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(71) Applicant: **TP VISION HOLDING B.V.** [NL/NL]; High Tech Campus 5, NL-5656 AE Eindhoven (NL).

(72) Inventors: **RAO GANESH, Ramachandra**; c/o TP Vision Netherlands B.V., Prins Bernhardplein 200, Floor 8, Amsterdam 1097 JB (IN). **LANGENDIJK, Erno Hermanus Antonius**; c/o TP Vision Netherlands B.V., Prins Bernhardplein 200, Floor 8, NL-1097 JB Amsterdam (NL).

(74) Agent: **HUTTER, Jacobus Johannes**; J.W. Frisolaan 13, NL-2517 JS The Hague (NL).

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(54) Title: SURFACE LIGHTING DEVICE

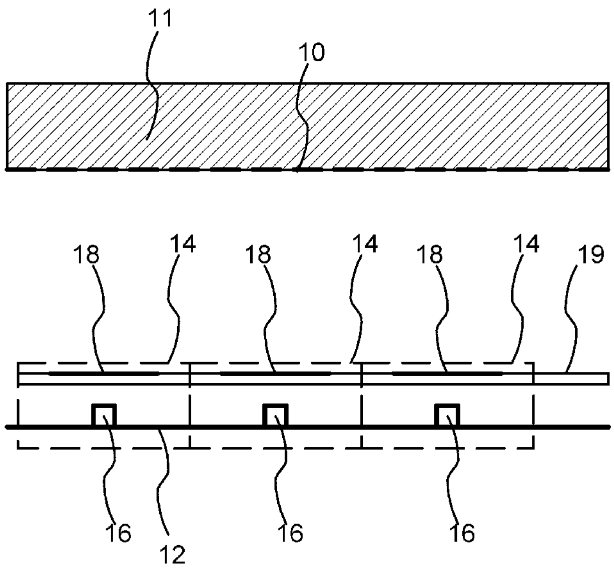


Fig.1

(57) Abstract: A surface lighting device serves to output light with homogeneous intensity over an aperture. The surface lighting device has an array of lighting units. Each lighting unit contains a light source and a mask located between the aperture and the light source. The lighting units are provided on a back plane with a reflective surface directed towards the aperture. Each mask are optically partially transmissive and partially reflective, with a reflective surface facing the light source and the back plane. The size of the masks is selected to balance an amount of light that is transmitted through the masks and an amount of light is passed to the aperture between the masks after reflection between the mask and the backplane. Preferably, square shaped masks are used, when the array has the same pitch in the row and column direction.

Surface lighting device

FIELD OF THE INVENTION

The invention relates to a surface lighting device, such as a backlight for an LCD display screen.

BACKGROUND

From US patent no 6,007,209 a backlight for an LCD display panel is known that comprise an array with rows and columns of LEDs located on a diffusively reflective back wall, and opaque light masks located between the LEDs and an output aperture of the back light. The masks have a rectangular shape, with a size that is slightly larger than that of the underlying LEDs, to act as a shield for the LEDs. The light masks are coated with diffusively reflective material. The aperture is covered by a diffusive layer.

The masks prevent the LEDs from directly illuminating the aperture. The masks effectively serve to prevent the LEDs from creating individual spots of relatively high intensity light on the display. Light from the LEDs typically undergoes several reflections before emerging from the aperture. This results in a back light with substantially position and direction independent light intensity.

It is desirable to make a back light as thin as possible. The thickness is determined by the need to make light intensity of the back light uniform. Uniformity is achieved by mixing light from different directions in the space provided by the thickness.

SUMMARY

Among others, it is an object to provide for reduction of the thickness of a surface lighting device with substantially uniform light intensity.

A surface lighting device according to claim 1 is provided. Herein a partly transmissive and partly reflective mask is used over each light source of an array of light sources of an array of light sources. Each light source may contain a plurality of LEDs for example. The array may be an array of rows and columns. The size of the mask is set so that first total amounts of light (light intensities) transmitted through a mask and second total amounts of light emerging between the masks, integrated over positions along a notional line segment between adjacent light sources, are substantially balanced, that is, that the total amounts of light are at most within a factor 0.8 of each other and more preferably within a factor 0.9.

