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(54) Title: PLASMONIC FILTER

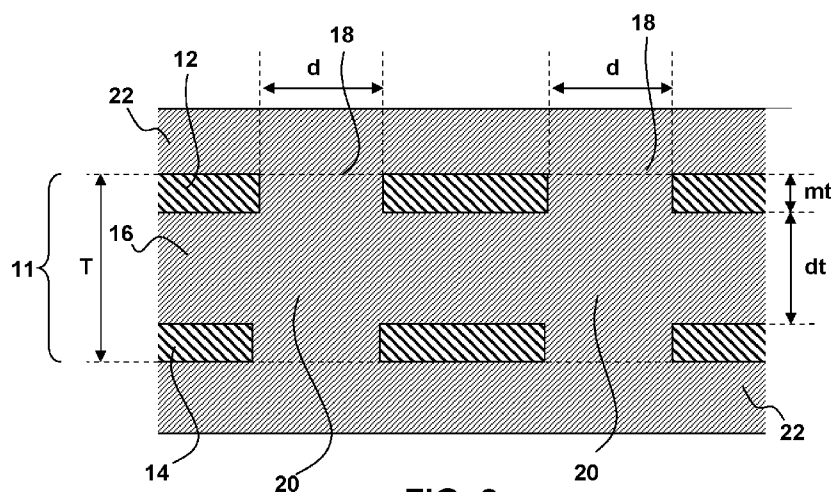


FIG. 2

(57) Abstract: A plasmonic filter for passing light of a predetermined filter wavelength is presented. The plasmonic filter comprises: a filter structure comprising first and second metal layers separated by a dielectric layer; and an array of holes extending through the filter structure. The holes have a diameter less than the filter wavelength, and the holes are filled with a dielectric material.

PLASMONIC FILTER

Field of Invention

The present invention relates to the field of optical filters, and more
5 particularly to plasmonic filters.

Background to the Invention

It is widely known that plasmonic hole arrays in thin metal films can be
engineered as optical band-pass filters. The extraordinary optical transmission
10 (EOT) phenomenon, observed in a single optically-thick metal film perforated
with a periodic sub-wavelength hole array, has been extensively studied for
additive colour filtering (ACF) applications. Such plasmonic filters have
selective transmission bands that are associated with the excitation of surface
plasmon polaritons (SPPs). These EOT transmission bands can be spectrally
15 tuned throughout the entire visible spectrum by simply adjusting geometric
parameters, such as the periodicity, shape and size of the sub-wavelength
holes.

Thus, unlike conventional on-chip organic colour filters, plasmonic filters have
20 the advantage of being highly tunable across the visible spectrum of light and
employ only a single perforated metallic layer to fabricate filters, each of which
selectively transmits a different colour.

Single-layer nanostructured metals also have advantages over organic colour
25 filters due to their ease of fabrication and device integration, and greater
reliability under high temperature, humidity and long-term radiation exposure.

However, conventional plasmonic filters comprising a single metal layer
perforated with an array of sub-wavelength holes have a relatively broad
30 transmission band, especially when they are designed to transmit the longer
visible wavelengths. For example, for a plasmonic filter comprising a thin
metal layer (having a thickness of 40nm and hole diameter of 230nm),
simulations show that the transmission band is formed from a single broad
peak. Further, for the case of a plasmonic filter comprising a thicker metal

layer (having a thickness of 150nm and hole diameter of 230nm), simulations show that the transmission band contains two distinct peaks. In both cases, these transmission bands are too broad to be ideal filters in a colour filter array.

5

Summary of the invention

According to a first aspect of the invention, there is provided a plasmonic filter for passing light of a predetermined filter wavelength comprising: a filter structure comprising first and second metal layers separated by a dielectric layer; and an array of holes extending through the filter structure, wherein the
10 holes have a diameter less than the filter wavelength, and wherein the holes are filled with a dielectric material.

The array of holes may be considered as extending through the metal layers
15 of the filter structure, wherein the holes and the spacing between the holes in the layer stacking direction are filled with a dielectric.

Thus, there is proposed a plasmonic filter structure comprising a dielectric layer sandwiched between two metal layers nanostructured with sub-
20 wavelength hole arrays. Embodiments may be thought of as being double layer metallic hole arrays, wherein the hole arrays are filled with a dielectric material.

When referring to a "sub-wavelength hole" it should be understood as
25 referring to a hole in the filter structure having a diameter less than the wavelength of the light that the plasmonic filter structure is adapted to preferentially transmit (e.g. the wavelength of interest).

Proposed embodiments demonstrate a narrower transmission band than
30 conventional single metal layer plasmonic filters, and may therefore be used in a colour filter array for example. Accordingly, when combined with a CMOS image sensor, embodiments may be used for full-colour imaging in digital cameras.

The dielectric layer in the filter structure may comprise a high-index dielectric material having a first dielectric constant (i.e. dielectric permittivity) which is greater than the dielectric constant of the dielectric material filling the holes.

- 5 Alternatively, the dielectric layer in the filter structure may comprise a high-index dielectric material having a first dielectric constant which is equal to the dielectric constant of the dielectric material filling the holes. Put another way, the dielectric layer in the filter structure may be formed from the same dielectric material that fills the holes.

10

The total thickness of the filter structure may be substantially equal to half the filter wavelength. Put another way, the total thickness between the outer metal surfaces may be comparable to half the wavelength of the light to be filtered.

- 15 The thickness of each of the first and second metal layers may be less than 100nm. Further, the thickness of each of the first and second metal layers may be less than or equal to 60nm.

In embodiments, the thickness of the dielectric layer may be greater than
20 40nm.

The first and second metal layers must be able to support surface plasmons at the filter wavelength. They may comprise Au, Ag, Al or an Al-alloy.

- 25 Embodiments may further comprise an outer dielectric layer covering at least one of the upper and lower surfaces of the filter structure. The outer dielectric layer may comprise a dielectric material having a second dielectric constant which is less than or equal to the dielectric constant of the dielectric material that separates the metal layers in the filter structure. Furthermore this second
30 dielectric constant can be less than, or equal to, the dielectric constant of the dielectric material filling the holes. If the outer (e.g. overlying) dielectric layer is thin, the transmission properties of such an embodiment may be sensitive to the environment and thus used as a biosensor, for example.

The combination of dielectric material(s) and metal employed in the embodiments may be used to control the width of the transmission peaks. For example Al-Si₃N₄-Al embedded in SiO₂ may be used to create filters that are broad enough to be used as a colour filter in a digital camera. Other combinations of dielectrics may provide narrower transmission peaks. These might be used in conjunction with the organic RGB colour filters currently used in cameras to create cameras for multi-spectral, if not hyper-spectral imaging. Embodiments may therefore be of particular relevance to the field of colour filters for digital cameras.

Embodiments may be more convenient to manufacture and more flexible than the conventional organic RGB filters. Also, the proposed concept for a plasmonic filter may provide narrower transmission peaks than conventional all-metal plasmonic filters. Such reduction in transmission peak width results in peaks whose width is either comparable to, or narrower than, the width of the transmission regions of the organic RGB filters. Furthermore, the peak transmission may be larger than the peak transmission in conventional plasmonic filters made in Al films.

Also, compared to conventional all-metal designs, embodiments may have less metal around the sub-wavelength holes in the filter structure. This may create a narrower transmission peak.

Further developments of the invention are the subject-matter of the dependent claims.

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Programme (FP7-PEOPLE-2012-ITN) / ERC grant agreement no. [317497].

