

:

(54)

, 2
 .
 3
 가 , 2
 SPR
 40 80

5

, , , , , , , , ,

pler) (SPR: surface plasmon resonance) SPR (cou
 SPR

(SPR) , (LS), (SD),
 (SD)
 SPR (10 1)
 (superstrate) (LS) (SD)
 (IC) , (SD) (OC)

SPR 5가 , LS, SD, OD, IC OC
 . A , 5 가 (A, B, C)
 (DOE) , IC OC가 , , OD IC
 OC가 SPR . C LS OD , 5 가

A SPR (, BIA IBIS)가 . A
 C 20 가 , 가 가 . SPR LS
 SD (IC OC) , OD (Texas Ins
 truments) (Spreeta) SPR
 (EP 0 797 090가). SPR
 , SD 가 가

A 가 C 가 B .
 (oblique angle) SPR IC OC LS, SD IC
 SD 80 °
 가

SPR , SPR 40 ° 80 ° SPR
 (5,313,264).
 , IC OC 가 SPR
 가 SPR
 p a_p

$$a_p = \frac{m\lambda}{n_g x_p} y_i \left[1 + \left(\frac{x_p}{y_i} \right)^2 \right]^{1/2} \quad (1)$$

, m , x_p y_i p
 , p=0 가 , p=N 가 . p
 y_i (M) , y_i M+1 .
 SPR , 670nm 가 , SPR 1.65
 가 (, 가), SD 1.46
 SPR (,) , SPR 73 °
 , SPR , 3mm y_i=2mm,
 x_{p=0} =8mm x_{p=N} =5mm 가 7050 (d)가
 (a_N - a₀)/7050=0.003nm
 100nm 800nm .
 , 가
 100 , 0.3nm 가
 , m=1 ,

m, m > 10, SPR, m < 10

[P.P. Clark C. Londono, 15, 39 - 40 (1989)]
 [J. Futhey M. Fleming, 4 - 6]
 1992 9 OSA

(variable - energy e - beam lithography) [E.B. Kley
 B. Schnabel, Proc. SPIE 2640, 71 - 80 (1995)]
 an, Appl. Optics 36, 4666 - 4674] [G.P. Behrmann M.T. Duign
 (kinoform) (phase) [L.B. Lesem, P.M.
 Hirsch, J.A. Jordan Jr., IBM J. Res. Develop. 13, pp. 150 - 155(1969)]

50nm - 1000nm

[J.D. Mansell, D.R. Neal, S.W. Smith, Appl. Optics 36, pp.
 4644 - 4647(1997)] (grey - tone) [5,48
 2,800 (1996 1 9)] UV
 20nm

[N.K. Sheridan Appl. Phys. Lett. 12, 316 - 318(1968)],

[M. Breidne, S. Johansson, L.E. Nilson H. Ahlen, Opt. Acta 26, 1427(1979)]

[E.B. Champagne, J. Opt. Soc. Am. 57, 51(1967); J. Latta, Appl. Opt. 10, 5
 99(1971); M. Miler, I. Koudela, I. Aubrecht, Appl. Opt. 38, 3019 - 3024(1999)].

SPR
 R ,
 OC SD IC SPR IC SP
 3 가
 , SPR IC OC
 SPR 40°
 SPR
 가 SPR 가
 가 ,
 가
 가 3
 1 , 1 , 1
 1 2 1 2 1
 1 2 1 가 ,
 2 1 2 가 , 1 2
 1 2 가 ,

1 2 , 가
 1 가 40
 , .
 , 1 ,
 180 ,
 1 2 2
 1 2 2 ,
 2 2 ,
 1 1 가 ,
 2 2 가 , 1 2
 1 2 가 ,
 1 2 , 2 가
 2 가 40
 , .
 , 1 2 가 . , 1
 2 HeCd , Kr - , (excimer) ,
 . 1 2
 , , .
 1 가 .
 , ,
 , - - (sacrificial - layer - etch) 1 2 가 .
 - - ,
 .
 가 가 1 2 , 1 2 가 .
 가 1 2
 , 가 가 1 2
 , 가 가 1 2
 1 2 .
 , , .

