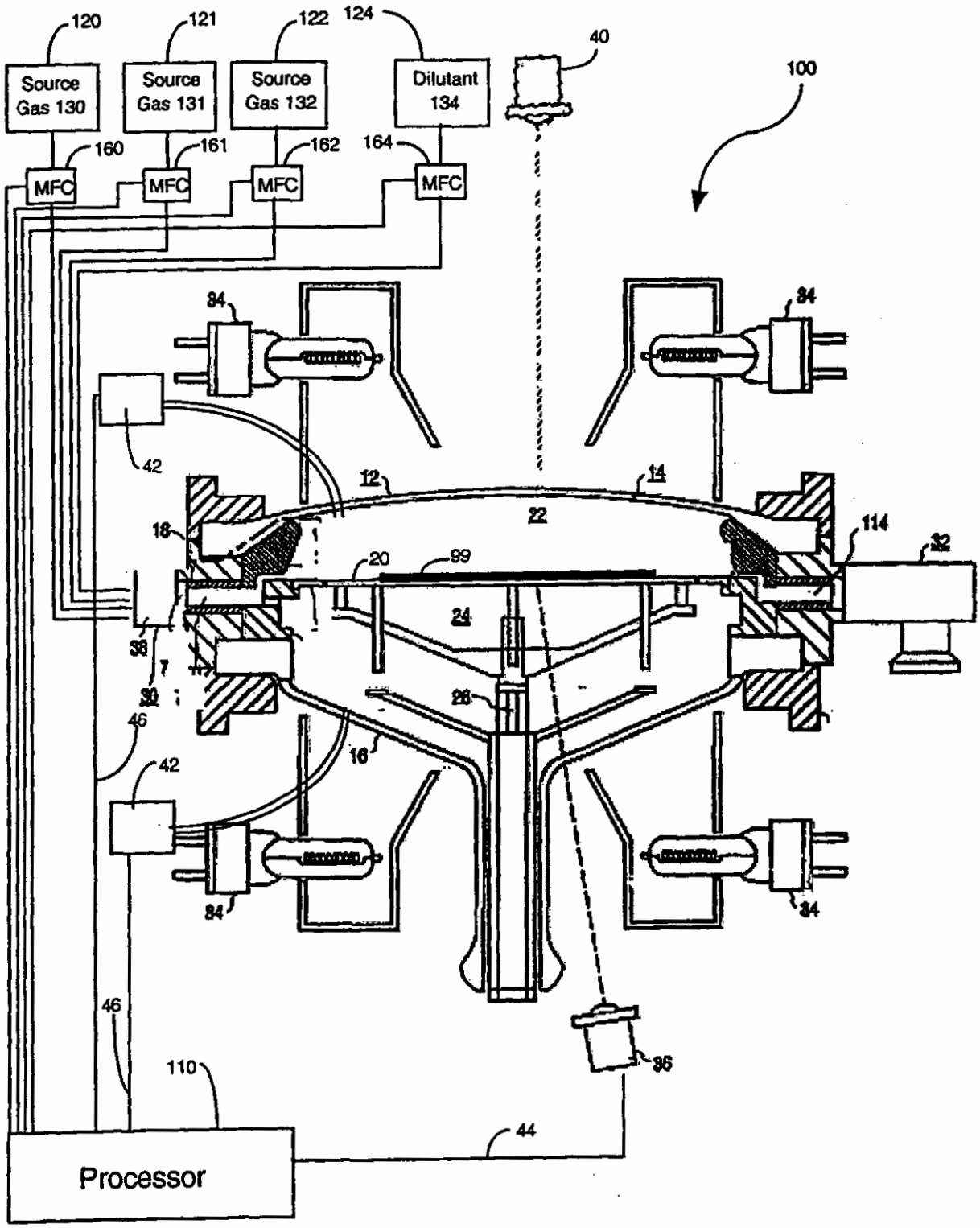

120
121
122
124
Source Gas 130
Source Gas 131
Source Gas 132
Dilutant 134
40
100
160
161
162
164
MFC
MFC
MFC
MFC
84
84
42
12
14
22
18
114
32
20
99
24
36
7
30
26
46
16
42
84
84
46
110
44
Processor
96

Figure 1

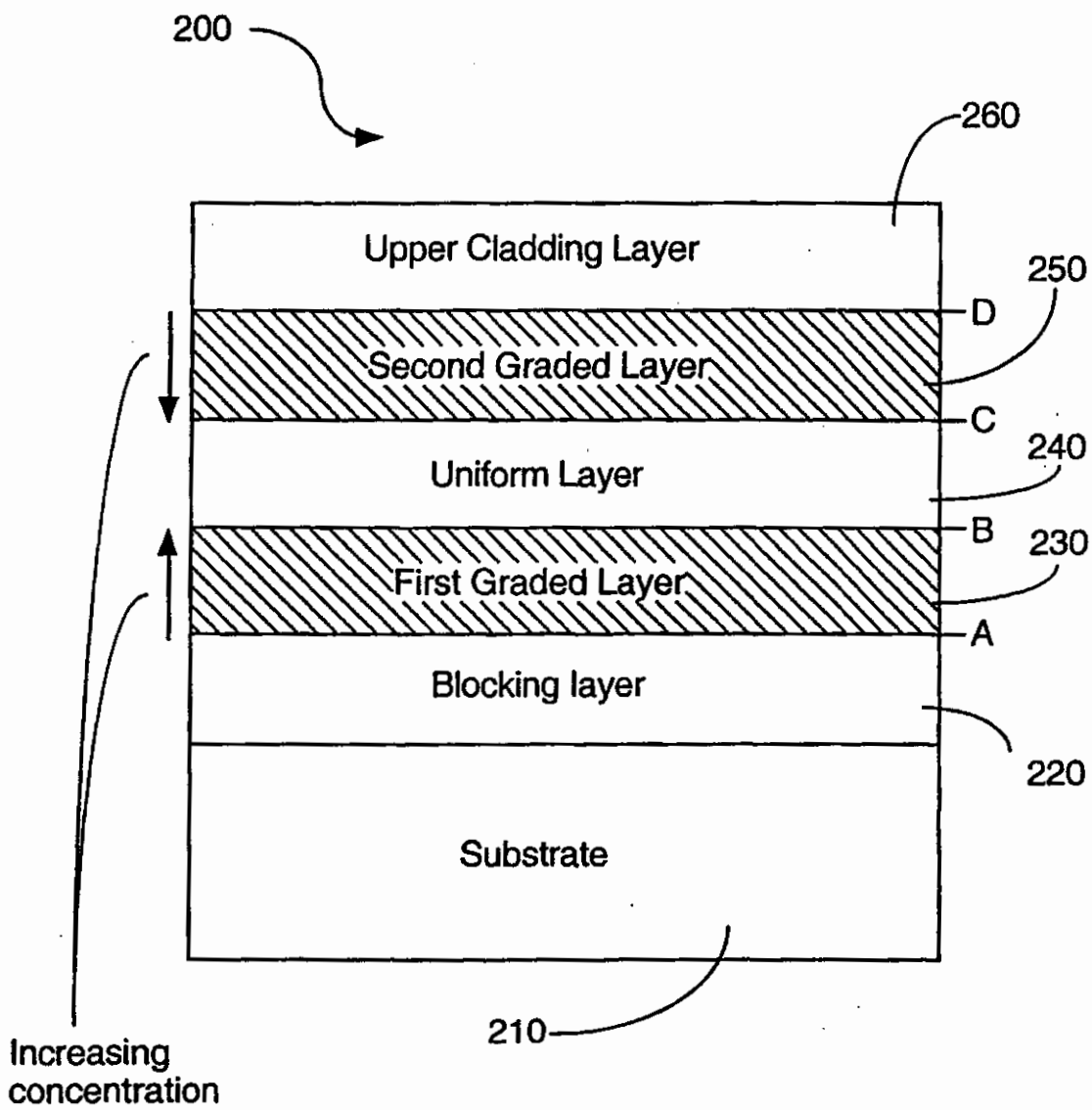
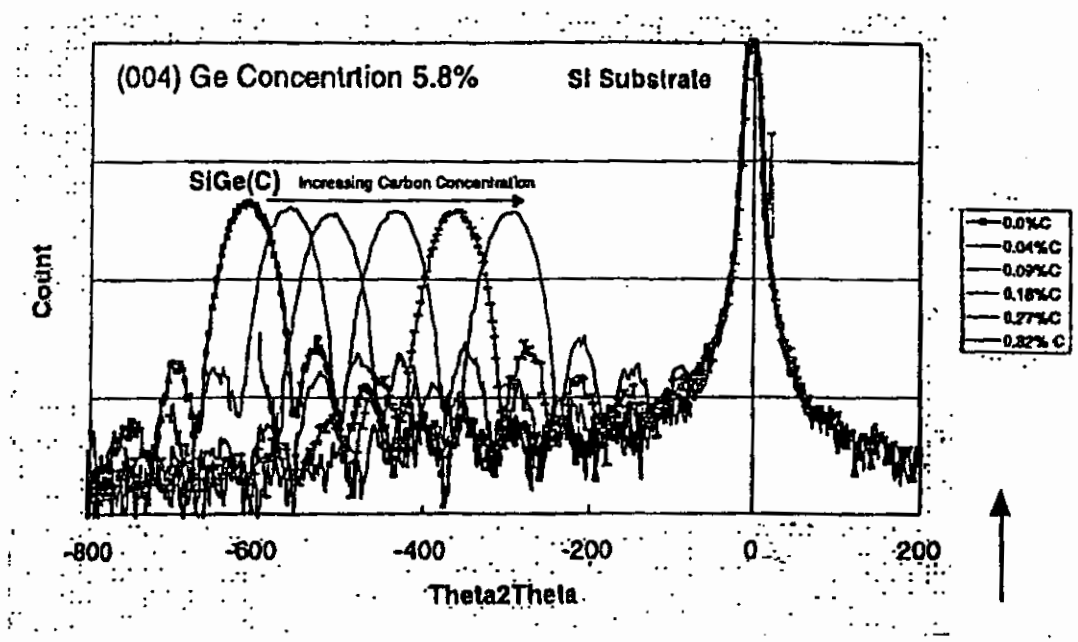

