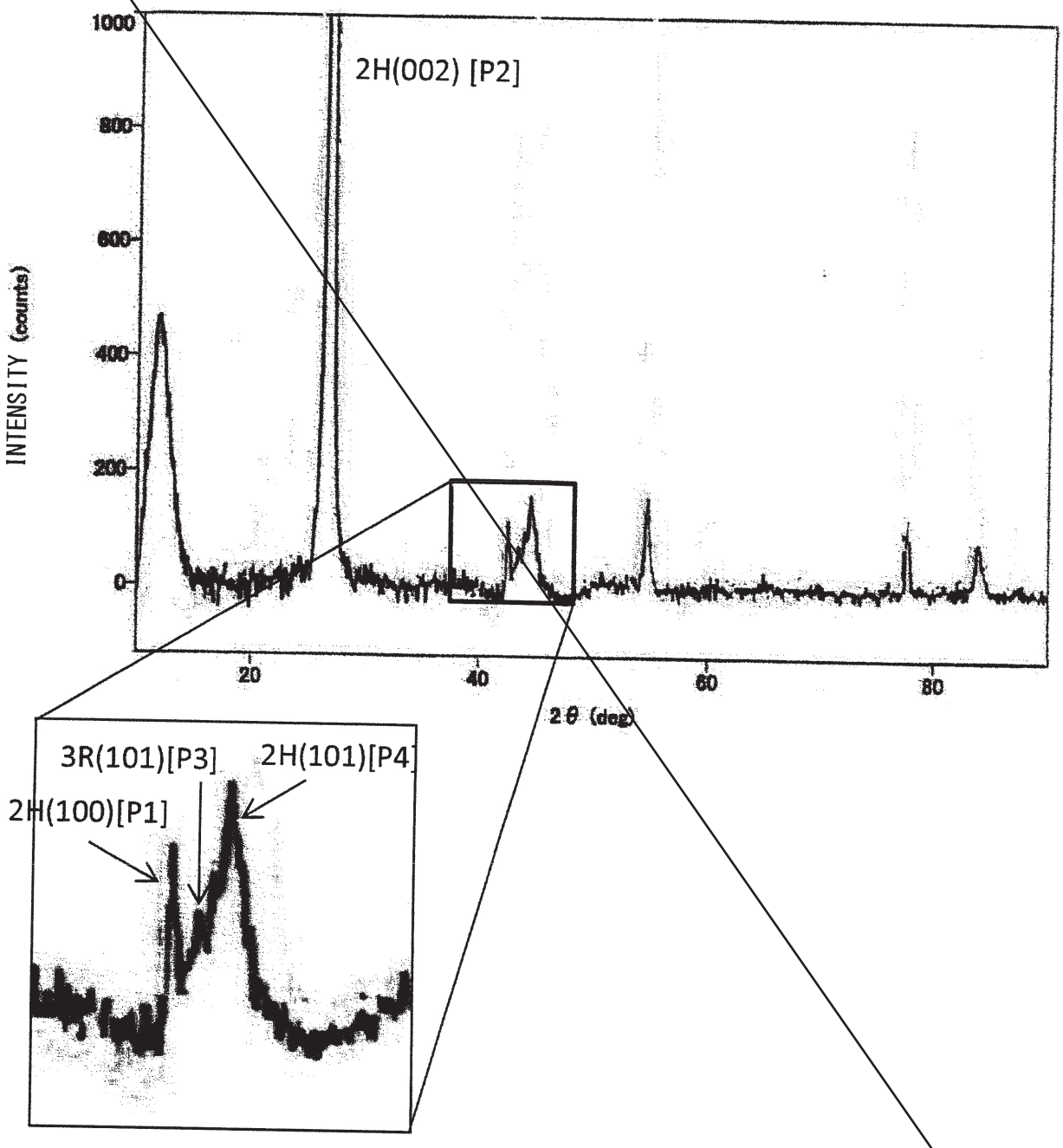

1000
800
600
400
200
0
INTENSITY (counts)
2H(002) [P2]
20
40
60
80
2θ (deg)
3R(101)[P3]
2H(101)[P4]
2H(100)[P1]

Fig. 8

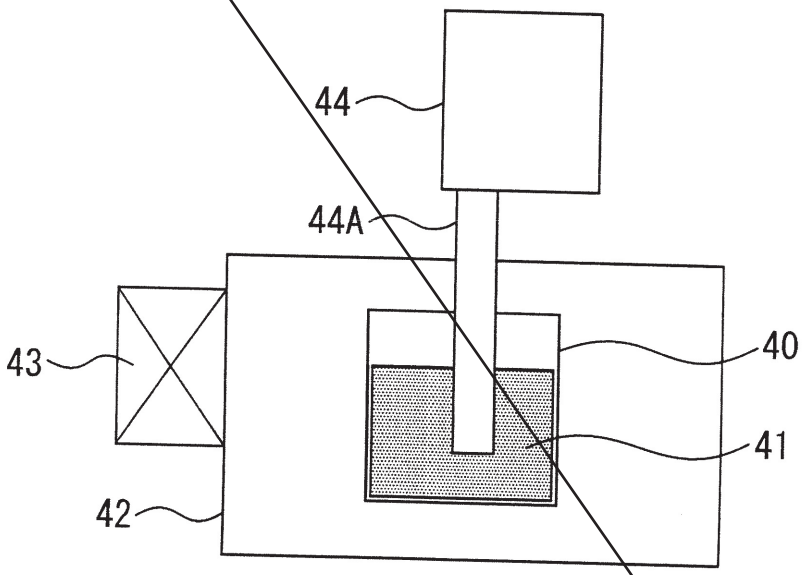
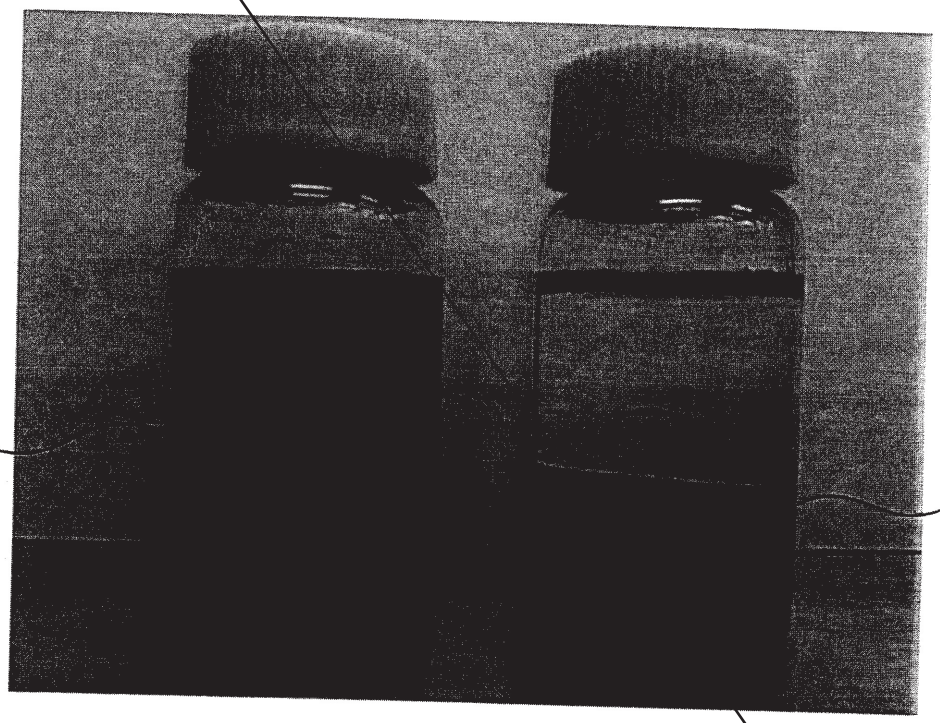


Fig. 9



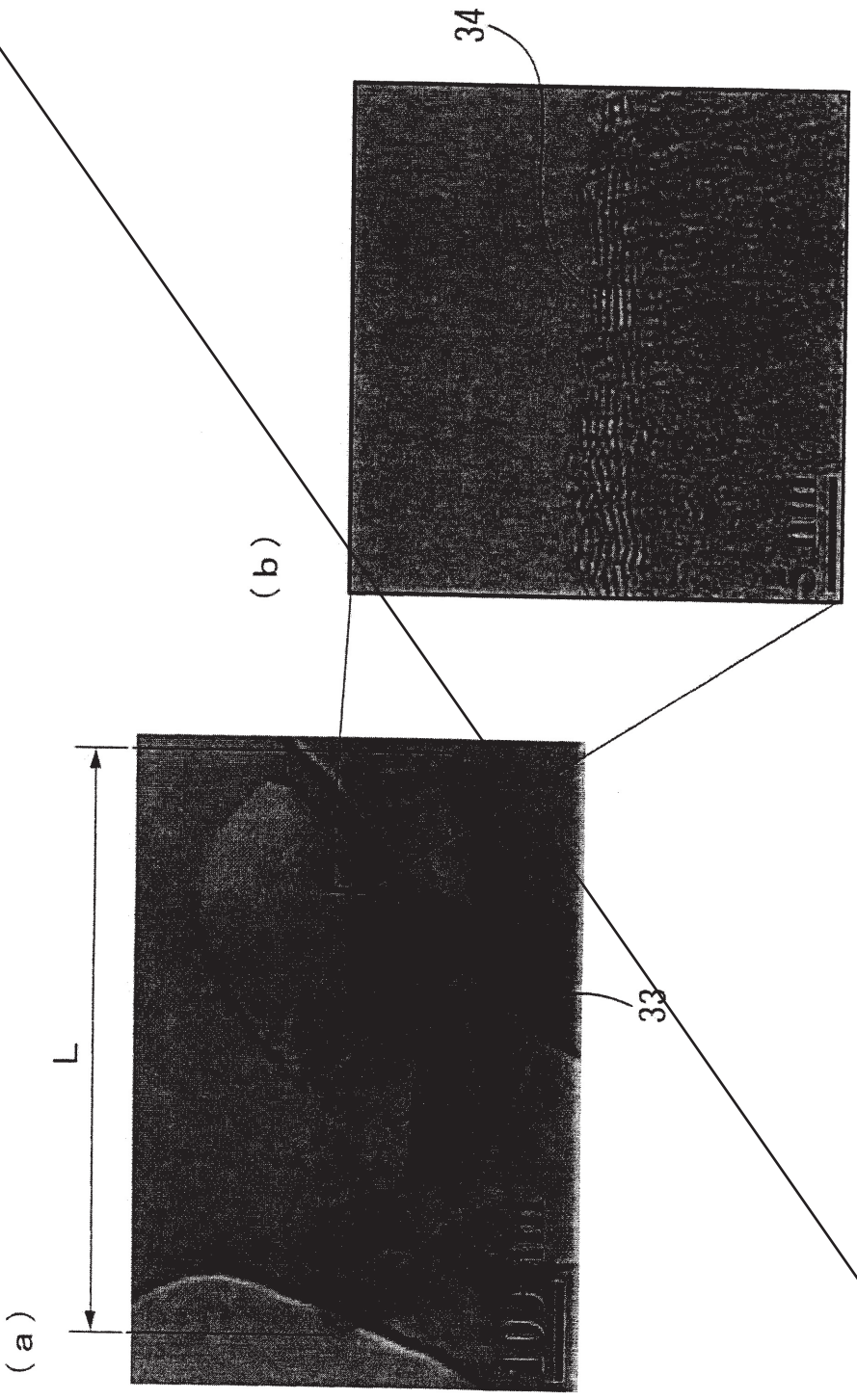
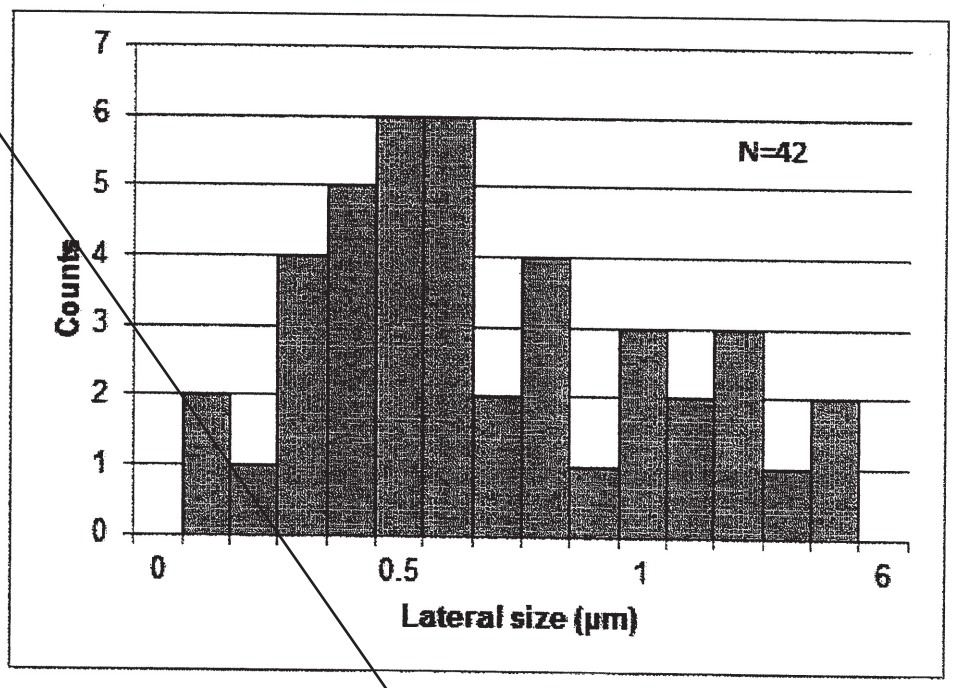


Fig. 10

Fig. 11

(a)


N=42
Counts
Lateral size (μm)
0
1
2
3
4
5
6
7
0
0.5
1
6

(b)

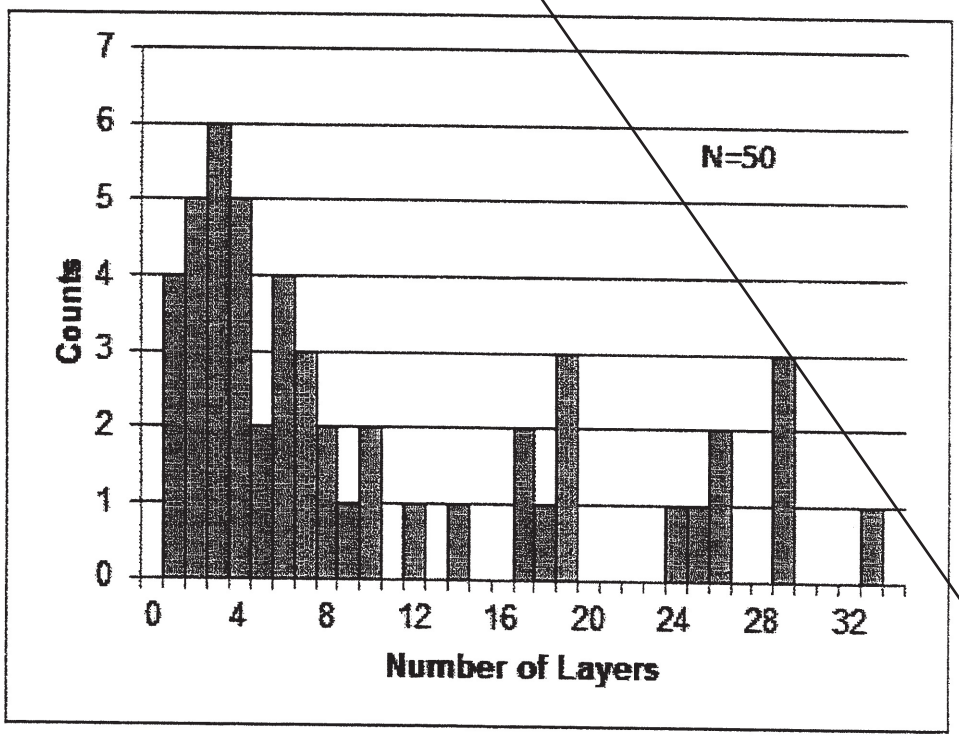
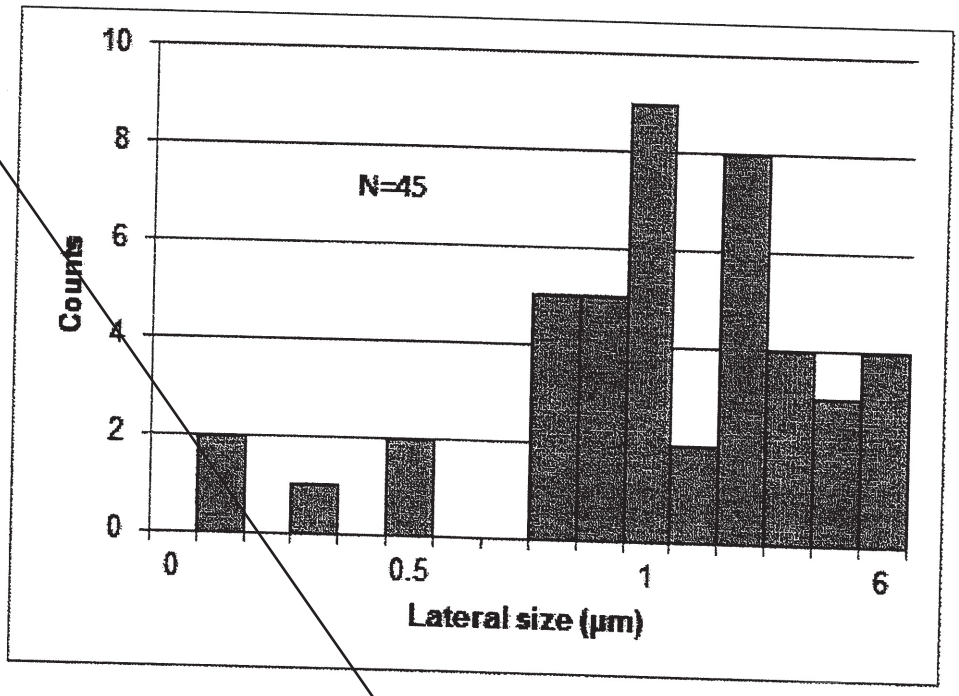

N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

Fig. 12

(a)


10
8
6
4
2
0
Counts
N=45
0
0.5
1
6
Lateral size (μm)

(b)

