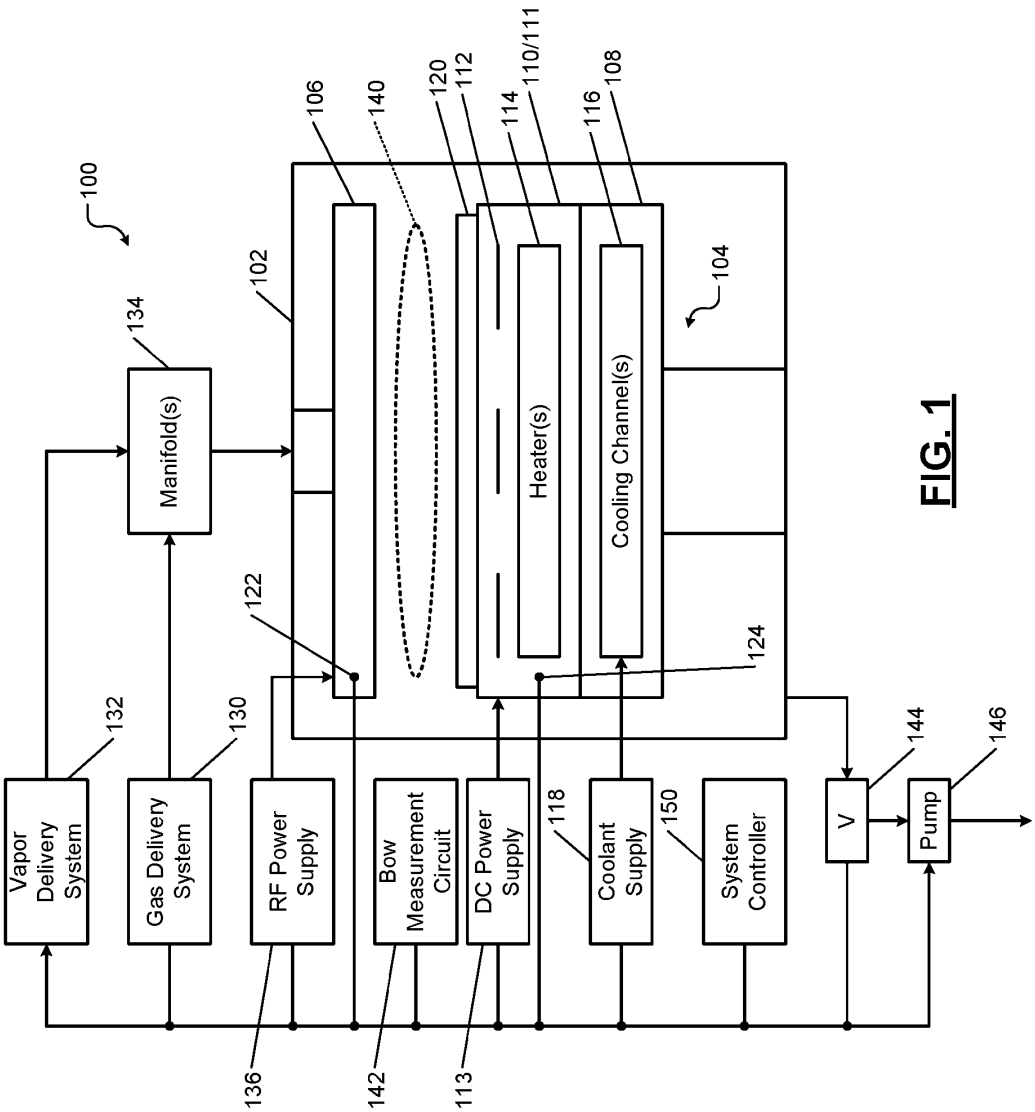

100
102
104
106
108
110/111
112
114
116
120
122
124
130
132
134
136
140
142
144
146
150
Manifold(s)
Heater(s)
Cooling Channel(s)
Vapor Delivery System
Gas Delivery System
RF Power Supply
Bow Measurement Circuit
DC Power Supply
Coolant Supply
System Controller
V
Pump
113
118

FIG. 1

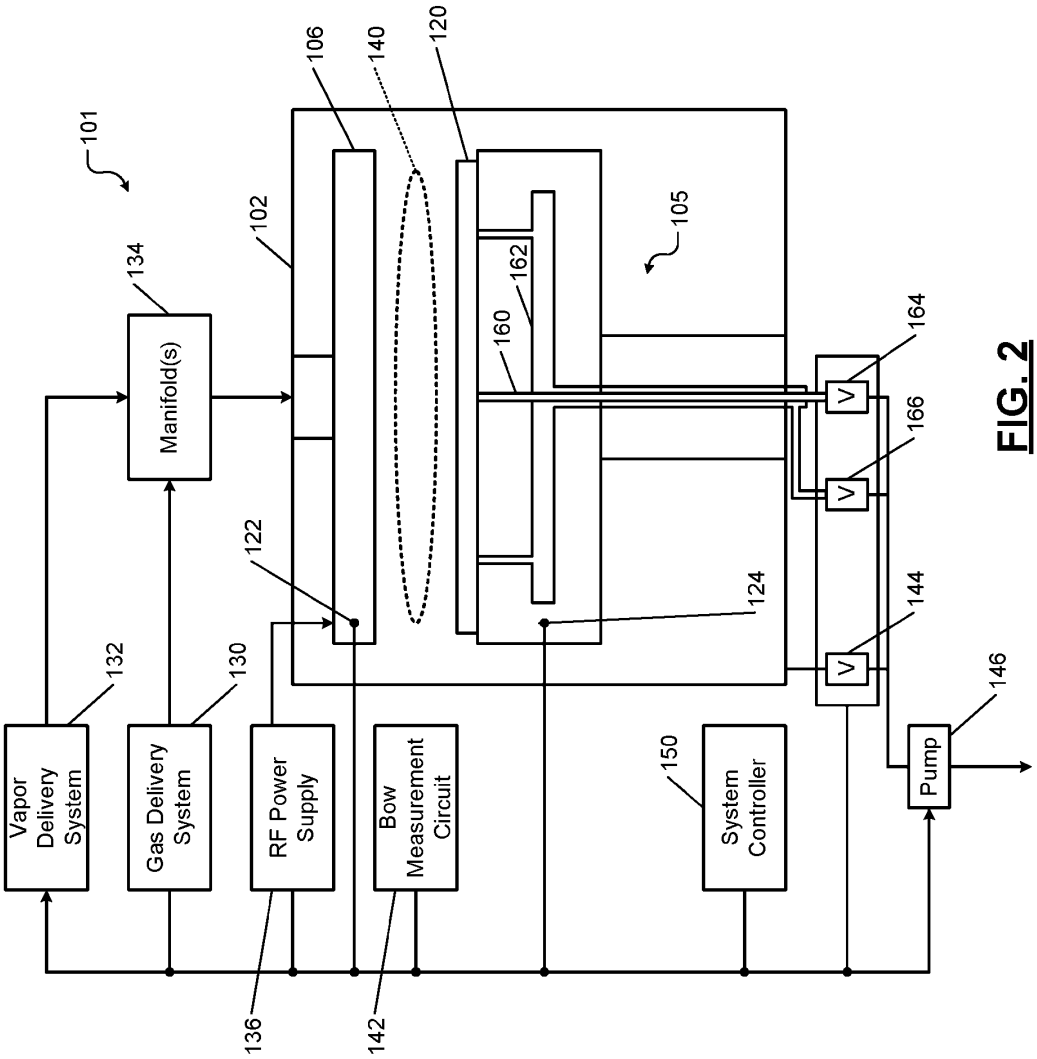

101
102
105
106
120
122
124
130
132
134
136
140
142
144
146
150
160
162
164
166
Manifold(s)
Vapor Delivery System
Gas Delivery System
RF Power Supply
Bow Measurement Circuit
System Controller
Pump
V
V
V