200
260
Upper Cladding Layer
250
D
Second Graded Layer
C
240
Uniform Layer
B
230
First Graded Layer
A
Blocking layer
220
Substrate
210
Increasing
concentration

Figure 2A

X-Ray Photoelctron Deffraction Graph
of a Si Substrate and SiGeC Layers with
Different C Concentrations



Approximate
concentrations
of substitutional
carbon atoms

Figure 2B

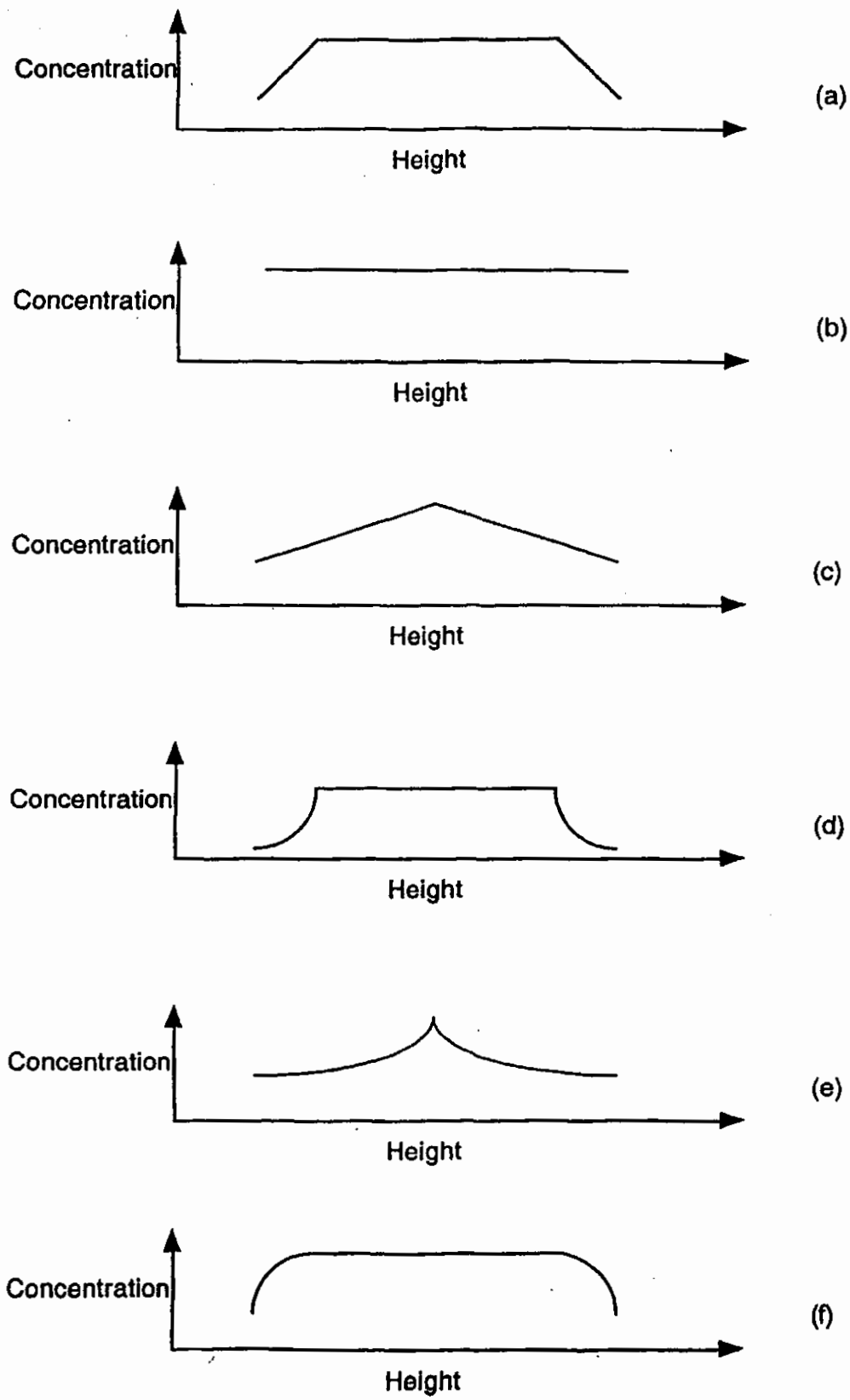

Concentration
Height
(a)
Concentration
Height
(b)
Concentration
Height
(c)
Concentration
Height
(d)
Concentration
Height
(e)
Concentration
Height
(f)

Figure 3

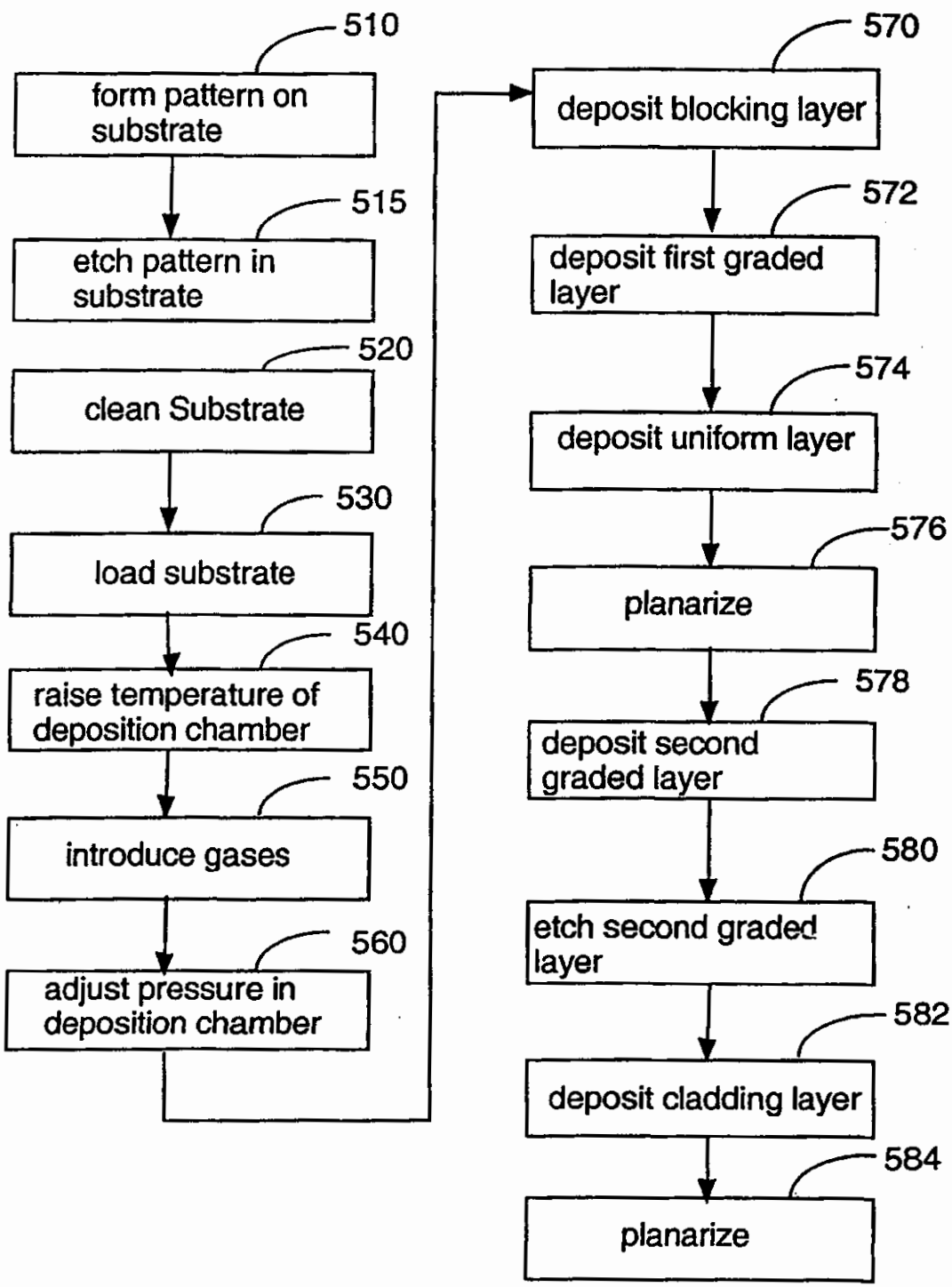

510
form pattern on substrate
515
etch pattern in substrate
520
clean Substrate
530
load substrate
540
raise temperature of deposition chamber
550
introduce gases
560
adjust pressure in deposition chamber
570
deposit blocking layer
572
deposit first graded layer
574
deposit uniform layer
576
planarize
578
deposit second graded layer
580
etch second graded layer
582
deposit cladding layer
584
planarize