1, 1, 2, ,
 ,
 - x 가 , record 가 , 1 1
 2가 2 , x 3
 ;

$$a_{record}(x) = \frac{\lambda_{record}}{\sin(\theta_1) + \sin(\theta_2)}$$

- read 가 , n_g 가 , 1
 , 2가 , x
 3 ;

$$a_{read}(x) = \frac{\lambda_{read}}{n_g(\sin(\theta_0) - \sin(\theta_i))}$$

- x_{centre} 가 , A_0, A_1, A_2, A_3 $a_{record}(x)$ $a_{read}(x)$ 1, 2, 3,
 4 , 1 2

$$a_{record}(x) - a_{read}(x) = A_0 + A_1(x - x_{centre}) + A_2(x - x_{centre})^2 + A_3(x - x_{centre})^3$$

2

가

1

2

가

1

2

40

2

1

가

가

1 SPR 5
 1d , 1a 1c (in) 0 (out)
 , 1e (div)

2 SPR 4

3 4가 가 SPR , 3a
 , 3b , 3c
 , 3d

4 , 4a , 4b SPR
 () ()
 4c SPR () ()
 , 4d SPR ()
 , 4e SPR ()

5 1c 1 (8) ,
 가 .

6 5 .

7 1b 1 (2) ,
 가 .

8 7 .

9 1c 1 (8) ,
 , 5 .

10 1b 1 (2) ,
 , 7 .

11 (7, 7') SPR ,
 11a A - A , 11b SPR .

1 SPR 5가 1a SPR
 (1), 1 (2), 2 (3), (superstate)
 SPR (4), SPR (5) SPR

(photodiode), (charge - coupled - d
 evice), (5)

1a SPR 1 (2) (5) 1b
 , 2

1c SPR (1), 1 (8), 2
 (9), (4) SPR 1 (8) (4)

1d (in) (8')
 (out) (9') 1d in (8')
 (extrapolated ray) (10) (10) (+)
 out 99') (10) in (-) 1d
 (10) out

1d in out

1 , 2 1 , +1 -1 1 1d SPR
 (8') (9') in out 1

가 100% 가 1
 in out (40%) 1a 1c 1a 1c 1d
 (LS) (LD) (LS) (LD)

SPR 가 , LS

1e (3') 가
 SPR , div 가
 가 가
 0° 20° 가

2 SPR 4가 가 2a
 2d , SPR
 (1), 1 (2), 2 (3), (4), (5),

(6) 2a SPR (2) 1 (4) 2
 (6) 2b (4)

2c SPR (1), 1 (8"), 2
 (9"), (4) SPR (4) 2 (9")
 1 (8") SPR 가 2c ,
 (8", 9") 2d
 (8", 9") 0

3 가 , (a) , (b) , (c)
 , (d) SPR
 가 SPR , , , , , , , ,

4 1 , a_p X_p p 4a , 가 , a_0 $X_{p=0}$
 , a_N $X_{p=N}$

4b 3a 3b 가 n_c ((x_c, y_c) 가 n_i SPR (x_i, y_i))
 4c 가 n_i SPR (x_i, y_i)
 (x_c, y_c) SPR (x_i, y_i)
 , , 가 4 $x - y$ 가 , 4b
 4c

$$a_p = \frac{m\lambda}{n_s} \left[\frac{x_p}{\sqrt{x_p^2 + y_i^2}} - \frac{x_c - x_p}{\sqrt{(x_c - x_p)^2 + y_c^2}} \right]^{-1} \quad (2)$$

(2) , , 가 x - y

4d 3c 3d 가 n_c ((x_i, y_i))
) 가 n_i SPR (x_i, y_i)
 4e SPR (x_i, y_i) 가 n_i SPR 4d 4e
 (1) $y_c > x_c - x_p$ (2)

(1) (2) (a_pn_g/m) (1)

$$\frac{a_p n_g}{m\lambda} = \left(\frac{y_i}{x_p}\right) \left[1 + \left(\frac{x_p}{y_i}\right)^2\right]^{1/2} \quad (3)$$

(2)

$$\frac{a_p n_g}{m\lambda} = \left[\frac{\left(\frac{x_p}{y_i}\right) - \left(\frac{x_c}{y_i} - \frac{x_p}{y_i}\right)}{\sqrt{\left(\frac{x_p}{y_i}\right)^2 + 1} \sqrt{\left(\frac{x_c - x_p}{y_i}\right)^2 + \left(\frac{y_c}{y_i}\right)^2}} \right]^{-1} \quad (4)$$

(x_p/t), (x_c/t), (y_c/t) [4] y_i SPR
 , SPR 0.8 < (x_p/y_i) < 6 40° 80° (3)
 가 a_pn_g/m 1.6 1.0

