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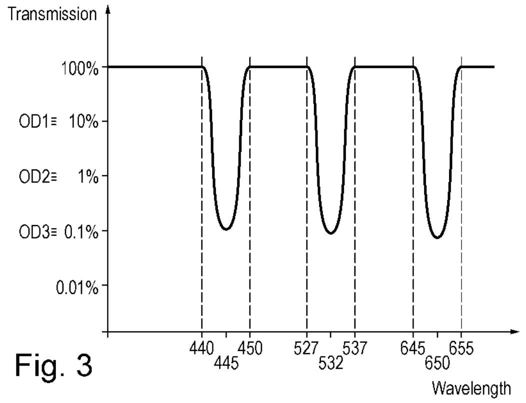

Fig. 3

(57) Abstract: A method of forming a conformable filter for a vehicle window, comprising the steps of: -selecting at least a first wavelength corresponding to a predetermined laser threat; -providing a conformable photosensitive film and exposing said film to radiation from a focused laser source of said first wavelength to create a first filter region therein configured to substantially block incident radiation thereon substantially only of said first wavelength; -determining if an essential lighting source outside or inside the vehicle includes said first wavelength and, if so, -selecting a bandwidth corresponding to a first predetermined wavelength band including said first wavelength and exposing said polymeric film to radiation from one or more further laser sources of respective different wavelengths within said first predetermined wavelength band to create a notch filter region therein, including said first filter region, said notch filter region being configured to substantially block incident radiation thereon at wavelengths within said first predetermined wavelength band whilst substantially allowing visible wavelengths outside of said first predetermined wavelength band to be transmitted therethrough, and wherein said bandwidth is selected to optimise visibility through said filter of said essential lighting source.

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FILTER

The present invention relates to a filter, and also to a window for a vehicle, the window comprising such a filter.

It is known from US2014/0293467 to provide a generally transparent filter comprising a nanoparticle metamaterial structure such that a particular wavelength of electromagnetic radiation may be blocked. The use of such a filter at the windscreen (or windshield) of an aircraft protects against laser threats, which may damage pilot eyesight or temporarily dazzle the pilot. However, this method of forming laser protective/blocking films complex and costly, and typically only permits blocking of one or up to two laser wavelength bands. Furthermore, the film is generally rigid, and not easily conformable to a curved shape of a typical windscreen.

It is also known from, for example, US2014/0009827, to provide a generally transparent, conformable filter formed by holographic exposure of a photosensitive polymeric film by a plurality of coherent radiation sources for the purpose of forming eyeglasses for viewing stereoscopic images. However, there are a number of issues with the described method which make it unsuitable for forming laser protective/blocking filters of the type described above. Firstly, the bandwidth (or 'wavelength band') of blocked wavelengths is inevitably relatively high which means that the overall 'colour' of the resultant film is quite pronounced and the visible light transmission (%) is relatively low (indeed, can be as low as 15%). This is clearly undesirable, and in many cases unacceptable, particularly for the application referenced above – it is self evident that the pilot must be able to see clearly through the aircraft vehicle.

Still further, and in relation to windscreens/windshields for aircraft in particular, it is essential that the pilot can see the landing lights and cockpit instrument lights clearly. If the spectral bandwidth of a laser protective/blocking filter is too large, it can also block at least some of these types of lights, which is clearly undesirable and, in many cases, entirely unacceptable. It may also be required for the filter to block a specific wavelength of radiation emanating from inside the cockpit (such that it cannot be seen from the outside of the aircraft). Specific examples might again include cockpit instrument lights, but also radiation from a heads up display being used within the cockpit by the pilot. Clearly, it is essential in such cases, i.e. where the filter is required to block several different wavelengths, that the respective notch filter regions can be formed with relatively very narrow bandwidths such that the VLT and perceived ‘colour’ is not unacceptably affected.

Thus there is provided an alternative to metamaterial-type optical filter in mitigating laser dazzle threats, that is conformable to a curved shape of a typical windscreen and that permits a number of notch filter regions to be provided very precisely therein, each configured to block a relatively very small spectral bandwidth of radiation around, or including, a specifically selected wavelength.

In accordance with a first aspect of the present invention, there is provided a method of forming a conformable filter for a vehicle window, comprising the steps of:

- selecting at least a first wavelength corresponding to a predetermined laser threat;
- providing a conformable photosensitive film and exposing said film to radiation from a focused laser source of said first wavelength to create a first filter region therein configured to substantially block incident radiation thereon substantially only of said first wavelength;
- determining if an essential lighting source outside or inside the vehicle includes said first wavelength and, if so,
- selecting a bandwidth corresponding to a first predetermined wavelength band including said first wavelength and exposing said polymeric film to radiation from one or more further laser sources of respective different wavelengths within said first predetermined wavelength band to create a notch filter region therein, including said first filter region, said notch filter region being configured to

substantially block incident radiation thereon at wavelengths within said first predetermined wavelength band whilst substantially allowing visible wavelengths outside of said first predetermined wavelength band to be transmitted therethrough, and wherein said bandwidth is selected to optimise visibility through said filter of said essential lighting source.