FIG. 2

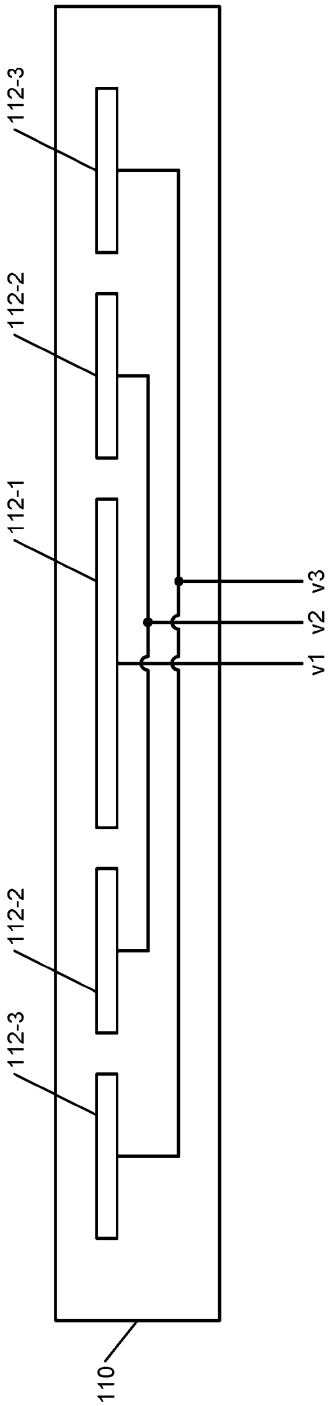

112-3
112-2
112-1
112-2
112-3
v3
v2
v1
110

FIG. 3

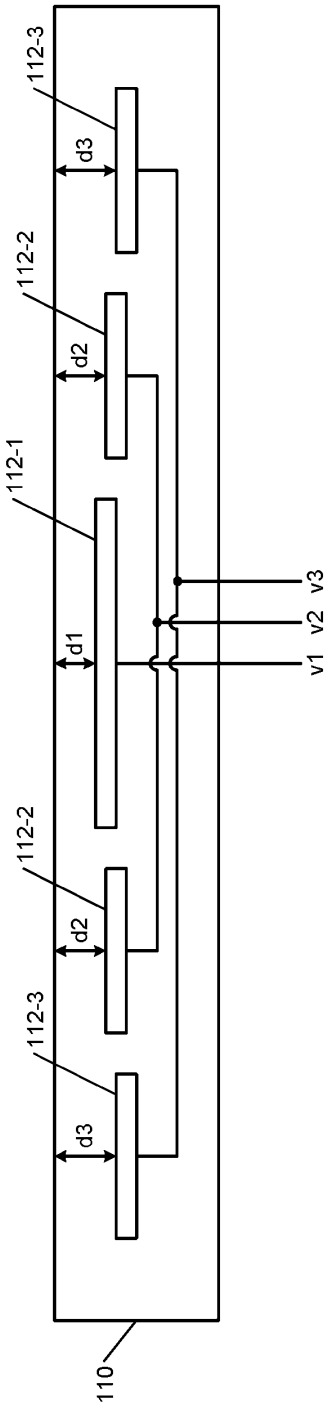
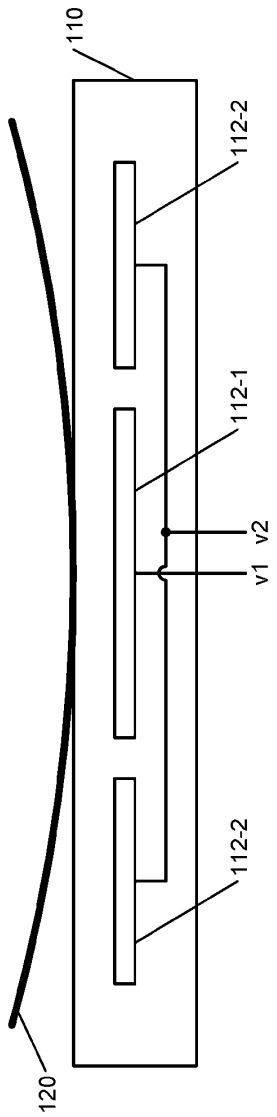
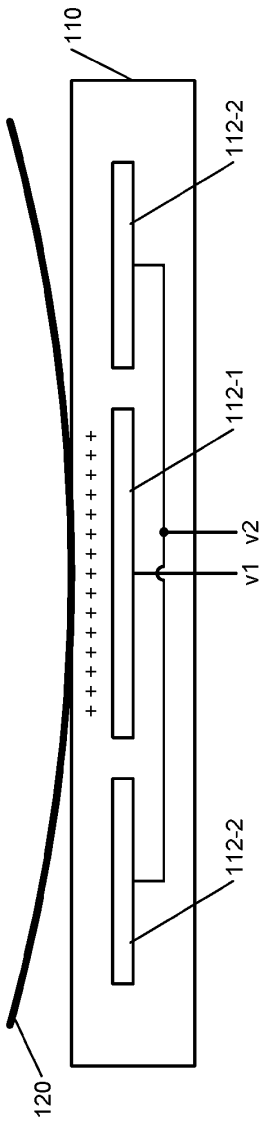