Brief description of the drawings

An example of the invention will now be described with reference to the accompanying diagrams, in which:

FIGS. 1A and 1B depict plan view and cross-sectional view of a plasmonic filter according to an embodiment, respectively;

FIG. 2 is a cross-sectional view of a plasmonic filter according to another embodiment, respectively;

5 FIG. 3 is a cross-sectional view of a plasmonic filter according to yet another embodiment, respectively;

FIG. 4 is a graph illustrating the simulated transmission spectra for a conventional plasmonic filter, the plasmonic filter of Figure 2, and the plasmonic filter of Figure 3, when the hole array periodicity $a_x=350\text{nm}$, the hole diameter, d , is 230nm , the total thickness of the filter structure, T , is 150nm and the metal thickness, mt , for the filters of Figures 2 and 3 is 40nm ;

FIG. 5 is graph of simulated transmission versus wavelength for various values of array periodicity, a_x , when the metal thickness, mt , is 40nm , and the ratios between the periodicity, a_x , and the hole diameter, d , and the ratio diameter and the total filter structure thickness, T , are both maintained at a constant value of 1.53;

FIG. 6 is graph illustrating the simulated variation of the transmission spectra with hole diameter for a periodicity, a_x , of 350nm , a metal thickness, mt , of 40nm and a 150nm thick plasmonic filter structure according to an embodiment;

FIGS. 7A through 7F show the simulated transmission spectra of plasmonic filters according to an embodiment made from $\text{Al-Si}_3\text{N}_4\text{-Al}$ embedded in SiO_2 , when the hole array periodicity $a_x=350\text{nm}$, the hole diameter, d , is 230nm ; and

25 FIG. 8 is graph illustrating the simulated variation of the transmission spectra with total filter structure thickness, T , for a periodicity, a_x , of 350nm , a metal thickness, mt , of 40nm and a diameter, d , of 230nm according to an embodiment.

30 **Detailed description**

Embodiments provide a plasmonic filter comprising a stacked Metal-Dielectric-Metal filter structure. Simulations have demonstrated that such embodiments provide improved filter characteristics (e.g. a narrower transmission band or a higher maximum transmission or both) than

conventional single metal layer plasmonic filters. Embodiments may therefore be of particular relevance to applications that employ optical filters and to colour filter arrays, for example.

5 The term vertical, as used herein, means substantially orthogonal to the surface of a substrate. The term lateral, as used herein, means substantially parallel to the surface of a substrate. Also, terms describing positioning or location (such as above, below, top, bottom, etc.) are to be construed in conjunction with the orientation of the structures illustrated in the diagrams.

10 The diagrams are purely schematic and it should therefore be understood that the dimensions of features are not drawn to scale. Accordingly, the illustrated thickness of any of the layers should not be taken as limiting. For example, a first layer drawn as being thicker than a second layer may, in practice, be thinner than the second layer.

15 Referring to Figures 1A and 1B, there is depicted a plasmonic filter according to a first embodiment. More specifically, Figure 1A is a plan view and Figure 1B is a cross-sectional view of the plasmonic filter.

The plasmonic filter 10 is for passing light of a predetermined wavelength of interest (referred to as the "filter wavelength"). The plasmonic filter comprises a filter structure 11 formed from first 12 and second 14 metal layers separated by a dielectric layer 16.

20 The two metal layers 12 and 14 and the dielectric layer 16 are nanostructured with a sub-wavelength hole array. The array of holes 18 extends through the two metal layers 12 and 14 and the dielectric layer 16 of the filter structure. The holes 18 are spaced apart in a hexagonal pattern so that there is an equal pitch or periodicity (ax) (i.e. the distance between equivalent points of adjacent holes) between all holes. Although the embodiment of Figure 1 employs a hexagonal pattern of holes (wherein the angle between the two arrows depicting the pitch/periodicity ax is 60°), other patterns or arrangements of holes may employed in alternative embodiments.

25 As shown in Figure 1B, the holes 18 are filled with a dielectric material 20.

In the embodiment of Figure 1, the dielectric layer 16 comprises a dielectric material (SiO_2) having a first dielectric constant which is equal to the

dielectric constant of the dielectric material 20 filling the holes. More specifically, the dielectric layer 16 is formed from the same dielectric material 20 that fills the holes 18, namely SiO₂. However, it will be appreciated that, in other embodiments, the dielectric layer 16 can comprise a dielectric material having a first dielectric constant which is not equal to the dielectric constant of the dielectric material 20 filling the holes. Thus the dielectric layer 16 may be formed from a different dielectric material than that which fills the holes 18.

The total thickness (T) of the filter structure 11 of this embodiment is designed to be less than or equal to $\frac{3}{4}$ of the filter wavelength in the dielectric filling the holes. More specifically, the total thickness (T) of the filter structure is 150 nm, wherein the thickness (mt) of each of the first 12 and second 14 metal layers is 40 nm, and the thickness (dt) of the dielectric layer 16 is 70 nm.

Referring now to Figure 2, there is shown a cross-sectional view of a plasmonic filter according to another embodiment. More specifically, the embodiment of Figure 2 is a modified version of the embodiment of Figure 1, wherein the only difference is that the embodiment of Figure 2 further comprises an outer dielectric layer 22 covering the upper and lower surfaces of the filter structure 11.

Here, the outer dielectric layer 22 comprises a dielectric material having a second dielectric constant which is equal to the dielectric constant of the dielectric material 20 that fills the holes 18. Thus, the dielectric layer 16 and the outer dielectric layer 22 are both formed from the same dielectric material 20 that fills the holes 18. The first 12 and second 14 metal layers may therefore be considered as being completely encased (with their holes filled) in a single dielectric material.

Referring now to Figure 3, there is shown a cross-sectional view of a plasmonic filter according to yet another embodiment. More specifically, the embodiment of Figure 3 is a modified version of the embodiment of Figure 2, wherein, in the embodiment of Figure 3, the dielectric layer 16 and the dielectric material 20 which fills the holes 18 are formed from silicon nitride (Si₃N₄), and the outer dielectric layer 22 covering the upper and lower surfaces of the filter structure 11 is formed from a different dielectric material

(SiO₂) than that of the dielectric layer 16 and the dielectric material 20 which fills the holes 18 (Si₃N₄).

More specifically, the dielectric layer 16 comprises a high-index dielectric material having a first dielectric constant which is equal to the dielectric constant of the dielectric material 20 filling the holes, and the outer dielectric layer 22 comprises a dielectric material having a second (low) dielectric constant which is less than the dielectric constant of the dielectric material 20 filling the holes.

Thus, the filter structure 11 may therefore be considered as being encased in dielectric material having a dielectric constant which is different from that of the dielectric material employed in the filter structure.

Turning now to the operating characteristics of the proposed embodiment, FIG. 4 illustrates the simulated transmission spectra of the following: a conventional plasmonic filter, the plasmonic filter of Figure 2, and the plasmonic filter of Figure 3.

The simulation results in Figure 4 show that employing a stacked metal-dielectric-metal filter structure creates two distinct transmission peaks.. Further, using a different dielectric in the filter structure as compared to the encasing outer dielectric layer 22, that is using the embodiment in Figure 3, increases the separation between the two peaks, increases the height of the shorter wavelength peak and also broadens this peak.

Accordingly, proposed embodiments may demonstrate a narrower transmission band than conventional single metal layer plasmonic filters.

Parameter Selection

The proposed structure has several parameters that may be used to control the width and height of the transmission peak, the wavelength at which peak transmission occurs, and also the amount of undesirable transmission at other wavelengths. These parameters include: the choice of the metal and the dielectric, the metal thickness, the stack thickness, the periodicity of the holes and the diameter of each hole.

- Choice of Metals

The metal should support surface plasmon polaritons.

The metals which are commonly used in plasmonic applications are Au, Ag and Al. Since Al or Al alloys are already available in some CMOS

processes it is convenient to use Al or its alloys when creating plasmonic filters for colour cameras. Thus, the metal layers may comprise Au, Ag, Al or an Al-alloy.

- Choice of Dielectric between the metals films and in the holes.

5 Increasing the difference between the dielectric constant of the inner dielectric (e.g. the dielectric material(s) employed in the filter structure) and the outer dielectric (e.g. the outer dielectric layer) shifts the shorter wavelength transmission peak to longer wavelengths, which results in a broader transmission peak. The longer transmission peak also shifts to longer
10 wavelengths and this increases the separation of these two peaks.

