FIG.1

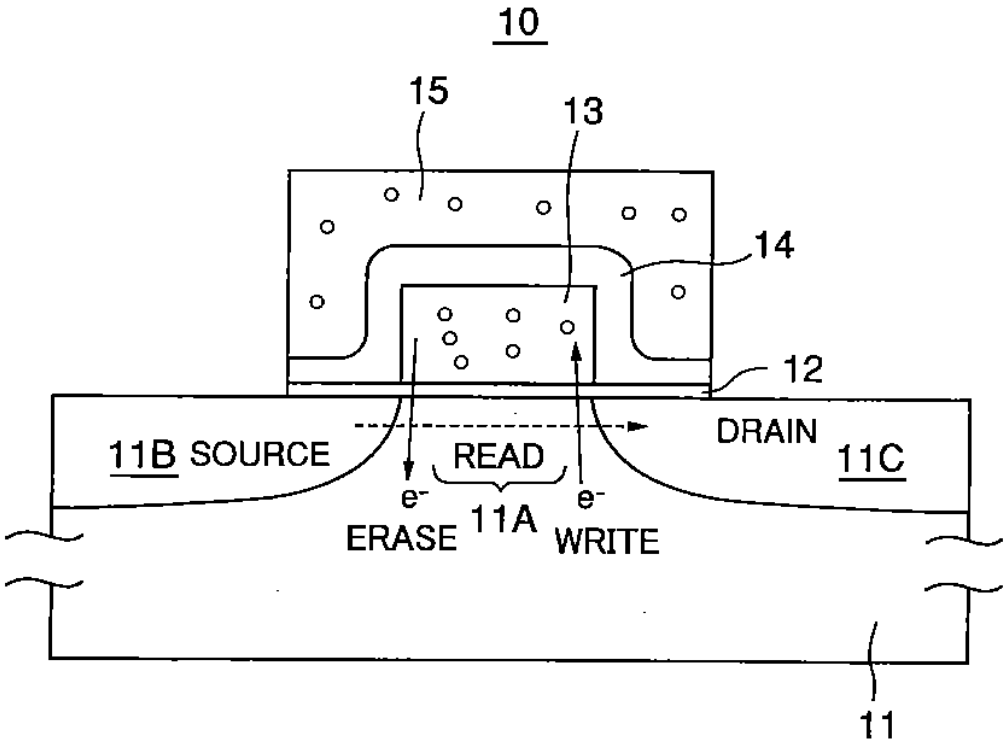


FIG.2A

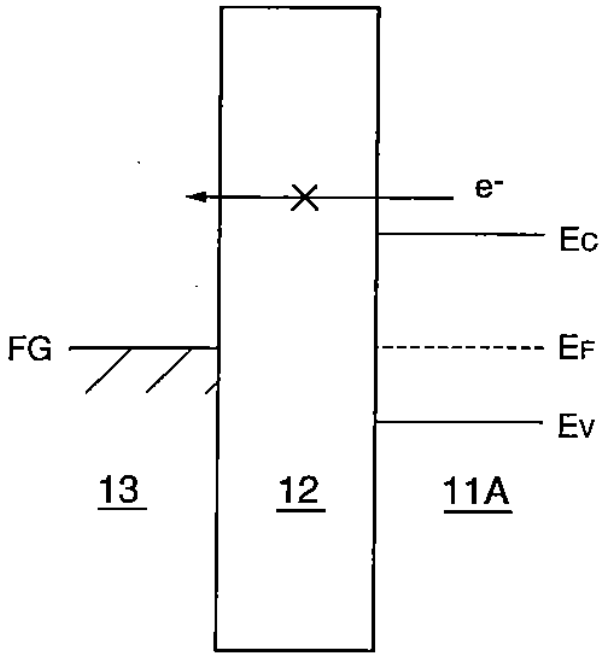


FIG.2B

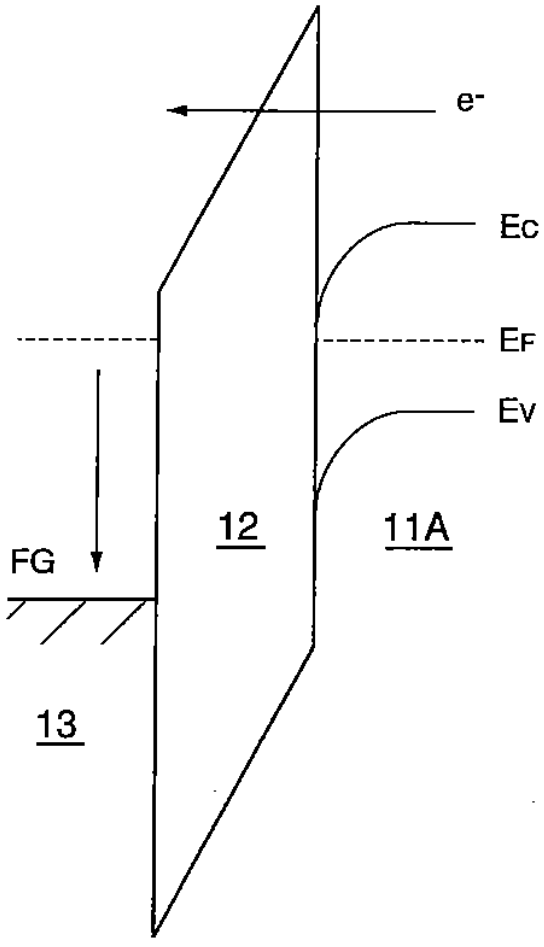


FIG.3

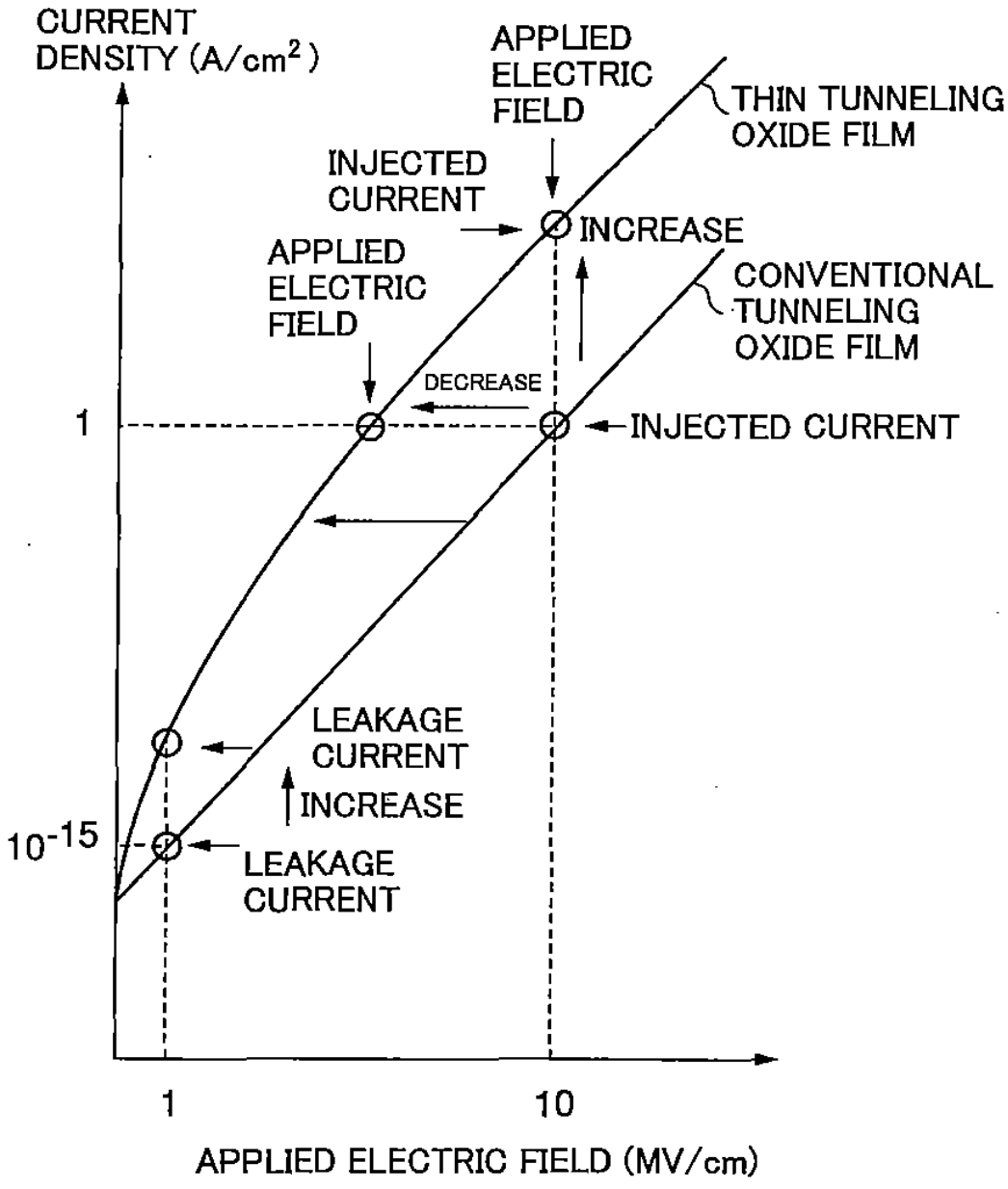

CURRENT DENSITY (A/cm²)
APPLIED ELECTRIC FIELD
THIN TUNNELING OXIDE FILM
INJECTED CURRENT
INCREASE
APPLIED ELECTRIC FIELD
CONVENTIONAL TUNNELING OXIDE FILM
DECREASE
1
INJECTED CURRENT
LEAKAGE CURRENT
INCREASE
10⁻¹⁵
LEAKAGE CURRENT
1
10
APPLIED ELECTRIC FIELD (MV/cm)