Figure 4

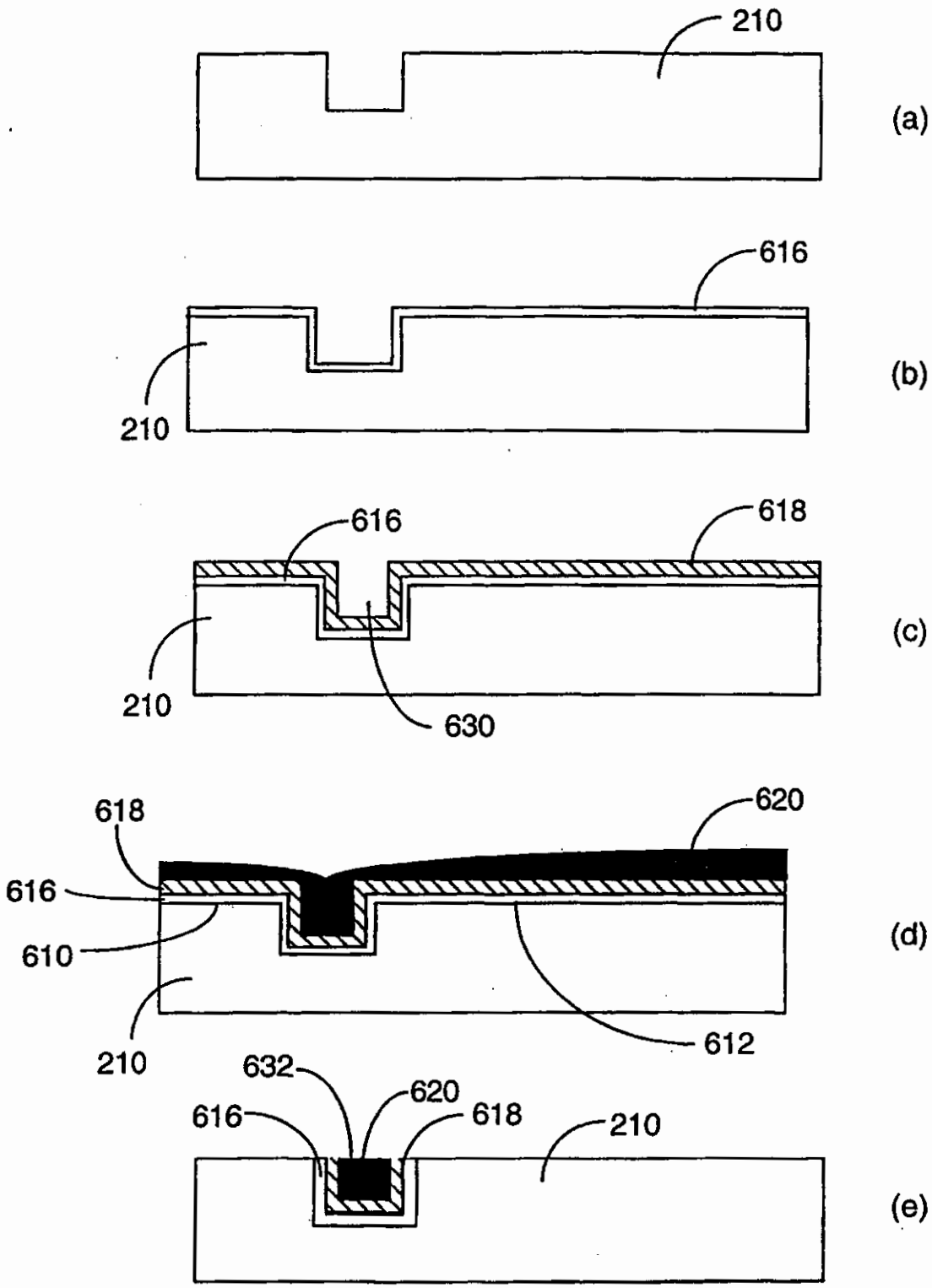

210
(a)
616
210
(b)
616
618
210
630
(c)
618
620
616
610
210
612
(d)
632
620
616
618
210
(e)

Figure 5

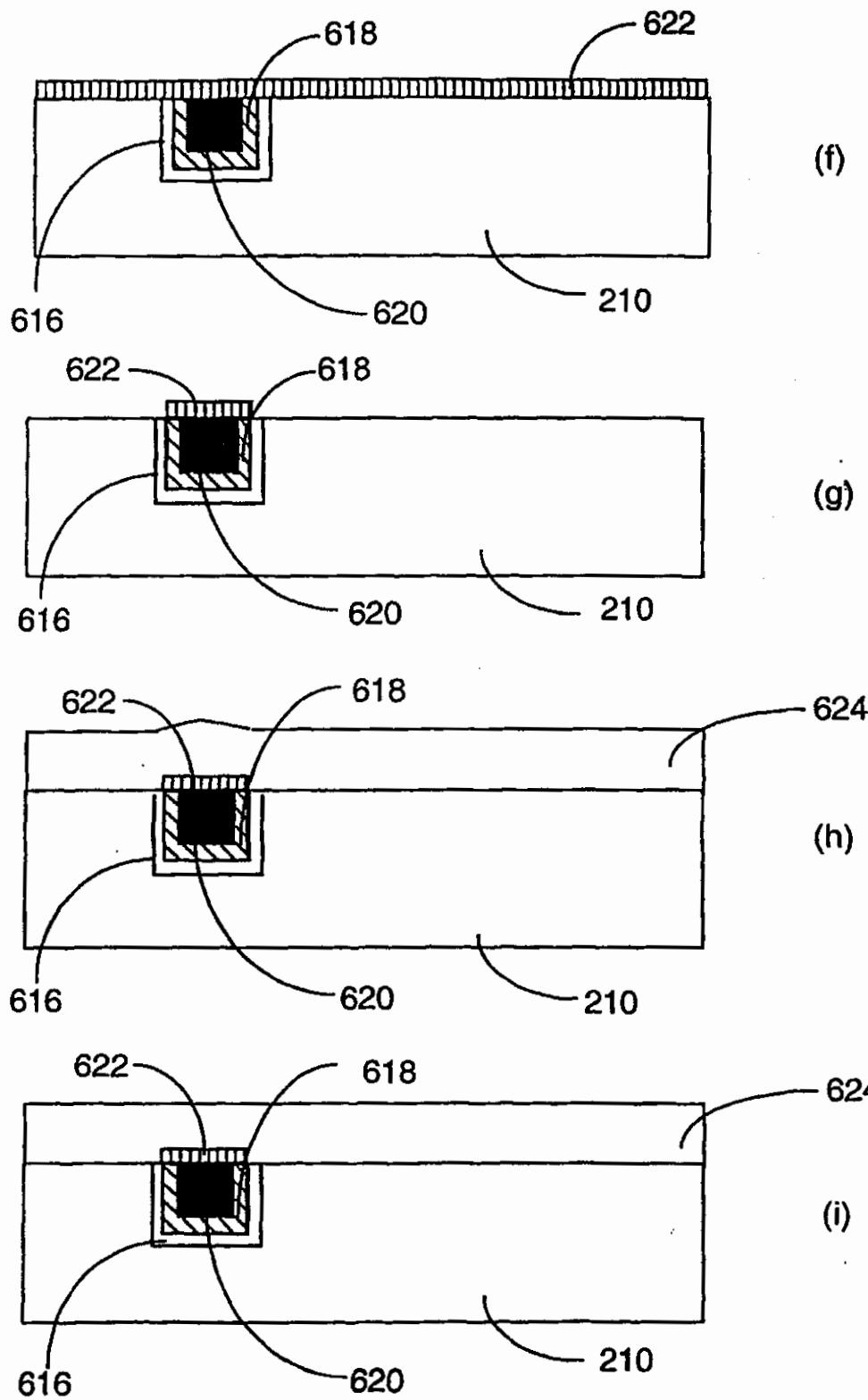

618
622
(f)
616
620
210
622
618
(g)
616
620
210
622
618
624
(h)
616
620
210
622
618
624
(i)
616
620
210