 Depending upon the details of the manufacturing process, the holes can either be filled with the final external/outer dielectric that is deposited or it can be filled with the dielectric that is used to separate the metal layers (i.e. the dielectric material between the two metal layers in the layer stacking
15 direction). It may be preferable to fill the holes with a dielectric material having a higher dielectric constant than the material on the outer surfaces of the metal layers (e.g. the outer dielectric layer(s)). This is because the change in dielectric constant at the ends of the holes results in a higher peak transmission.

- 20 - Choice of Dielectrics on the each side of the filter

 It has been found to be preferable to employ an outer dielectric layer having a lower dielectric constant than the dielectric material(s) employed in the filter structure. Acceptable performance can be obtained when the dielectric constant of the outer dielectric material on the incident (e.g. upper)
25 side of the filter structure is higher than the dielectric constant of the outer dielectric material on the other (e.g. lower) side of the filter structure. However, it may be preferable to employ the same outer dielectric material on both sides of the filter. A symmetric structure may therefore be preferable.

- Periodicity and Geometry

30 The array of holes can be arranged in a square or hexagonal grid pattern. The hexagonal grid pattern may be preferred due to having less sensitivity to the polarisation of the light and a higher peak transmission.

 FIG. 5 is a graph of simulated transmission versus wavelength for various values of array periodicity (ax, measured in nm). Each plot is for a

different value of a_x , as shown in the key, in units of nanometres. Thus, it illustrates the influence of the array periodicity on the transmission properties.

It is seen that the transmission peaks shift along the visible wavelength range as periodicity of the array is varied.

5 Here, to remove the dependence on the diameter and the total thickness of the stack, the ratio a_x/d and d/T have been kept both constant at 1.53, i.e. the structure scales linearly with the periodicity. The maximum transmission is relatively constant along the entire optical spectrum, varying in a range of about 5%.

10 It is noted, however, that although periodic arrays have been simulated, it has been reported that the dominant interaction may be between nearest neighbouring holes. Periodic arrays of holes are therefore not considered essential. In other words, the array of holes need not be arranged in a periodic pattern in an embodiment of the invention.

15 - Hole Diameter

Figure 6 is a graph illustrating the simulated variation of the transmission spectra with hole diameter, d , for a 150nm thick plasmonic filter structure according to an embodiment. Each plot is for a different value of d , as shown in the key, in units of nanometres

20 The simulation results in Figures 6 suggest that the position of the shorter wavelength transmission peak is insensitive to variations in the hole diameter. However, as might be anticipated, larger diameter holes transmit more light both at the peak and at wavelengths shorter than the wavelength at which there is zero transmission through the filter, in this case 450nm. . There is a secondary transmission peak, in this case at wavelengths longer than 700nm, and the transmission in the region increases rapidly once the hole diameter is larger than 220nm. The preferred choice of hole diameter may therefore depend upon the application.

- Metal thickness

30 The metal in each of the two metal layers should preferably be thin. In particular the thickness of each metal layer should be significant less than the wavelength of the filter light when it is in the dielectric that fills the holes. This suggests that the metal layer should preferably be thinner than 100nm.

Thinner metal layers have been simulated for different total stack thicknesses. Figures 7A through 7F and 8 show the simulated transmission spectra of plasmonic filters according to the invention made from Al-Si₃N₄-Al embedded in SiO₂. Here, the aim is to create a filter with a peak transmission at approximately 550nm.

Figure 7A is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 10 nm. Each plot in the graph is for a different value of T, as shown in the key, in units of nanometres

Figure 7B is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 20 nm.

Figure 7C is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 30 nm.

Figure 7D is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 40 nm.

Figure 7E is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 50 nm.

Figure 7F is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 50 nm.

Figure 8 is a graph illustrating the simulated variation of the transmission spectra with total thickness T of the stack wherein the metal layer thickness mt is 40 nm over wider range of total stack thickness than Figure 7D.

When metal thickness mt=10nm there is a relatively high transmission peak, however, the minimum in transmission at approximately 470nm doesn't reach zero and in general there is a lot of light transmitted at unwanted wavelengths. Increasing the metal thickness to mt=20nm reduces the amount of unwanted light that is transmitted, particularly at shorter wavelengths. However, good transmission only occurs for a narrow range of thicknesses.

This suggests that this thickness would be vulnerable to process variations in the amount of dielectric in the stack. For $m_t=50\text{nm}$ and 60nm the different thicknesses either have significant transmission around 700nm or a secondary peak emerging between the transmission zero around 450nm and 500nm . In some applications this secondary peak might be tolerable. However, these thicknesses show less peak transmission than the $m_t=30\text{nm}$ or $m_t=40\text{nm}$ cases. The thickness of each of the first and second metal layers may thus be less than 100nm . Further, the thickness of each of the first and second metal layers may be less than or equal to 60nm . A preferable Al thickness may therefore be between 30nm and 50nm .

- Dielectric Film Thickness

The dielectric layer between the two metal layers should preferably be thick enough to prevent the filter structure from behaving as a single metal layer. Simulation results suggest that for Si_3N_4 this means that the dielectric between the metal layers should preferably be thicker than 40nm .

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A plasmonic filter for passing light of a predetermined filter wavelength comprising:

5 a filter structure comprising first and second metal layers separated by a dielectric layer; and

an array of holes extending through the filter structure,
wherein the holes have a diameter less than the filter wavelength,
and wherein the holes are filled with a dielectric material.

10

2. The plasmonic filter of claim 1, wherein the dielectric layer comprises a high-index dielectric material having a first dielectric constant which is greater than the dielectric constant of the dielectric material filling the holes.

15 3. The plasmonic filter of claim 1 or 2, wherein the dielectric layer comprises a high-index dielectric material having a first dielectric constant which is equal to the dielectric constant of the dielectric material filling the holes.

20 4. The plasmonic filter of any preceding claim, wherein the total thickness of the filter structure is less than or equal to $3/4$ of the filter wavelength in the dielectric material filling the holes.

25 5. The plasmonic filter of any preceding claim, wherein the total thickness of the filter structure is substantially equal to half the filter wavelength in the dielectric material filling the holes.

6. The plasmonic filter of any preceding claim, wherein the thickness of each of the first and second metal layers is less than 100nm.

30

7. The plasmonic filter of claim 5, wherein the thickness of at least one of the first and second metal layers is less than or equal to 60nm.

8. The plasmonic filter of any preceding claim, wherein the thickness of the dielectric layer is greater than 40nm.

5 9. The plasmonic filter of any preceding claim, wherein the first and second metal layers are able to support surface plasmons at the filter wavelength.

10. The plasmonic filter of any preceding claim, wherein the first and second metal layers comprise Au, Ag, Al or an Al-alloy.

10

11. The plasmonic filter of any preceding claim, further comprising:
an outer dielectric layer covering at least one of the upper and lower surfaces of the filter structure,

15 12. The plasmonic filter of claim 11, wherein the outer dielectric layer comprises a dielectric material having a second dielectric constant which is equal to the dielectric constant of the dielectric material filling the holes.

