

FIG. 1A

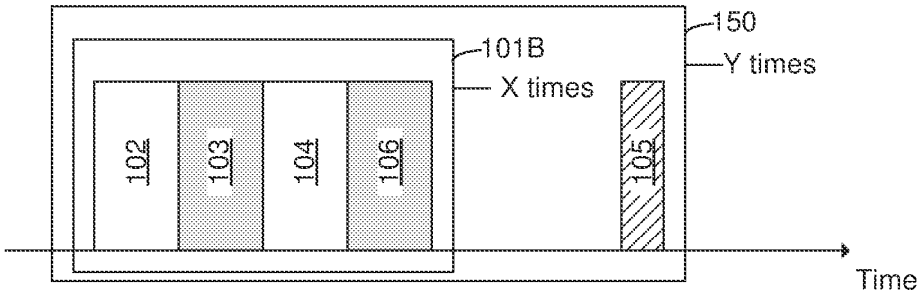


FIG. 1B

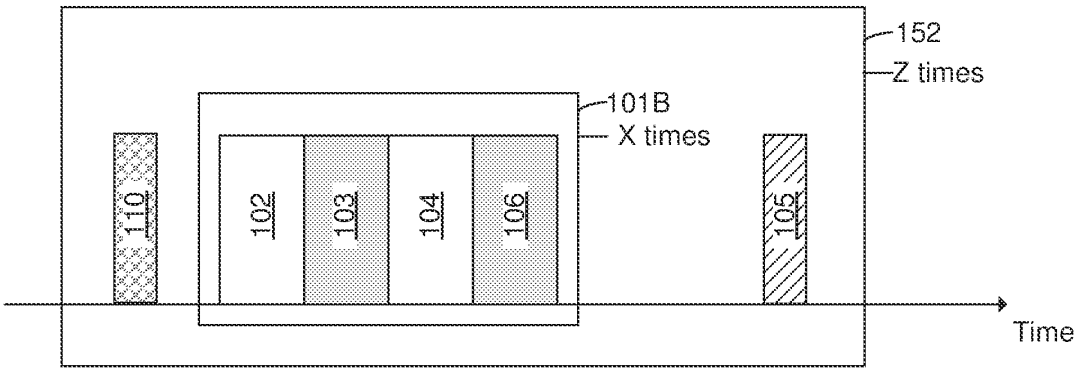


FIG. 1C

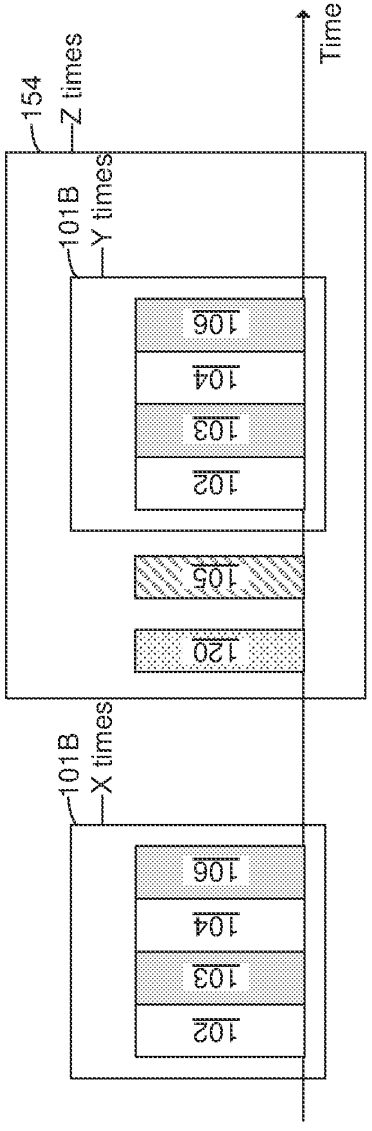

Time
154
Z times
101B
Y times
106
104
103
102
105
120
101B
X times
106
104
103
102

