

(19) (KR)
(12) (A)

(51) 。 Int. Cl. 7
H01L 27/112

(11)
(43)

2003 - 0014653
2003 02 19

(21) 10 - 2002 - 0046850
(22) 2002 08 08

(30) 09/924,577 2001 08 09 (US)

(71) - ()
(94304) 3000

(72) 95070 가 5085
94087 1161
94306 3234

(74)

:

(54) 가

P 가 (" OTP") (700) . OT
(790) (230,330) (790) (430,530)
가 (790) , 가 (790)
가 (280,380) 가 (280,380)가
, (230,330) 가 (230,330)
, (790) 가 , 가
가 .

1a

1a (anti - fuse) (resistance characteristic)

,

1b

,

1c

/

,

1d

-

,

2a

OTP

1

,

2b , 2a

,

(cross - point nature)

,

2c 2d

2a

,

3a

OTP

2

,

3b , 3a

,

,

3c 3f 3a

,

4a

OTP

3

,

4b , 4a

,

,

5a

OTP

4

,

5b , 5a

,

,

5c

5a

,

6a

2

,

6b 6c

3

,

6d

3

,

6e 4d 3 ,
 7a 2 ,
 7b 7c , , ,
 7d (equalized potential
 sensing method) (current sensor) ,
 8a 8b , , .

200 : 210 :
 220 : 1 230 :
 240 : 250 : 2
 260 : 280 :

, " VERTICALLY ORIENTED NANO - FUSE AND NANO - RESISTOR CIRCUIT ELEMENTS"
 _____ , " ONE - TIME PROGRAMMABLE FUSE/ANTI - FUSE COMBINATION
 MEMORY CELL" _____ , " ONE - TIME PROGRAMMABLE VERTICA
 LLY ORIENTED FUSE AND VERTICALLY ORIENTED FUSE/DIODE UNIT MEMORY CELL AND ONE - TIME
 PROGRAMMABLE MEMORY USING THE SAME" _____

가 (programmable memory device) .
 , (vertically oriented fuse) (fuse and anti - f
 use combination unit memory cell) 가 (one - time programmable storage de
 vice) .
 , 가 가 . 가 , ,
 , 가 가 .
 , 가 (non - volatile me
 mory), .

(one - time programmable; OTP) 가 (re - progra
 mmable) . , OTP 가 (charge
 storage)(EPROM), OTP 4) 가 1) (anti - fuse), 2) , 3) (charge
 (breakdown) 가 - - (metal - insulator - metal)
 , 가 , 10V (large drive transistor)가
 , (access transistor)
 가 (planar fuse)
 8² ((minimum photolithographic feature size))
 , (end) (contact region) , 가
 , 8² , 가 가
 , 가 .
 EPROM , (write voltage) - ((floating gate))
 Fowler - Nordheim electron tunneling) . EPROM OTP
 , 가 .
 ROM , OTP ROM ((ROM enable) 가 , ROM " (field programmed)" , ROM 가
 , ROM ,
 OTP , (cross - point memory) 4²
 substrate) , (single plane of memory) , (single crystal silicon
 (sense and programming electronics) ,
 OTP 가 .
 , 가 (OTP) .
 (row direction) (row conductor)
 (column conductor) (intersection)
 (cross - point)가 ((state element))
 . (electrical contact) .

, OTP
 (ground) (V_{WR}) 가 , ,
 (critical voltage drop) (V_c) 가
 , OTP
 (V_{RD}) 가 , ,
 가 1 () 가
 2 ()
 가 OTP 가
 가,
 OTP
 가 4 2
 가
 가 (OTP)
 , OTP
 가 1 가
 1a (t_0) (R_{2AF}) (V_C) 가 , 가 (t_1) , (R_{1AF})
 가 (V_C) 가 , (t_1)
 , (insulating material), (conducting material)
 (multi - layer stack), (dispersed conductive inclusion)
 (amorphous) (crystalline) , (phase change material), (Si)
 (silicide - forming metal)
 (sandwiched) 가 가가 가
 (SiO_x) , (SiN_x) , (SiO_xN_y) , (AlO_x) , (TaO_x) , $(TiO$
 $x)$, (AlN_x) , (Si) , (Ge) ,
 , $(InTe)$, $(SbTe)$, $(GaAs)$, $(InSe)$, $(InS$
 b) , , , , , (Sn) , , , (Pb) ,
 (Bi) 가 , , , (W) , $(P$
 $t)$, (Pd) , (Co) , (Ni) , (Ti)

n) Quantum mechanical tunneling current)가
 m) (polycrystalline)가
 0.5 (nm) 50 nm 가
 (pre-breakdown conditio
 (significant q
 5 nm
 1 nm 100 n

가
 가
 가

(V_C)
 100 (μm^2) 가
 (V_C)
 가 ($10^7 - \mu m^2$)
 (metal migration)
 가 (current transport)
 가

(open circuit)가
 (thin film resistor)
 (refractory metal)(
 (low melting metal)(
 (transition metal)(

1b
 (t₁) (I_C)가
 (thermal runaway)
 (R_{2F})가
 (R_{1F})
 (R_{2F})
 I²Rt 가 (R_{1F})
 (heating)
 (dissipation of po
 (t₂)
 1
 2