Thus, by selecting a (advantageously, relatively small) bandwidth of a notch filter region that covers a first wavelength included in, for example, the cockpit instrument lights or the landing lights, blocking of those lights is minimised (to that very small bandwidth) and the remaining visible light radiated thereby can pass through such that the pilot's vision in respect of these essential lighting sources is not significantly adversely compromised. Advantageously, the selected bandwidth may be 10nm or less, so as to maximise or optimise VLT and, therefore, the visibility through the filter of the essential lighting source. However, the present invention is not necessarily intended to be limited in this regard.

The method may further comprise the steps of selecting an additional predetermined wavelength band corresponding to visible light emitted by a light source internal to the vehicle, in use, and exposing said film to radiation from one or more focused laser sources of respective wavelength(s) within said additional predetermined wavelength band to create a respective notch filter region therein configured to substantially prevent said light from said internal light source from being seen through the filter from outside of the vehicle.

The first predetermined wavelength band may cover or be centred on 532nm.

This provision tunes the filter for mitigating attacks by a commonly available laser, and so could provide protection in a number of situations.

The film may be formed of a photosensitive polymer material, which may have a visible light transmission of at least 85 % and may have a thickness of 1 to 100 micrometers.

In accordance with another aspect of the present invention, there is provided a conformable filter formed by the method substantially as described above.

The filter may be additionally for preventing transmission of radiation in a second predetermined wavelength band, the second predetermined wavelength band covering the wavelength of a second predetermined laser threat.

The provision of such a second filter band enables the filter to attenuate a further laser wavelength and thus can guard against another likely threat.

The second predetermined wavelength band may cover or be centred on 445nm.

The filter may be for additionally preventing radiation in a third predetermined visible radiation band, the third predetermined wavelength band covering the wavelength of a third predetermined laser threat.

The provision of such a third filter band enables the filter to attenuate a further laser wavelength and thus can guard against another likely threat.

The third predetermined visible wavelength band may cover or be centred on 650nm.

More generally, the filter may be for preventing radiation from two or more predetermined wavelength bands, including at least one wavelength band corresponding to a predetermined laser threat and at least one wavelength band corresponding to an internal light source of the vehicle.

The filter may be comprised by a single layer of material adapted or configured for preventing the transmission of the predetermined visible wavelength band or bands.

The provision of a single layer which attenuates at a plurality of frequencies, particularly over narrow bands or notches, allows for convenient retrofit or assembly of the layer into or onto window/substrate structures.

The bandwidth of at least one of the predetermined bands may be between 10nm and 5nm. The provision of narrow wavelength bands tends to give, for the filter material, a higher VLT% in general, but it is to be understood that the present invention is not necessarily intended to be limited in this regard.

The filter may have an optical density of at least 2 at the first predetermined wavelength band.

This has been determined to be a threshold for defence which is suitable for various applications, but particularly aerospace applications where threats may be at a considerable stand-off range (e.g. 100m).

Further, the filter may have an optical density of at least 2 at each predetermined wavelength band. However, it is to be understood that the present invention is not necessarily intended to be limited in this regard. In particular, lower or higher optical densities may, in some cases, be adequate and/or more appropriate when considering, for example, the overall VLT of the filter.

Nevertheless, an optical density of 2 has been determined to be a threshold for defence which is suitable for various applications, but particularly aerospace applications where threats may be at a considerable stand-off range and will, in many cases, be appropriate.

The filter may be provided as a conformal film for coupling to a window.

This further contributes to the ability of the filter to be retrofit conveniently, or be assembled within a part conveniently.

According to a further aspect of the invention there is provided a multi-layered window comprising a filter according to the first aspect of the invention, wherein the filter is interposed between layers of the window.

According to a still further aspect of the invention there is provided a window for a vehicle, the window comprising a filter according to the first aspect of the invention.

So that the invention may be well understood, exemplary embodiments thereof shall now be discussed with reference to the following figures, of which

Figure 1 is a schematic perspective view of a filter according to an exemplary embodiment of the present invention applied to a substrate;

Figure 2 is a schematic diagram illustrating a process of forming a filter region for use in a method according to an exemplary embodiment of the present invention;

Figure 3 is a schematic perspective view of the filter of Figure 1 configured to detect radiation;

Figure 4 is a graph in which the transmission characteristic of the filter of Figure 1 is plotted, and

Figure 5 illustrates schematically the filter of Figure 1 implemented on the windscreen of a vehicle.

With reference to Figure 1 there is shown a layer of filter material 10 applied to a first face of a substrate 20 to provide a window 100 adapted for mitigating laser threats such as dazzle. The substrate 20 is substantially transmissive of visible light (for example it may have a visible light transmission (VLT%) of around 90% of normally incident light) and may be formed for example from a glass or a plastics material such as polycarbonate.

The filter material 10 is an interference filter formed by holographically exposing a photosensitive film with a plurality of lasers having a set of predetermined wavelengths within a selected wavelength band of bandwidth 10nm or less.