FIG.4A

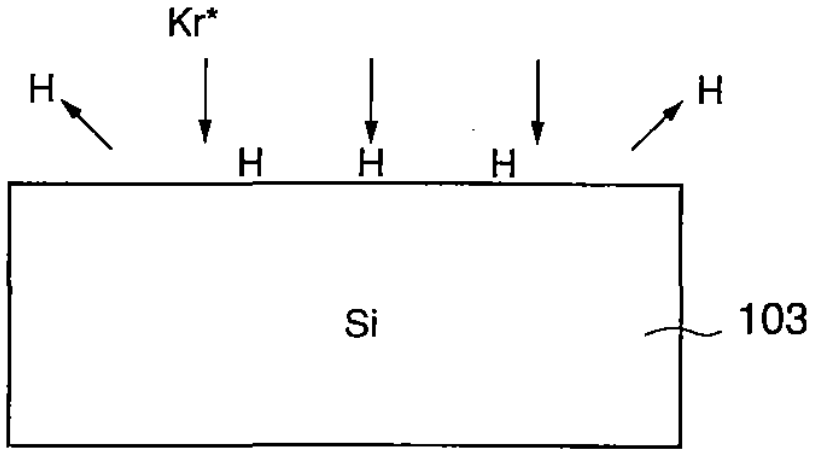


FIG.4B

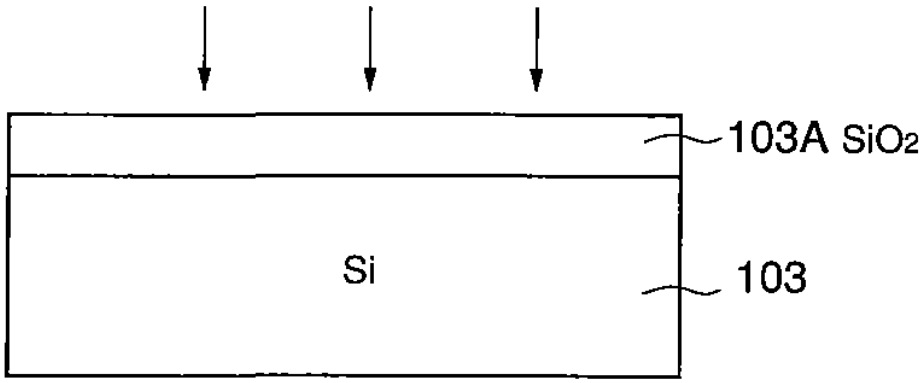


FIG.4C

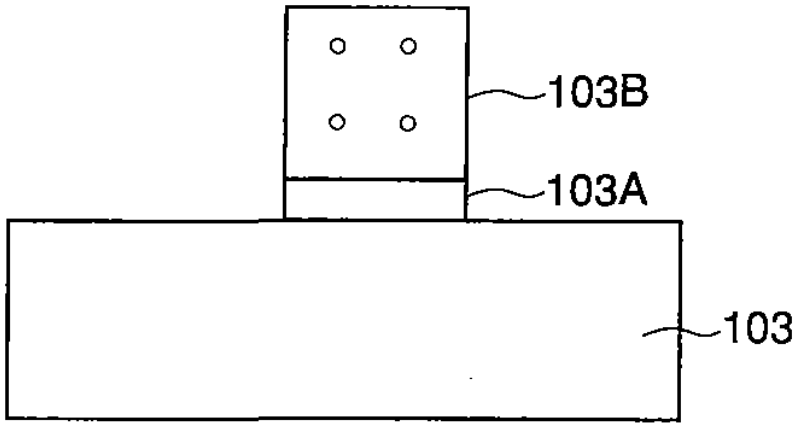


FIG.5

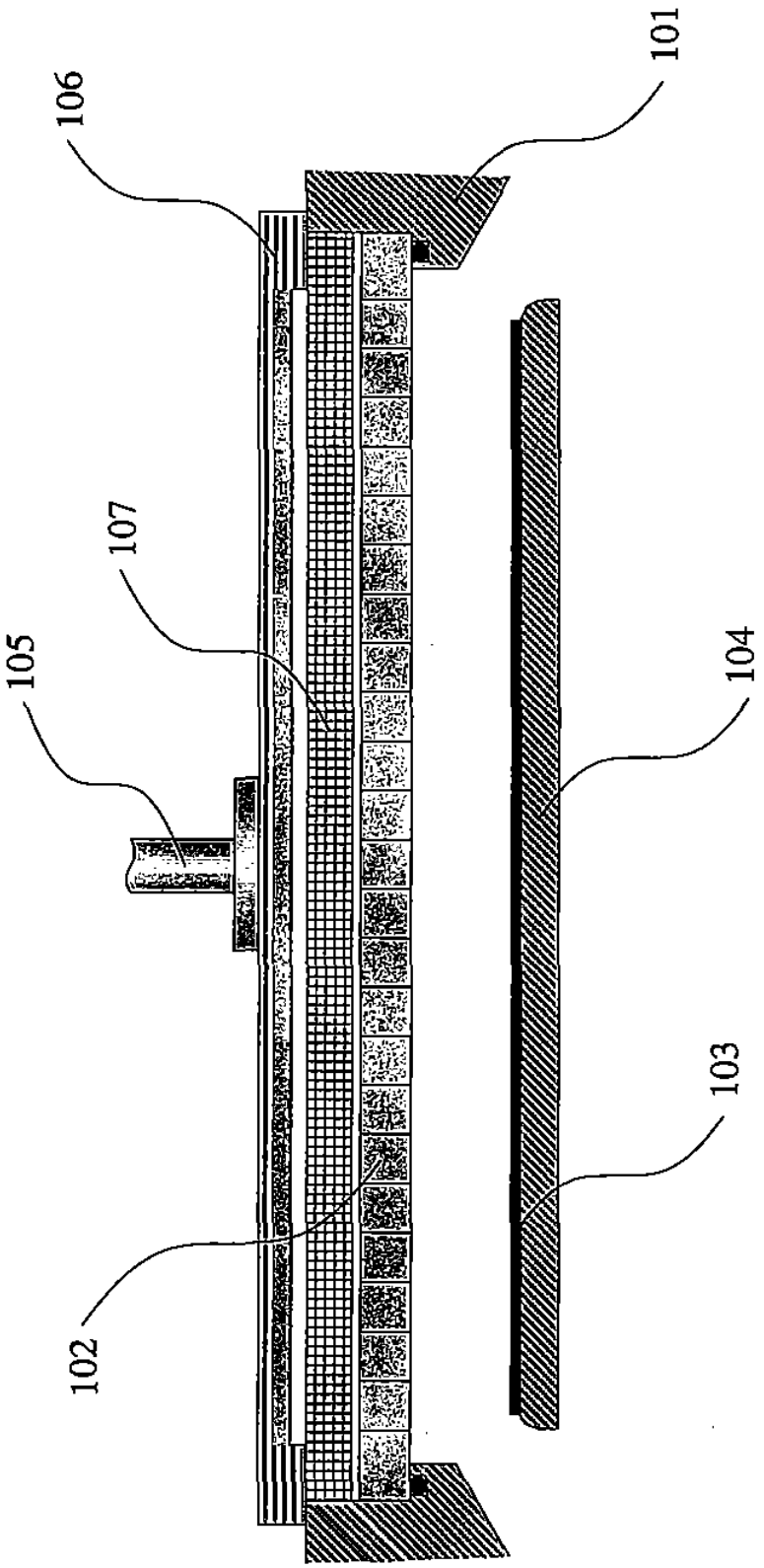


FIG.6

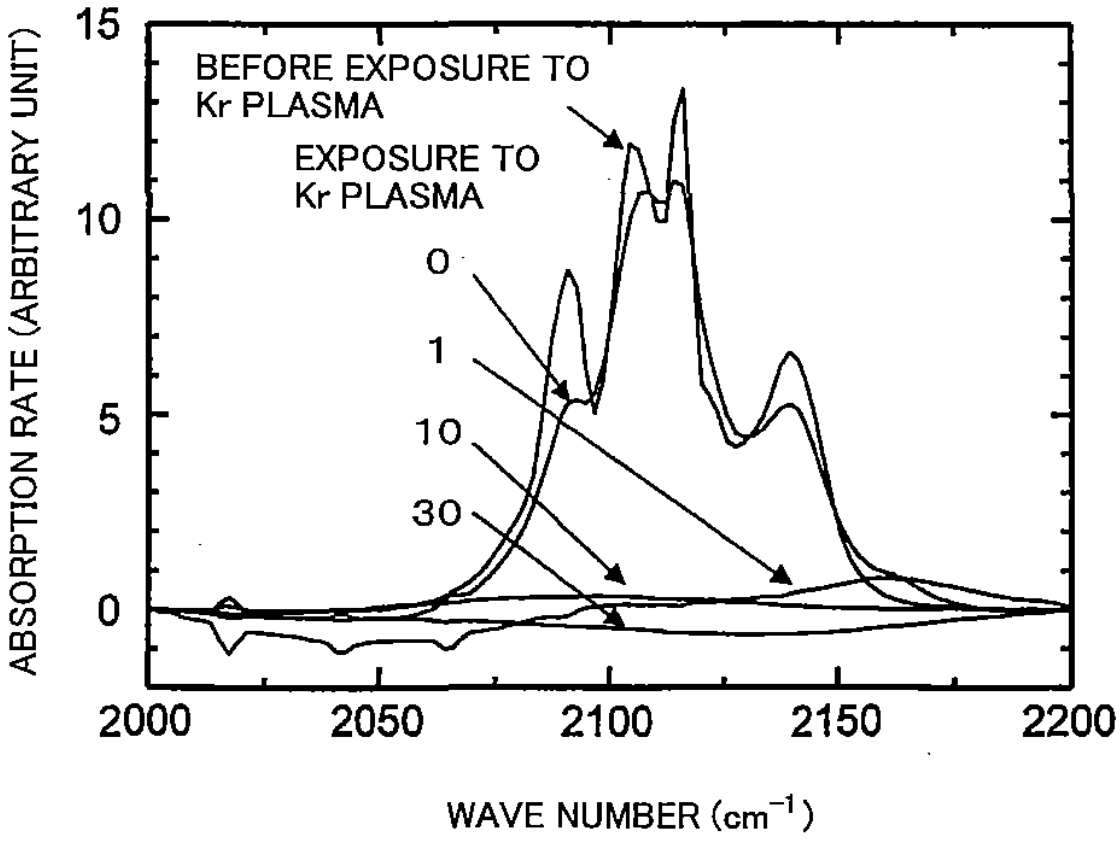

15
10
5
0
ABSORPTION RATE (ARBITRARY UNIT)
BEFORE EXPOSURE TO
Kr PLASMA
EXPOSURE TO
Kr PLASMA
0
1
10
30
2000
2050
2100
2150
2200
WAVE NUMBER (cm^{-1})

FIG.7

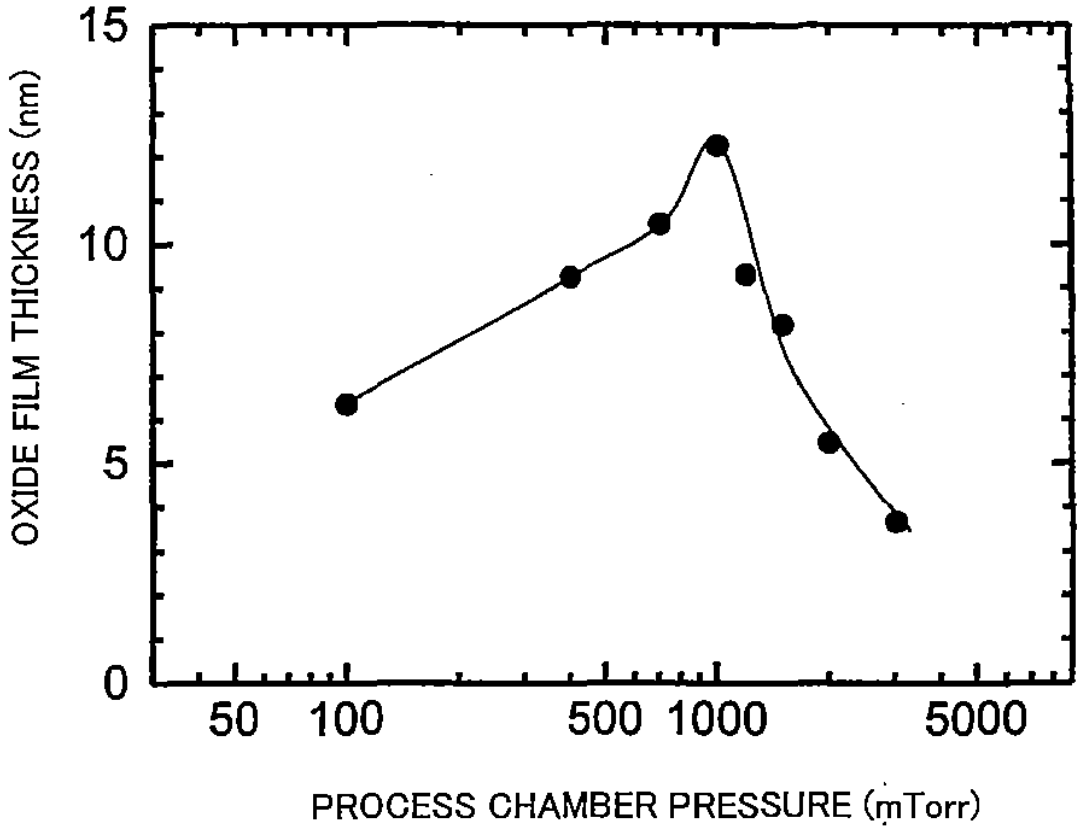

15
10
5
0
OXIDE FILM THICKNESS (nm)
50
100
500
1000
5000
PROCESS CHAMBER PRESSURE (mTorr)

FIG.8

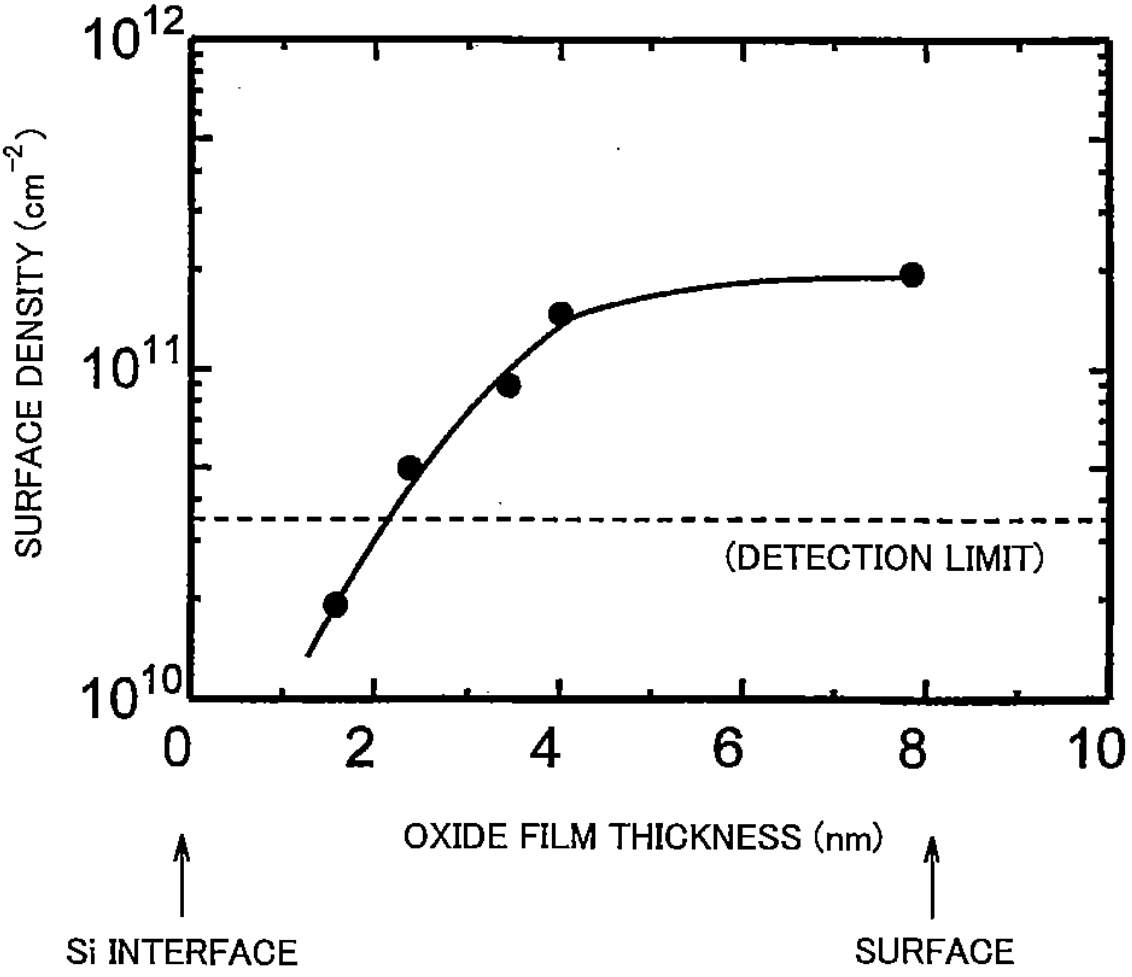

10^{12}
10^{11}
10^{10}
SURFACE DENSITY (cm^{-2})
(DETECTION LIMIT)
0
2
4
6
8
10
OXIDE FILM THICKNESS (nm)
Si INTERFACE
SURFACE

