FIG. 1A

100a

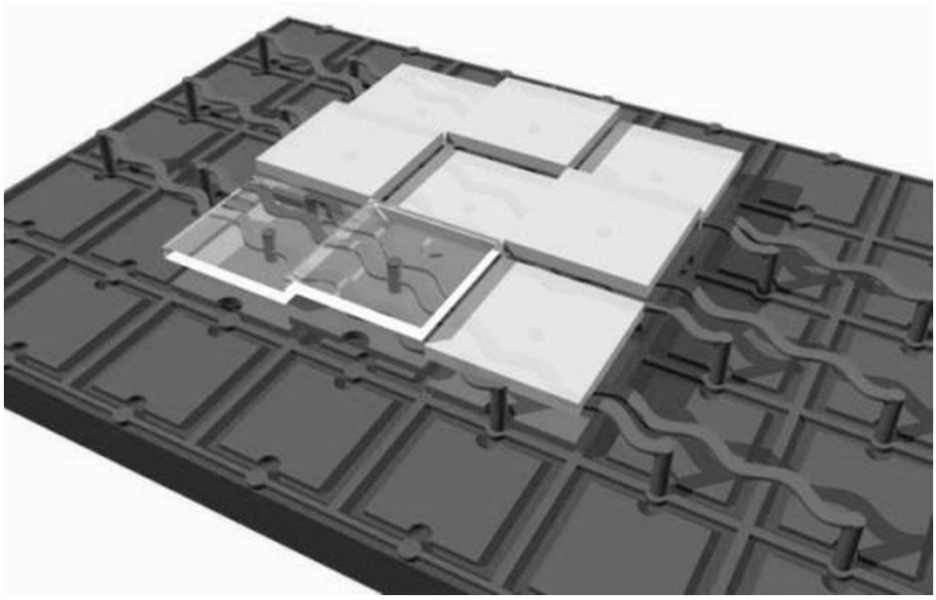


FIG. 1B

100b

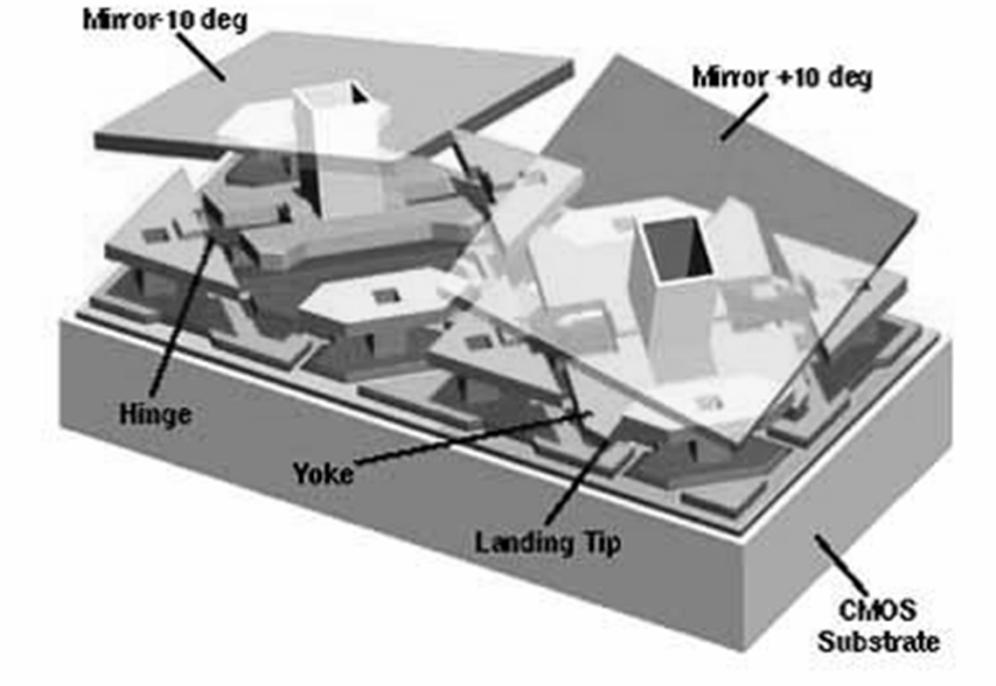


FIG. 1C

100c

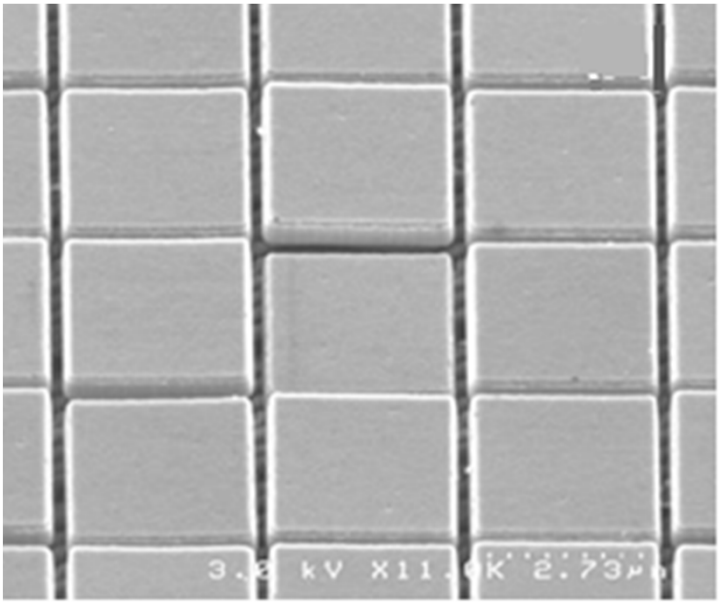


FIG. 1D

100d

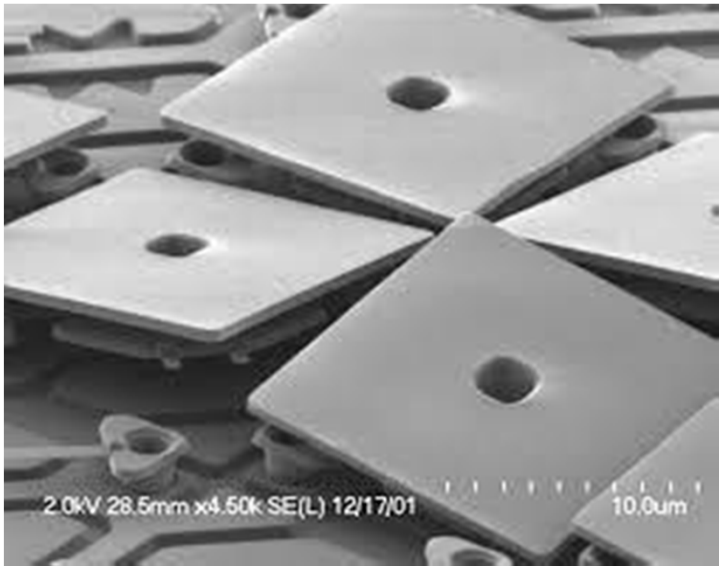


FIG. 2A

200a

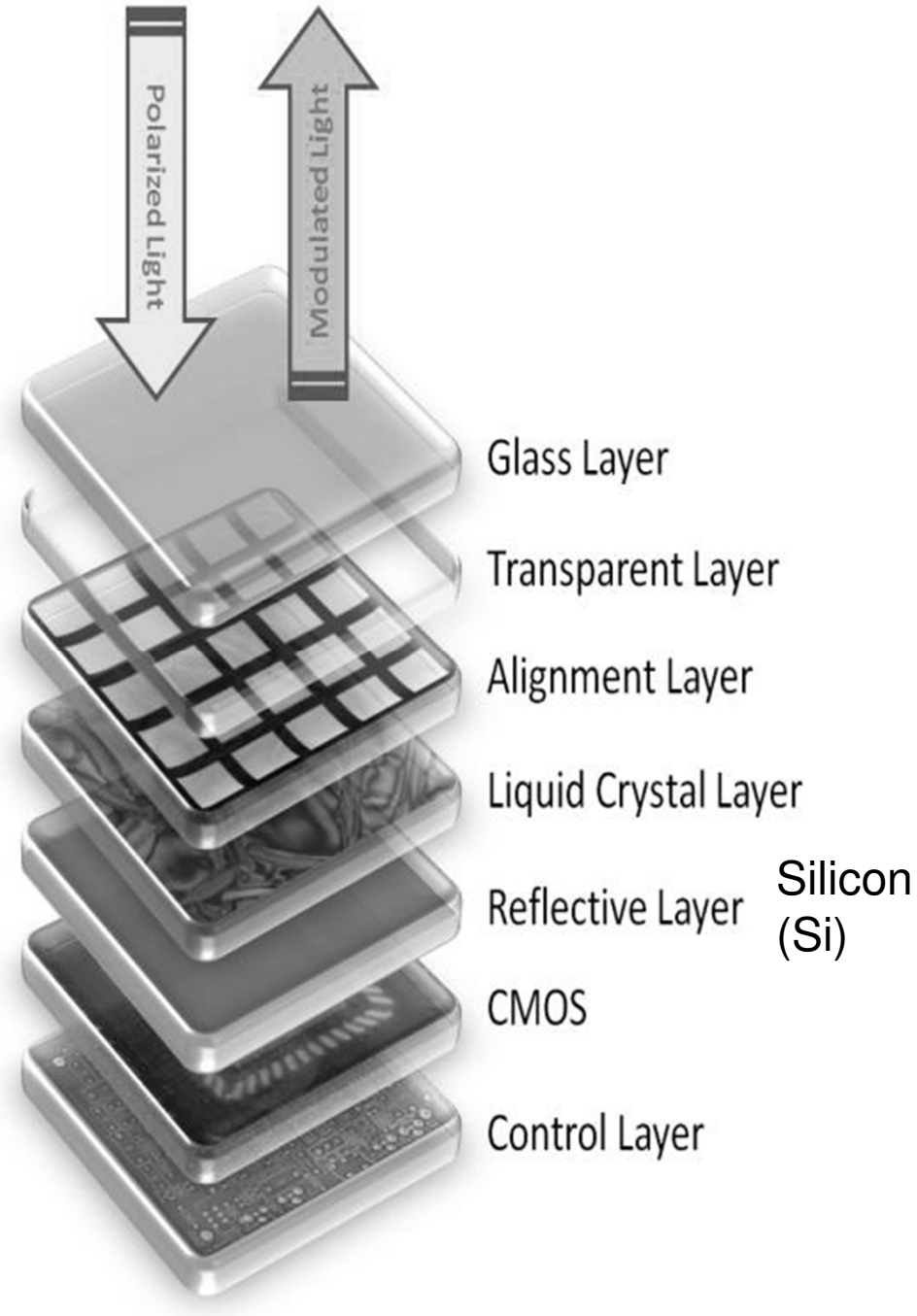

Polarized Light
Modulated Light
Glass Layer
Transparent Layer
Alignment Layer
Liquid Crystal Layer
Reflective Layer
Silicon (Si)
CMOS
Control Layer

FIG. 2B

200b

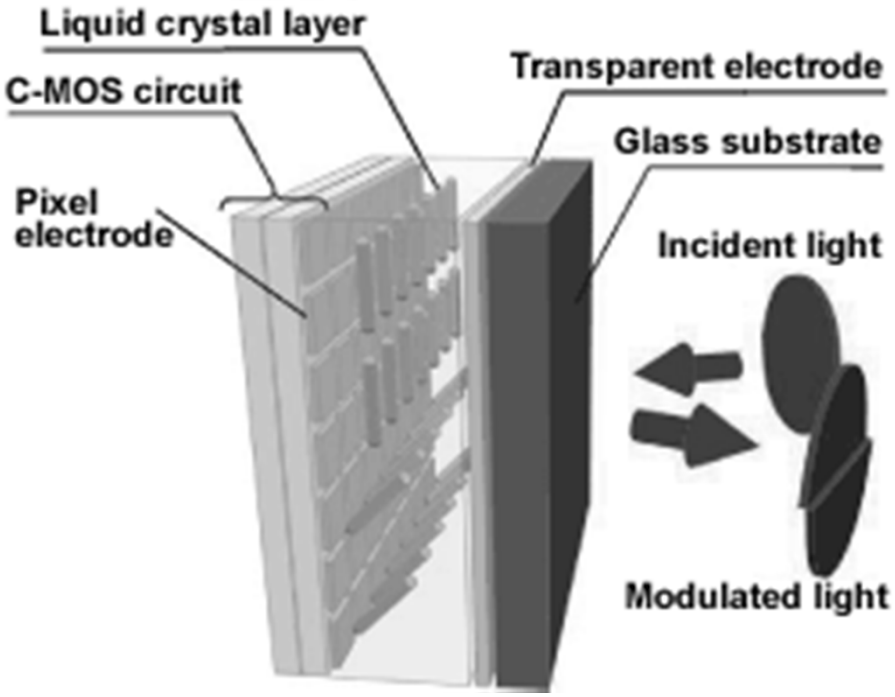


FIG. 2C

200c

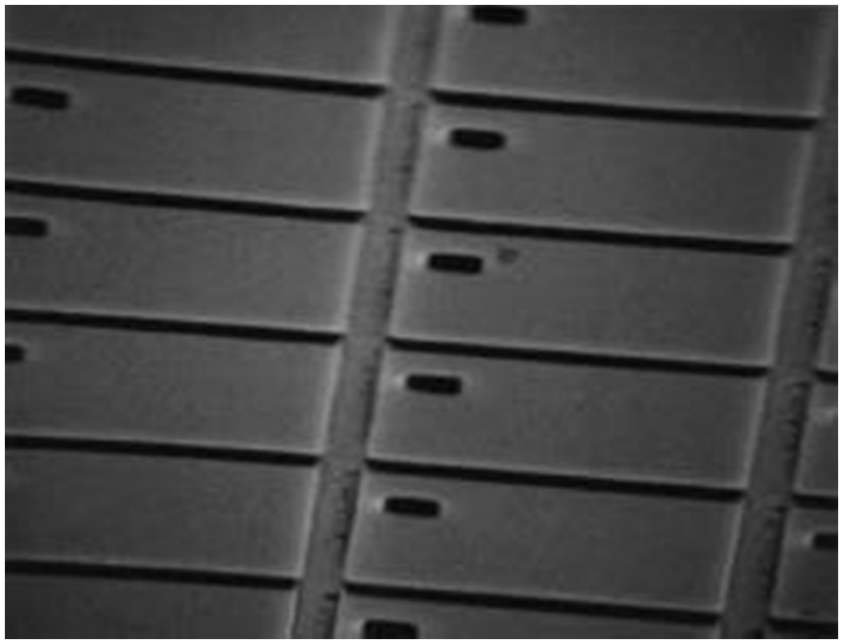


FIG. 2D

200d

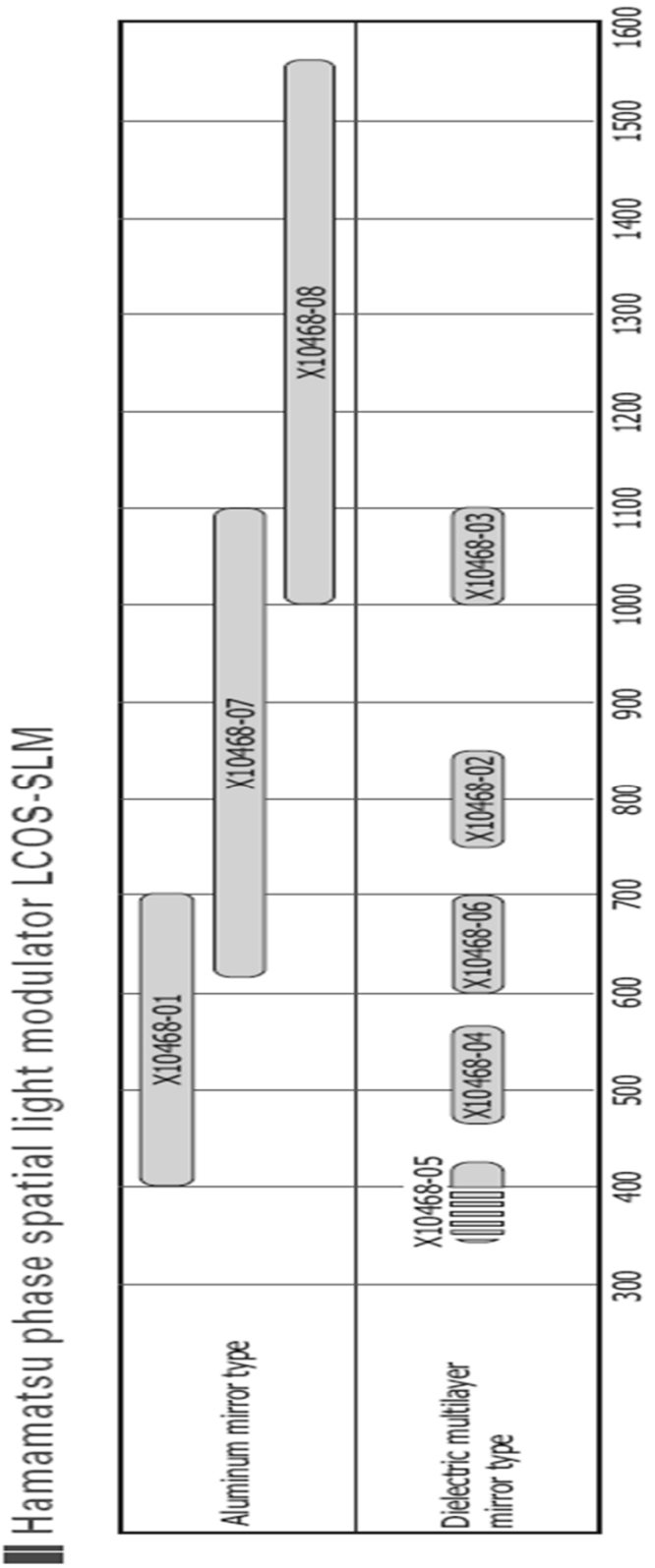

Hamamatsu phase spatial light modulator LCOS-SLM
Aluminum mirror type
Dielectric multilayer mirror type
X10468-01
X10468-07
X10468-08
X10468-05
X10468-04
X10468-06
X10468-02
X10468-03
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Wavelength (nm)