FIG. 1D

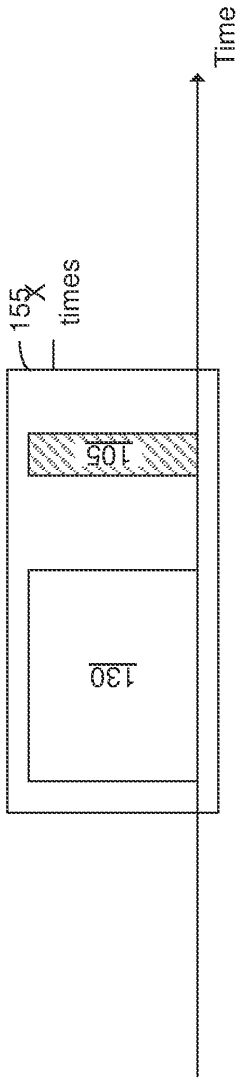

Time
155
X
times
105
130

FIG. 1E

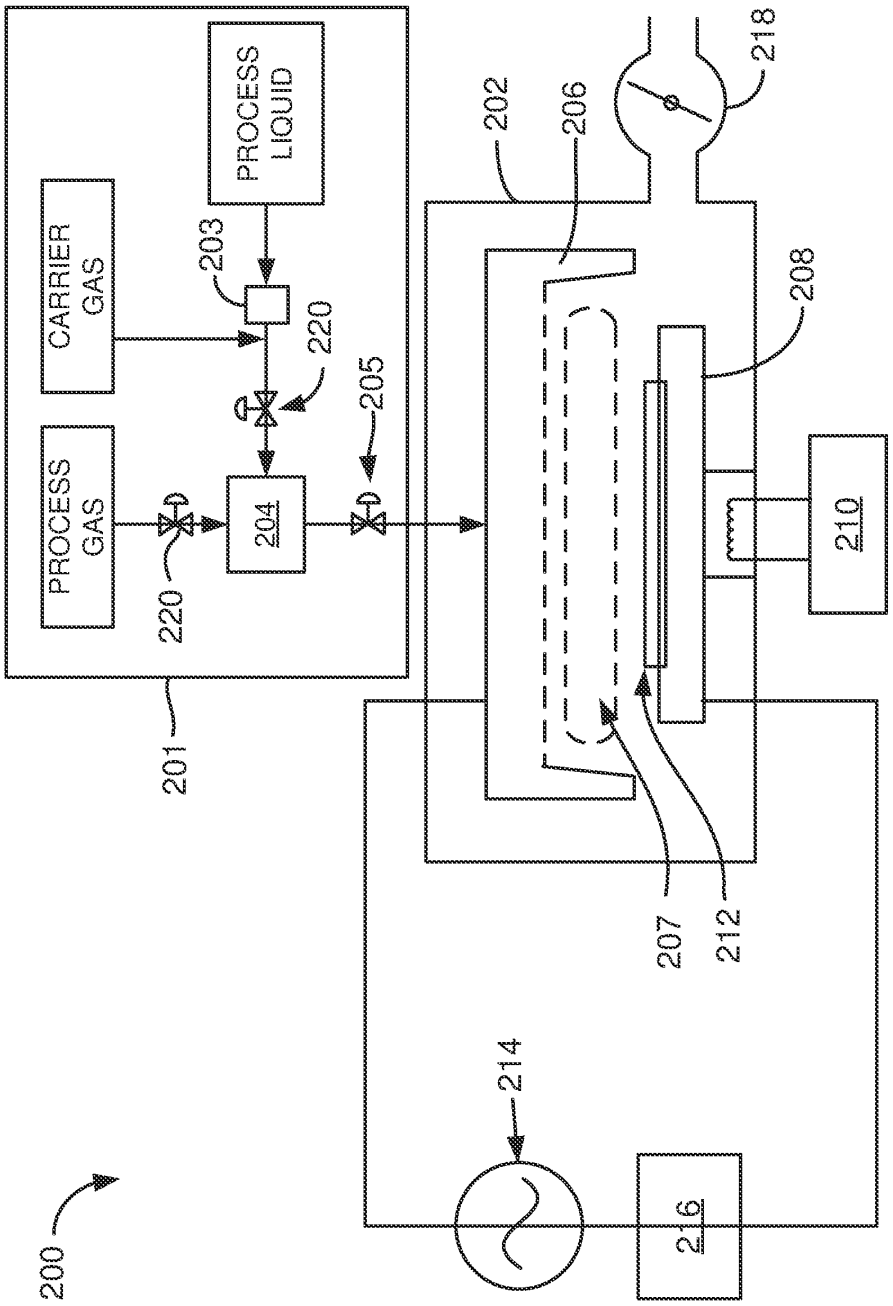

PROCESS LIQUID
CARRIER GAS
PROCESS GAS
203
220
205
220
204
201
202
206
218
208
210
207
212
214
216