112-3
d3
112-2
d2
112-1
d1
112-2
d2
112-3
d3
v3
v2
v1
110

FIG. 4



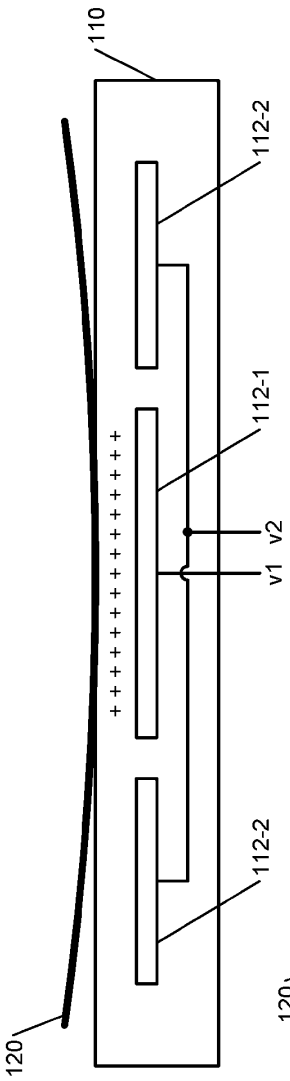
V1=0V
V2=0V

FIG. 5



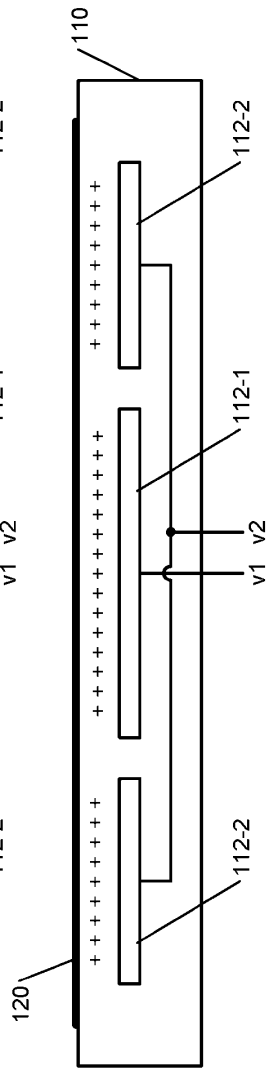
V1=1000V
V2=0V

FIG. 6



V1=1000V
V2=0V

FIG. 7



V1=1000V
V2=1000V

FIG. 8

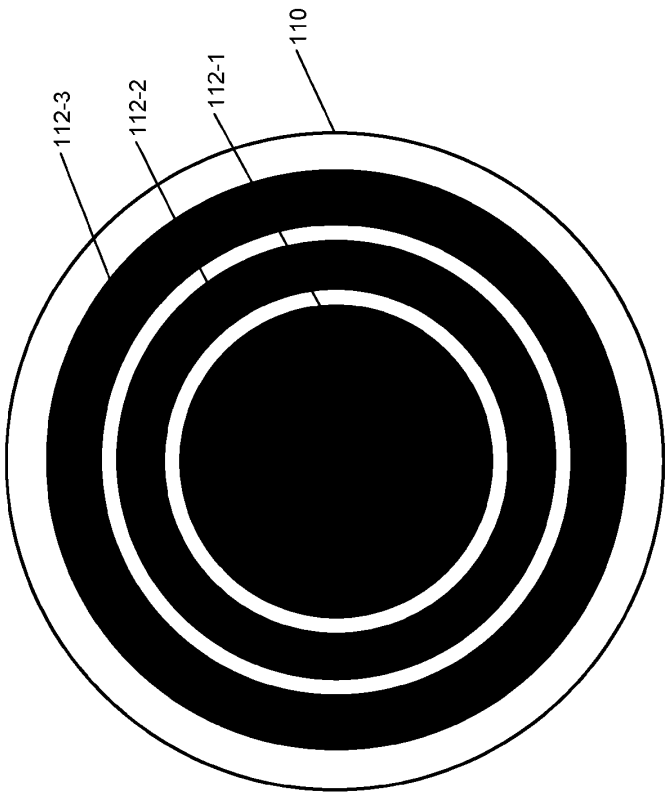


FIG. 9

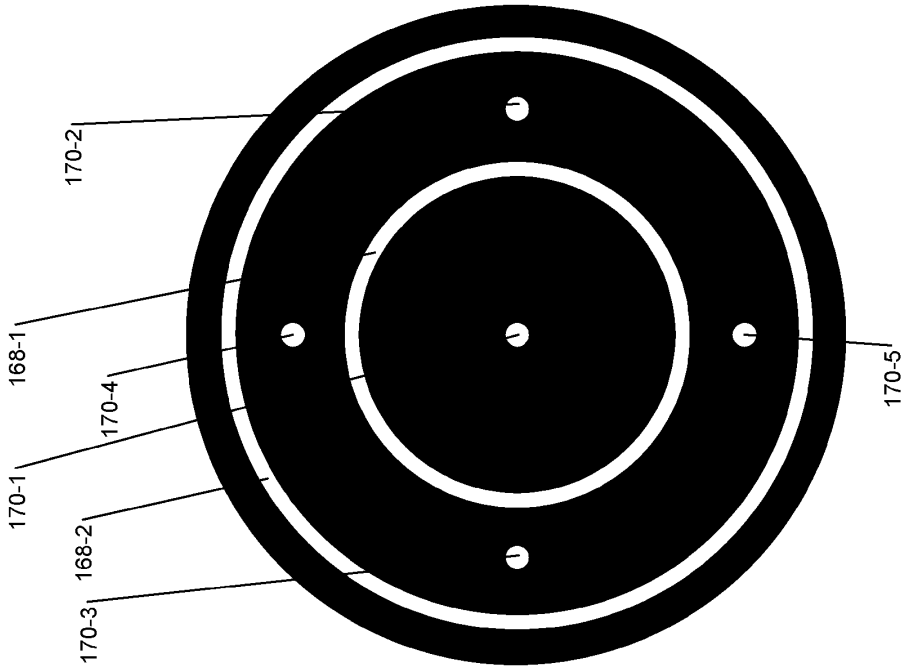


FIG. 10B

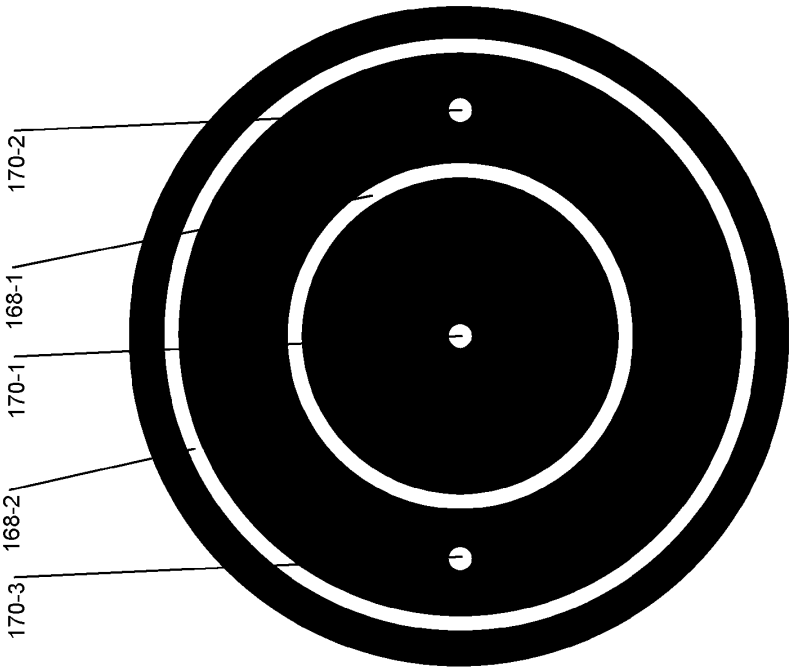


FIG. 10A

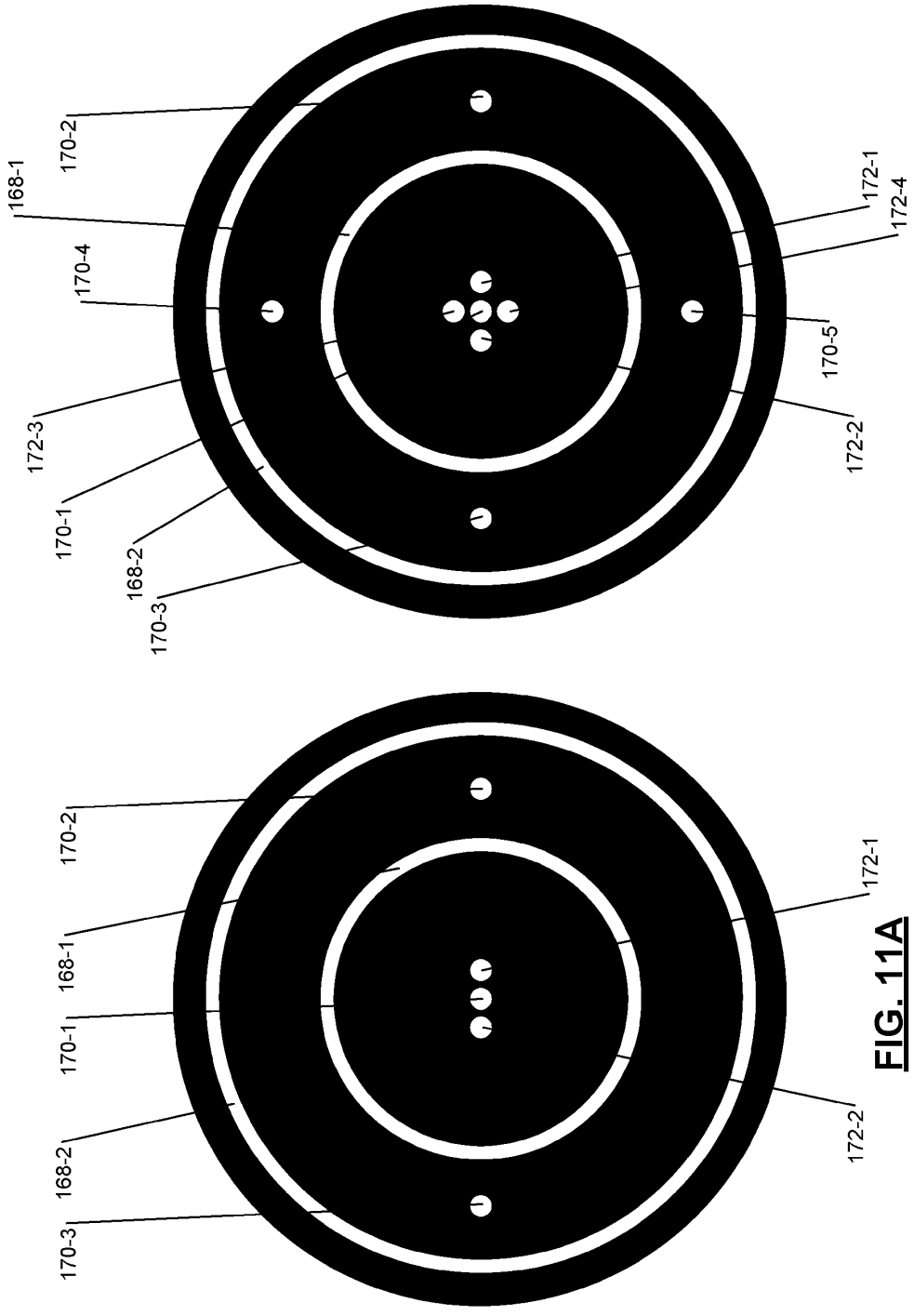
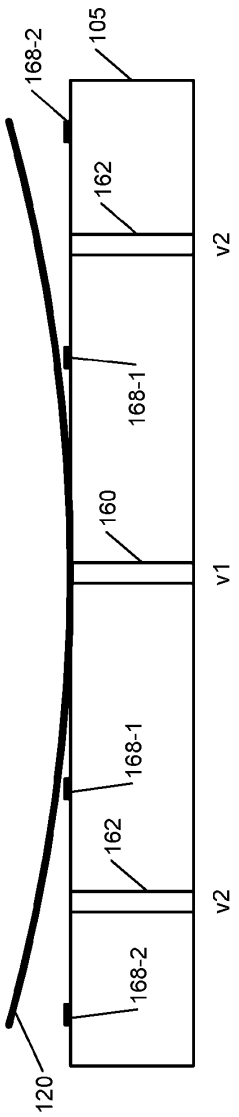


