FIG. 1

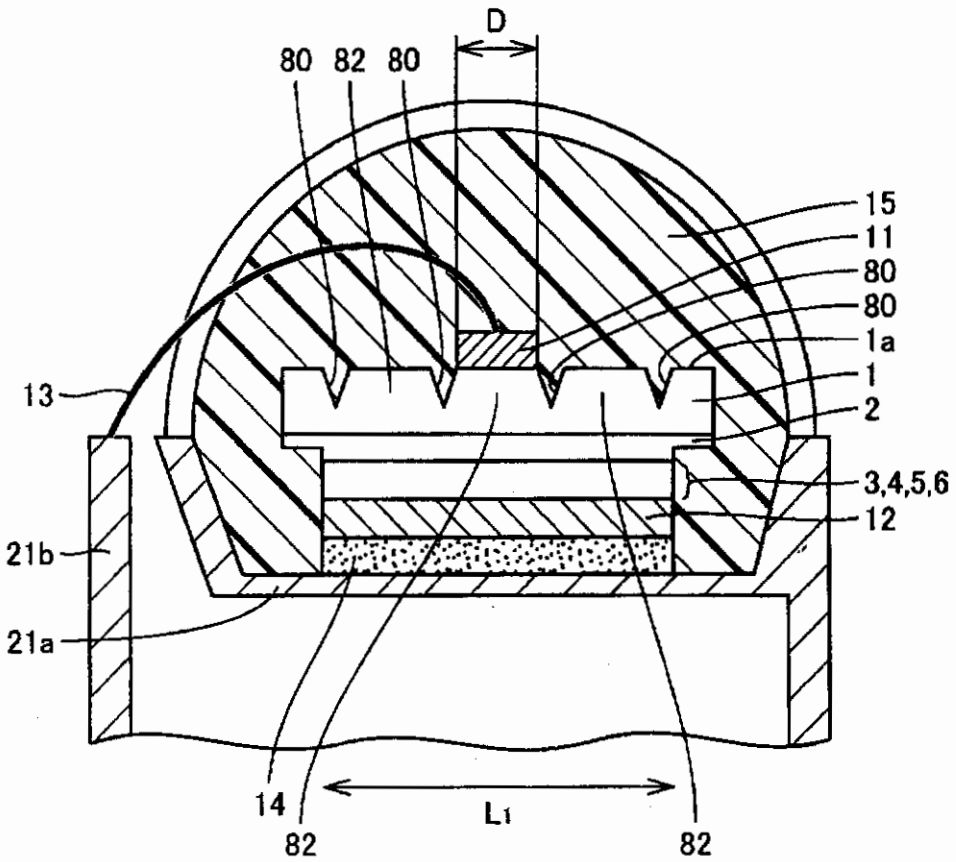


FIG. 2

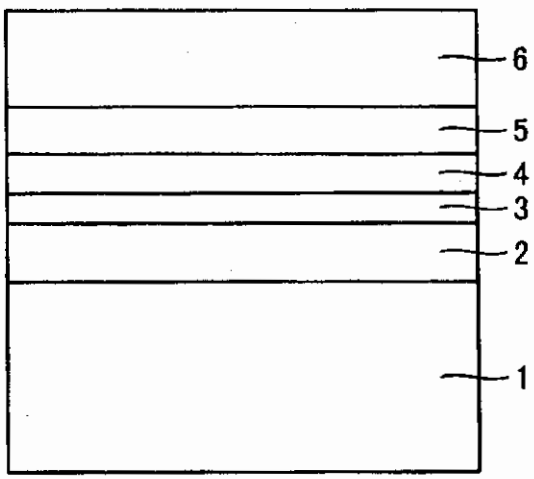


FIG. 3

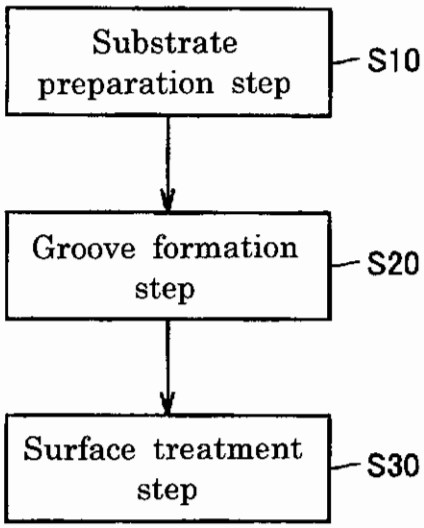

Substrate preparation step
S10
Groove formation step
S20
Surface treatment step
S30