200

FIG. 2

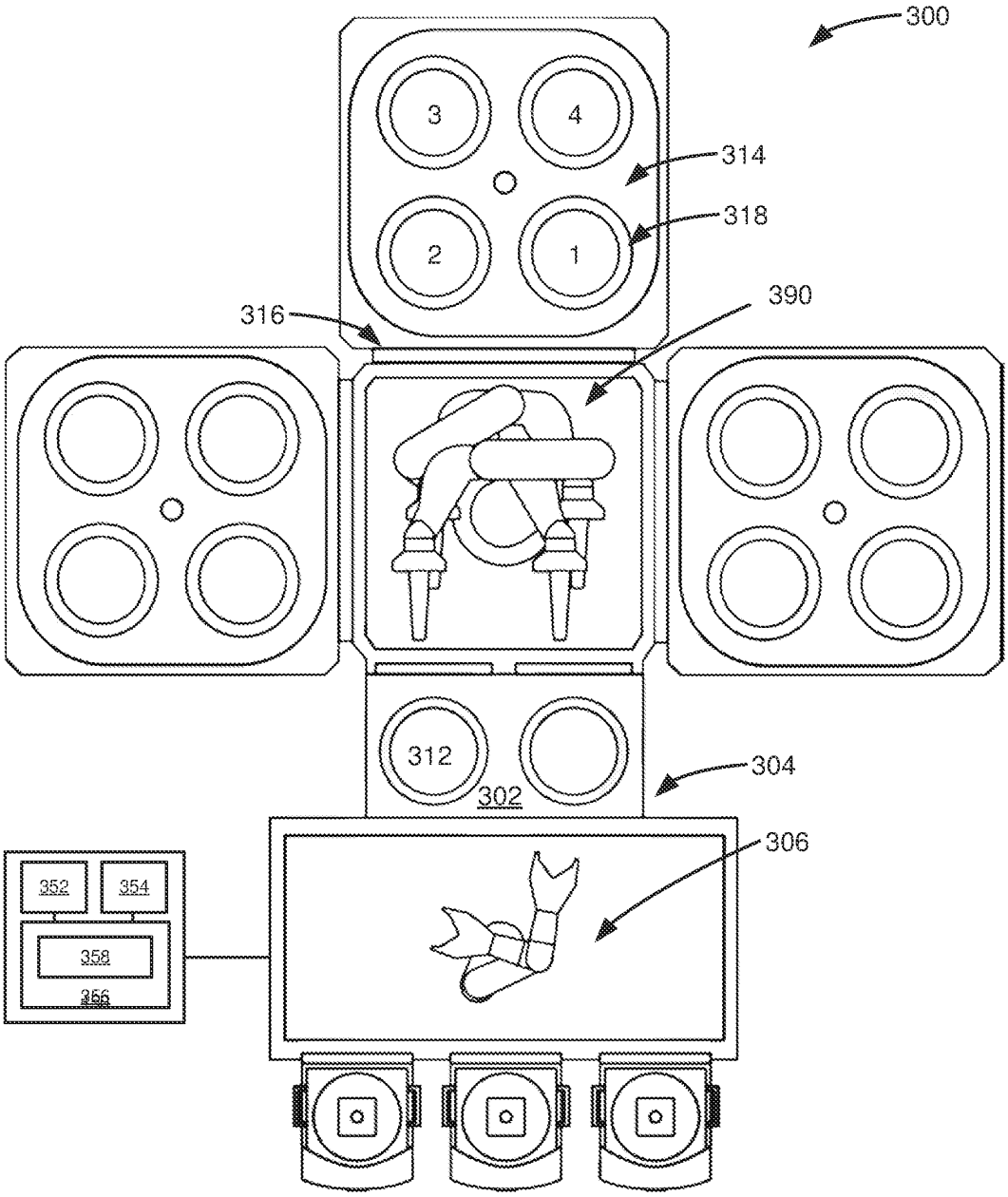


FIG. 3

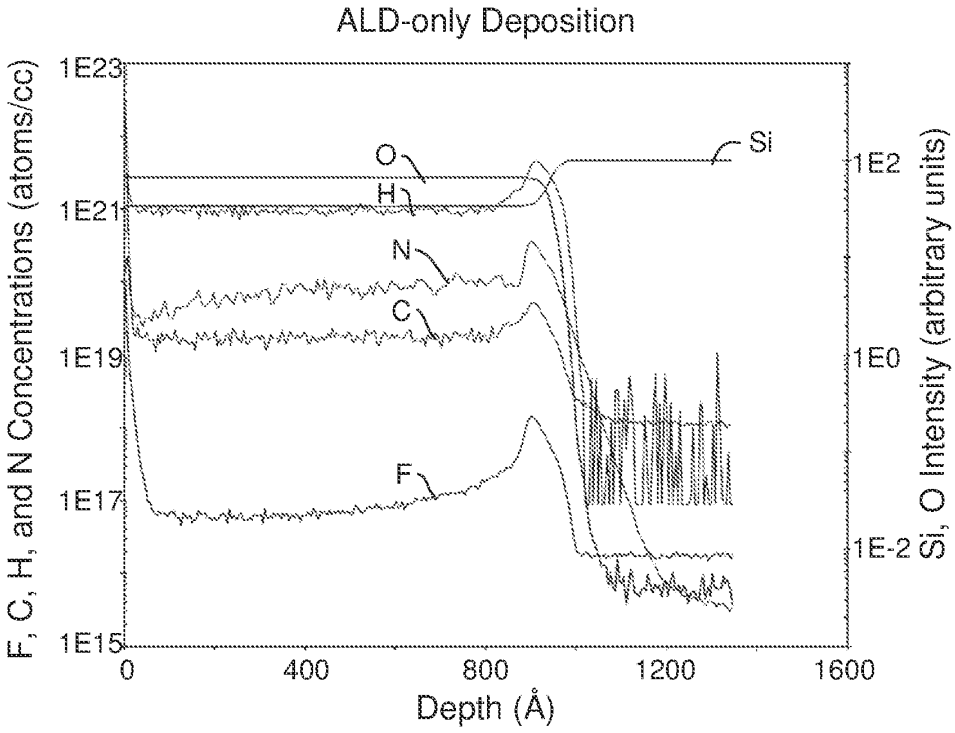

ALD-only Deposition
F, C, H, and N Concentrations (atoms/cc)
Si, O Intensity (arbitrary units)
Depth (Å)
1E23
1E21
1E19