FIG. 3

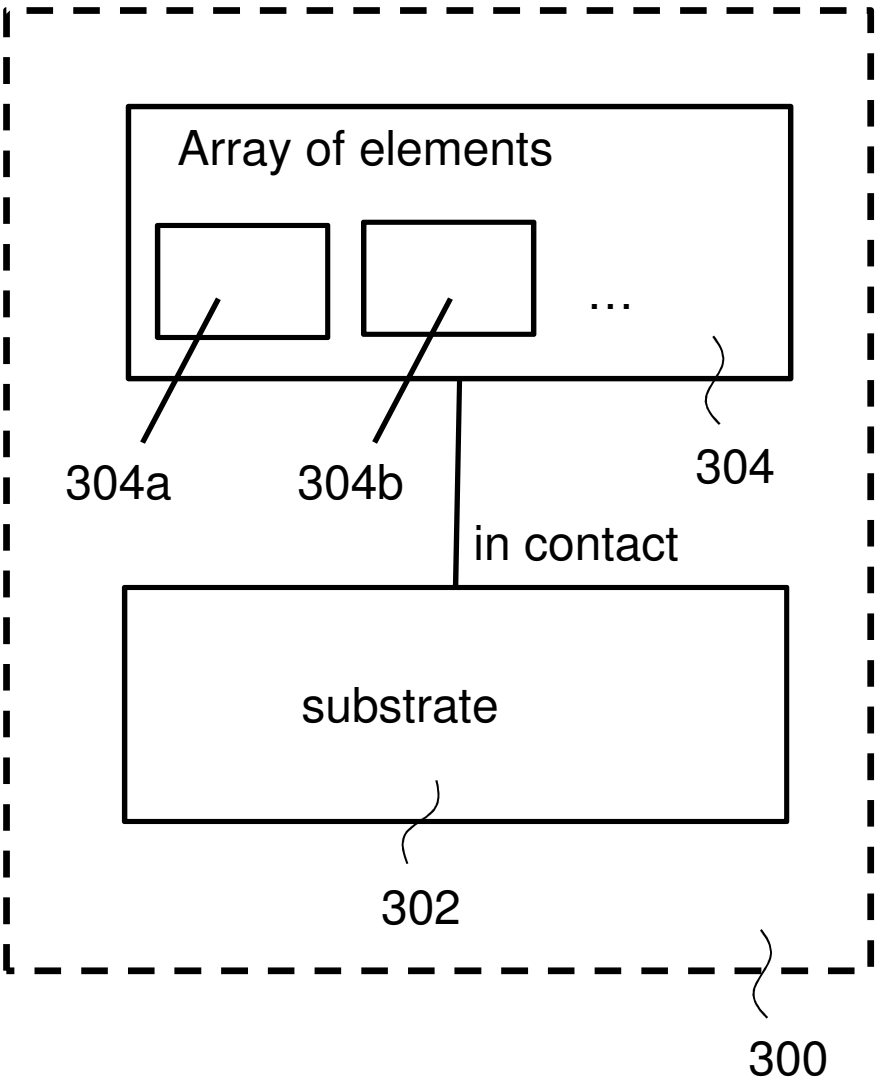

Array of elements
...
304a
304b
304
in contact
substrate
302
300

FIG. 4

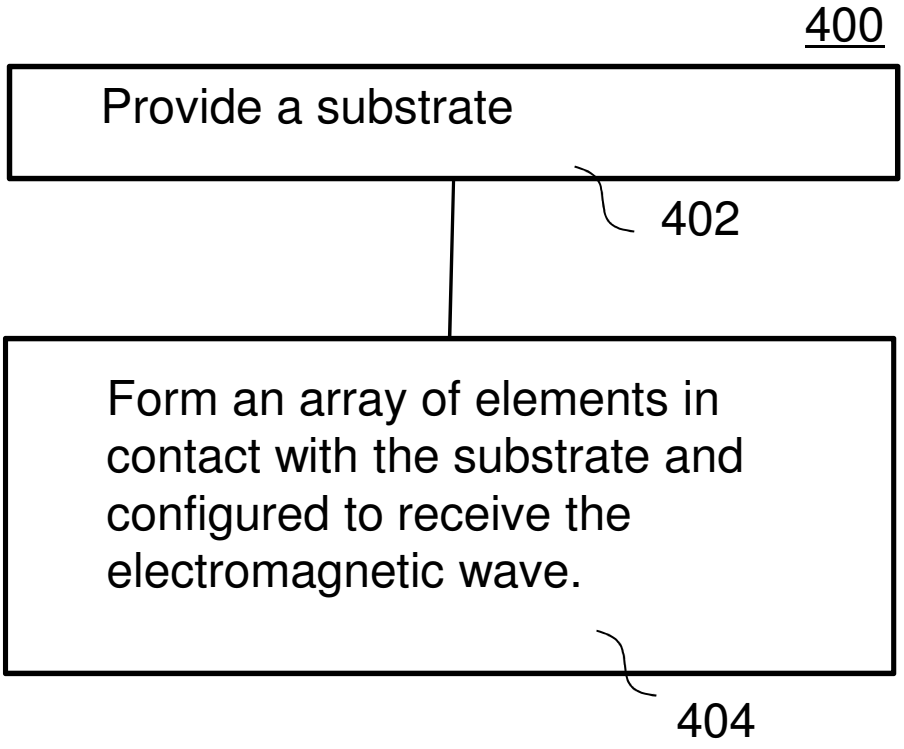

400
Provide a substrate
402
Form an array of elements in contact with the substrate and configured to receive the electromagnetic wave.
404

FIG. 5

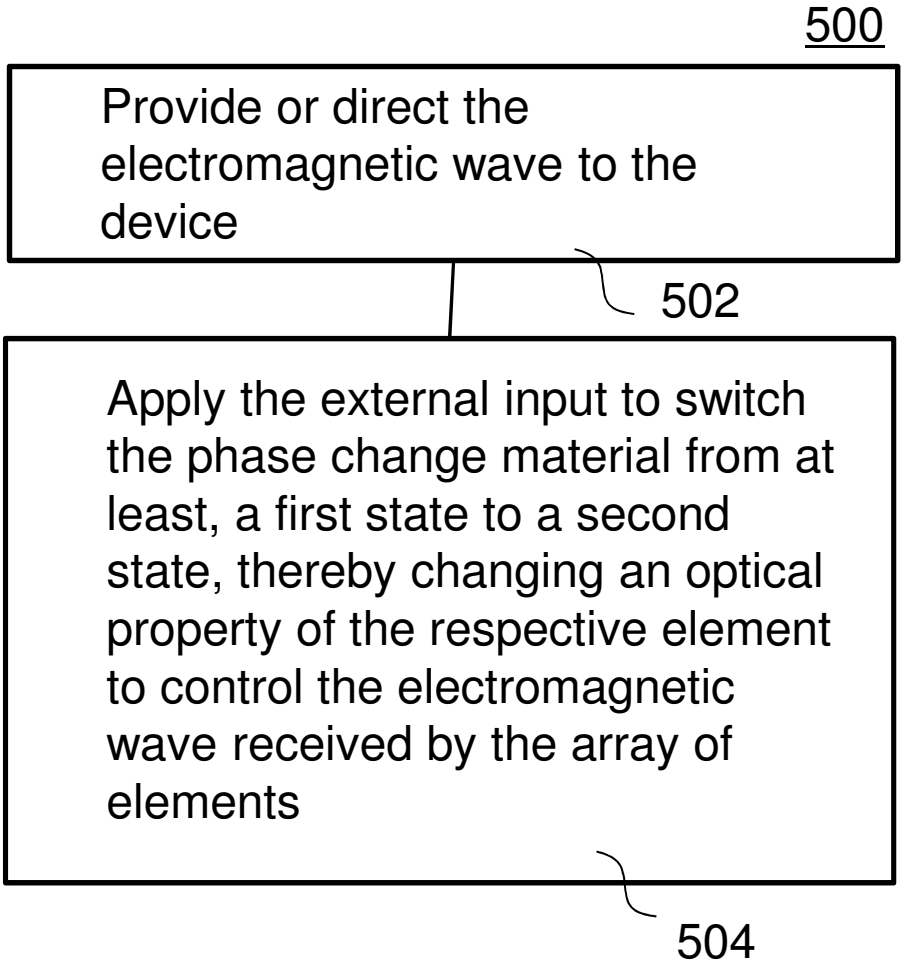

500
Provide or direct the electromagnetic wave to the device
502
Apply the external input to switch the phase change material from at least, a first state to a second state, thereby changing an optical property of the respective element to control the electromagnetic wave received by the array of elements
504

FIG. 6A

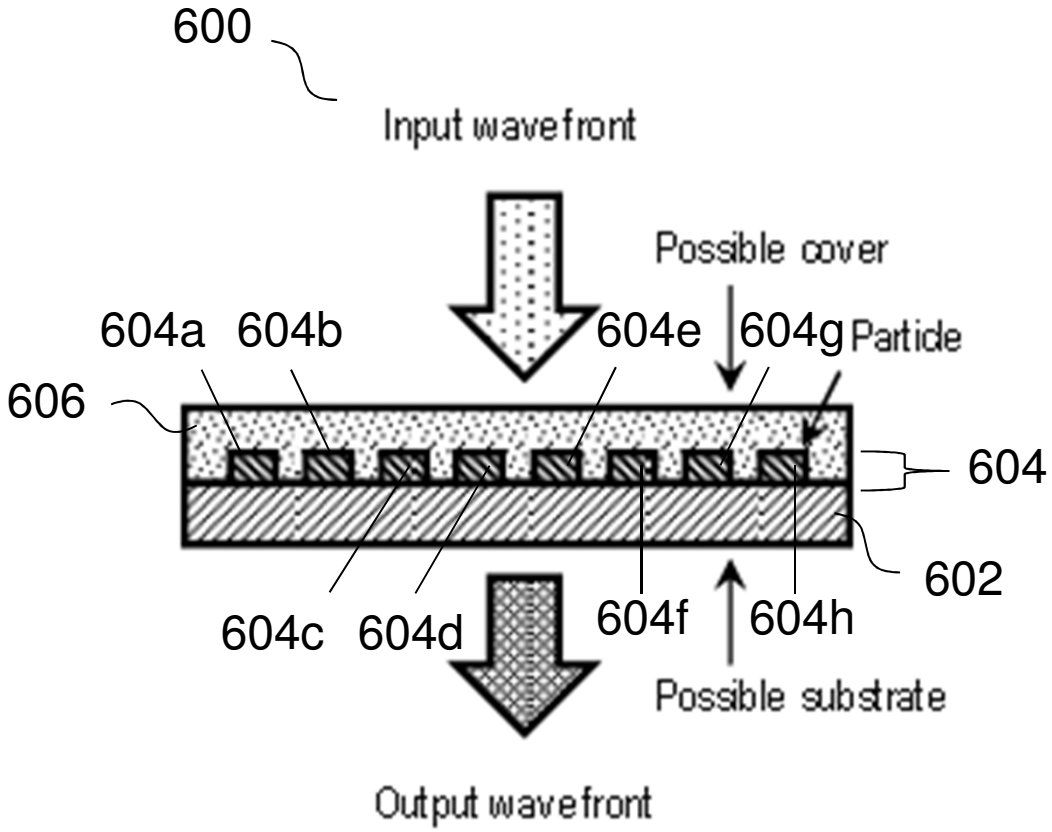
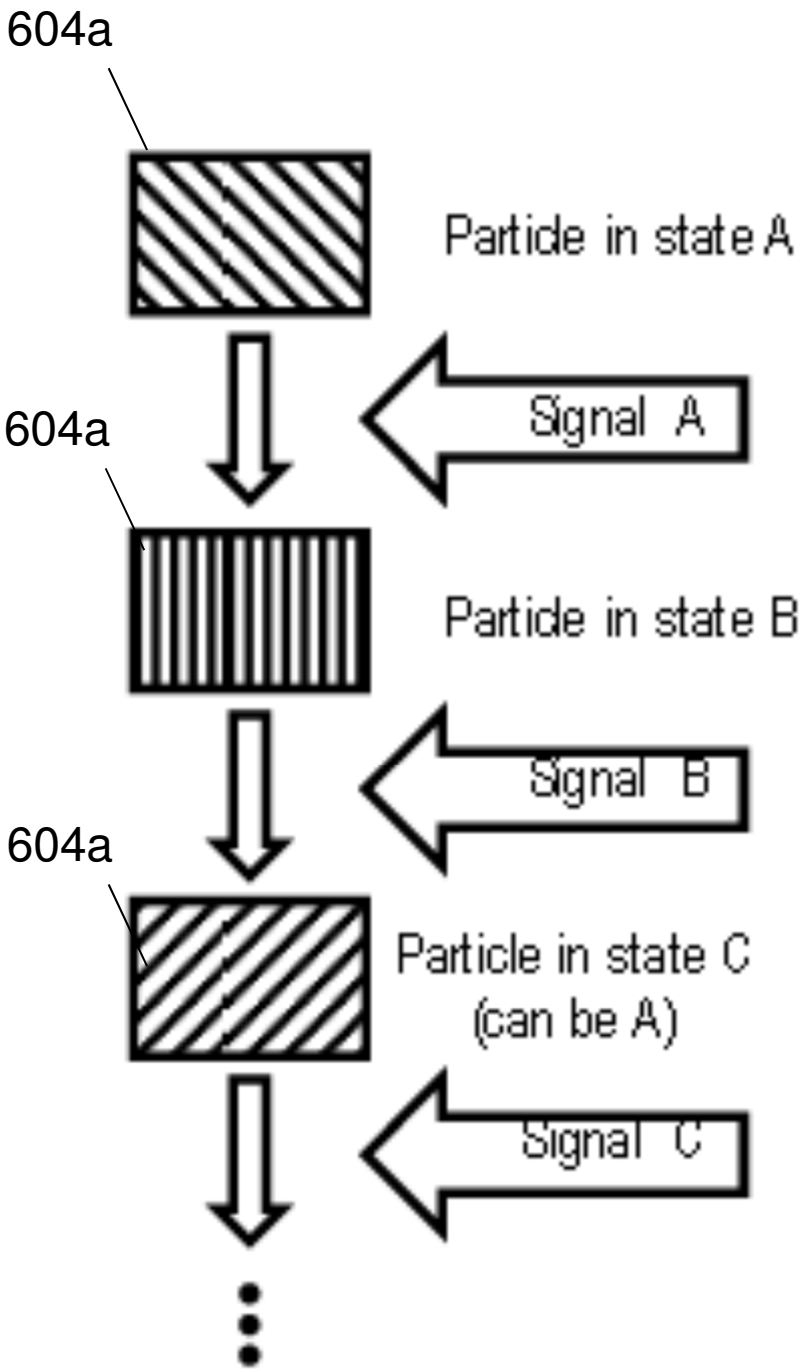

