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96 - 341085

1996 12 20

(JP)

(73)

가 가

가 22 22

(72)

139 - 1 - 413

(74)

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(54)

， (4) (1) (1) ，

· GaP (4) (Al_xGa_{1-x})_{1-y}In_yP

· (Al_xGa_{1-x})_{1-y}In_yP 2 1 ， ， ，

1

1 1 ，

2A 2B 1 ，

3 2 ,

4A 4B 2 ,

5 ,

6 GaP ,

7A 7B GaP ,

8 ,

9A 9B .

10 ,

11 .

*

1,11: 2,12: 3,13:

4,14: 6,16: 7,17: n -

8,18: p -

AlGaInP

" AlGaInP ' $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ x, y가 0 x, y 1

$(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ In $y = 0.51$ GaAs , Ga , In
 $y = 0.51$, $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ Al $x = 0$ 0.7 , $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$
, $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ 8 $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$
 GaP , n - GaAs (211), n - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$
(203), $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (210), p - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (205) p -
(206) n - GaAs (212) (210)
 GaP (entraP) , (203, 205) (210)
((DH)). , n - (207) GaAs (212) p - (208)
(206) . In y GaAs $y = 0.51$
, $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ ((210) (203, 205)) Ga
, 9A , (210) (Ec) Ga
((Ev) , 9B Ga
 $G(E)$ (P_{10} , P_{20}) Ga (Ec, Ev) . , $(\text{Al}_x\text{Ga}_{1-x})$
 $_{1-y}\text{In}_y\text{P}$ (210) (p - n) Ga
) .
, 8 , GaAs (212) 1.42 eV
As $1/2$ GaP , GaAsP, AlGaAs , Ga
 $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$, GaAs Ga
(Ga " " " ") .
, 10 n - GaAs (311), n - (DBR)
(313), n - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (303), $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (310), p -
 $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (305) p - GaP (306) n - GaAs (301)
(Appl. Phys. Lett., vol. 61, No. 15 (1992), pp. 1775 - 1777) Ga
GaAs (301) n - (303) 2
DBR (312) , (310) DBR (313)
GaAs (301) 11 , n - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$
(403), $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (410), p - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ (405) p -
GaP (406) GaAs , GaAs
(403) () (420) GaP (414;
2.27 eV) (Appl. Phys. Lett., vol. 64, No. 21 (1994), pp. 2839 - 2841) Ga
.
, 10 , (310) Ga DBR (313)
 Ga DBR (313) CaAs (301) . 10
8 1.5 .
, 11 GaP (414) .
, $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$ GaAs $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$
(650 - 550 nm) , GaP (2.27 eV)
 $_{1-y}\text{In}_y\text{P}$ (103), , 6 , n - GaInP (104), n - $(\text{Al}_x\text{Ga}_{1-x})$
(105) p - GaP (106) n - GaP (101) (110), p - $(\text{Al}_x\text{Ga}_{1-x})_{1-y}\text{In}_y\text{P}$.

, 5, GaP 5.451 $(Al_x Ga_{1-x})_{1-y} In_y P$
 01) , GaP $(Al_x Ga_{1-x})_{1-y} In_y P$ GaP (1
 5.451 3.6% , GaAs $(Al_x Ga_{1-x})_{1-y} In_y P$ (103, 110
 105) GaP (101) GaInP (104)
 $(Al_x Ga_{1-x})_{1-y} In_y P$ (103, 110 105)
)가 가 (misfit dislocation;
 가 , 가
 , 7A , (110) (Ec) 가 (Ev)
 가 , meV 가 7B (Ec#, Ev#
 :) 가 G(E) (P₁₀, P₂₀)
 , GaAs (band) (Ec, Ev)
 $(Al_x Ga_{1-x})_{1-y} In_y P$ (103, 110 105) GaP
 (101) 8 2 (2 order)
 , ()
 가 .