73° 가 x_c/t = 3.4 가 35°
 / (y_c/t) 3.7 (4)
 20 0.6

1c 1 5 6 , ,
 (, SPR) 6 ,
 5 6 3c 3d 1 0.5 3μm 가
 (12) UV

eCd , Kr 가 가 H
 (14)
 5 (18) (20) (18)
 (11) (14) (20) (18) (11) (20)
 (14) (18) (11) (20)
 (18) 20)

5 (15 17) 2 ,
 SPR (21) , 가
 442nm 가 (ShiPLY) S1828
 5W/m²
 30 50 (11') (21') 5 6 (21)
 (25) (14) (21') (21') (22 24) 6
 SPR 10° 20° ,
 SPR 40° 80° , 가
 가 (splitter) , 가
 가 가
 1c 2 (9) 1
 (11) (14) (12)
 1 (13) 180° 2 1
 1c 1
 (14) (13)
 2c (8" , 9") 2d (8' , 9') ,
 (8" , 8') 5 (15 17) 2
 SPR (, SPR
 SPR SPR SPR 1
 SPR SPR 1 SPR 2
 SPR 2 SPR 1
 1b 2b 1 (2) 7 8
 SPR (11) , 가 0.5 3μm
 (12) (34)
 2 (26) 7 (27) (29)

(26) (27 29) (11')

1

7 (30 32) 2
 SPR
 가
 8 (11') (34')
 (26) (34') (34) (11) 1 7
 (34') (35 37) 8 (38)

1b 2b 2 (3) 1
 (33) 180° (11) (26) (11) 1
 2b 1 1a 2a 2a 1b 1b
 2b 1a 2a 1b 1b

SPR
 / (11')
 (, 가
) (33)
 5 (13) 7
 6 8 9 10

2 record 2

$$a_{record} = \frac{\lambda_{record}}{\sin(\theta_1) + \sin(\theta_2)} \quad (5)$$

record , 1, 2 2 (9 10) .

가 0 (11') (6 8) ,

read

$$a_{read} = \frac{\lambda_{read}}{n_g \sin(\theta_0)} \quad (6)$$

$$a_{read}(x) = n_g \left[A_0 + A_1(x - x_{centre}) + A_2(x - x_{centre})^2 + A_3(x - x_{centre})^3 \right] \quad (11')$$

$$a_{record}(x) - a_{read}(x) = A_0 + A_1(x - x_{centre}) + A_2(x - x_{centre})^2 + A_3(x - x_{centre})^3 \quad (7)$$

$$\begin{matrix} x_{centre} & A_0, A_1, A_2, A_3 & x_{0, y_0} & x_r, y_r \\ (39, 41) & & (40, 42) & \end{matrix}$$

$$A_0(x_r, y_r, x_0, y_0) = 0$$

$$A_1(x_r, y_r, x_0, y_0) = 0$$

$$A_2(x_r, y_r, x_0, y_0) = 0$$

$$A_3(x_r, y_r, x_0, y_0) = 0$$

(J. Latta), Appl. Opt. 10, 599 (1971)

$$a_{read} = \frac{\lambda_{read}}{n_g (\sin(\theta_0) - \sin(\theta_i))} \quad (6')$$

$$\begin{matrix} (46) & (48) & (13) & (40) & (43) & (45) \\ (25) & & & & & \\ (52) & (54) & (33) & (42) & (49) & (5) \\ (38) & & & & & \\ 1) & & (33) & & (41) & \end{matrix}$$

SPR (7, 7') SPR 11a A - A 11

SPR

R SPR

가 SPR SPR SPR

가 SPR

(7) 2 가

0.5 5mm 50 200 μ m 가

가 가

3 2 SPR

(SRP: surface relief pattern) SPR()

SPR (sacrificial - layer - etch) , SRP()

[(K. Reimer) , Proc. SPIE, 3226, MEMS III(Microelectronic Structures and MEMS for Optical Process ing III), (Austin), 6(1977)].

SRP SRP

가

SPR SPR ()

가 SPR

(SRP) / SPR /
 (galvano - solution) /
 0.3nm Ni가 (shim) Ni SRP Ni SRP /
 Ni SRP가 SPR SPR /
 SRP 가 SRP SPR SPR /
 SPR SPR

SPR M 1010), (: ULTEM 1000, ULTE
 8, (: TOPAS), 293, XU - 21

(70 200)
 0.2 0.7% (a_{read})

가 SPR

(57)

1.

1 , 1 ,

1 2 1 2 1 ,

1 1 가 ,

2 2 가 , 1 2

1 2 가 ,

1 1 가 40

2.

1 ,

9 , - - , ,

11.