600
Input wavefront
Possible cover
604a
604b
604e
604g
Particle
606
604
602
604c
604d
604f
604h
Possible substrate
Output wavefront

FIG. 6B


604a
Particle in state A
Signal A
604a
Particle in state B
Signal B
604a
Particle in state C
(can be A)
Signal C

600c

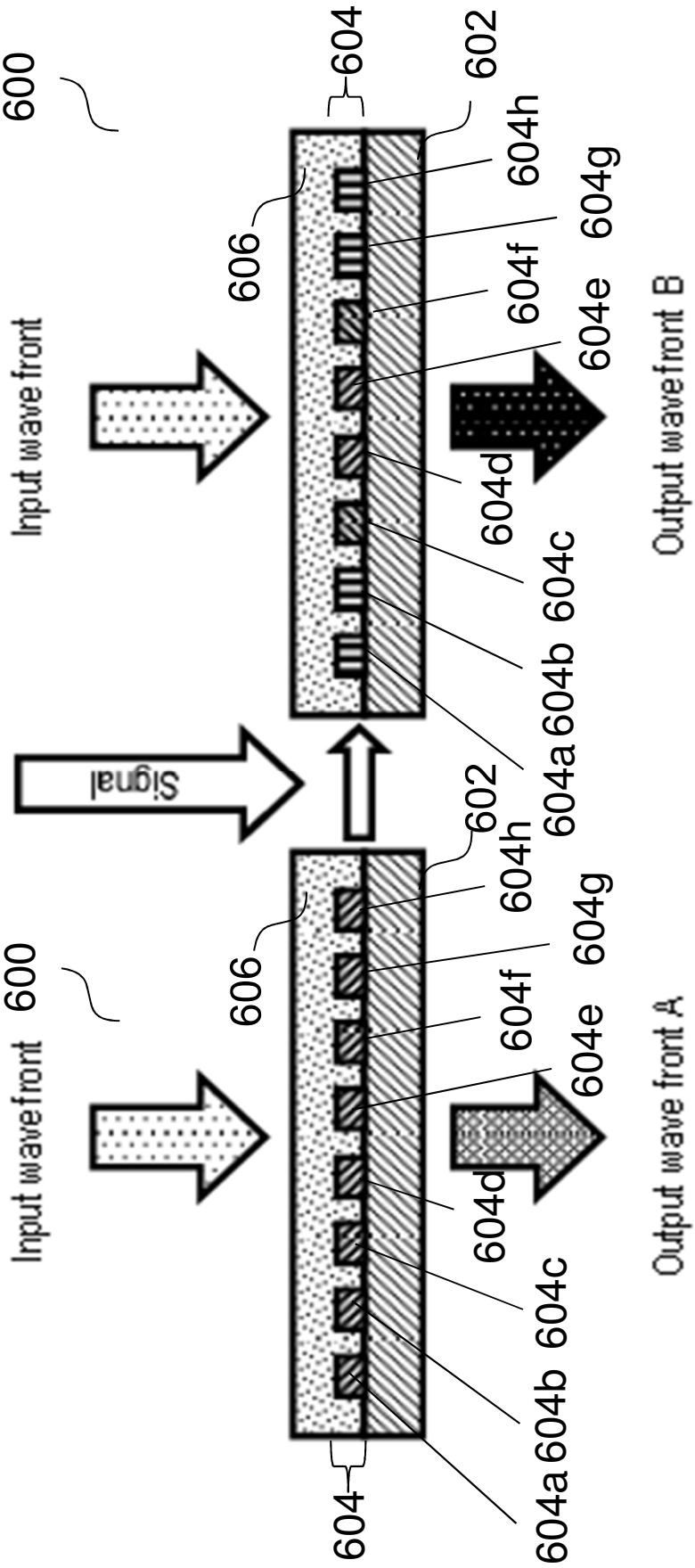

600
604
602
606
604h
604g
604f
604e
604d
604c
604b
604a
Input wavefront
Output wavefront B
Signal
Output wavefront A