Conformable photosensitive (e.g. polymeric) films for use in exemplary embodiments of the present invention will be known to a person skilled in the art, and the present invention is not necessarily intended to be limited in this regard. Such photosensitive polymeric films are provided having varying degrees of inherent visible light transmission (VLT), ranging from less than 70% (and possibly, therefore, having a coloured tinge) up to 99% or more (and being substantially colourless and transparent). In respect of the present invention, suffice it to say that a photosensitive flexible/conformable (e.g. polymeric) film is selected having an inherent VLT of, for example, at least 85%. The film typically has a thickness of 1 to 100 micrometers. Thinner, currently known, films may not achieve useful optical densities. Indeed, in respect of currently known photosensitive polymeric films, the degree to which a selected radiation wavelength can be blocked (i.e. the effectiveness of a filter region formed therein) is determined by the thickness and refractive modulation index of the film and, also, by the optical design. Thus, the filter region thickness is ideally matched to the application and the potential power of the source from which protection is required (which may be dictated, at least to some extent, by the minimum distance from the target platform the laser threat may realistically be located and this, in turn, is dictated by application). In general, thicker films and films with higher refractive modulation indices would be selected if it were required to provide protection from higher power radiation sources or to provide greater angular coverage, but this might then have a detrimental effect on the inherent VLT of the film, so a balance is selected to meet the needs of a specific application.

Thus, once the film has been selected, the required holographic exposure thereof is effected to form the filter regions of a required notch filter region to be provided thereon. Referring to Figure 2 of the drawings, distinct filter regions defining a notch filter region of a predetermined bandwidth (e.g. 5 - 10nm) may be formed by exposing the film to the intersection of two counter propagating laser beams for each of a set of laser wavelengths within the selected wavelength band having a selected spectral bandwidth. Each laser 100 (of a wavelength within the selected spectral bandwidth) produces a laser beam 120 which is controlled by a shutter 140. The laser beam 120 is directed by a mirror 160 into a beam splitter 180 wherein the beam is divided into equal beam segments 200. Each beam segment 200 passes through a microscope objective 220 and is then reflected by a respective mirror 360 onto the photosensitive polymer film 320. Other optical devices (not shown) may be provided between the microscope objective 220 and the mirror 360 to, for example, focus or diverge the respective beam segments 200, as required. Furthermore, masking or other limiting techniques may be utilised to limit the extent or thickness to which the film is exposed to the beam segments 200, as will be understood by a person skilled in the art. As a specific (non limiting) example, if it is required to provide a notch filter region of bandwidth 5nm around 520nm, then a plurality of lasers 100 may be used to produce the notch filter region of (purely by way of example) 517.5nm, 518nm, 518.5nm, 519nm, 519.5nm, 520nm, 520.5nm, 521nm, 521.5nm, 522nm and 522.5nm. The above-described exposure process may be performed consecutively for each of these laser wavelengths or, in other exemplary embodiments, the exposures may be performed substantially simultaneously. Other apparatus for forming a holographic filter region at each specified wavelength is known and could, alternatively, be used.

Referring specifically to the present application of a filter for a vehicle (e.g. aircraft) windscreen/windshield, additional consideration must be given to the fact that a) the pilot still needs to be able to see landing lights/cockpit instrument lights, etc. clearly through the filter; and b) it may be required to block visible light from within the cockpit (e.g. from cockpit instrument displays, heads-up displays, etc) from being seen from outside the vehicle. The filter of the present invention, and the proposed method of manufacturing such a filter, can be effectively used to additionally meet these types of specification. Thus, in the first case of essential lighting sources, the key here is to ensure that if one of the notch filter regions for blocking a laser threat covers one or more wavelengths emitted by an essential lighting source, the bandwidth of that notch filter region should be made as small as possible to optimise the trade off between its laser protective characteristics and its ability to transmit sufficient essential light. Indeed, if a particular wavelength of the overlapping bandwidth can be identified as not being an expected laser threat but being included in the spectral bandwidth of the essential lighting source, that wavelength could, in theory, be omitted from the notch filter region formation process, so as to maximise transmission of the essential light without adversely affecting the required laser protective characteristics. In the second case, a further notch filter region covering the wavelength band of the internal light source(s) to be ‘hidden’ can be formed in the film in the manner described above, but consideration will still need to be given to its OD and bandwidth to ensure that the overall VLT of the filter is not significantly adversely compromised by the addition of a further notch filter region. The method proposed herein by the inventors meets both of these needs.

Once the exposure process has been completed, the resultant hologram can be fixed by, for example, a bleaching process.

The transmission characteristic (which may alternatively be referred to as the transfer function) of visible electromagnetic radiation incident on the filter 10 is illustrated in Figure 3. The transmission intensity relative to incident radiation intensity is shown on the y-axis and the wavelength of the incident radiation is shown on the x-axis.

As can be seen on the plot, across the range of wavelengths the intensity of the transmitted radiation is close to 100% of that which is incident. In general a VLT% of 90% would be acceptable if 100% was not feasible.

There are three distinct notches in the transmission characteristic associated with three wavelength bands. These are in particular a 10nm band centred on 455nm, a 10nm band centred on 532nm and a 10nm band centred on 650nm. In general any three notches from the group consisting of 405 nm, 455 nm, 520 nm, 532 nm, and 650 nm may be selected. Further, notches may be chosen to coincide with any expected laser threat wavelength. Still further, the bandwidth may be 5 nm.