2 7 , 1 2 가 1 2 가

12.

11 , 가 .

13.

11 12 , 가 1 2

14.

11 12 , 가 1 2

15.

11 12 , 가 1 2

16.

8 15 , .

17.

16 , , ,

18.

, 가 ,

1 2

가 ,

1 2 40 2 1

19.

18 , 가

20.

18 , 가

21.

18 20 , 가

22.

18 20 , 가

23.

18 22 가 , 가 ,

24.

1 17 , 1 2

- x 가 , record 가 , 1 1 ,
 2 가 2 , x 3 ;

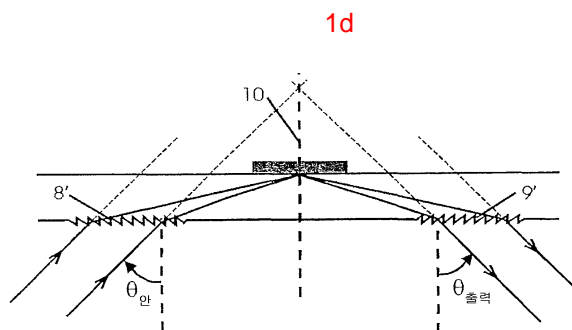
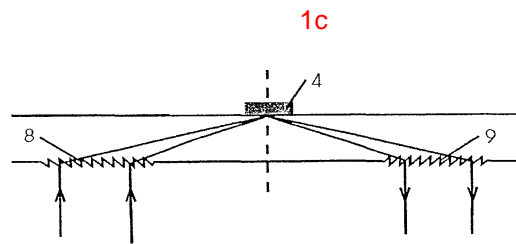
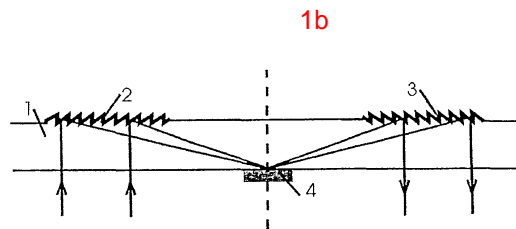
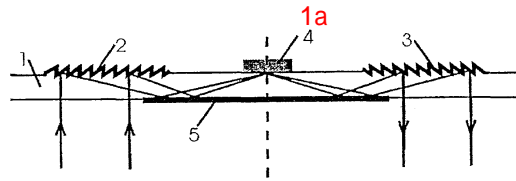
$$a_{record}(x) = \frac{\lambda_{record}}{\sin(\theta_1) + \sin(\theta_2)}$$

- read 가 , n_g 가 , 1 x
 3 , 2 가 ;

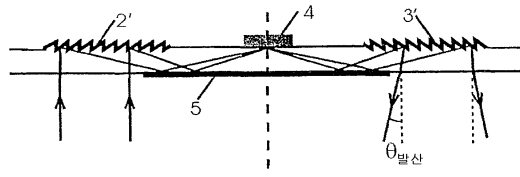
$$a_{read}(x) = \frac{\lambda_{read}}{n_g(\sin(\theta_0) - \sin(\theta_i))}$$

- x_{centre} 가 , A_0, A_1, A_2, A_3 $a_{record}(x)$ $a_{read}(x)$ 1, 2, 3,
 4 , 1 2

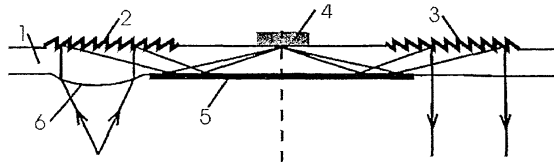
$$a_{record}(x) - a_{read}(x) = A_0 + A_1(x - x_{centre}) + A_2(x - x_{centre})^2 + A_3(x - x_{centre})^3$$