1 (/)
 (I_C) 가 1 가
 2 가
 (V_R) 가
 1
 2

1c, (R_{1AF}) , (t_0) , V_C 가 가, (t_1) , (I_C) 가 가, (t_2) 가, (R_{2F}) , $1c$, (t_2) 0. $(f$ inite resistance) 가 R_{1AF}) 1 , $($ infinite resistance) (R_{2F}) , $(1c)$. 2 , (V_C) 가 1 , (t_0) (t_2) 가 가 가 $1d$ 가 $(/ /)$ 2 (vertical height) 1 , 30 1 (lat eral thickness) 1 , 가 1 . 1 , 2 가, 2 (V_C) 1 (I_C) 가, 1 2 가 $($ equipotential method) 1 2 . $2a$ OTP (200) 1 (200) 1 (280) (230) (200) , 1 $($ (closed region) (285) $(230,280)$ 가 $($

, (230) ()

, OTP 가

(200) (210) , (210) (closed region)(285)
 1 (220) , (280) (285) (center region) (oc
 copying) (insulating plug)(240) , 2 (250) (260)(1
 (220), (230) (240))

(280) , , , , , (low melting
 temperature) , , (230) , , ,

(260,210) , , , , ,
 (220,230) (240) (260,210) . 1 2

(240) , (void)
 (230) (230)

(240) (230) , (280)
 (230)

2a (285) (260)가 (230) ,
 (210)가 (280) 가 , 2a (285)
 (260,210) (conductive path)가
 (210) , (230) , (280) , (260)
 (210) , (230) , (280) , (260)

2b , (260,210) (115) (285) (edge)
 (230) (240) 2a (200)
 (280)(2b) (240) (230) 가 ,
 (230) (260,210)
 215) (215)() (285) ((285)

, 1 2 (220,250) 2b , , (230)
 (240)가 (215) . , (260) (spacer)(230)
 (240)

, 2b, (285) (285) (annulus) (230)
 (285) (240) (cylindrical)
 ellipse), (285) (enclosed shape), (rectangular), (square), (
 (240)

2c 2d 2a 1 2c (290) (2
 00) 2d (290,290b)가
 (290 / 290b) (280)
 (230) (280) (290 / 290b)가 (
 280) (Schottky) (ohmic) (290 / 290b)가 (
 (230) (290 / 290b) , ,

2c (290)가 (285) (280) (230)
 2d (290b) 2c 1 (280) (290)가 (280) 가 (230)
 (210) (280) (230) 2
 (290 / 290b) (260) (210)
 가 가 (260)
 (210) I^2Rt

가 (290 / 290b)
 tact) (rectifying or ohmic con
 가 (290 / 290b) (210,260)

가 (260,210) (290 / 290b)

3a OTP (300) 2
 1 (300) (330) (330)
 (320) (330)

(300) (bottom) (310) (330) (310)
 U' (385) 3a (330) 3d
 (300) 'U' (385)
 (340) (300) 'U' (385) (380) (360)
 (320)

, (340)가 , 'U' (385) .

3b 3a (300) , (360)
 (380) (380)(3b)
 (330) (340) (380)
 (definition insulating) (patterning) (plane of the film)
 (330) , (340) (310)(
 3b) 'U' (385)

3c 3f 3a (300) . 3c , (3
 90)가 (330) (380) , 1
 (300) (390) 3c
 (390) 3b (315)

3d , 'U' (385) , 3a (300) 3d
 , (330)
 , 3e (390)가 'U' (385) 가
 (330)가 'U' (385) (330)가 (380)
 가

3a 3e (330) , (340) , 'U' (385)
 (310) 2
 , (330) (360) 1 (330)
 (360) (inverted) 'U' (385) (340)
 'U' (385) (300) (310)
 'U' (385) (380) 가 3f

4a OTP (400) 3
 2 (400) (430)
 (430)가 (485)
 (400) (410) , (410) (385) 1
 (420) , (385) (440) , 2 (450) (460)(
 1 (420) (430))

(440)가
 1 (460)가 (430)
 (460,410)
 4b (460,410) (415) (430) (485)
 (440) 4a (400)
 5a OTP (500) 4
 (530) (520) (530)
 (500) (510) (530) (510)가
 U' (585) 3a (530)
 5c (500) U' (585) (5)
 40) (500) U' (585) (560) (520)
 5b 5a (500) (560)
 (530) (540) (510)(5
 b) U' (585) (5)
 15)
 5a 5c (530) (540) U' (585)
 (510) 2
 (530) (560) 1
 6a (600) 2
 (600) (660,610) (660,610) 2a
 5c (state e
 lement) (692)가 (692) 2a 3e 1
 4a 5c 2 6a
 (692)
 6b 6c 3 6b (6
 02) (660) (610) (692) (6
 60,610)가 (692)가 (602) (699)
 가 6b 3 가 (660,610)
 (692)

6b 3 가 4 , N+1
 N , 2
 4 가 6c N 가 2N
 , 6b (692) , 6c (694) (604)
 6d , 3a 3e (300)((601)) 3
 , (601) (662,612) , (632) , (642)
 , (632) (682) (662,612) (696)
 (682)가 , 3d 5a 5c (500) 3 가
 , (696) 6d
 6e 3 6e ,
 (606) (662) , (612) , (632) , (642)
 , (606) (696) (682)
 (606) (699) 가 6e , 3 가 ,
 , 가 6e , N 2N 가
 , N+1 N
 7a (700) 2 ,
 (760) (710) (760,710)
 () , (790)가 (790) 1 2
 , (790)가 (760) (710)
 (790)
 7b 7c , , (700)
 7b (700) (row addressing circuit)(715)
 (735) (715) (725)
 (760) (725)
 (735) (745) (710)
 (745) , 7c , (745) (75)
 5) (710) (755)
 1 2 ,
 7d (755) , (755)
 (790), , 1 2 ,
 (790)