FIG. 4

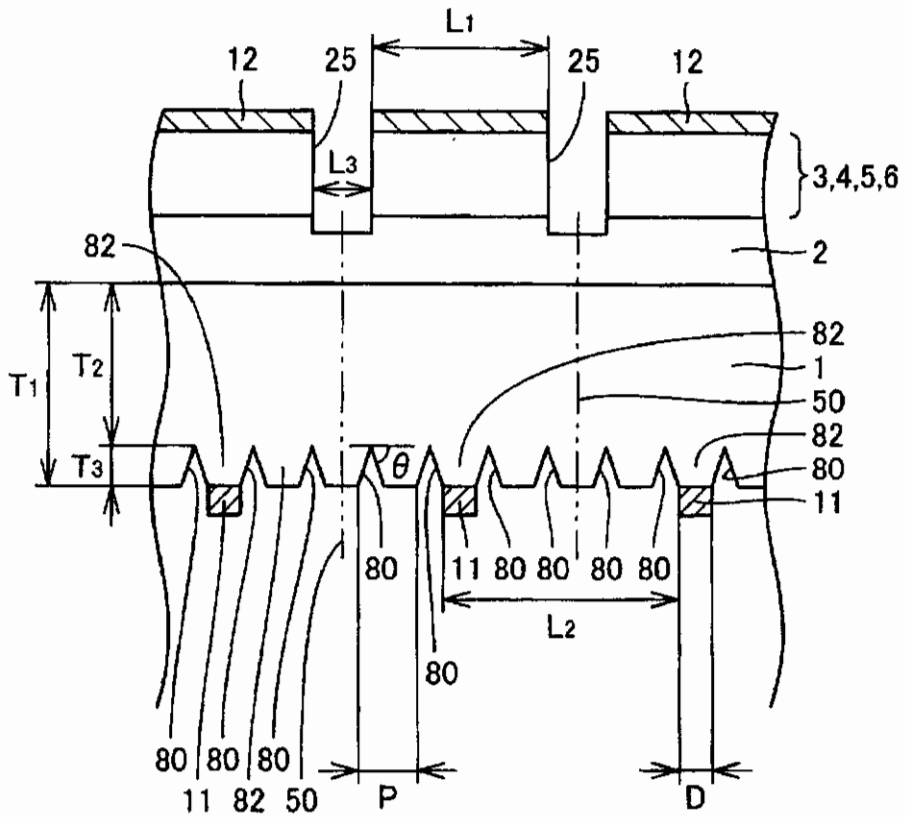

L1
12
25
25
12
L3
3,4,5,6
82
2
T1
T2
T3
θ
82
1
50
82
80
11
80
80
80
80
80
80
80
80
80
11
82
50
P
D
L2

FIG. 5

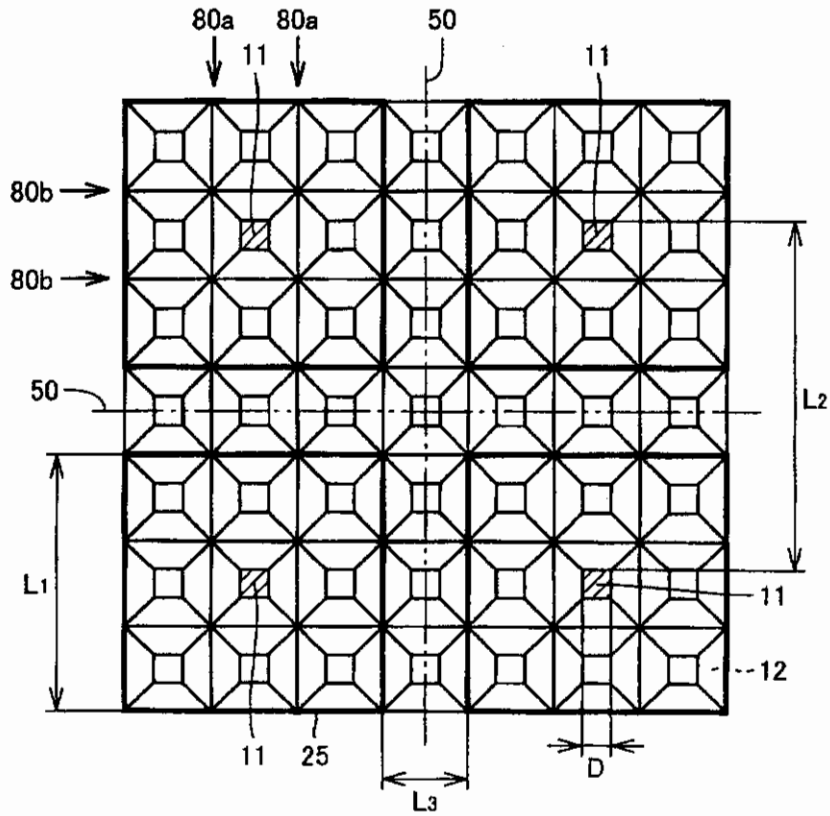