Thus uniformity in at least one direction is obtained. In a further embodiment these intensities are balanced at least for intensities passing through a notional lines segment between the positions of adjacent light sources at the level of the masks in different directions. Thus uniformity in different directions is obtained.

Preferably the sizes of all masks in the array are set in this way, to minimize ripple in the variation of intensity. In an embodiment the size of the mask is set to balance these intensities at least for intensities passing through a virtual line segment between the positions of adjacent light sources at the level of the masks.

As noted the array may be an array of rows and columns of lighting units, which define a direction of the rows (the direction of the line between light sources of adjacent lighting units in the row) and a similar direction of the columns. Similarly a diagonal direction arises between the row and column direction. In an embodiment, the distances between adjacent lighting units in the columns and rows of the array are equal. In an embodiment, the masks are square. In another embodiment the masks at least have a greater ratio between their diameter in the diagonal direction and their diameter in the row and column direction than a circle (e.g. a diameter in the diagonal direction of sqrt(2) times the diameter of the mask in the row and column direction or between the diameter in the row direction and twice that diameter). This improves uniformity.

The surface lighting device may be fully transmissive between the edges of the masks. This improves power efficiency Alternatively, material that is partially transmissive and partially reflective may be used between the edges, but with a higher transmission coefficient (e.g. at least two times higher) than in the mask.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects and advantageous aspects will become apparent from a description of exemplary embodiments, using the following figures.

Figures 1, 2 show a cross section of back lights

Figure 3 shows a top view of a back light

Figure 4 shows a plot of uniformity versus thickness

Figure 5 illustrates a pair of unit cells

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Figure 1 shows a partial cross section of a back light. The cross-section shows an aperture 10, a back surface 12 and a row of lighting units 14. Each lighting unit comprises a light source 16 and a mask 18. Each light source 16 may comprise a plurality of LEDs 16. Light source 16 may be located over back surface 12, on it, or in recesses in back surface 12 for example. Aperture 10 may be a virtual plane that need not form a definite structure, but a Brightness Enhancement Film (BEF) sheet or DBEF sheet (not shown) my be present at the location of aperture 10 . In a display device, the back light may be combined with an LCD panel 11, the surface of the LCD panel 11 being located at the virtual plane defined by aperture 10. In an embodiment a light diffusive layer may be used located between masks 18 and aperture 10. Masks 18 may be provided on a foil 19 for example.

Figure 2 shows a partial cross section of another embodiment of a back light. In this embodiment masks are provided located on a light guide plate 20 (LGP). In this case a light diffusive layer may also be used located between masks 18 and aperture 10. In another embodiment, masks 10 may be embedded in a transparent layer.

Figure 3 shows a partial top view of the back light, showing the locations of an array of lighting units 14. In top view only masks 18 are visible, but the position of light sources 16 is indicated by dashed lines. Lighting units 14 in the array are located at positions that repeat periodically in two directions. The array can be described as a matrix of square unit cells 30 (one indicated), with edge length equal to the repetition distance of the light sources, the unit cells forming an array of virtual tiles that covers the back surface.

Optically, in the wavelength range of light sources 16, back surface is reflective and preferably diffusively reflective. As used herein “reflective” does not exclude that part of the incident light is absorbed on reflection. In this wavelength range masks 18 are partially transmissive and partially reflective. As used herein “partially” is used to indicate that both reflection and transmission occur. In an embodiment, a mask is used that has a transmission coefficient T of 4 percent and reflection coefficient R of 92%, so that 4% of incident light intensity is transmitted and 92% is reflected diffusively, 4% being absorbed. Such a mask may be formed for example from a white layer, i.e. a layer that provides for diffuse transmission of all wavelengths used. The transmission and reflection of such a layer may be adjusted by adding a specularly reflective metal layer of a selected thickness on the white layer on the mask surface facing aperture 10, e.g. with a reflectivity of 98% and an absorption of 2%. In this or other embodiments, transmission may also be adjusted by providing holes evenly distributed over each mask, the holds leaving a fraction of the area of the mask open for transmission. In another embodiments a mask may comprise a stack of layers. Dependent on the construction of the mask different combinations of transmission coefficient and reflection coefficient values may be realized.