7c 가 , ()가 (710)
 가 . (745) 가 가 . ,가 (virt
 ual ground potential)가 (755) 가 . , (710)
 (755) (I_S) 가 . ,
 (710) (710) 가 가 .
 (I_S) , 가 .
 , (I_S) , (V_R) 가 .
 / 가
 가 가 , 가 가 가 가
 가 가 가 가/ 가/ 가
 . (700) .
 /
 가 가
 가 .
 가, (700)
 가 . CMOS (support circu
 it) (715,735) ,
) . (700) .

8a 8b , , (800)
 . 8a , 7b
 , (790)가 (810)). (790) (760)
 (V_{WR}) 가(820)) (710) (830)
 (820,830)

7b (800) 7b , 3
 (790)가 (790) 가 가 . (V
 (790) 가 가 가 (V_{WR})
 (I_S) , (760) 3 (710) .
 (parallel writing) 가 , , (790) ,
 (760) 가 가 (7b) . 3 (V_{WR}) 1
 (710) 가 가 , 1 3 4 (710) , 4
 (790)가

가 . /
 , 가
 , 가 ,
 .

8b (790)가 (850) ((840)) 7c (790) (790) (710) (760) (V_R) (860) 가(

(790)가 (805) 가 7c (790) 가 7c 가 3 가 , 가 가 (790)가 (790)가 () ()

, 가 , , (790)가 ,

, 가 , " " " " 가 , " " " " 가 " " " "

, " " , (horizontal) 가 , " "

가 가

OTP

가,

OTP

4²

가

(57)

1.

가 (one - time programmable memory array) (700) ,

(row direction) (row conductor) (760) ,

(column direction) (710) - (760)

(intersection) (cross - point)가 - ,

(fuse) (230,330) (710) (state element) (790) - (anti - fuse) (280,380) (790) (760)

가 (700).

2.

1 , (790)

(230,330) (280,380) (thin conductor) (290,390)

가 (700).

3.

가 (700) , (760) , (710) - (760)

가 - ,

ed fuse) (430,530) , (790) - (790) (760) (vertically orient (710)

-

가 (700).

4.

1 3 , (790) (insulator) (220,320,420,520)

가 (700).

5.

1 3 , (790) (230,330,430,530)

가 (700).

6.

1 3 ,
 (790) (230,330,430,530) (230,330,430,530)
 (void)
 가 (700).
 7.
 가 ,
 (760) ,
 가 - , (710) - (760)
 (760) (230,330) (710) (790) - (280,380) (790) (combination) , (430,530) (790)
 (700) ,
 (700) (700) (760) (row addressing circuit) (715) ,
 (700) (710) (735)
 가 .
 8.
 7 ,
 가 (700) (715) (735)
 가 (700)
 가 .
 9.
 7 ,
 (760) (row transistor) (725) - (760)
 가 (725)가 - ,
 (710) (column transistor) (745) - (745)
 (715) (equalized potential) 가 - ,

(710) (current sensor) (755) - (755)
 (790) , (755) (710)
 가 (virtual potential) 가 -

가 .

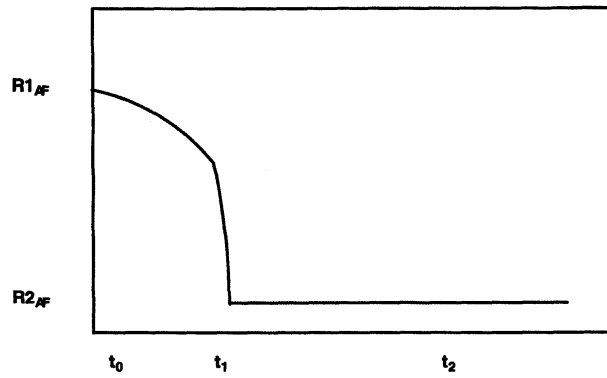
10.

1 7 ,

(280,380) 가 (280,380)

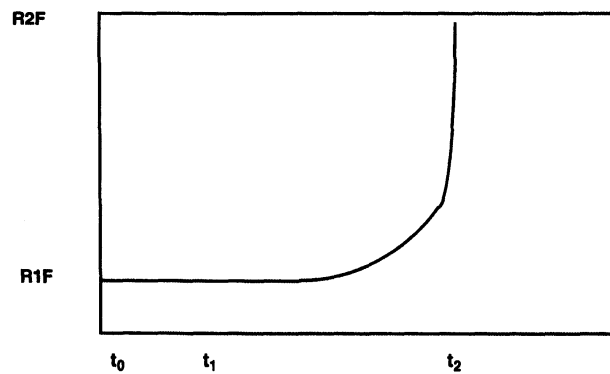
가 (700) .