1E17
1E15
1E2
1E0
1E-2
0
400
800
1200
1600
O
H
N
C
F
Si

FIG. 4A

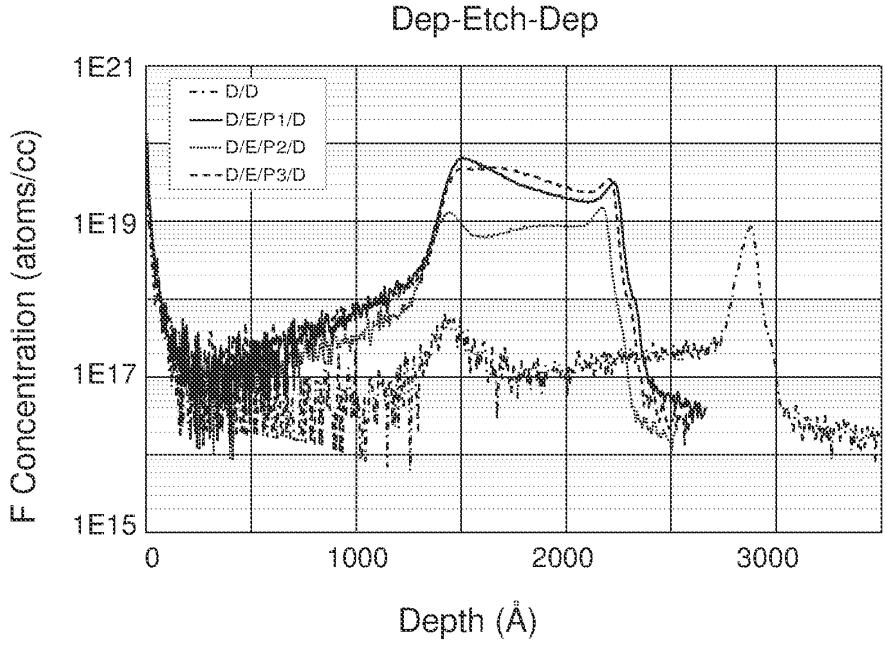

Dep-Etch-Dep
F Concentration (atoms/cc)
Depth (Å)
1E21
1E19
1E17
1E15
0
1000
2000
3000
D/D
D/E/P1/D
D/E/P2/D
D/E/P3/D