FIG. 6C

FIG. 6D

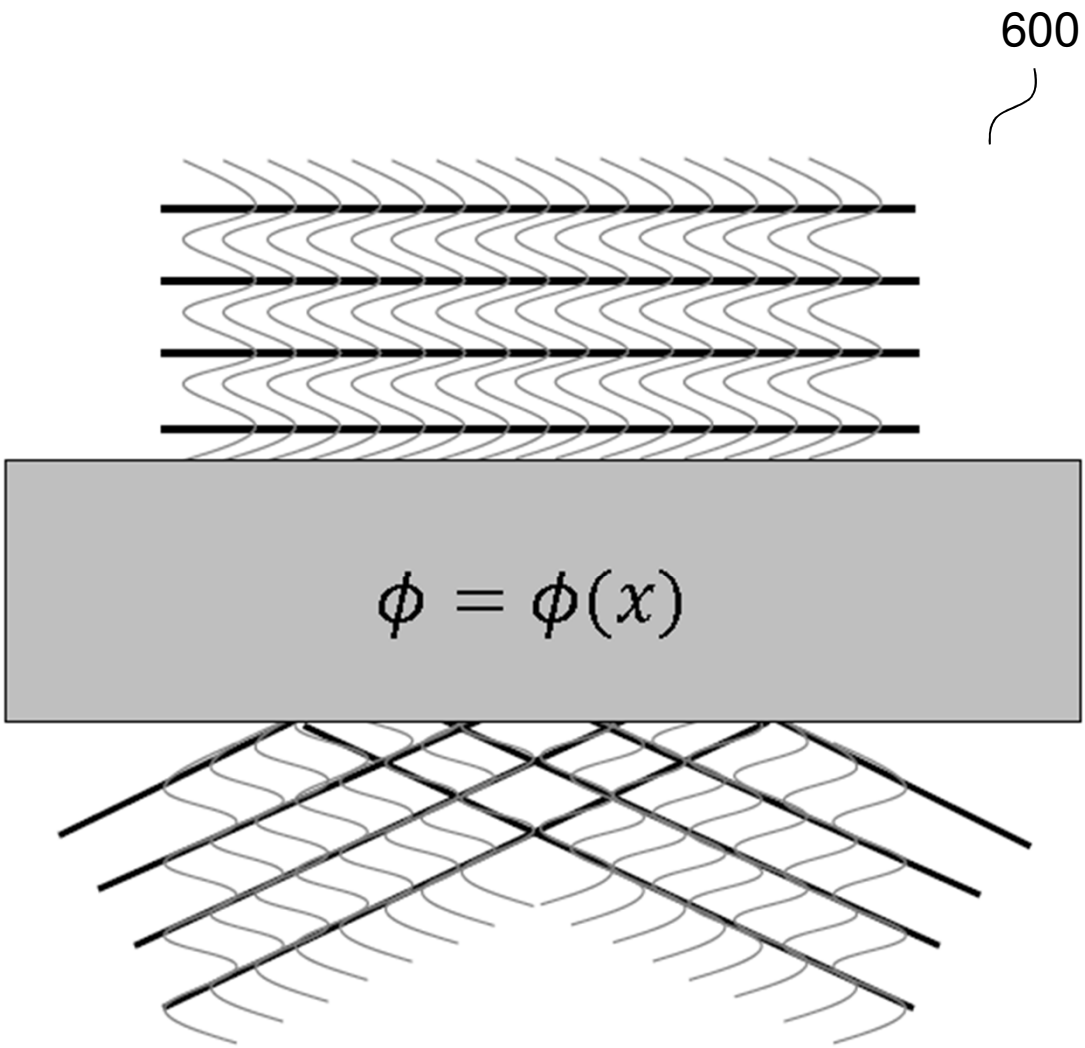


FIG. 7A

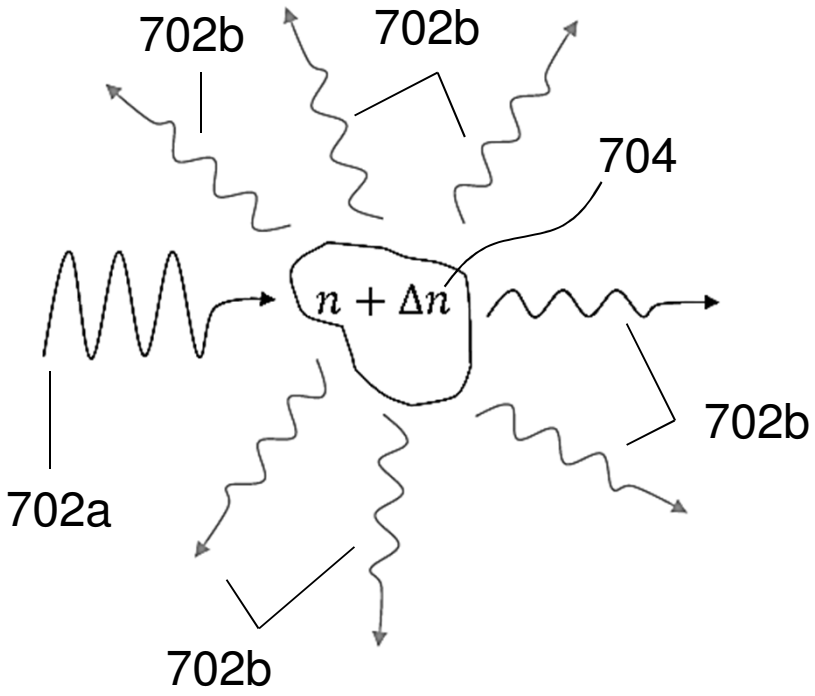


FIG. 7B

710

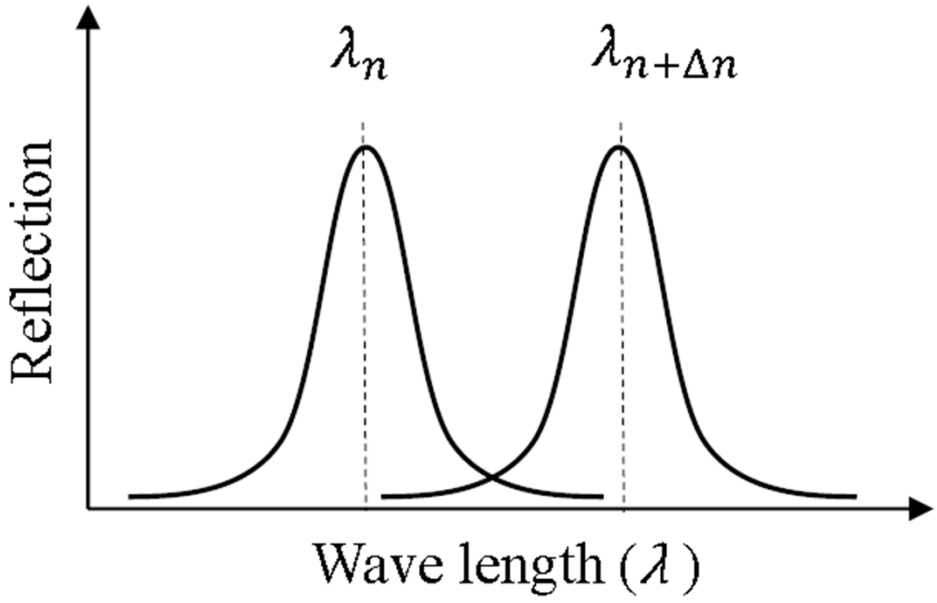


FIG. 7C

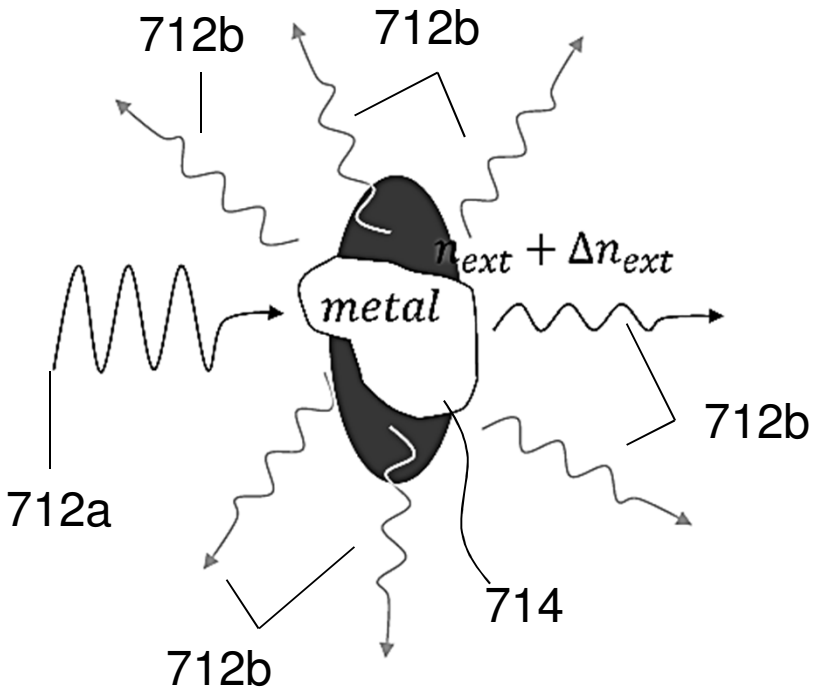


FIG. 7D

720

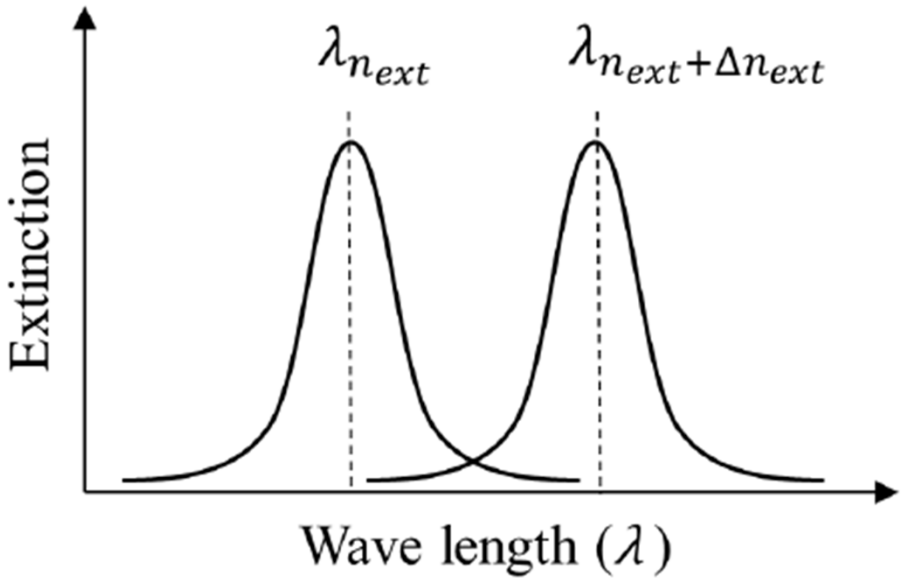


FIG. 7E

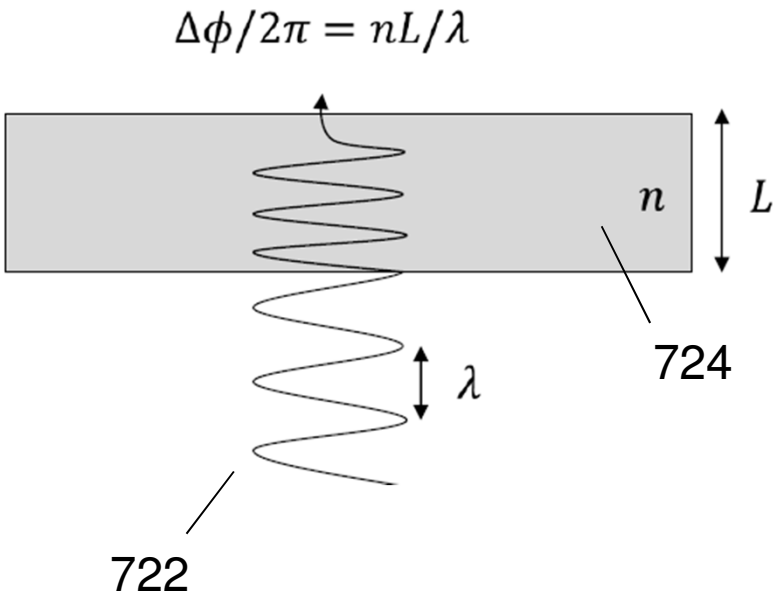

$\Delta\phi/2\pi = nL/\lambda$
n
L
λ
724
722

FIG. 7F

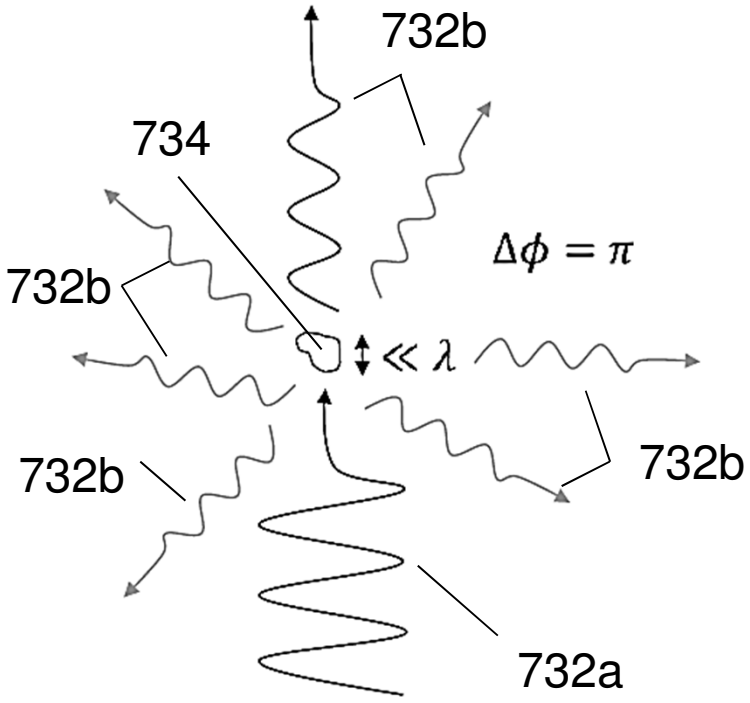

732b
734
$\Delta\phi = \pi$
732b
$\ll \lambda$
732b
732b
732a

FIG. 7G

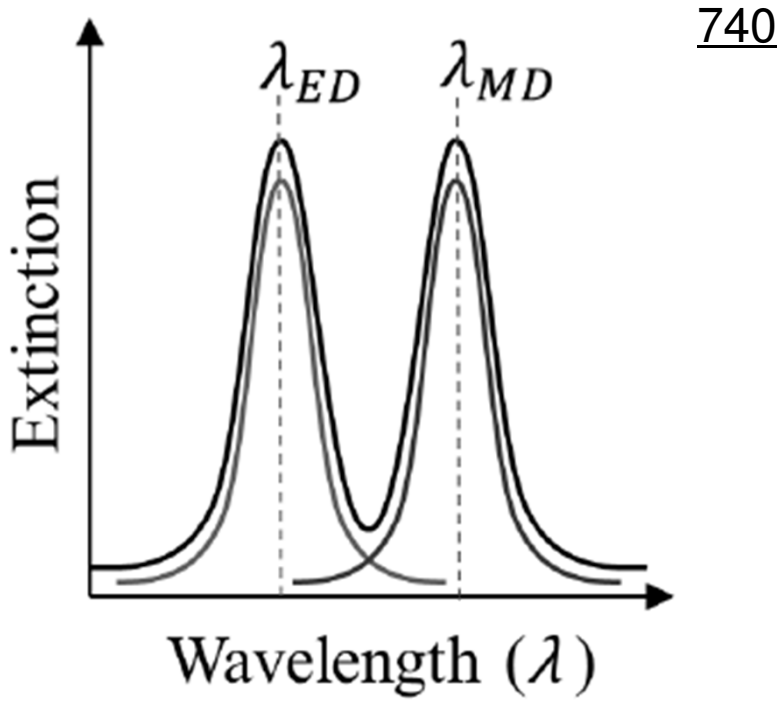

740
λ_{ED}
λ_{MD}
Extinction
Wavelength (λ)

FIG. 7H