In operation the back light produces light that has a substantially uniform intensity at aperture 10, that is, an intensity that is substantially independent of position in the plane of aperture 10 (as used herein a uniform distribution will refer to a light intensity at aperture wherein variations as a function of position are below a specified maximum amplitude). The uniformity is achieved partly by lighting units 14 and the variation of intensity is reduced due to the distance from masks 18 to aperture 10.

Figure 4 illustrates the effect of the distance Diffusor(z) from masks 18 to aperture 10. This distance is plotted horizontally and the resulting amount of spatial variation in light intensity at aperture 10 is plotted vertically (in arbitrary units). The highest curve shows the amount of variation when there are no masks. The other curves illustrate curves for various types of mask 18. As can be seen, in each case the variation drops from left to right, with increasing distance. However, in order to achieve the same amount of variation (the same level relative to the vertical axis), less distance is needed when masks are used than when no masks are used.

The components of the spatial variation of the intensity at low spatial frequencies at the level of masks 18 mostly determine how much distance is needed to aperture 10. Herein the low spatial frequencies are typically the fundamental spatial frequencies corresponding with the inverse of the unit cell size. The lower the amplitude of the variation at these spatial frequencies, the lower the required distance to aperture 10.

In more detail, light sources 16 emit light in a range of directions, with an intensity that depends on the direction of emission. Typically, 15percent of light intensity is emitted within a cone of directions of 30 degrees width, with the central axis of the cone directed towards aperture 10. Masks 18 perform various functions. First of all masks 18 prevent that more than a fraction of the light from light sources 16 reach aperture 10 directly. Masks 18 reflect a majority of the light intensity back towards back surface 12, which in turn reflects light upwards towards masks 18 and aperture 10. Preferably, both masks 18 and back surface 12 are diffusively reflective (not specularly reflective), that is, they reflect light distributed over a range angles even when the light is incident at a single angle. A surface with Lambertian reflection properties may be used for example.

Light from the light source 16 of a lighting unit 14 typically will be reflected back and forth between the mask 18 of the lighting unit 14 and the back surface 12.

Eventually, the remaining light emerges beyond the edges of the mask 18. At each reflection from the mask a fraction T (e.g. 4%) of the incident light is transmitted through the mask 18 concurrently with the reflection and another fraction B (e.g. 4%) is absorbed at reflection from mask 18 and back surface 12.

This gives rise to a light intensity between mask 18 and back surface 12 that decreases with lateral distance (i.e. distance along back surface 12) from the light source 16. The intensity of light transmitted through the mask decreases with the lateral distance in proportion with light intensity between mask 18 and back surface 12, reduced by the factor T. The intensity of light emerging around the edges of mask 18 is substantially proportional to the light intensity between mask 18 and back surface 12 at the edge of mask 12, but without reduction by the factor T.

For the embodiment comprising a light guide plate LGP, this relation may be modified to incorporate the steep Fresnel angles. In a Light Guide plate system (e.g. PMMA, n=1.5) with a R.I difference with air, as result of Fresnel reflections, a part of the light will be reflected by the surface back into the light guide. Especially at angles close to the critical angle, the amount of Fresnel reflection will be substantial. A major part of this (Fresnel) reflected light will leave the light guide at the front side at the area around the mask. Depending on segment design, the brightness caused by the Fresnel reflection can be so high that it cannot be compensated by adapting the out-coupling and translucency pattern. In that case, the uniformity of the back light will be affected. A slight increase of the dimension of the mask or adapting the mask design can be used to compensate for this, optionally in combination with an absorber around the light source.