1a
 반퓨즈의 저항



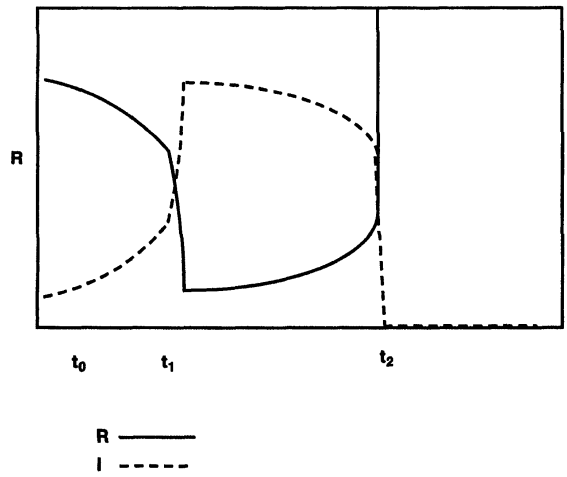
1b

퓨즈의 저항



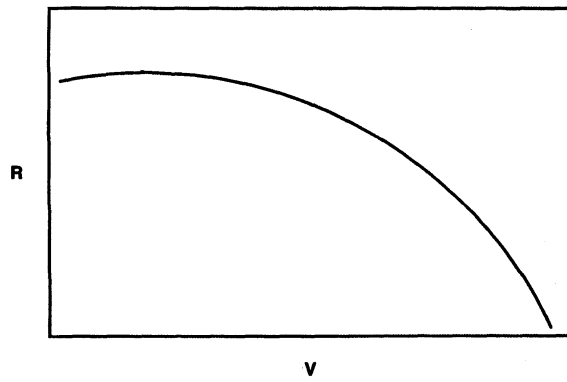
1c

셀의 저항/전류 특성

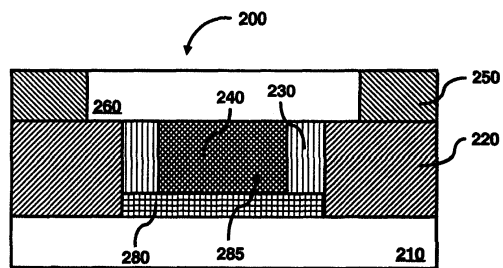


1d

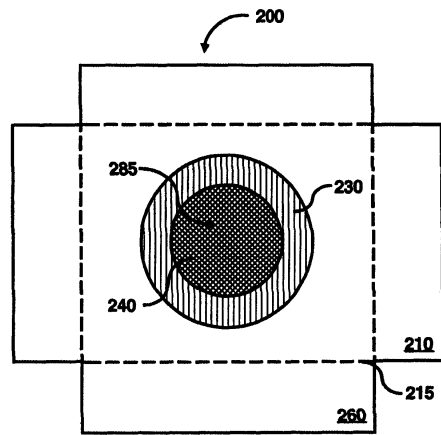
반퓨즈의 전압/저항 특성



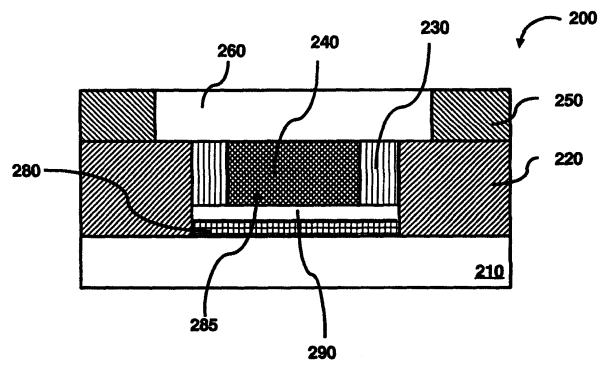