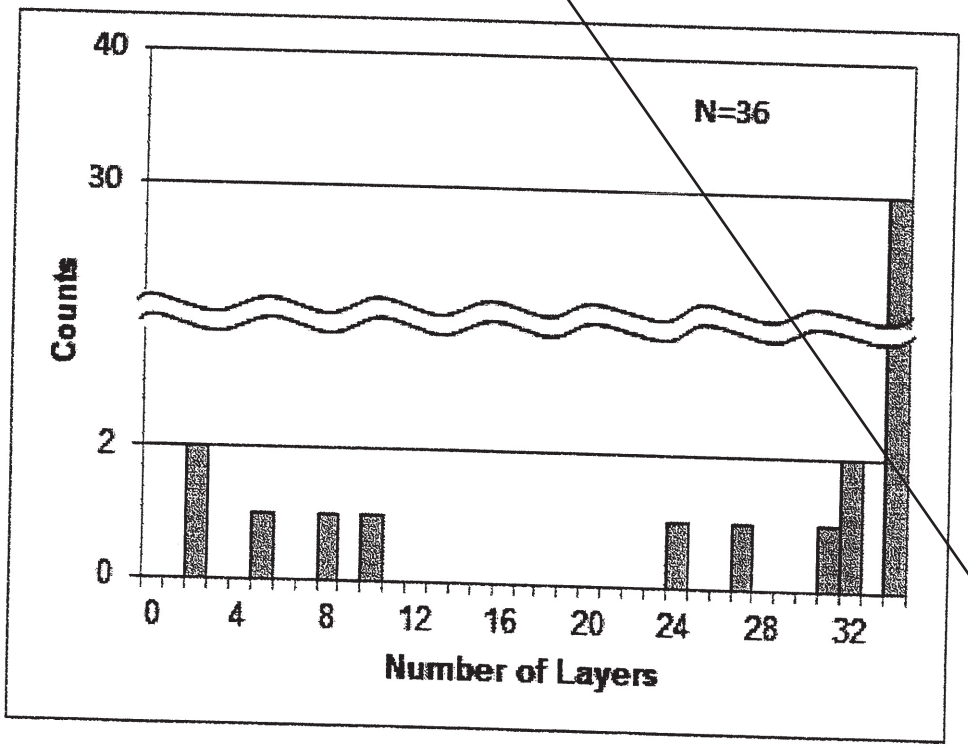
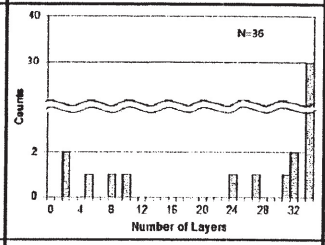
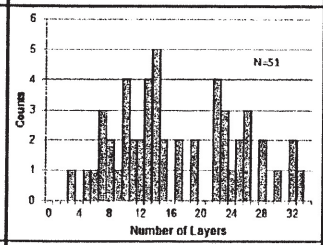
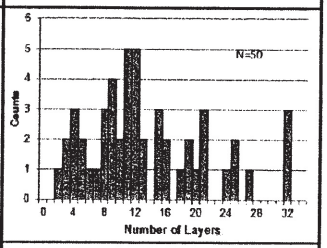

40
30
2
0
Counts
N=36
0
4
8
12
16
20
24
28
32
Number of Layers

Fig. 13

SAMPLE No.	1	2	3
DISTRIBUTION OF LAYERS			
P3/(P3+P4)	23%	31%	38%
TEN LAYERS OR LESS	10%	25%	38%
P1/P2	0.008	0.016	0.016
P1	120	342	128
P2	15000	20993	8253
P3	50	321	173
P4	160	698	282

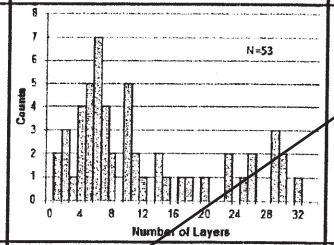
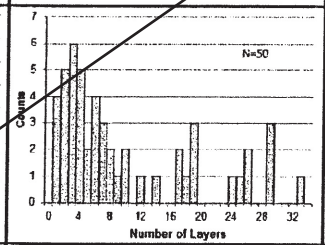
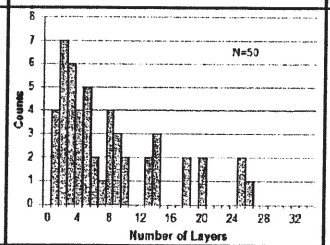
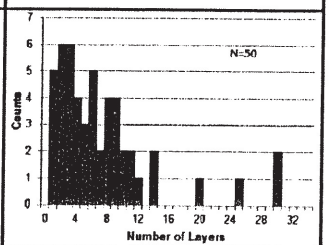
SAMPLE No.	4	5	6	7
DISTRIBUTION OF LAYERS				
P3/(P3+P4)	42%	46%	51%	58%
TEN LAYERS OR LESS	62%	68%	76%	82%
P1/P2	0.014	0.012	0.014	0.012
P1	253	162	66	151
P2	18226	13157	4675	12850
P3	320	396	170	452
P4	435	466	162	325

Fig. 14

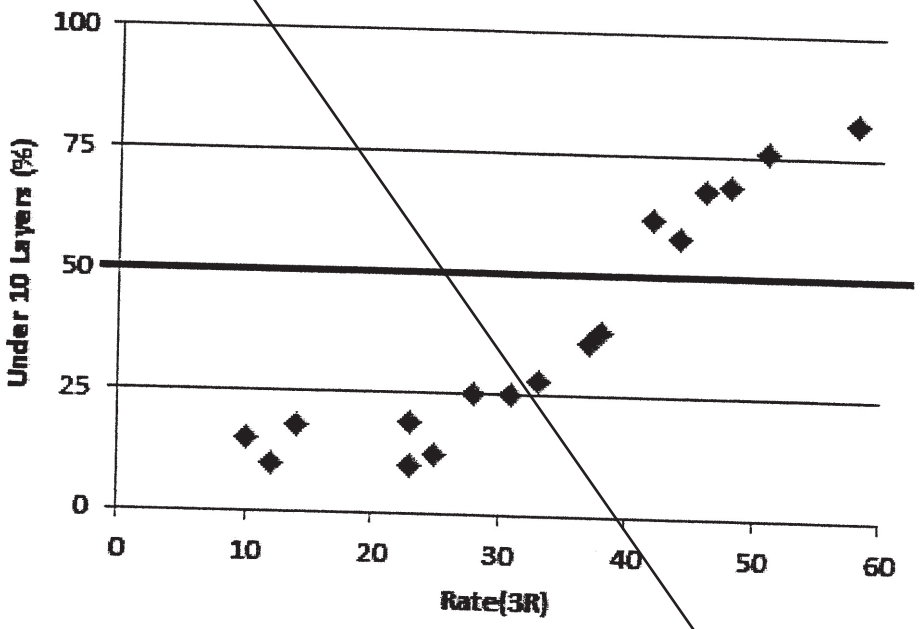
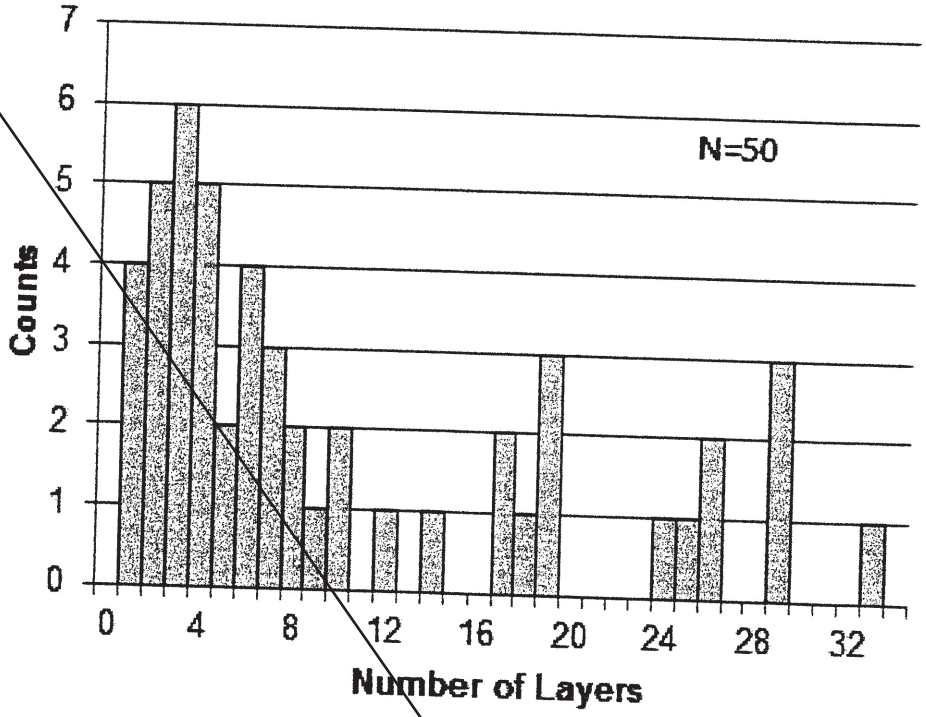


Fig. 15

(a)


N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

(b)

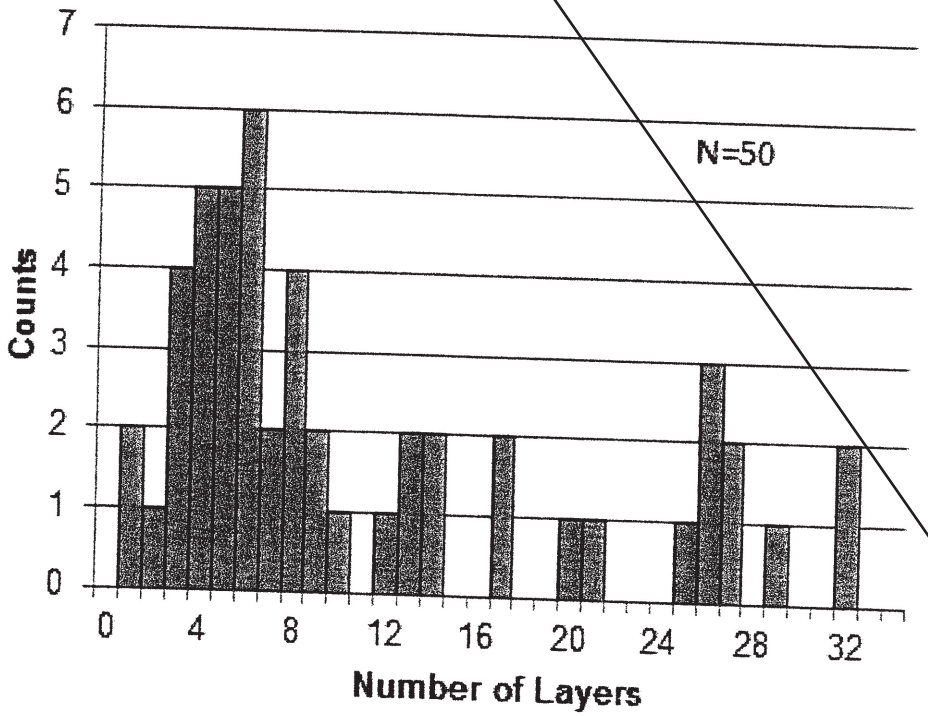

N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

Fig. 16

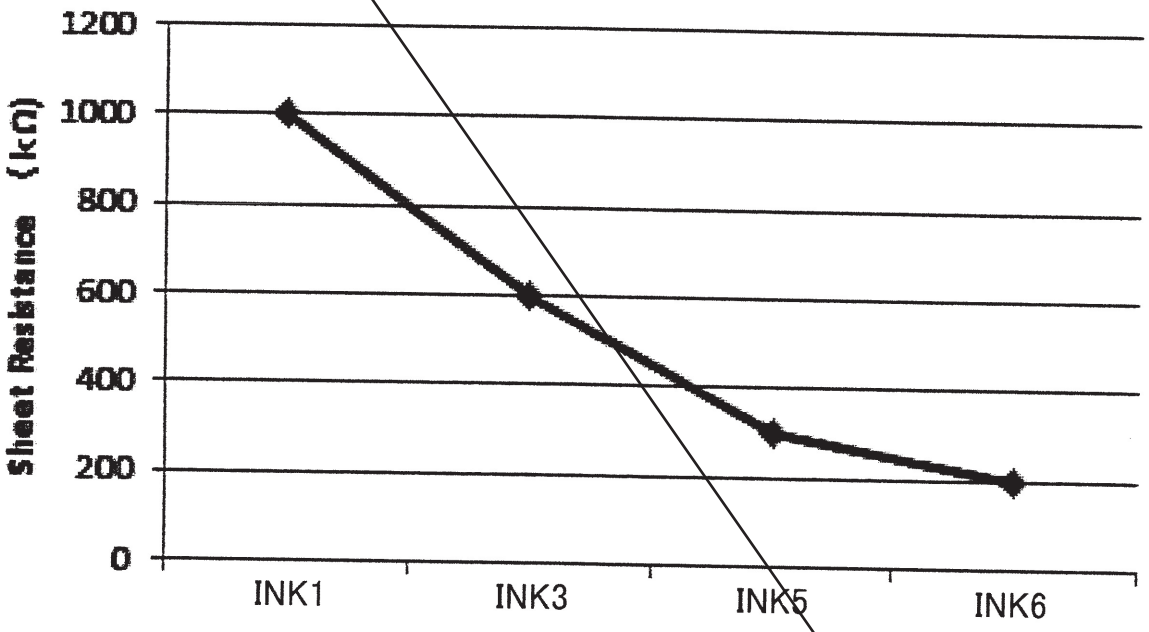

Sheet Resistance (kΩ)
1200
1000
800
600
400
200
0
INK1
INK3
INK5
INK6

Fig. 17

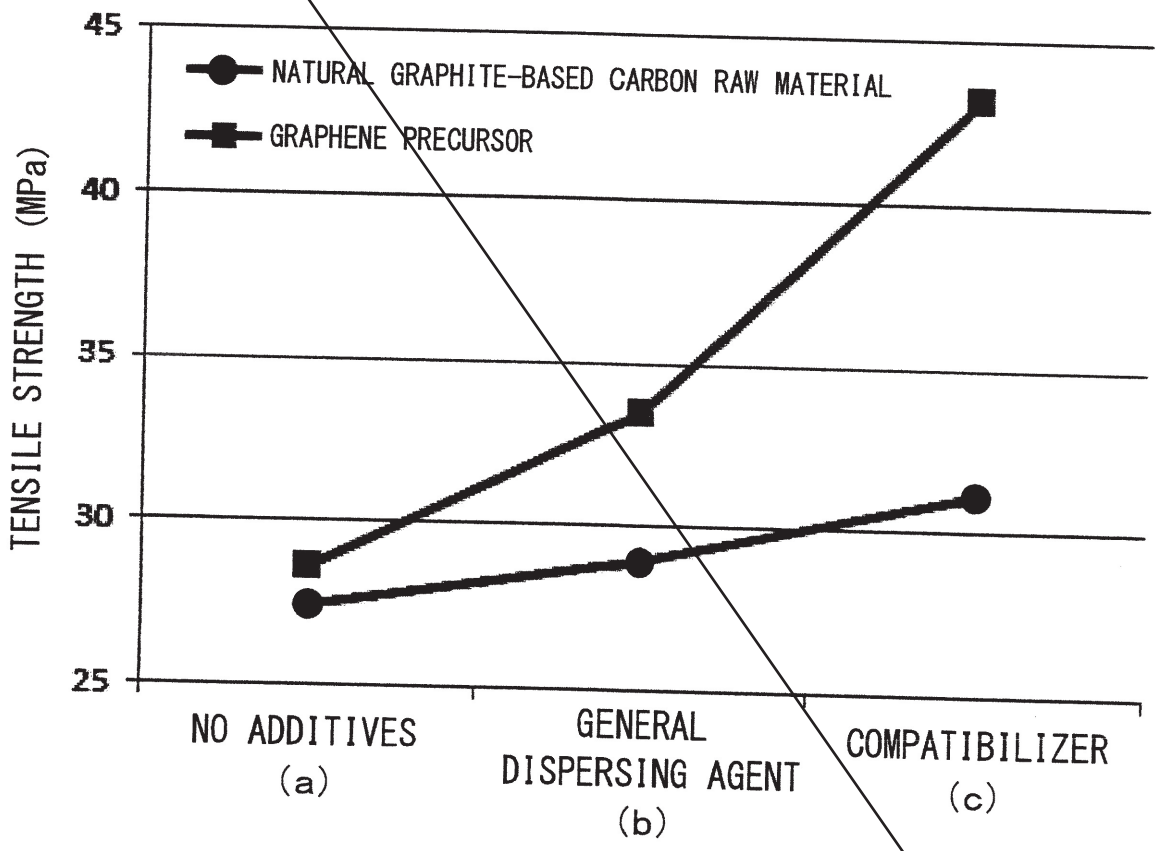

45
40
35
30
25
TENSILE STRENGTH (MPa)
NATURAL GRAPHITE-BASED CARBON RAW MATERIAL
GRAPHENE PRECURSOR
NO ADDITIVES
(a)
GENERAL
DISPERSING AGENT
(b)
COMPATIBILIZER
(c)

