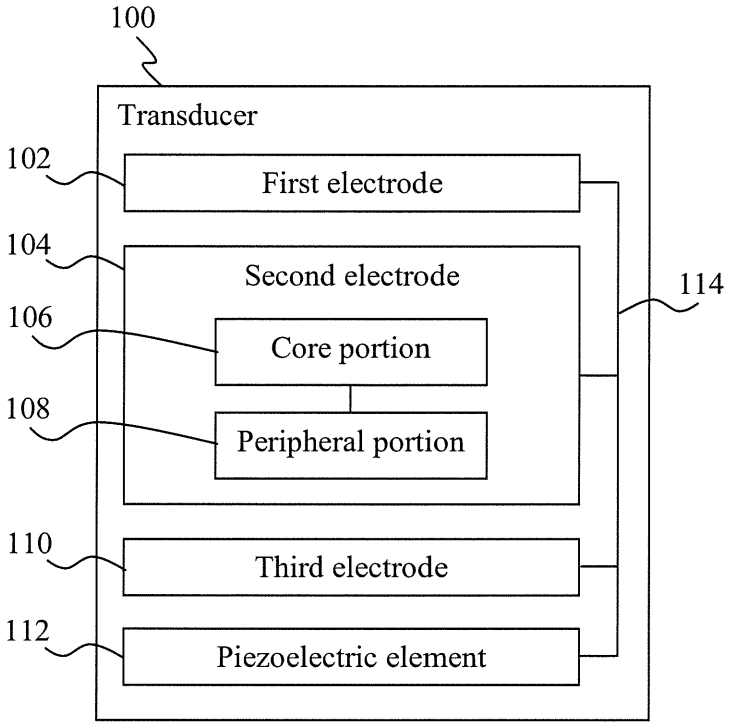

100
Transducer
102
First electrode
104
Second electrode
106
Core portion
108
Peripheral portion
114
110
Third electrode
112
Piezoelectric element

FIG. 1A

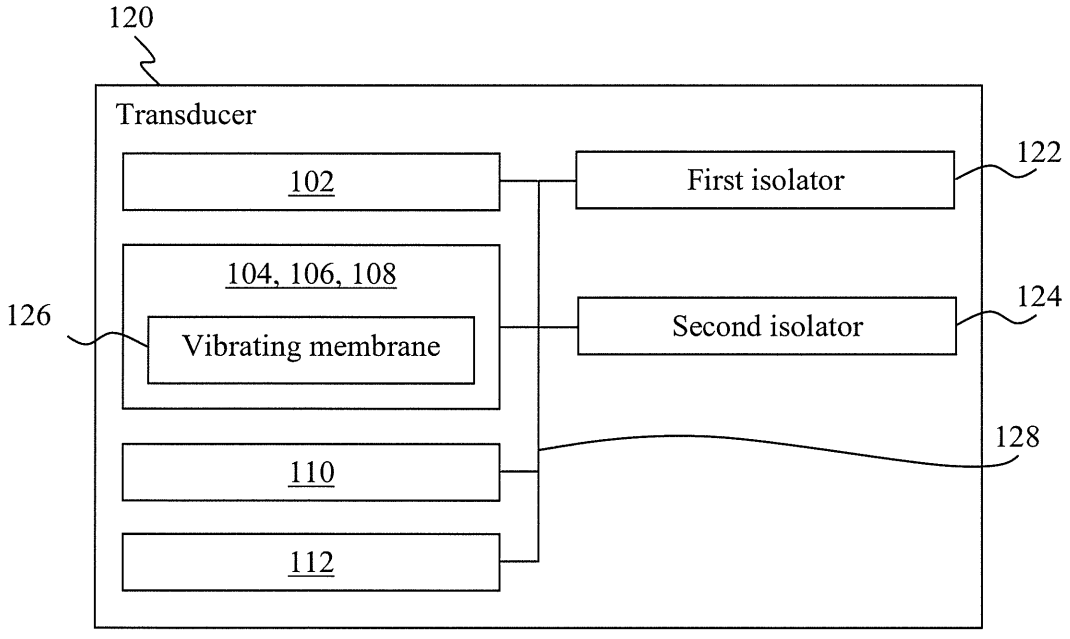

120
Transducer
102
First isolator
122
104, 106, 108
126
Vibrating membrane
Second isolator
124
128
110
112

FIG. 1B

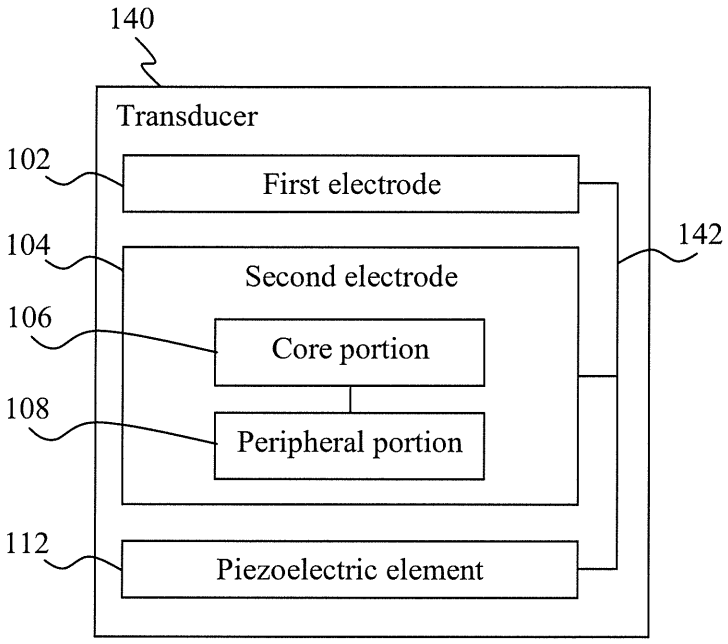

140
Transducer
102
First electrode
142
104
Second electrode
106
Core portion
108
Peripheral portion
112
Piezoelectric element