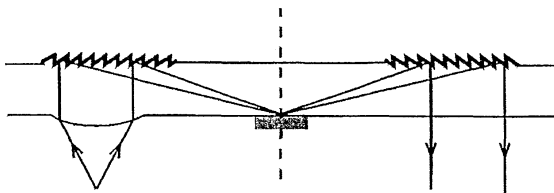
1e



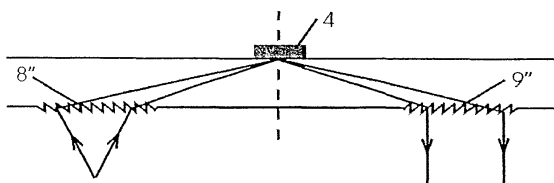
2a



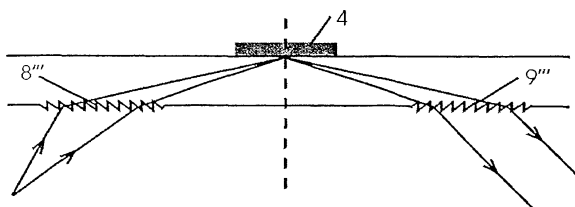
2b



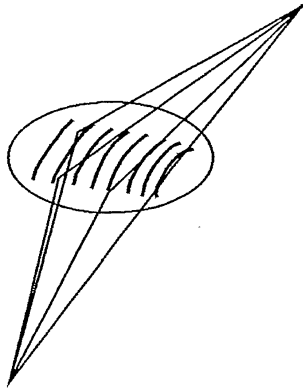
2c



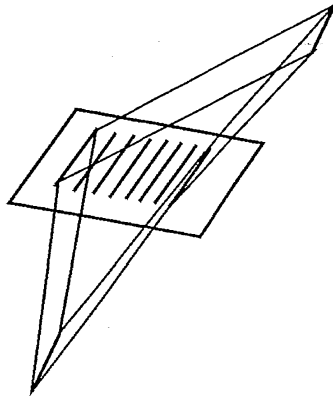
2d



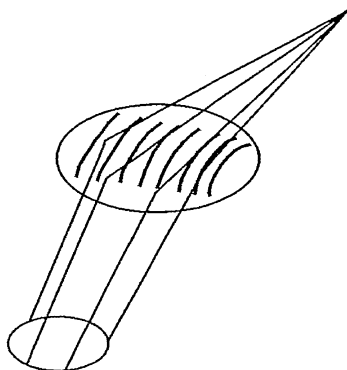
3a