Fig. 18

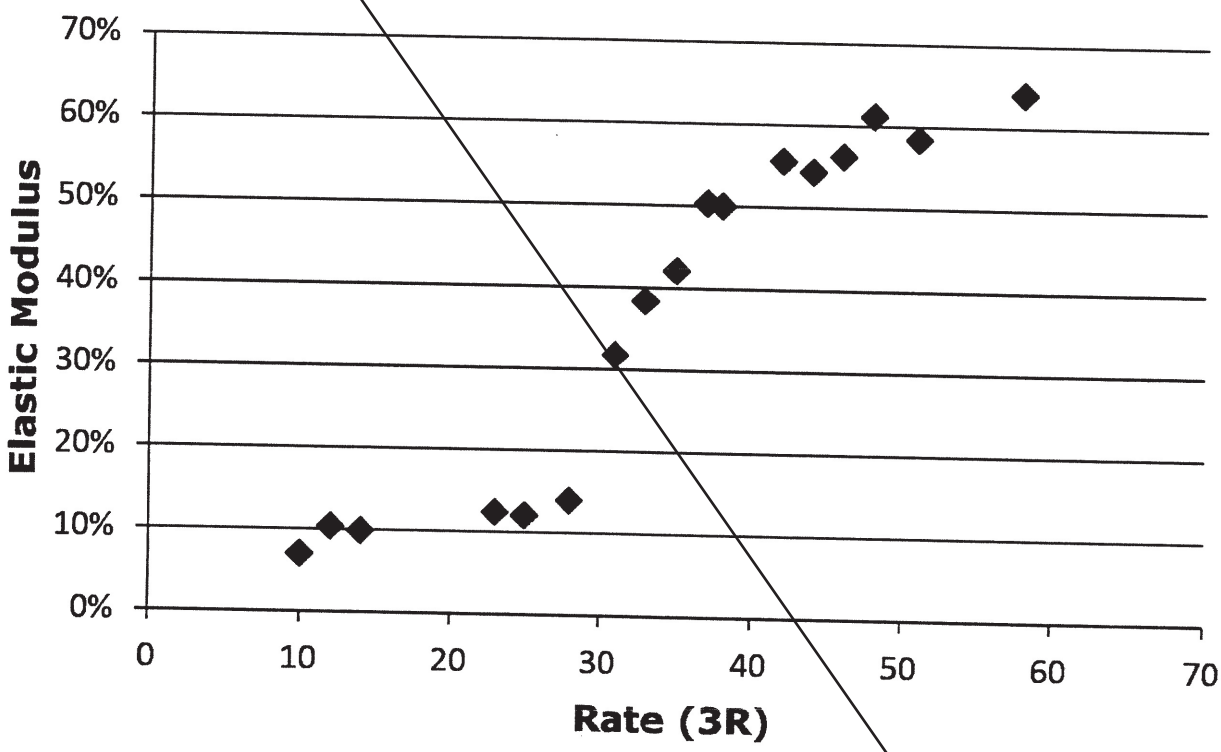
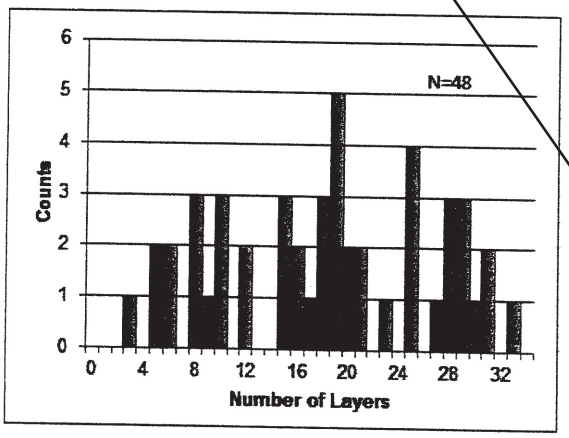

70%
60%
50%
40%
30%
20%
10%
0%
Elastic Modulus
0
10
20
30
40
50
60
70
Rate (3R)

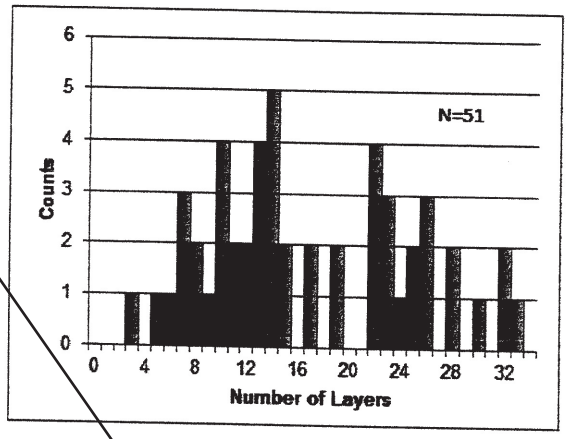
Fig. 19

(a)



P3/(P3+P4)=28%
TEN LAYERS OR LESS: 25%

(b)



P3/(P3+P4)=31%
TEN LAYERS OR LESS: 25%

Fig. 20

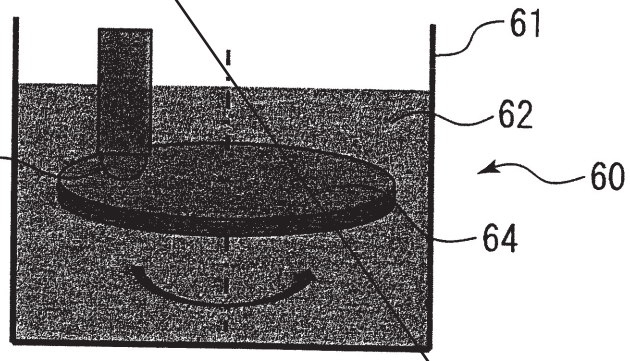


Fig. 21

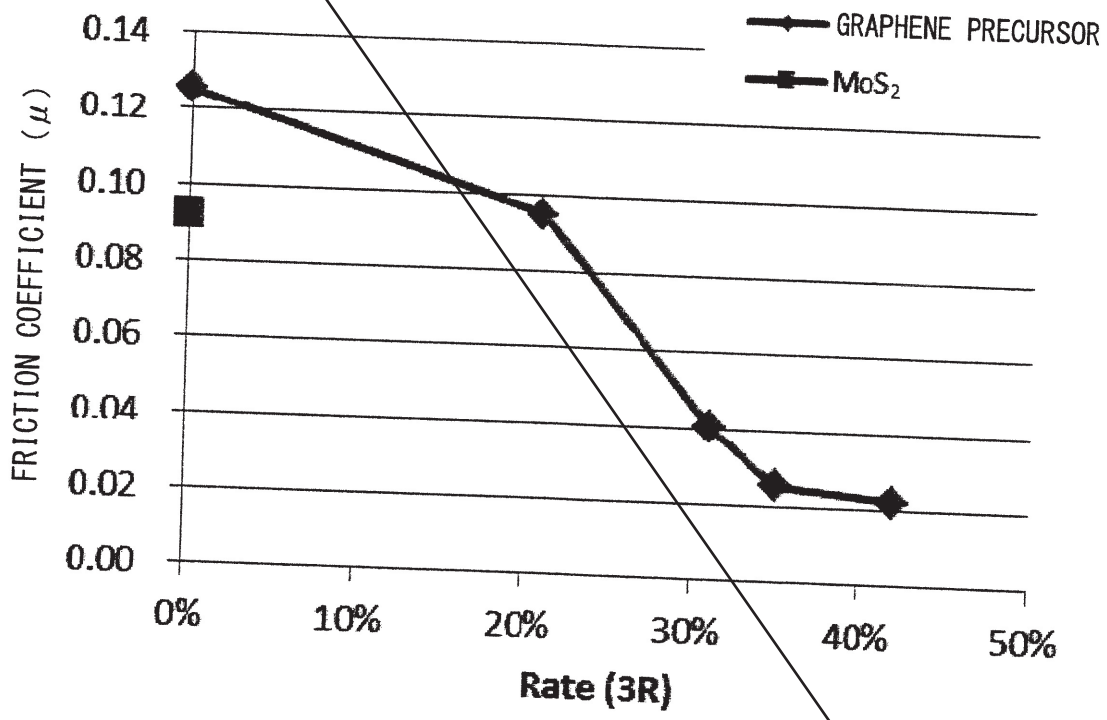

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 22

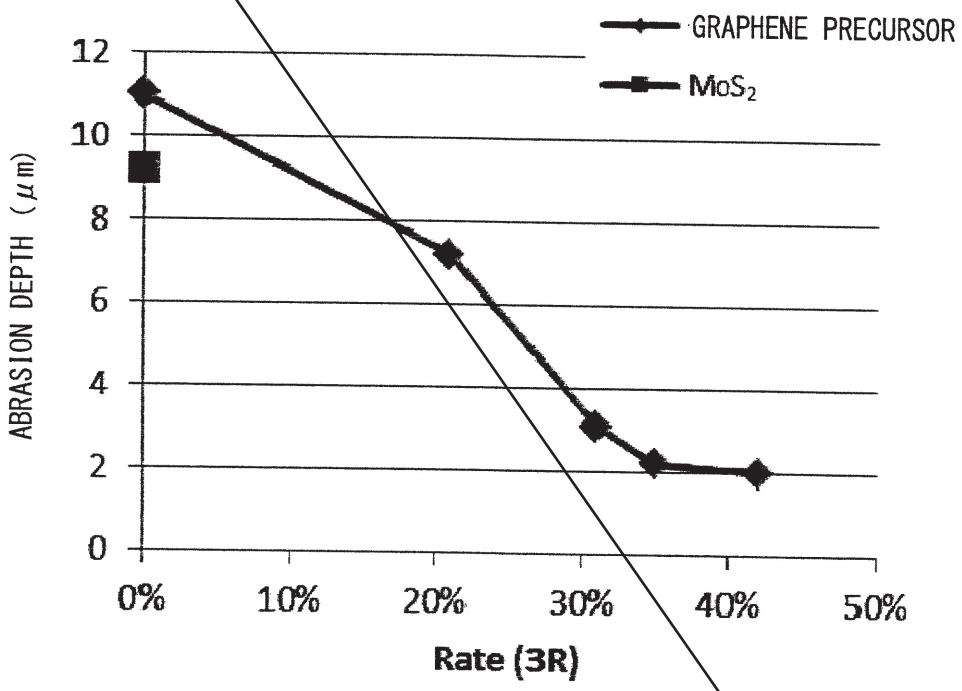

GRAPHENE PRECURSOR
MoS2
ABRASION DEPTH (μm)
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 23

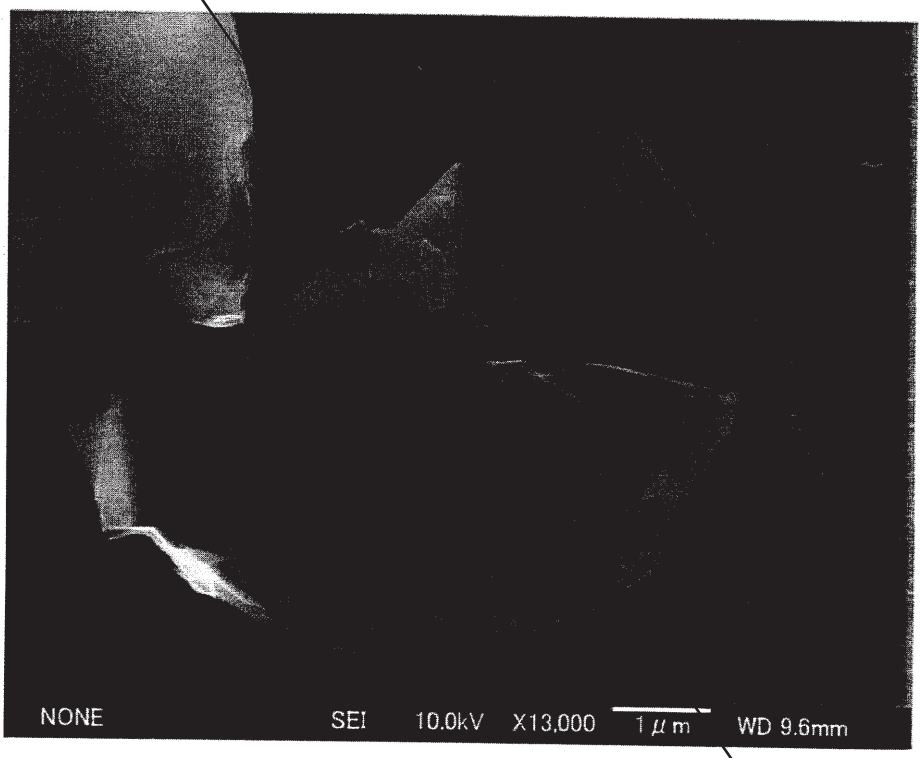


Fig. 24

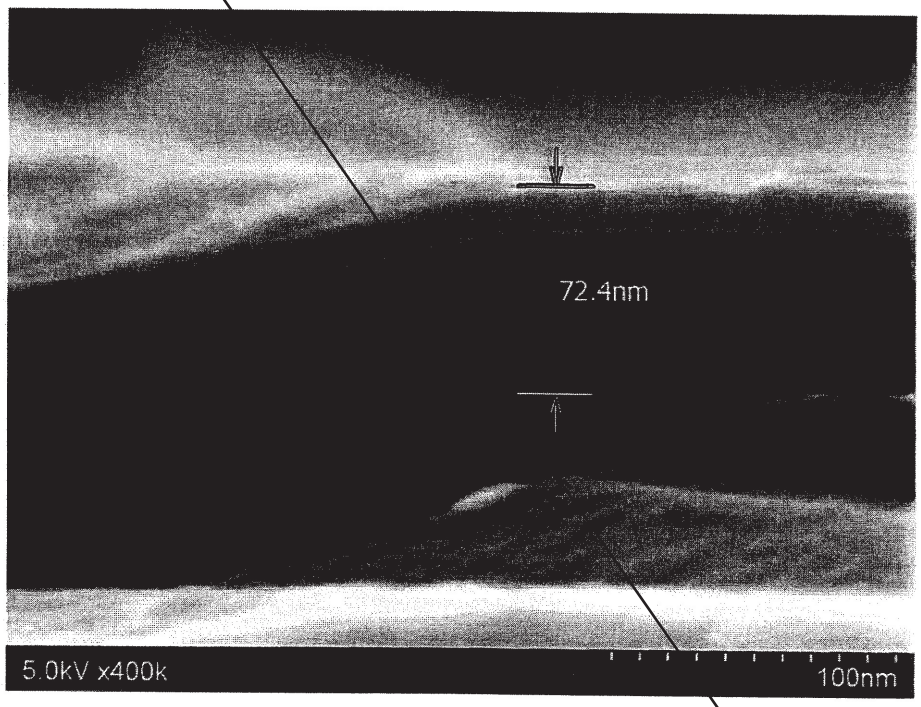


Fig. 25

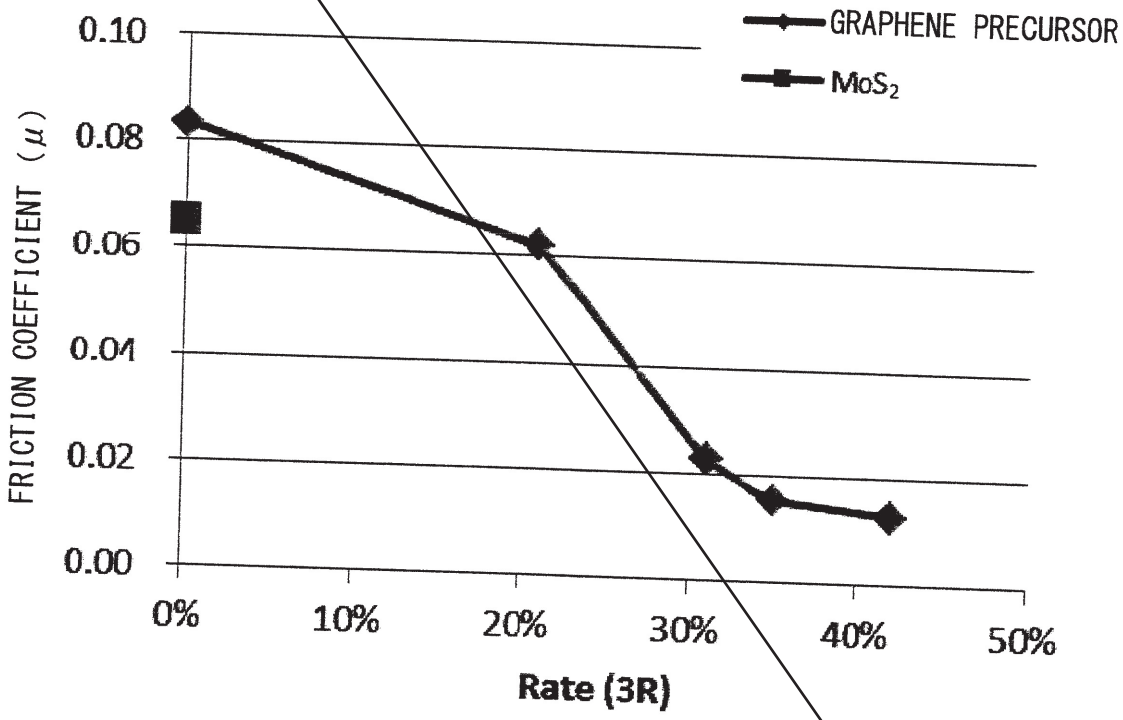

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 26

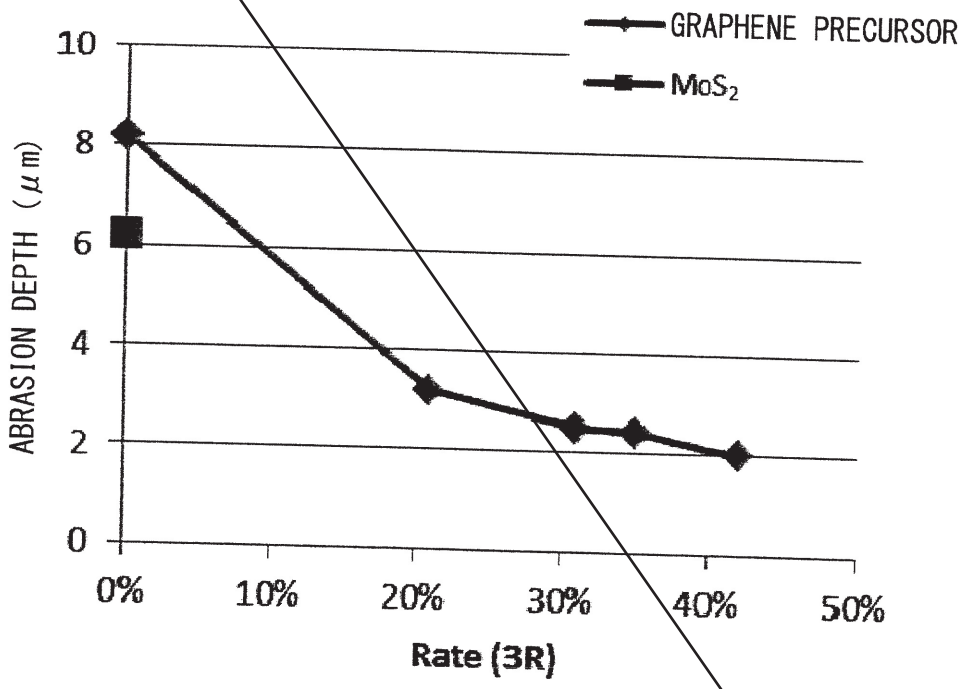

GRAPHENE PRECURSOR
MoS_2
ABRASION DEPTH (μm)
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 27