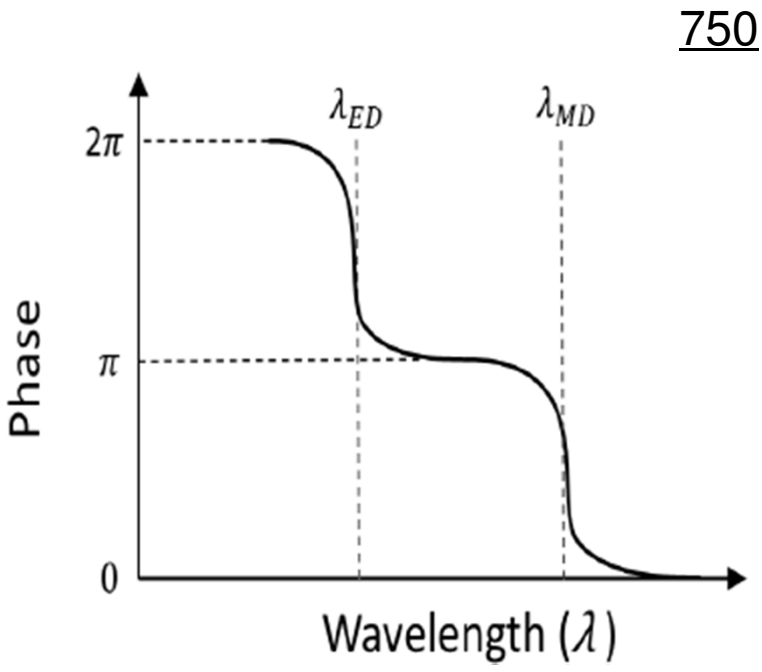

750
λ_{ED}
λ_{MD}
2π
π
0
Phase
Wavelength (λ)

FIG. 7I

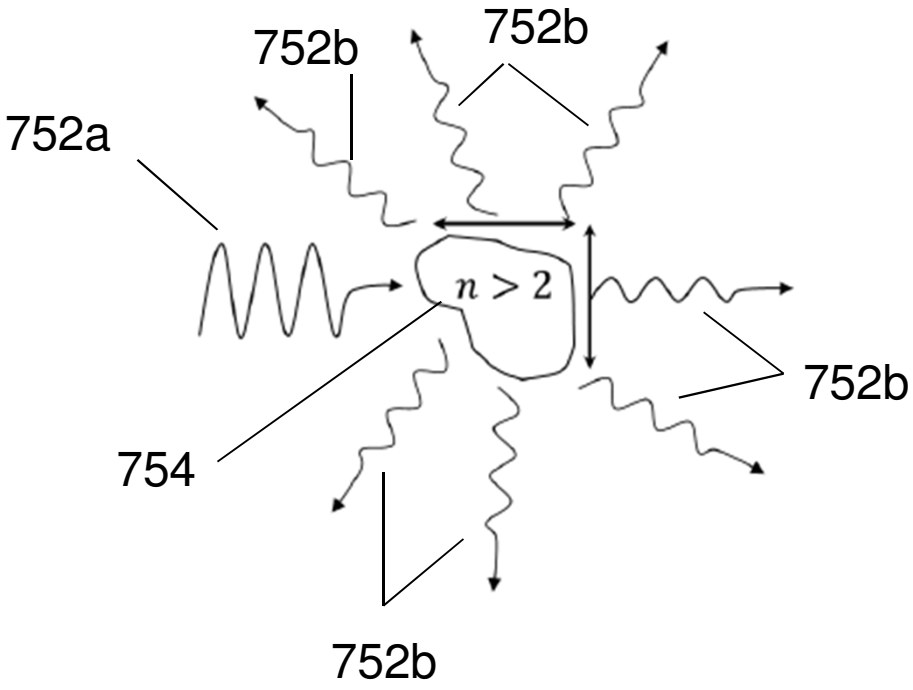


FIG. 7J

760

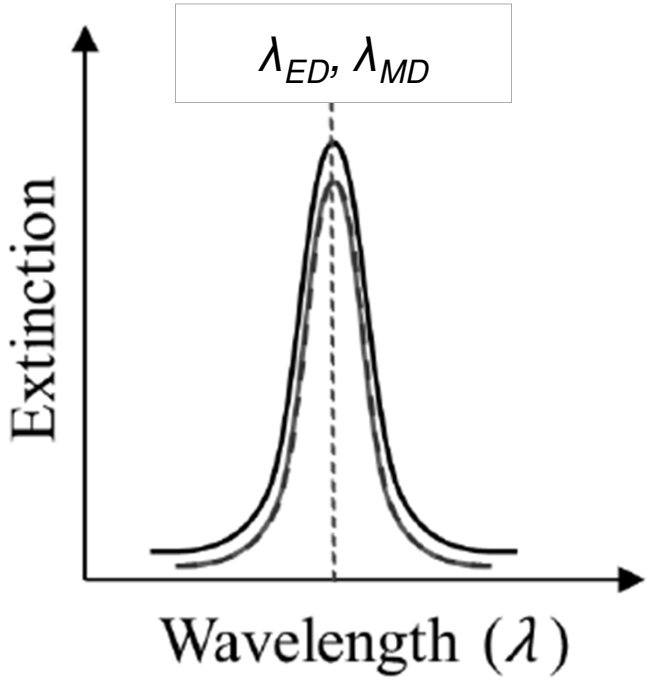


FIG. 7K

770

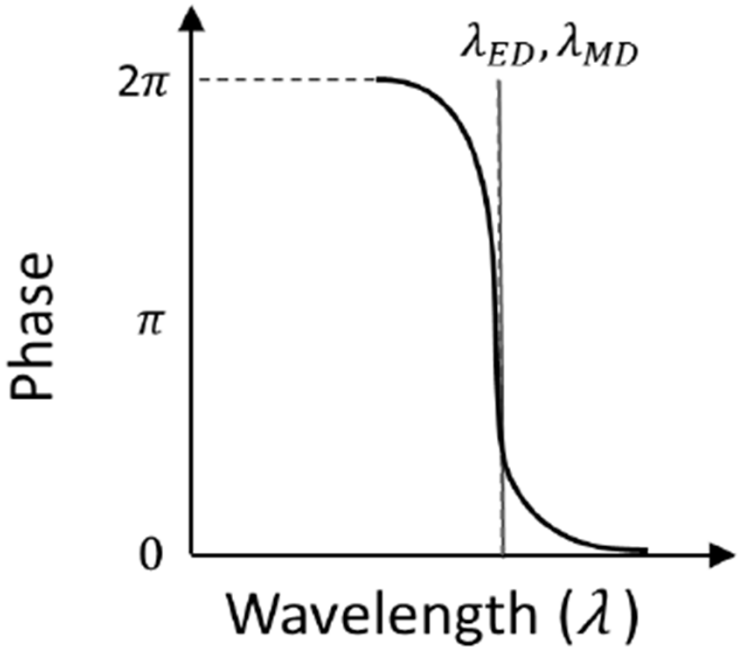


FIG. 7L

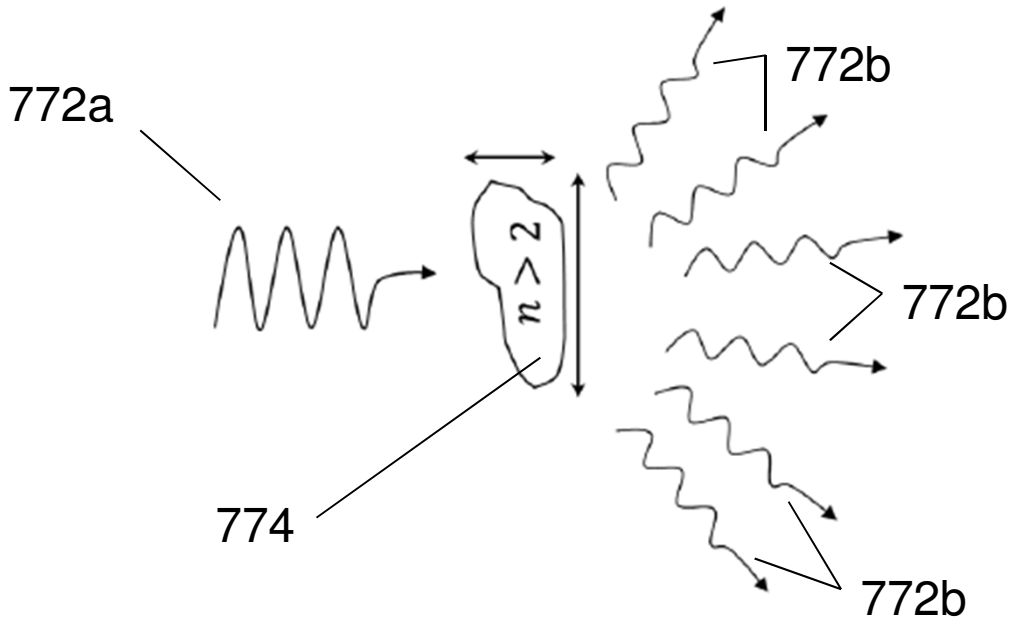


FIG. 8A

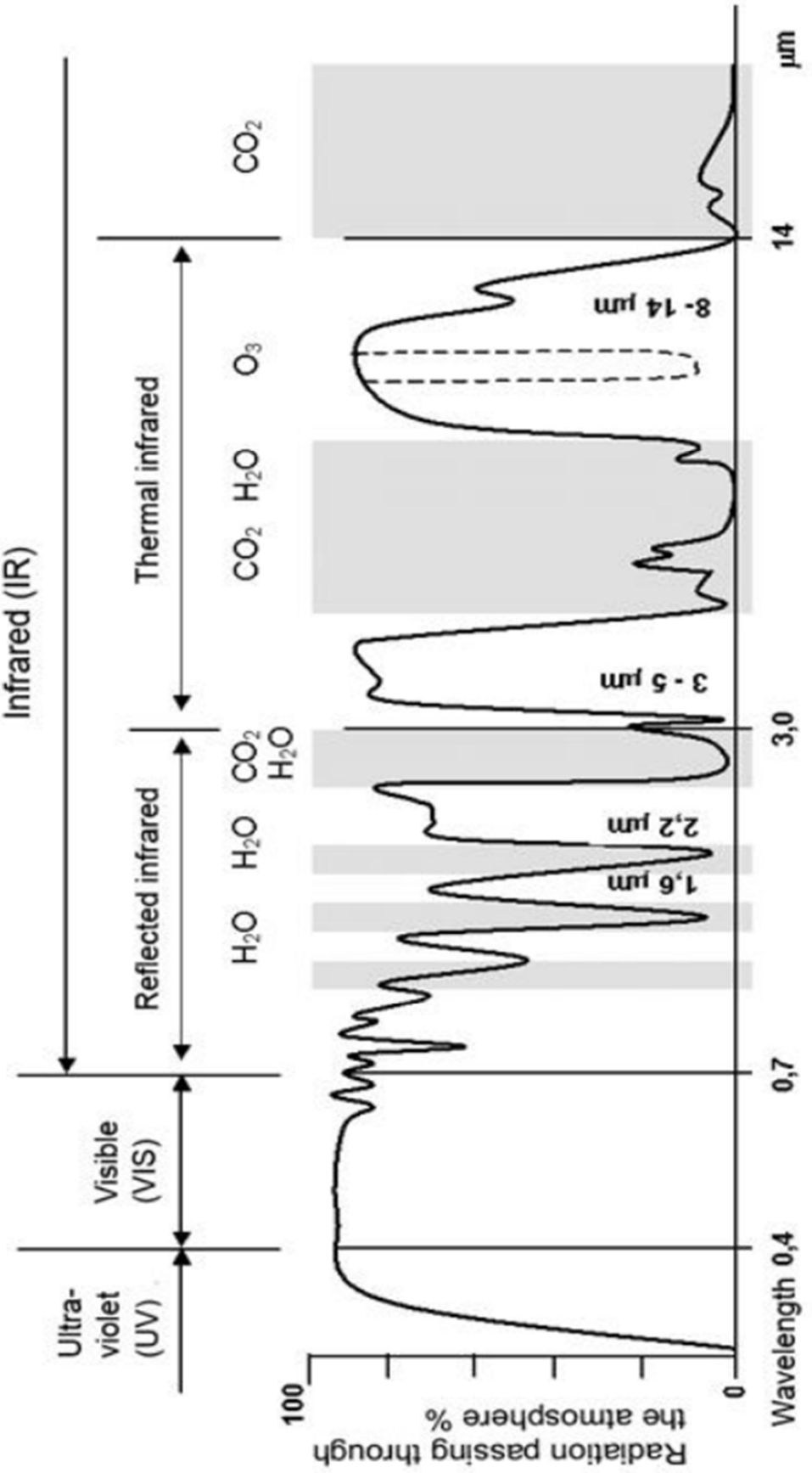

800a
Infrared (IR)
Ultra-violet (UV)
Visible (VIS)
Reflected infrared
Thermal infrared
H_2O
H_2O
CO_2
H_2O
CO_2
H_2O
O_3
CO_2
1,6 µm
2,2 µm
3 - 5 µm
8- 14 µm
100
0
Radiation passing through the atmosphere %
Wavelength 0,4
0,7
3,0
14
µm