20 13. The plasmonic filter of claim 11, wherein the outer dielectric layer comprises a dielectric material having a second dielectric constant which is less than the dielectric constant of the dielectric material filling the holes

14. A plasmonic filter substantially as herein described above with reference to the accompanying figures.

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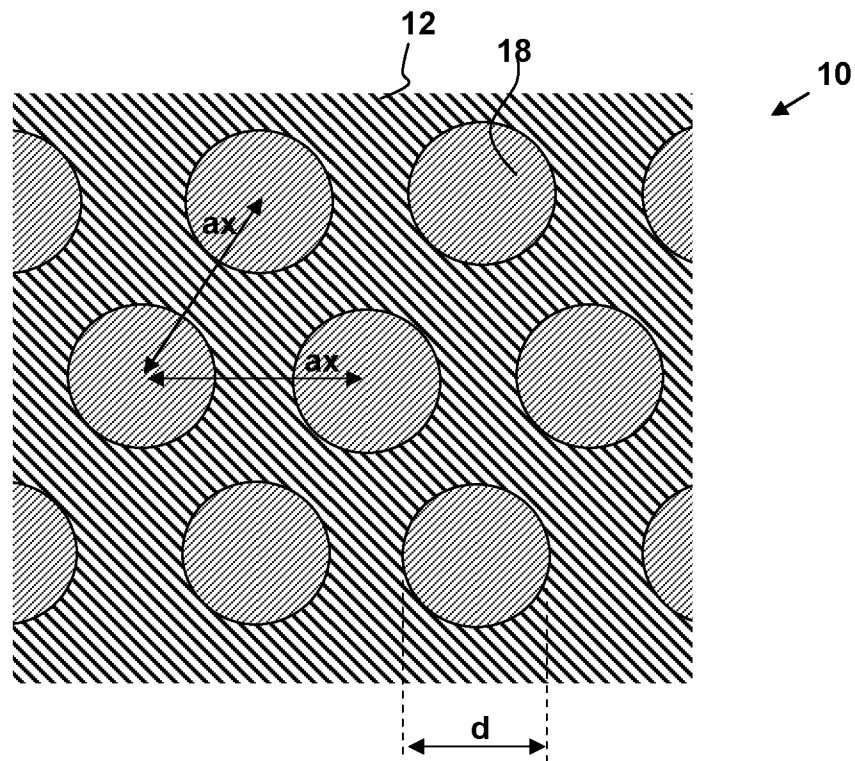