Figure 5

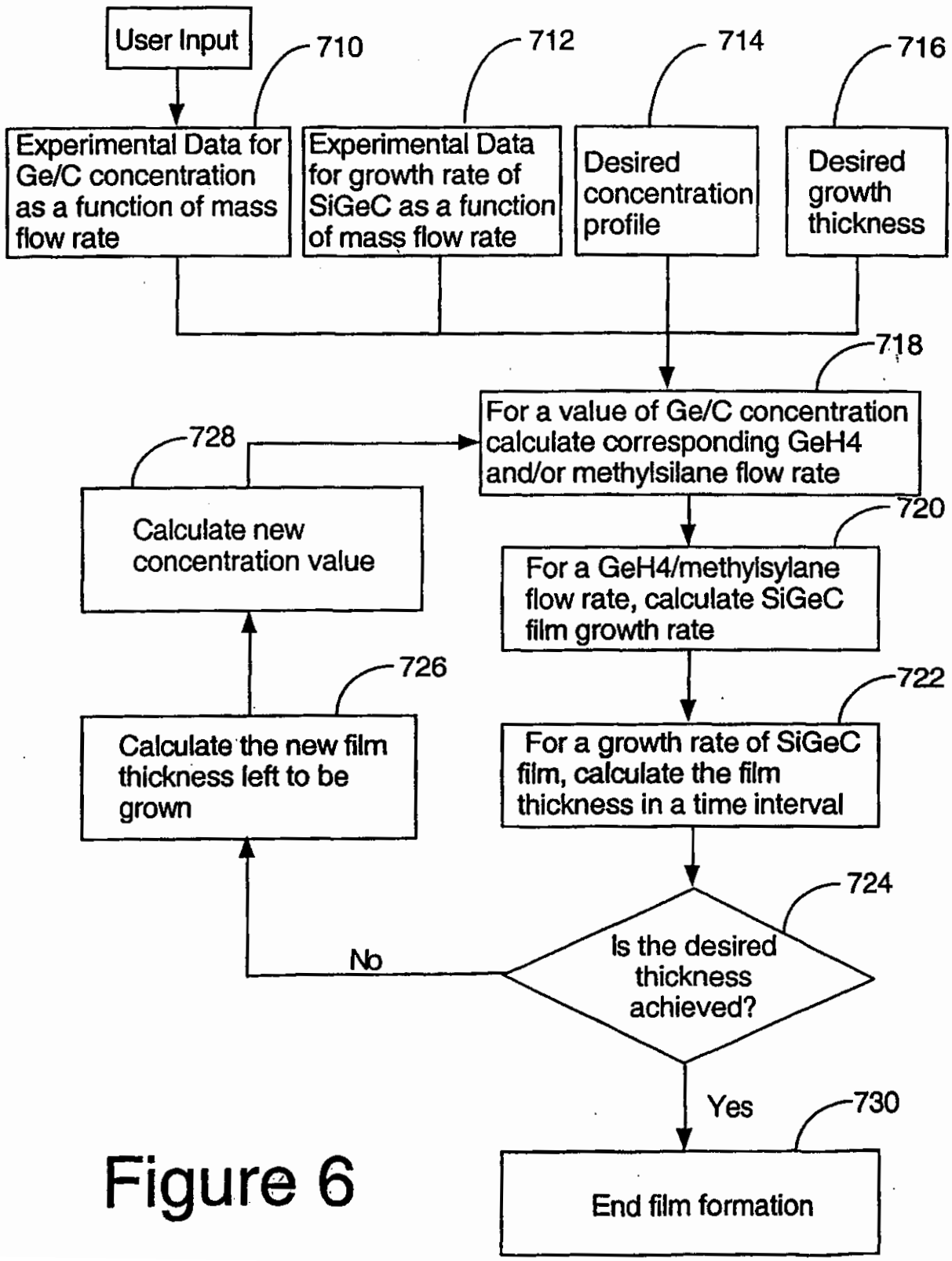

User Input
710
712
714
716
Experimental Data for Ge/C concentration as a function of mass flow rate
Experimental Data for growth rate of SiGeC as a function of mass flow rate
Desired concentration profile
Desired growth thickness
718
For a value of Ge/C concentration calculate corresponding GeH4 and/or methylsilane flow rate
728
Calculate new concentration value
720
For a GeH4/methylsylane flow rate, calculate SiGeC film growth rate
726
Calculate the new film thickness left to be grown
722
For a growth rate of SiGeC film, calculate the film thickness in a time interval
724
Is the desired thickness achieved?
No
Yes
730
End film formation