At the centre of each of these bands, the intensity of the transmitted radiation is at a minimum and has an optical density of approximately 3, which is equivalent to 0.1% of the initially incident radiation. Additional notches may, of course, be provided for blocking internal light from being seen outside the vehicle.

With reference to Figure 2 there is shown generally at 200 a window. The window 200 comprises a transparent substrate 20 a first face of which has been coupled a radiation detector in the form of a detector layer 30.

Coupled to the opposite face of the detector layer 30 there is provided a layer of the holographic filter material 10.

As such the substrate 20, detector layer 30 and filter material 10 can be considered as a stacked multi-layer structure.

The detector layer 30 comprises an array of photodetectors 32 distributed so as to extend substantially across the window 200. The photodetectors 32 are sufficiently small to be substantially invisible to the casual observer (though in practice there may be some reduction on the VLT%). Each photodetector is electrically connected to a processor module 34. In some embodiments, including the present one, each photodetector is uniquely connected to a unique port on the processor module 34.

The processor module 34 is in turn connected to an alert module 36.

Figure 4 shows a window 200 as shown in Figure 2 deployed as a windscreen on a vehicle V, which in this example is an aircraft. A pilot P is positioned behind the windscreen and a laser beam L, having a wavelength of 532 nm, is shown pointing at the windscreen. Laser beam L will have some degree of divergence as the beam propagates through the atmosphere, which will result in a certain 'spot size' observed at the windscreen.

In operation the window 200 may be used to mitigate the effects of the laser beam L, and alert the pilot to the existence of the laser threat.

In particular, as the laser beam L propagates onto the window 200 it will pass through the substrate 20 and into the detector layer 30 where some laser light will fall on one or more of the photodetectors 32 (depending on spot size).

The laser light subsequently propagates from the detector layer 30 and on the filter 10 where the light becomes substantially attenuated. Assuming the filter 10 to have the transmission characteristics shown in Figure 3 and the laser beam L to be a green laser of 532 nm, the laser beam L will be attenuated to 0.1% of its original intensity.

Accordingly, the pilot P is able to look out of the windscreen with a reduced chance of the laser beam L harming his or her sight, or distracting him or her from flying the plane safely.

Meanwhile, the laser light having fallen on certain photodetectors 32, an electrical signal is generated at each illuminated detector 32 and sent to the processing unit 34. At the processing unit 34 the electrical signals received from the illuminated photodetectors 32 are analysed to confirm or deny the detection of a laser beam. In this case, the processing module 36 generates a signal confirming the presence of the laser beam and relays this to the alert module 36.

Each photodetector 32 can have a unique location at the filter, registered with the processor module such that signals from each photodetector 32 can be correlated with a certain location at the filter. Further this location can be correlated with a particular point on the window provided the relationship between the window and the filter is registered at the processing module. Thus the processing module can determine, from detecting which photodetectors are illuminated, not only the presence of a threat but also the general dimensions of the 'spot' and where on the window the illumination is occurring. Some information relating to the source of the threat can be derived from such measurements. If embodiments are provided with layers of photodetectors, it may be possible to establish more confident estimates of the threat location.

In the present embodiment the photodetectors 32 are configured for detecting radiation at the predetermined wavelength or predetermined wavelengths. For example the photodetector 32 could be configured to send a signal only if 527- 537 nm radiation illuminated it. As such the system needs less noise-rejection provisions and/or can provide fewer false positive signals.

Upon receiving the signal confirming the presence of the laser beam, the alert module issues an alert to notify the pilot P (or another operator) of the laser beam. Such alert could be a visual alert (for instance on an instrument in the cockpit) and/or an audible alert. Such alert could be a signal sent (e.g. by an RF transmitter within the alert module) to a further aircraft or a further element of aerospace infrastructure such as an Air Traffic Control base.

Accordingly, should the pilot be otherwise unaware of the laser beam (for instance because it is sufficiently attenuated by the filter 10 to be negligible within the vehicle) the alert will inform as to the existence of the threat and further action (reporting to ground based security personnel, warning other aircraft) can be taken to address or remove the threat.

As an alternative to window 200, the window 100 may be provided as the windscreen in vehicle V. Here there is no detection layer 30 and so there can be no automatic alert or detection of the laser threat.

Nonetheless the holographic filter 10 will function to attenuate the intensity of the laser beam L and thereby protect the pilot.

The above discussion has provided an overview of how the present invention may mitigate the threat of laser beams.

Presently various lasers are commercially available which could be used against a number of targets at a number of different stand-off ranges. The likely distance and the power of the laser determine how effective the filter needs to be in order to prevent injury to the onlooker. An intensity-at-eyeball of 0.001 W/cm^2 or less should be sufficient to prevent eye damage.

Table 1 shows, for a 3 W laser with 0.5 mrad beam divergence and no atmospheric loss at various stand-off distances, the calculated minimum optical densities (OD) such that damage to the eye can be avoided by blinking (i.e. damage is negligible at this OD unless exposure is greater than 0.5 s, which is a determined minimum multiplied by a factor of safety of 2), and such that there is enough protection to render negligible the risk of damage from a 10 second exposure. Accordingly suggested ranges for ODs are proposed.