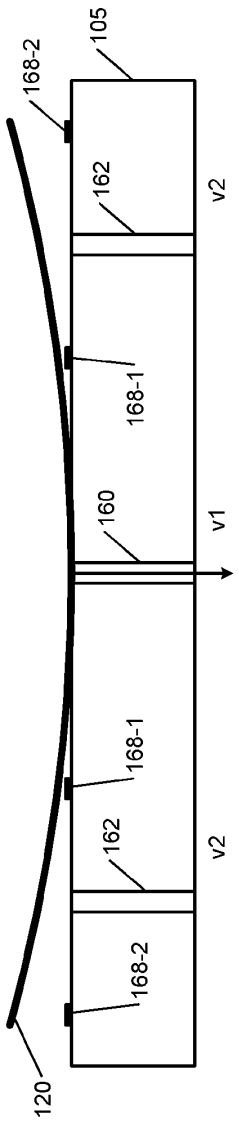
FIG. 11B

FIG. 11A



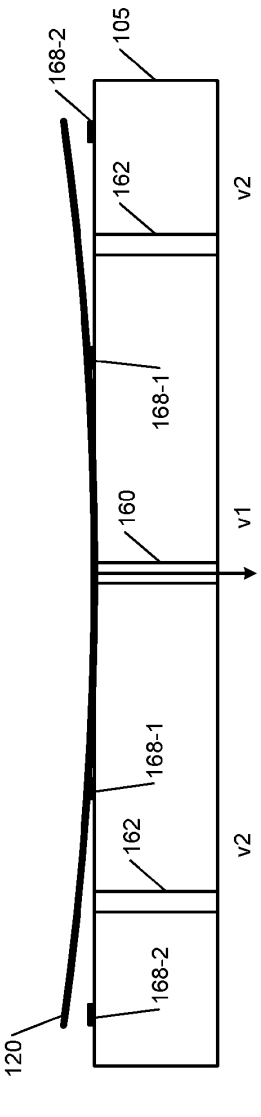
V1=off
V2=off

FIG. 12



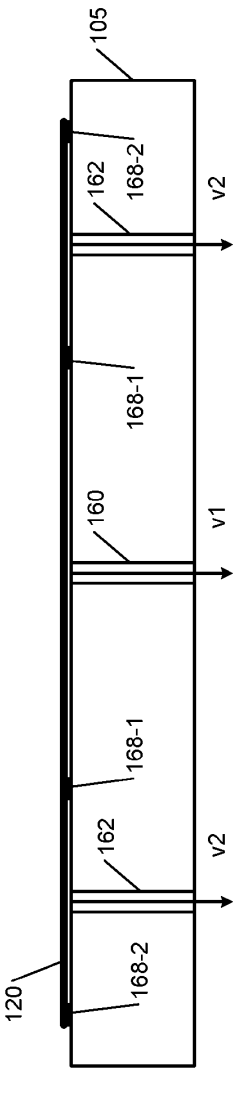
V1=on
V2=off

FIG. 13



V1=on
V2=off

FIG. 14



V1=on
V2=on

FIG. 15

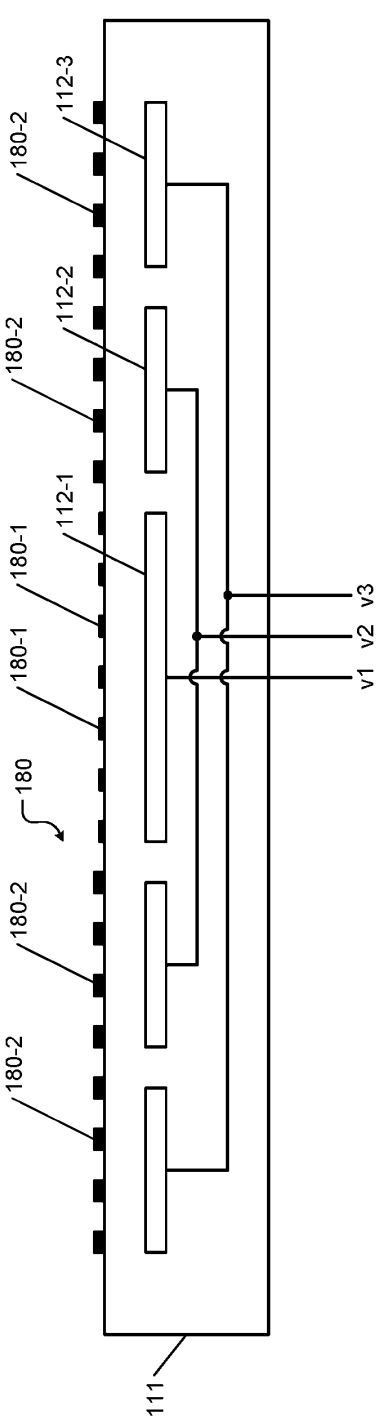

112-3
180-2
112-2
180-2
112-1
180-1
180-1
180
180-2
180-2
v3
v2
v1
111

FIG. 16

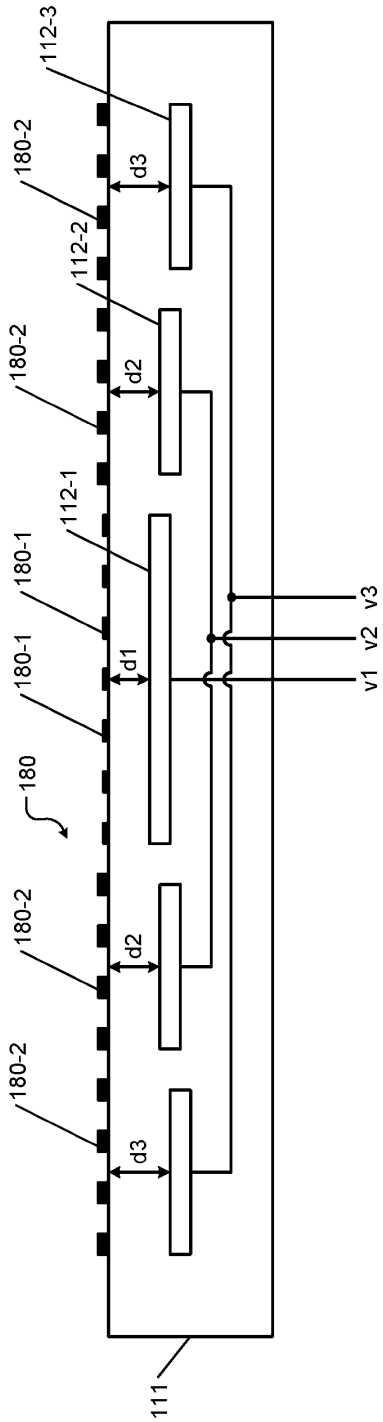
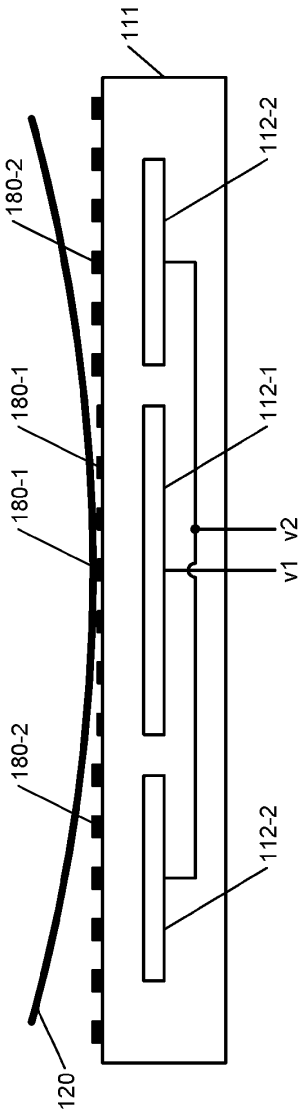
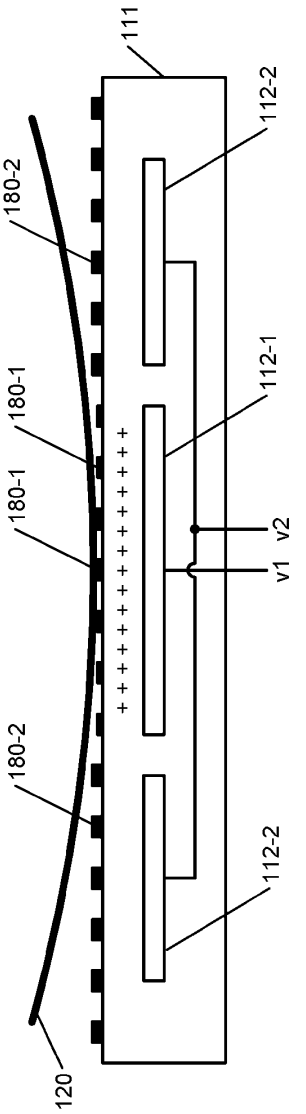

112-3
180-2
d3
112-2
180-2
d2
112-1
180-1
180-1
d1
180
180-2
d2
180-2
d3
v3
v2
v1
111

FIG. 17



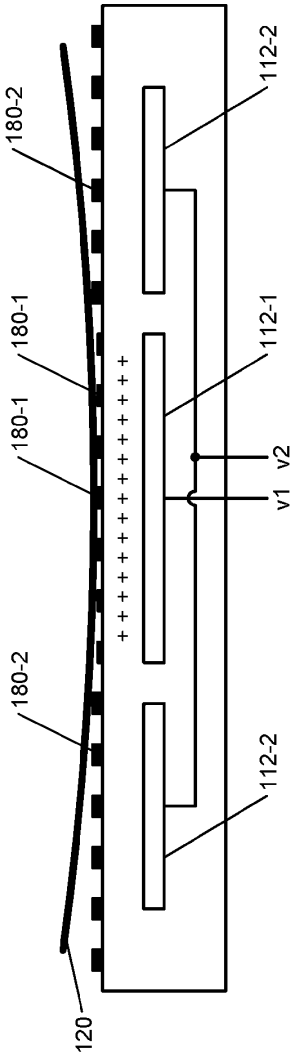
V1=0V
V2=0V

FIG. 18



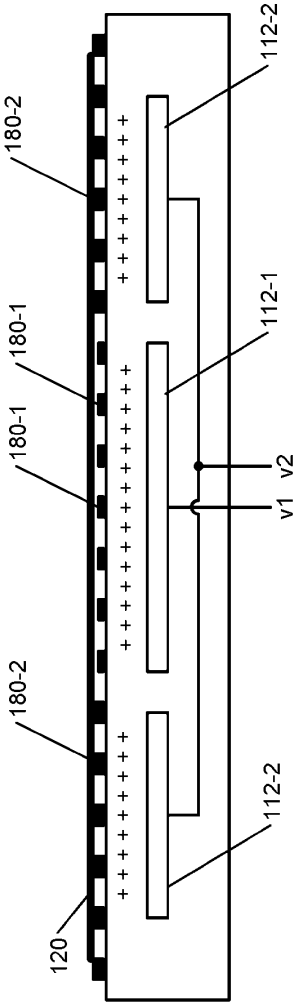
V1=1000V
V2=0V

FIG. 19



V1=1000V
V2=0V

FIG. 20



V1=1000V
V2≥ 1000V

FIG. 21

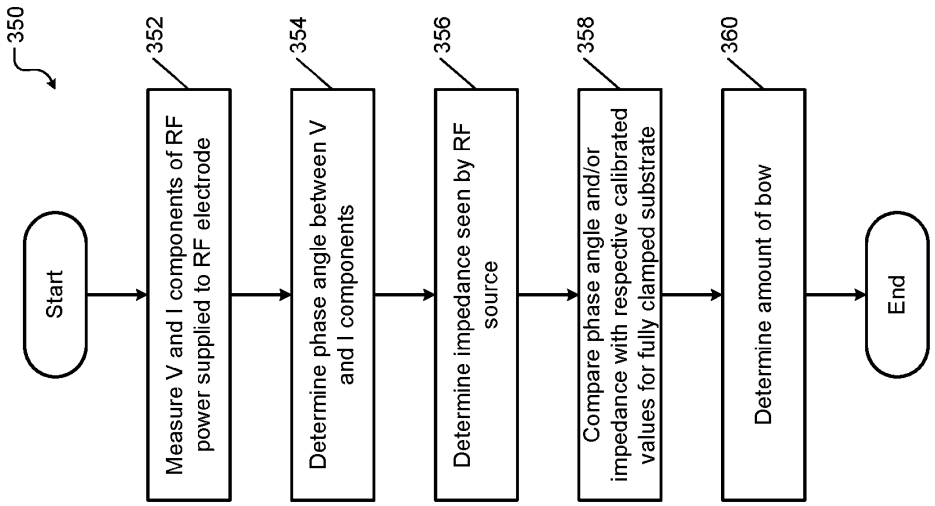

350
Start
352
Measure V and I components of RF power supplied to RF electrode
354
Determine phase angle between V and I components
356
Determine impedance seen by RF source
358
Compare phase angle and/or impedance with respective calibrated values for fully clamped substrate
360
Determine amount of bow
End