Figure 6

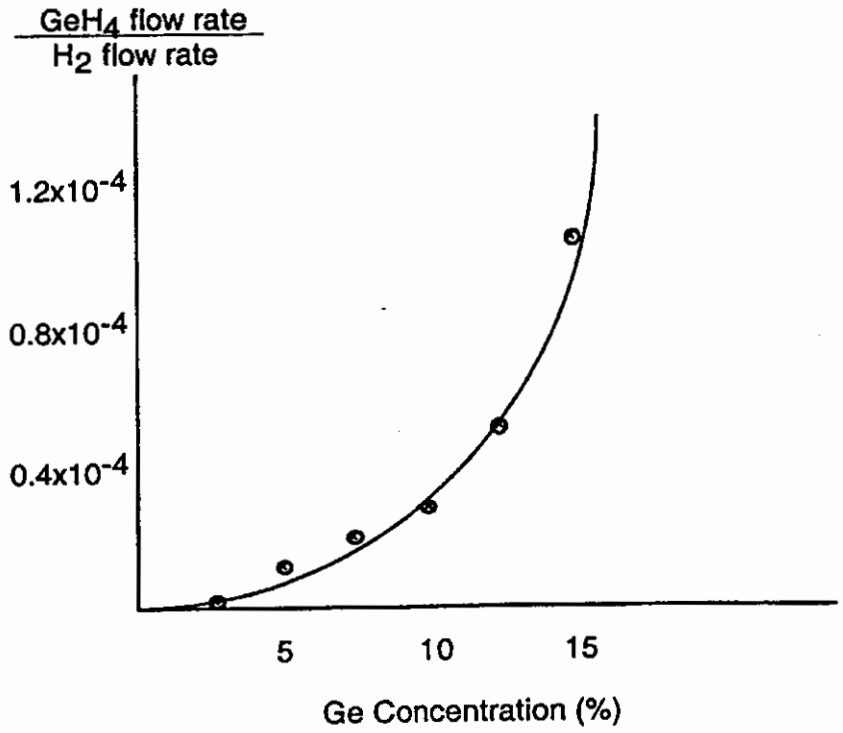


Figure 7A

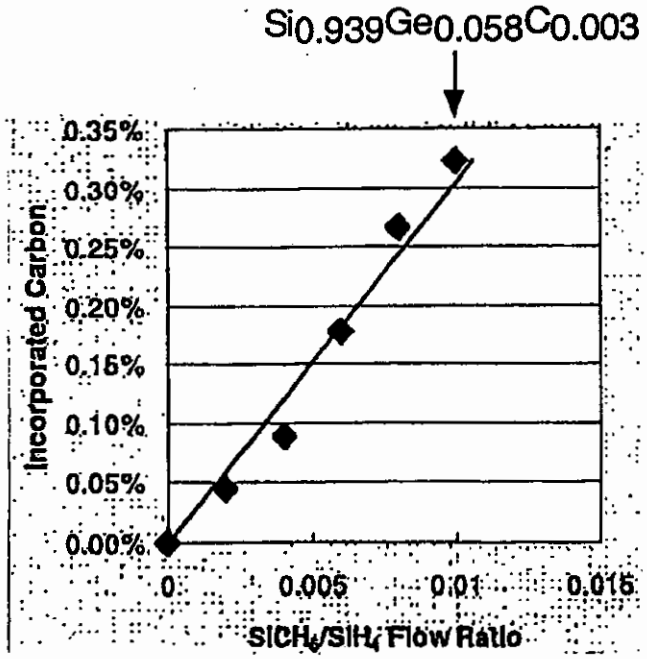


Figure 7B

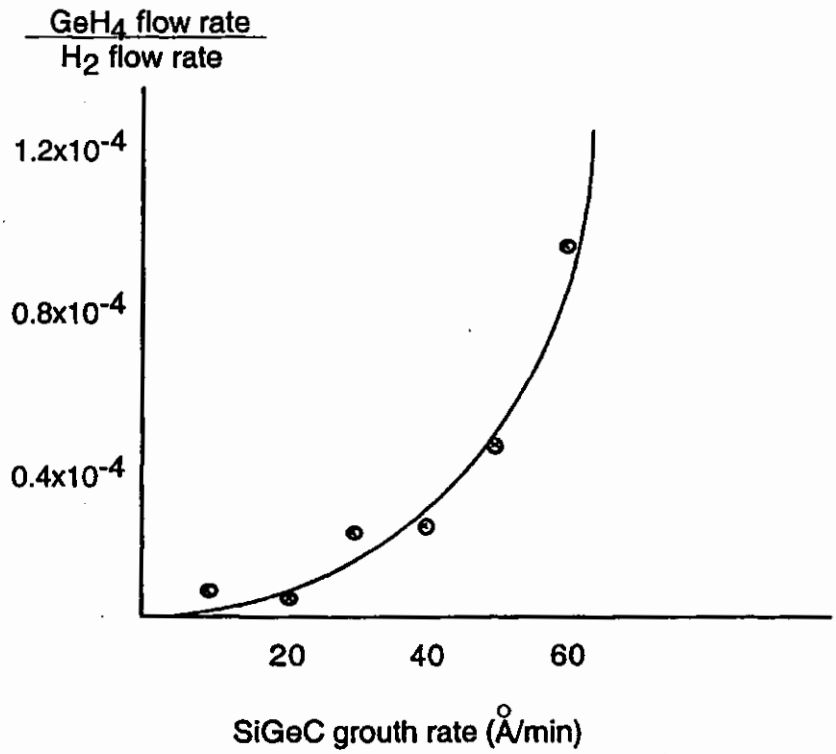
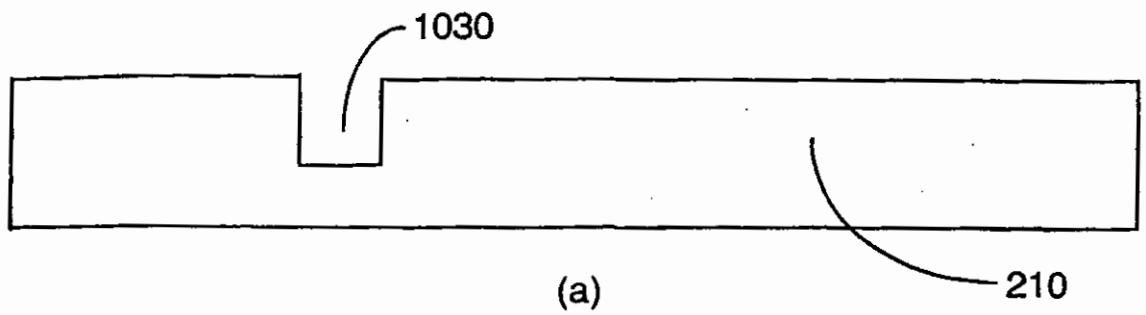
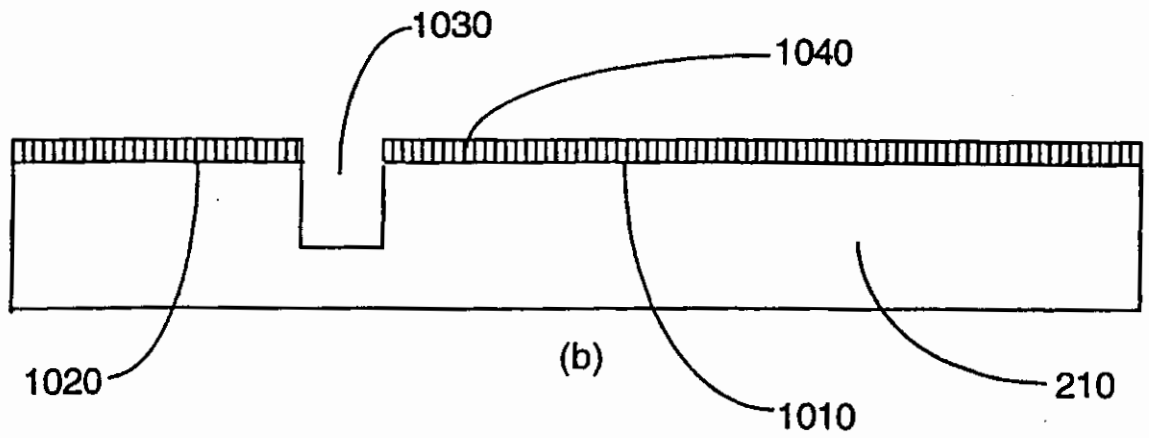

GeH4 flow rate
H2 flow rate
1.2x10-4
0.8x10-4
0.4x10-4
20
40
60
SiGeC grouth rate (Å/min)

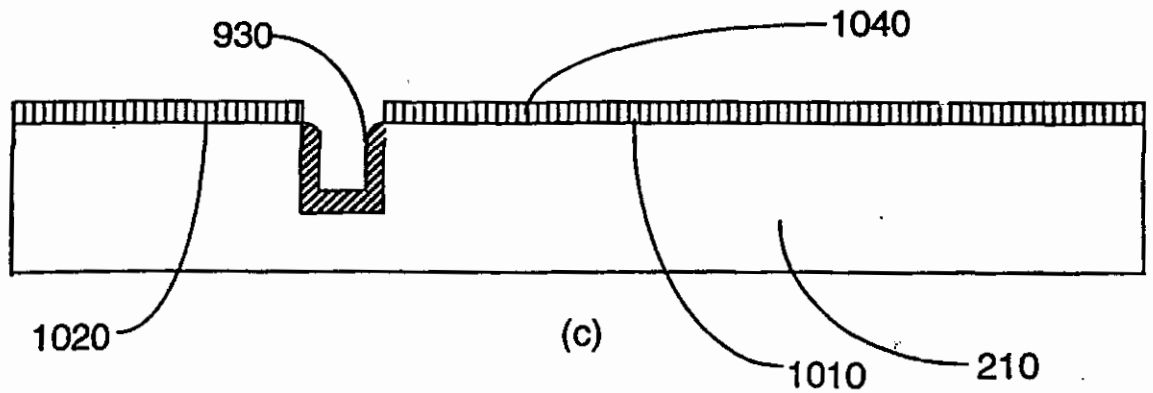
Figure 8



(a)



(b)



(c)

Figure 9

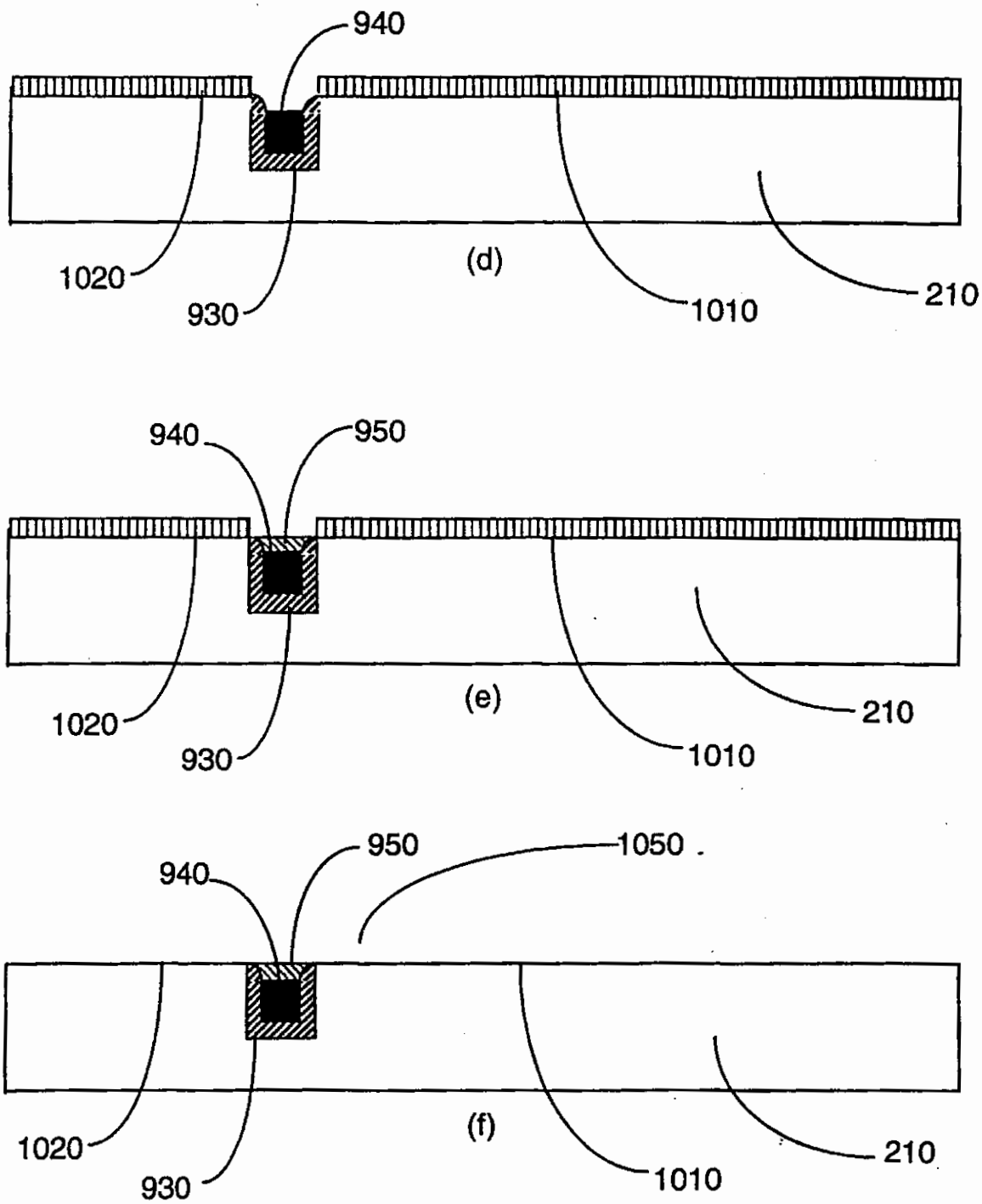

940
1020
930
(d)
1010
210
940
950
1020
930
(e)
1010
210
950
1050
940
1020
930
(f)
1010
210

