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N

(72)

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63376- 5000
501

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63376- 5000
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63376- 5000
501

1

2

1

3

2

4

3 ,

5

2

6

1

1

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8

5 /

9

2

10

9

11

1

N

12

11

P, As

13

1

P-

14

13

B, Al, Ga

15

1

N

5cm

16

1

17

(oxygen precipitate nuclei)

, 5m *cm

N

, 10m *cm , , N

18

17 , ,

N , ,

19

18 , ,

P, As , ,

20

17 , ,

P- , ,

21

20 , ,

B, Al, Ga , ,

22

17 , ,

N 5cm , ,

23

17 , ,

100 m + cm 100 + cm , ,

24

17 , ,

15
(oxygen interstitial atoms) , ,

25

24 , ,

50% , ,

26

24 , ,

10% , ,

[0001]

(N+) P- (P+) N (N) N

[0002]

(Czochralski process), (seed crystal) (molten silicon)

(immersed),

[0003]

(oxygen precipitate), (cluster) (gettering)

(nucleation center)

[0004]

5, 994, 761 (Faster) (thermal annealer)

(vacancy)

6, 336, 968

[0005]

(self interstitial)

N (avalanche breakdown voltage)

[0006]

5m *cm

100m *cm

N

[0008]

N () N/N+ N /P+

(4 800 16 1000)

[0010]

I.

[0011]

(ingot)

(Czochralski crystal growing method)

(predominant intrinsic point defect)

(lapping)

[0012]

 5×10^{17} 9×10^{17}

(ASTM

F-121-83).

(

),

[0013]

(1410)

750

350

(cooling rate)

(

)

(annealing heat-treatment)

(dissolve)

(rapid thermal

[0014]

N

P

N

P

5m · cm

N+ P+

3m · cm

2m · cm

1m · cm

[0015]

 1.24×10^{19} at/cm³

N

 3.43×10^{19} at/cm³ 2.25×10^{19} at/cm³

N

N

 7.36×10^{19} at/cm³ 2.1×10^{19} at/cm³

P-

 3.7×10^{19} at/cm³

P-

5.7x

 10^{19} at/cm³ 1.2×10^{20} at/cm³

P

[0016]

II.

[0017]

Oxidation Induced Stacking Faults)

(ASF;

(RTA; Rapid Thermal Annealer)

1175 , 1200 , 1150 , 1200 1275
 (3) , (20 30 40 50 10
 60)

[0018] , RTA (RTA ; Rapid Thermal Annealing furnace)

RTA , RTA . RTA
1200 ,
RTA Mattson Technology() 3000 RTP

[0019] III. (profile)

[0020] **CSF**
(number density)

DSF
(nucleated oxygen agglomerates)
(oxygen clustering)

[0021] A (cooling at nosphere)

[0022]

(frankel pair recombination)

[0023]

(Q),

0.001 (atm) 1000 (ppma; parts per million atomic)
 , 0.002 atm (2,000 ppma),
 0.005 atm (5,000 ppma), 0.01 atm (10,000 ppma) .

[0024] B

[0025] (diffusivity), , , 700 (

700 , 800 , 900 1, 000

- [0027] (950) 20 / 10 /
5 /
- [0028] 20 / 950 1150 (2, 3, 4, 6)
) (2, 3, 4, 6)
- [0029] (nitriding atmosphere; (N₂)) (, , , ,)
- [0030] IV.
- [0031] (out-diffusion)
- 15 10
20% 10% 5
3 50%
- [0032] V.
- [0033] 5cm
- (chemical vapor deposition) 5, 789, 309
- 10m · cm² 100m · cm² N
300m · cm 10 · cm 100 · cm
- [0034] N 4.8 × 10¹⁸ at/cm²
4.3 × 10¹³ at/cm² 7.8 × 10¹⁶ at/cm², N
4.4 × 10¹⁴ at/cm² 1.9 × 10¹⁶ at/cm²
- [0035] N N

[0036]

(feed) , N
 (carrier gas)

[0037] VI.

[0038]

0.001 (atm) 1000 ppma
 , 0.002 atm (2,000 ppma), 0.005
 atm (5,000 ppma), 0.01 atm (10,000 ppma)

[0039]

, (950)
 20 / , 10 / , 5 / (20 /
 . , 950 1150 , 1150
) , 950 , 2 3 4 6 2 3 4 6

[0040] VII.

[0041]

(grain boundary),
 5, 792, 700
 5, 310, 698 , (Si H)

[0042]

, (thistor) MOSFET JFET

[0043]

, " (said)", " (the)", " (a, an)"
 " , " , "
 "N+", "N++" "P+", "P++"
 "N+", "N++" "P+", "P++"
 "N+", "N++" "P+", "P++"

[0044]

[0045]