FIG. 8B

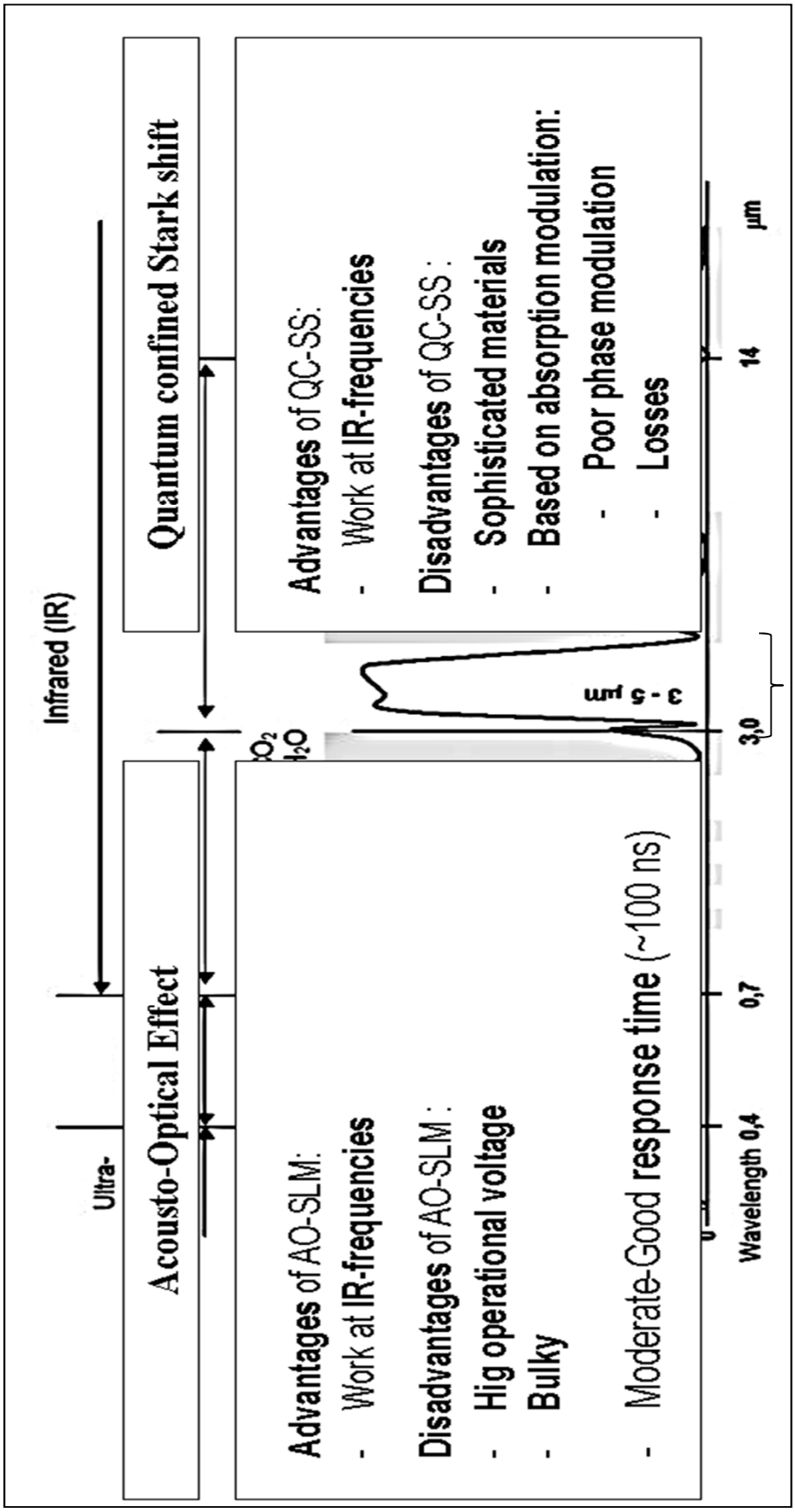

800b
Infrared (IR)
Ultra-
Acousto-Optical Effect
Quantum confined Stark shift
Advantages of AO-SLM:
- Work at IR-frequencies
Disadvantages of AO-SLM :
- Hig operational voltage
- Bulky
- Moderate-Good response time (~100 ns)
Advantages of QC-SS:
- Work at IR-frequencies
Disadvantages of QC-SS :
- Sophisticated materials
- Based on absorption modulation:
- Poor phase modulation
- Losses
CO_2
H_2O
3 - 5 μm
3,0
0
Wavelength 0,4
0,7
14
μm
region of interest

FIG. 9

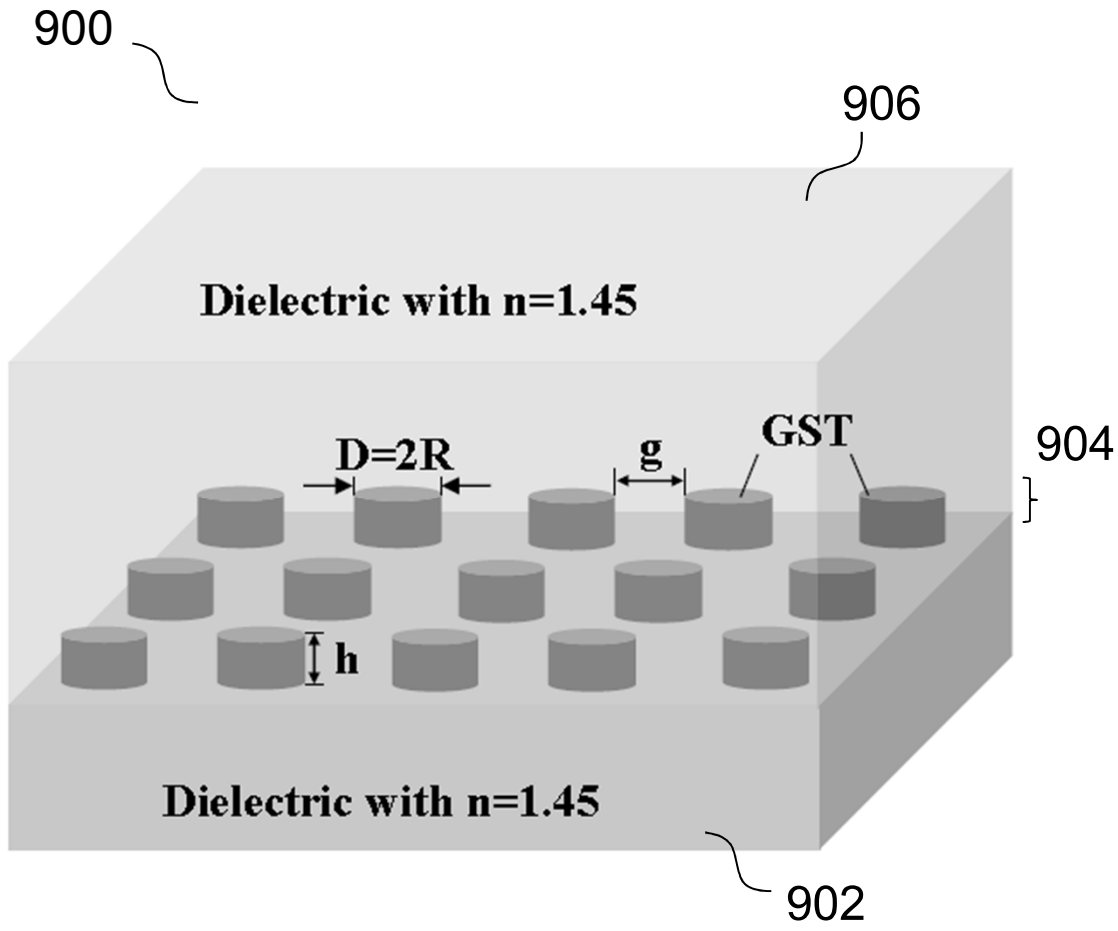

900
906
Dielectric with n=1.45
D=2R
g
GST
904
h
Dielectric with n=1.45
902

FIG. 10A

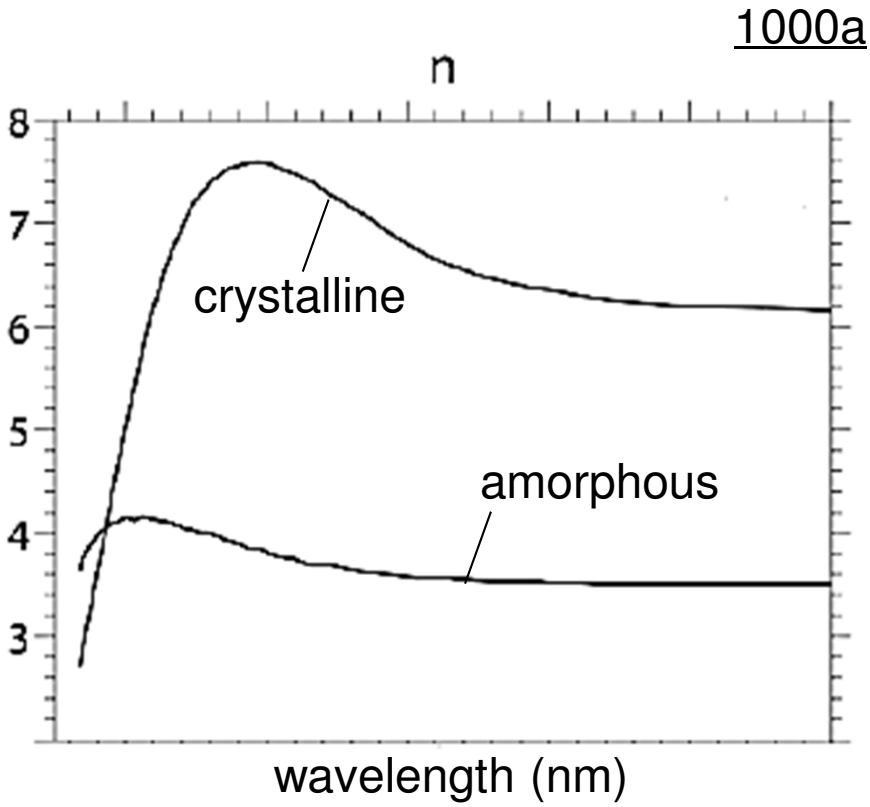


FIG. 10B

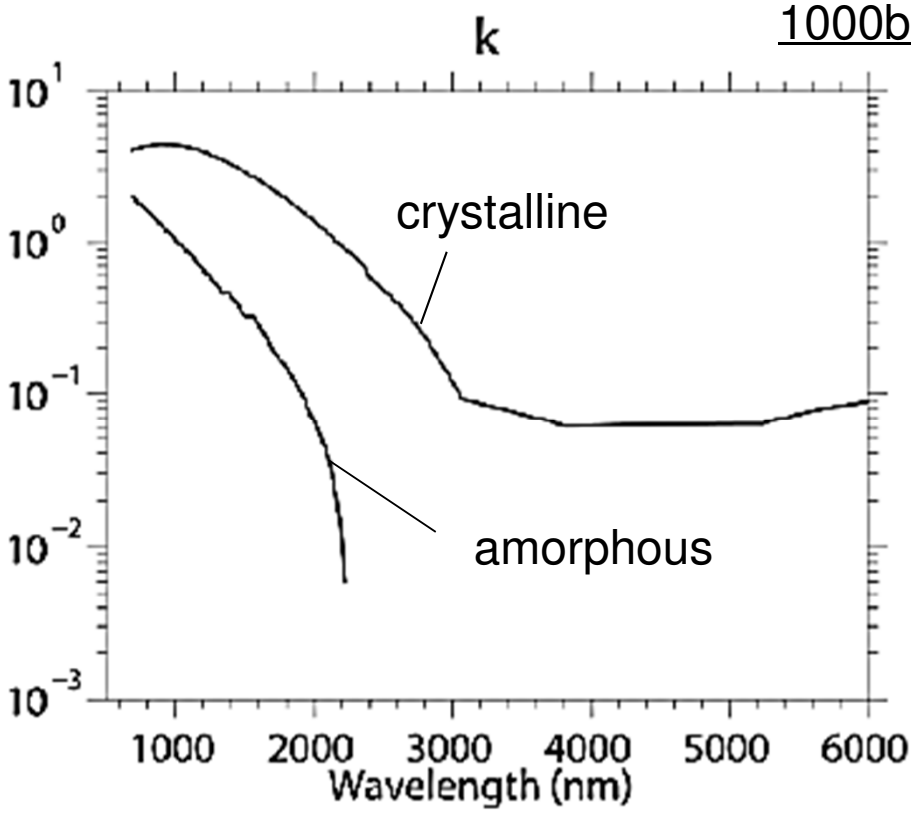


FIG. 10C

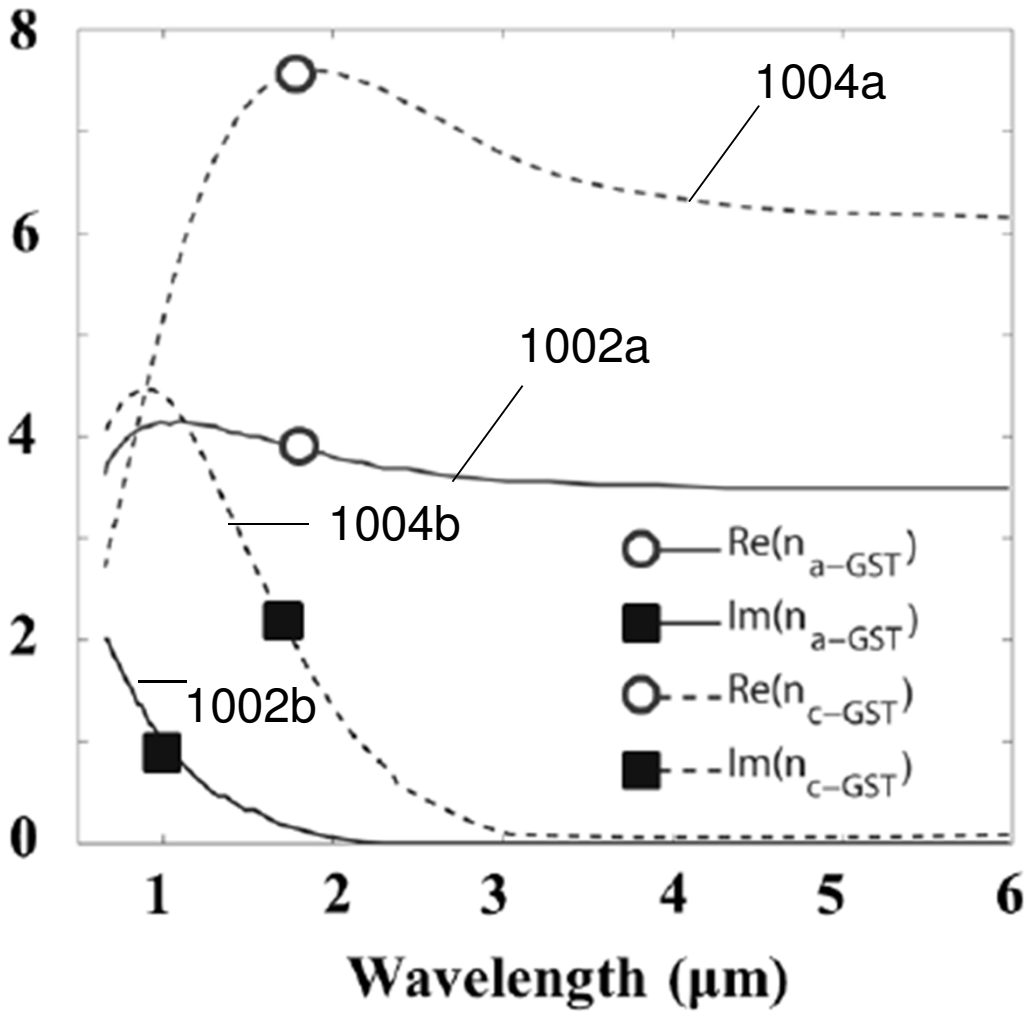

1000c
1004a
1002a
1004b
1002b
Re(n a–GST)
Im(n a–GST)
Re(n c–GST)
Im(n c–GST)
8
6
4
2
0
1
2
3
4
5
6
Wavelength (μm)