FIG. 4B

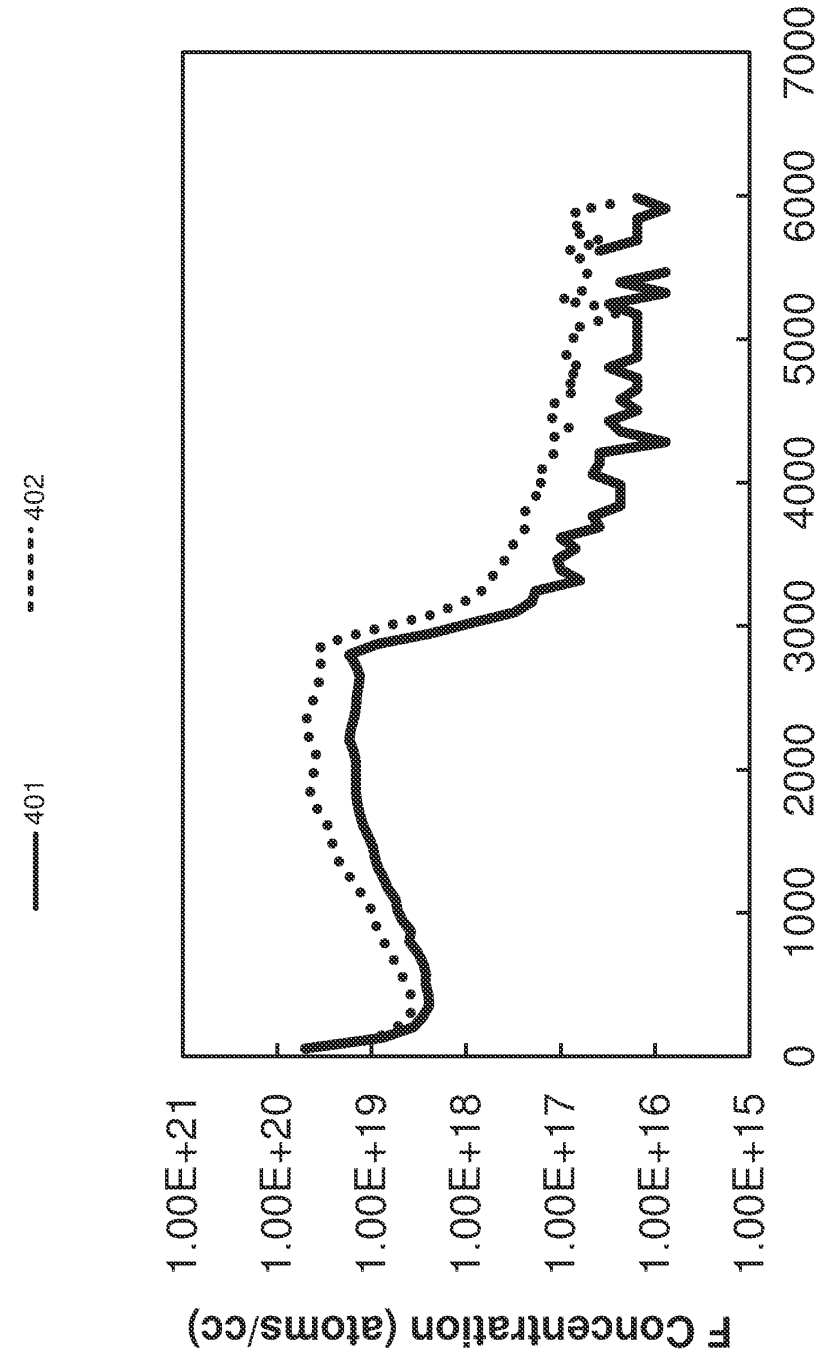

401
402
F Concentration (atoms/cc)
1.00E+21
1.00E+20
1.00E+19
1.00E+18
1.00E+17
1.00E+16
1.00E+15
0
1000
2000
3000
4000
5000
6000
7000
Depth (Å)