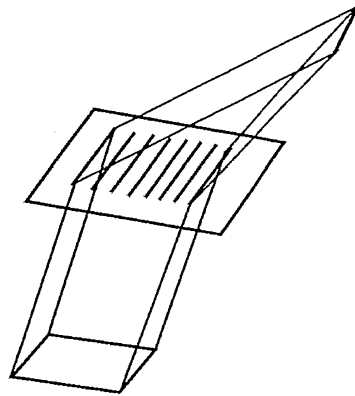
3b



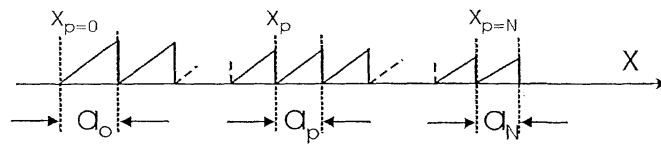
3c



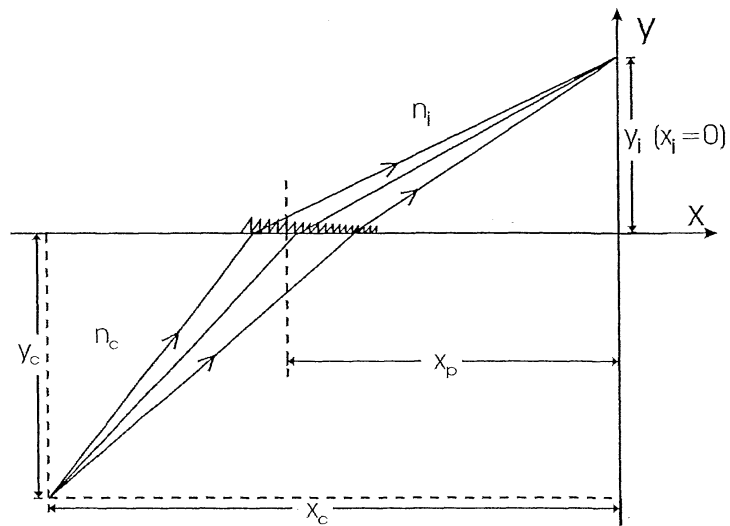
3d



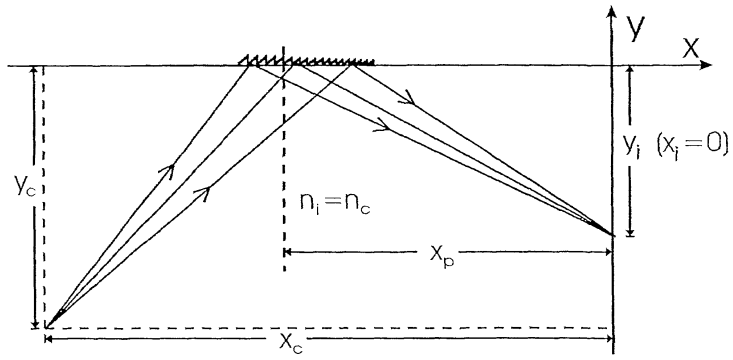
4a



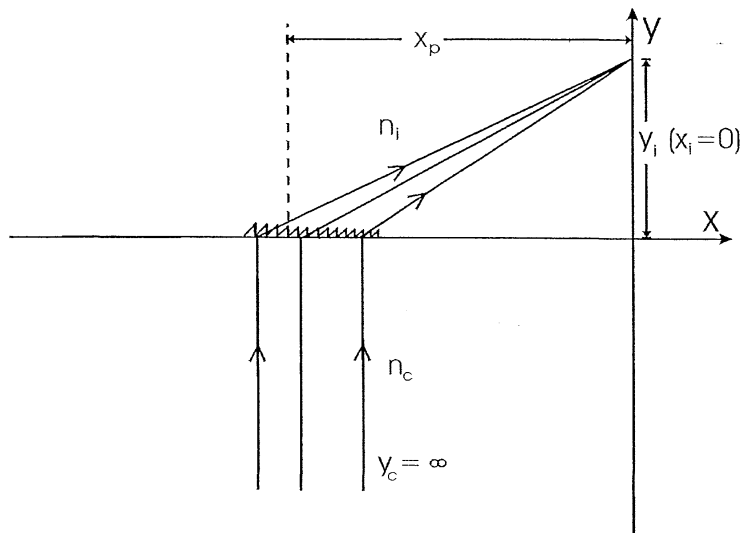
4b



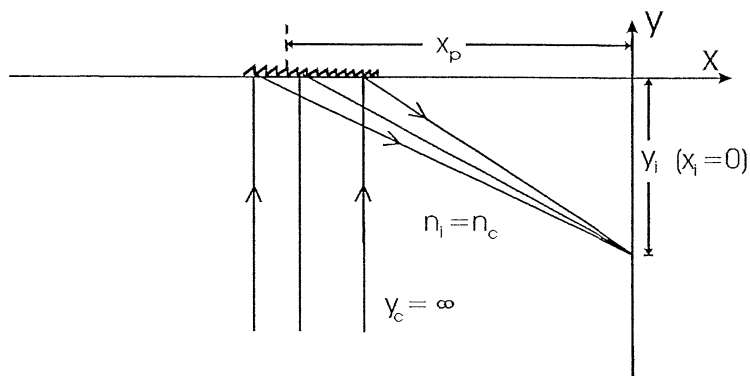
4c



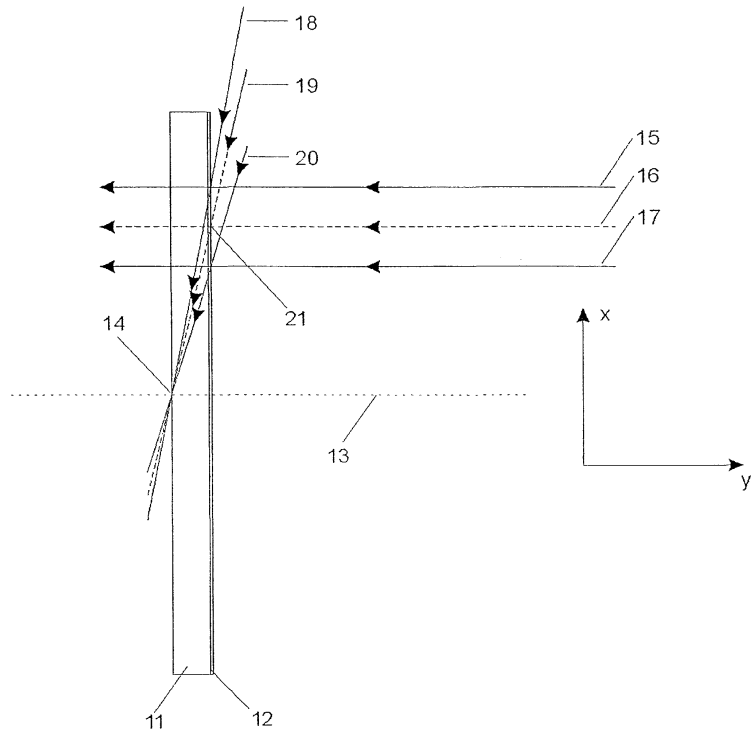