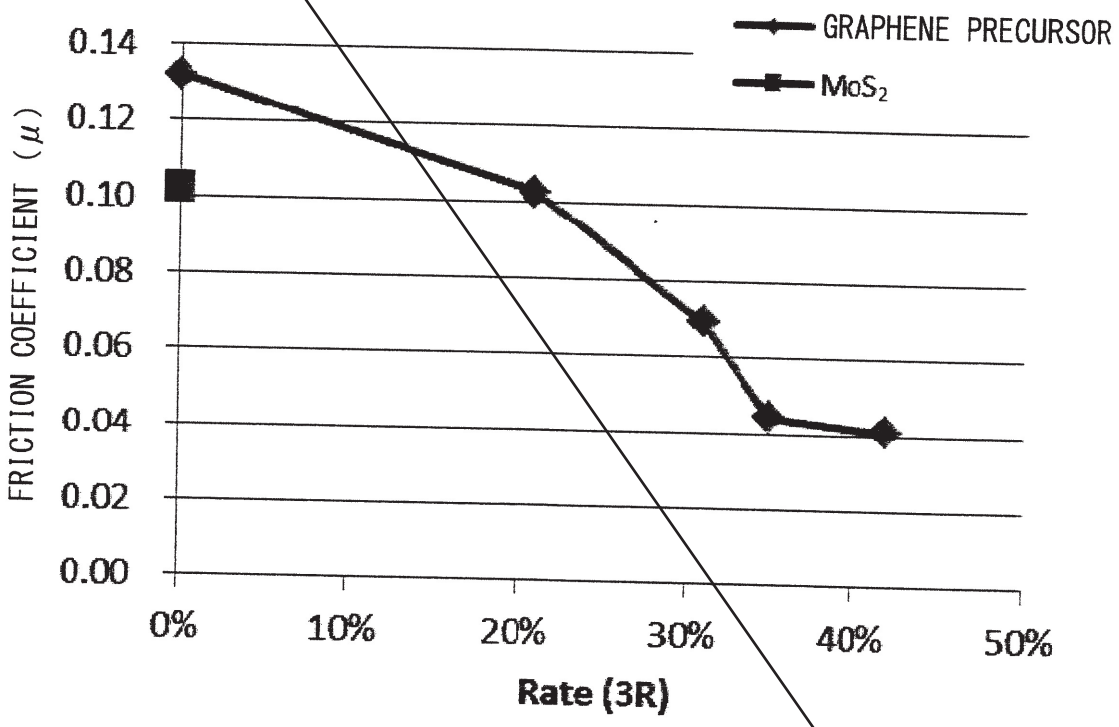

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 28

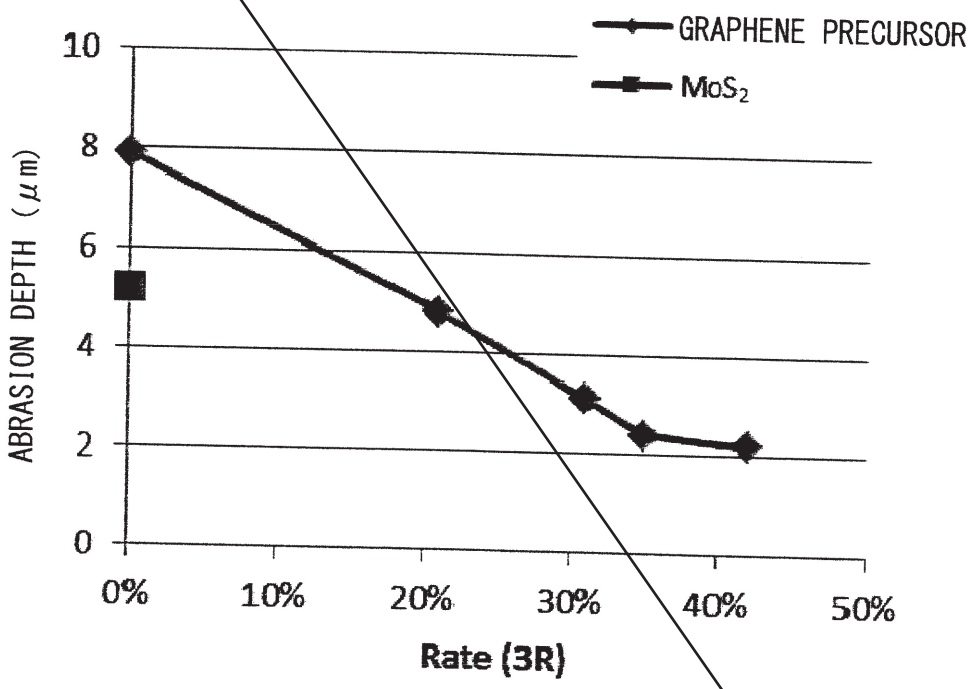

GRAPHENE PRECURSOR
MoS_2
ABRASION DEPTH (μm)
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 29

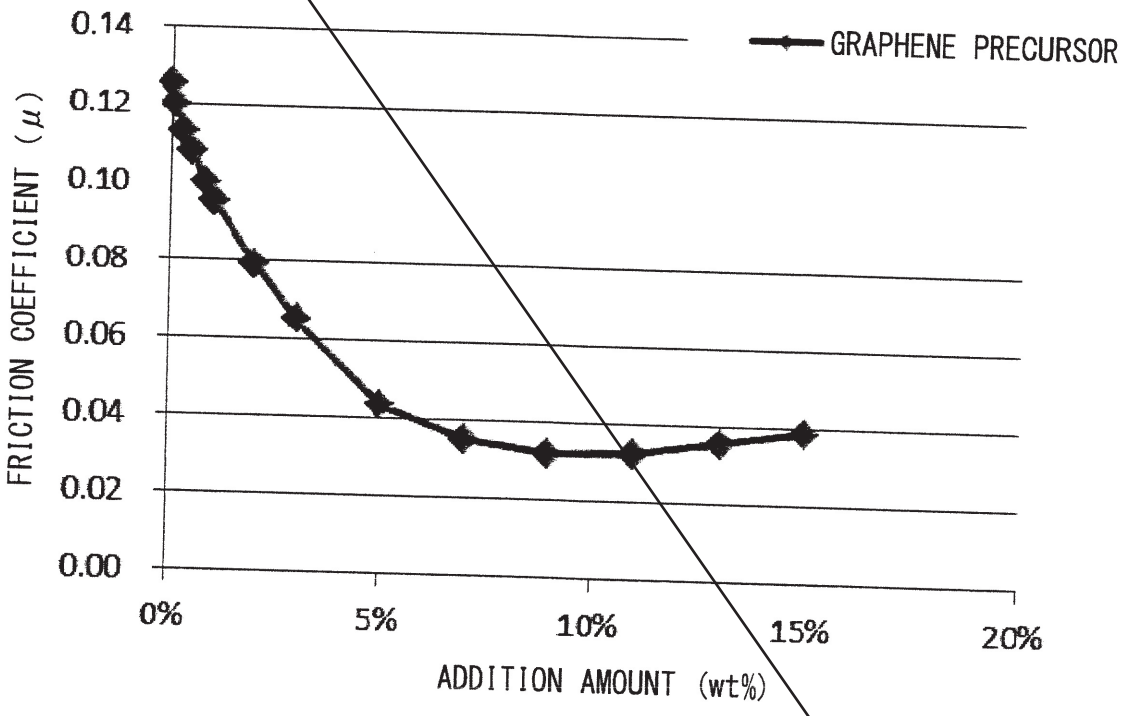

0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
FRICTION COEFFICIENT (μ)
GRAPHENE PRECURSOR
0%
5%
10%
15%
20%
ADDITION AMOUNT (wt%)

Fig. 30

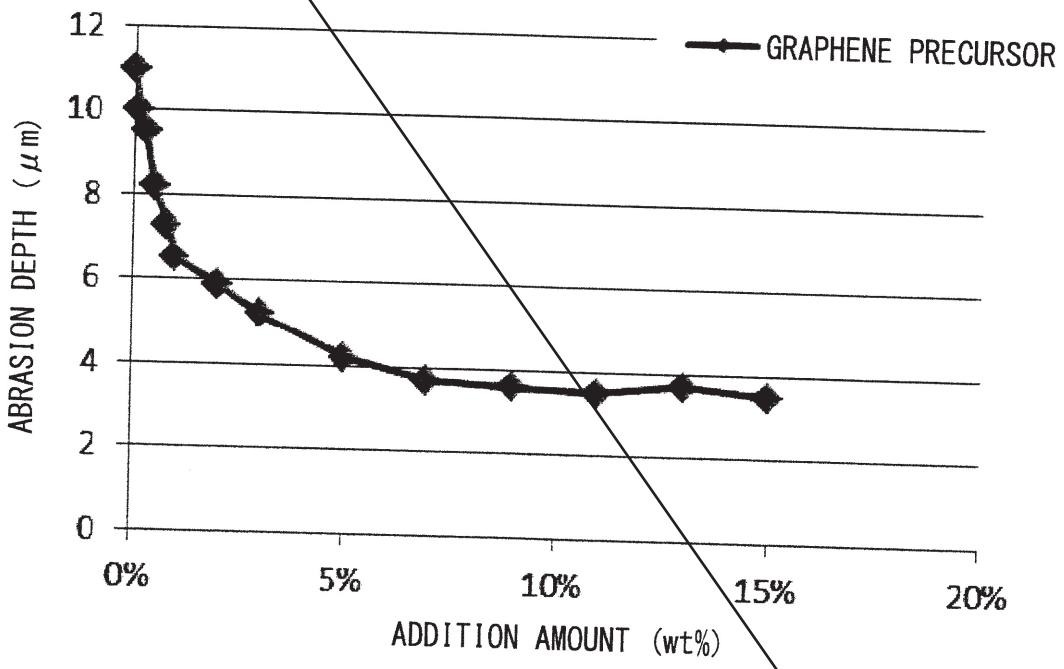
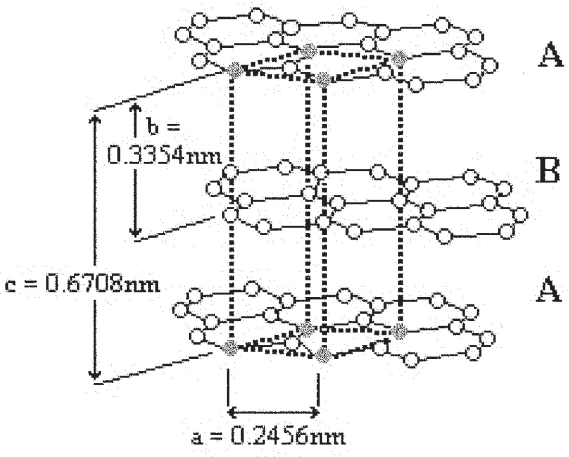

12
10
8
6
4
2
0
ABRASION DEPTH (μm)
GRAPHENE PRECURSOR
0%
5%
10%
15%
20%
ADDITION AMOUNT (wt%)

Fig. 1

（a）



（b）

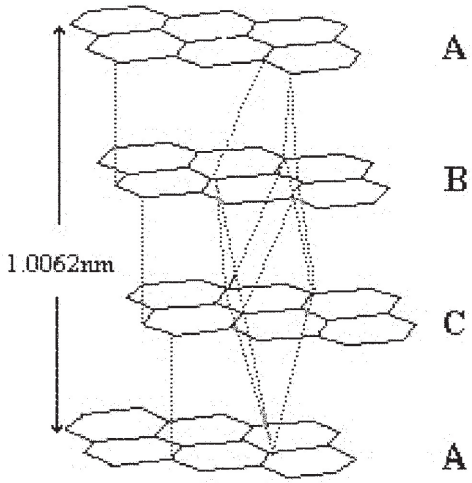


Fig. 2

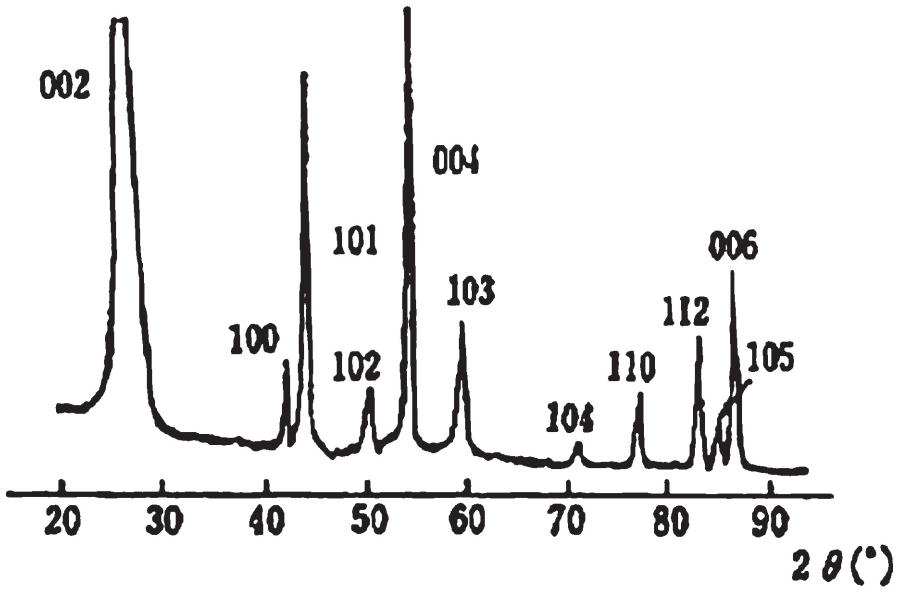

002
100
101
102
004
103
104
110
112
105
006
20
30
40
50
60
70
80
90
2θ(°)

Fig. 3

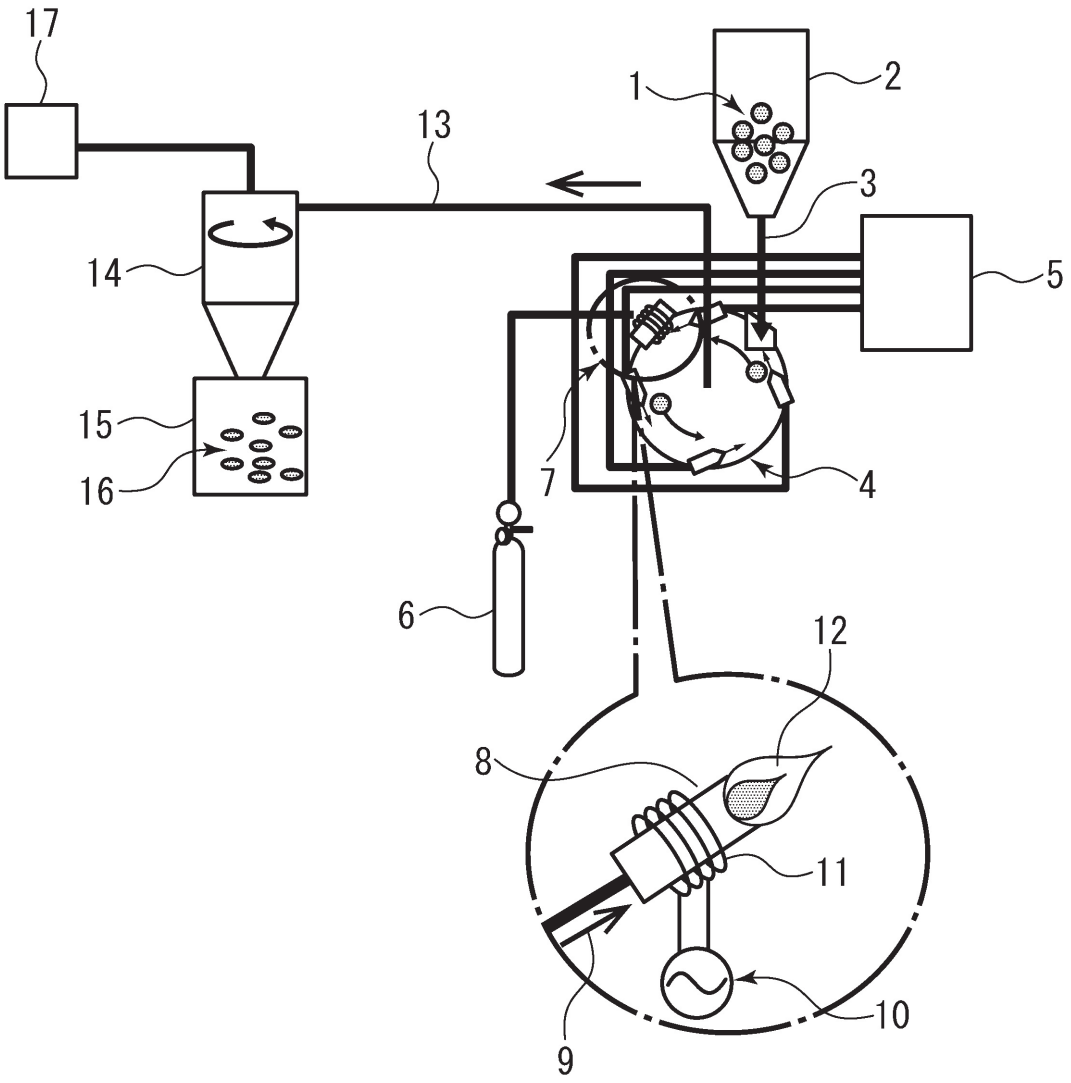
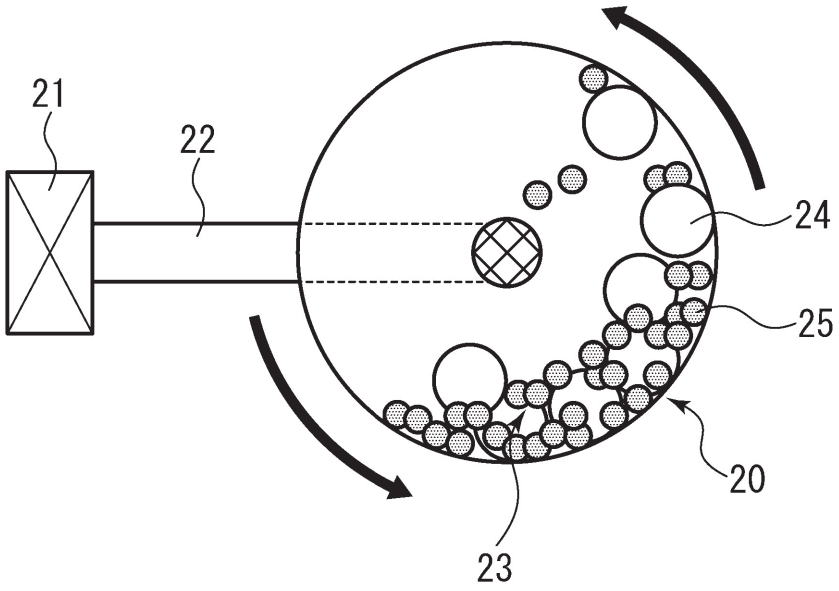