FIG.9

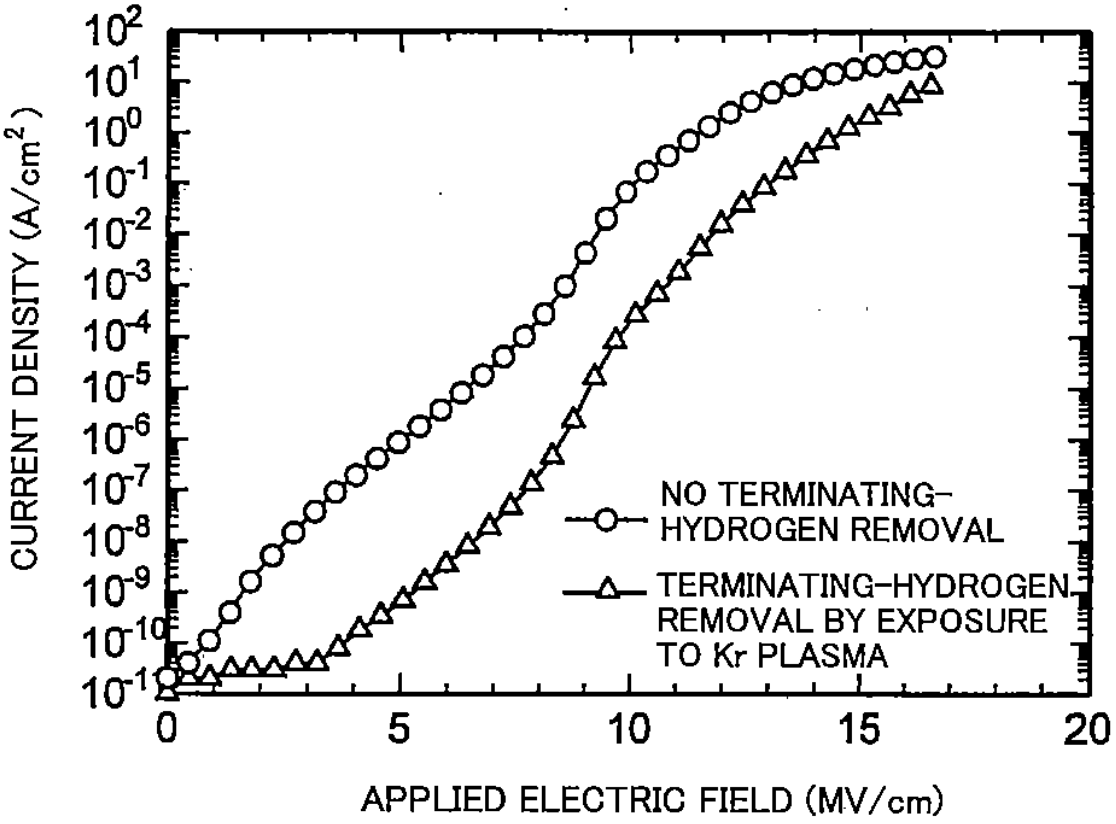

CURRENT DENSITY (A/cm²)
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
10⁻¹⁰
10⁻¹¹
0
5
10
15
20
APPLIED ELECTRIC FIELD (MV/cm)
NO TERMINATING-HYDROGEN REMOVAL
TERMINATING-HYDROGEN REMOVAL BY EXPOSURE TO Kr PLASMA

FIG.10

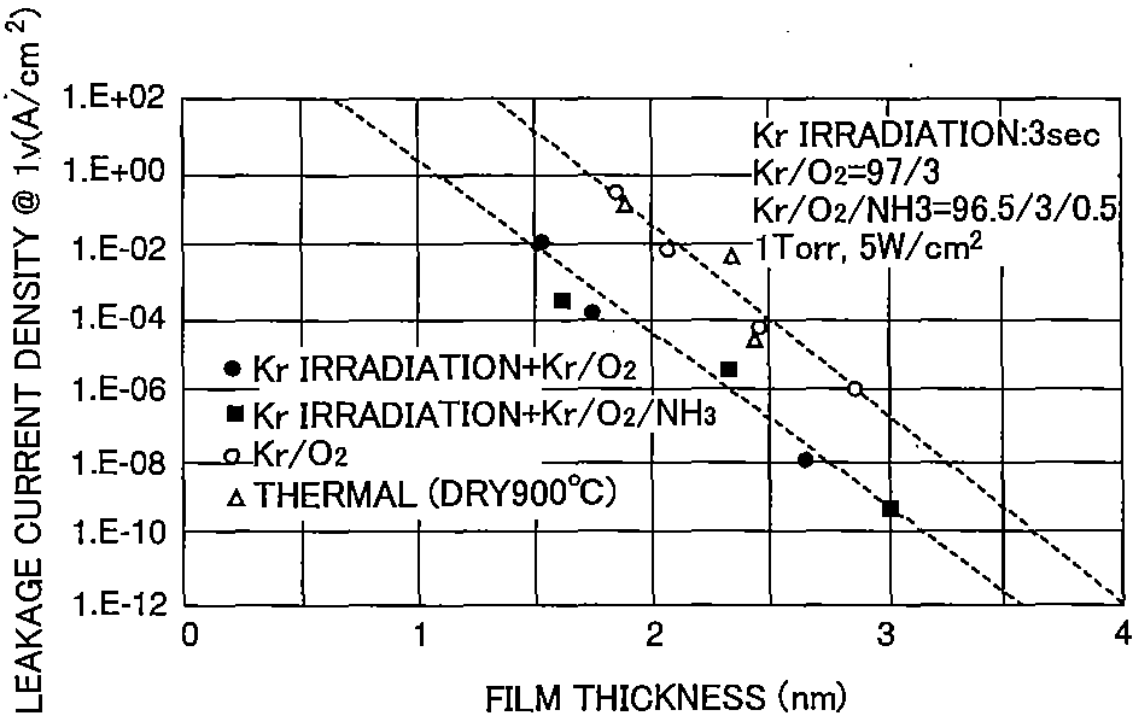

LEAKAGE CURRENT DENSITY @ 1v(A/cm 2)
1.E+02
1.E+00
1.E-02
1.E-04
1.E-06
1.E-08
1.E-10
1.E-12
0
1
2
3
4
FILM THICKNESS (nm)
Kr IRRADIATION:3sec
Kr/O2=97/3
Kr/O2/NH3=96.5/3/0.5
1Torr, 5W/cm2
● Kr IRRADIATION+Kr/O2
■ Kr IRRADIATION+Kr/O2/NH3
○ Kr/O2
△ THERMAL (DRY900℃)

FIG.11A

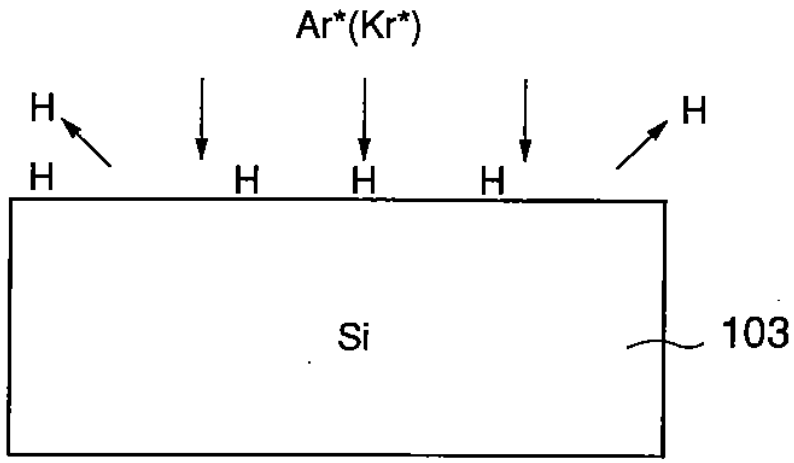


FIG.11B

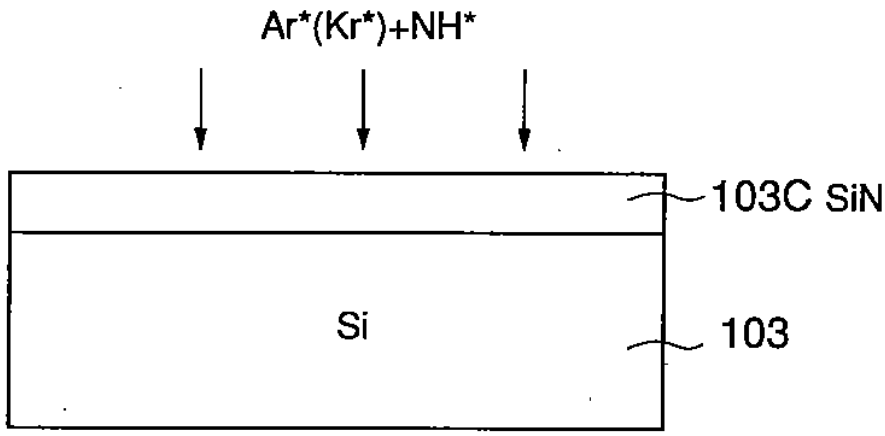


FIG.11C

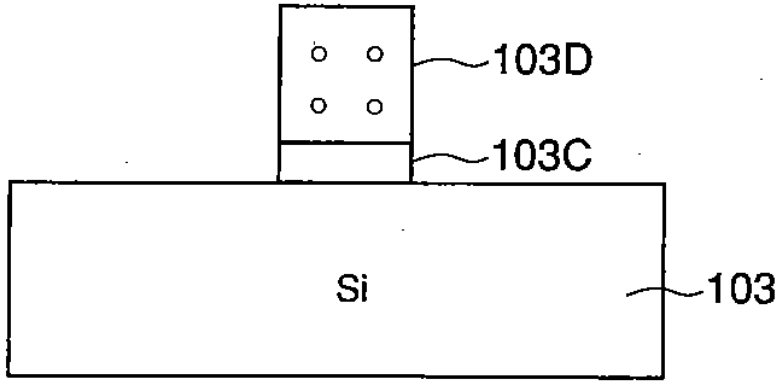


FIG.12

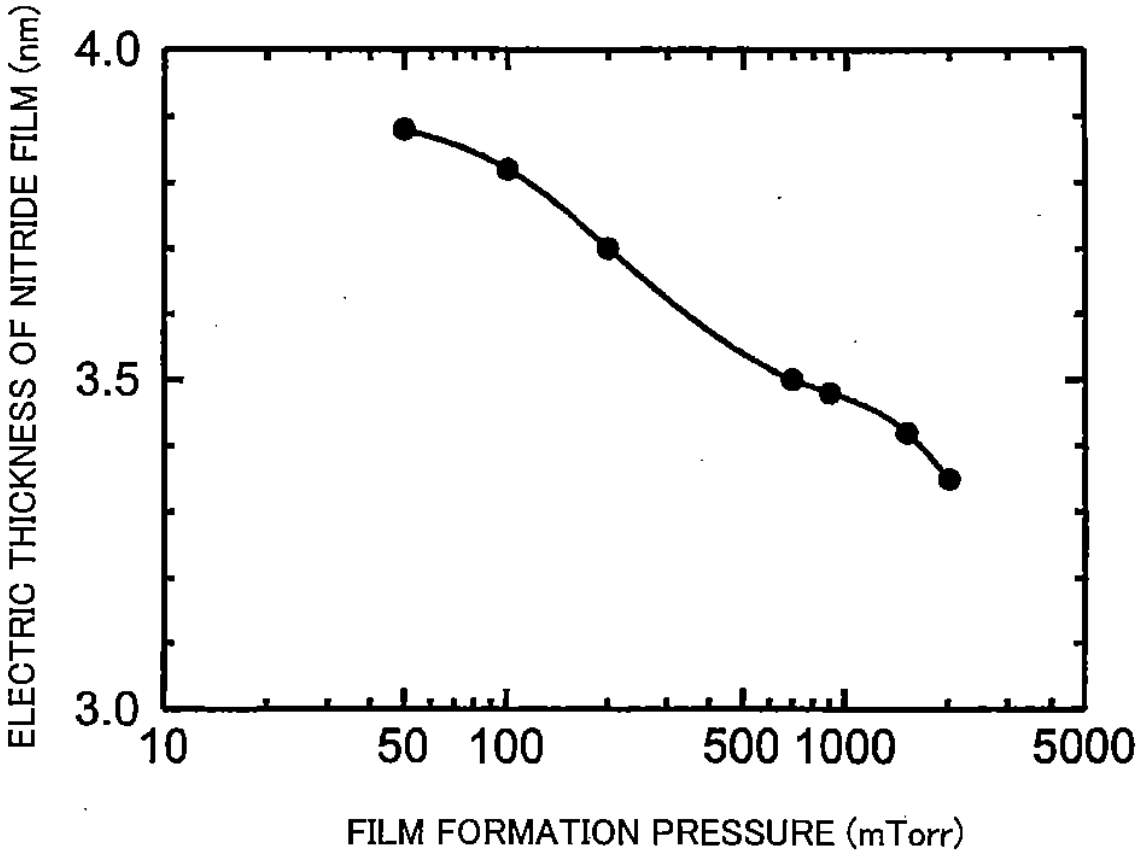

ELECTRIC THICKNESS OF NITRIDE FILM (nm)
4.0
3.5
3.0
10
50
100
500
1000
5000
FILM FORMATION PRESSURE (mTorr)