FIG. 11A

1100a

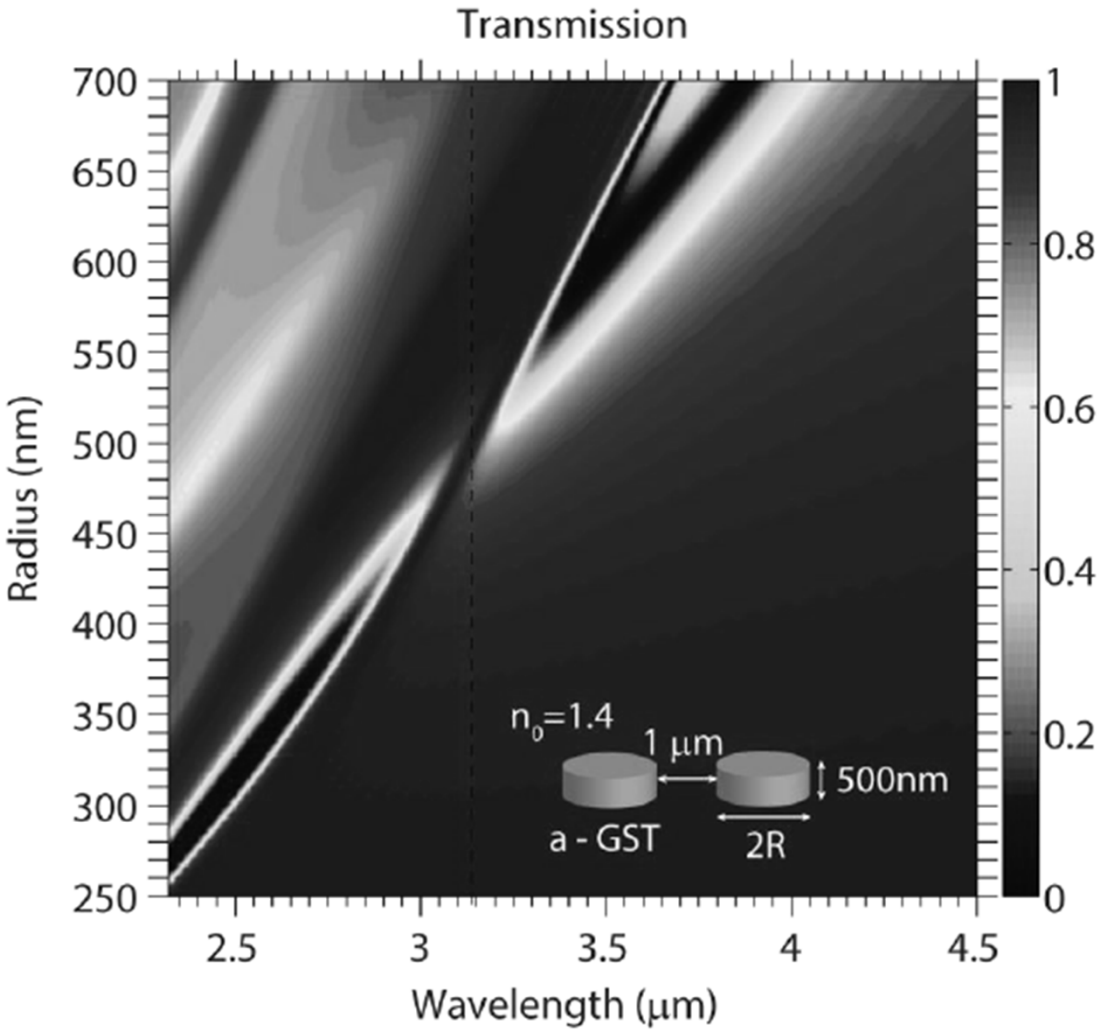


FIG. 11B

1100b

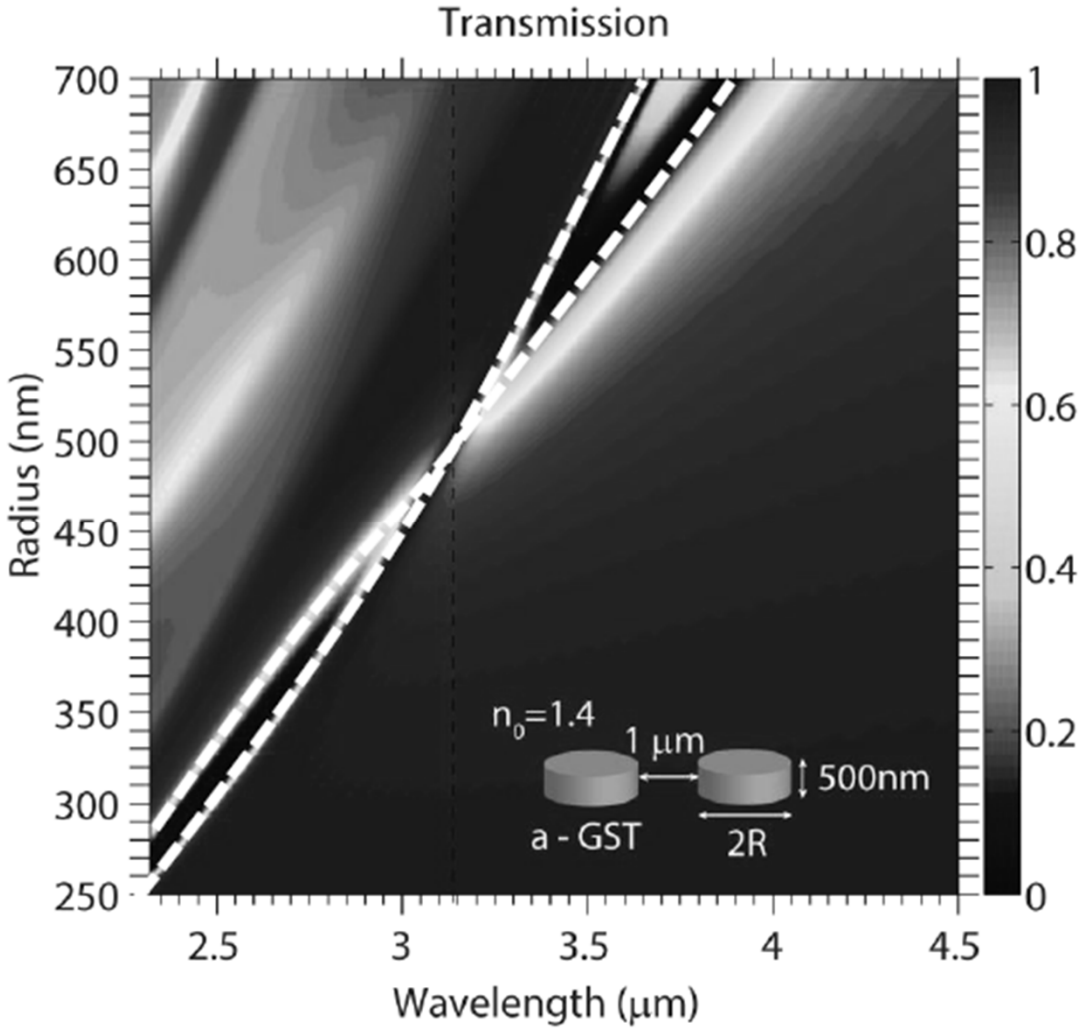


FIG. 11C

1100c

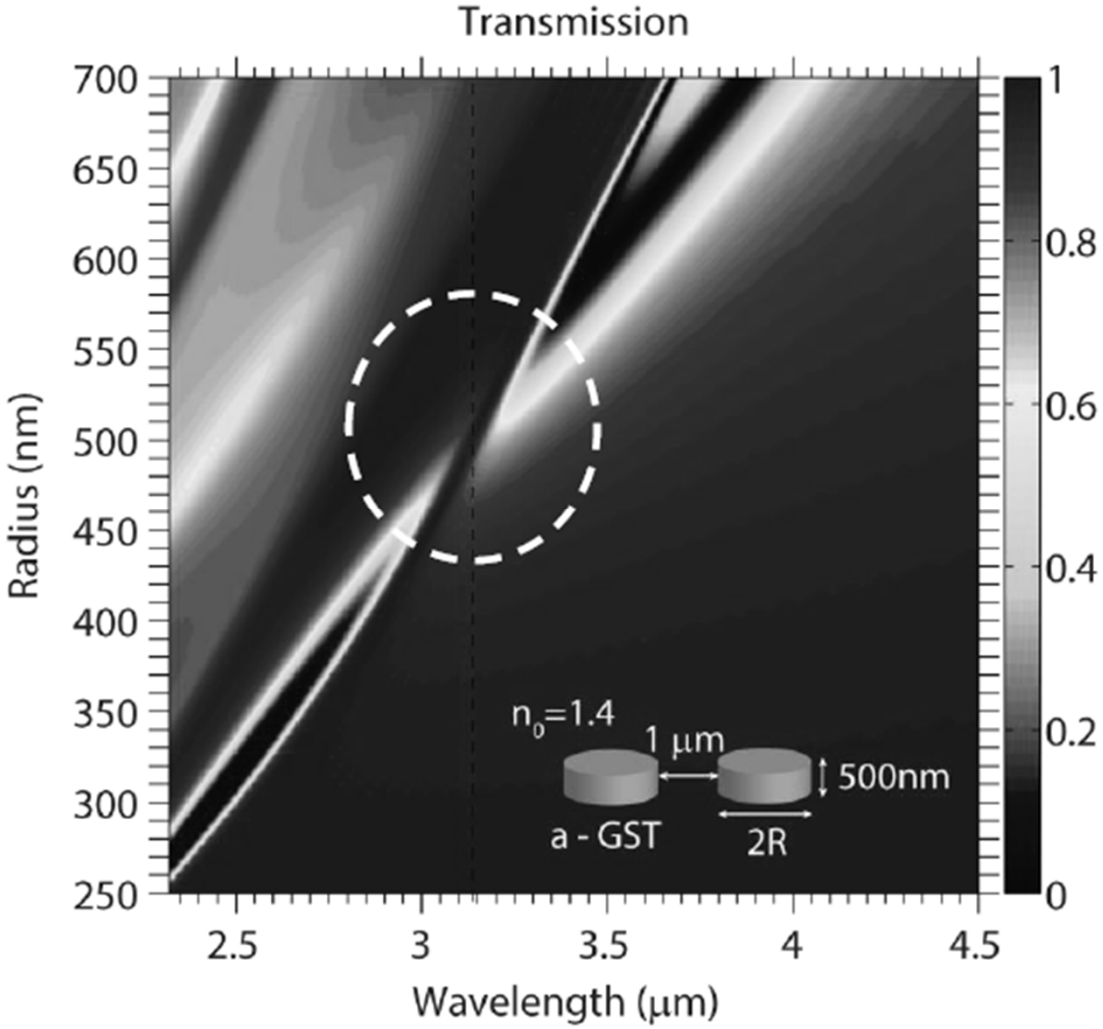


FIG. 11D

1100d

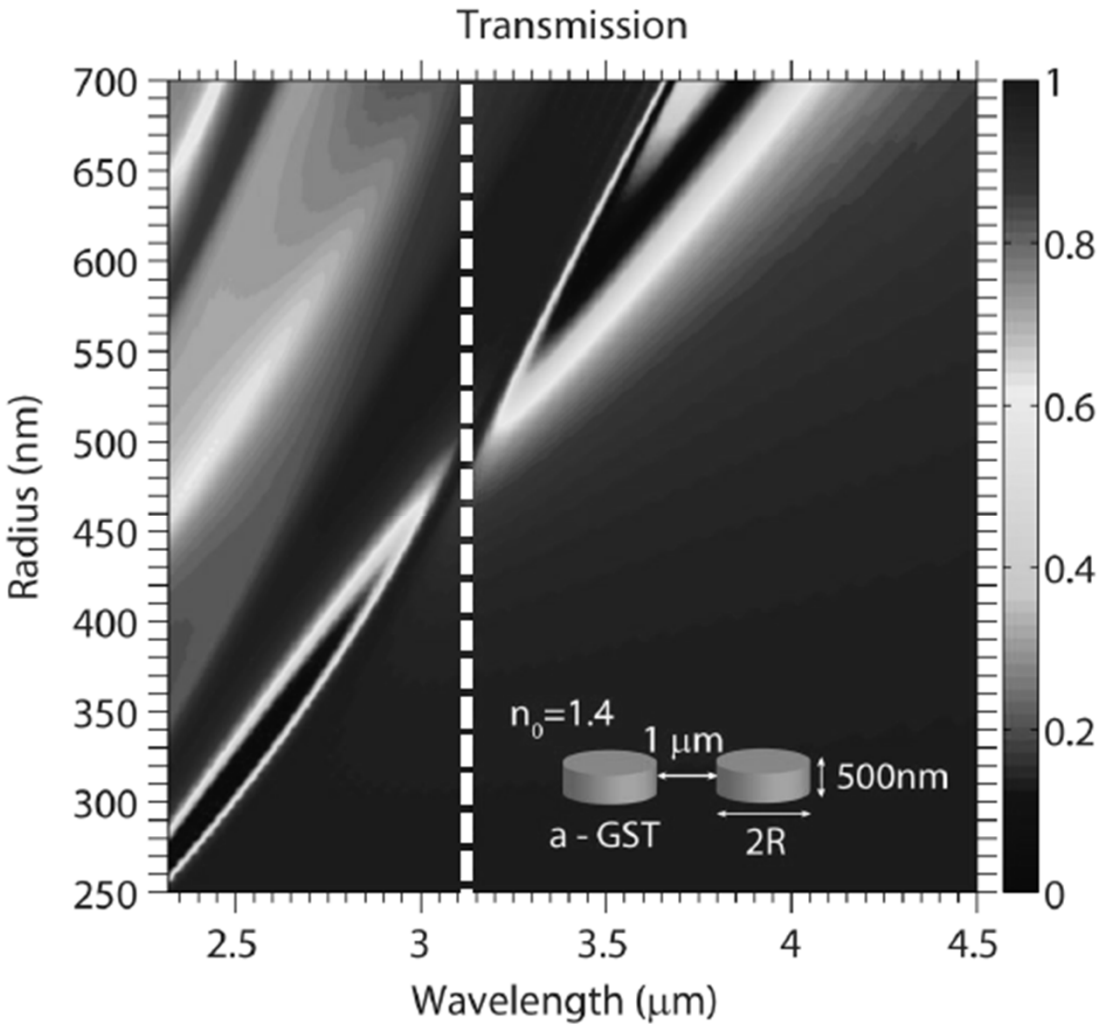


FIG. 11E

1100e

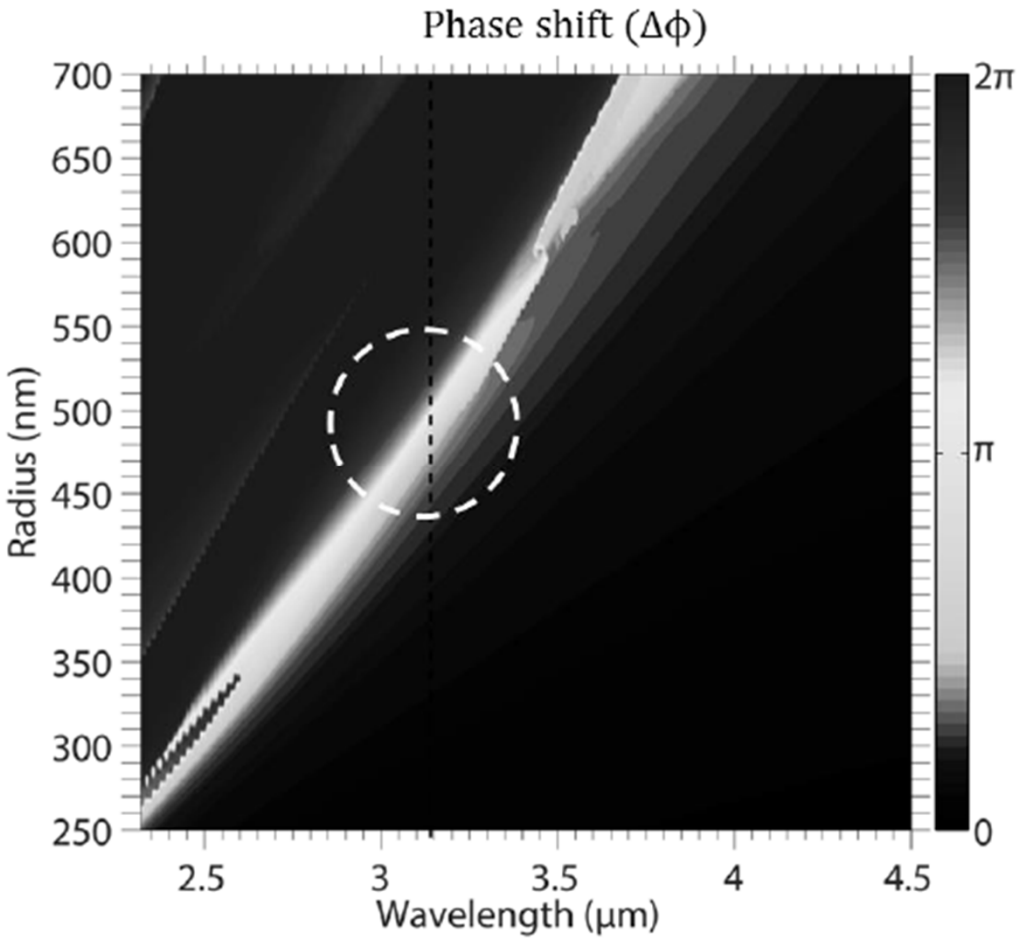


FIG. 11F

1100f

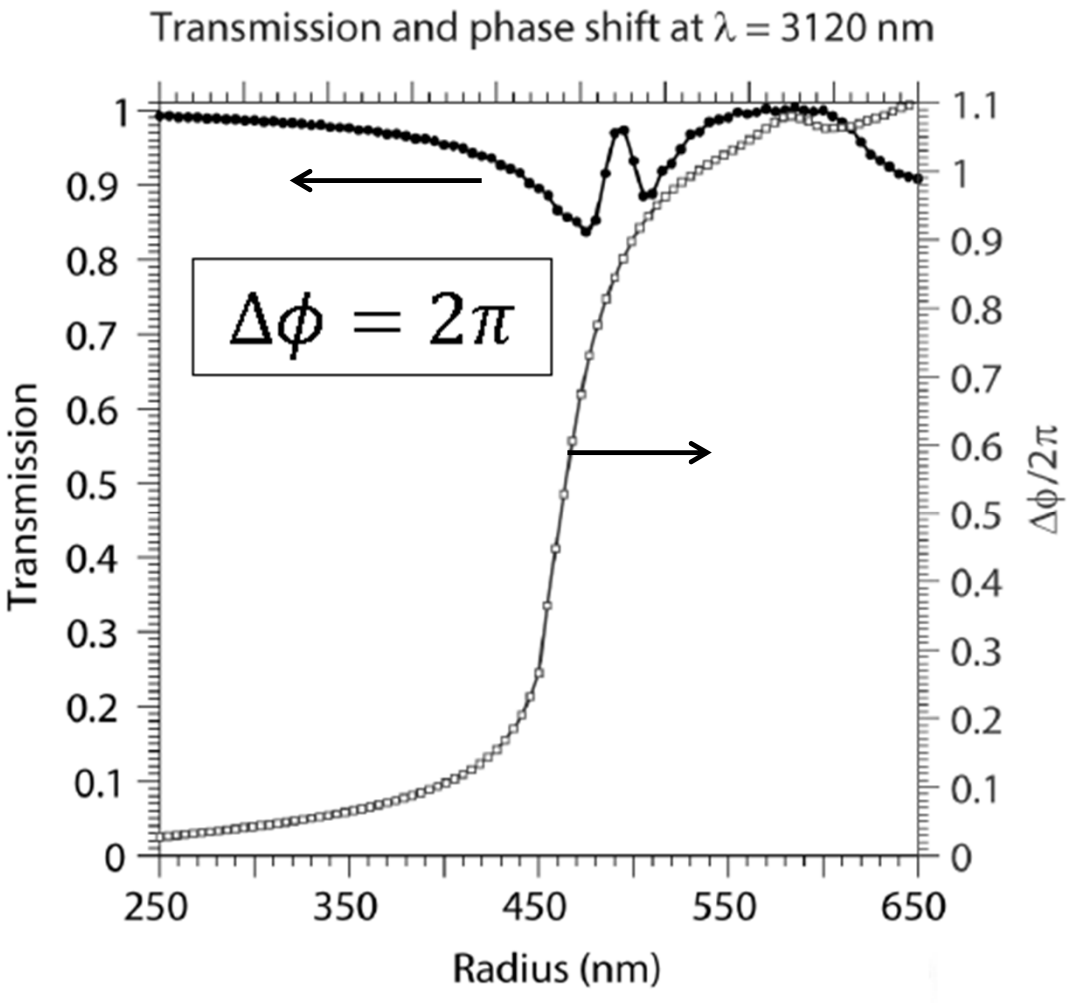


FIG. 12

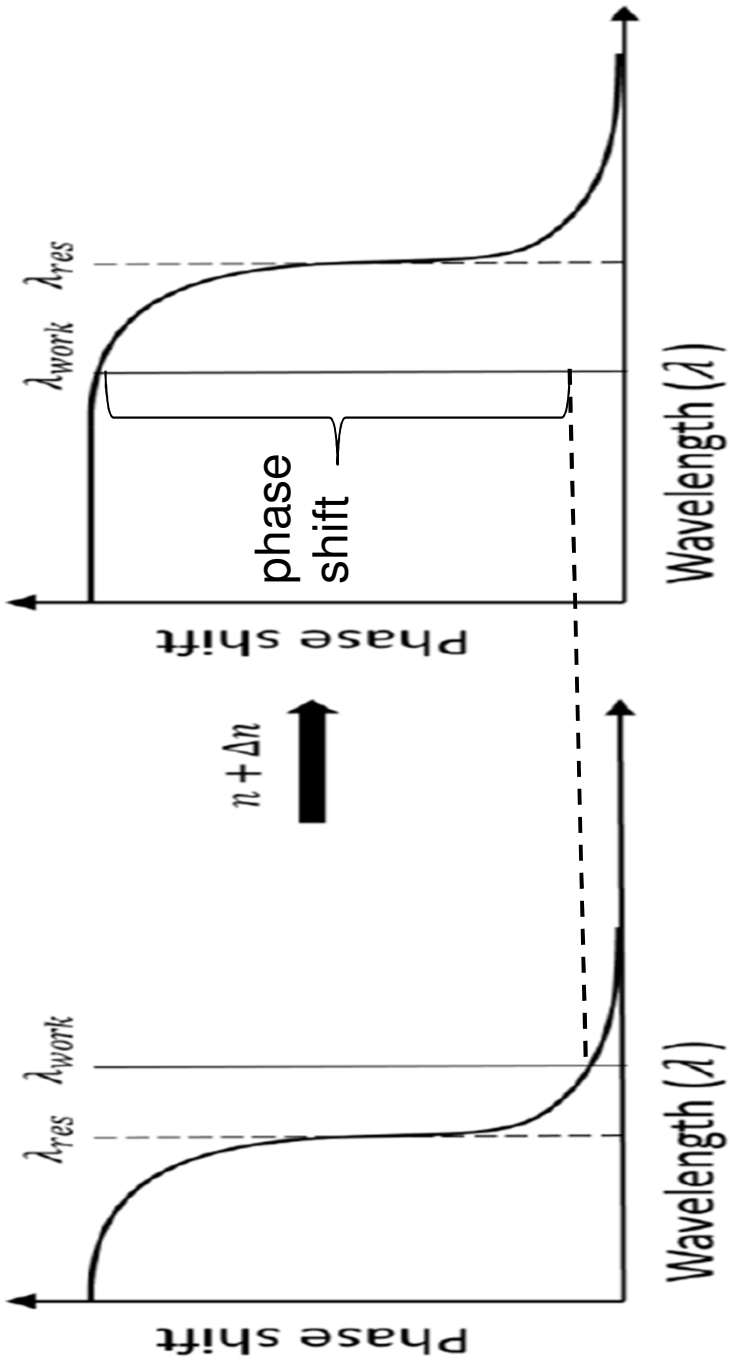

Phase shift
Wavelength (λ)
λres
λwork
phase shift
n + Δn
Phase shift
Wavelength (λ)
λres
λwork