In an approximation wherein it is assumed that the mask size is small (compared to the lateral distance over which the intensity decay by a half), the ratio between total intensity (power) transmitted through the mask 18 and total intensity emerging around the mask 18 is approximately 2*AM*T/(h*S), wherein AM is the mask area of the mask 18, T is the transmission coefficient of the mask 17, h is the distance between the mask 18 and back surface 12 and S is the length of the perimeter of the mask 18. A similar ratio can be approximated for a line that runs through the centre of the mask. This similar ratio is then between total intensity (power) transmitted through the mask 18 along the line and total intensity emerging around the mask 18 along the line. This similar ratio is approximately LM*T/h, wherein LM is the length of the segment of the line on the mask.

The use of masks 18 that cover only part of the unit cells has the effect that it may variation of light intensity at the level of the masks. But even with a continuous mask (no gaps between masks) the decrease of light transmitted intensity with lateral distance may contribute to variation of light intensity as a function of lateral position The component of this variation with a fundamental spatial frequency corresponding to the inverse of the size of the unit cell has to be reduced by means of the distance between the mask and aperture 10. The higher the rate of decrease with lateral position the larger distance from mask 18 to aperture 10 is needed to compensate for the variation in the case of a continuous mask. On the other hand a reduction of the rate of decrease with lateral distance can be achieved by using masks 18 with a lower transmission coefficient T. But this means that a smaller fraction of light would be transmitted through the masks 18. In the case of a continuous mask, this would mean that relatively more light would be absorbed.

With the discrete masks 18 that leave gaps between masks for light to emerge beyond the edges of masks 18, a lower transmission coefficient T results in more light intensity of emerging light. The intensity of light emerging around masks 18 should substantially balance the intensity of light transmitted through the masks. This minimizes the low spatial frequency component of the variation of light intensity as a function of lateral position and hence it minimizes the distance between masks 18 and aperture 10 needed to realize uniform intensity.

Figure 4 shows a plurality of curves of the amount of variation of the amount of variation for different values of the mask size divided by the unit cell size in the case of square masks, for configurations that are otherwise similar. As can be seen, the different values lead to different results, which makes it possible to achieve the same uniformity with less distance between masks 18 and aperture 10 by selecting an optimal ratio. In a mask-aperture distance range of 6-14 millimeter masks that have substantially half the size of the size of the unit cells are optimal.

In more specific terms, the above mentioned balancing occurs when the ratio RL=ID/IM between ID, the total light intensity emerging within a unit cell around the mask 18 of the lighting unit 14 of the unit cell, and IM the total light intensity transmitted within a unit cell through the mask 18 of the unit cell, is substantially equal to one. The ratio is considered to be substantially equal to one for example if $0.8*IM < ID < 1.2*IM$ and more preferably $0.9*IM < ID < 1.1*IM$.

Although this condition has been expressed in terms of areas of laterally different positions (corresponding to different projections on aperture 10), it should be appreciated that a similar condition can be expressed in terms of lines of laterally different positions.

Figure 5 illustrates the parameters that are used in this case. The condition is expressed for a line segment 40 from a first light source 16a of a first unit cell 42a to a second light source 16b of a second unit cell 42b, adjacent the first unit cell 42a. In these terms the ratio RL'=ID'/IM' is considered, between ID,' the total light intensity emerging along the line segment 40 around the masks 18 of the first and second unit cells, and IM' the total light intensity transmitted through the masks 18 of the first and second unit cells 42a,b at positions along the line segment. RL'may be taken to be substantially equal to one. This is the case for example if 0.8*IM'<ID'<1.2*IM' and more preferably 0.9*IM'<ID'<1.1*IM'. Preferably, such a condition should be met for all pairs of adjacent unit cells in the array. However, improved uniformity will be achieved already locally if the condition is met for one pair. A first and second of such conditions may be used, a first one for unit cells 42a,b that are adjacent in a same row and a second pair for unit cells 42a, 42c that are adjacent in a same column.