()

GaP $(Al_x Ga_{1-x})_{1-y} In_y P$

2

1

2

1

2

1

2

1 [110] 15 ° AlGaInP (001) MOCVD ()
 n - InGaP (2), Si (Al_xGa_{1-x})_{1-y}In_yP (x=1.0, y=0.51) (3),
 (Al_xGa_{1-x})_{1-y}In_yP (x=0.5, y=0.51) (4), Zn (Al_xGa_{1-x})_{1-y}In_yP (x=1.0, y=0.51)
 (5) Zn GaP (6) , GaP (1) n - (7) ,
 (6) p - (8) . 15 ° (1)
 , (100) (just) (4) (Al_xGa_{1-x})_{1-y}In_yP
 1 1 × 10¹⁷ - 1 × 10¹⁹ cm⁻³
 2 1 × 10¹⁷ - 1 × 10¹⁸ cm⁻³ .

GaP (1) (Al_xGa_{1-x})_{1-y}In_yP (3, 4 5) , 2A
 (4) (Ec) 가 (
 Ev) 가 meV 가 2B 가
 (가)가 가 G(E) (P₁₀ , P₂₀)

, (4) 1 가 (Al_xGa_{1-x})_{1-y}In_yP (
 x=0.5, y=0.51) () Ec 30 meV E_(N) 2
 (Al_xGa_{1-x})_{1-y}In_yP (x=0.5, y=0.51) 가 () 60 meV
 E_(zn) (2B P₁, P₂ E_(N) E_(zn)
 G(E) E_(N) E_(N) E_(N)
 E_(zn) (band) Ec Ev 30 meV E_(N) E_(N)
 E_(zn) E_(N) E_(zn) Ec Ev 200 meV
 , E_(N) E_(zn) E_(N) E_(zn) E₁ (GaP
 (4) E_(N) (4) GaP (1)) ,
 AlGaInP 650 nm - 550 nm) ,

, 1 E_(N)
 E_(zn) E₁ = 2.16 eV 574 nm , 1.0%
 , 8 GaAs AlGaInP
 (Al_xGa_{1-x})_{1-y}In_yP (210) 가 x=0.5, y=0.51
 Eg (=2.25 eV) 550 nm , 0.1% ,
 x, y 10 8
 x=0.38, y=0.51 , 572 nm , 0.35% ,
 , 1 8
 3 .

(4) (5) 가 , (4) Al x=0.75
 , x=0.75, y=0.51 5
 55 nm 0.2% .
 (2)

3 2 ALGaInP (001)

[110] 15° n - GaP (11) MOCVD (

) n InGaP (12), Si (Al_xGa_{1-x})_{1-y}In_yP (x=1.0, y=0.51) (13),

Se · Mg (Al_xGa_{1-x})_{1-y}In_yP (x=0.5, y=0.51) (14), Zn (Al_xGa_{1-x})_{1-y}In_yP (x=1.0, y=0.51) (15) Zn GaP (16), GaP (11) n -

(17), (16) p - (18)

1 가 15° (1) , (100) (just)

(14) (Al_xGa_{1-x})_{1-y}In_yP

Se 1 × 10¹⁷ - 1 × 10¹⁹ cm⁻³ 2 Mg

1 × 10¹⁷ - 1 × 10¹⁸ cm⁻³

GaP (11) (Al_xGa_{1-x})_{1-y}In_yP (13, 14 15) , 4A

(14) (Ec) 가

(Ev) 가

(가) 가 , 4B

(P₁₀, P₂₀) , (band) G(E)

, (14) 1 Se가 (Al_xGa_{1-x})_{1-y}In_yP (x=0.5, y=0.51) () Ec 190 meV E_(Se) 2

Mg가 (Al_xGa_{1-x})_{1-y}In_yP (x=0.5, y=0.51) 가 () 64 meV

E_(Mg) (4B P₁, P₂) Se E_(Se) E_(Mg)