FIG.13A

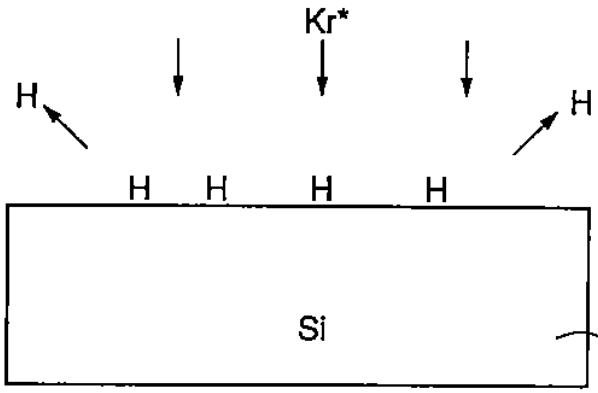


FIG.13B

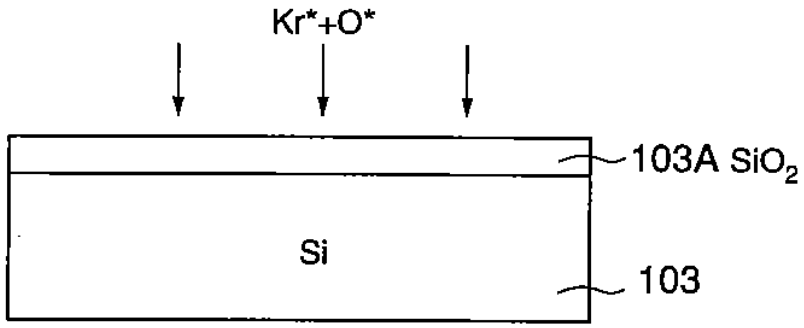


FIG.13C

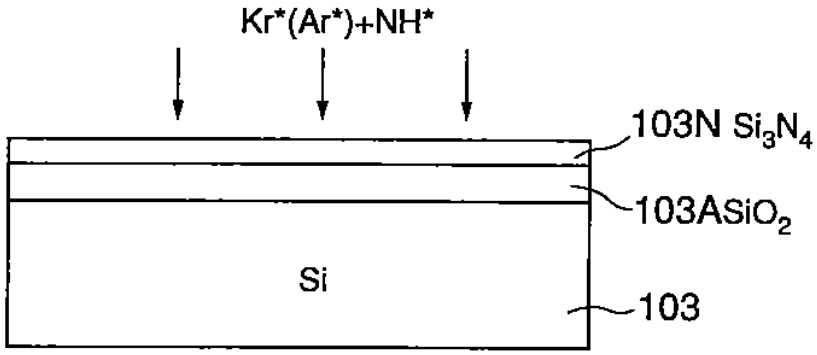


FIG.13D

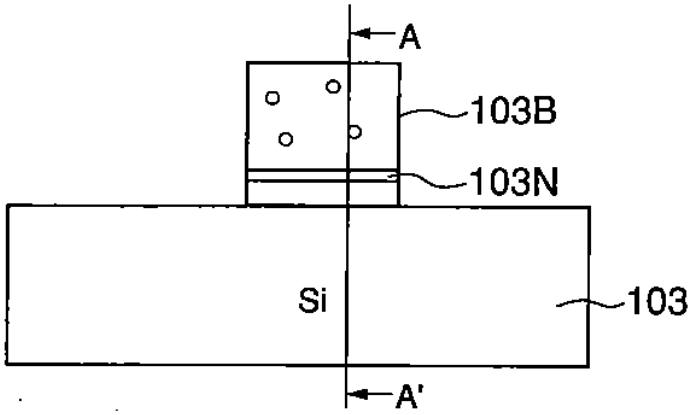


FIG.14

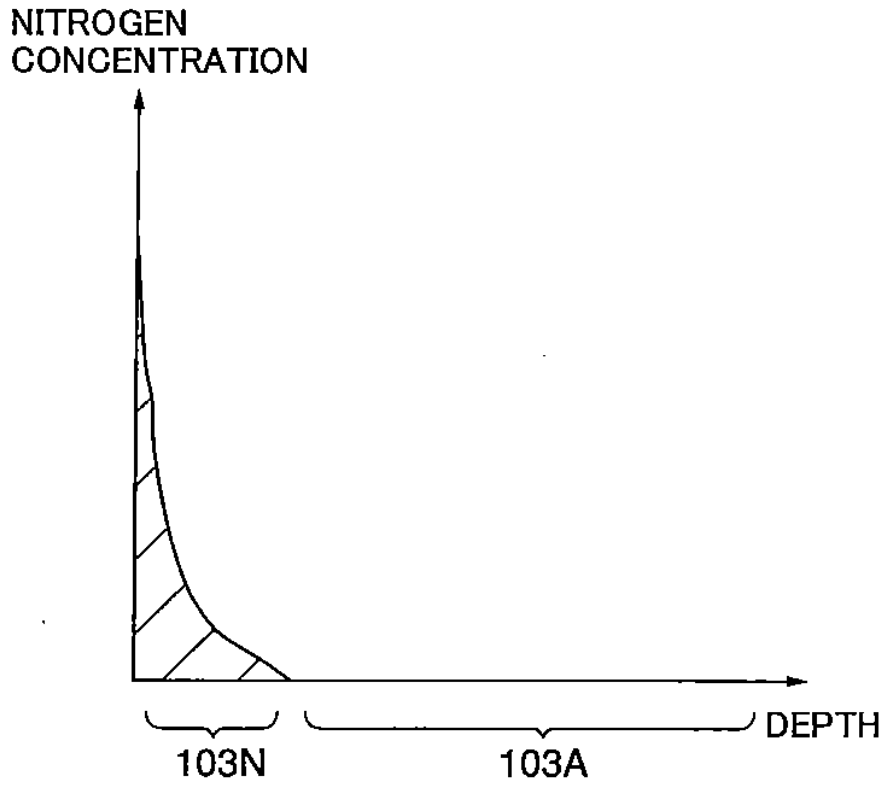


FIG.15

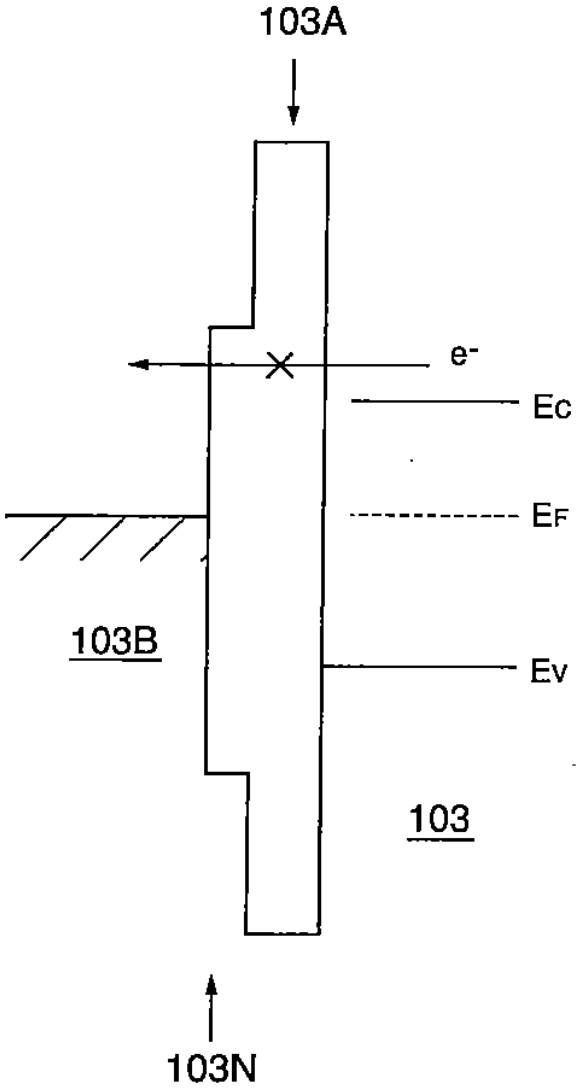


FIG.16A

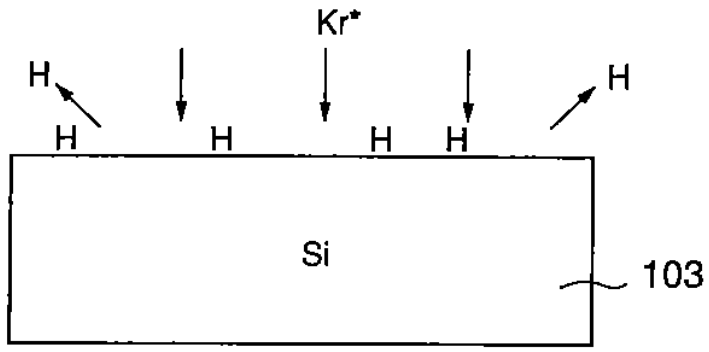


FIG.16B

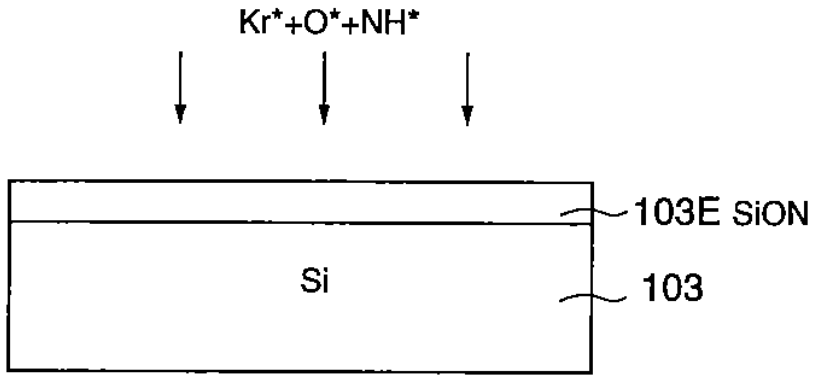


FIG.16C

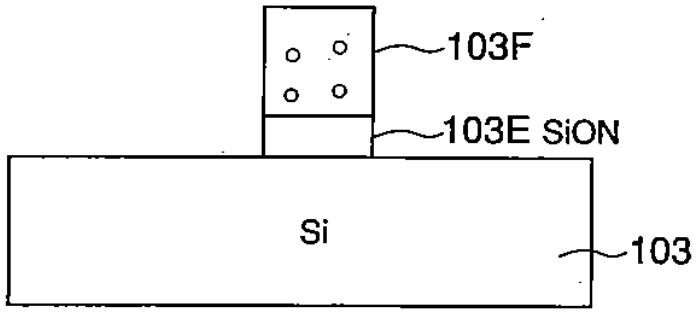
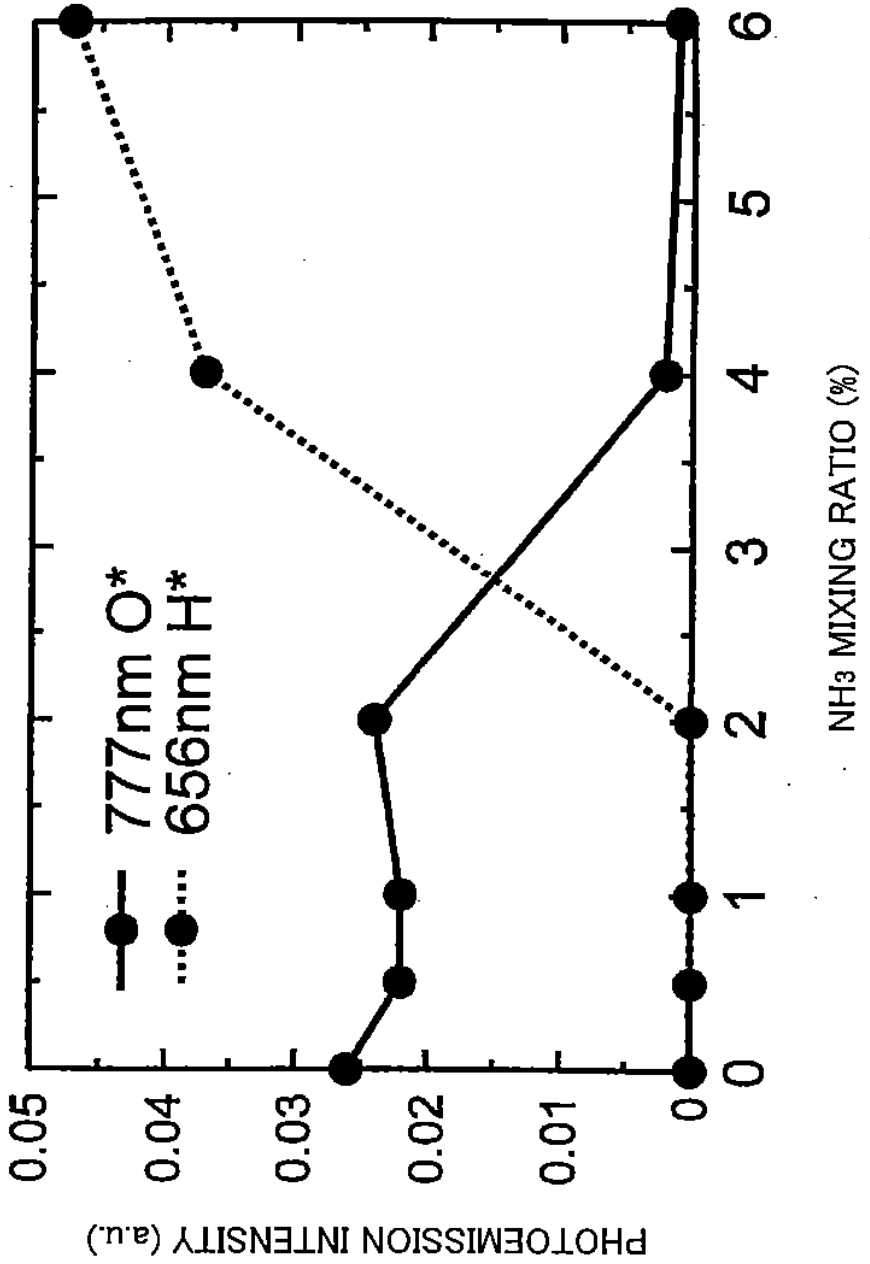