Distance (m)	Beam diameter (mm)	'Spot' Size (mm^2)	Intensity (W/Cm^2)	Typical application	min OD for 0.5s exposure	min OD for 10s exposure	Example OD ranges (to nearest 0.5)
0	3	7.1	42.4	n/a	4.03	4.63	4.5-6.0
5	6	23.8	12.6	Car/train/bus	3.50	4.10	3.5-5.5
10	8	50.3	6.0	Car/train/bus	3.18	3.78	3.5-5.5
50	28	615.8	0.5	Car/train /bus/aircraft	2.10	2.70	2.5-4.0
100	53	2206.2	0.1	Car/train /bus/aircraft	1.40	2.00	1.5-3.5
500	253	50272.6	0.006	Aircraft	0.18	0.78	0.5-2.5
1000	503	198712.8	0.002	Aircraft	n/a	0.30	0-1.5

Table 1

Table 2 shows, for a 1 W laser with 1.2 mrad beam divergence and no atmospheric loss at various stand-off distances, the calculated minimum optical densities (OD) such that damage to the eye can be avoided by blinking (i.e. damage is negligible at this OD unless exposure is greater than 0.5 s , which is a determined minimum multiplied by a factor of safety of 2), and such that there is enough protection to render negligible the risk of damage from a 10 second exposure. Accordingly suggested ranges for ODs are proposed.

Distance (m)	Beam diameter (mm)	'Spot' size (mm2)	Intensity (W/Cm2)	Typical application	min OD for 0.5s exposure	min OD for 10s exposure	Example OD ranges (to nearest 0.5)
0	3	7.1	14.1	n/a	3.55	4.15	4.0-5.5
5	9	63.6	1.57	Car/train/bus	2.59	3.20	3.0-4.5
10	15	176.7	0.57	Car/train/bus	2.15	2.76	2.5-4.5
50	63	3117.3	0.03	Car/train /bus/aircraft	0.88	1.48	1.0-3.0
100	123	11882.3	0.008	Car/train /bus/aircraft	0.30	0.90	0.5-2.5
500	603	285577.8	0.0004	Aircraft	n/a	n/a	0.5-1.5
1000	1203	1136635.3	0.00009	Aircraft	n/a	n/a	n/a

Table 2

These experiments show that an optical density of 2 would tend to provide sufficient attenuation for aerospace applications, where attackers would struggle to get within 100 m of the aircraft. Similar considerations and conclusions can be drawn from these experimental results to provide additional notches for blocking internal light from being seen outside the vehicle, and to optimise the notches to maintain adequate visibility of the essential light sources.

So that the dazzle can be prevented (dazzle being where the vision of the operator is temporarily impaired by the laser light but not permanently damaged) the OD values given in Table 1 or Table 2 should be increase in each scenario by 1, or more preferably 1.5 (i.e. and OD of 1 should become and OD of 2 or 2.5 to prevent dazzle).

In a variant of the radiation detector shown in Figure 2, the radiation detector may have the form of a patch arranged in the plane of the filter, or in other words at or near a boundary of the filter. Said patch could comprise an localised photodetector or array thereof and would be interfaced with the processor module and alert module in an equivalent manner. This approach would be suited to contexts where the spot size of the laser was sufficiently large to illuminate the periphery of the window, so that the patch need not be positioned in the operator's view.

In a variant of the window and substrate arrangement of Figure 1, the window may be comprised by a number of laminar substrates between which could be positioned the filter 10.

In a variant of the window and substrate arrangement of Figure 2, the window may be comprised by a number of laminar substrates between which could be positioned the filter and detector.

It will be apparent to a person skilled in the art, from the foregoing description, that modifications and variations can be made to the described embodiments, without departing from the scope of the invention as defined by the appended claims.

CLAIMS

1. A method of forming a conformable filter for a vehicle window, comprising the steps of:

- selecting at least a first wavelength corresponding to a predetermined laser threat;
- providing a conformable photosensitive film and exposing said film to radiation from a focused laser source of said first wavelength to create a first filter region therein configured to substantially block incident radiation thereon substantially only of said first wavelength;
- determining if an essential lighting source outside or inside the vehicle includes said first wavelength and, if so,
- selecting a bandwidth corresponding to a first predetermined wavelength band including said first wavelength and exposing said polymeric film to radiation from one or more further laser sources of respective different wavelengths within said first predetermined wavelength band to create a notch filter region therein, including said first filter region, said notch filter region being configured to substantially block incident radiation thereon at wavelengths within said first predetermined wavelength band whilst substantially allowing visible wavelengths outside of said first predetermined wavelength band to be transmitted therethrough, and wherein said bandwidth is selected to optimise visibility through said filter of said essential lighting source.

2. A method according to claim 1, wherein said film is formed of a photosensitive polymer material.

3. A method according to claim 1 or claims 2, wherein said film has a visible light transmission of at least 85 %, and/or a thickness of 1 to 100 micrometers.

4. A method according to any of claims 1 to 3, further comprising the steps of selecting an additional predetermined wavelength band corresponding to

visible light emitted by a light source internal to the vehicle, in use, and exposing said film to radiation from one or more focused laser sources of respective wavelength(s) within said additional predetermined wavelength band to create a respective notch filter region therein configured to substantially prevent said light from said internal light source from being seen through the filter from outside of the vehicle.