4d



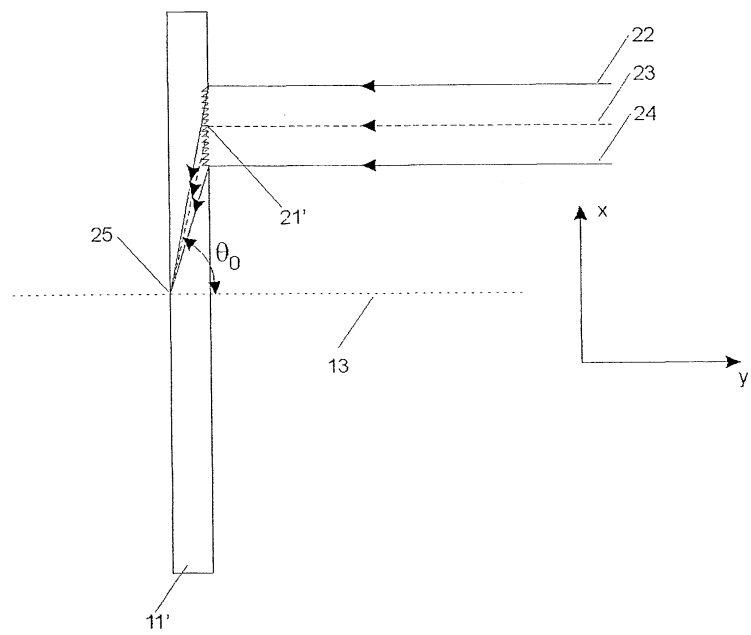
4e



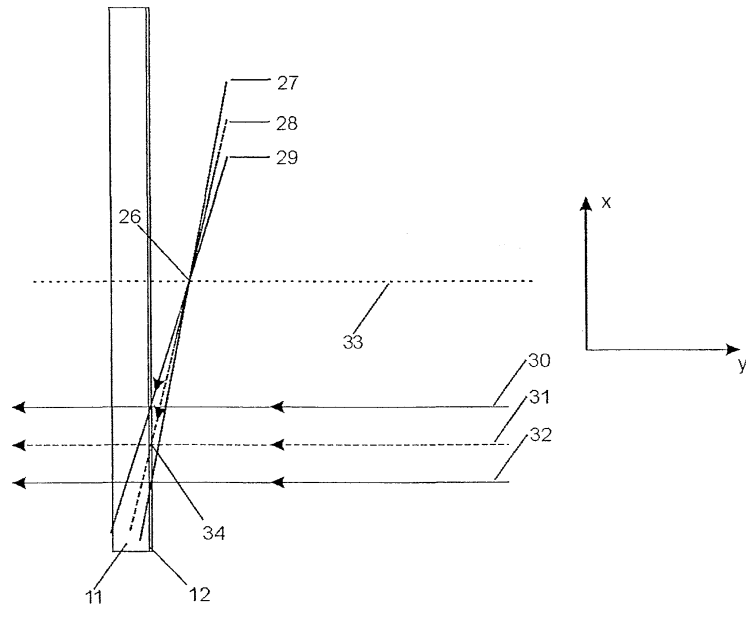
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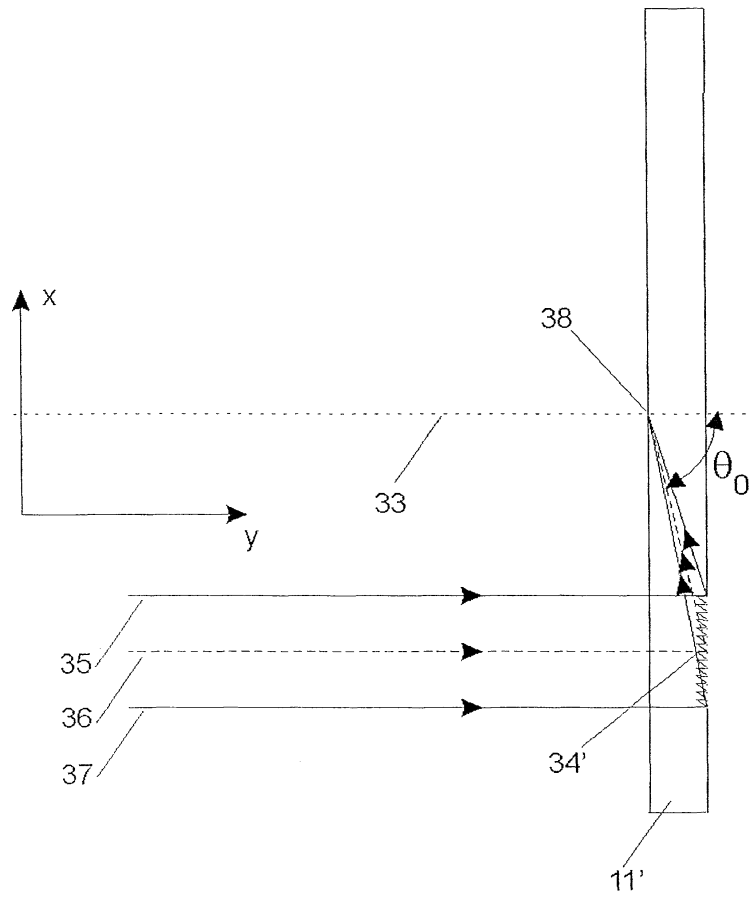
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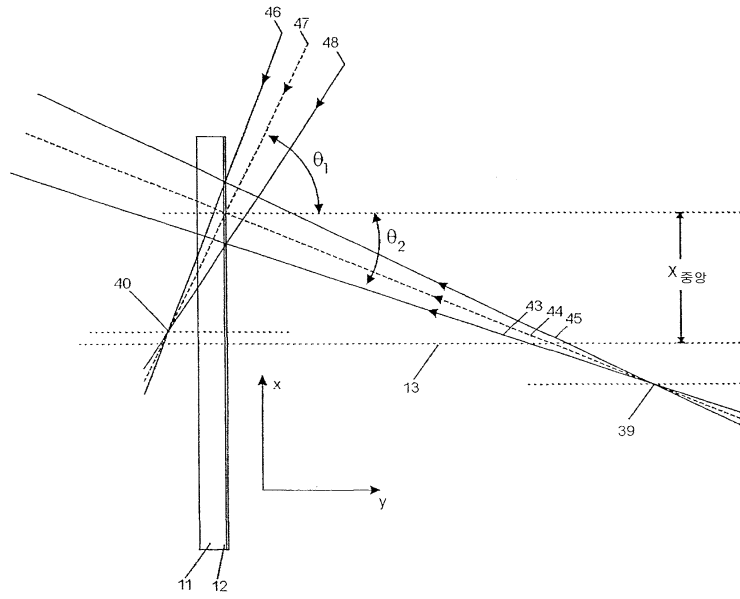
7