As will be realized, such a condition will be achieved by means of interplay of parameters such as the unit cell size (the distance between successive light sources), the mask size, the transmission coefficient T and the distance between masks 18 and back surface 12 on the other hand. Other parameters such as the absorption coefficients of masks 18 and back surface 12 may also play a role. For a prototype backlight it can easily be verified whether the condition is met by measuring light intensity as a function of position, or by using results form simulations. If the condition is not met one or more of these parameters can be adjusted to ensure that the condition is satisfied. For example, the mask size, unit cell size or distance between back surface 12 and masks 18 may be adapted. When a larger transmission coefficient T is used, a smaller mask size may be used and vice versa. Similarly when a larger transmission coefficient T is used, a larger unit cell may be used or vice versa. Similarly when a larger transmission coefficient T is used, a greater distance between masks 18 and back surface may be used. When a smaller unit cell size is used, a smaller mask size may be used and vice versa etc.

The shape of masks 18 also affects the variation of intensity and hence the distance between masks 18 and aperture 10 that is needed to realize a uniform light distribution at aperture 10. Preferably, the shape is selected to minimize the amplitude of the fundamental spatial frequency component of the variation of intensity at the level of masks 18.

As shown in figure 3, this may be realized by using masks 18 of a square shape. The effect of square shape masks may be compared with that of circularly shaped masks. In the case of square shaped masks the fraction F1 of the surface covered by the masks along a first line through a row of light sources is F=W/U, where W is the width of the square and U is the unit cell width. Along a second line, which runs diagonally from the light sources 16 of a first unit cell in a row N and column M to a second unit cell in a row N+1 and column M+1, this ratio is the same. For circular shaped masks with radius W, the fraction along the first line is F=W/U, but along the second line it is F=W/(sqrt(2)*U). This has the effect that for circular masks, if the radius W is selected to minimize the fundamental spatial frequency component of the variation of intensity along the first line, the fundamental spatial frequency component along the second line will not be minimal. In contrast, for a square mask 18 this component can be minimized at the same time. Even if the corners of the squares are rounded the effect may be better than that of a circular mask. Even though too much rounding may not be optimal, the effect may still be better than using circular masks, as long as the dimension of the mask in the diagonal direction is longer than that in the row and column direction.

Of course, this will be different if the unit cells are not square but rectangular. In that case rectangular masks with the same width/length ratio as the unit cells may be used. Similarly, if other unit cell shapes are used, polygonal masks 18 within the unit cells may be used that have with correspondingly different shapes, e.g. with edges within the unit cell that are perpendicular to lines between the light source 16 in the unit cell and light sources 16 of different unit cells, each at the same fraction (<0.5) of the distance to the light sources 16 of the different unit cells.

Although an embodiment has been described wherein completely transmissive gaps are present between masks 18, it should be appreciated that alternatively at the place of the gaps a further mask (not shown) may be used that has a higher transmission coefficient than masks 18. By balancing the total intensity transmitted through these further masks with that transmitted through masks 18, the required distance from the masks to aperture 10 can be minimized. However, substantially fully transmissive gaps are preferred, as this result in less absorption loss.

As was noted, the transmissivity of masks 18 may be realized by the use of holes distributed over the masks. The further mask could be realized by using more and/or larger holes at the location of the gaps than at the location of the masks. Of course, the holes should not be confused with the gaps. In each unit cell, the gaps is substantially a single continuous area along the edge of the unit cell, with at most narrow interruptions (the light source being at the centre), whereas most if not all of the holes are located away from the edges, similar holes being provided distributed over the mask area, and the holes being much smaller than the gaps. Typically, the gap extends over at least 10% of the unit cell length, whereas the holes extend over less than 5%.