FIG. 1C

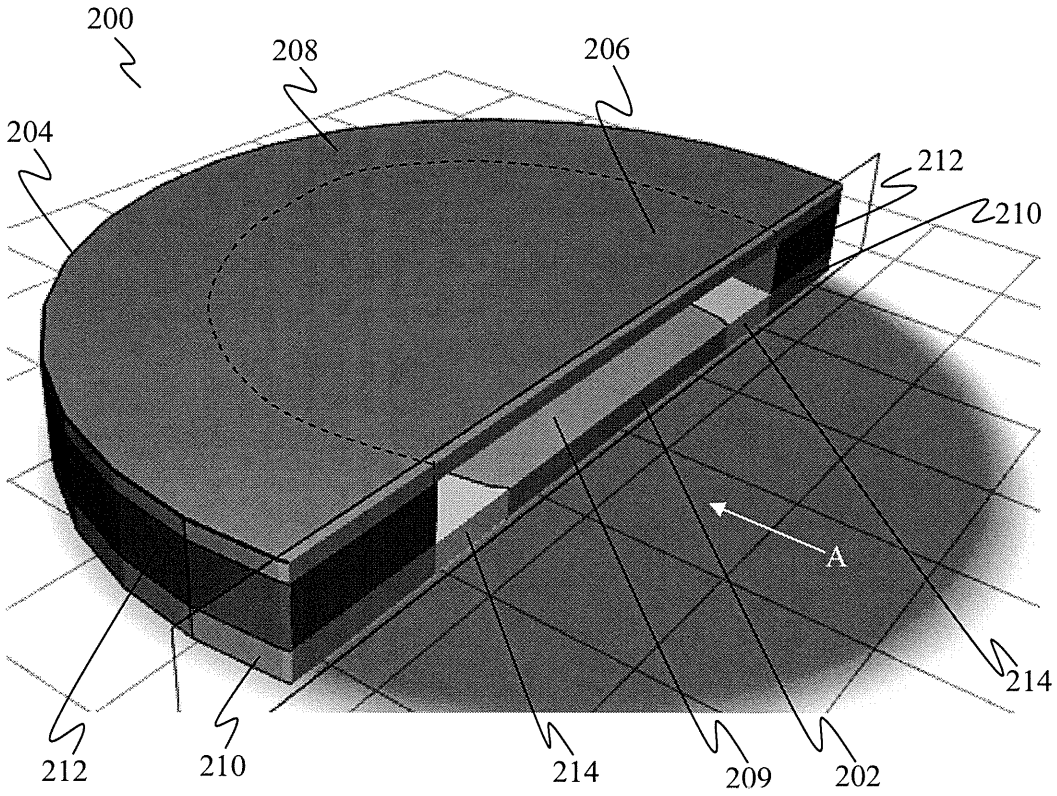

200
208
206
204
212
210
A
214
212
210
214
209
202

FIG. 2A

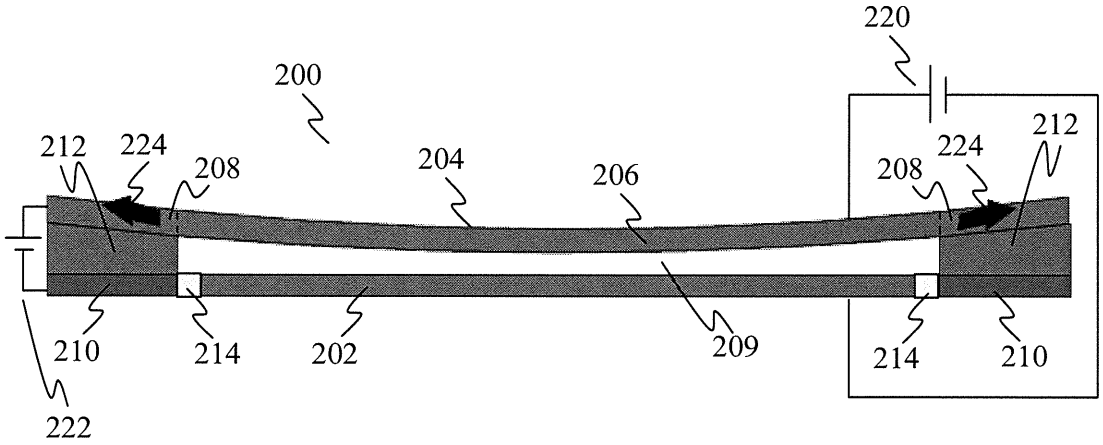

220
200
212
224
208
204
206
224
208
212
210
214
202
209
214
210
222

FIG. 2B

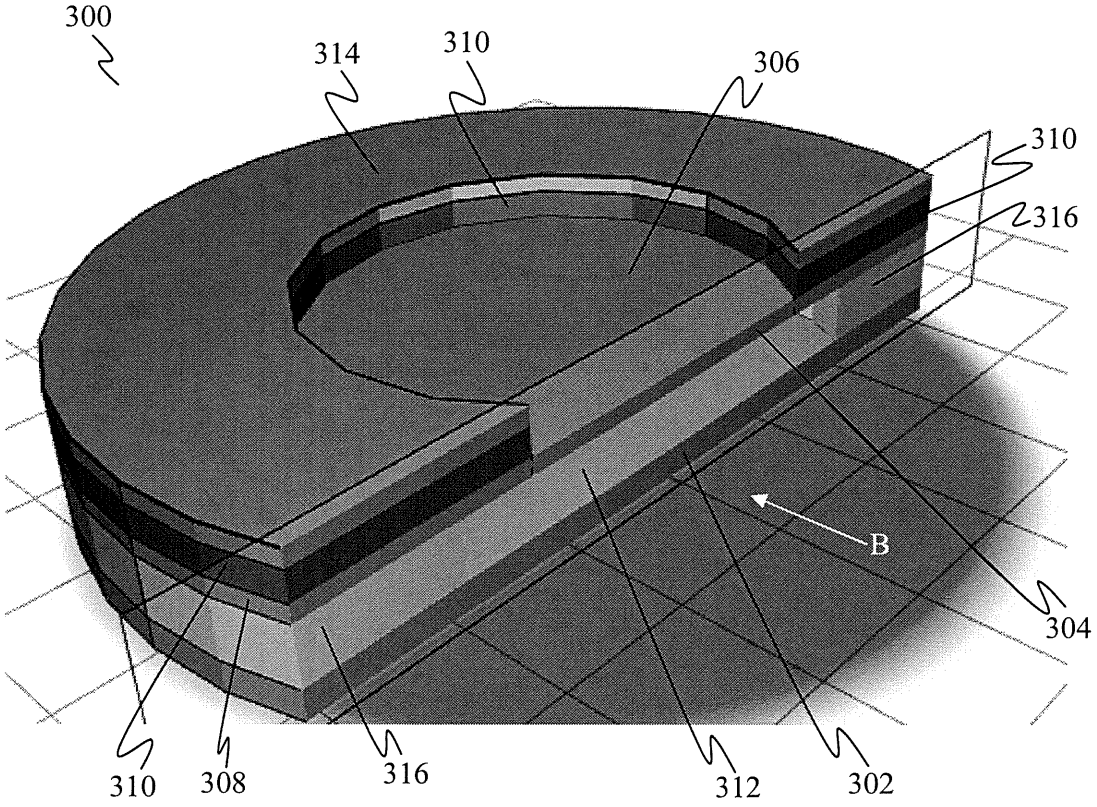