Figure 9

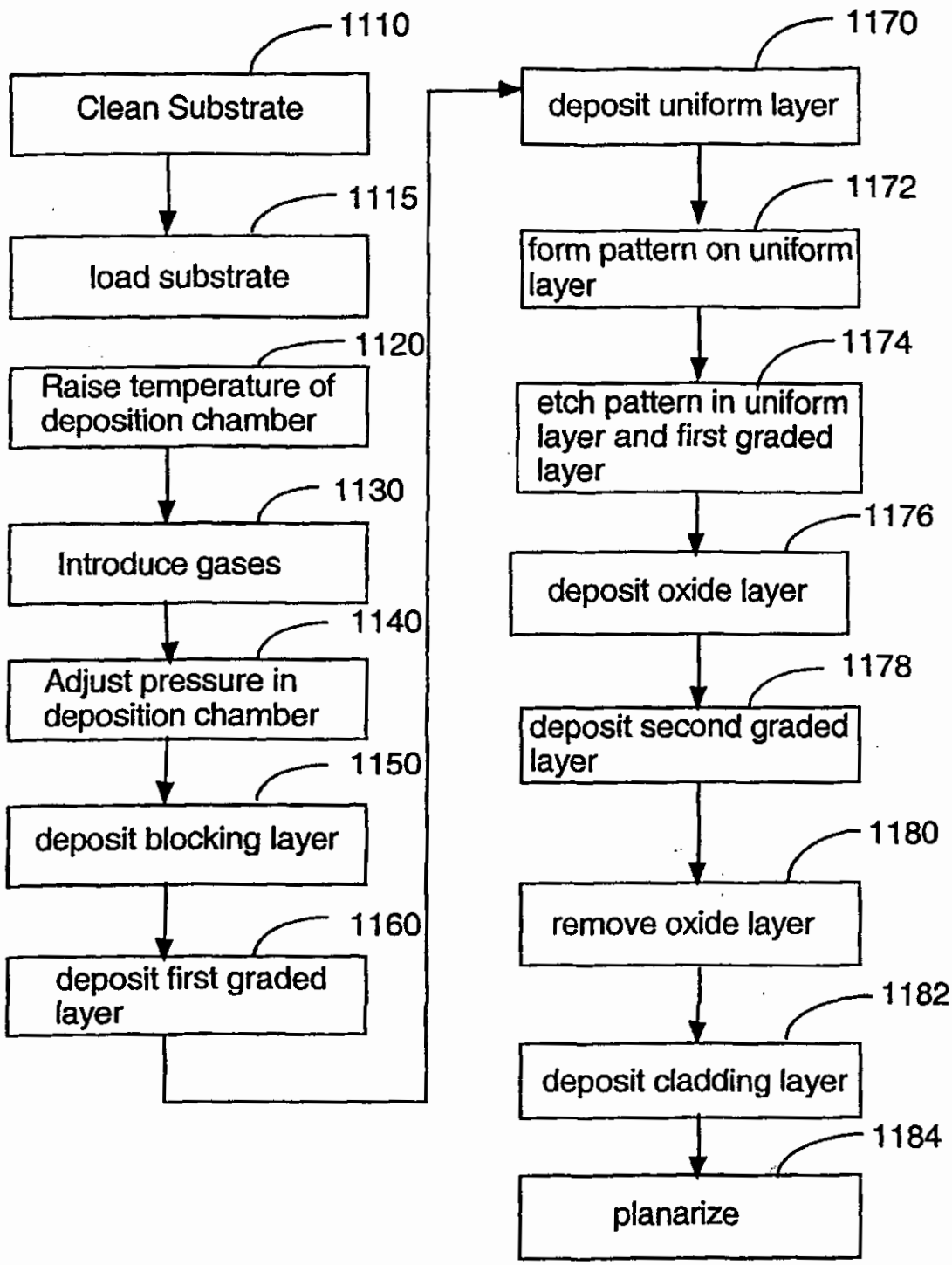

1110
Clean Substrate
1115
load substrate
1120
Raise temperature of deposition chamber
1130
Introduce gases
1140
Adjust pressure in deposition chamber
1150
deposit blocking layer
1160
deposit first graded layer
1170
deposit uniform layer
1172
form pattern on uniform layer
1174
etch pattern in uniform layer and first graded layer
1176
deposit oxide layer
1178
deposit second graded layer
1180
remove oxide layer
1182
deposit cladding layer
1184
planarize