FIG. 1A

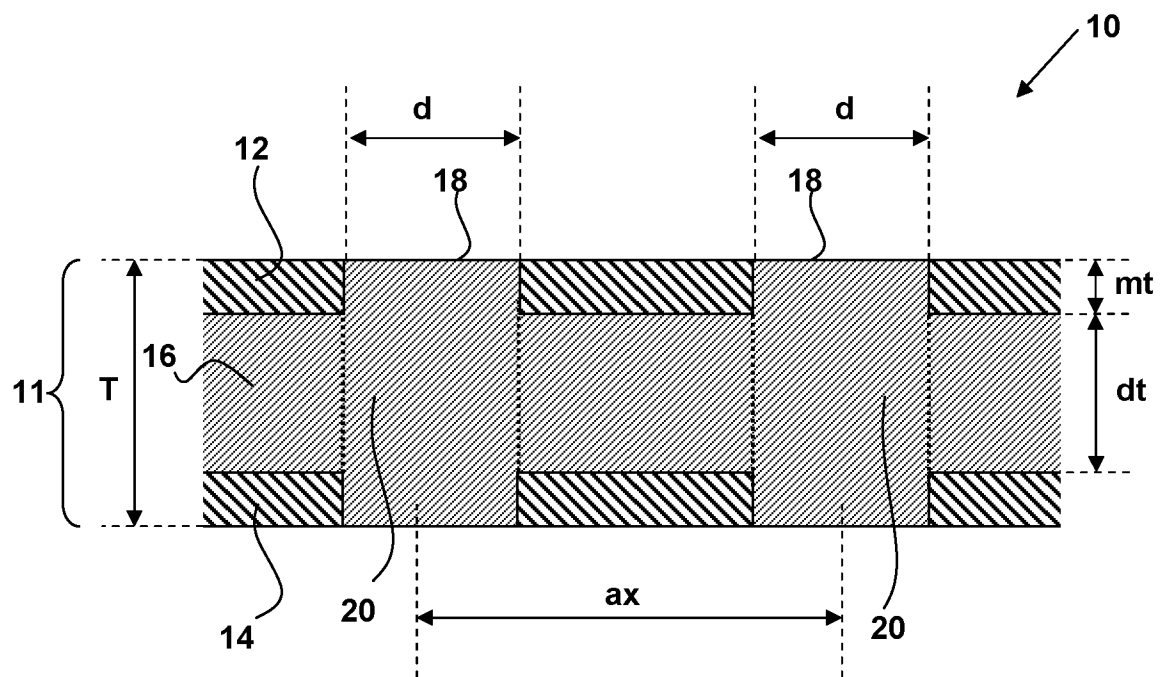


FIG. 1B

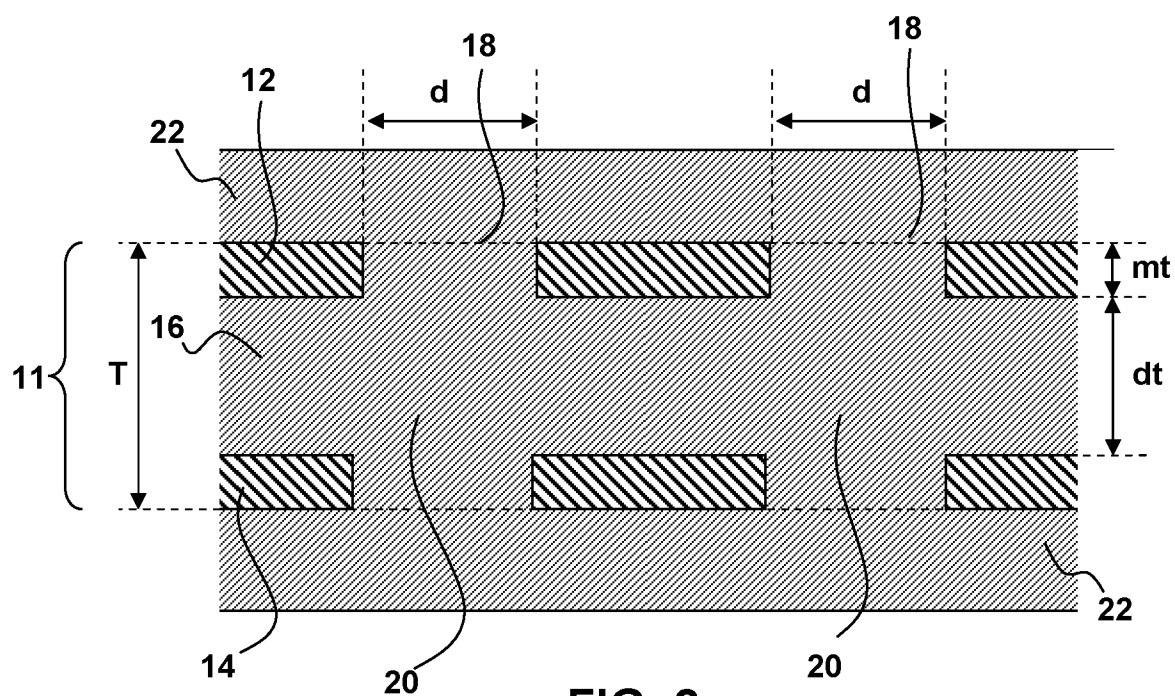


FIG. 2

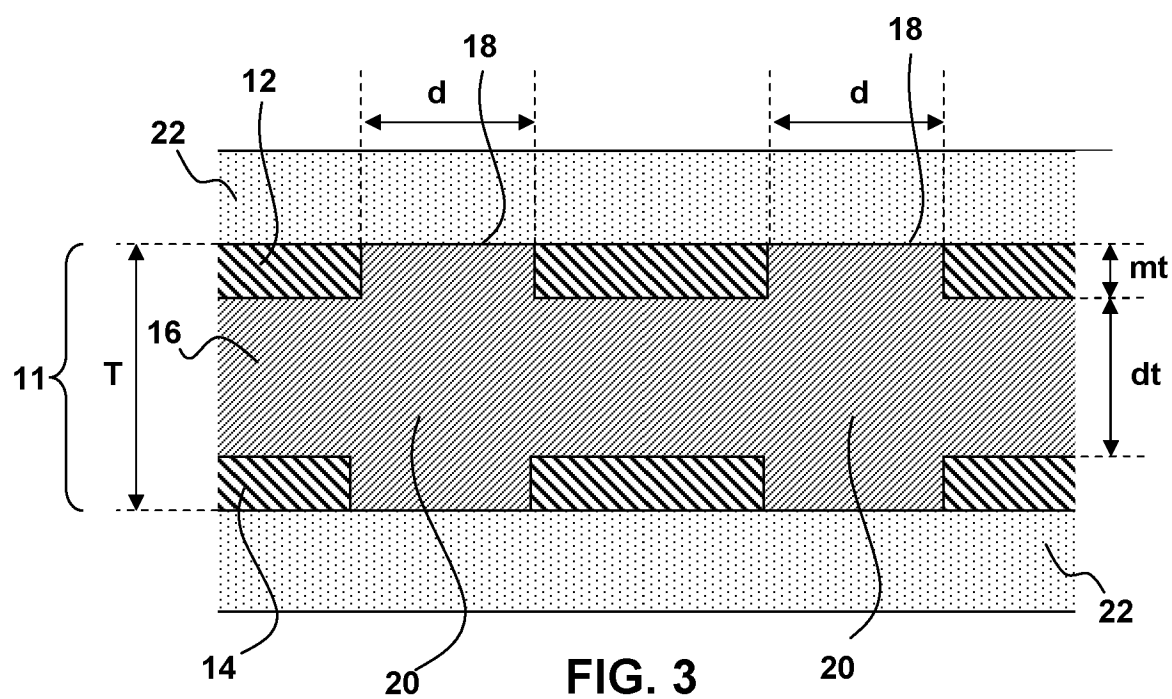


FIG. 3

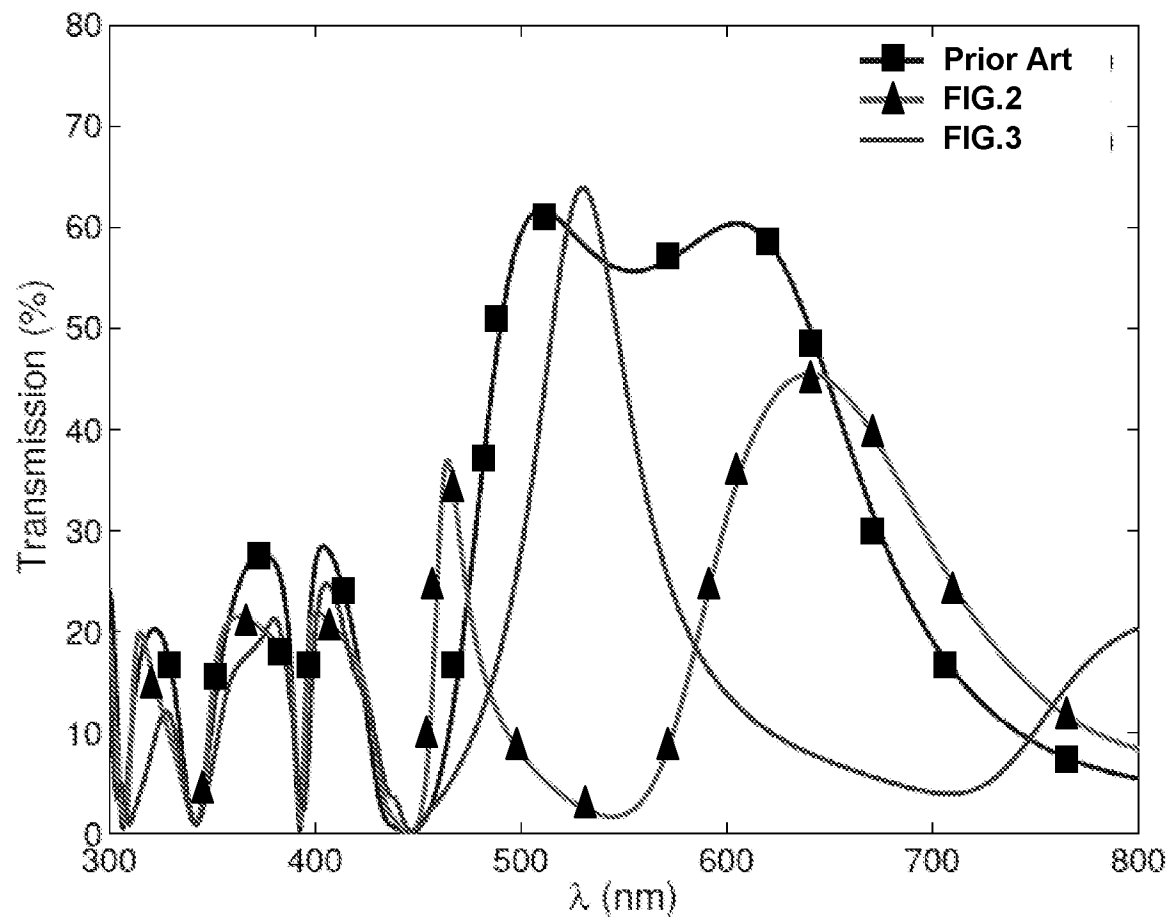