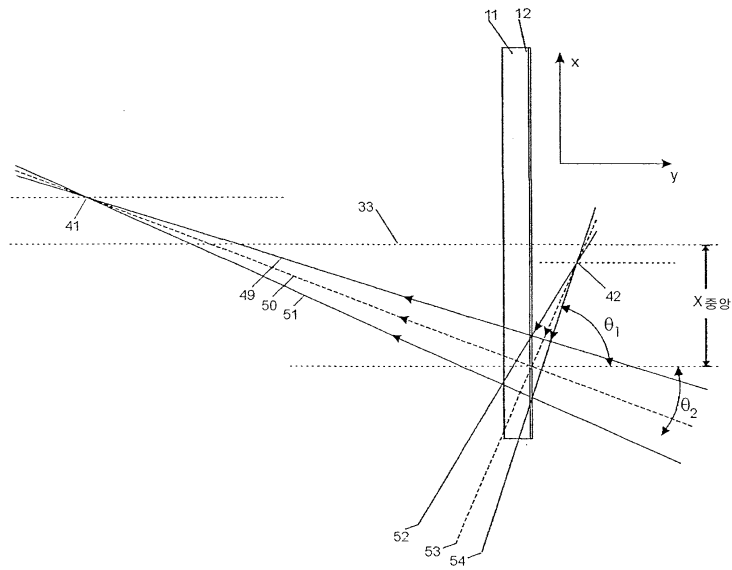
8



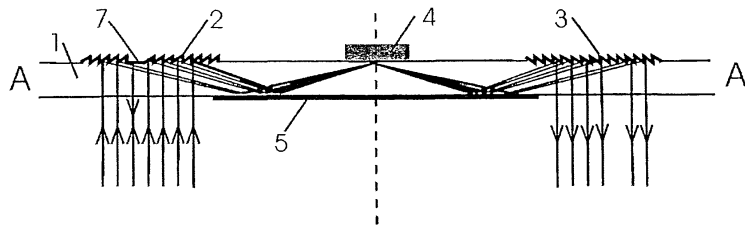
9



10



11a



11b