FIG. 26

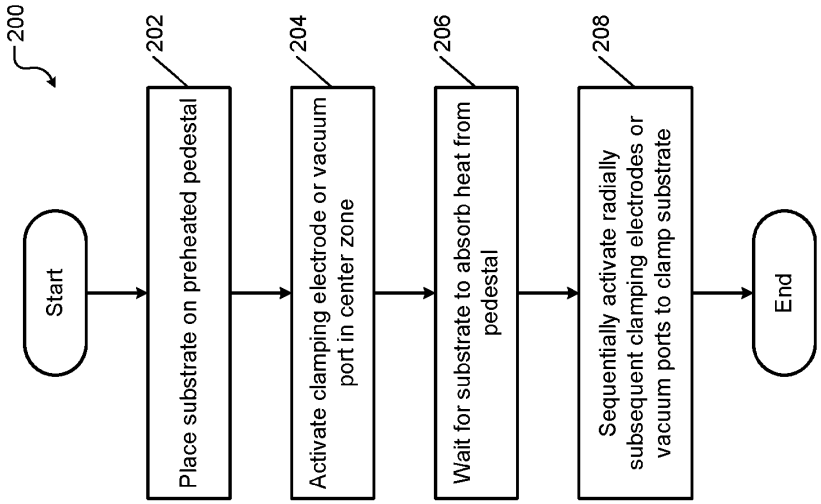

200
Start
202
Place substrate on preheated pedestal
204
Activate clamping electrode or vacuum port in center zone
206
Wait for substrate to absorb heat from pedestal
208
Sequentially activate radially subsequent clamping electrodes or vacuum ports to clamp substrate
End

FIG. 22

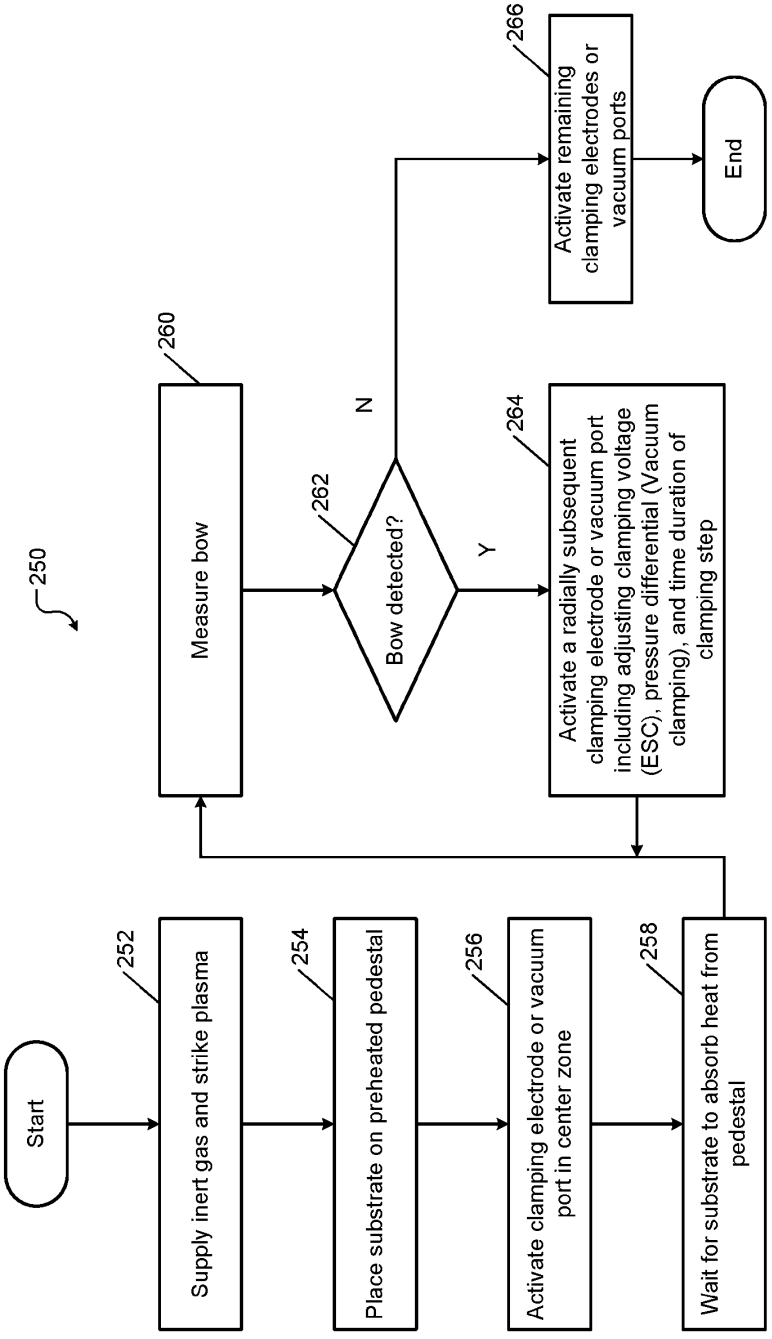

250
Start
252
Supply inert gas and strike plasma
254
Place substrate on preheated pedestal
256
Activate clamping electrode or vacuum port in center zone
258
Wait for substrate to absorb heat from pedestal
260
Measure bow
262
Bow detected?
N
Y
264
Activate a radially subsequent clamping electrode or vacuum port including adjusting clamping voltage (ESC), pressure differential (Vacuum clamping), and time duration of clamping step
266
Activate remaining clamping electrodes or vacuum ports
End

FIG. 23

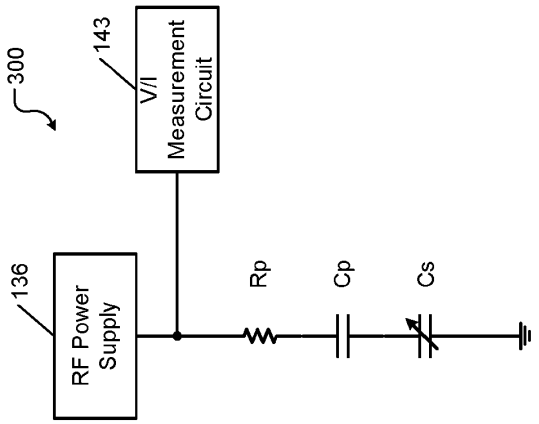

300
143
V/I Measurement Circuit
136
RF Power Supply
Rp
Cp
Cs

FIG. 25

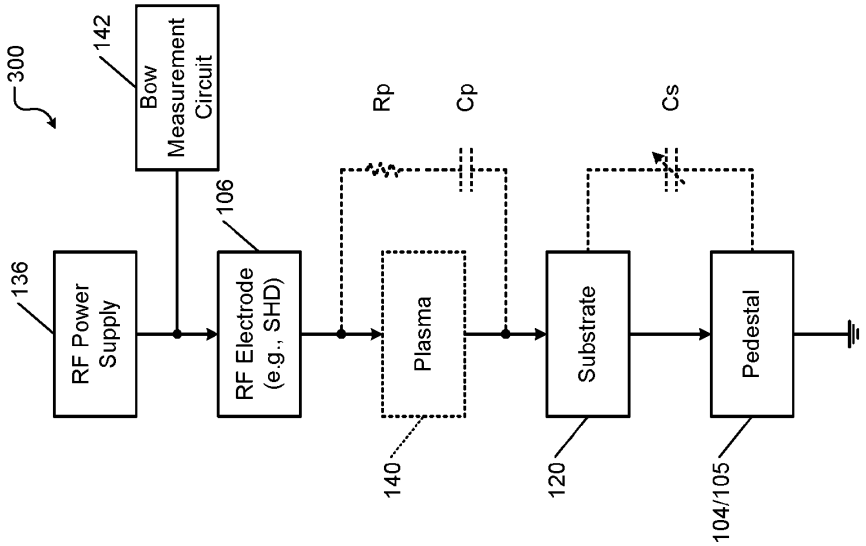

300
142
Bow Measurement Circuit
136
RF Power Supply
106
RF Electrode (e.g., SHD)
Rp
Cp
Cs
Plasma
Substrate
Pedestal
140
120
104/105