FIG. 4

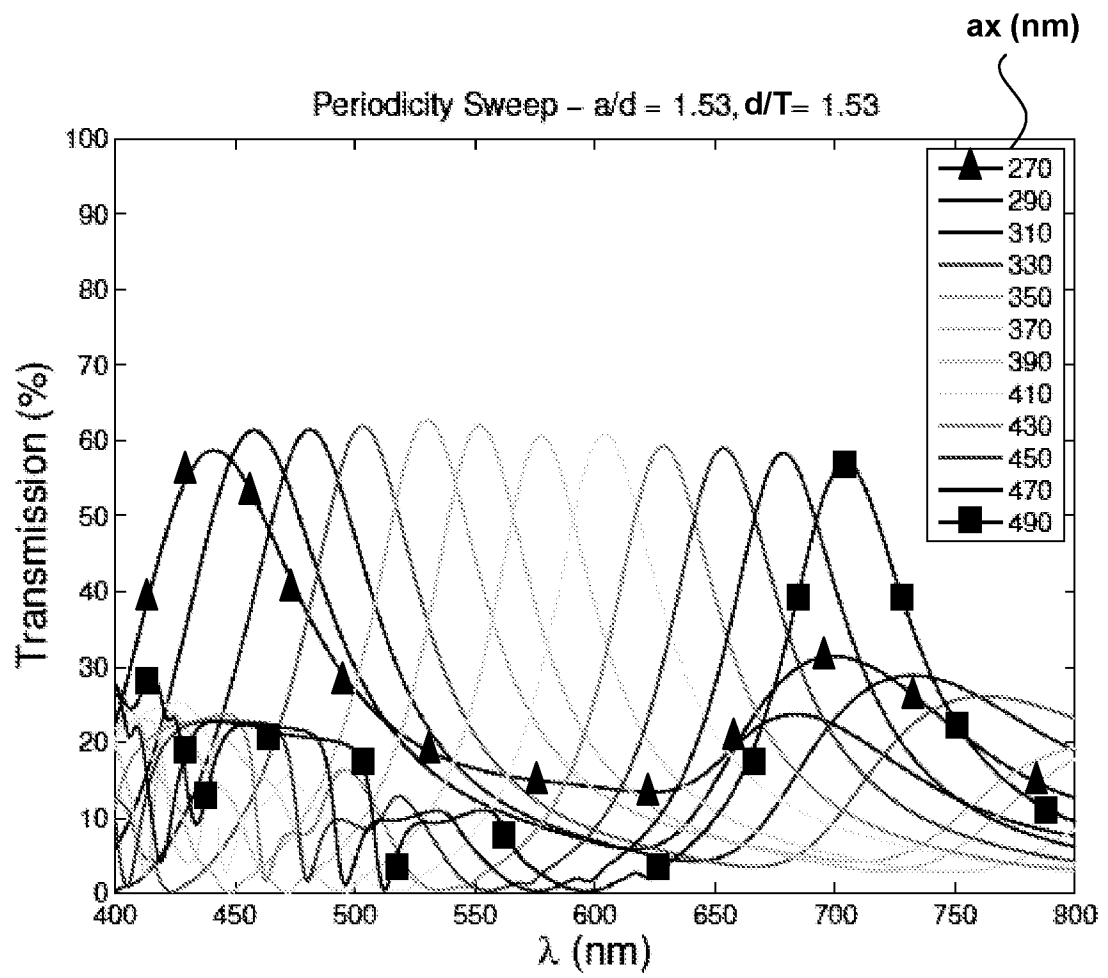


FIG. 5

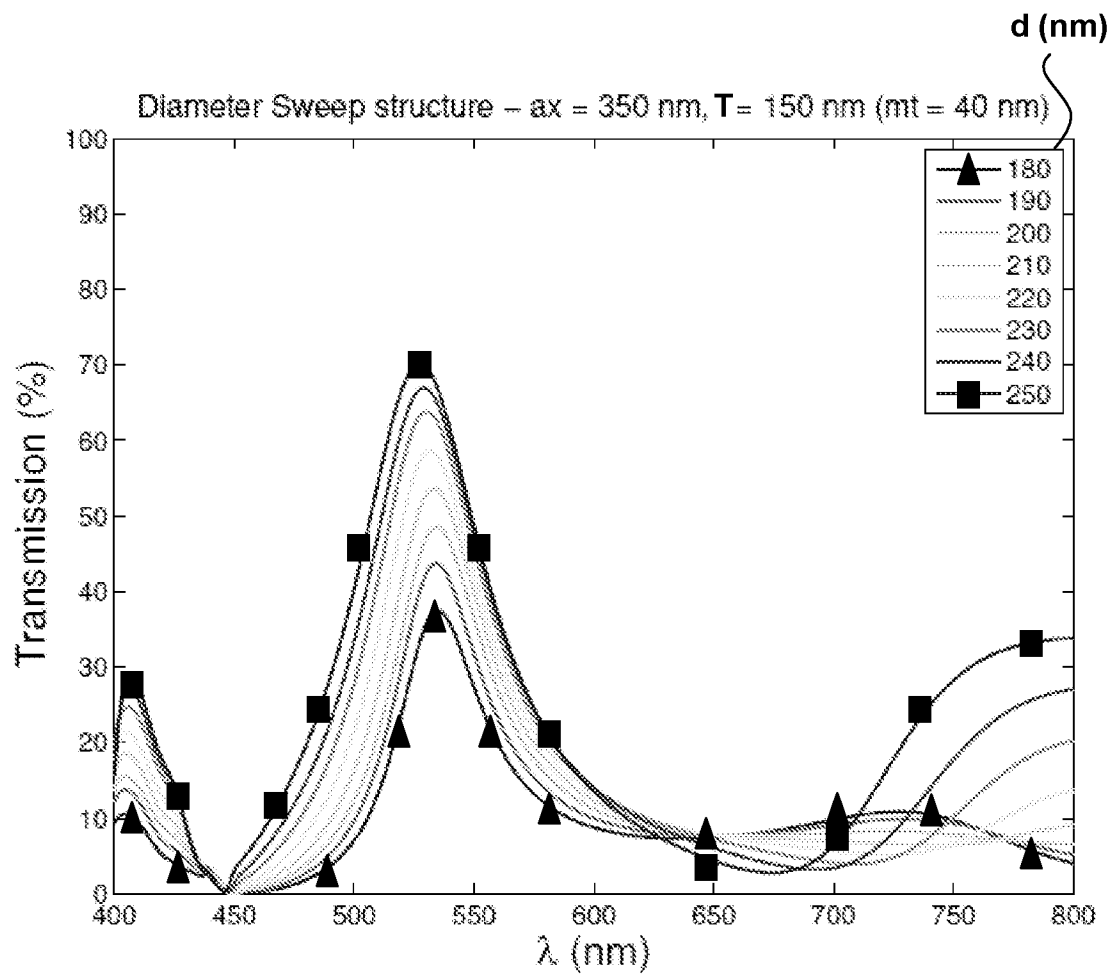


FIG. 6

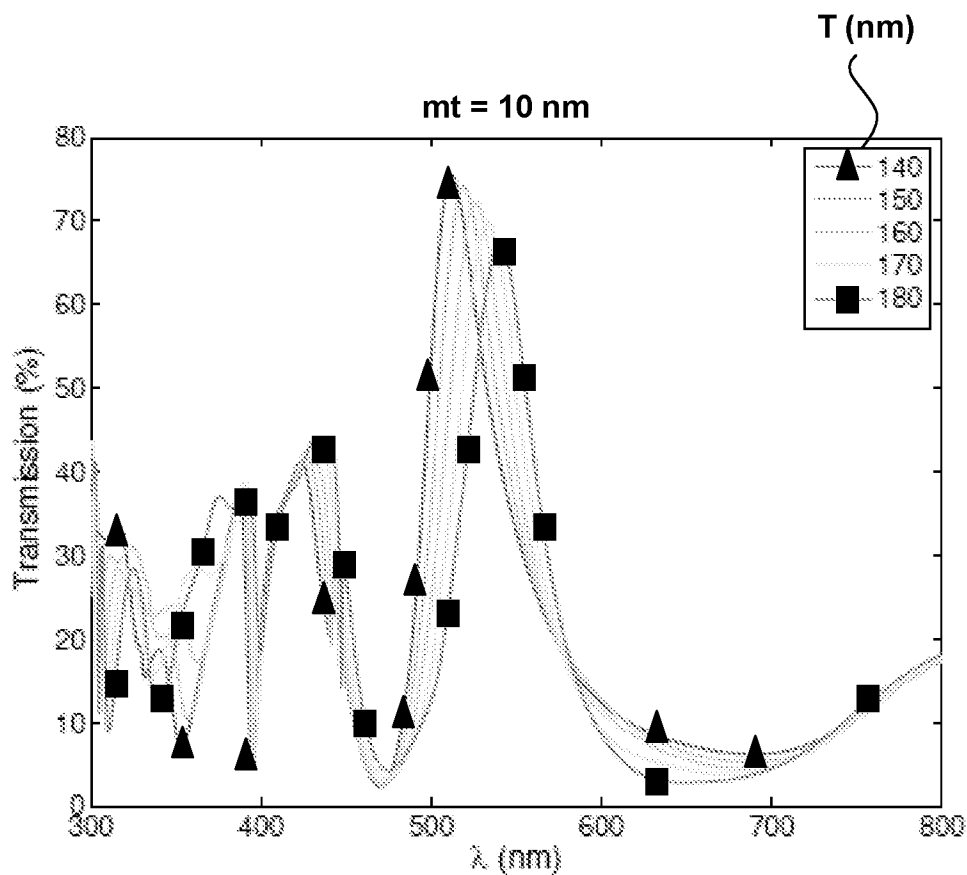


FIG. 7(A)