G(E) Ec Ev 30 meV E_(Se) Mg E_(Se) Mg

E_(Mg) E_(Mg) E_(Mg) Ec Ev 200 meV E_(Se) Mg

E_(Se) Mg E_(Mg) E_(Mg) E_(Mg) E_(Se) Mg

e) Mg Se E_(Mg) E_(Se) Mg E_(Mg) E_(Mg) E_(Se) Mg

IGaInP (14) GaP (11) E_(Mg) E₂ (GaP) A

650 - 550 nm), ,

, 2 , Se E_(Se) Mg E

(Mg) E₂=2.00 eV 621 nm , 4.5%

, 8 GaAs AlGaInP

, (Al_xGa_{1-x})_{1-y}In_yP (210) 가 x=0.5, y=0.51 ,

Eg(=2.25 eV) 550 nm , 0.1% ,

x, y , 2 8

10 , 8 GaAs AlGaInP

=0.8, y=0.51 , 635 nm , 0.15% ,

, 2 8

3 ,

, , 1 ,

2 ,

, GaP AlGaAs (6, 16)

, () 가 .

(57)

1.

(1,11) (4,14) (1,11)
(1,11),

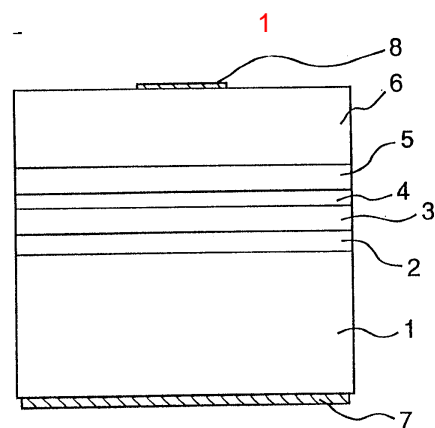
1 200 meV 가 2 30 meV 200 meV 가 30 meV

2.

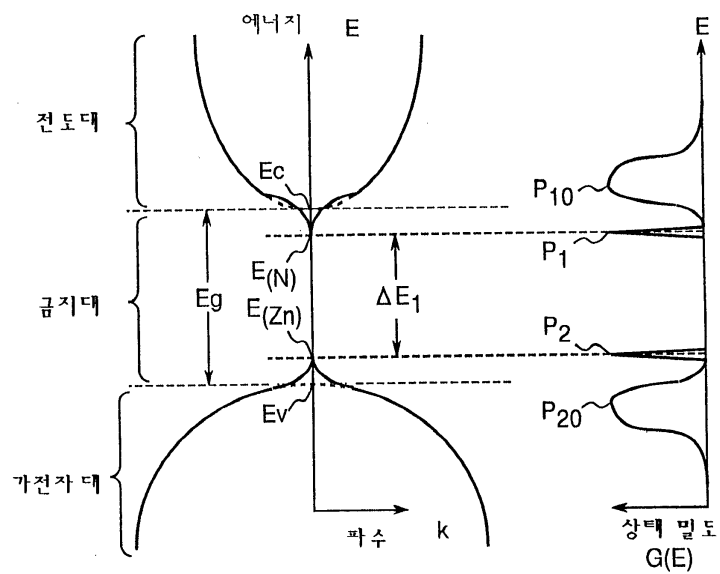
1 (4,14) 1 2

3.

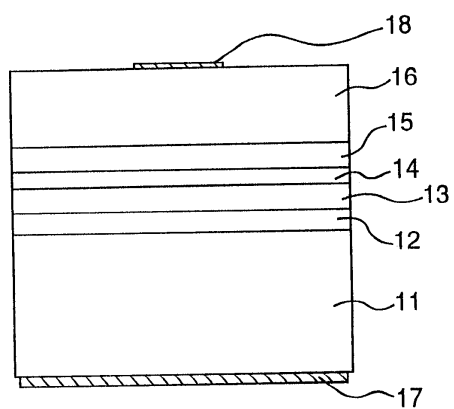
AlGaInP (4,14) GaP (1,11) GaP (1,11)
(4,14) AlGaInP 1 2