FIG.17


777nm O*
656nm H*
PHOTOEMISSION INTENSITY (a.u.)
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
NH3 MIXING RATIO (%)

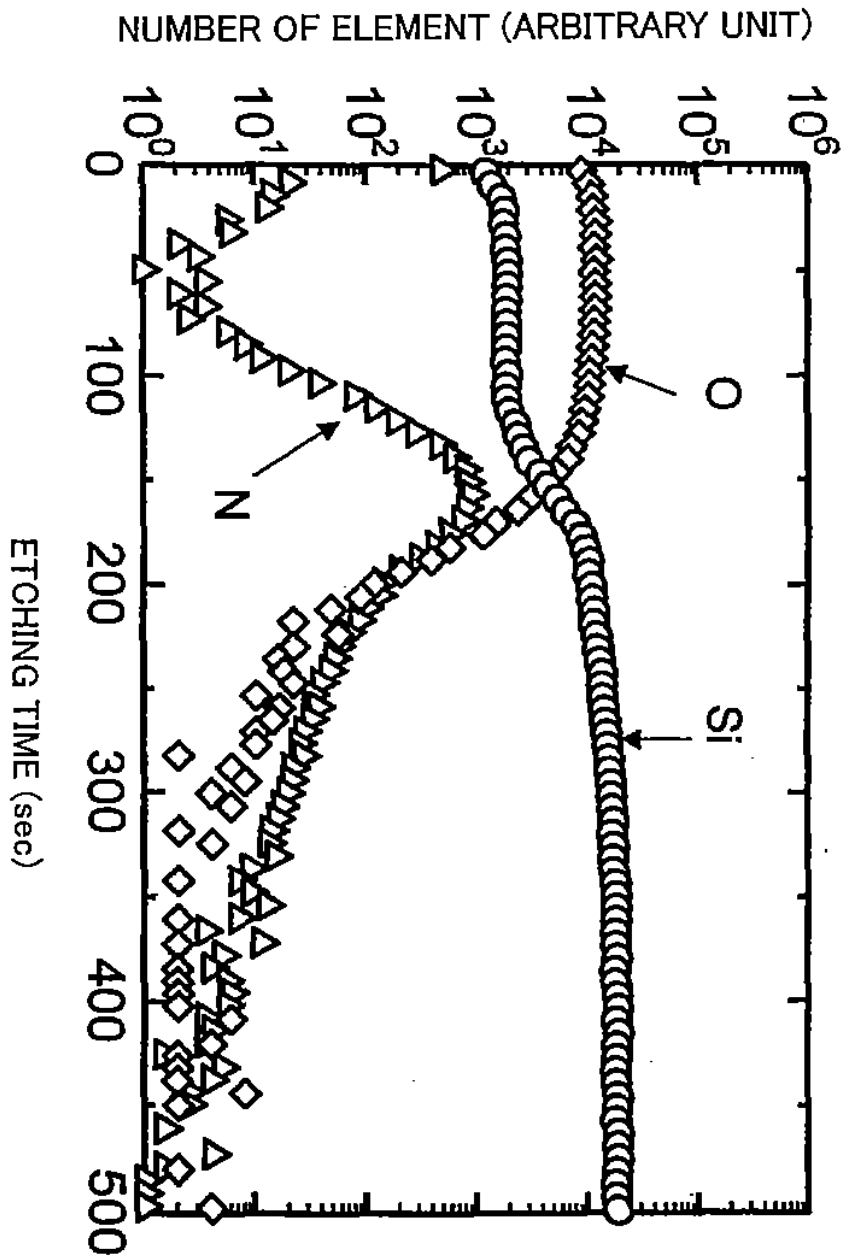
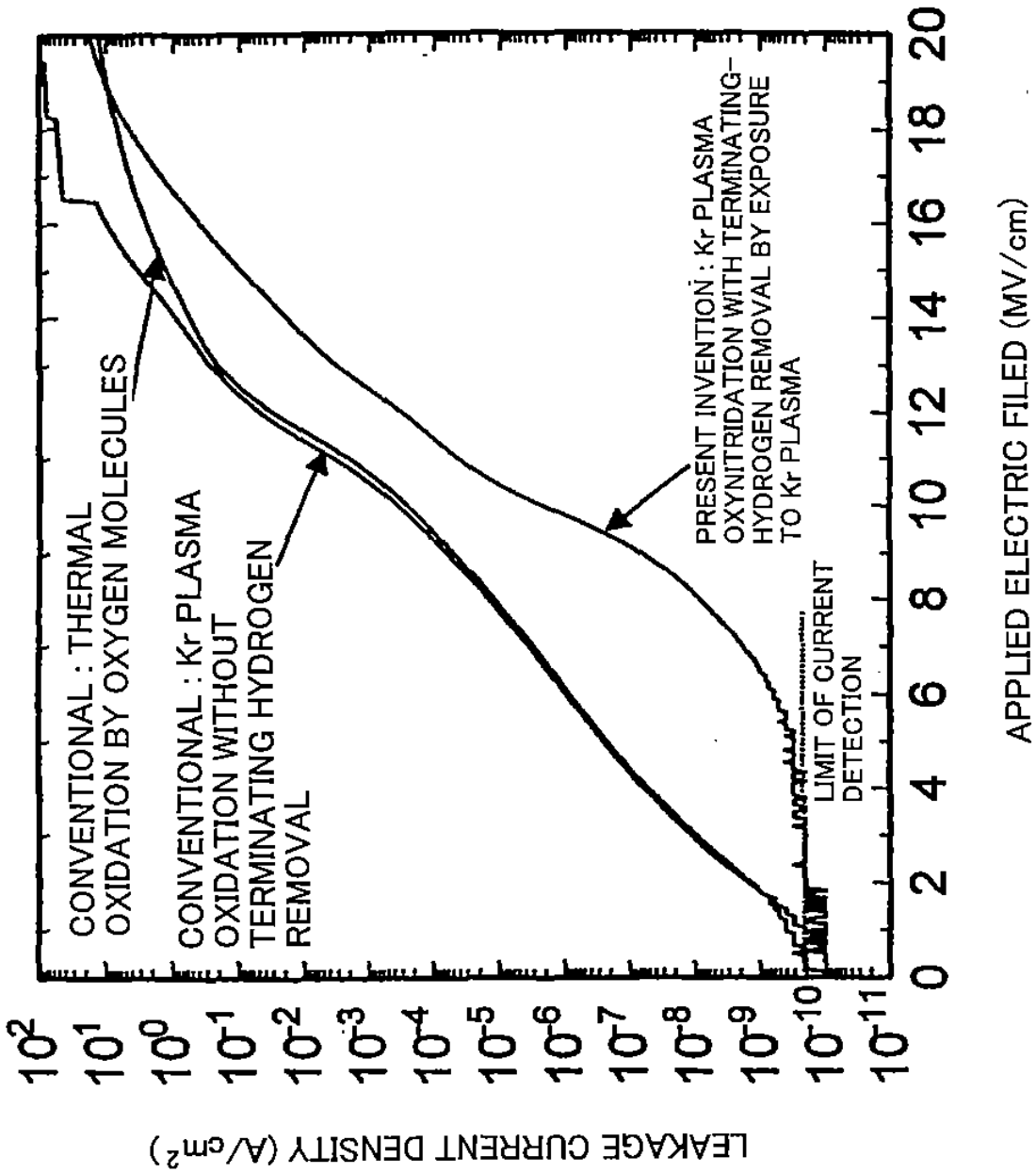


FIG.18

27 JUN 2005

FIG.19


LEAKAGE CURRENT DENSITY (A/cm²)
APPLIED ELECTRIC FILED (MV/cm)
CONVENTIONAL : THERMAL OXIDATION BY OXYGEN MOLECULES
CONVENTIONAL : Kr PLASMA OXIDATION WITHOUT TERMINATING HYDROGEN REMOVAL
PRESENT INVENTION : Kr PLASMA OXYNITRIDATION WITH TERMINATING-HYDROGEN REMOVAL BY EXPOSURE TO Kr PLASMA
LIMIT OF CURRENT DETECTION