Figure 10

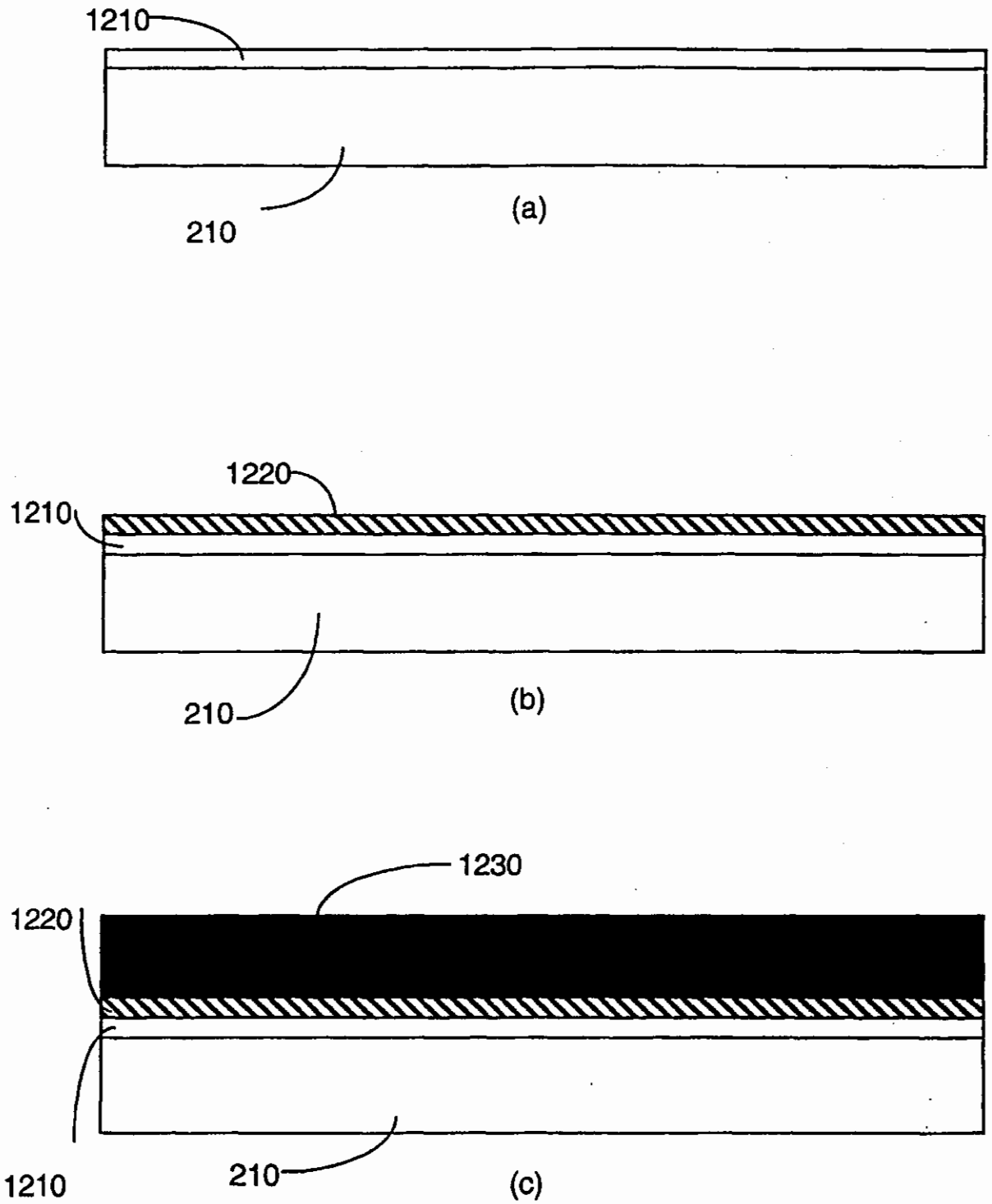
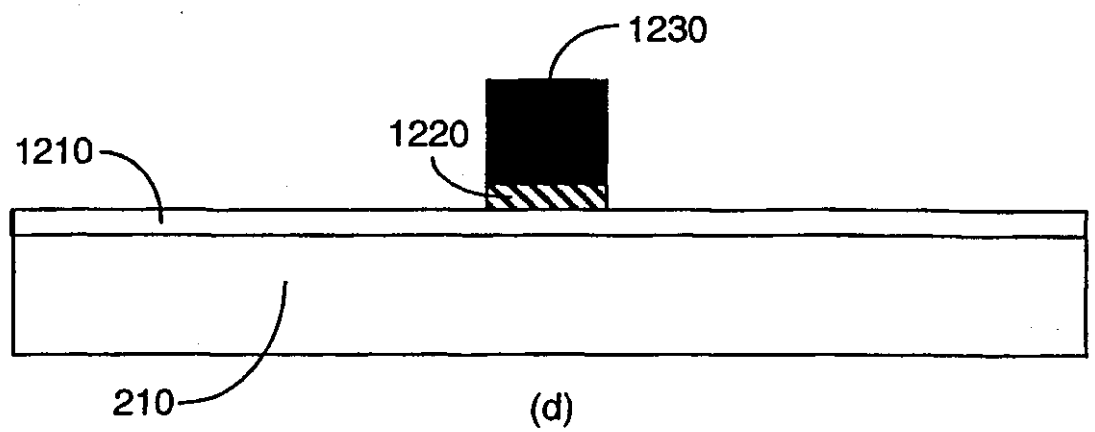
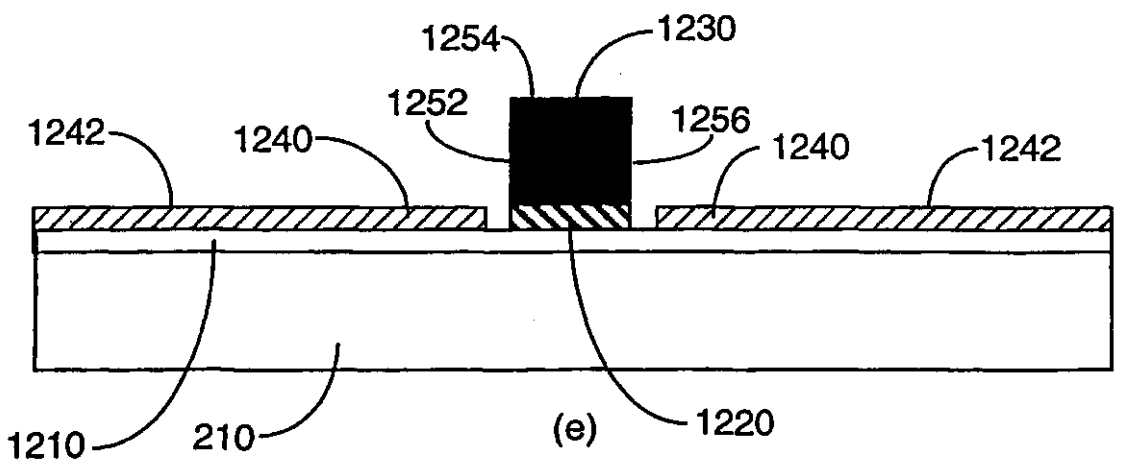


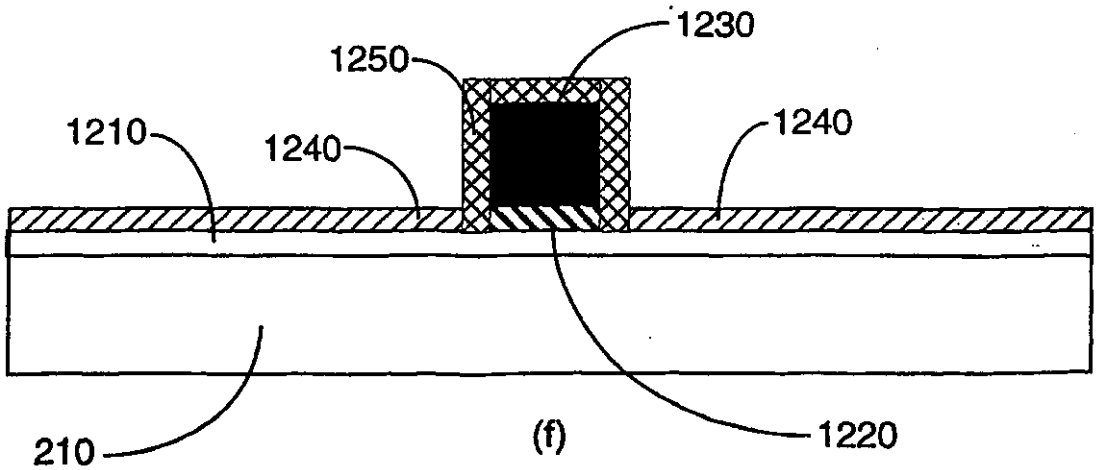
Figure 11



(d)



(e)



(f)

Figure 11

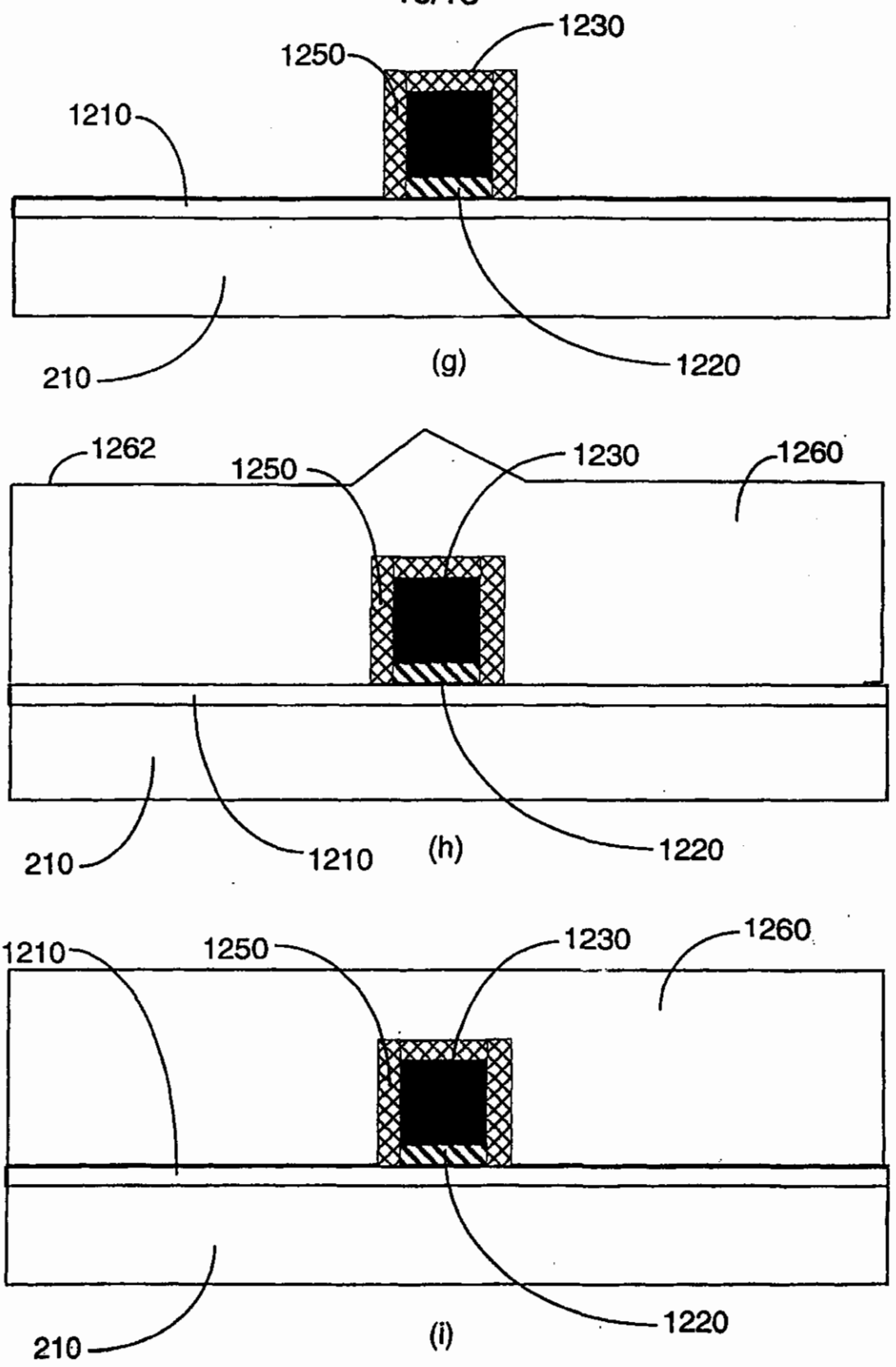

1230
1250
1210
210
(g)
1220
1262
1250
1230
1260
210
1210
(h)
1220
1210
1250
1230
1260
210
(i)
1220