80a
80a
50
11
11
80b
80b
50
L2
L1
11
12
11
25
D
L3

FIG. 6

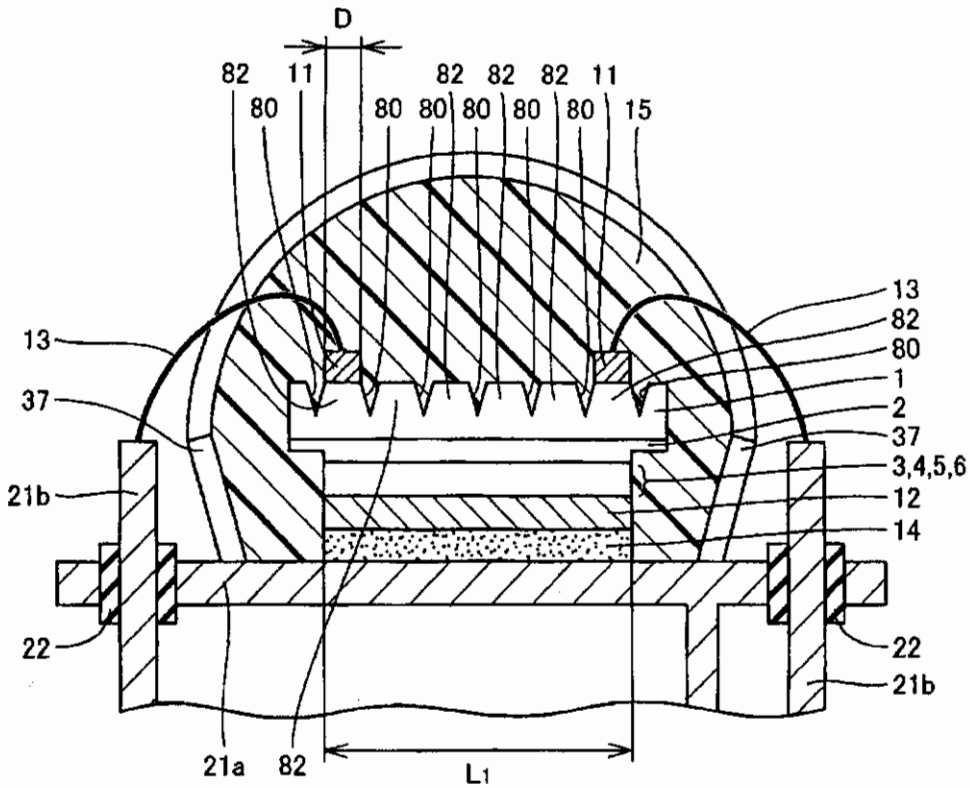

D
82
11
82
82
82
11
80
80
80
80
80
80
15
13
13
82
80
37
1
2
37
3,4,5,6
21b
12
14
22
22
21b
21a
82
L1