5. A conformable filter formed by the method of any of claims 1 to

4.

6. A filter according to claim 5, wherein the first predetermined wavelength band covers or is centred on 532nm.

7. A filter according to claim 5 or claim 6, wherein the filter is additionally for preventing transmission of radiation in a second predetermined wavelength band, the second predetermined wavelength band covering the wavelength of a second predetermined laser threat and, optionally, wherein the second predetermined wavelength band covers or is centred on 445nm.

8. A filter according to any of claims 5 to 7, wherein the filter is for additionally preventing radiation in a third predetermined visible radiation band, the third predetermined wavelength band covering the wavelength of a third predetermined laser threat and, optionally, wherein the third predetermined visible wavelength band covers or is centred on 650nm.

9. A filter according to any of claims 5 to 8, wherein the filter is for preventing radiation from two or more predetermined wavelength bands, including at least one wavelength band corresponding to a predetermined laser threat and at least one wavelength band corresponding to an internal light source of the vehicle.

10. A filter according to any of claims 5 to 9, wherein the filter is comprised by a single layer of material adapted or configured for preventing the transmission of the predetermined visible wavelength band or bands.

11. A filter according to any one of the preceding claims wherein the bandwidth of at least one of the predetermined wavelength bands is between 5nm and 10nm.

12. A filter according to any of claims 5 to 11, wherein the filter has an optical density of at least 2 at the first and/or each predetermined wavelength band.

13. A filter according to any of claims 5 to 12, wherein the filter is provided as a conformal film for coupling to a window.

14. A multi-layered window comprising a filter according to any one of claims 5 to 12, wherein the filter is interposed between layers of the window.