300
314
310
306
310
316
B
304
310
308
316
312
302

FIG. 3A

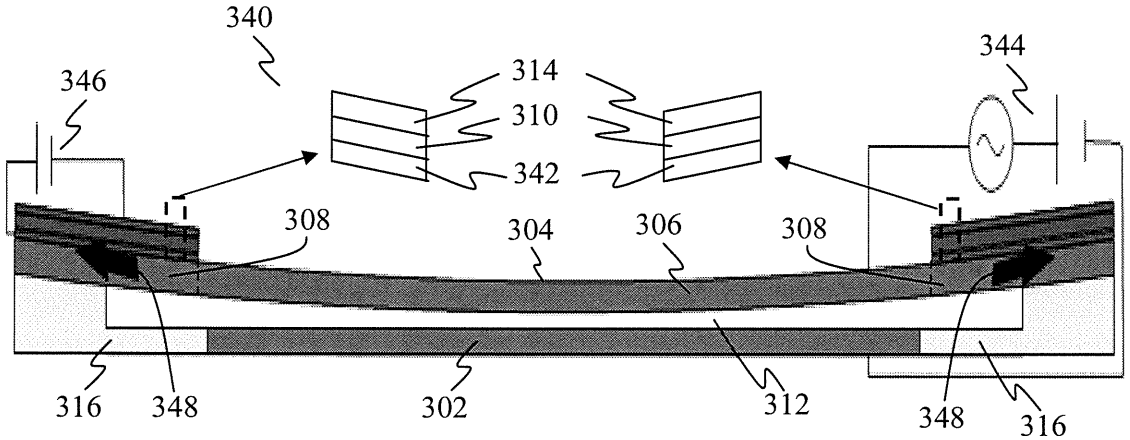

340
346
314
310
342
344
308
304
306
308
316
348
302
312
348
316

FIG. 3B

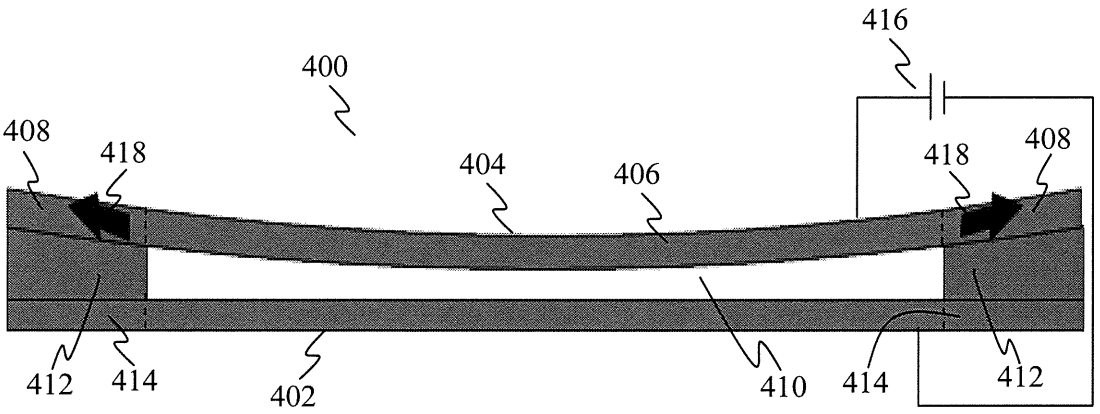


FIG. 4

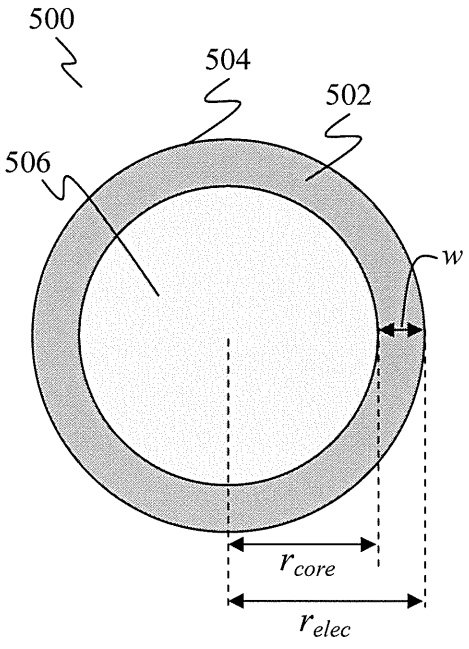