Fig. 4 (a)



(b)

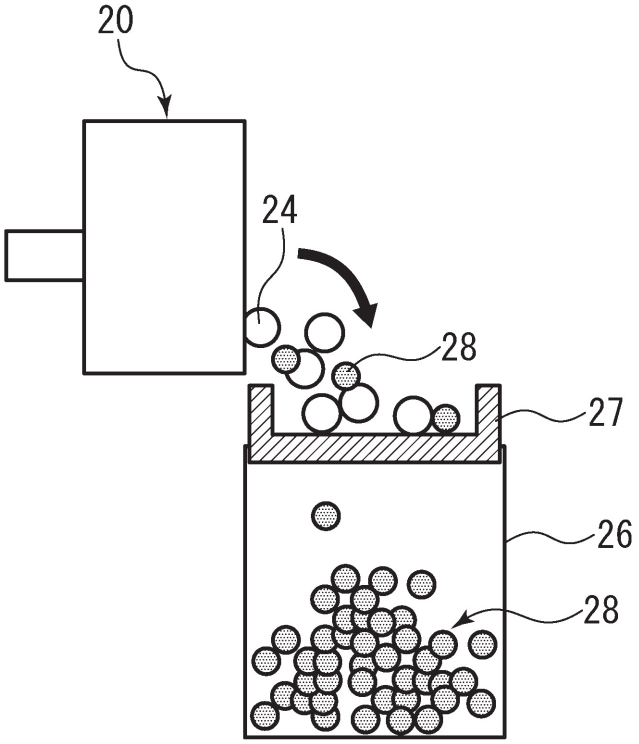


Fig. 5

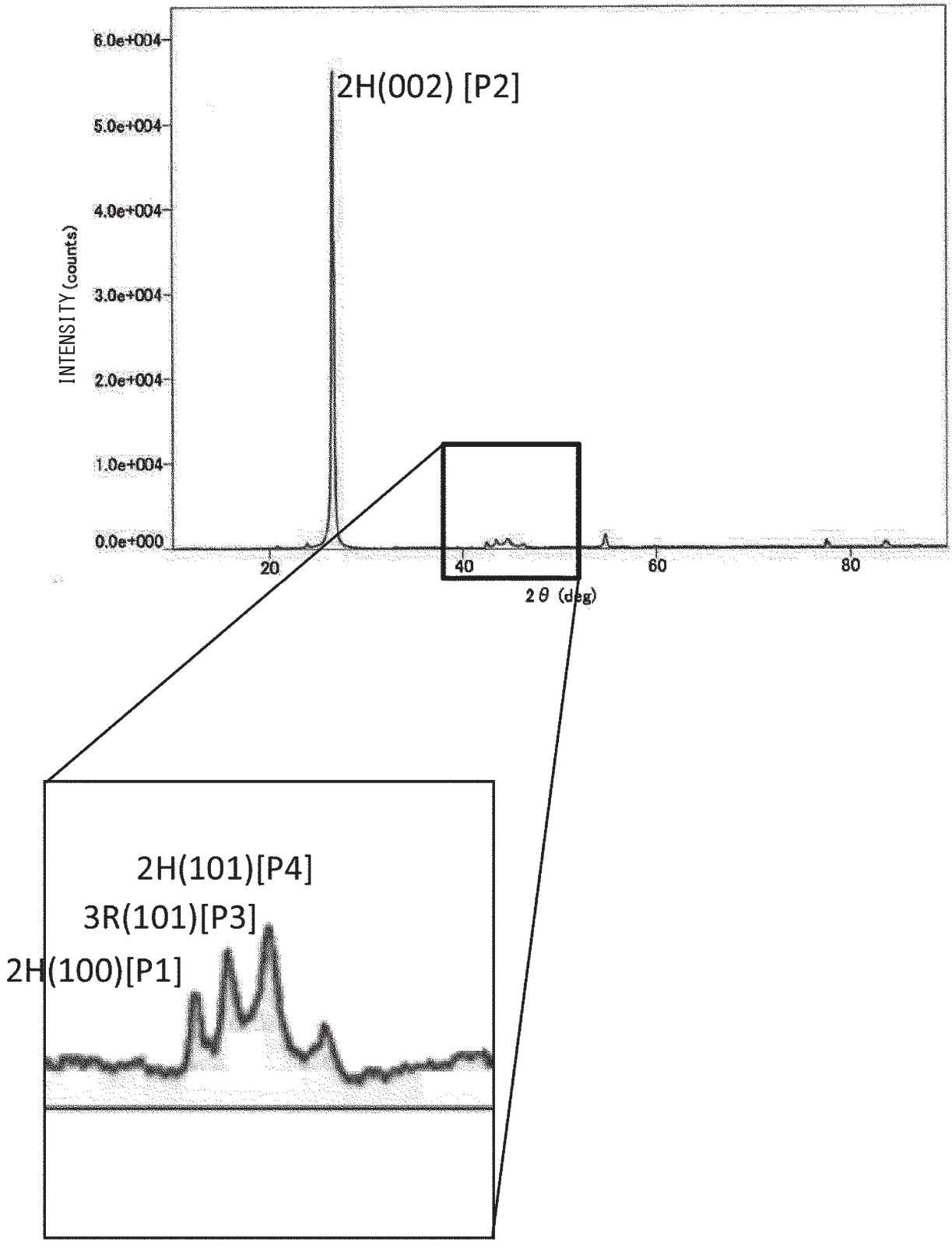

6.0e+004
5.0e+004
4.0e+004
3.0e+004
2.0e+004
1.0e+004
0.0e+000
INTENSITY (counts)
2H(002) [P2]
20
40
60
80
2θ (deg)
2H(101)[P4]
3R(101)[P3]
2H(100)[P1]

Fig. 6

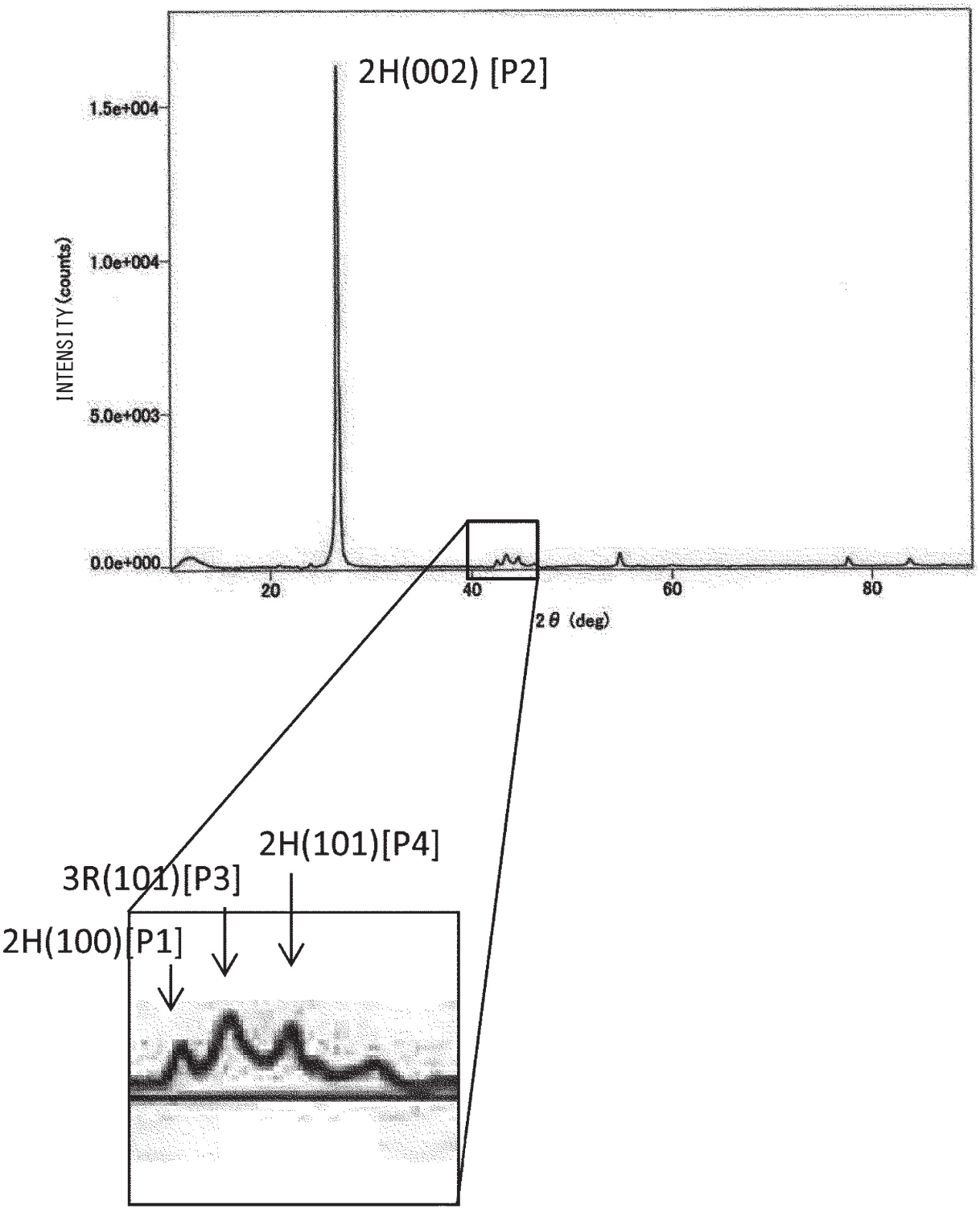

2H(002) [P2]
1.5e+004
1.0e+004
5.0e+003
0.0e+000
INTENSITY (counts)
20
40
60
80
2θ (deg)
2H(101)[P4]
3R(101)[P3]
2H(100)[P1]

Fig. 7

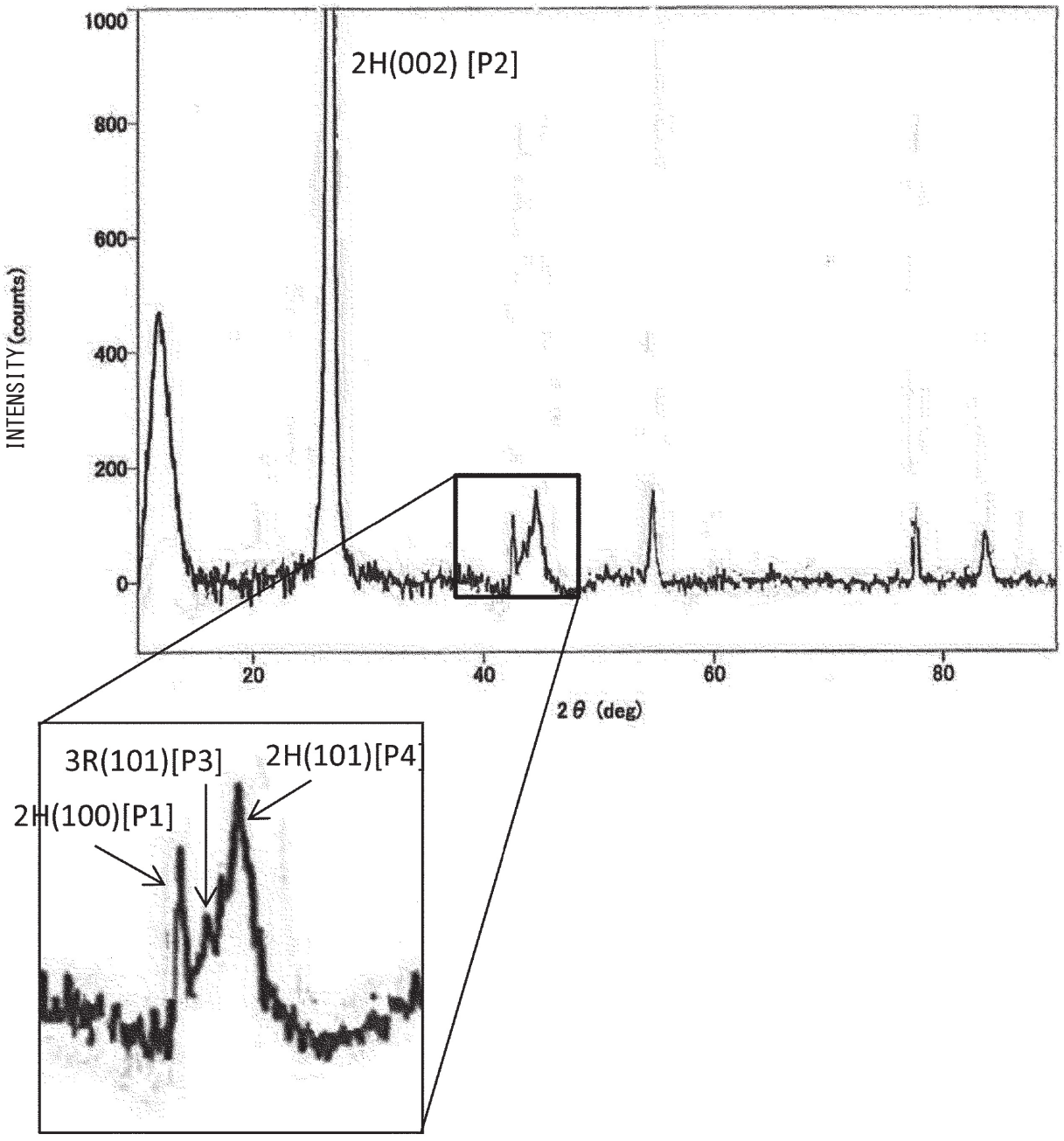

1000
800
600
400
200
0
INTENSITY(counts)
2H(002) [P2]
20
40
60
80
2θ (deg)
3R(101)[P3]
2H(101)[P4]
2H(100)[P1]

Fig. 8

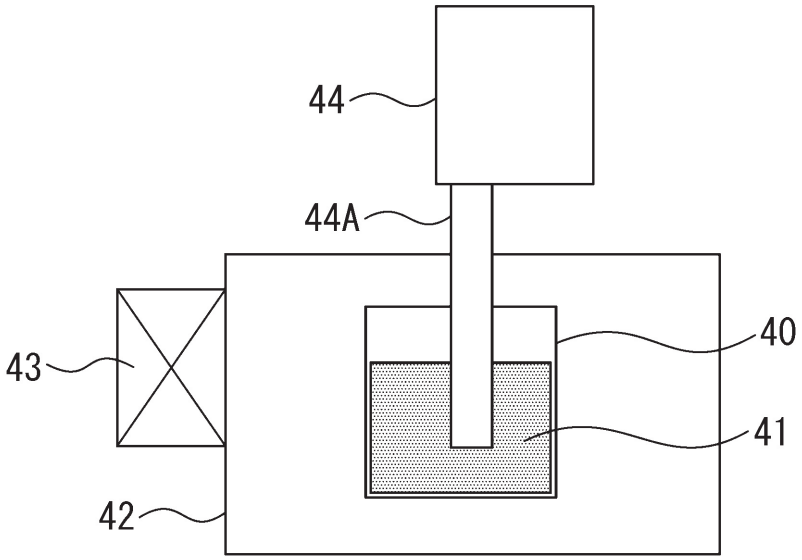
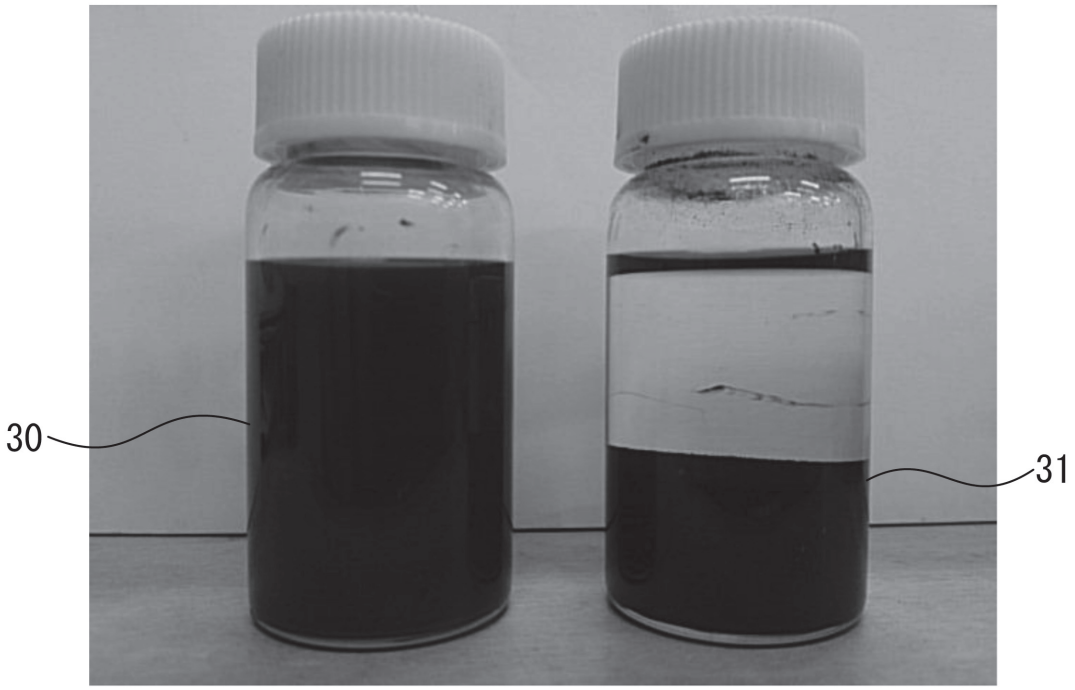