FIG. 4C

FIG. 5A

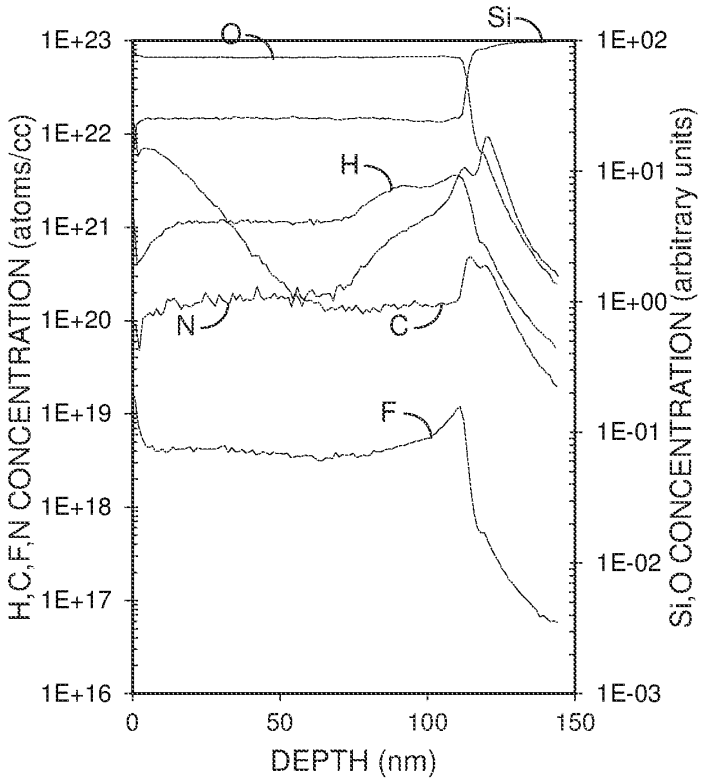
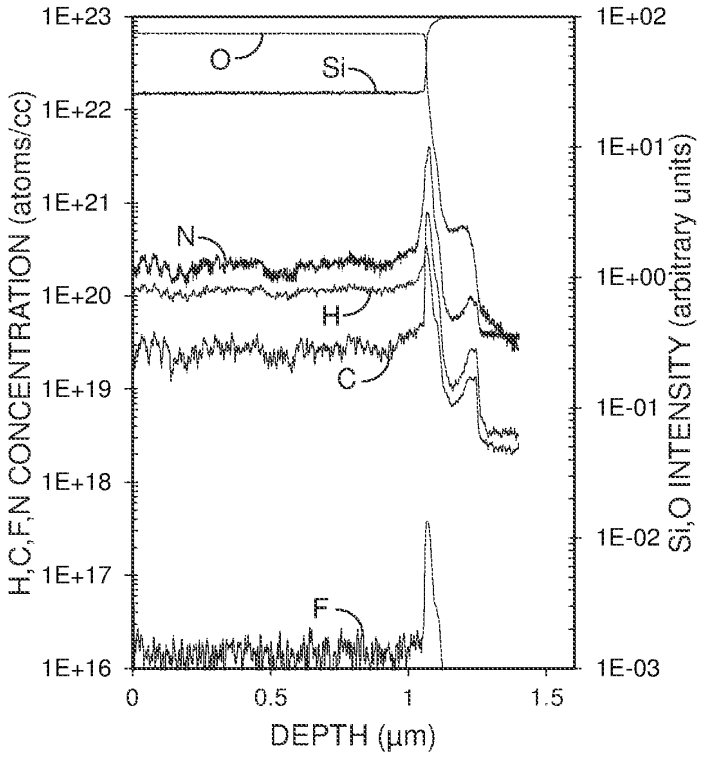

O
Si
H
N
C
F
1E+23
1E+22
1E+21
1E+20
1E+19
1E+18
1E+17
1E+16
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
50
100
150
DEPTH (nm)
H,C,F,N CONCENTRATION (atoms/cc)
Si,O CONCENTRATION (arbitrary units)