FIG. 5A

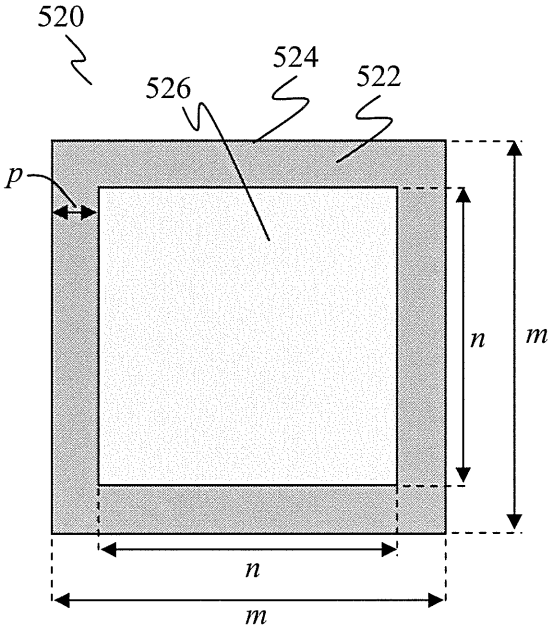


FIG. 5B

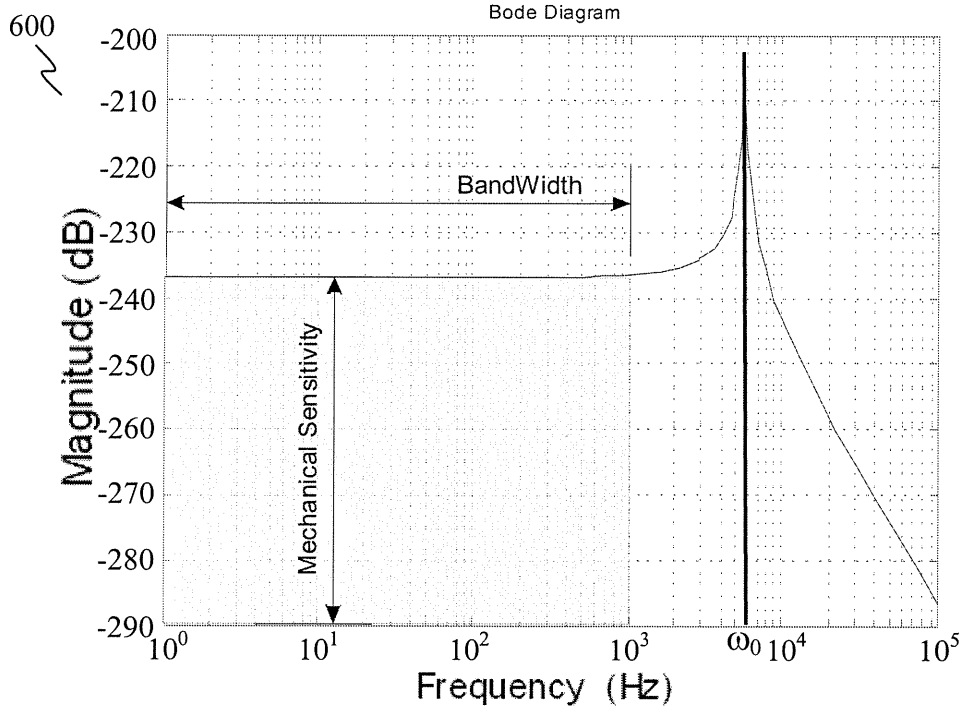

600
Bode Diagram
-200
-210
-220
-230
-240
-250
-260
-270
-280
-290
BandWidth
Mechanical Sensitivity
Magnitude (dB)
10^0
10^1
10^2
10^3
ω_0 10^4
10^5
Frequency (Hz)