2a



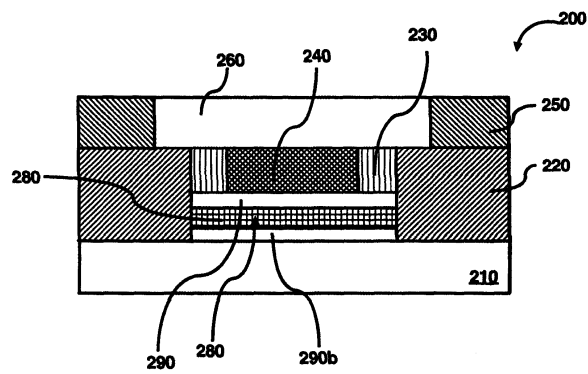
2b



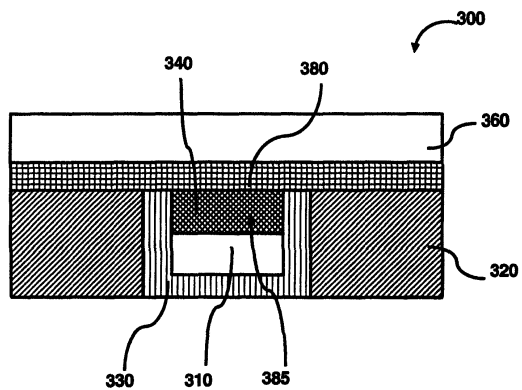
2c



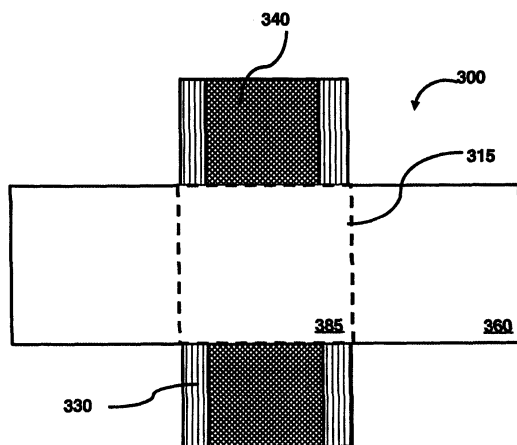
2d



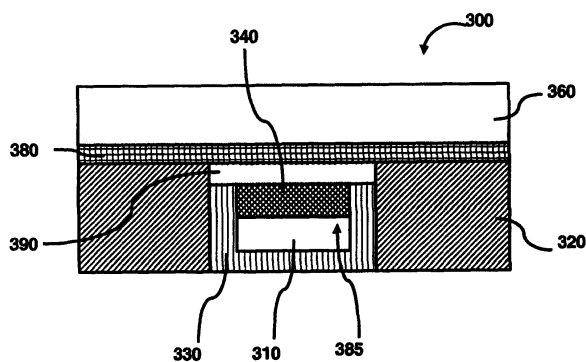
3a



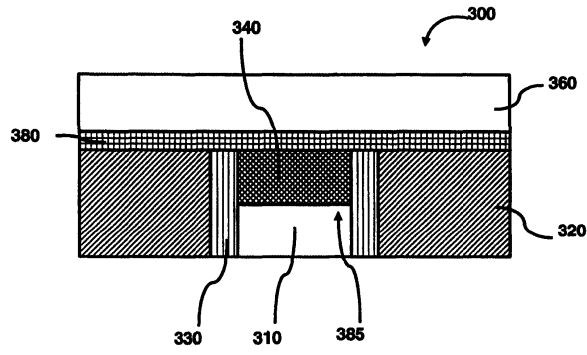
3b