Fig. 9



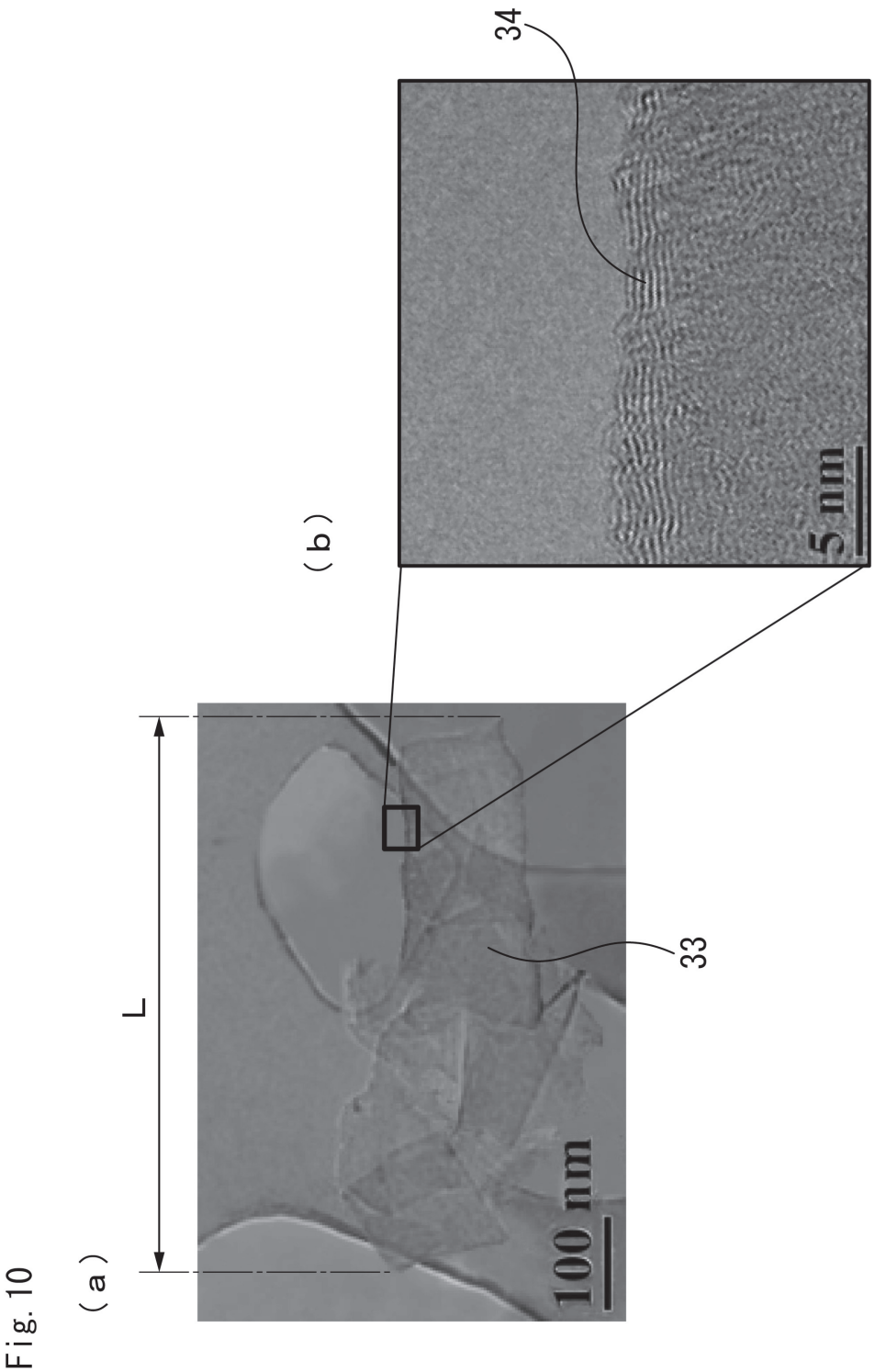
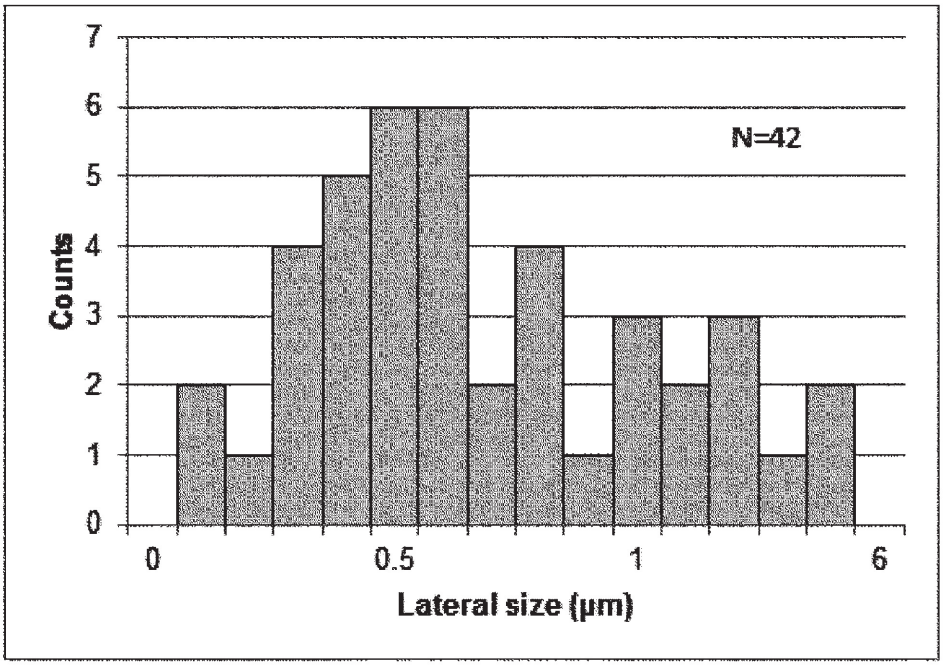


Fig. 10

Fig. 11

(a)


N=42
Counts
Lateral size (μm)
0
1
2
3
4
5
6
7
0
0.5
1
6

(b)

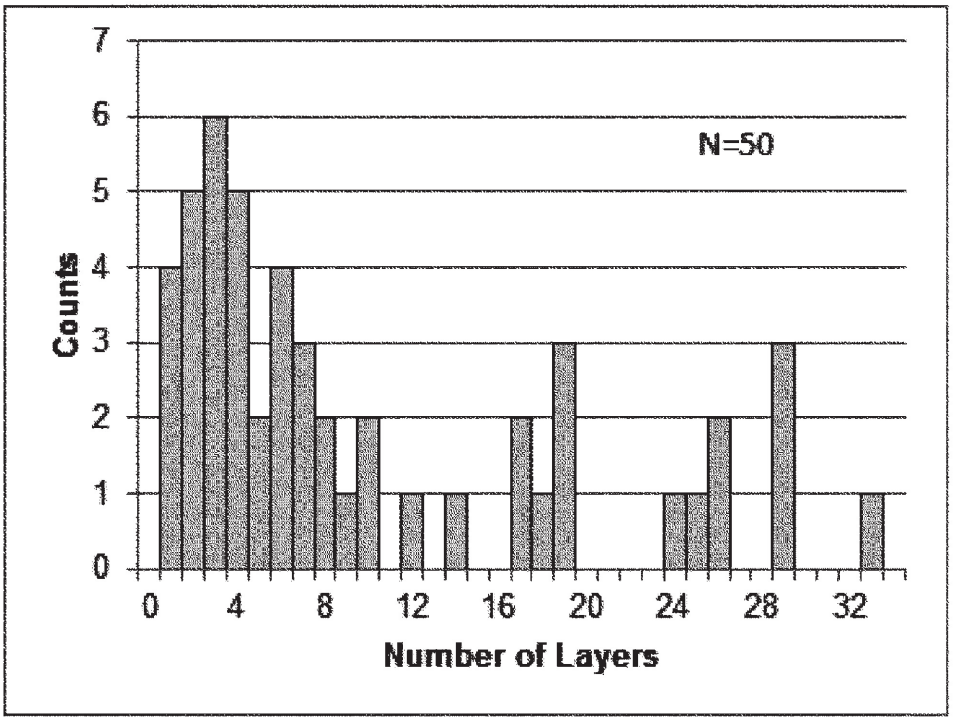
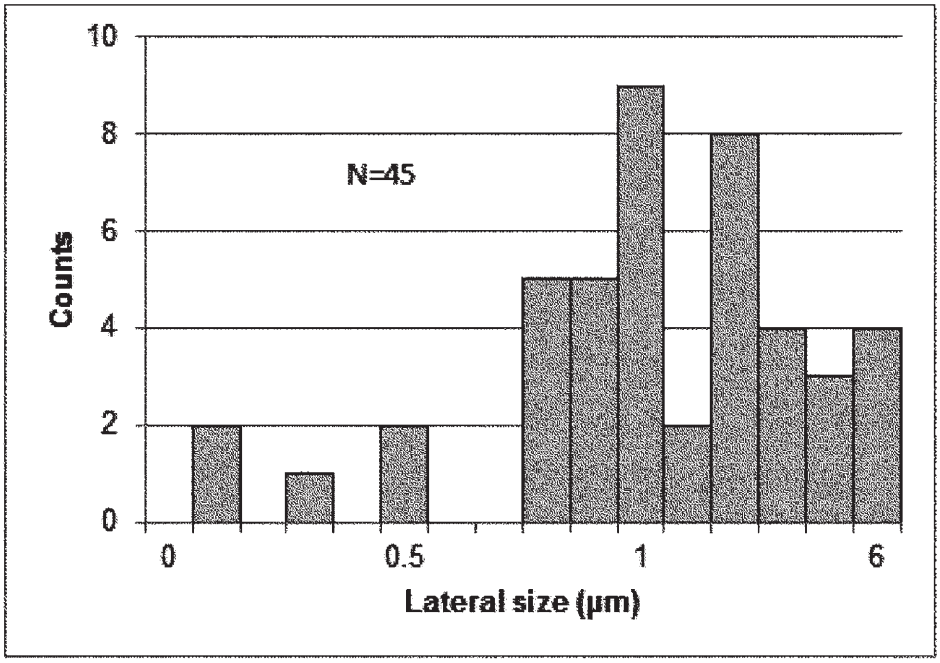

N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

Fig. 12

(a)


10
8
6
4
2
0
Counts
N=45
0
0.5
1
6
Lateral size (μm)

(b)

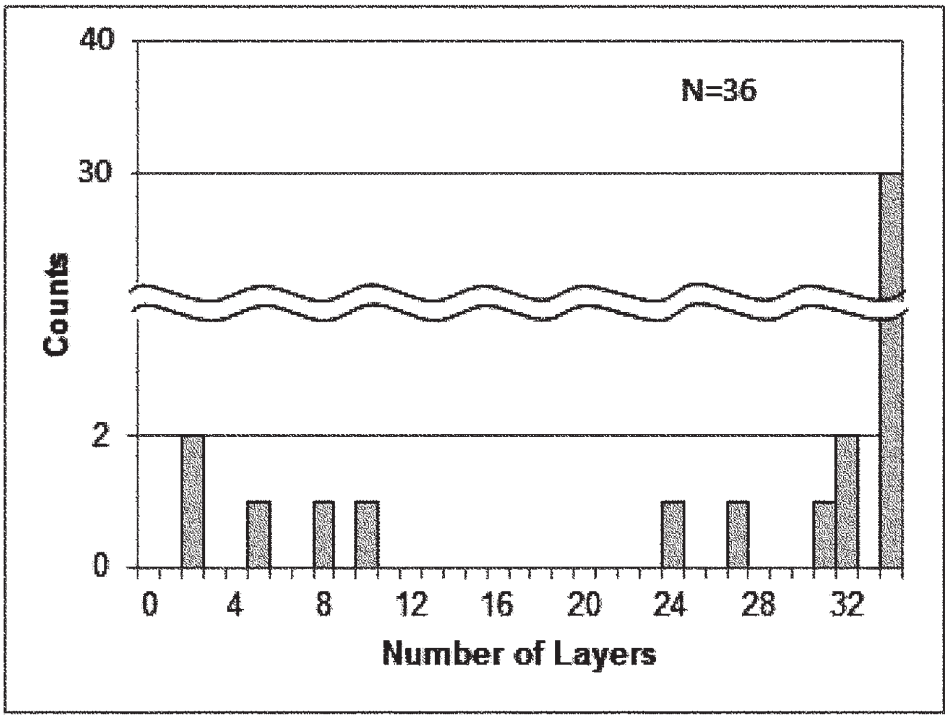
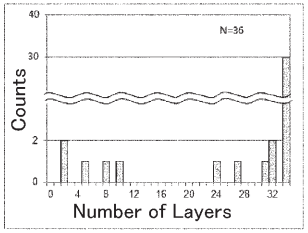
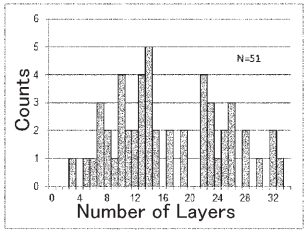
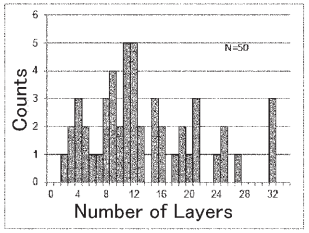

40
30
2
0
Counts
N=36
0
4
8
12
16
20
24
28
32
Number of Layers

Fig.13

SAMPLE No.	1	2	3
DISTRIBUTION OF LAYERS			
P3/(P3+P4)	23%	31%	38%
TEN LAYERS OR LESS	10%	25%	38%
P1/P2	0.008	0.016	0.016
P1	120	342	128
P2	15000	20993	8253
P3	50	321	173
P4	160	698	282

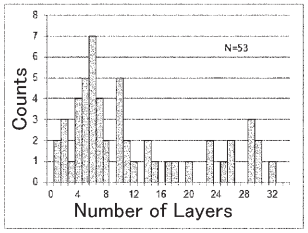
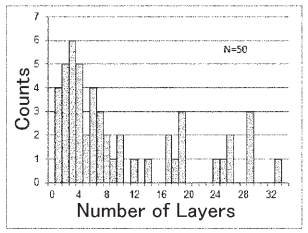
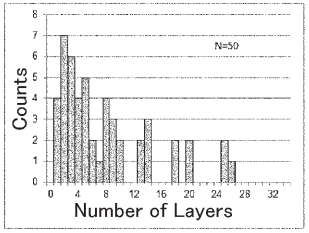
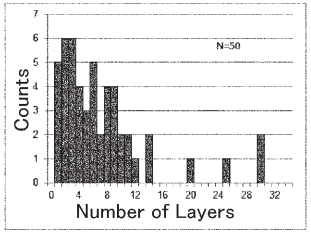
SAMPLE No.	4	5	6	7
DISTRIBUTION OF LAYERS				
P3/(P3+P4)	42%	46%	51%	58%
TEN LAYERS OR LESS	62%	68%	76%	82%
P1/P2	0.014	0.012	0.014	0.012
P1	253	162	66	151
P2	18226	13157	4675	12850
P3	320	396	170	452
P4	435	466	162	325

Fig. 14

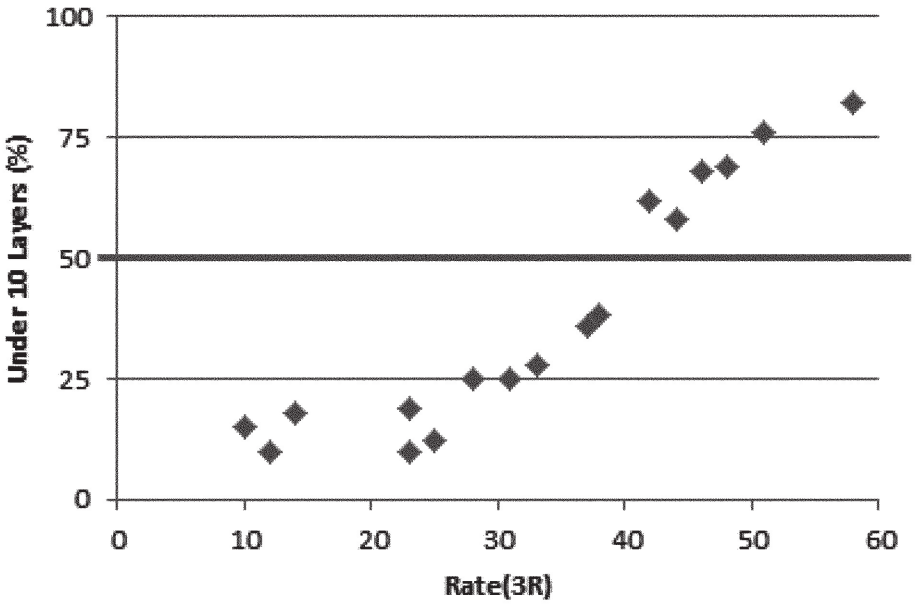
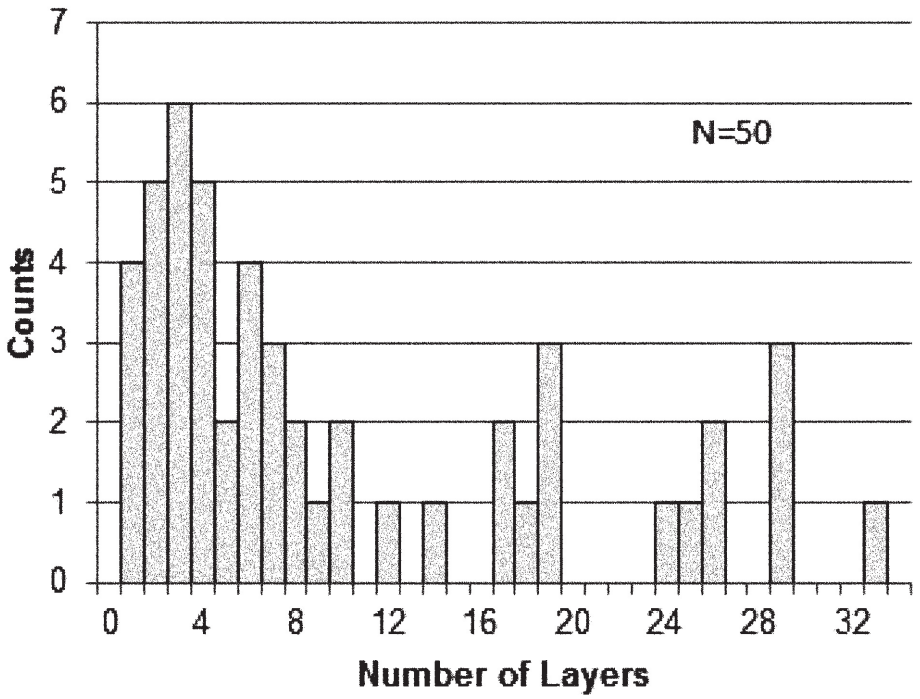