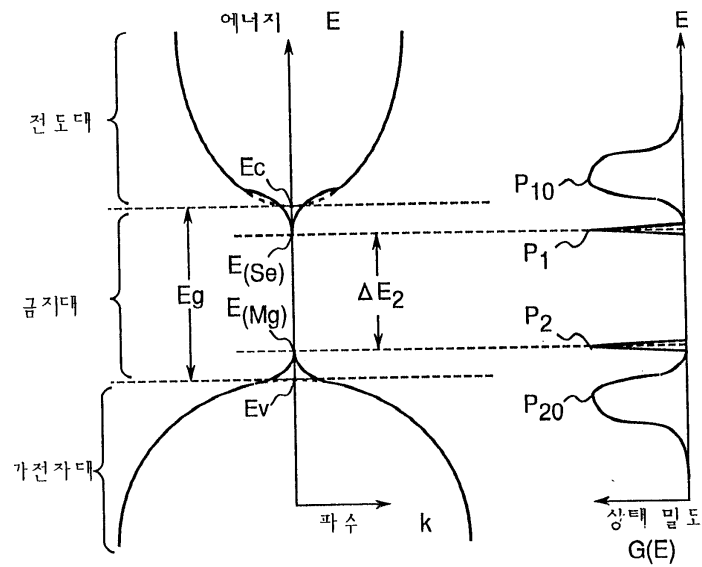
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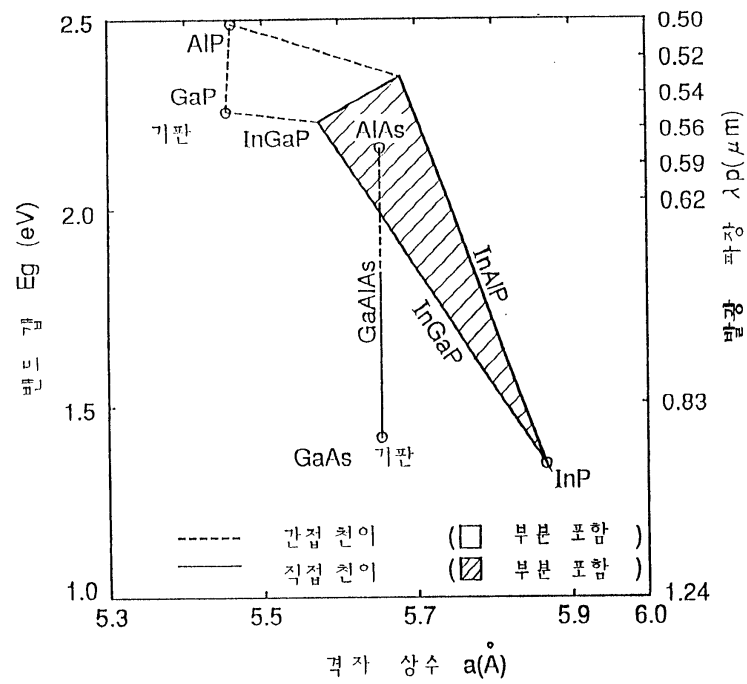
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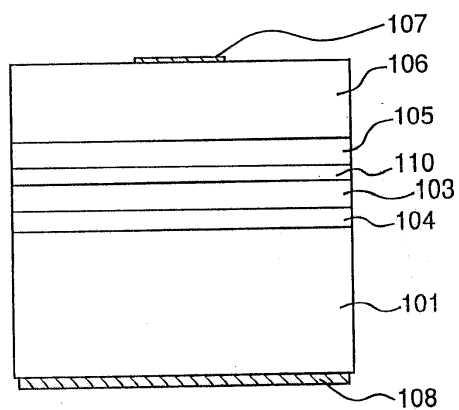