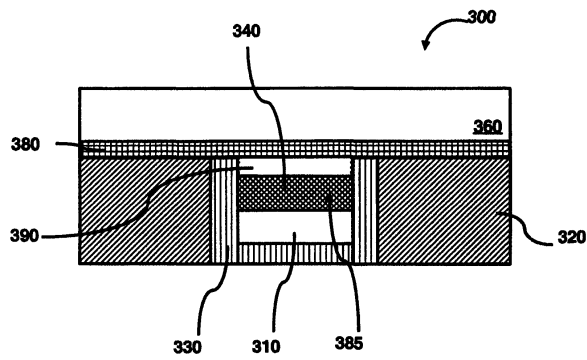
3c



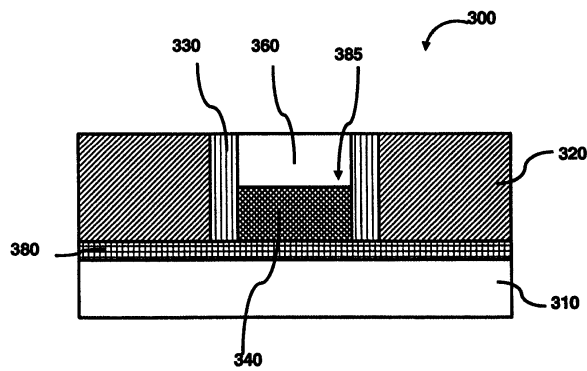
3d



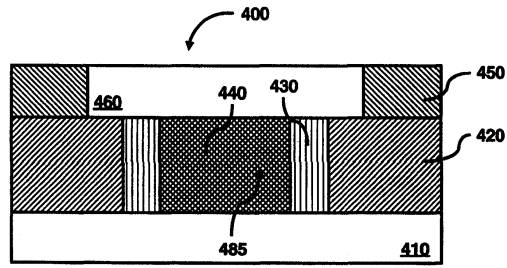
3e



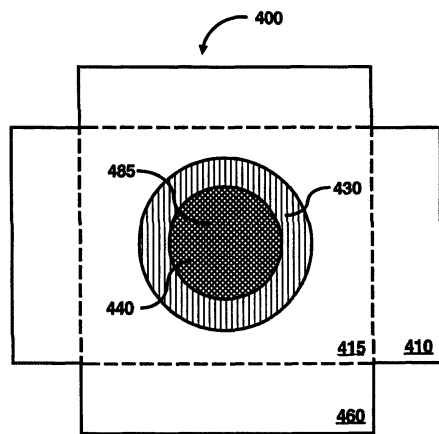
3f



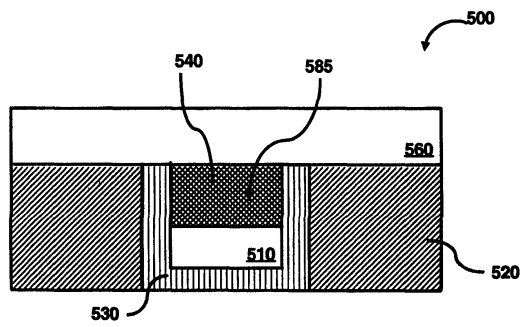
4a



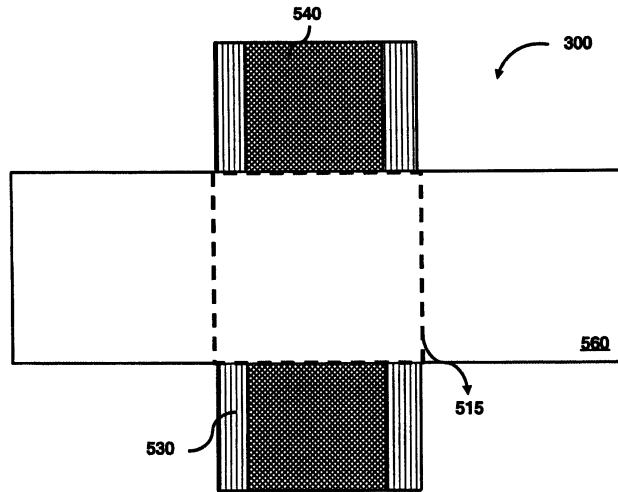