Figure 11

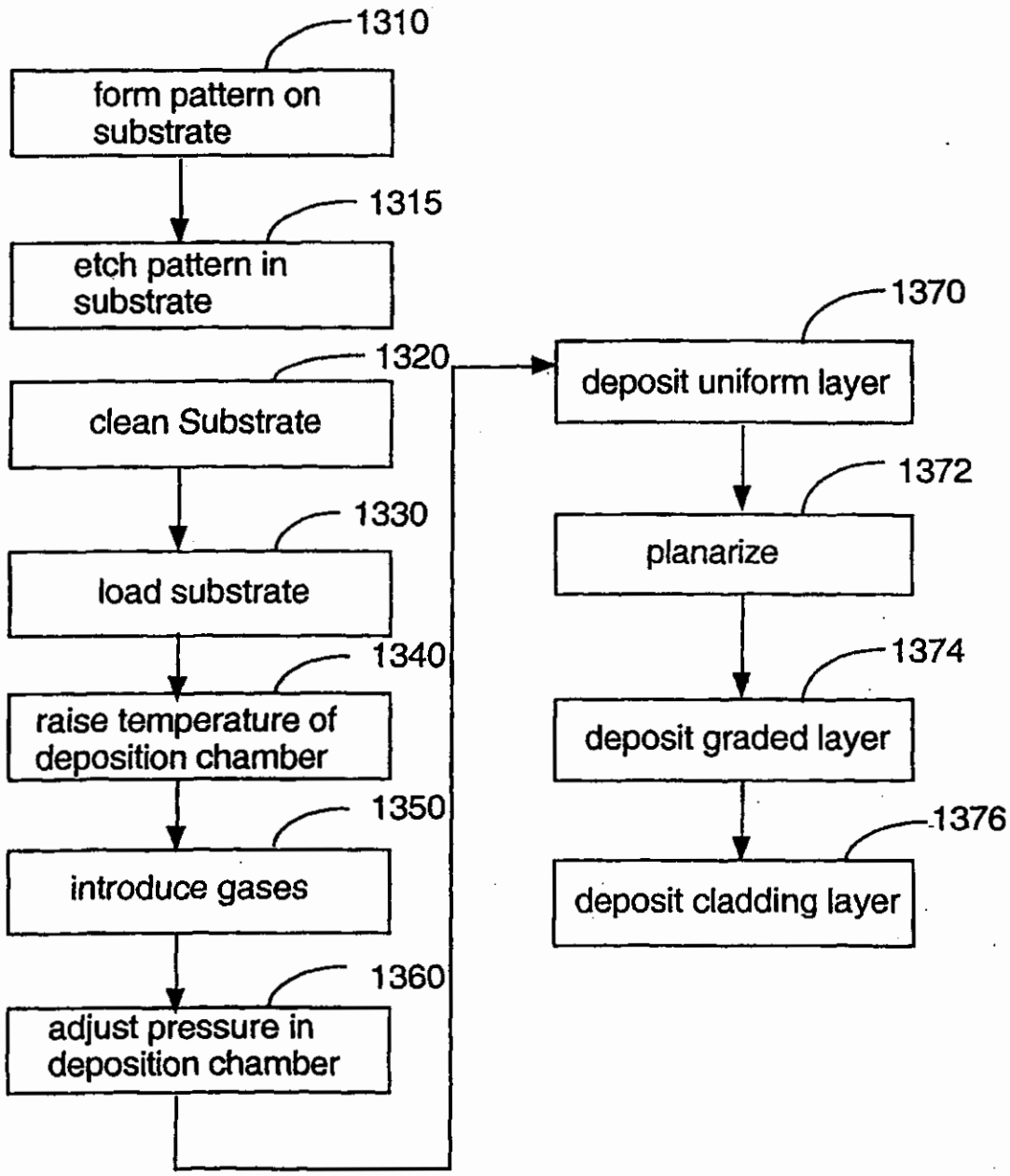

1310
form pattern on substrate
1315
etch pattern in substrate
1320
clean Substrate
1330
load substrate
1340
raise temperature of deposition chamber
1350
introduce gases
1360
adjust pressure in deposition chamber
1370
deposit uniform layer
1372
planarize
1374
deposit graded layer
1376
deposit cladding layer

Figure 12

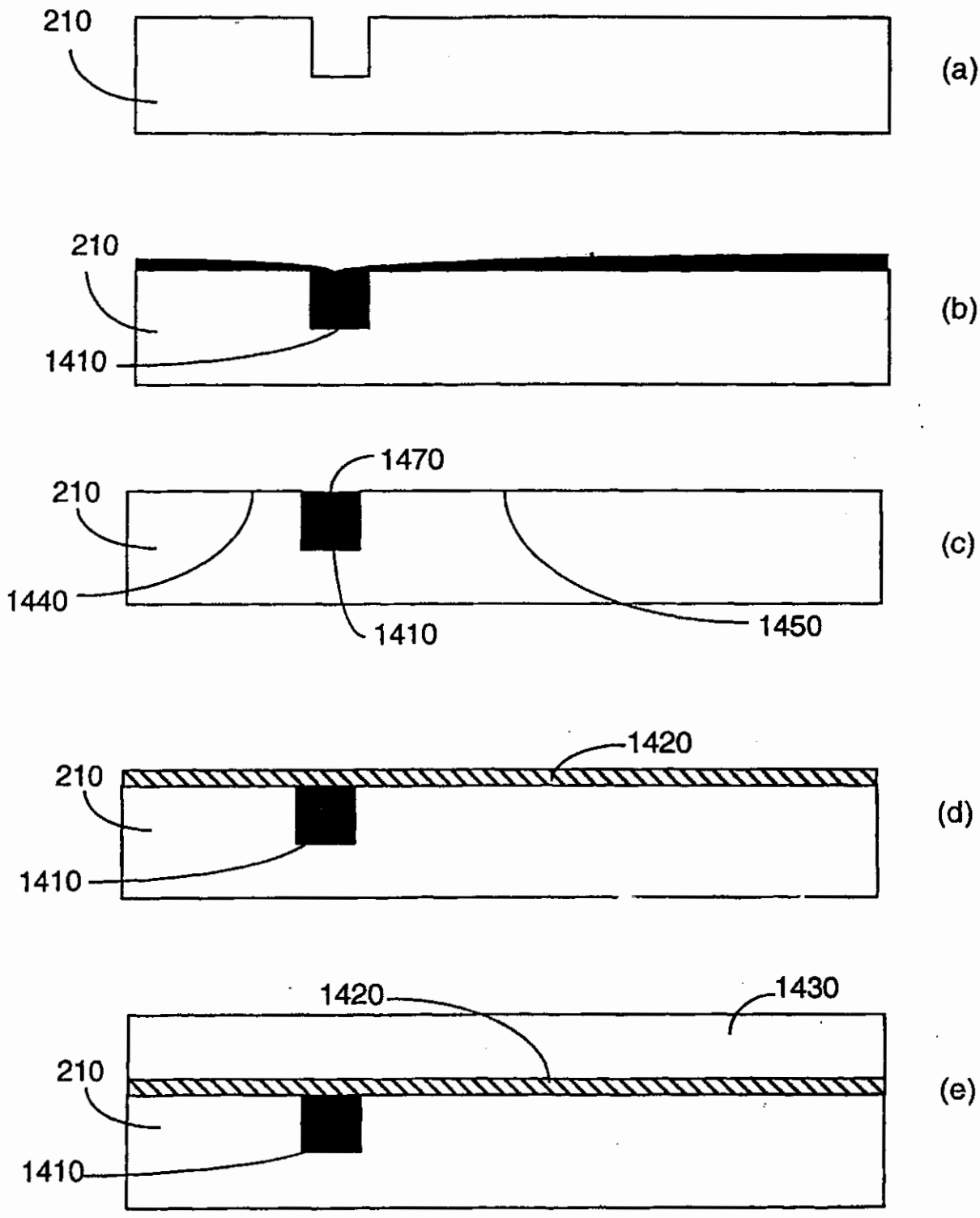

210
(a)
210
1410
(b)
1470
210
1440
1410
1450
(c)
1420
210
1410
(d)
1420
1430
210
1410
(e)

Figure 13