FIG. 5B


O
Si
N
H
C
F
1E+23
1E+22
1E+21
1E+20
1E+19
1E+18
1E+17
1E+16
1E+02
1E+01
1E+00
1E-01
1E-02
1E-03
0
0.5
1
1.5
DEPTH (µm)
H,C,F,N CONCENTRATION (atoms/cc)
Si,O INTENSITY (arbitrary units)

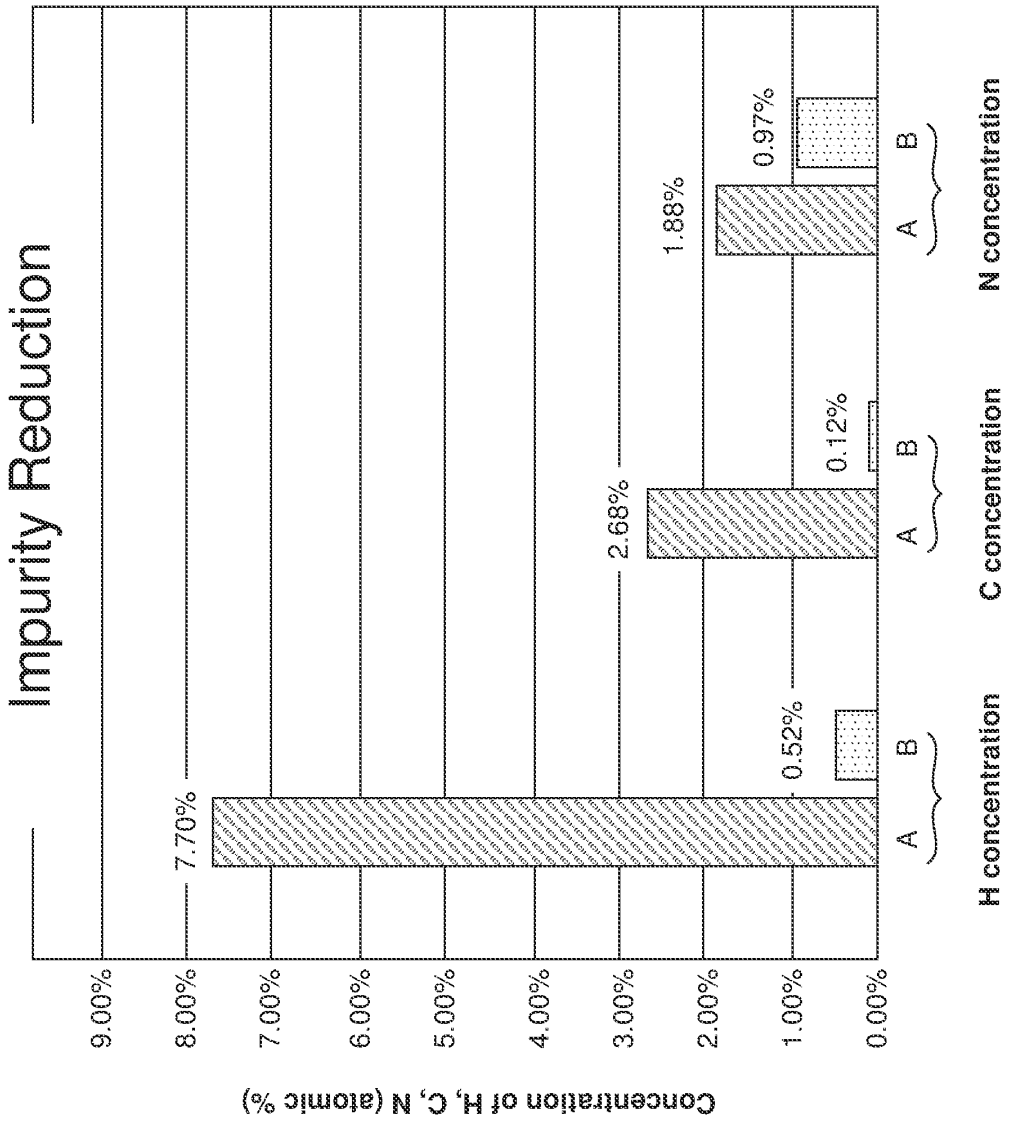

Impurity Reduction
Concentration of H, C, N (atomic %)
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
7.70%
0.52%
2.68%
0.12%
1.88%
0.97%
A
B
A
B
A
B
H concentration
C concentration
N concentration