FIG. 6

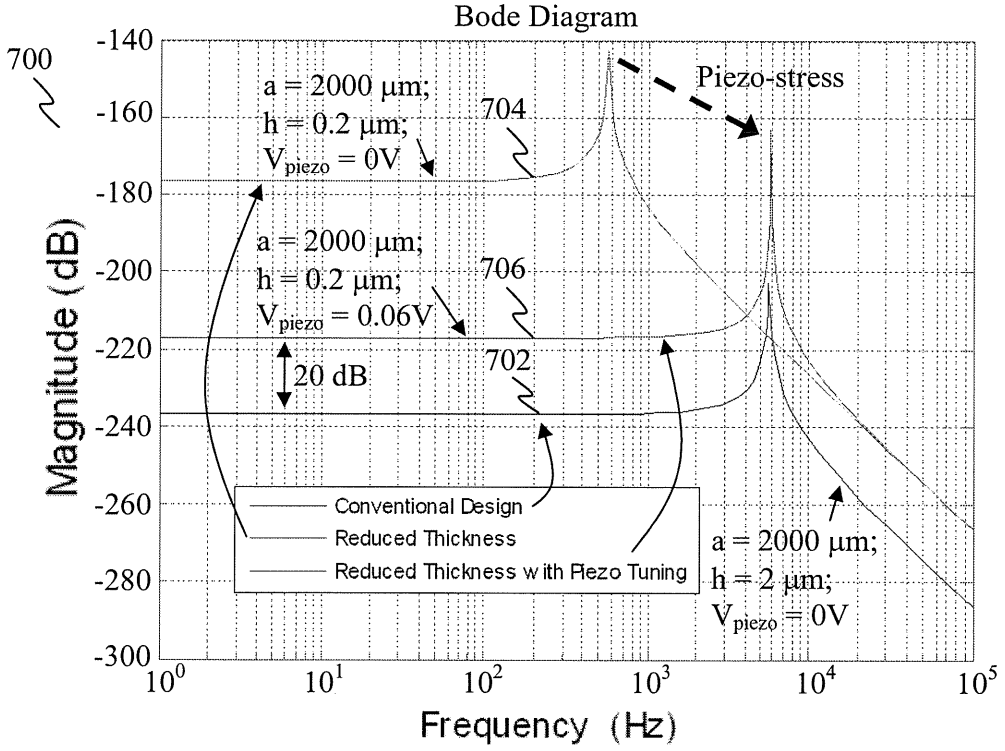

700
Bode Diagram
-140
-160
-180
-200
-220
-240
-260
-280
-300
a = 2000 µm;
h = 0.2 µm;
V_{piezo} = 0V
704
Piezo-stress
a = 2000 µm;
h = 0.2 µm;
V_{piezo} = 0.06V
706
20 dB
702
Conventional Design
Reduced Thickness
Reduced Thickness with Piezo Tuning
a = 2000 µm;
h = 2 µm;
V_{piezo} = 0V
Magnitude (dB)
10^0
10^1
10^2
10^3
10^4
10^5
Frequency (Hz)

FIG. 7

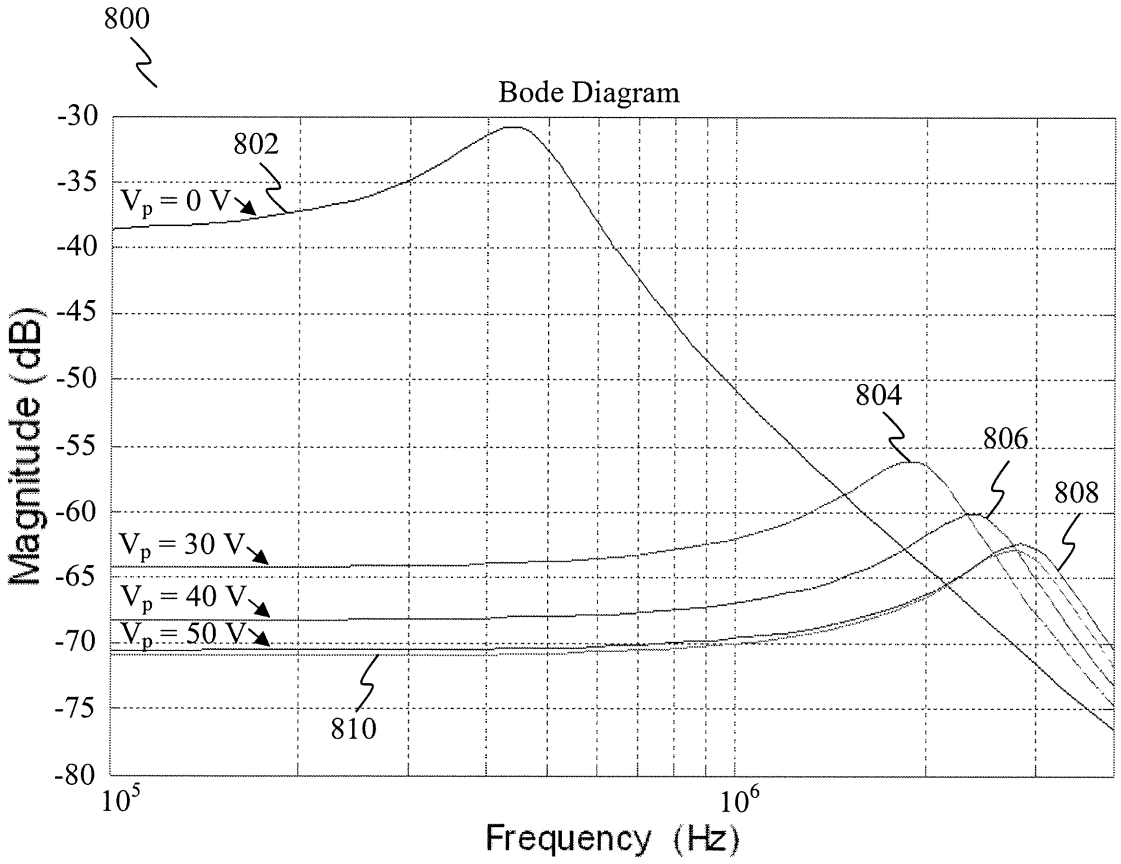

800
Bode Diagram
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
Magnitude (dB)
802
V_p = 0 V
804
806
808
V_p = 30 V
V_p = 40 V
V_p = 50 V
810
10^5
10^6
Frequency (Hz)