Fig. 15

（a）


N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

（b）

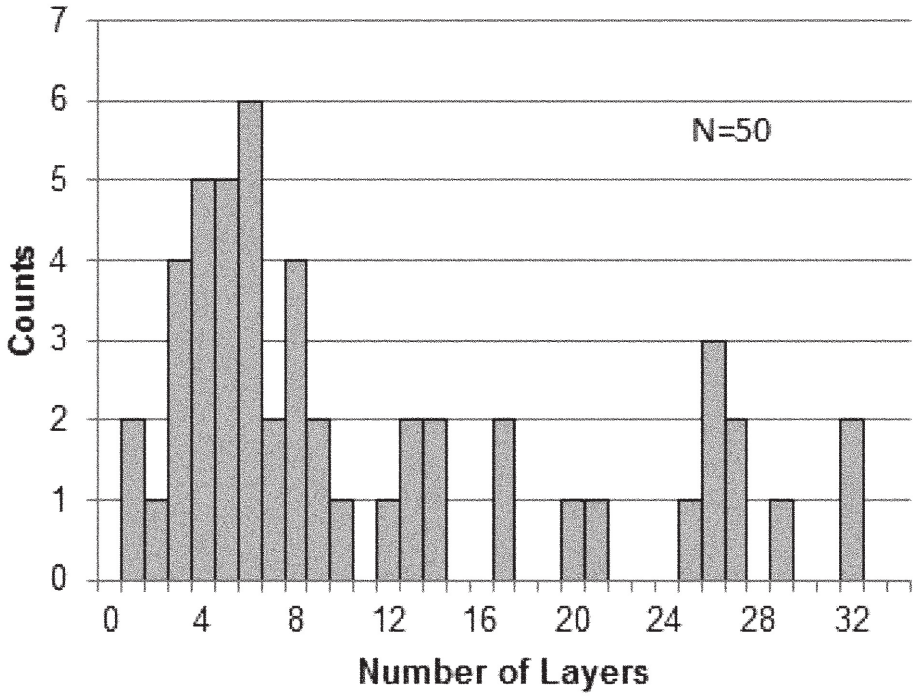

N=50
Counts
Number of Layers
0
1
2
3
4
5
6
7
0
4
8
12
16
20
24
28
32

Fig. 16

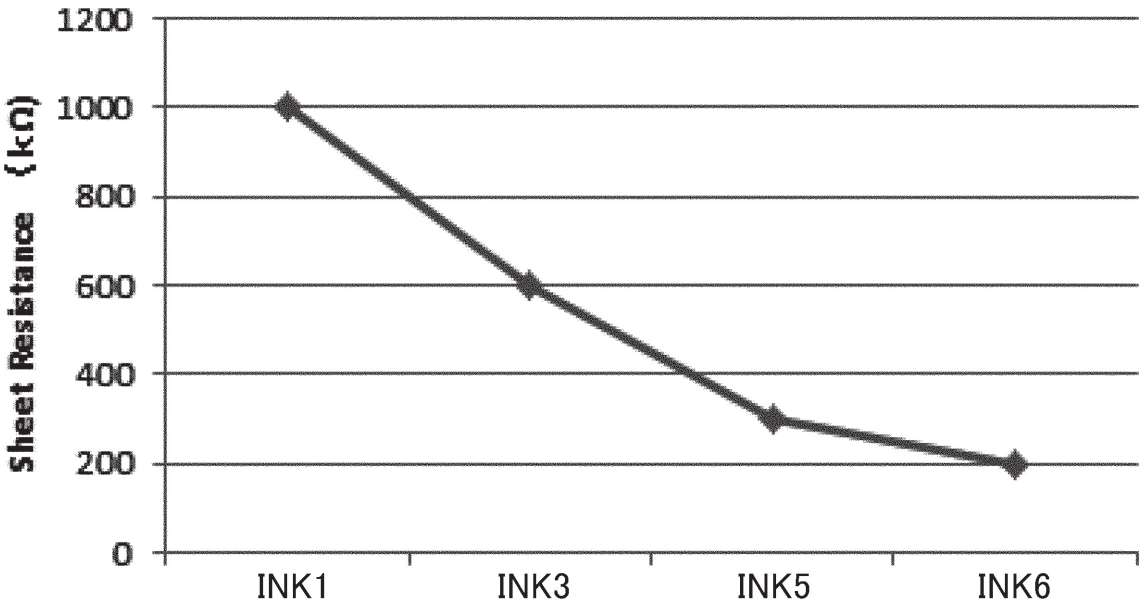

Sheet Resistance (kΩ)
1200
1000
800
600
400
200
0
INK1
INK3
INK5
INK6

Fig. 17

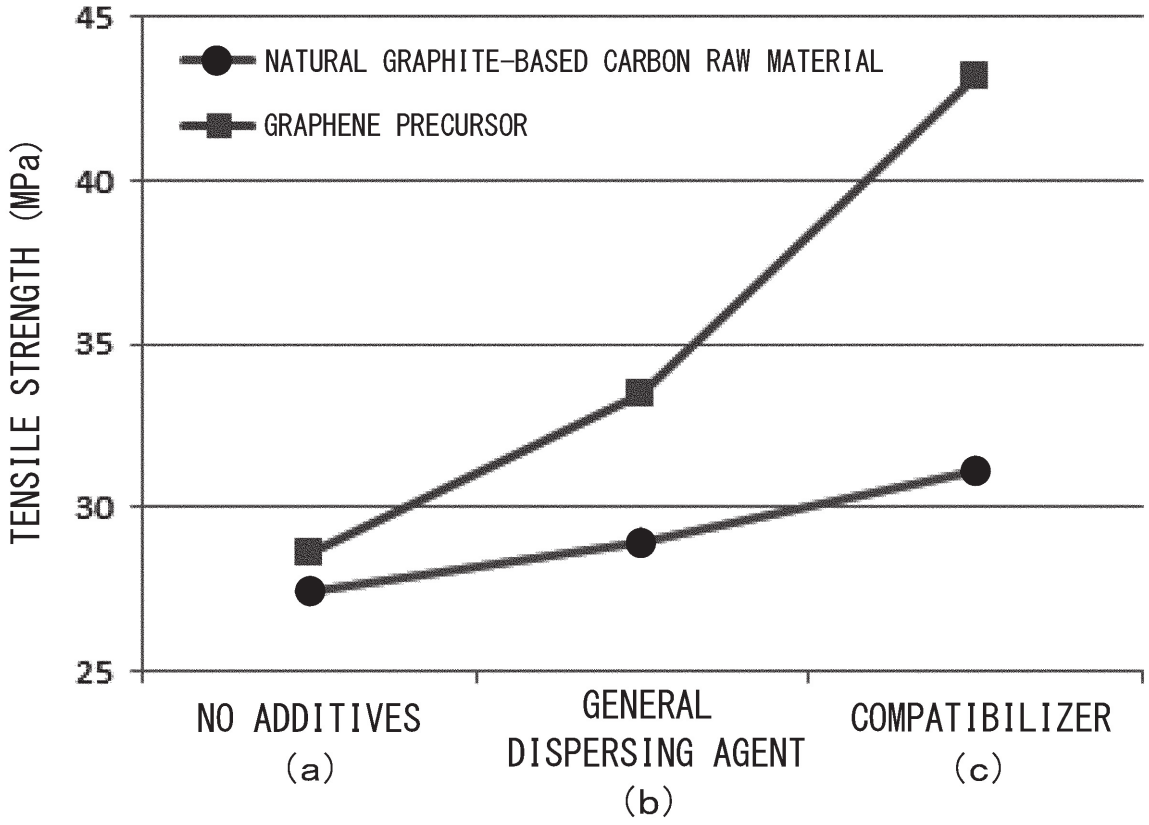

45
40
35
30
25
TENSILE STRENGTH (MPa)
NATURAL GRAPHITE-BASED CARBON RAW MATERIAL
GRAPHENE PRECURSOR
NO ADDITIVES
(a)
GENERAL
DISPERSING AGENT
(b)
COMPATIBILIZER
(c)

Fig. 18

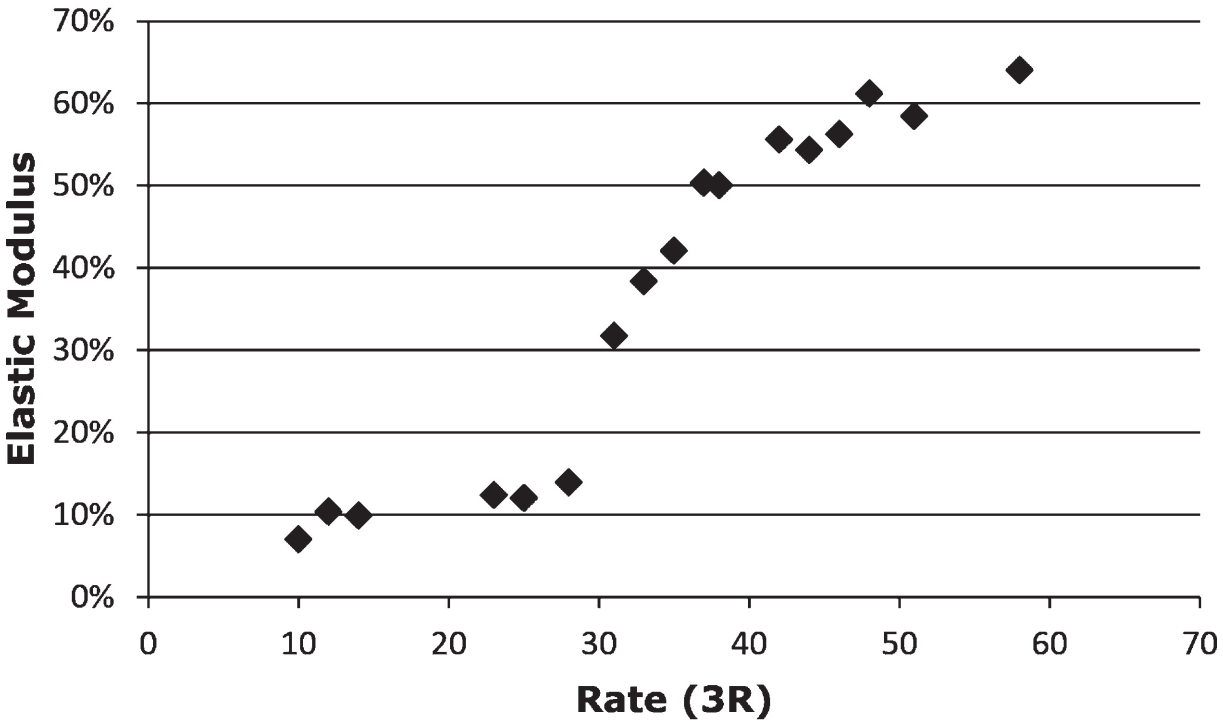
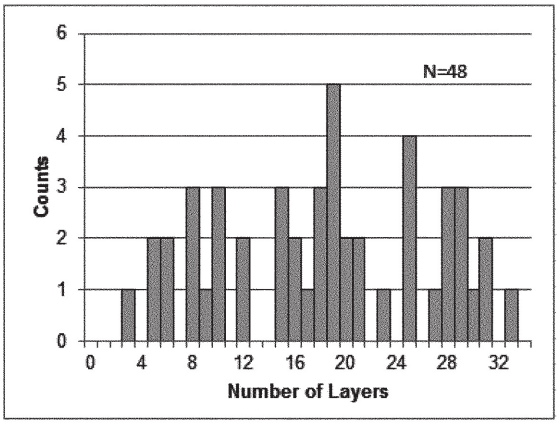

70%
60%
50%
40%
30%
20%
10%
0%
Elastic Modulus
0
10
20
30
40
50
60
70
Rate (3R)

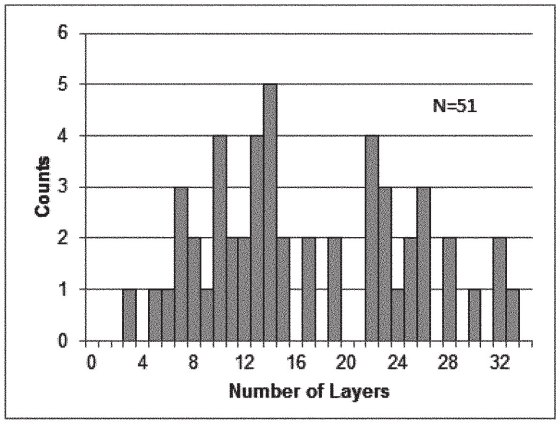
Fig. 19

(a)



P3/(P3+P4)=28%
TEN LAYERS OR LESS: 25%

(b)



P3/(P3+P4)=31%
TEN LAYERS OR LESS: 25%

Fig. 20

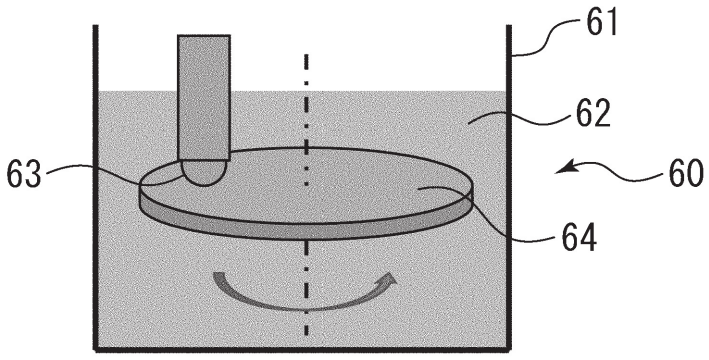


Fig. 21

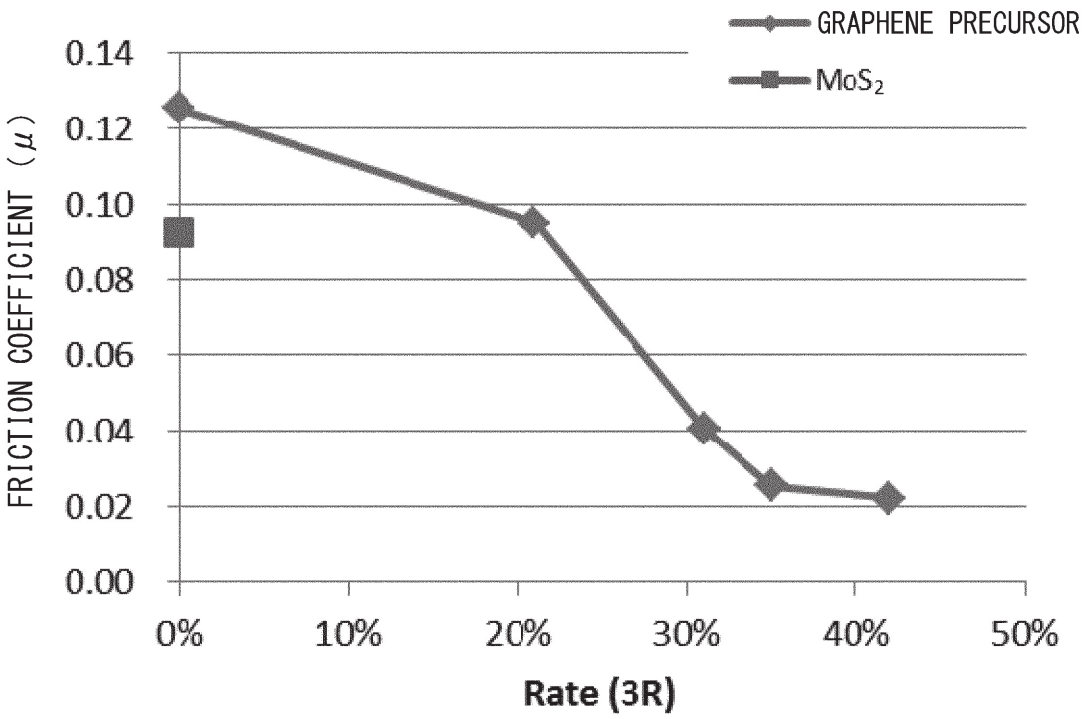

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 22

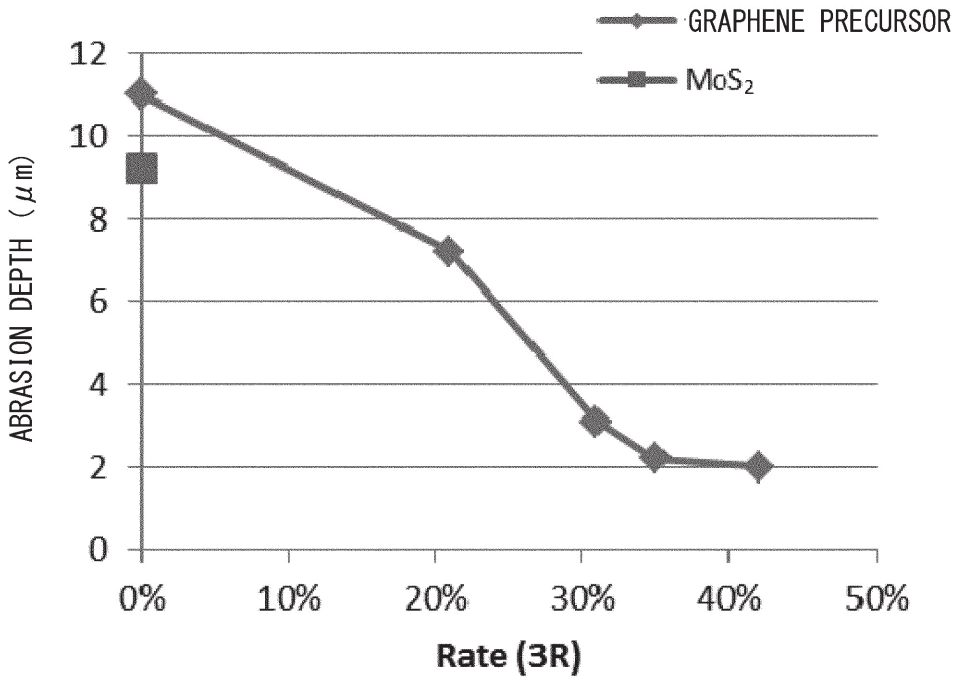

GRAPHENE PRECURSOR
MoS2
ABRASION DEPTH (μm)
12
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 23