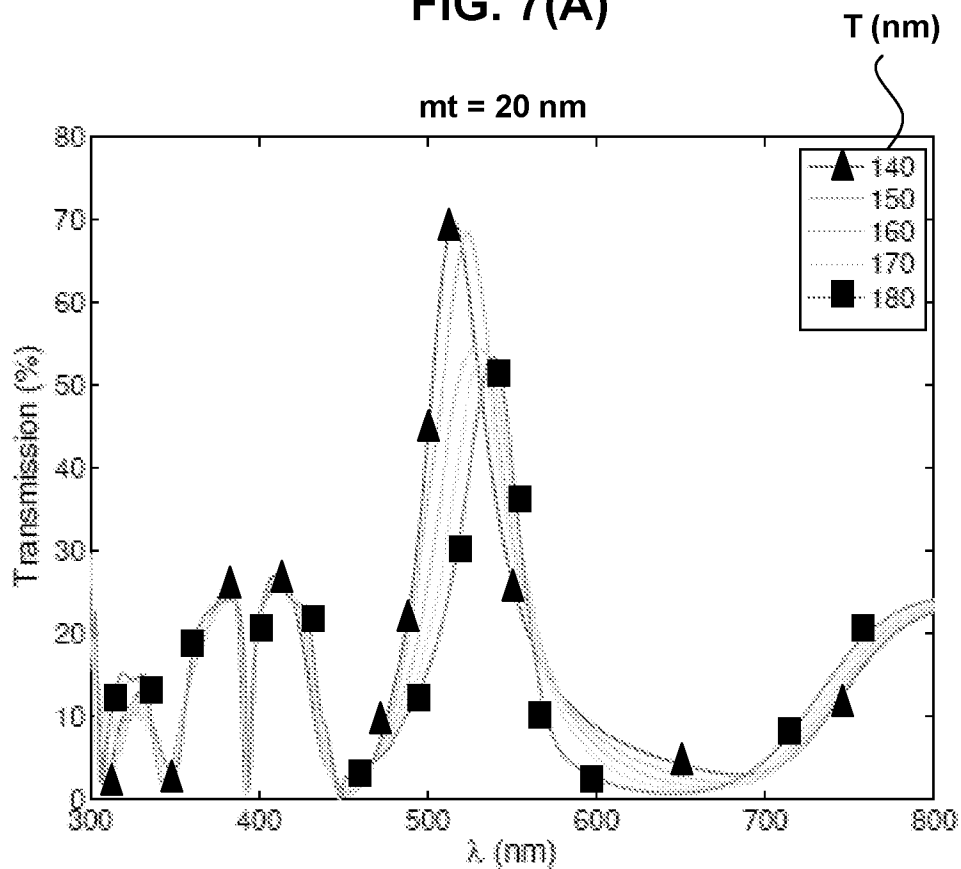


FIG. 7(B)

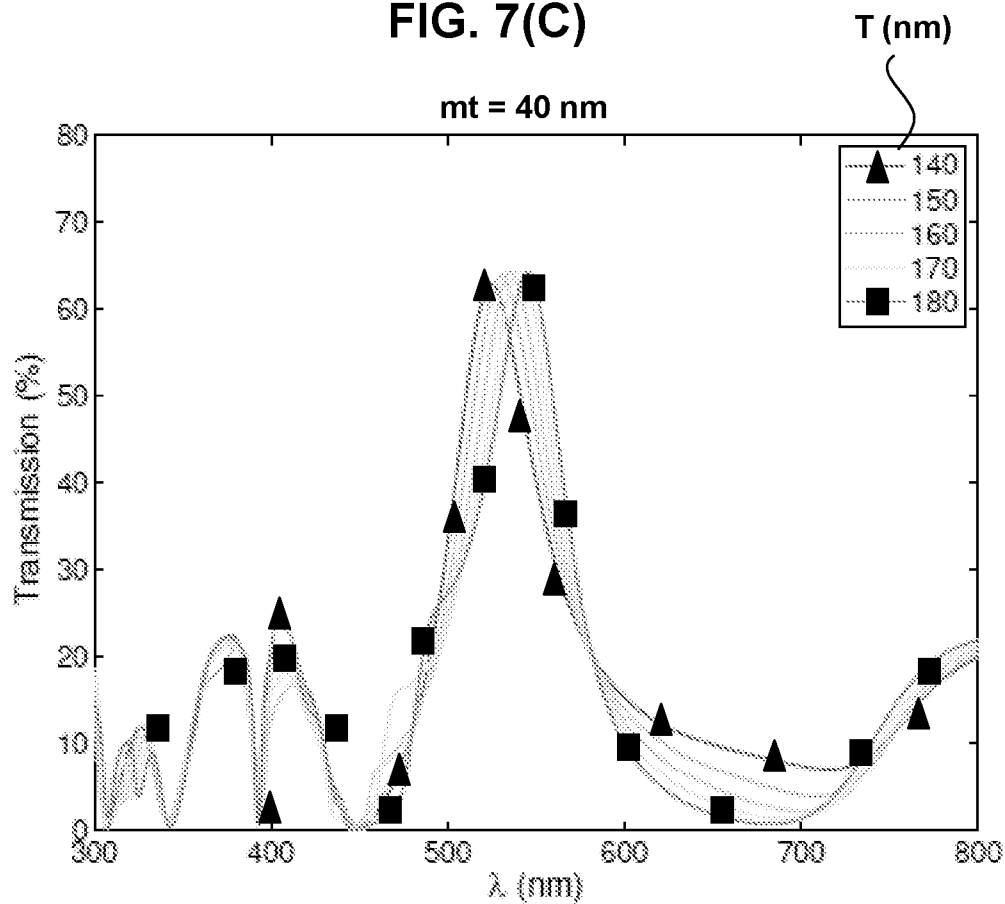
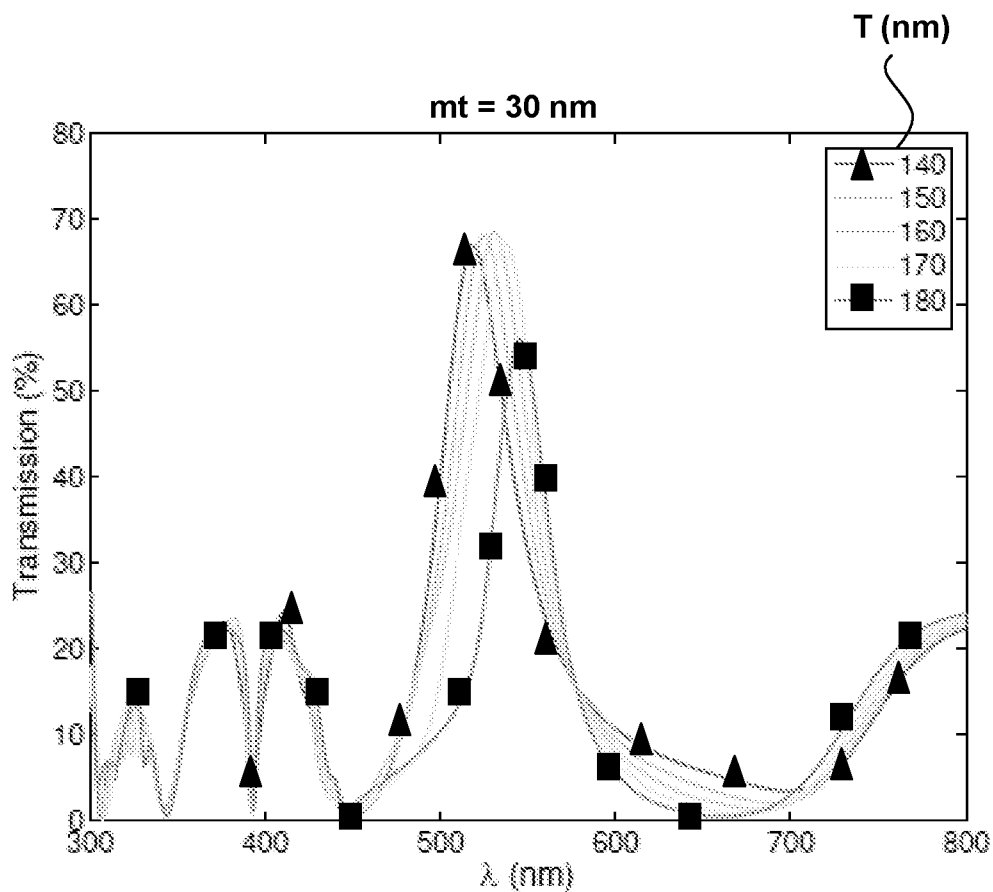


FIG. 7(D)