FIG. 8

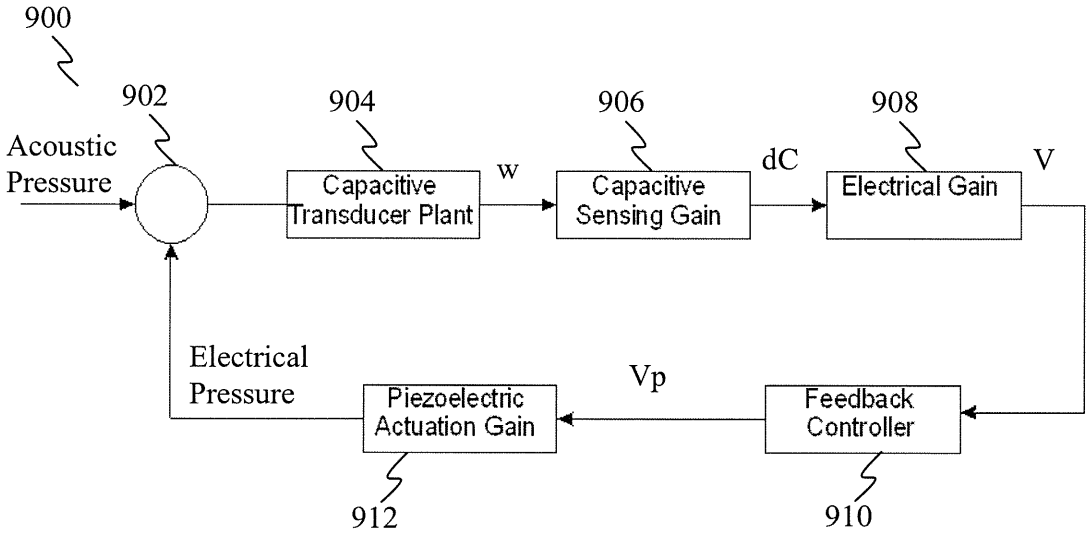

900
902
Acoustic Pressure
904
Capacitive Transducer Plant
w
906
Capacitive Sensing Gain
dC
908
Electrical Gain
V
Electrical Pressure
Vp
Piezoelectric Actuation Gain
Feedback Controller
912
910

FIG. 9

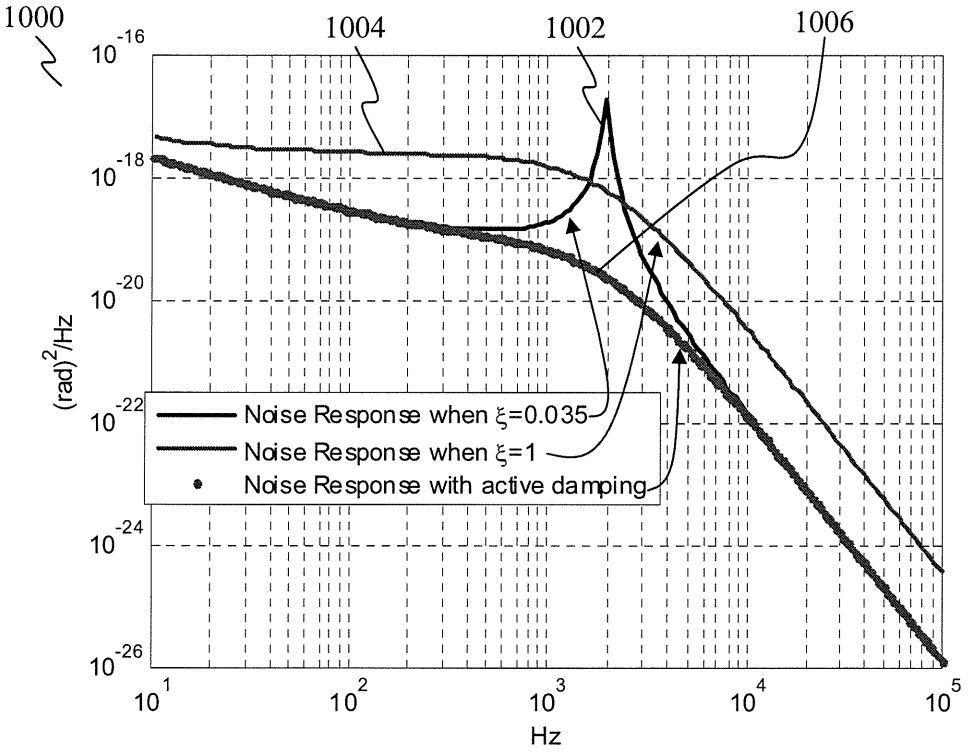

1000
1004
1002
1006
10^{-16}
10^{-18}
10^{-20}
10^{-22}
10^{-24}
10^{-26}
$(rad)^2/Hz$
Noise Response when ξ=0.035
Noise Response when ξ=1
Noise Response with active damping
10^1
10^2
10^3
10^4
10^5
Hz