FIG. 24

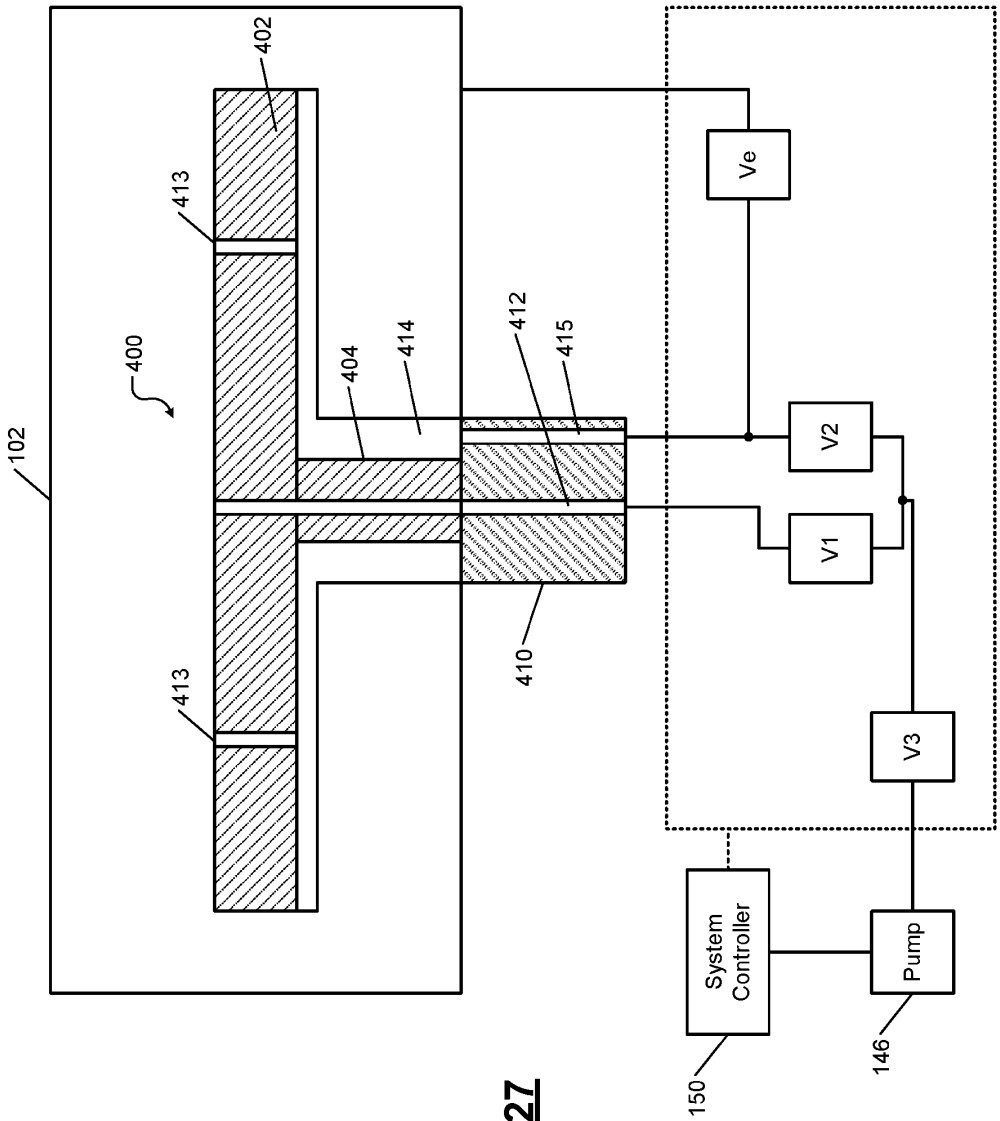

102
400
402
413
404
414
412
415
410
413
Ve
V2
V1
V3
System Controller
Pump
150
146

FIG. 27

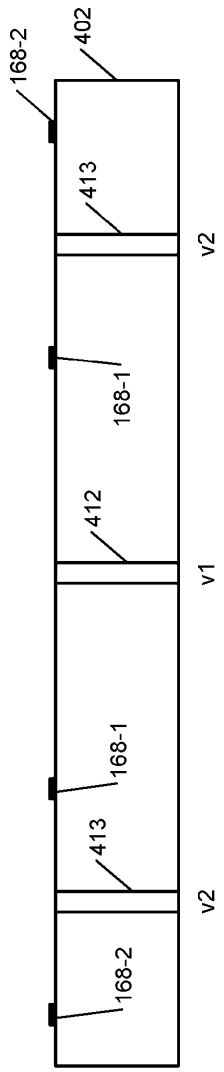


FIG. 28

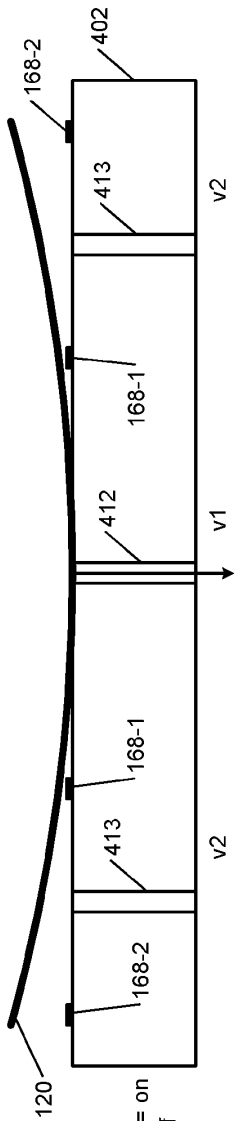


FIG. 29

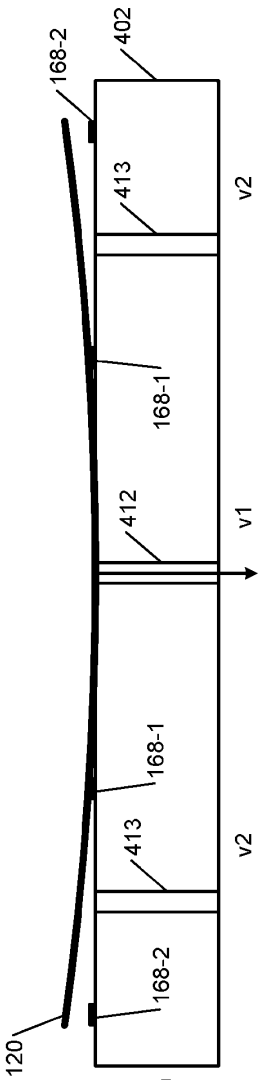


FIG. 30

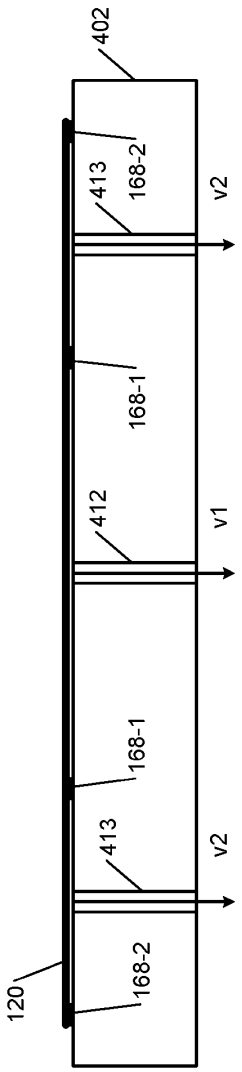


FIG. 31

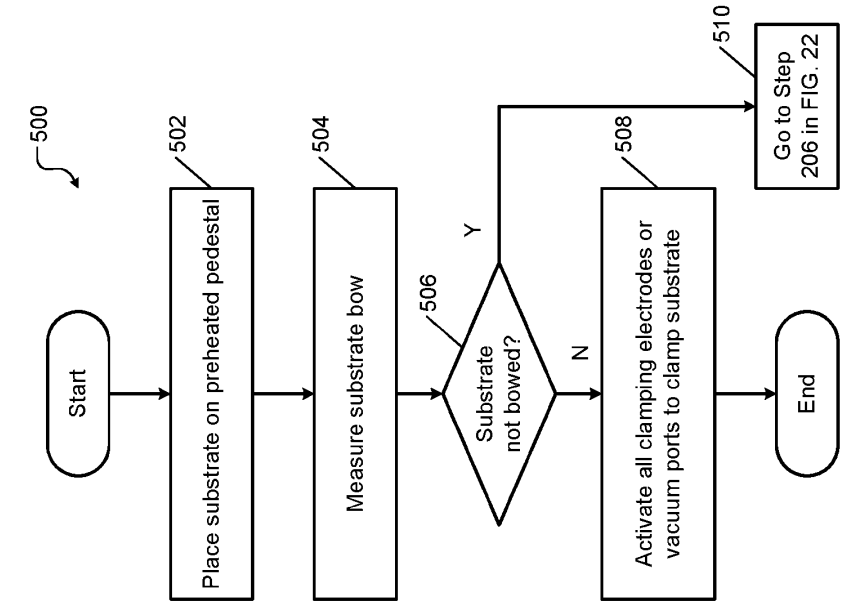

500
Start
502
Place substrate on preheated pedestal
504
Measure substrate bow
506
Substrate not bowed?
Y
N
508
Activate all clamping electrodes or vacuum ports to clamp substrate
510
Go to Step 206 in FIG. 22
End

FIG. 33

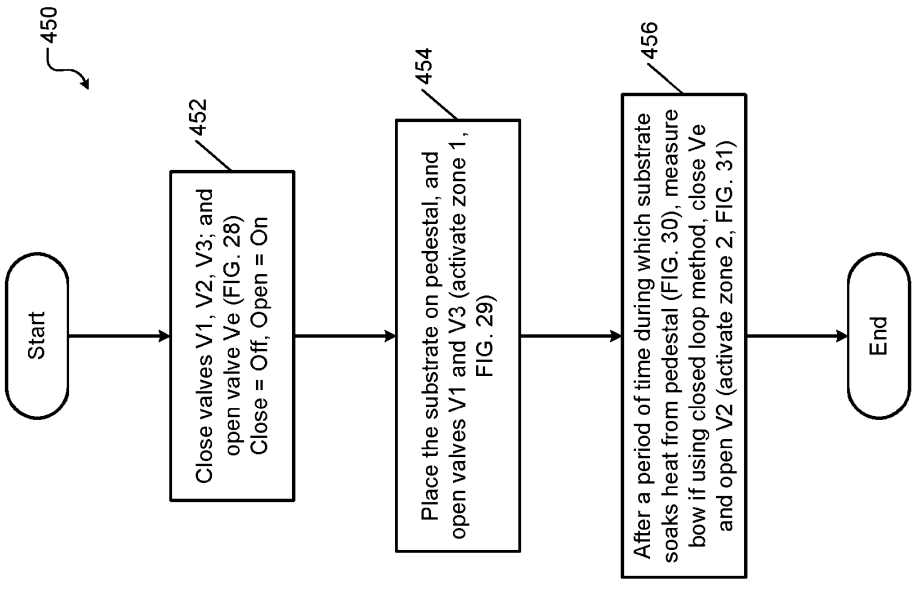

450
Start
452
Close valves V1, V2, V3; and open valve Ve (FIG. 28) Close = Off, Open = On
454
Place the substrate on pedestal, and open valves V1 and V3 (activate zone 1, FIG. 29)
456
After a period of time during which substrate soaks heat from pedestal (FIG. 30), measure bow if using closed loop method, close Ve and open V2 (activate zone 2, FIG. 31)
End