FIG. 7

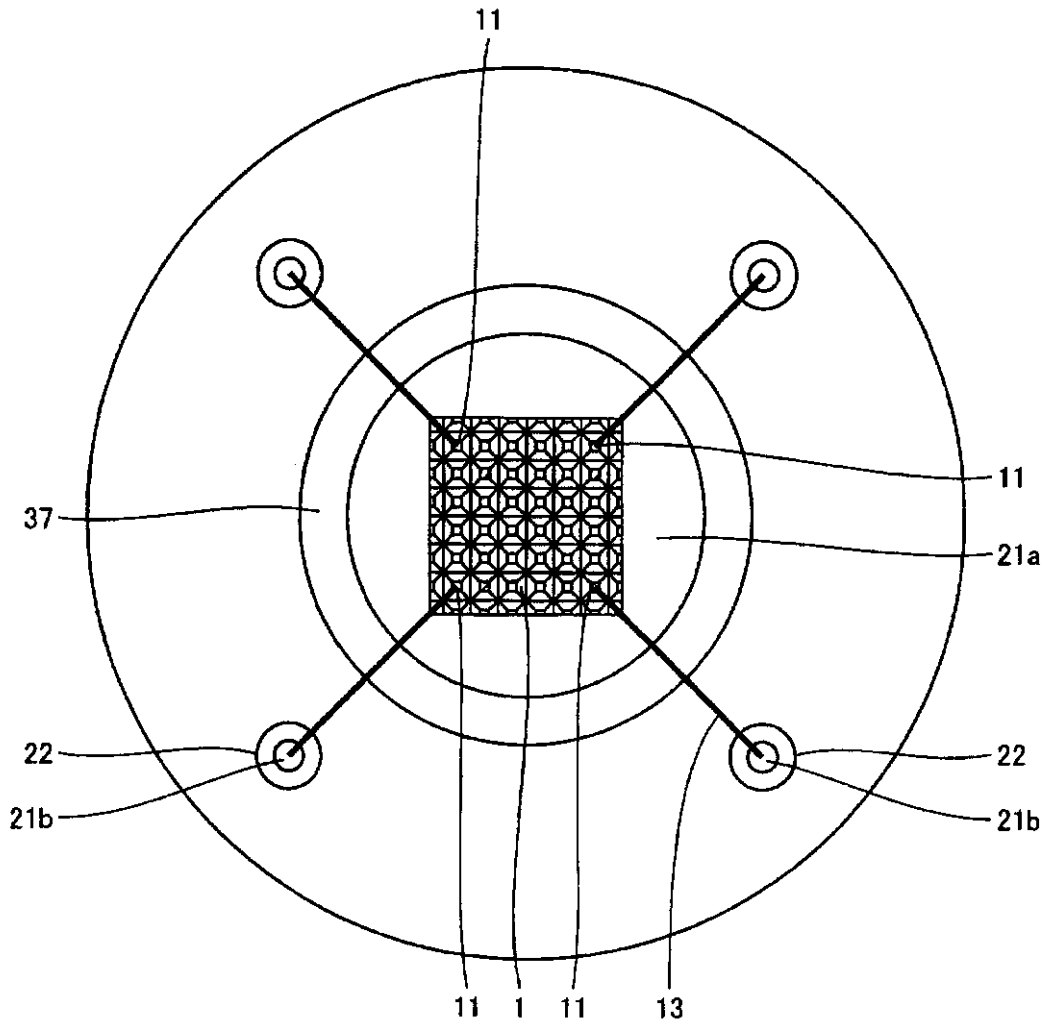


FIG. 8

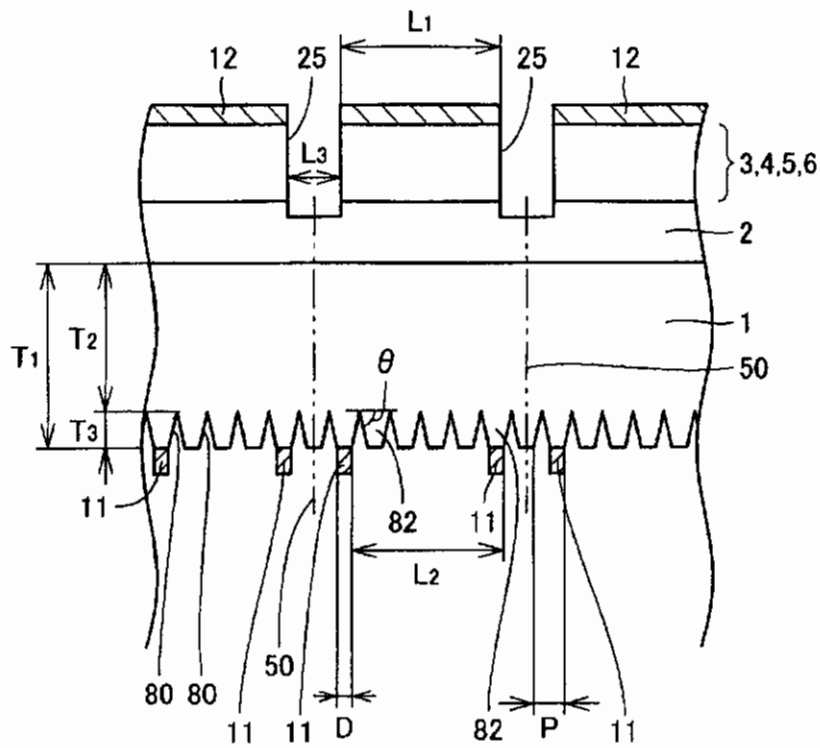

L1
12
25
25
12
L3
3,4,5,6
2
1
T1
T2
θ
50
T3
11
82
11
L2