FIG. 10

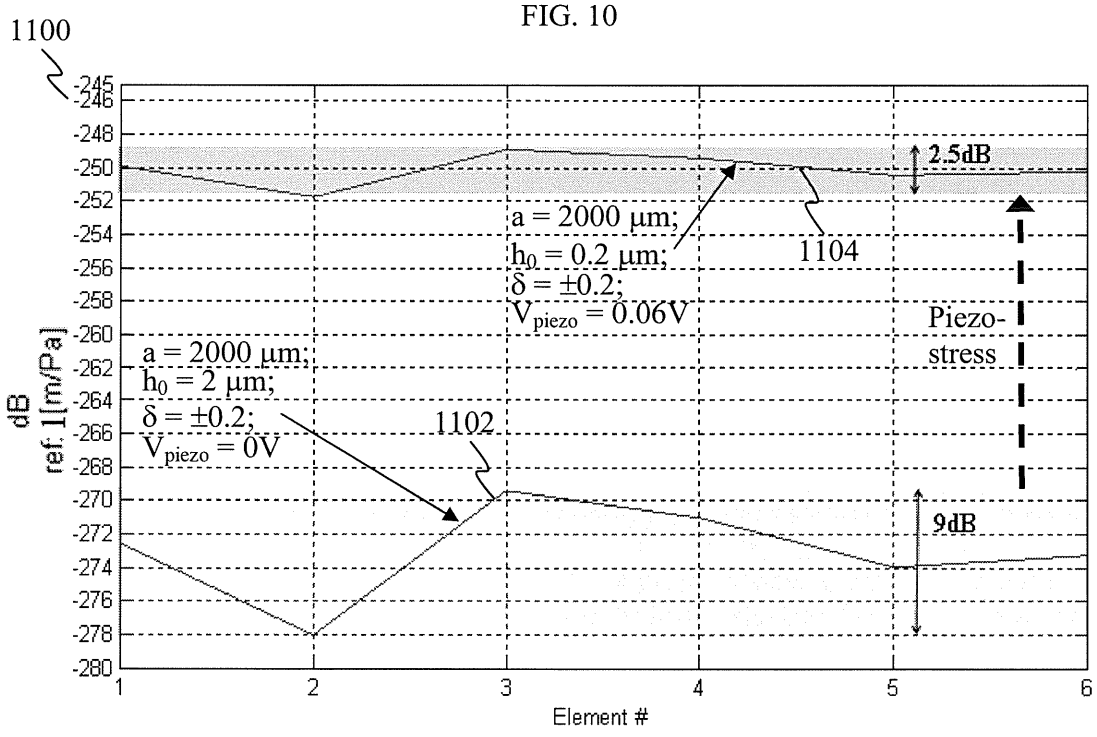

1100
-245
-246
-248
-250
-252
-254
-256
-258
-260
-262
-264
-266
-268
-270
-272
-274
-276
-278
-280
dB
ref. 1[m/Pa]
2.5dB
a = 2000 μm;
h_0 = 0.2 μm;
δ = ±0.2;
V_{piezo} = 0.06V
1104
Piezo-
stress
a = 2000 μm;
h_0 = 2 μm;
δ = ±0.2;
V_{piezo} = 0V
1102
9dB
1
2
3
4
5
6
Element #