FIG. 6

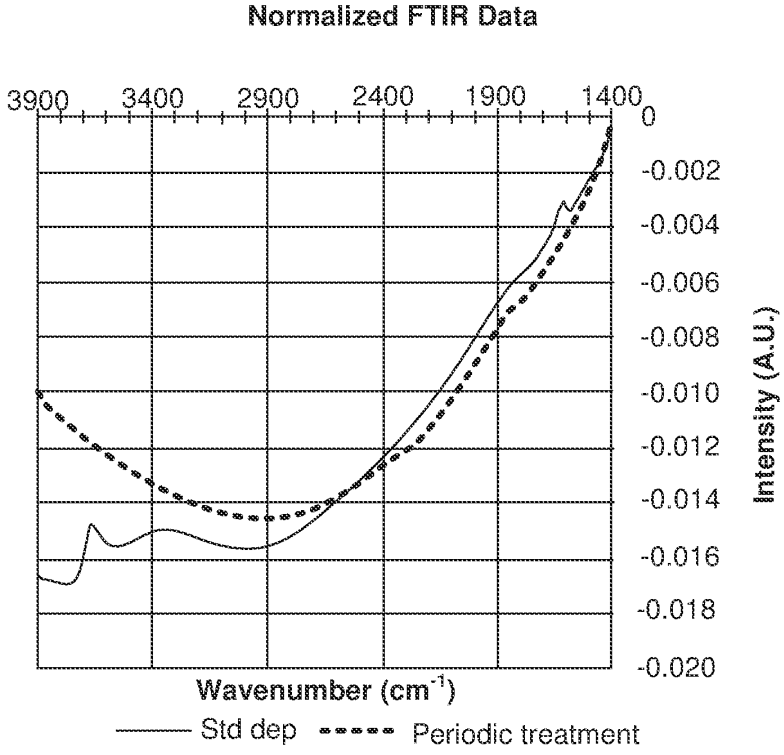

Normalized FTIR Data
3900
3400
2900
2400
1900
1400
0
-0.002
-0.004
-0.006
-0.008
-0.010
-0.012
-0.014
-0.016
-0.018
-0.020
Intensity (A.U.)
Wavenumber (cm-1)
Std dep
Periodic treatment

FIG. 7A

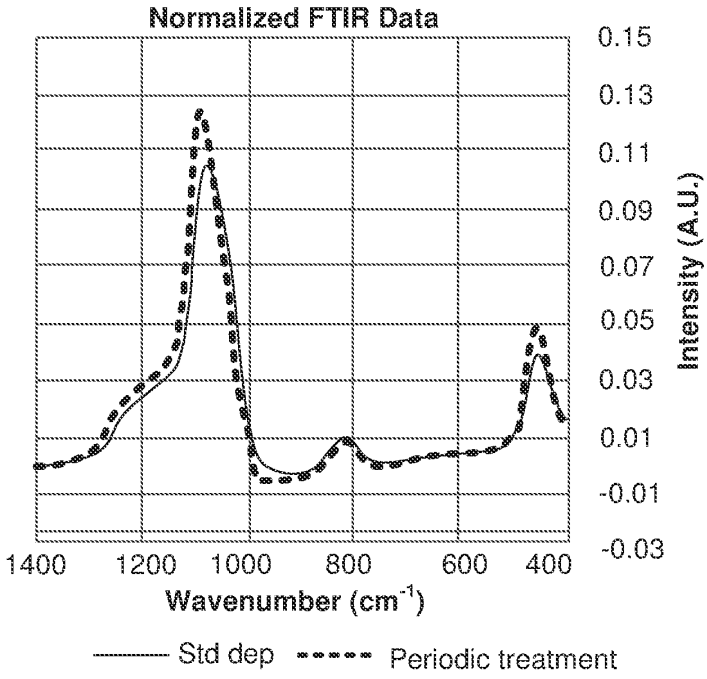

Normalized FTIR Data
0.15
0.13
0.11
0.09
0.07
0.05
0.03
0.01
-0.01
-0.03
Intensity (A.U.)
1400
1200
1000
800
600
400
Wavenumber (cm-1)
Std dep
Periodic treatment

FIG. 7B