2 7 JUN 2005

FIG.20

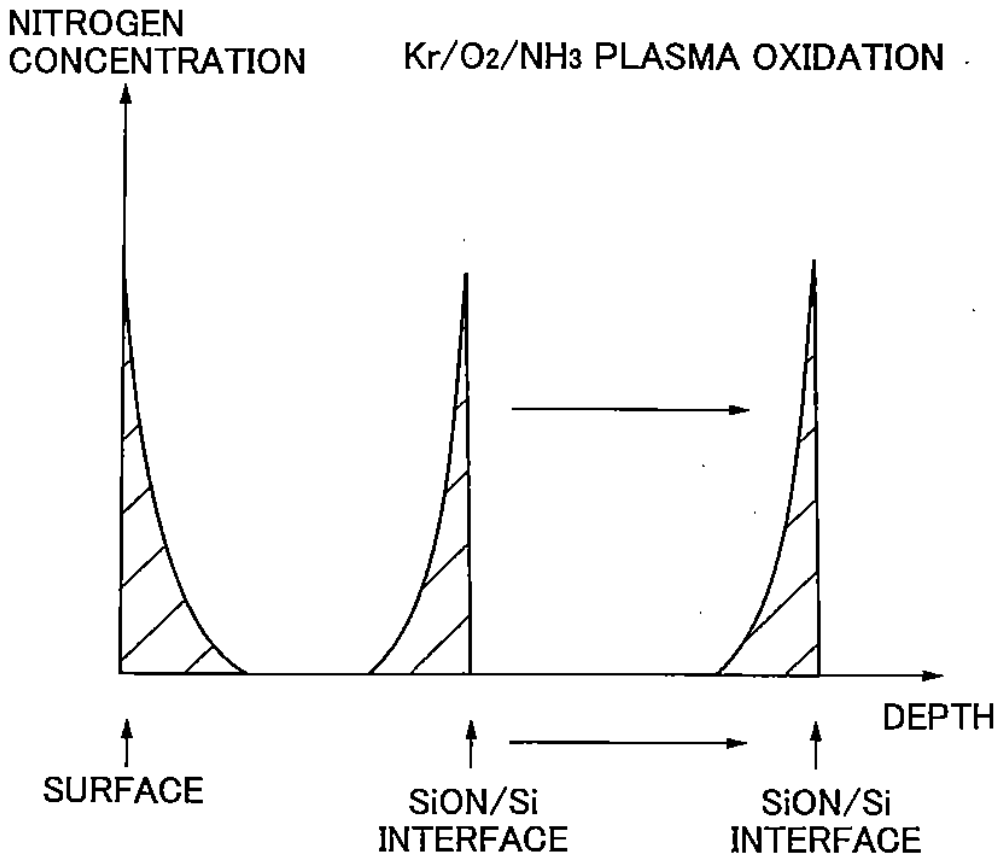


FIG.21A

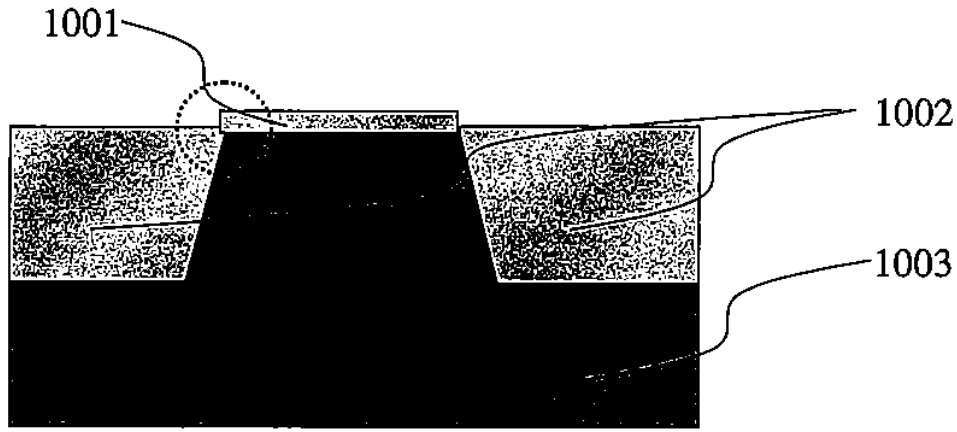
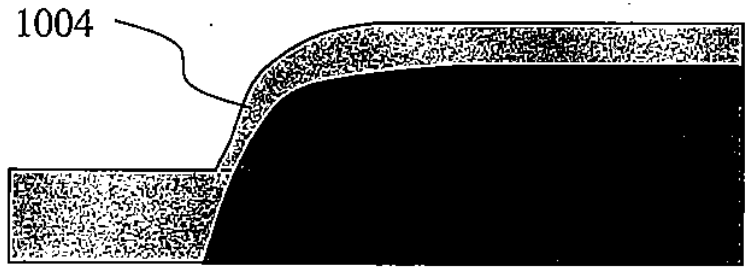
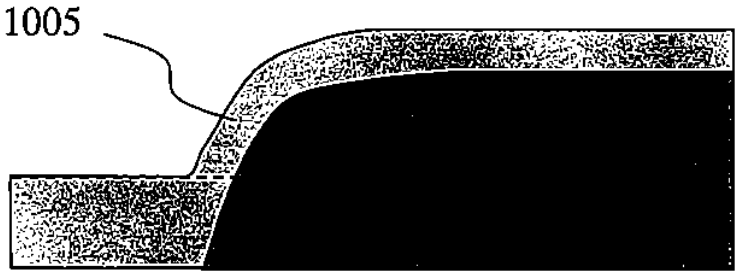


FIG.21B



CONVENTIONAL

FIG.21C



PRESENT INVENTION

27 JUN 2005

FIG.22

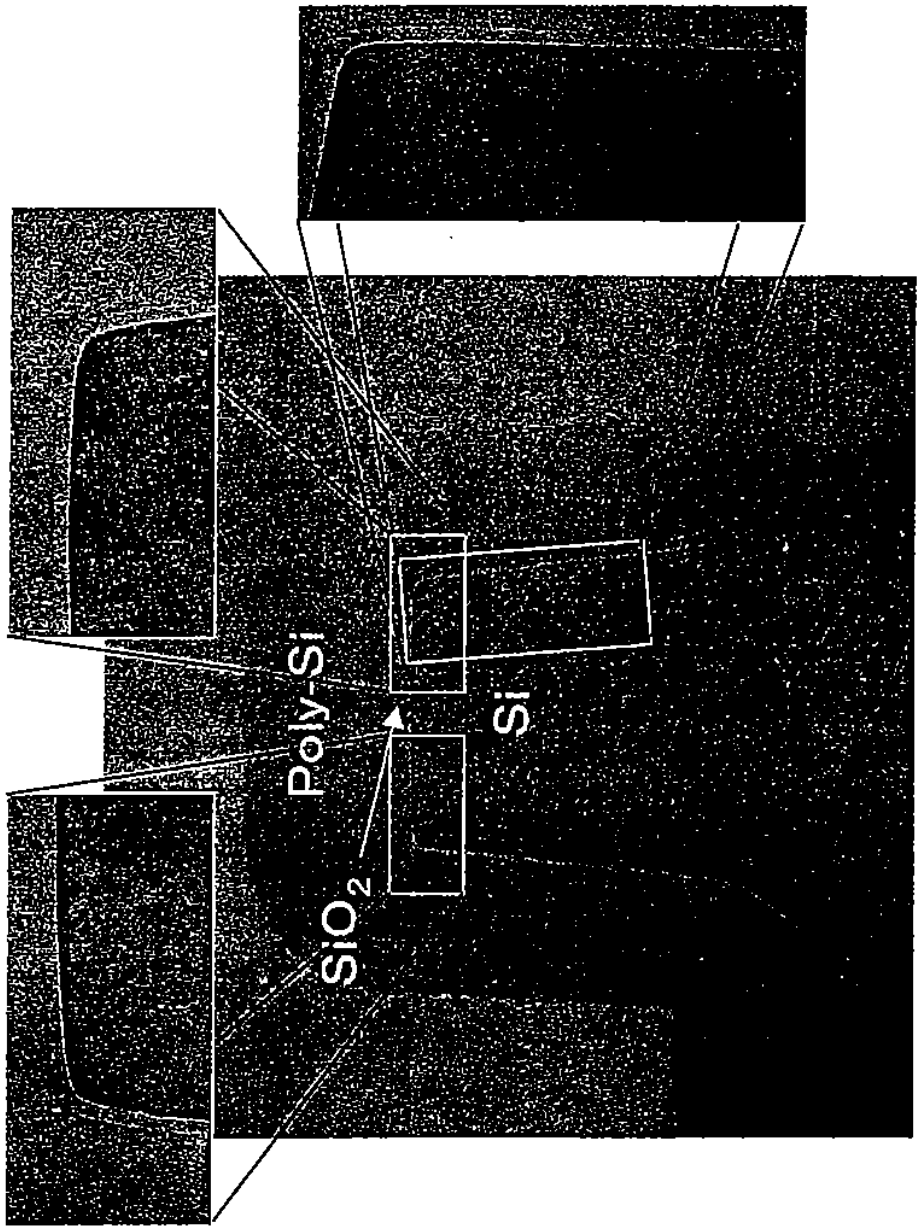


FIG.23

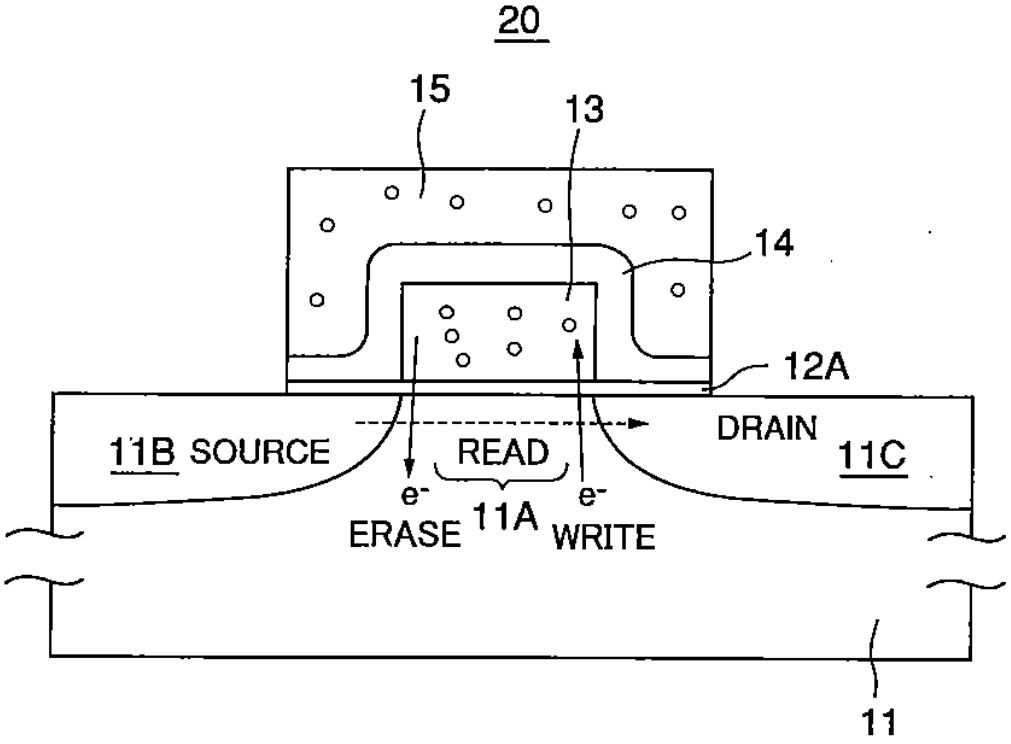


FIG.24

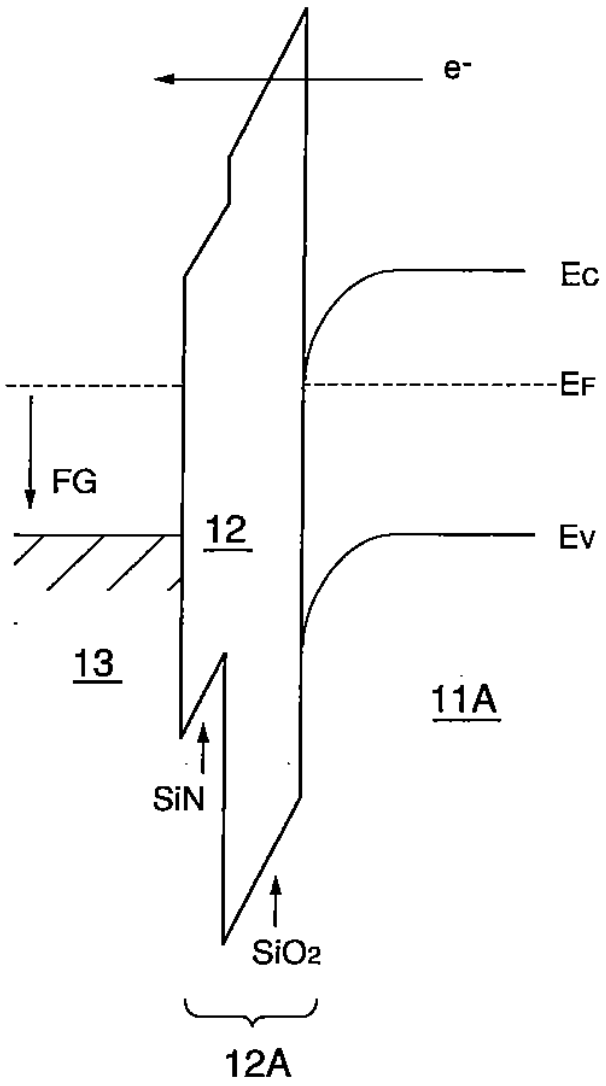


FIG.25

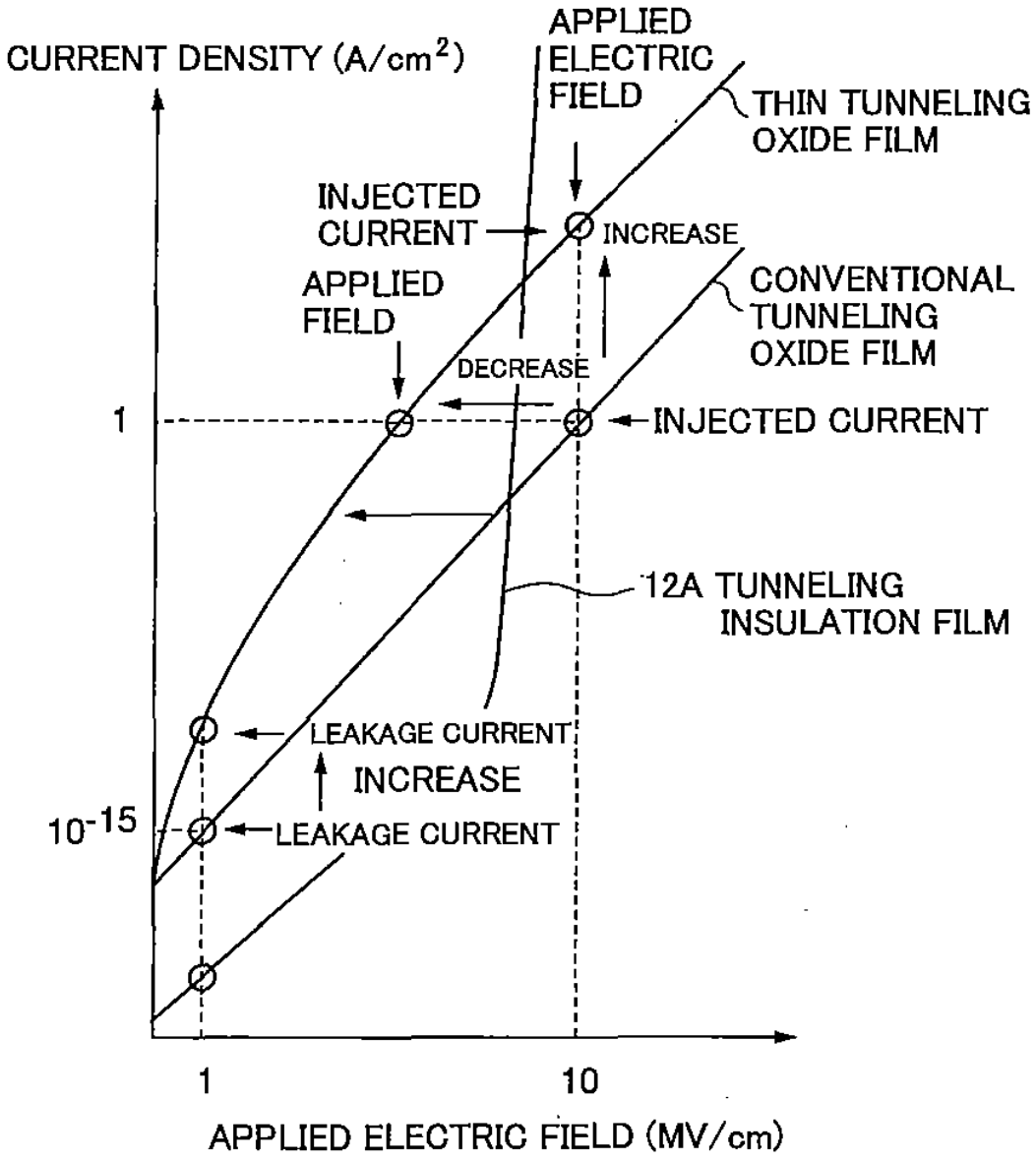

CURRENT DENSITY (A/cm^2)
APPLIED ELECTRIC FIELD
THIN TUNNELING OXIDE FILM
INJECTED CURRENT
INCREASE
APPLIED FIELD
CONVENTIONAL TUNNELING OXIDE FILM
DECREASE
1
INJECTED CURRENT
12A TUNNELING INSULATION FILM
LEAKAGE CURRENT
INCREASE
10^{-15}
LEAKAGE CURRENT
1
10
APPLIED ELECTRIC FIELD (MV/cm)