FIG. 11

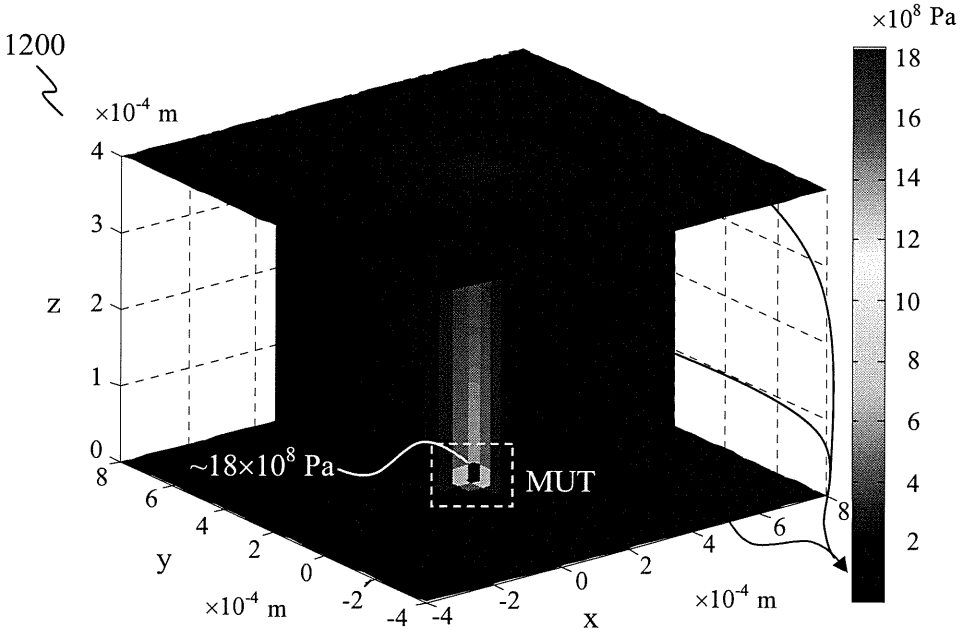


FIG. 12A

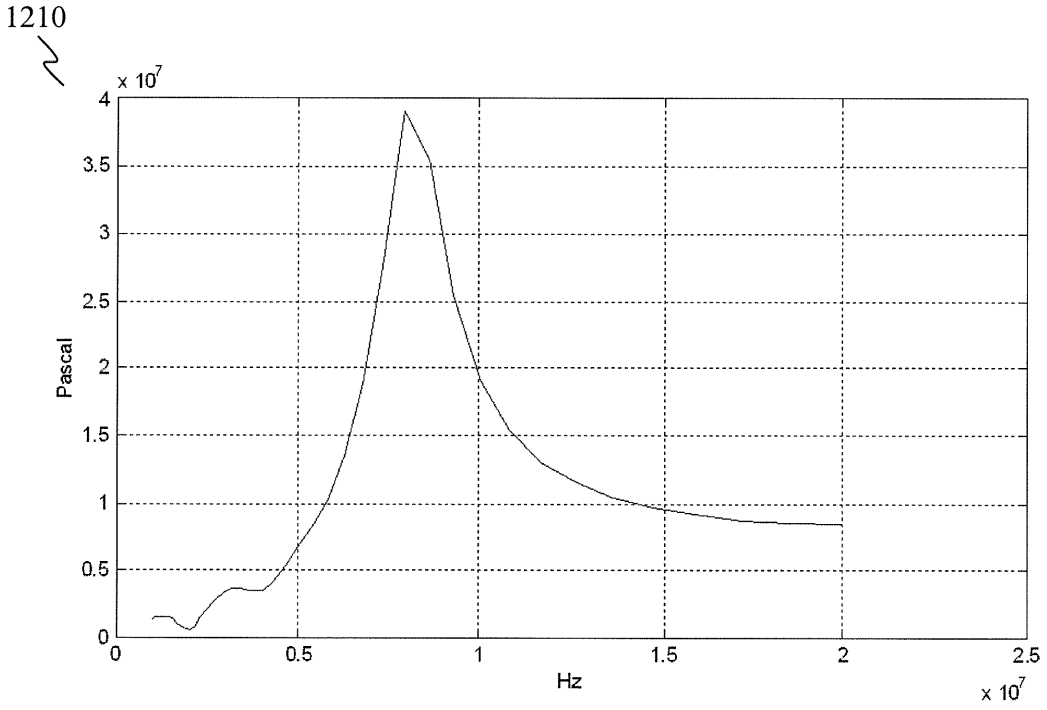


FIG. 12B

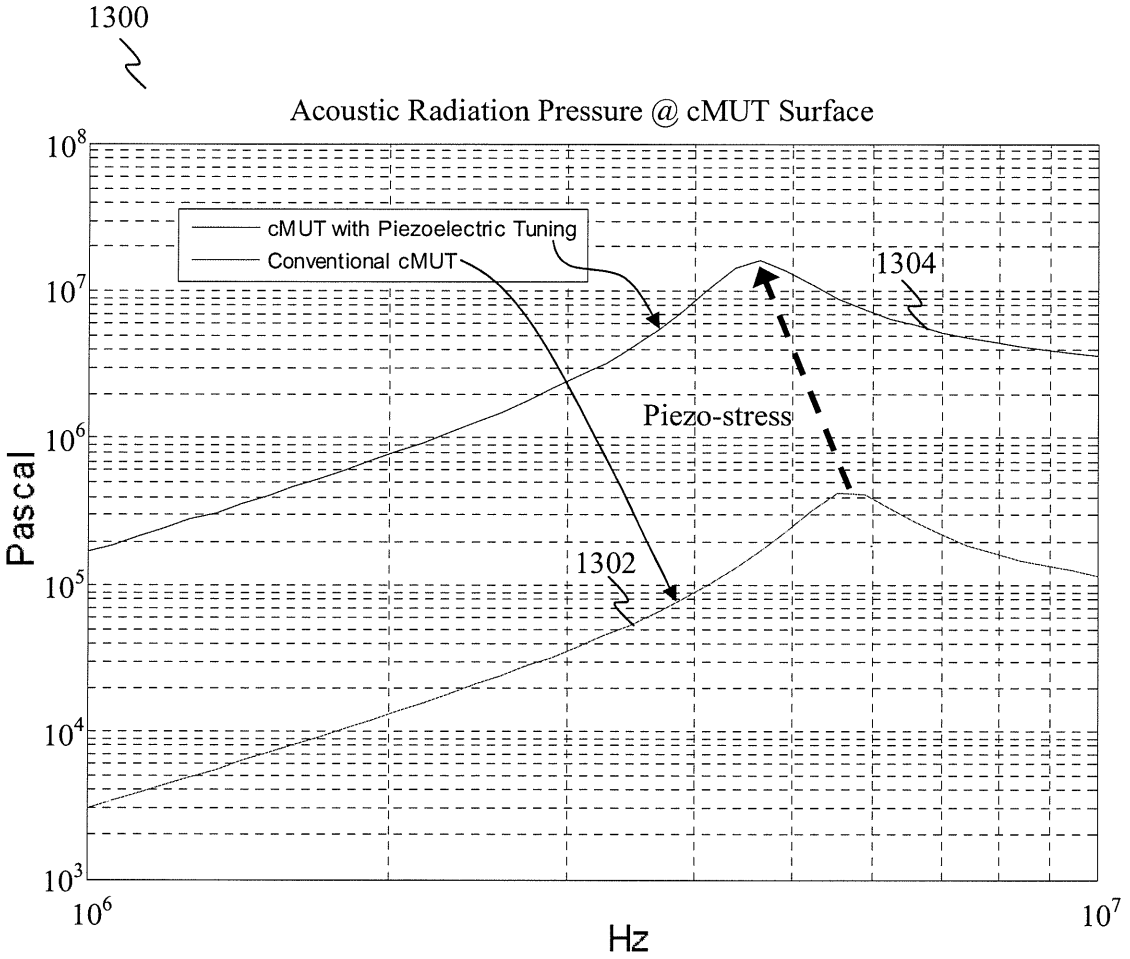

1300
Acoustic Radiation Pressure @ cMUT Surface
cMUT with Piezoelectric Tuning
Conventional cMUT
1304
Piezo-stress
1302
Pascal
Hz
10^8
10^7
10^6
10^5
10^4
10^3
10^6
10^7

FIG. 13