80
80
50
11
11
D
82
P
11

FIG. 9

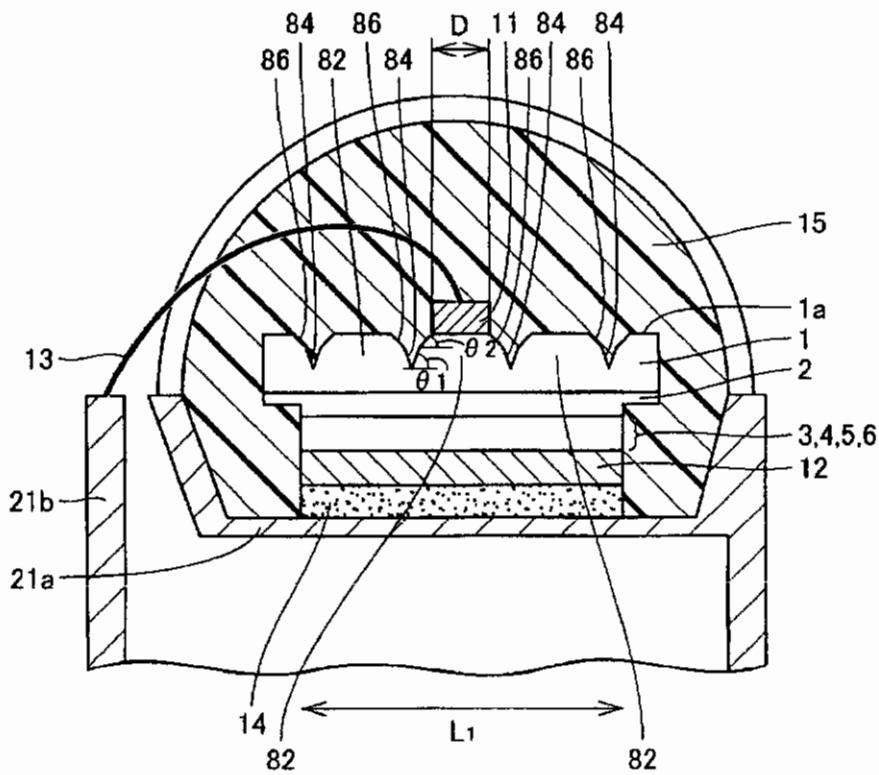

84
86
D
11
84
84
86
82
84
86
86
15
1a
13
θ2
θ1
1
2
3,4,5,6
12
21b
21a
14
82
L1
82