FIG.26

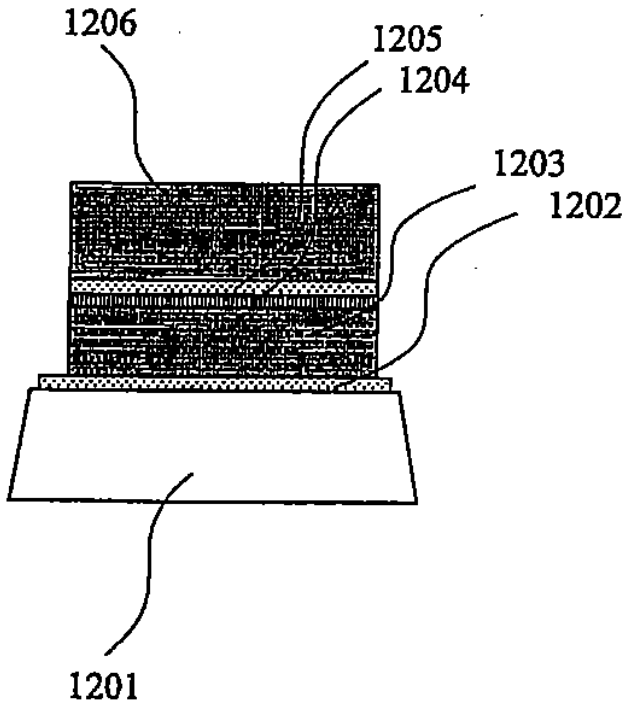


FIG.27

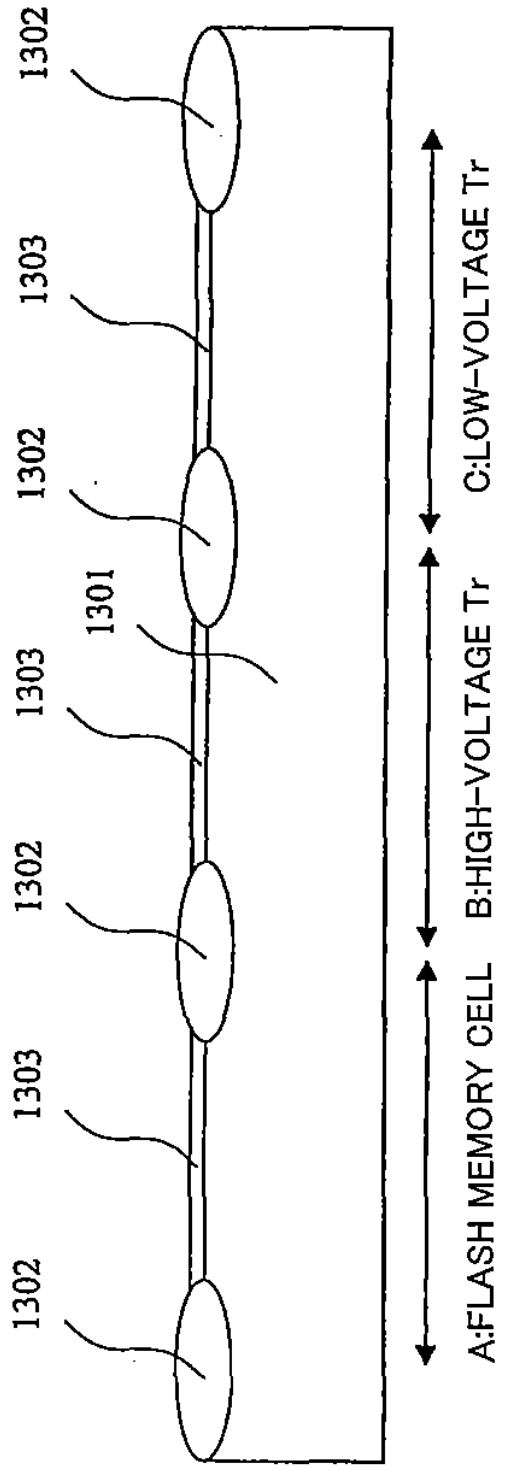

1302
1303
1302
1301
1303
1302
1303
1302
A:FLASH MEMORY CELL
B:HIGH-VOLTAGE Tr
C:LOW-VOLTAGE Tr

FIG.28

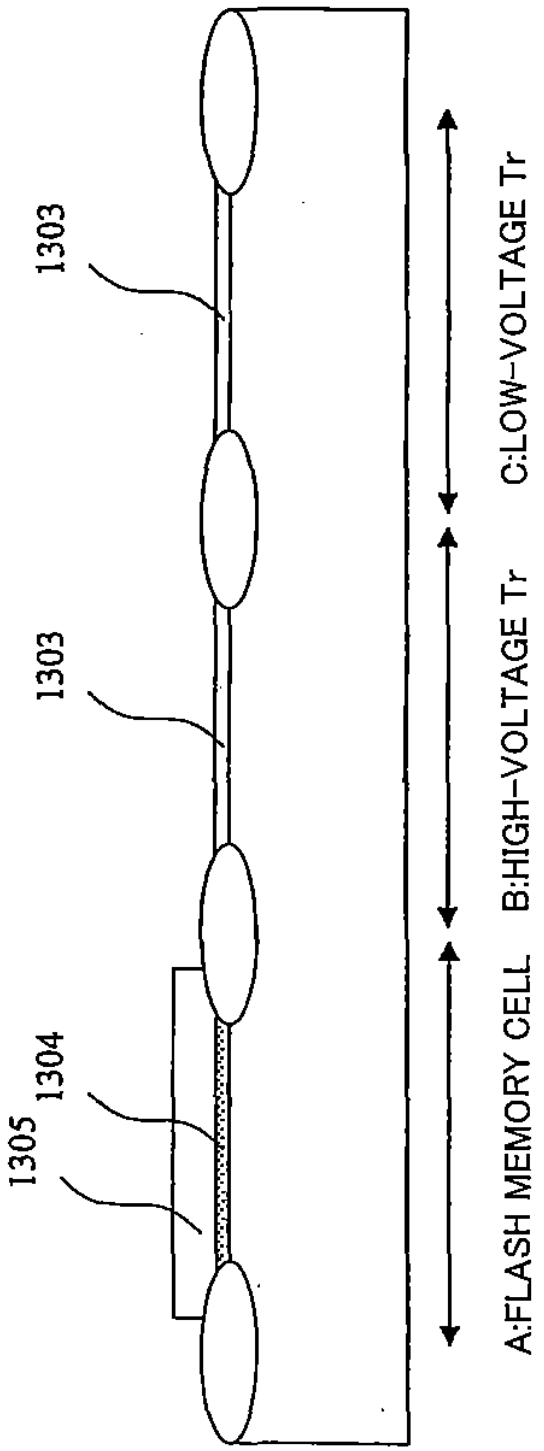
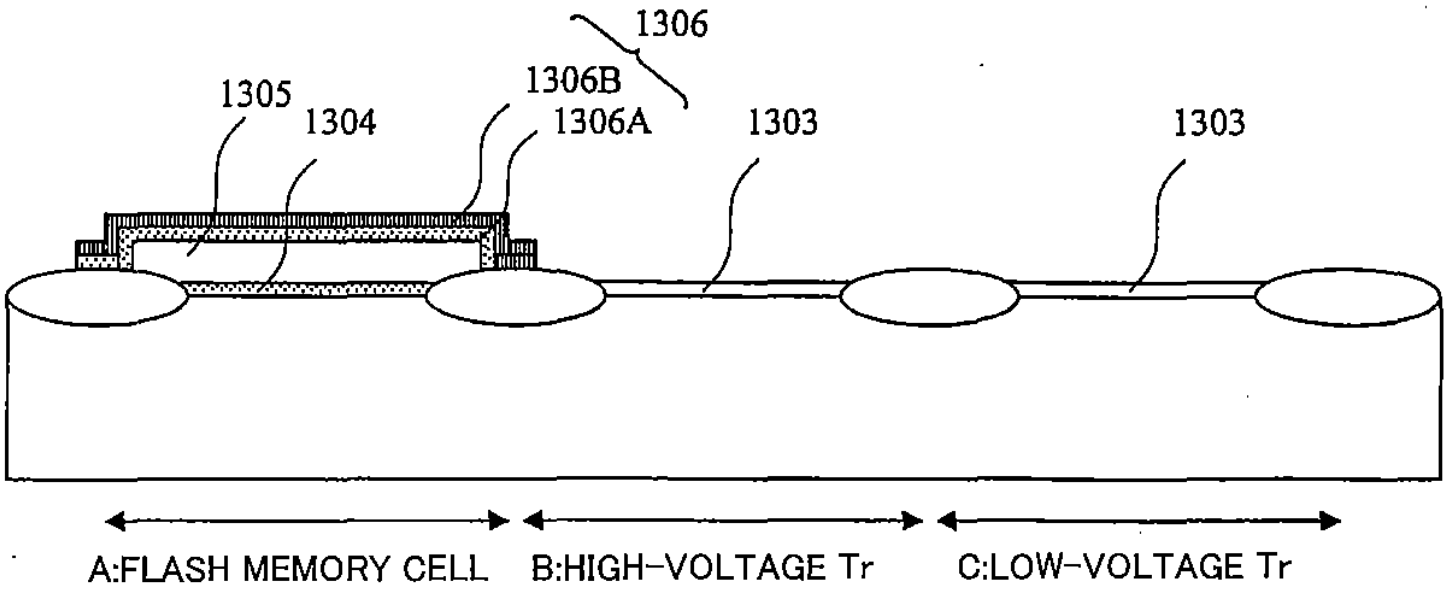
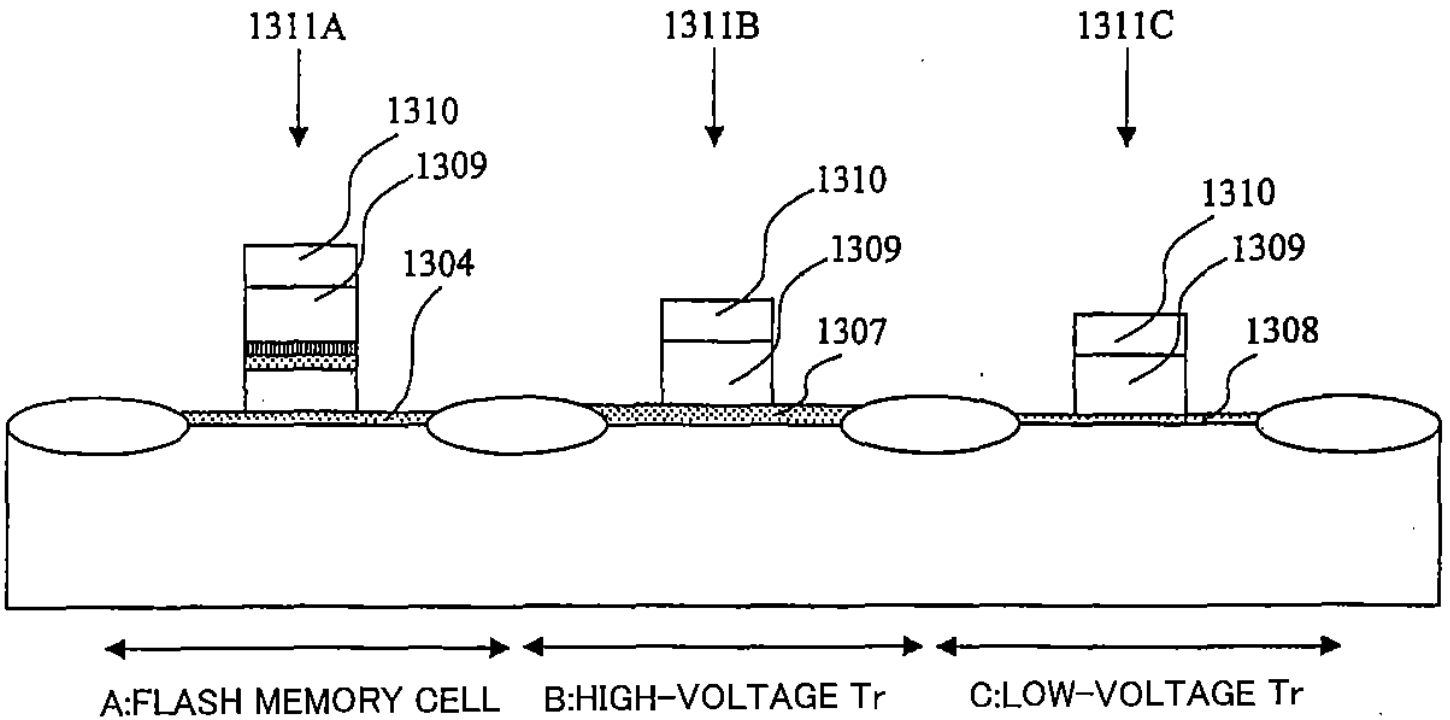