FIG. 32

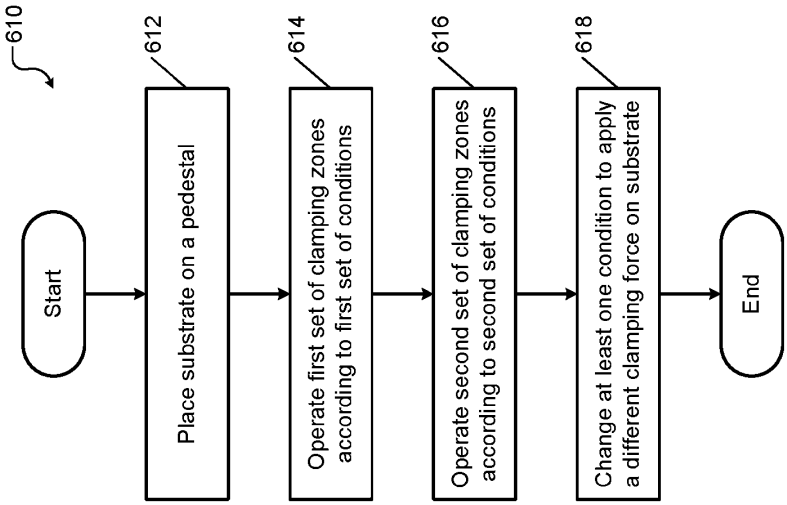

610
612
614
616
618
Start
Place substrate on a pedestal
Operate first set of clamping zones according to first set of conditions
Operate second set of clamping zones according to second set of conditions
Change at least one condition to apply a different clamping force on substrate
End

FIG. 35

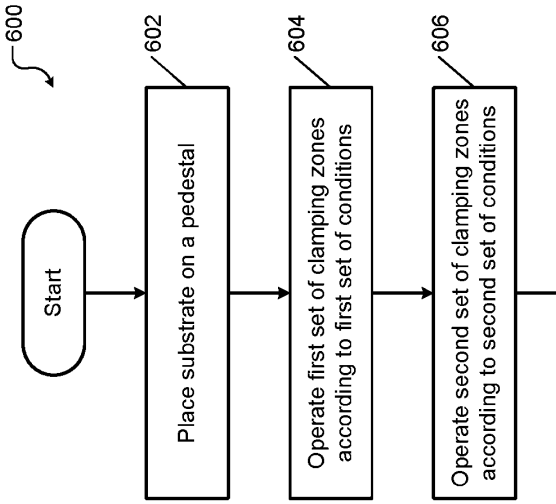

600
602
604
606
Start
Place substrate on a pedestal
Operate first set of clamping zones according to first set of conditions
Operate second set of clamping zones according to second set of conditions
End

FIG. 34

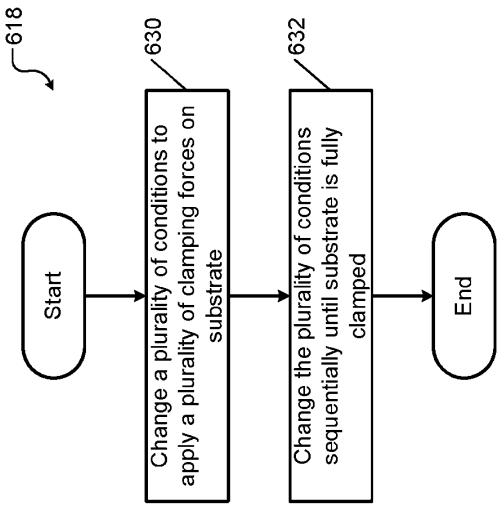

618
630
632
Start
Change a plurality of conditions to apply a plurality of clamping forces on substrate
Change the plurality of conditions sequentially until substrate is fully clamped
End

FIG. 37

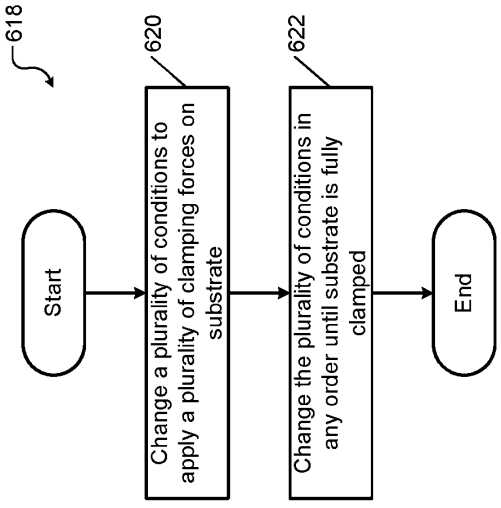

618
620
622
Start
Change a plurality of conditions to apply a plurality of clamping forces on substrate
Change the plurality of conditions in any order until substrate is fully clamped
End

FIG. 36

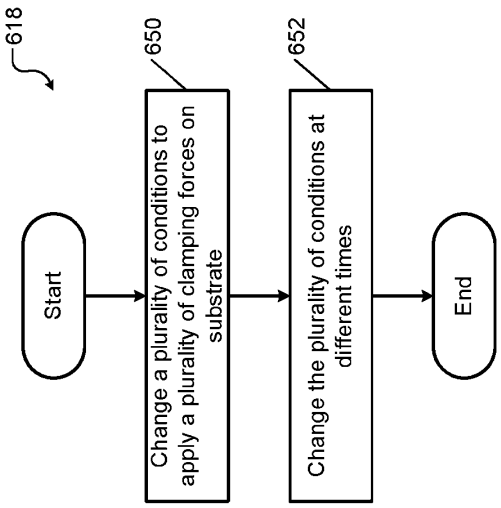

618
650
652
Start
Change a plurality of conditions to apply a plurality of clamping forces on substrate
Change the plurality of conditions at different times
End

FIG. 39

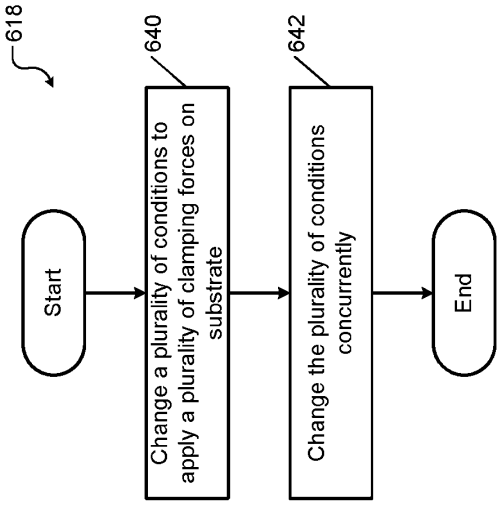

618
640
642
Start
Change a plurality of conditions to apply a plurality of clamping forces on substrate
Change the plurality of conditions concurrently
End

FIG. 38

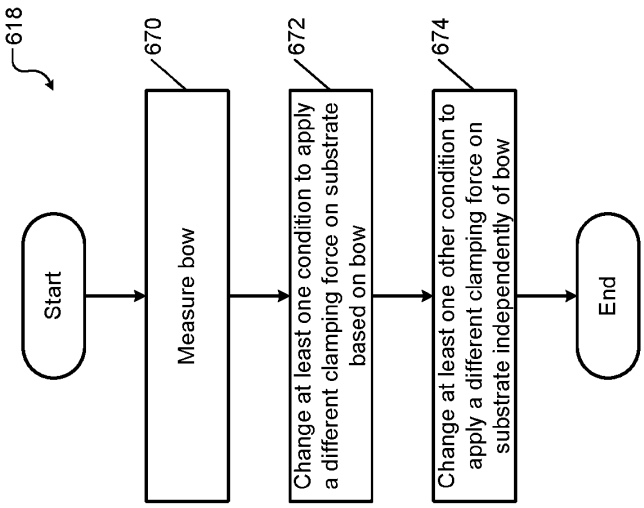

618
670
672
674
Start
Measure bow
Change at least one condition to apply a different clamping force on substrate based on bow
Change at least one other condition to apply a different clamping force on substrate independently of bow
End

FIG. 41

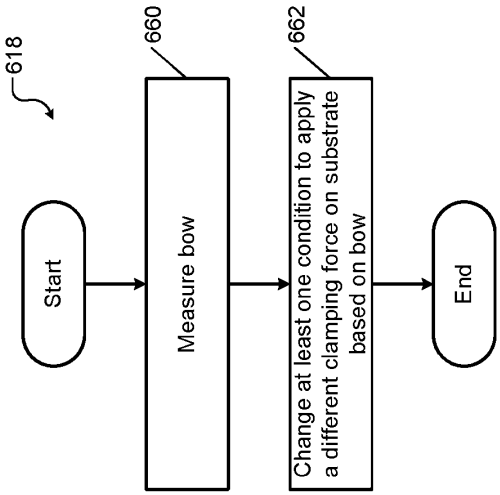

618
660
662
Start
Measure bow
Change at least one condition to apply a different clamping force on substrate based on bow
End