FIG. 10

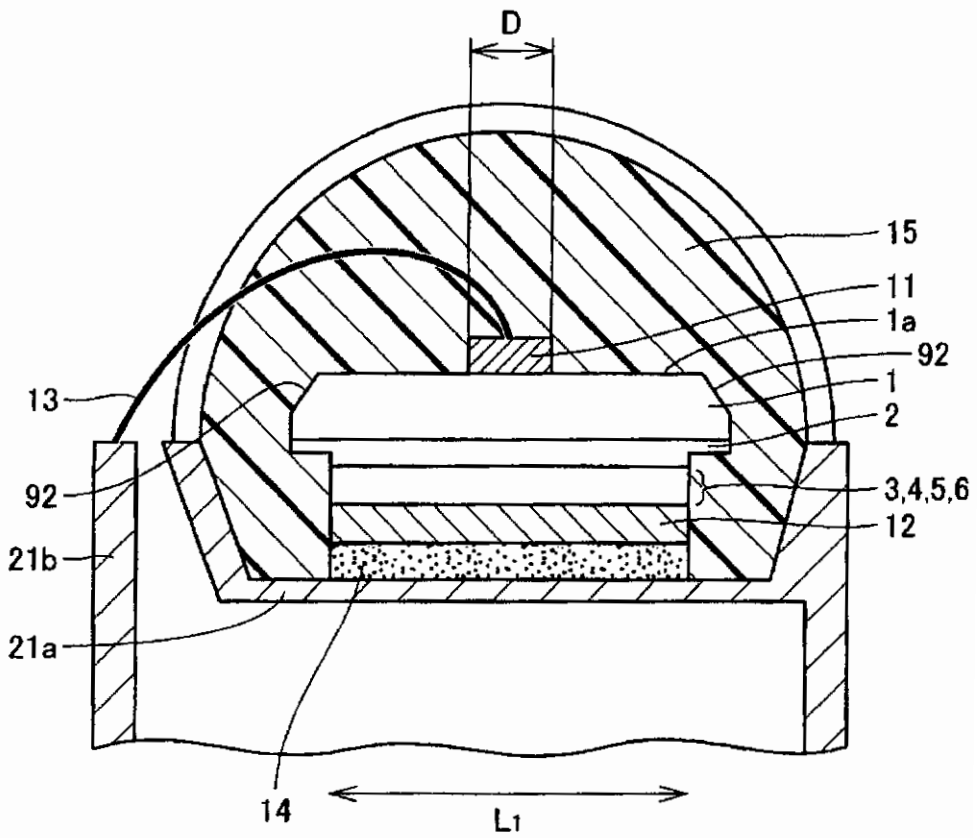


FIG. 11

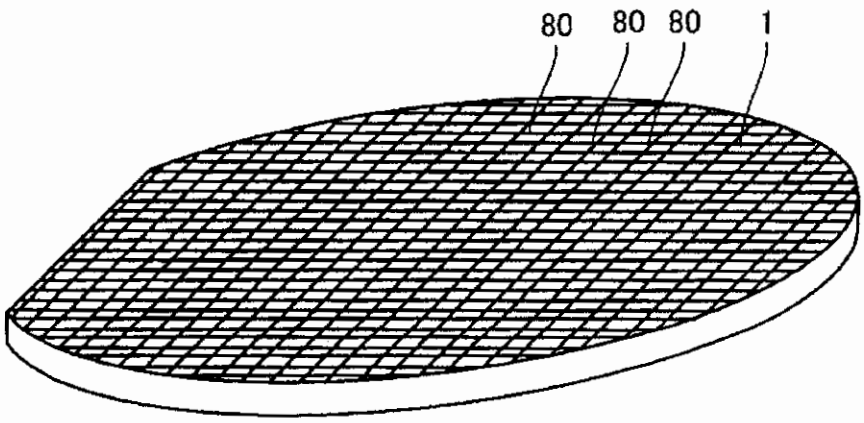


FIG. 12

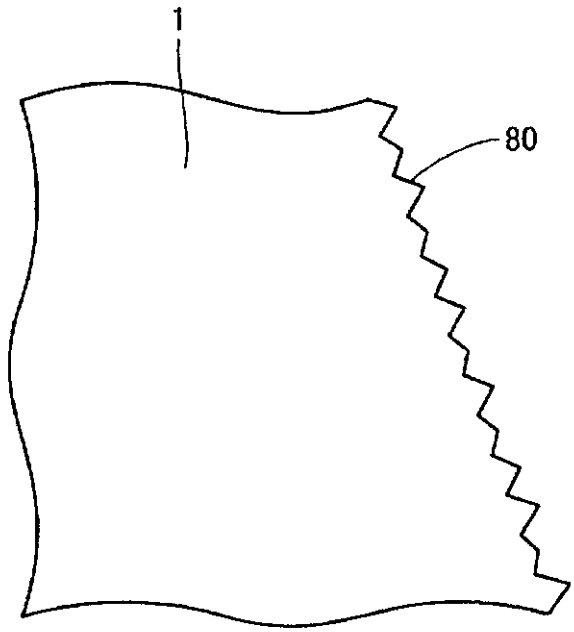


FIG. 13

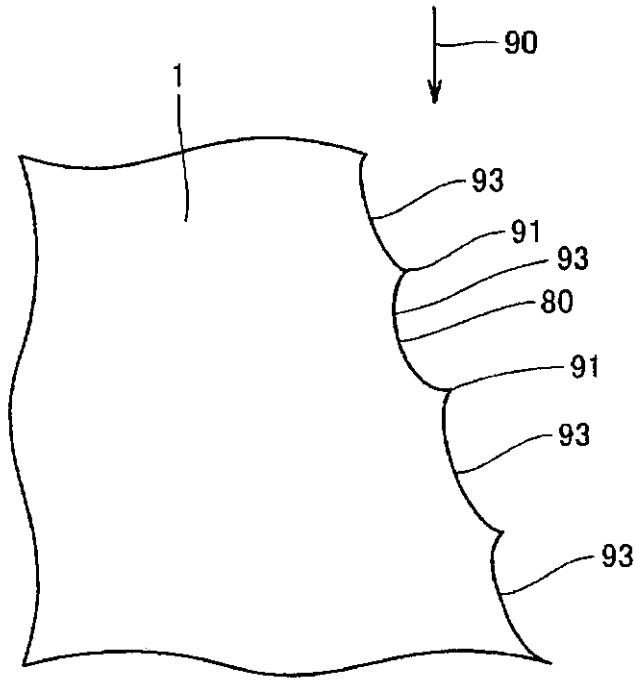


FIG. 14

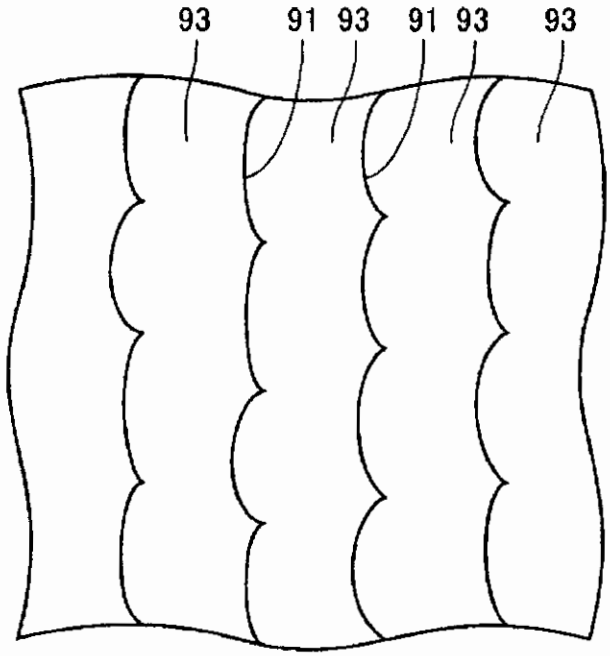


FIG. 15

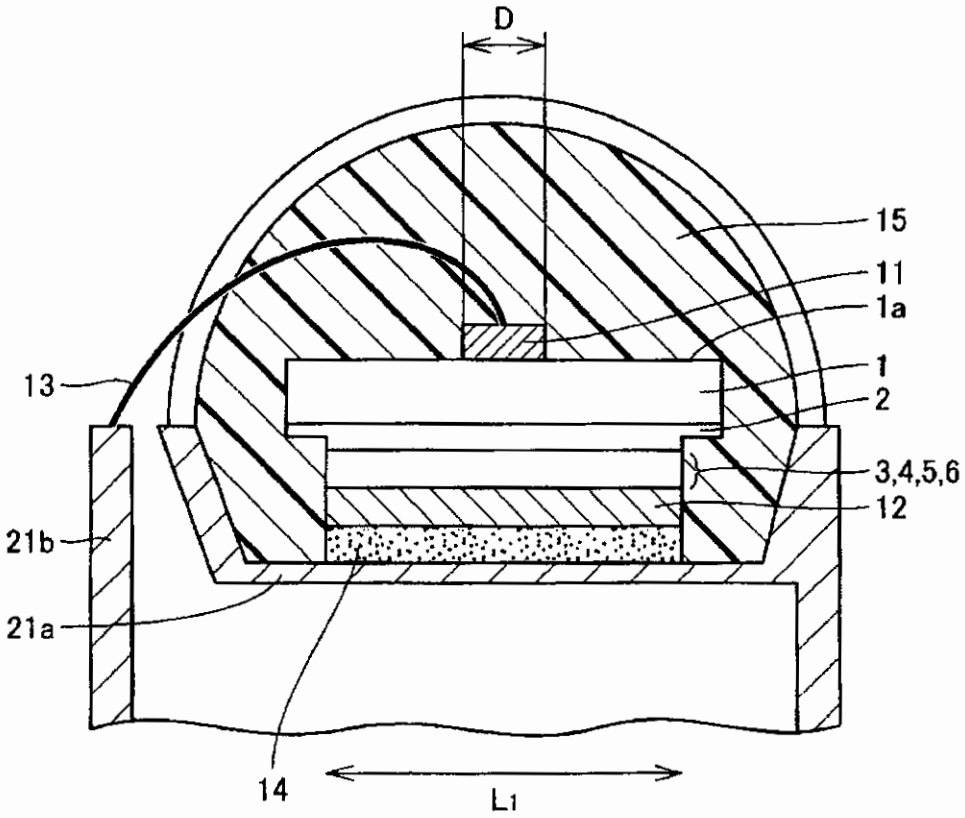


FIG. 16