15. A window for a vehicle, the window comprising a filter according to any of claims 5 to 12.

Fig. 1

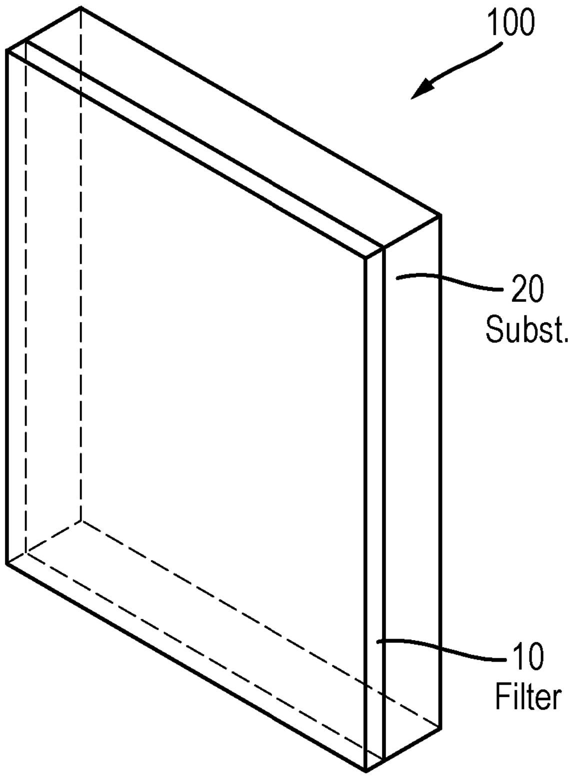

100
20
Subst.
10
Filter

Fig. 3

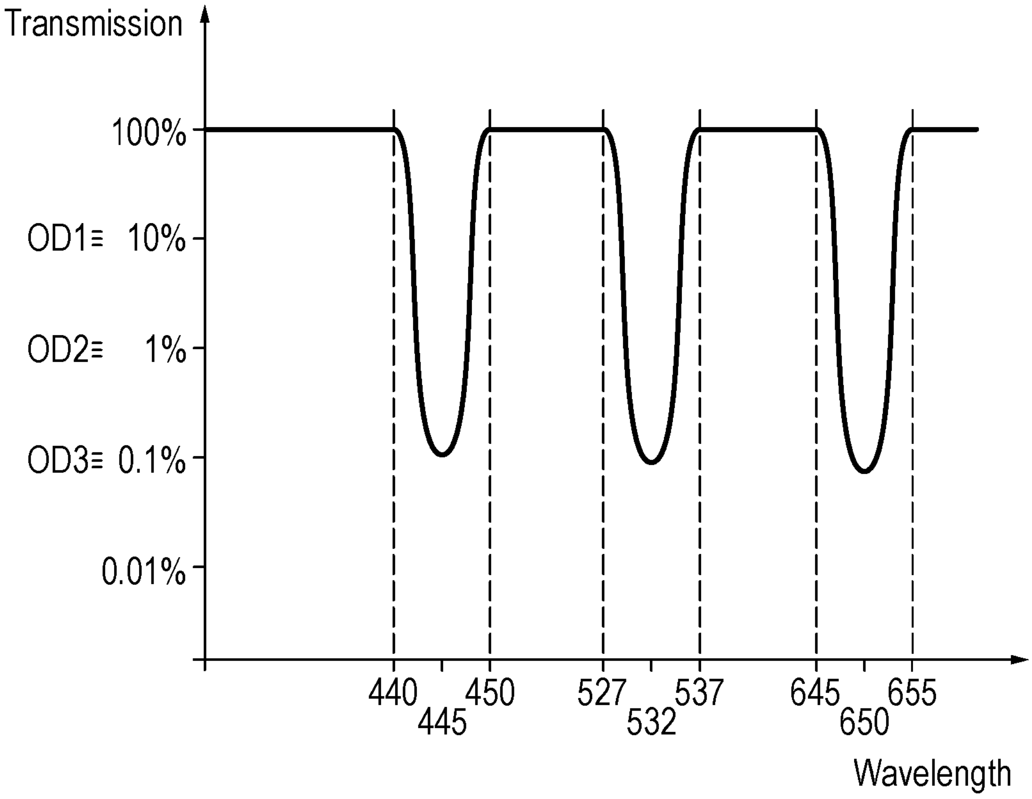

Transmission
100%
OD1≡ 10%
OD2≡ 1%
OD3≡ 0.1%
0.01%
440
445
450
527
532
537
645
650
655
Wavelength