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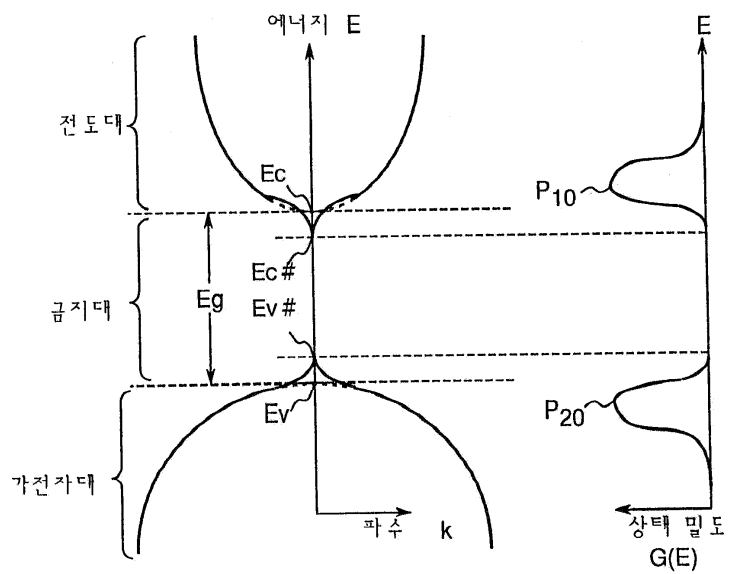
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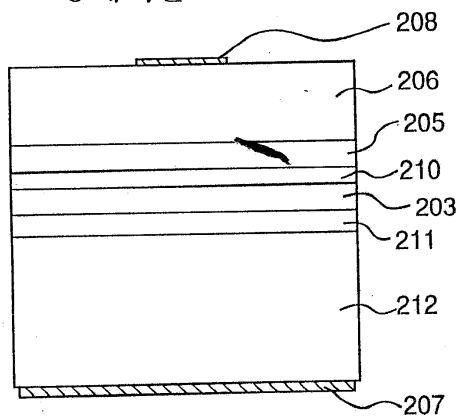
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종래기술



8

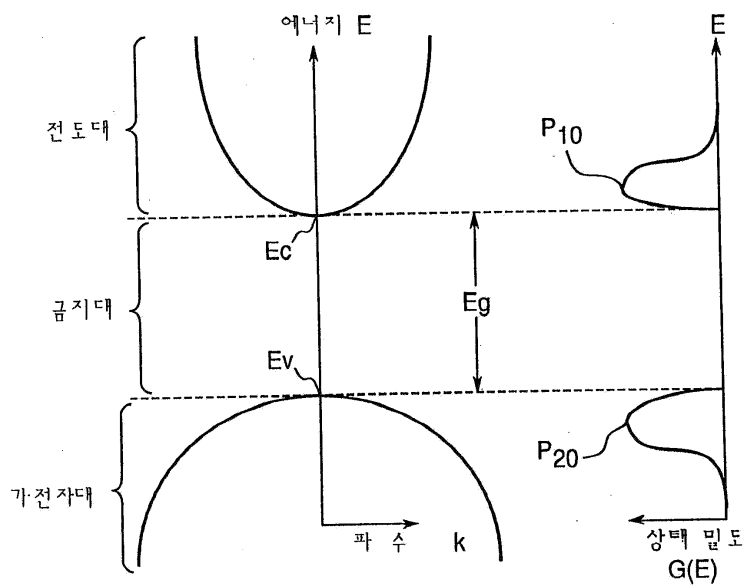
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9

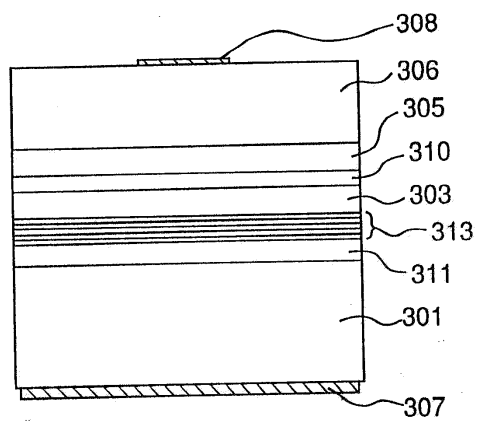
종래기술

종래기술



10

종래기술



11

종래기술