FIG. 40

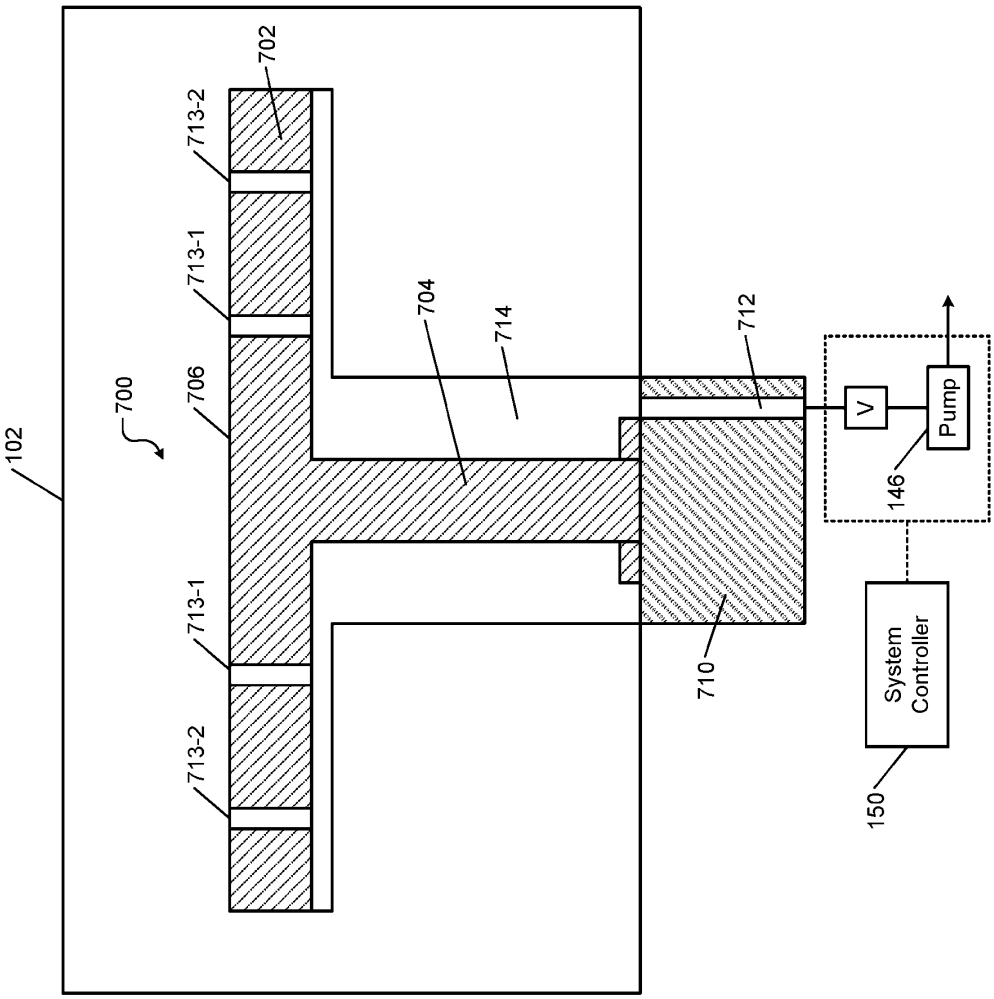

102
700
702
713-2
713-1
706
704
714
712
V
Pump
146
713-1
713-2
710
System Controller
150

FIG. 42

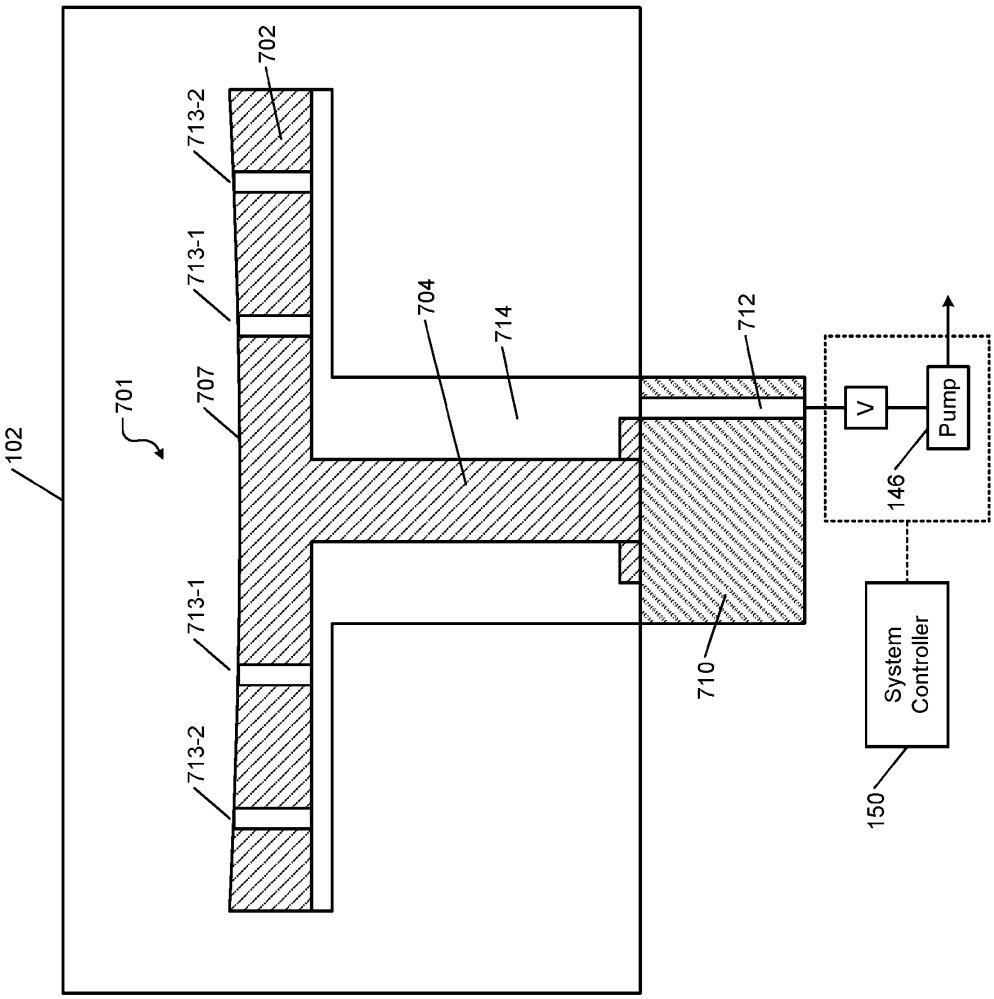

102
701
702
713-2
713-1
704
714
707
712
V
Pump
146
713-1
713-2
710
System Controller
150

FIG. 43

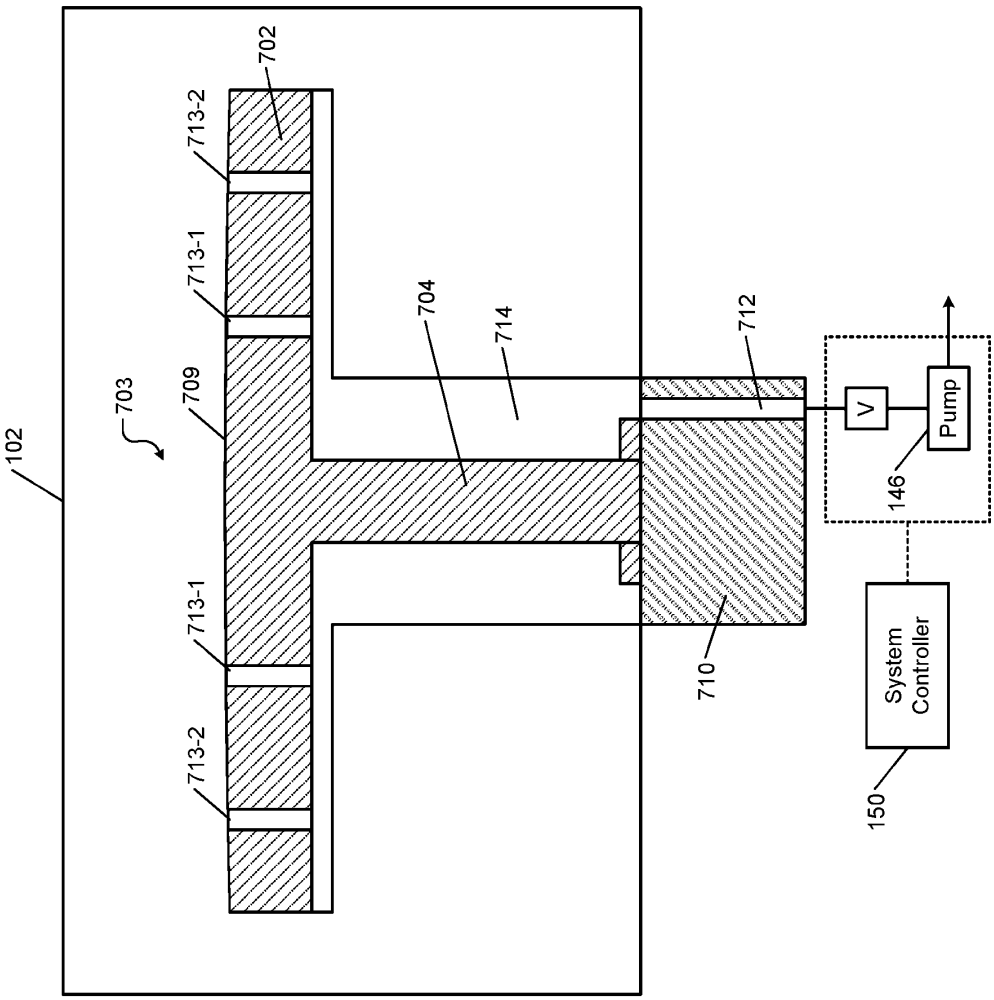

102
703
709
713-2
713-1
713-1
713-2
702
704
714
712
710
V
Pump
146
System Controller
150

FIG. 44