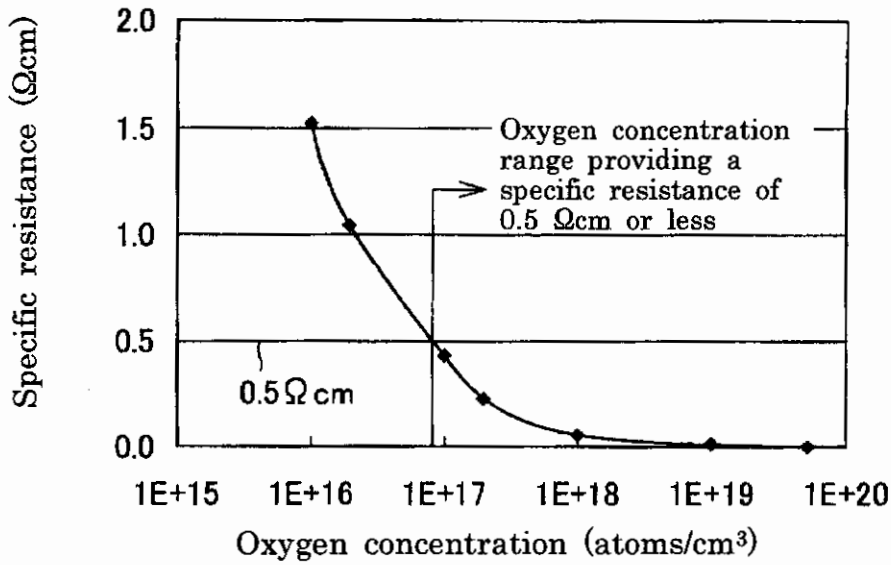

Specific resistance (Ωcm)
2.0
1.5
1.0
0.5
0.0
Oxygen concentration range providing a specific resistance of 0.5 Ωcm or less
0.5Ωcm
1E+15
1E+16
1E+17
1E+18
1E+19
1E+20
Oxygen concentration (atoms/cm3)

FIG. 17

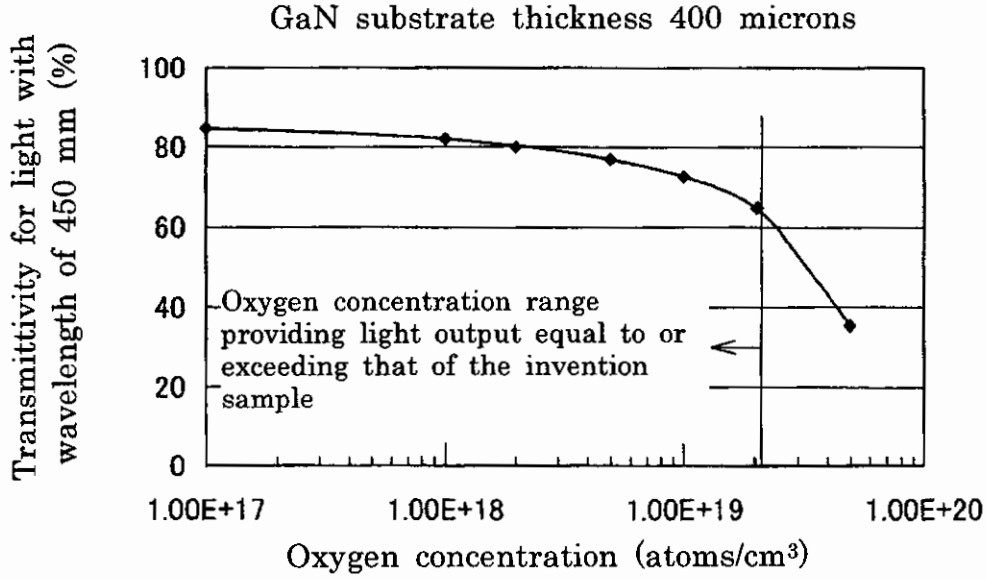

GaN substrate thickness 400 microns
Transmittivity for light with wavelength of 450 mm (%)
100
80
60
40
20
0
Oxygen concentration range providing light output equal to or exceeding that of the invention sample
1.00E+17
1.00E+18
1.00E+19
1.00E+20
Oxygen concentration (atoms/cm3)

FIG. 18

Relationship between substrate thickness, substrate plan size, oxygen concentration, and light output