FIG. 13A

1300a

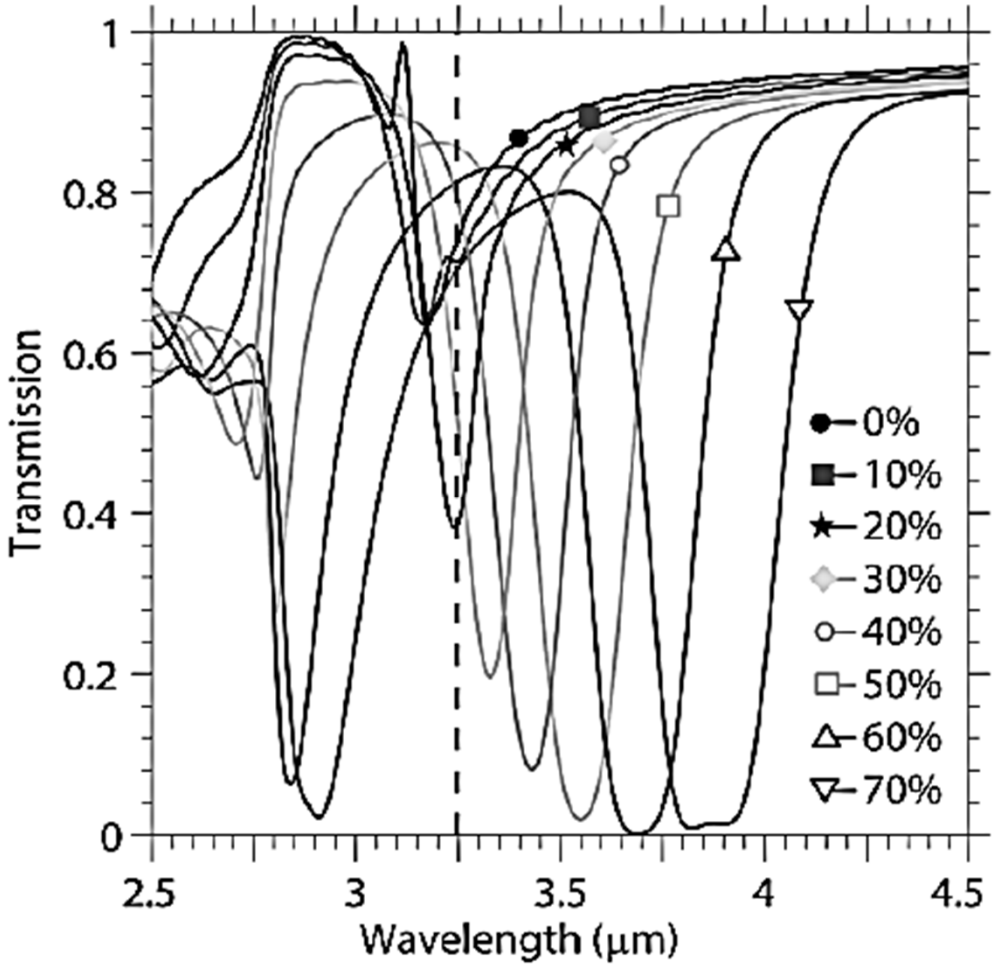


FIG. 13B

1300b

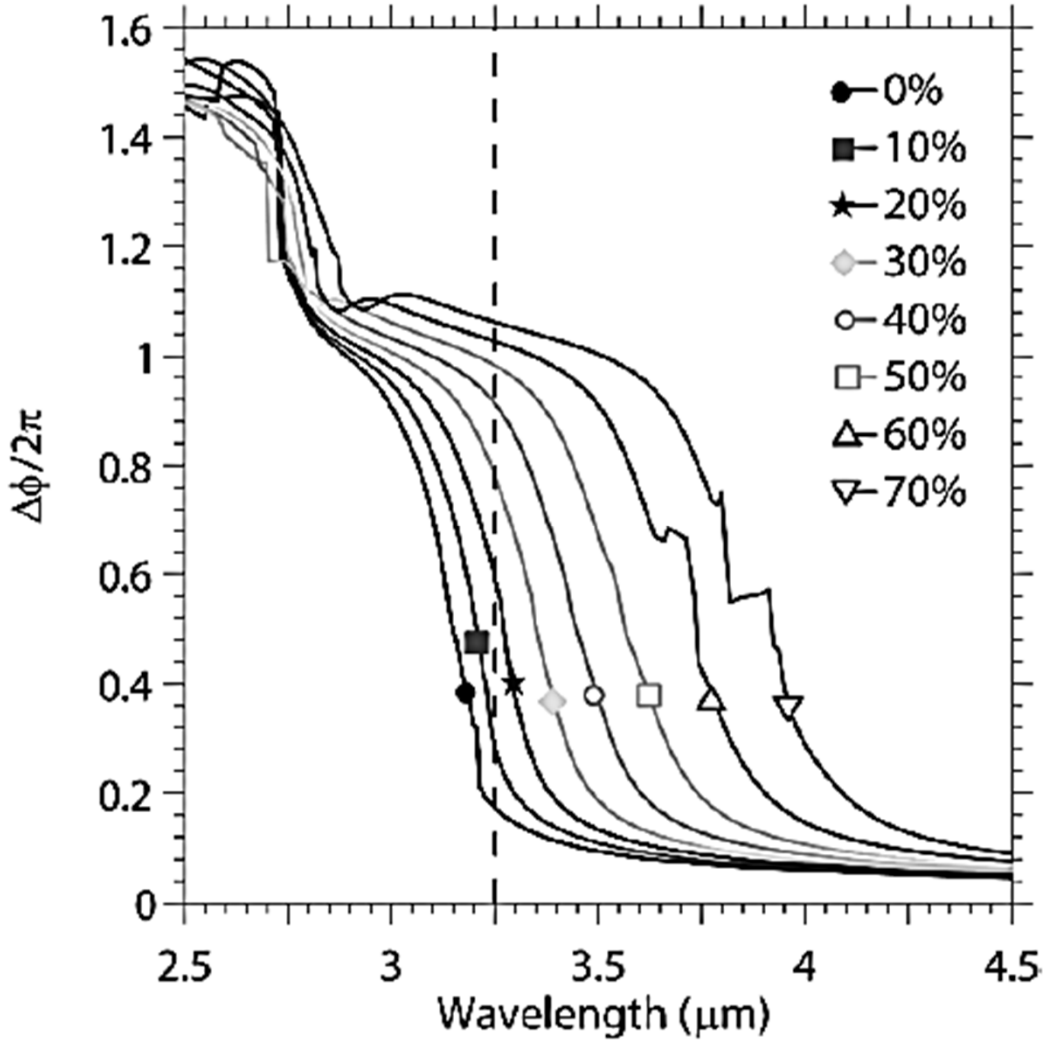


FIG. 13C

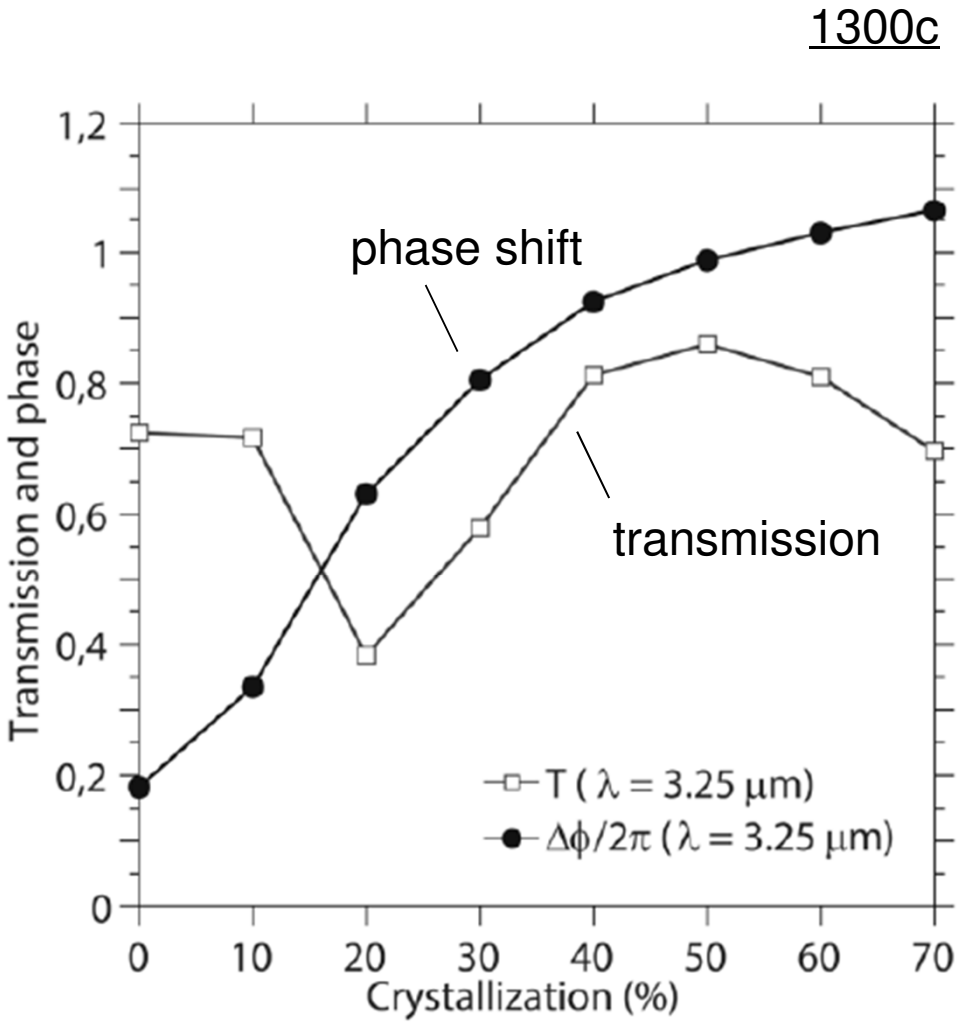

1300c
1,2
1
0,8
0,6
0,4
0,2
0
Transmission and phase
phase shift
transmission
T (λ = 3.25 μm)
Δϕ/2π (λ = 3.25 μm)
0
10
20
30
40
50
60
70
Crystallization (%)

FIG. 14

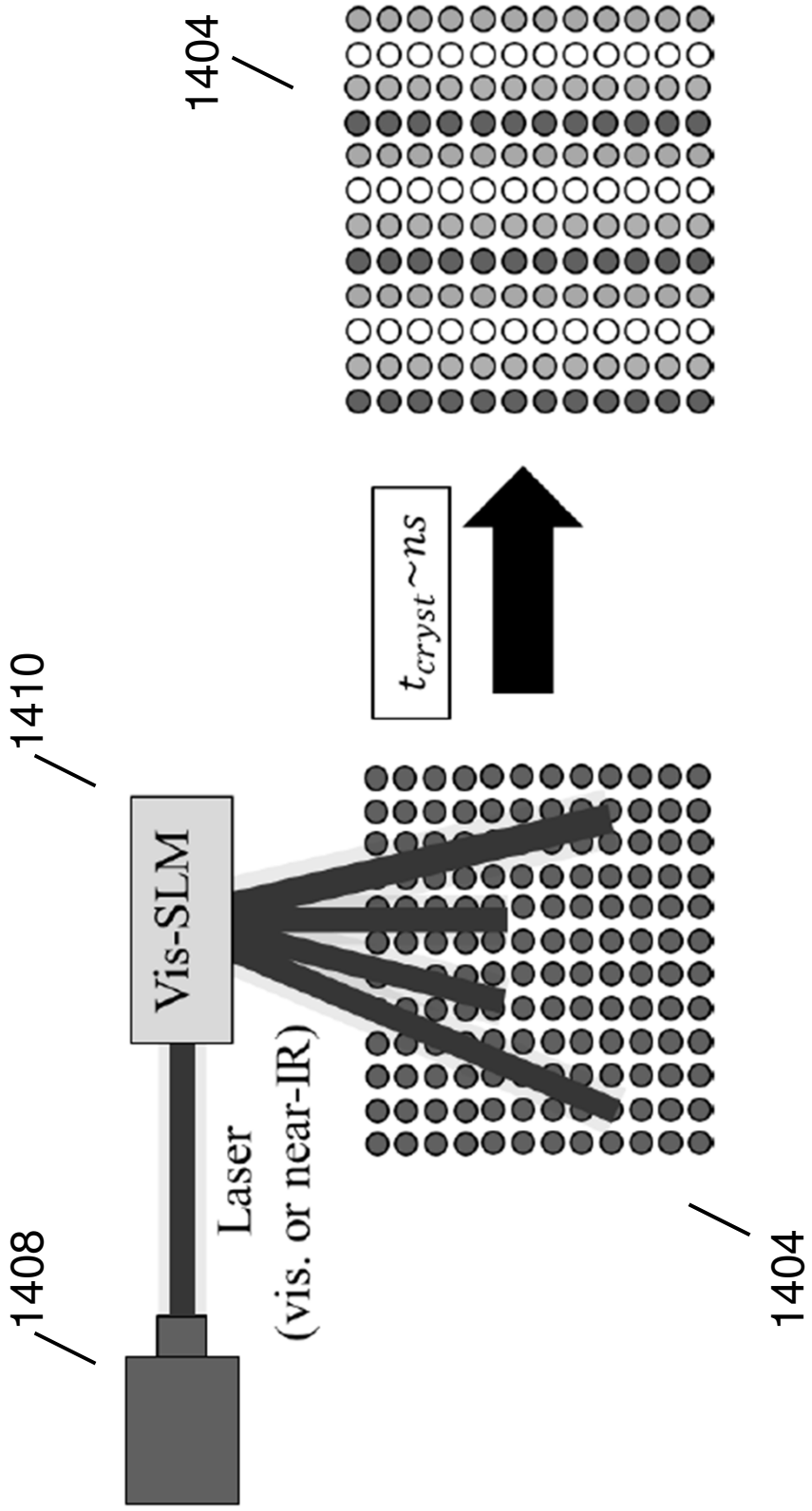


FIG. 15A

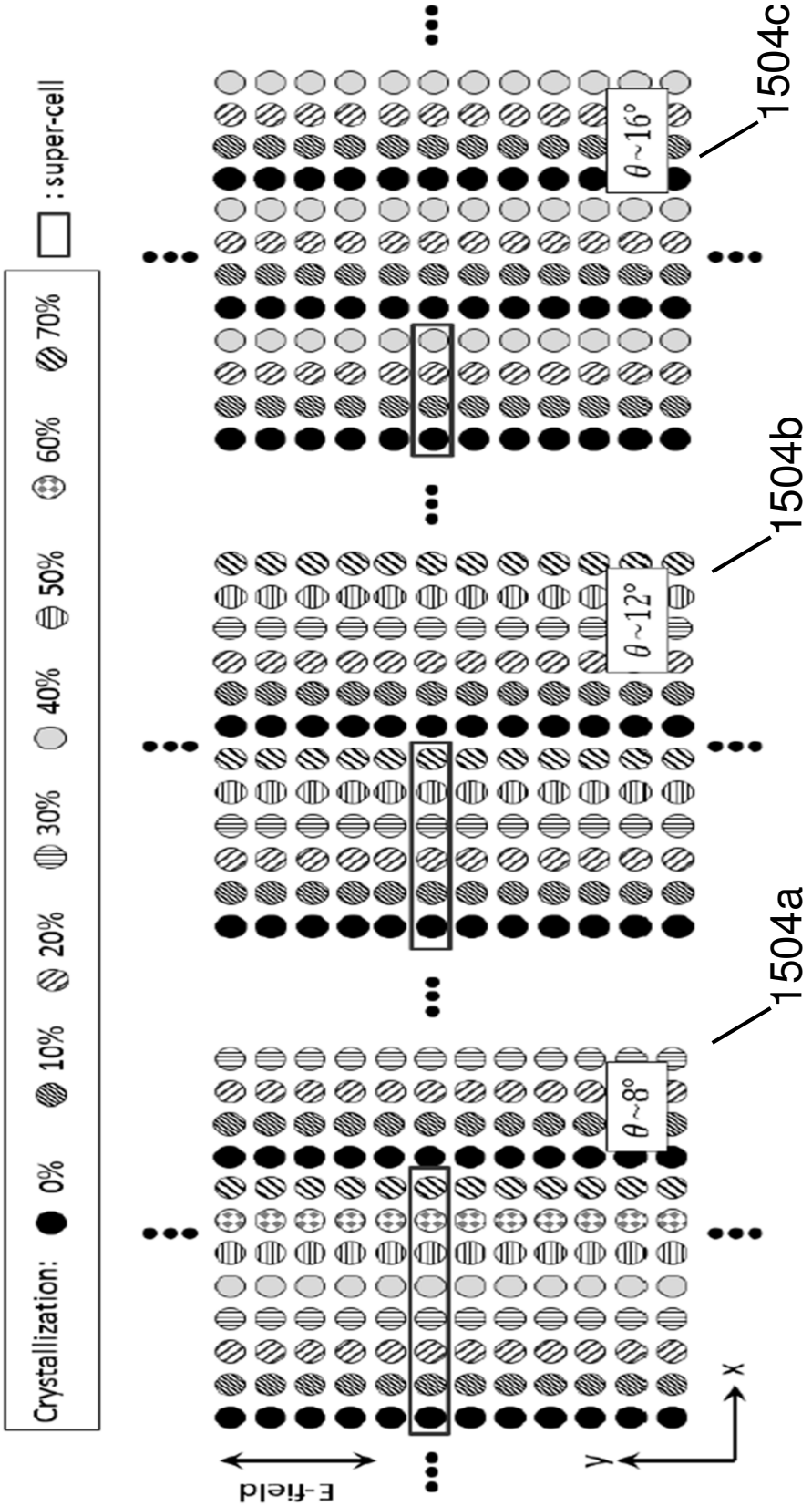
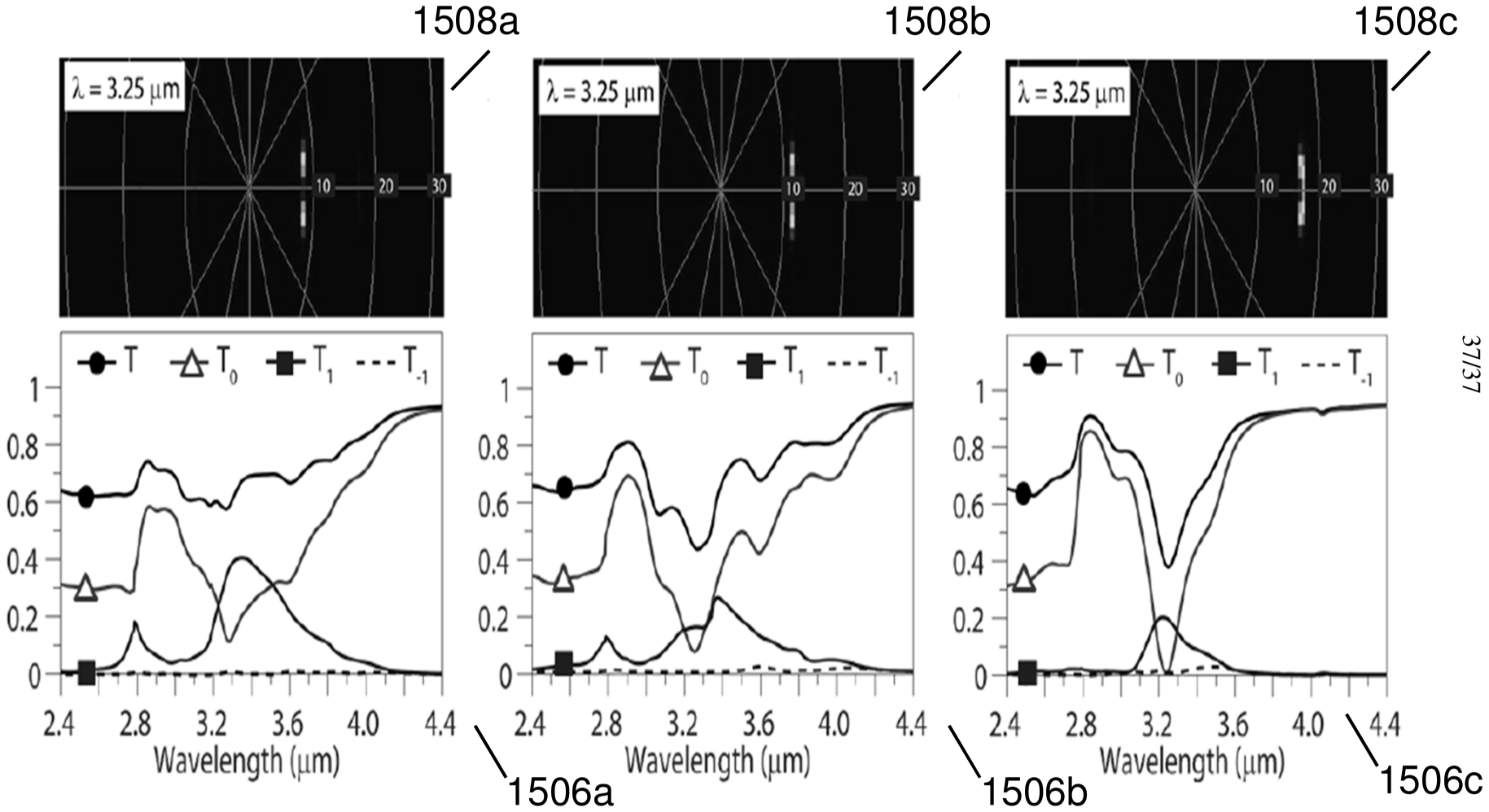

Crystallization:
0%
10%
20%
30%
40%
50%
60%
70%
: super-cell
θ~8°
θ~12°
θ~16°
1504a
1504b
1504c
E-field
y
x

FIG. 15B


1508a
1508b
1508c
λ = 3.25 μm
λ = 3.25 μm
λ = 3.25 μm
10
20
30
T
T0
T1
T-1
1
0.8
0.6
0.4
0.2
0
2.4
2.8
3.2
3.6
4.0
4.4
Wavelength (μm)
1506a
1506b
1506c