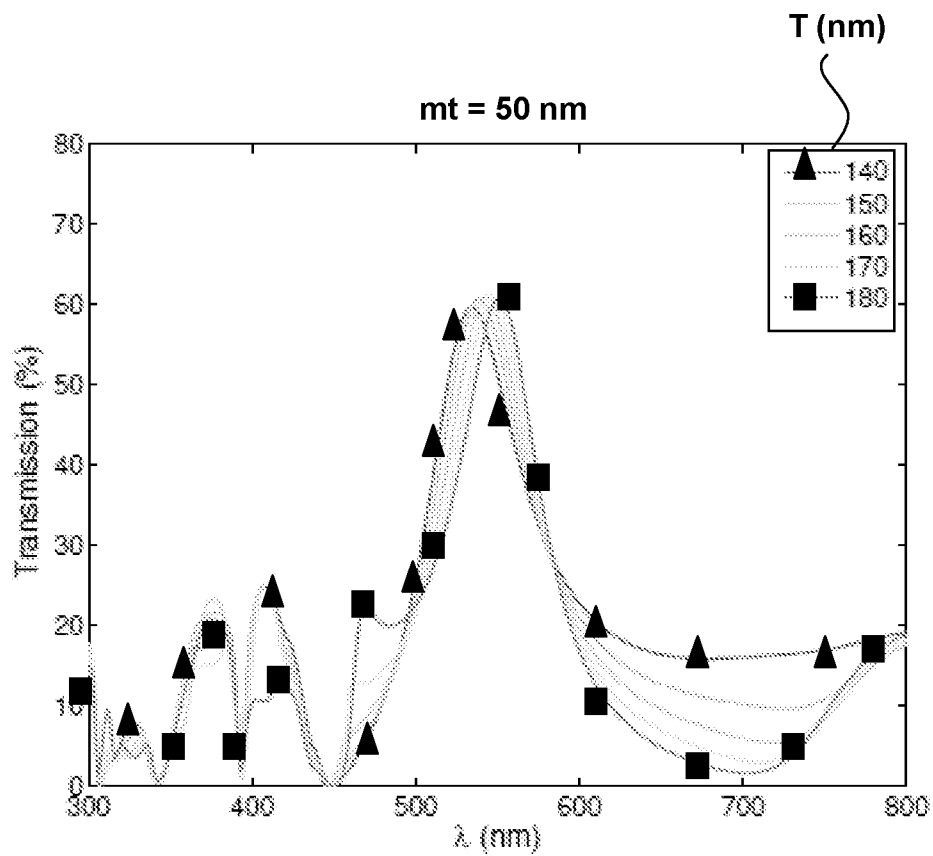


FIG. 7(E)

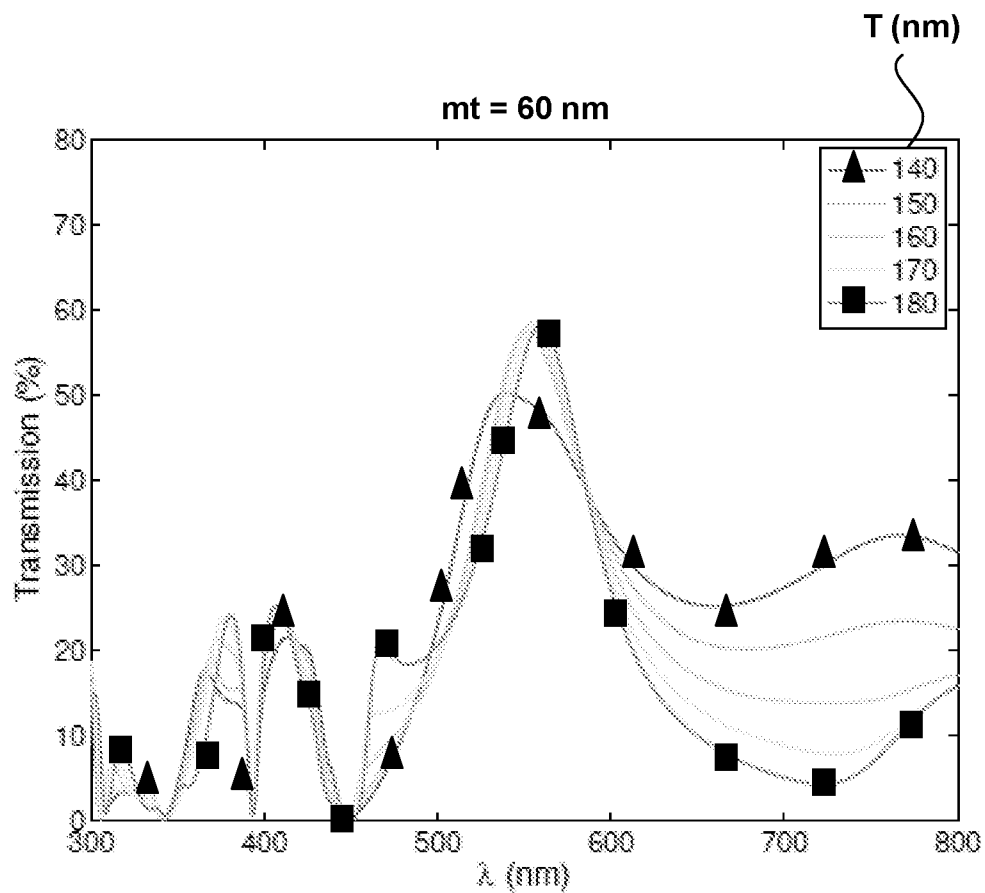


FIG. 7(F)

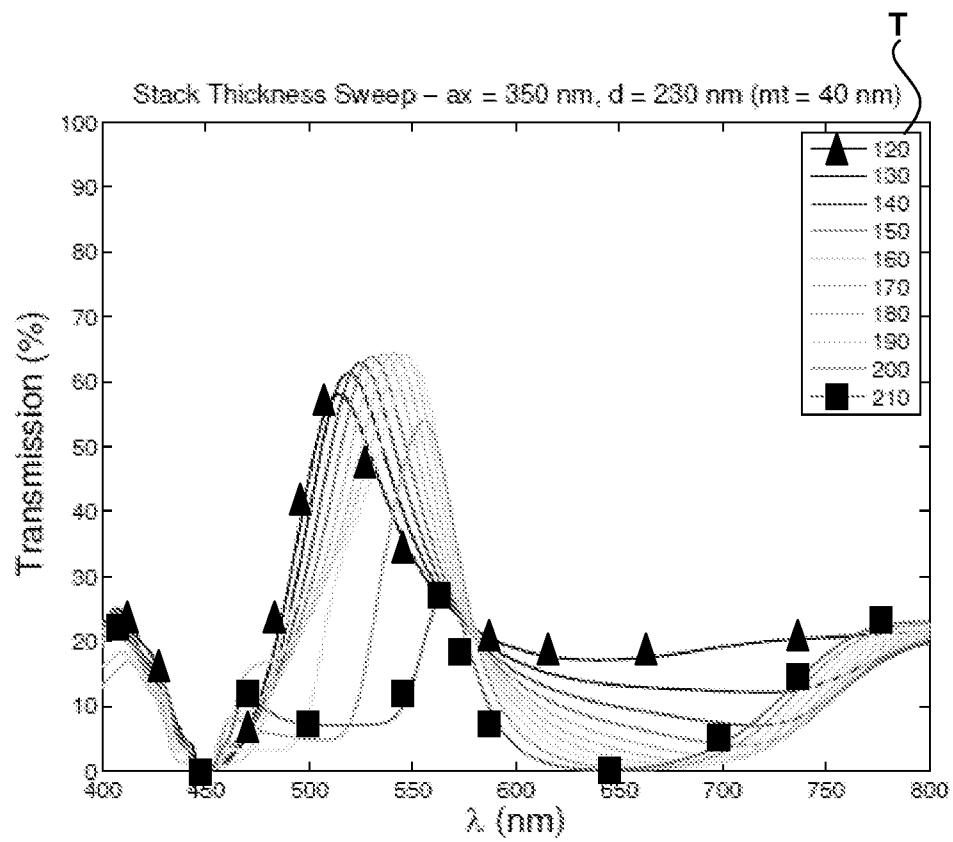


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2015/052178

A. CLASSIFICATION OF SUBJECT MATTER INV. G02B5/00 G02F1/055 G02F1/19 G02B5/30 H01L27/146 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G02B G02F H01L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/019189 A1 (CROUSE DAVID THOMAS [US] ET AL) 27 January 2011 (2011-01-27) figure 38 -----	1-14
X	US 6 646 782 B1 (RUSSELL STEPHEN D [US] ET AL) 11 November 2003 (2003-11-11) figure 4B -----	1-14
X	US 2012/075688 A1 (YAMADA TOMOHIRO [JP] ET AL) 29 March 2012 (2012-03-29) figure 7 -----	1-14
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 7 October 2015		Date of mailing of the international search report 20/10/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Quertemont, Eric

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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