1303
1303
1304
1305
A:FLASH MEMORY CELL
B:HIGH-VOLTAGE Tr
C:LOW-VOLTAGE Tr

FIG.29



27 JUN 2005

FIG.30



27 JUN 2005

FIG.31

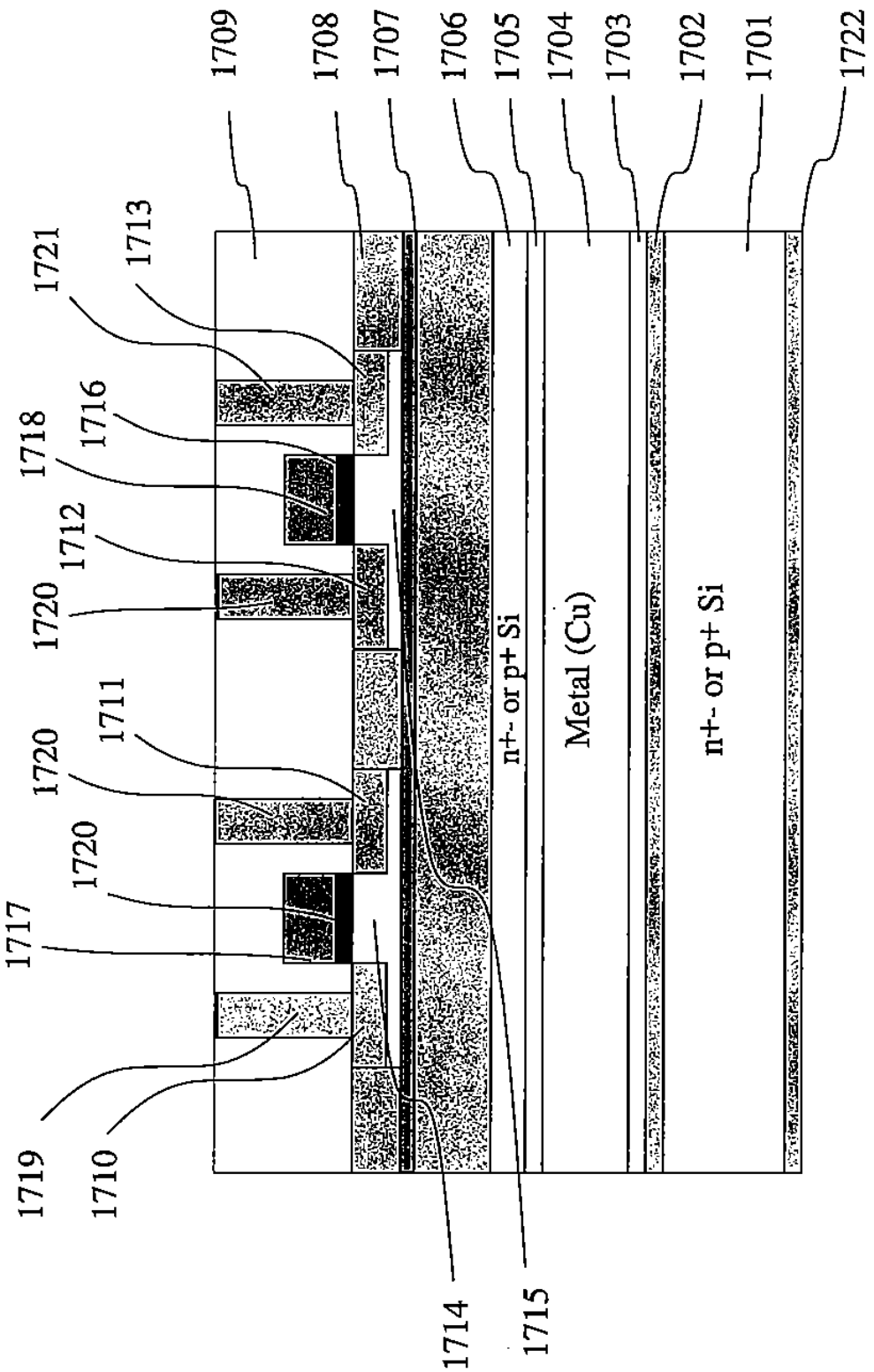

1709
1708
1707
1706
1705
1704
1703
1702
1701
1722
1721
1713
1718
1716
1712
1720
1720
1711
1720
1717
1719
1710
1714
1715
n+- or p+ Si
Metal (Cu)
n+- or p+ Si

FIG.32

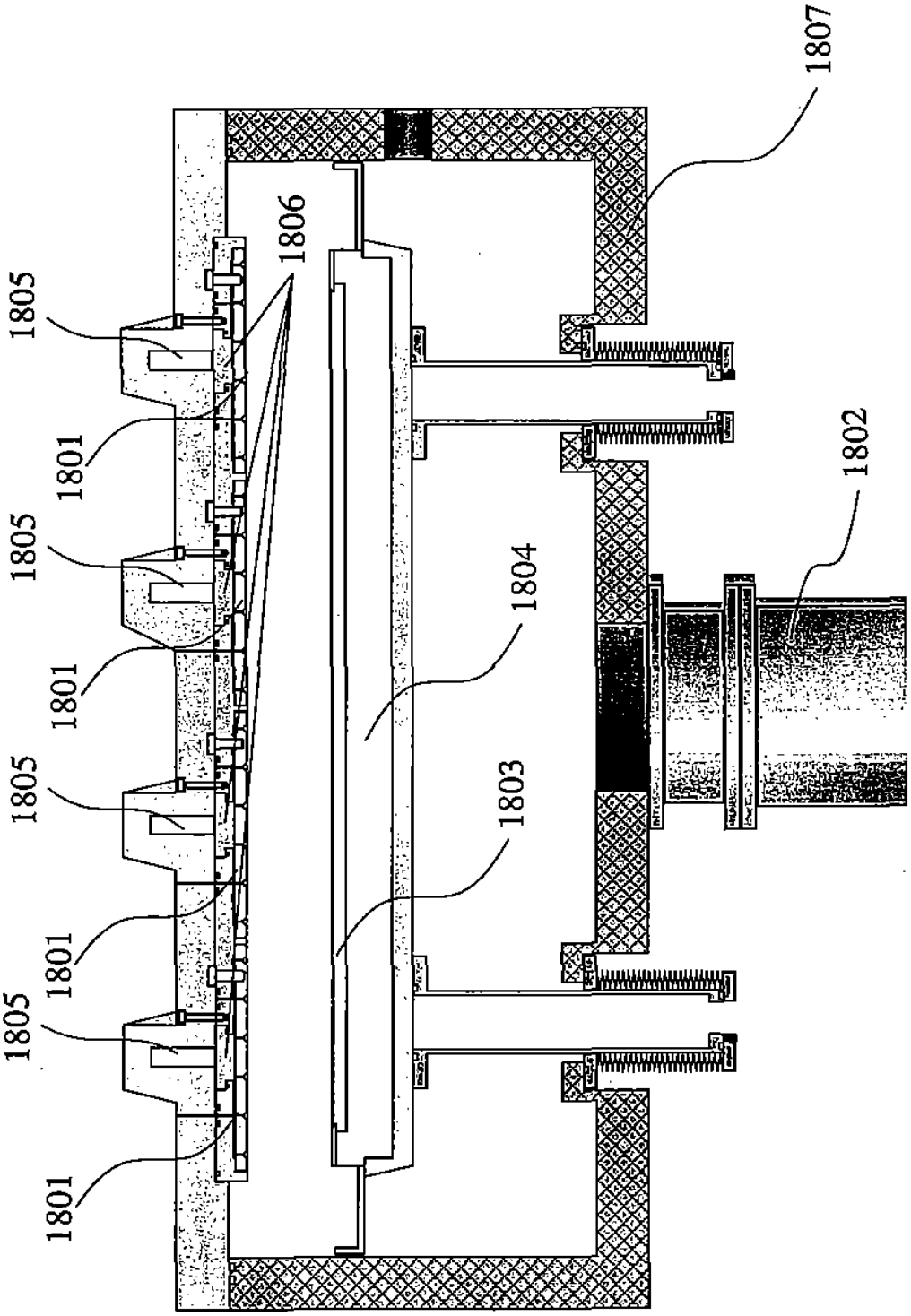

1807
1806
1805
1801
1805
1801
1805
1801
1805
1801
1802
1804
1803

FIG.33

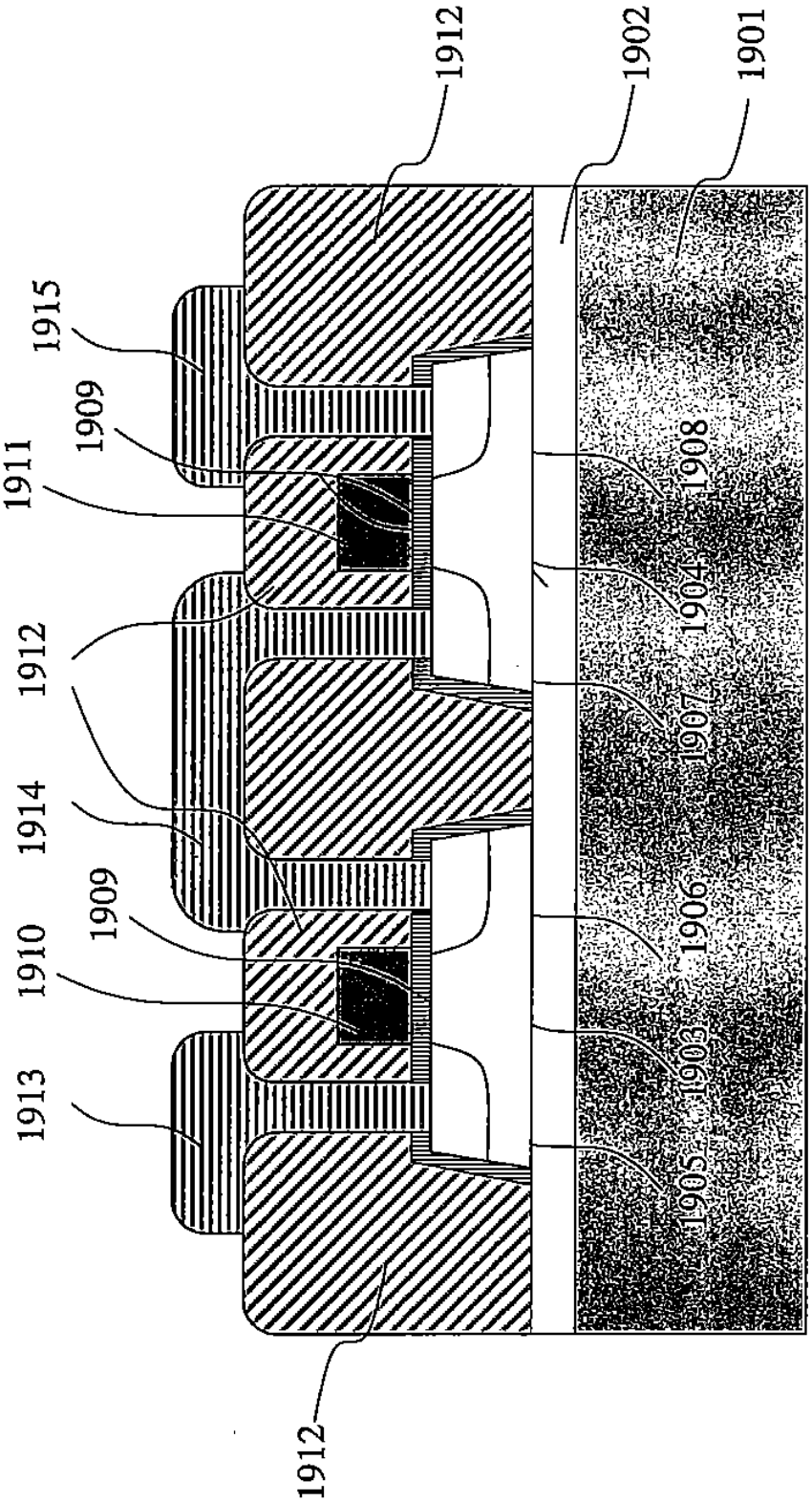

1912
1902
1901
1915
1909
1911
1908
1904
1912
1907
1914
1909
1906
1910
1913
1903
1905
1912

FIG.34