4b



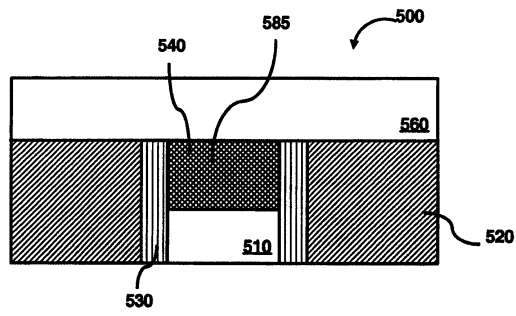
5a



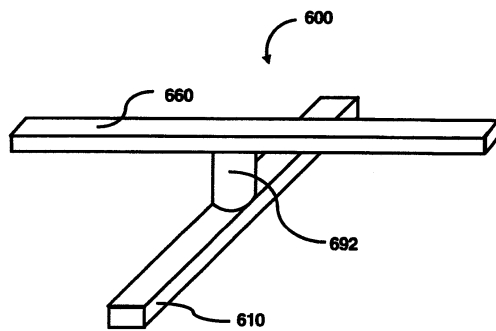
5b



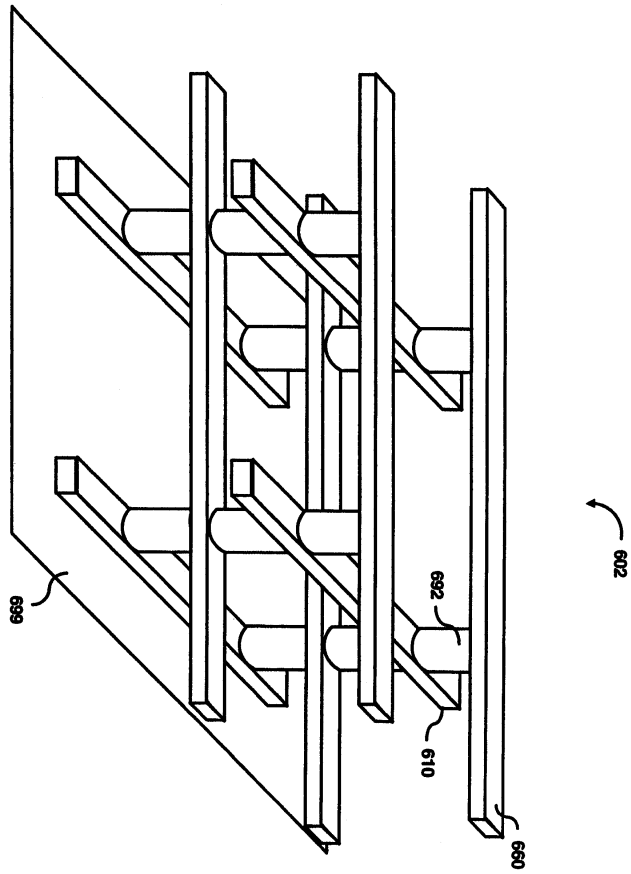
5c



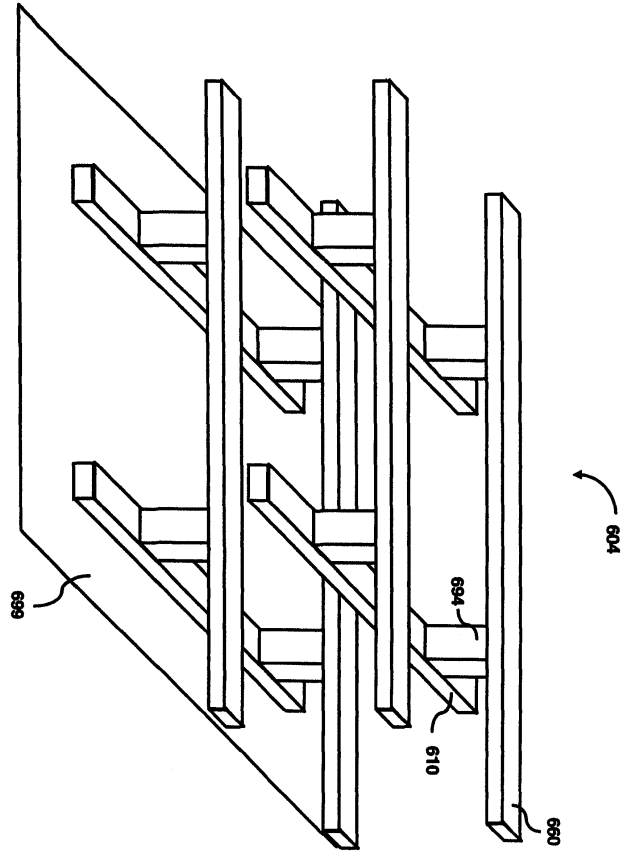
6a



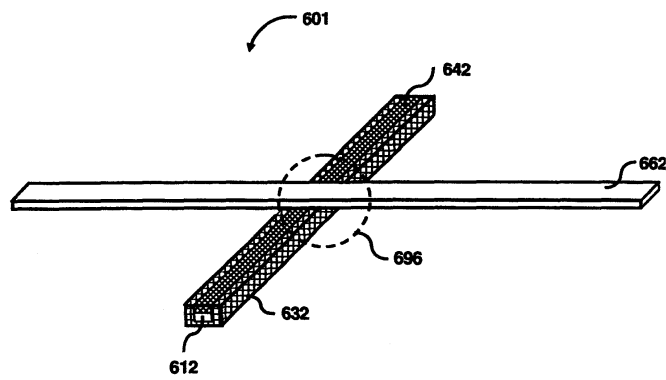
6b



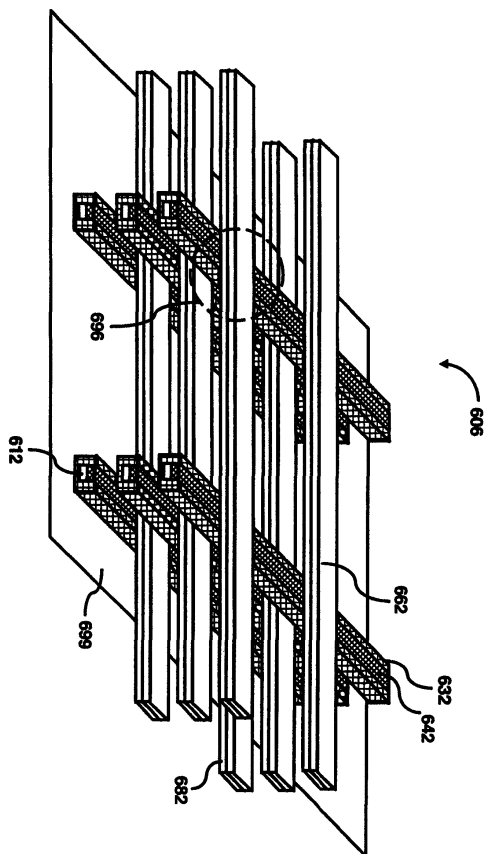