Fig. 2

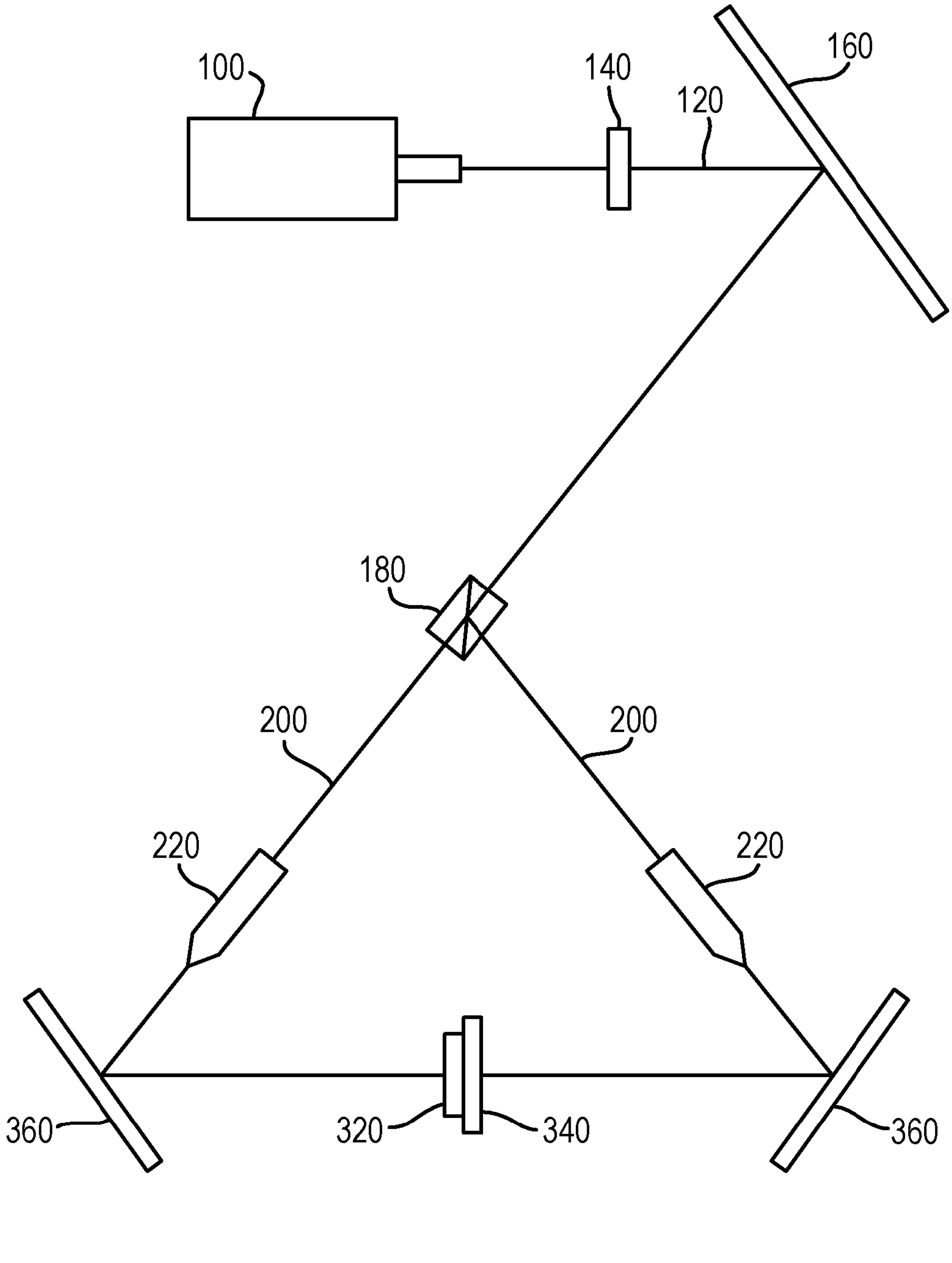


Fig. 4

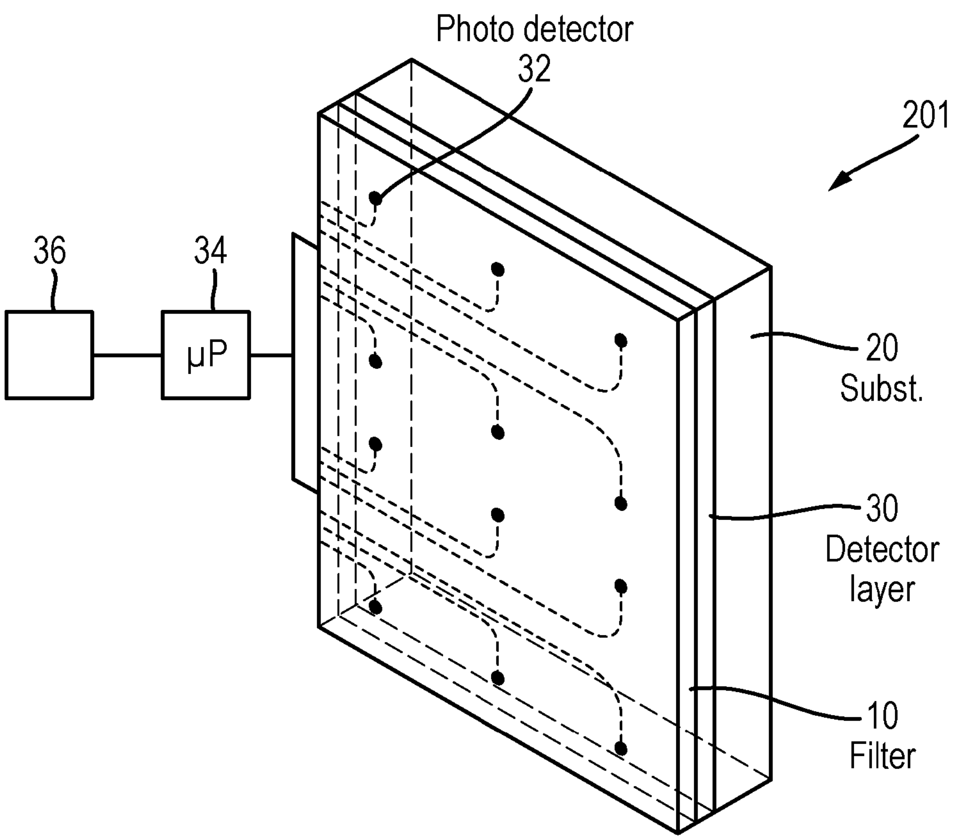
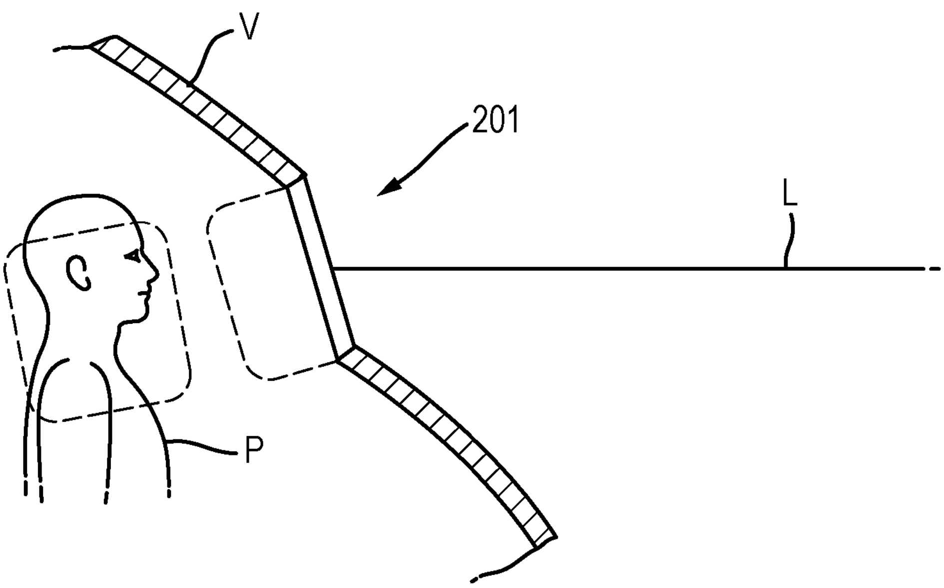


Photo detector
32
201
36
34
μP
20
Subst.
30
Detector
layer
10
Filter

Fig. 5


V
201
L
P

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2017/050740

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B5/20 G02B5/28 G02C7/10 A61F9/02
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 G02C A61F

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	EP 2 602 655 A1 (ESSILOR INT [FR]; UNIV PARIS 6 PIERRE ET MARIE CURIE [FR]) 12 June 2013 (2013-06-12)	1-3,5, 11,12
Y	figure 1 paragraph [0097] paragraph [0141] paragraph [0072] paragraph [0194] -----	4,6-10, 13-15
A	US 2013/215499 A1 (WANG LIGANG [US] ET AL) 22 August 2013 (2013-08-22) paragraph [0011] -----	1
Y	US 2010/149483 A1 (CHIAVETTA III STEPHEN V [US]) 17 June 2010 (2010-06-17) figure 1 paragraph [0046] - paragraph [0047] -----	4,6-10, 13-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 May 2017	08/06/2017

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2017/050740

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