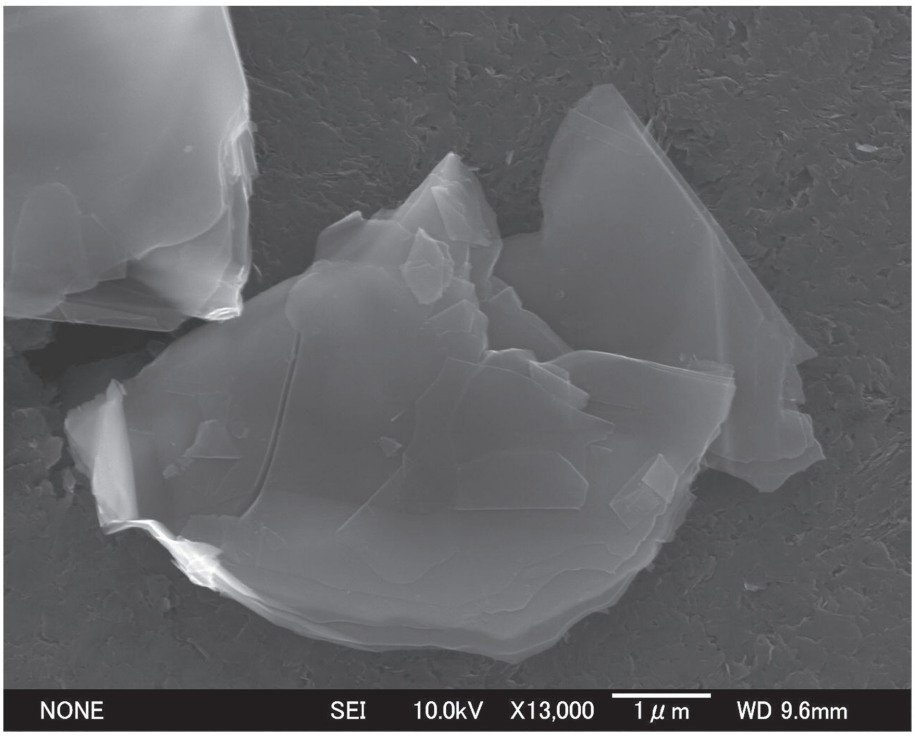


Fig. 24

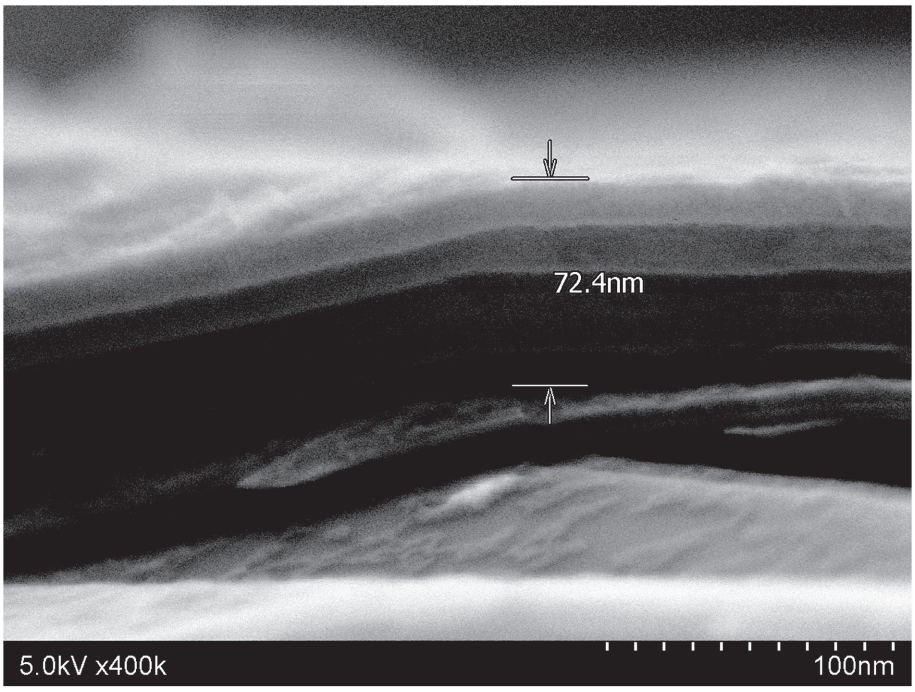


Fig. 25

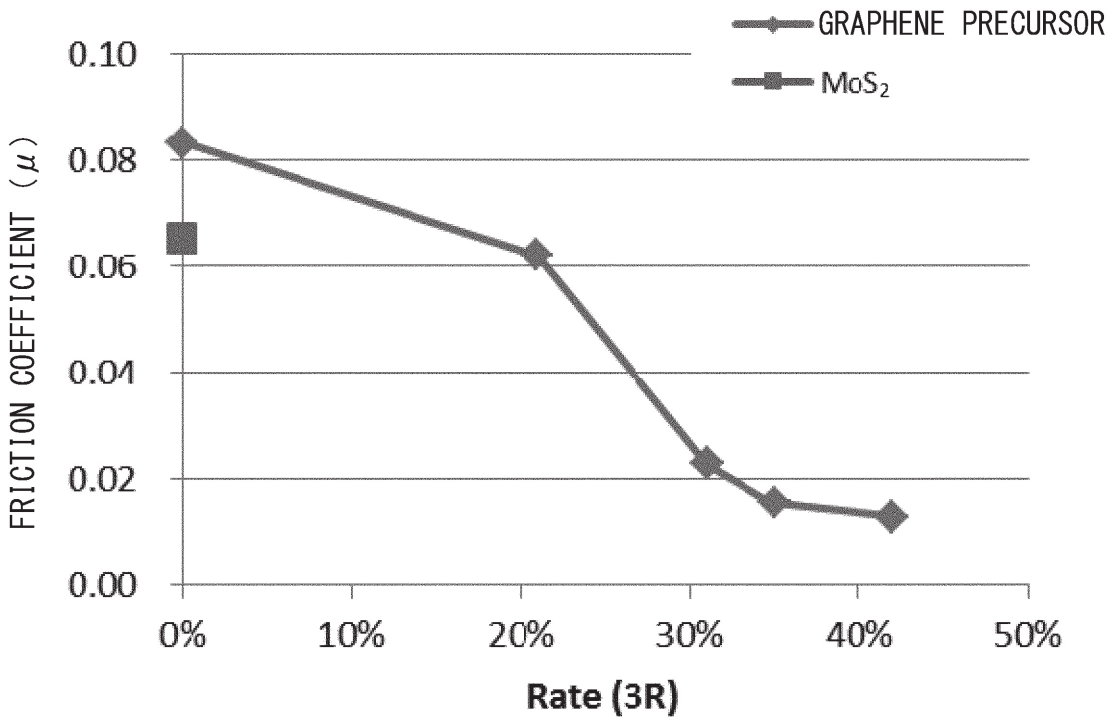

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 26

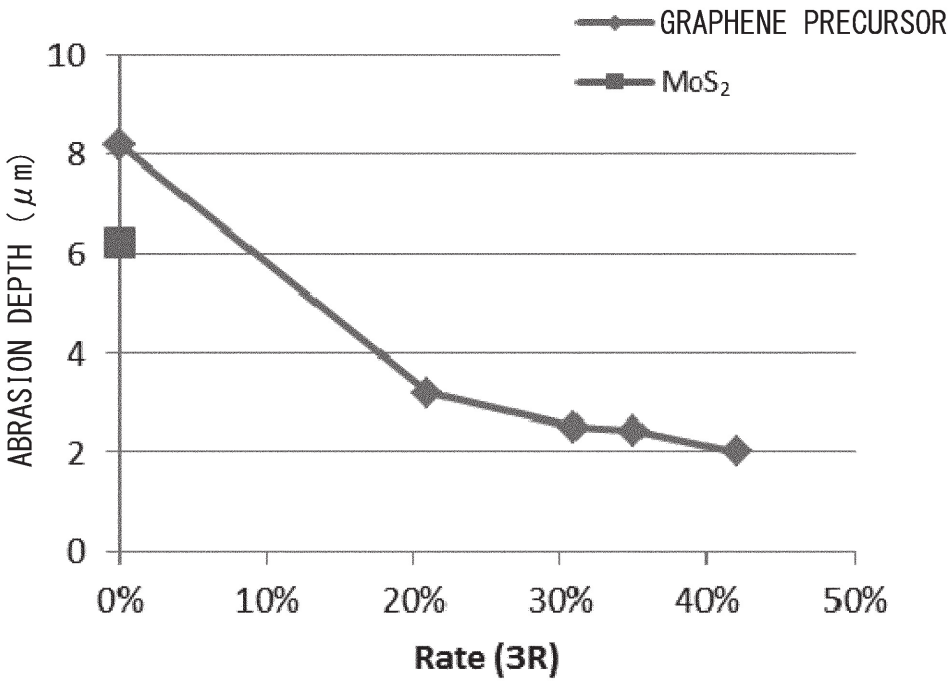

GRAPHENE PRECURSOR
MoS2
ABRASION DEPTH (μm)
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 27

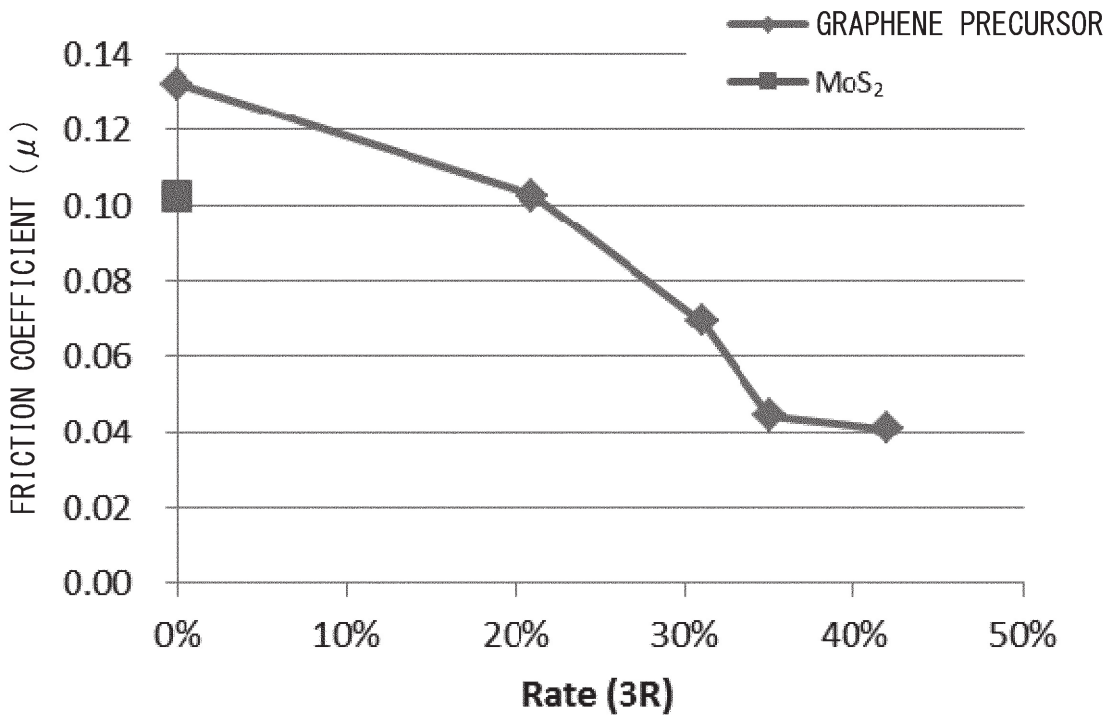

GRAPHENE PRECURSOR
MoS_2
FRICTION COEFFICIENT (μ)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 28

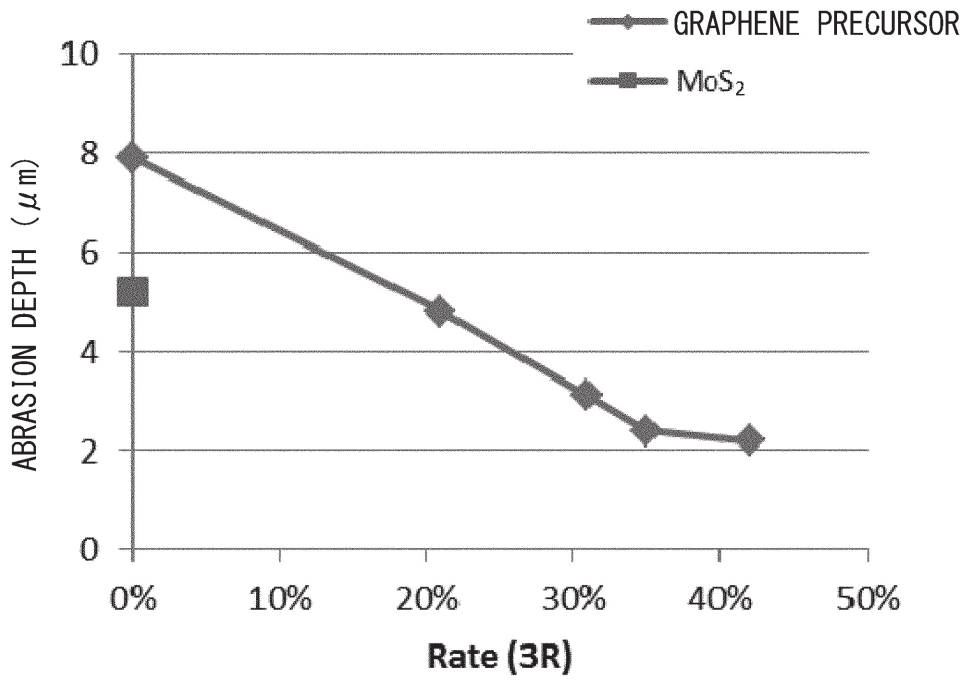

GRAPHENE PRECURSOR
MoS_2
ABRASION DEPTH (μm)
10
8
6
4
2
0
0%
10%
20%
30%
40%
50%
Rate (3R)

Fig. 29

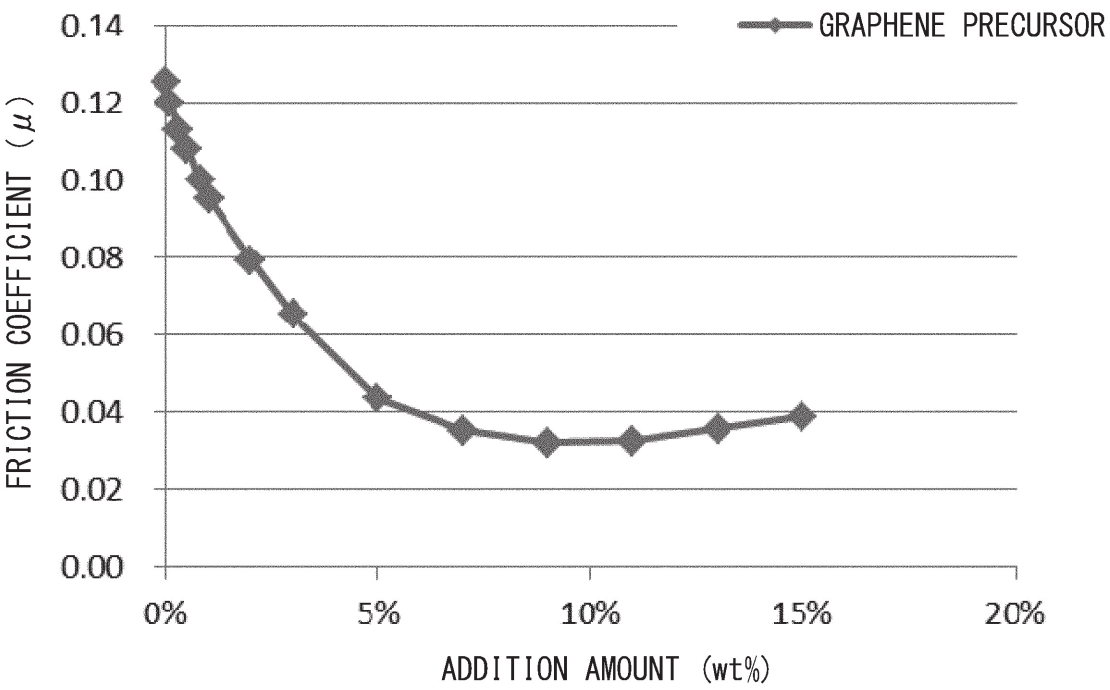
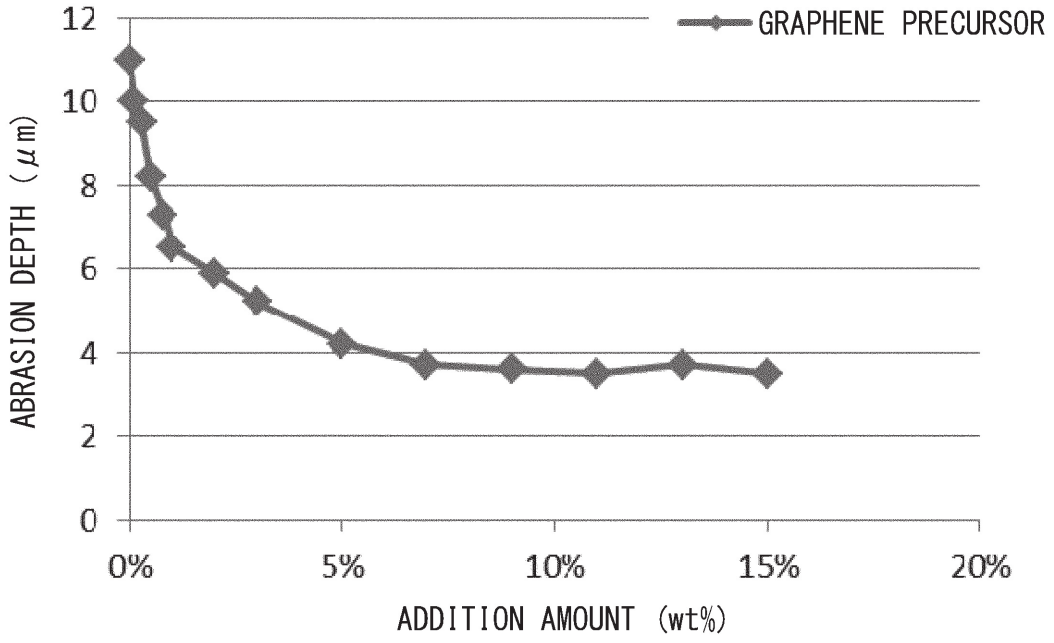

GRAPHENE PRECURSOR
FRICTION COEFFICIENT (μ)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0%
5%
10%
15%
20%
ADDITION AMOUNT (wt%)

Fig. 30


GRAPHENE PRECURSOR
ABRASION DEPTH (μm)
12
10
8
6
4
2
0
0%
5%
10%
15%
20%
ADDITION AMOUNT (wt%)