6c

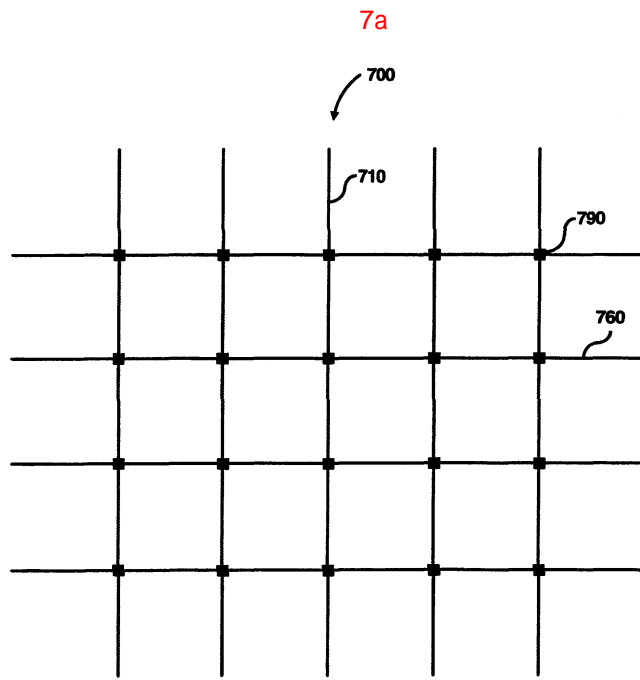


6d

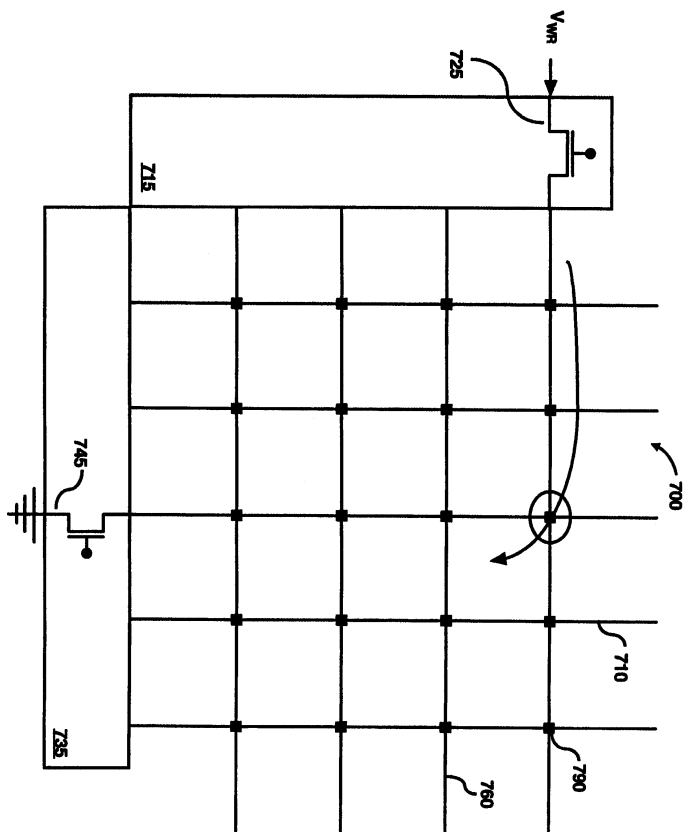


6e

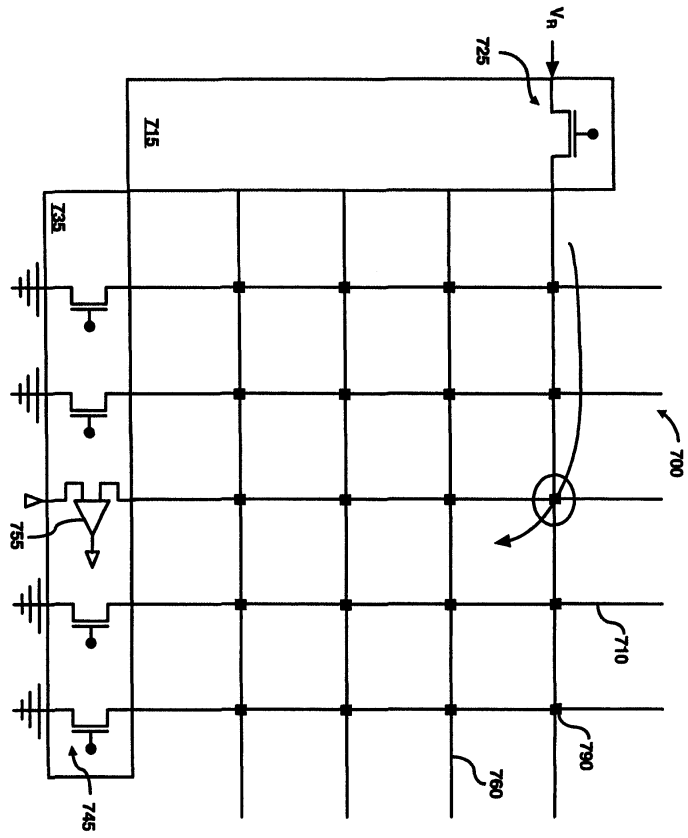


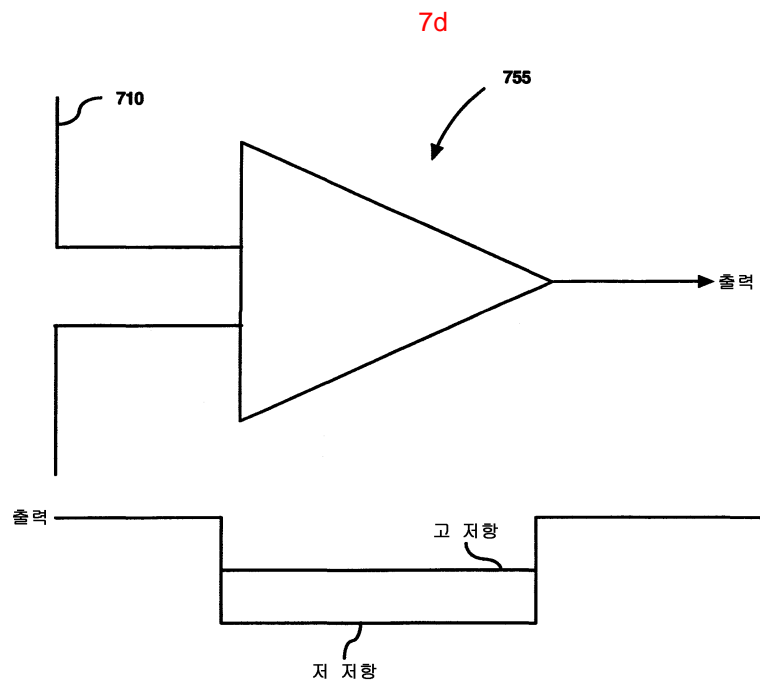


7b

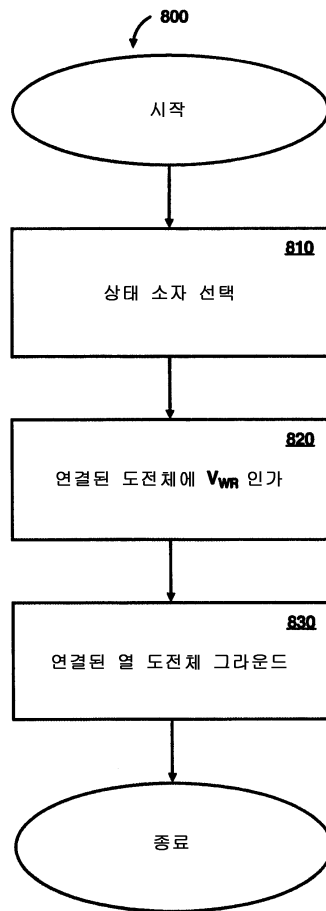


7c





8a



8b