Although an embodiment has been described wherein a periodic array of unit cells is used, that is, with the same distance distances between successive pairs of adjacent light sources, it should be appreciated that instead a less regular arrangement may be used, with varying distances between the light sources. In this case the mask size may be varied as well, according to one of the above mentioned conditions. However, a periodic array, or an array with areas of nearly periodic distances, is preferred as this provides for optimum large scale uniformity.

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 measured cannot be used to advantage. No reference sign in the claims should be construed as limiting the scope.

CLAIMS:

1 A surface lighting device having an aperture (10) for outputting light, the surface lighting device comprising

- an array of lighting units (14), each lighting unit (14) comprising a light source (16) and an optically partially transmissive mask (18) located between the aperture (12) and the light source (16), the mask (18) having a first reflective surface facing the light source (16), the array comprising a first and second one of the lighting units (42a, b) that are direct neighbors of each other in the array, the first one of the lighting units (42a) having a first one of the light sources (16) and a first one of the masks (18), the second one of the lighting units (42b) having a second one of the light sources (16) and a second one of the masks (18);

- a back plane (12) with a second reflective surface directed towards the first reflective surface of the masks (18) and the aperture (10); wherein

- intersections of a virtual line segment from the first one of the light sources (16) to the second one of the light sources (16) with edges of the first and second one of the masks (18) are located so that a first total amount of light transmitted through the first and second one of the masks (18) along the line segment is substantially equal to a second total amount of light emerging along the part of the line segment between the edges of the first and second one of the masks (18).

2 A surface lighting device according to claim 1, wherein the first total amount lies between 0.8 and 1.2 times the second total amount.

3. A surface lighting device according to claim 1, wherein the array comprises a third one of the lighting units (14) that is a direct neighbors of the first one of the lighting units in a direction transverse to a direction from the first one of the lighting units (42a) to the second one of the lighting units (42b), the third one of the lighting units having a third one of the light sources (16d) and a third one of the masks (18), and wherein

- further edges of the first and third one of the masks (18) are located on a further virtual line segment from the first one of the light sources (16a) to the third one of the light sources (16d) so that a third total amount of light transmitted through the first and third one of the masks (18) along the further line segment is substantially equal to a fourth total amount of light emerging along the further line segment between the further edges of the first and third one of the masks (18).

4. A surface lighting device according to claim 1, wherein said first and second total amount of light are substantially equal, when taking the first and second one of the lighting units from any pair of adjacent lighting units in the array.

5. A surface lighting device according to claim 1, wherein the array comprises rows and columns of lighting units, the first and second one of the masks having a rectangular cross-section with a virtual surface parallel to the back surface, a length-width ratio of the rectangular cross-section being substantially equal to a ratio of distances between adjacent lighting units in the columns and rows respectively.

6. A surface lighting device according to claim 5, wherein the distances between adjacent lighting units in the columns and rows are equal, the rectangular cross-section being a square cross-section.

7. A surface lighting device according to claim 1, wherein the array comprises rows and columns of lighting units, wherein the distances between adjacent lighting units in the columns and rows are equal, a diagonal distance from the first one of the lighting sources to an edge of the first one of the masks in a diagonal direction that is diagonal to directions of the rows and columns being larger than a main distance from the first one of the lighting sources to an edge of the first one of the masks in a direction to the second one of the light sources.

8. A surface lighting device according to claim 1, wherein the first one of the masks (18) is square.

9. A surface lighting device according to claim 1, wherein the lighting unit is fully transmissive beyond said edges of the mask (18).

10. A surface lighting device according to claim 1, wherein the first and second one of the masks (18) each comprise a plurality of holes through the mask (18), distributed over a surface area of the mask(18), the holes providing for partial transmission through the mask (18).

11. A surface lighting device according to claim 1, wherein the masks (18) of the lighting units of the array are embedded in, or provided on a polymer layer located between aperture on one hand and light sources and back plane on the other hand.

12. A surface lighting device according to claim 11, wherein the masks (18) of the lighting units of the array provided on a light guide plate.

13. A surface lighting device according to claim 1, wherein the first and/or second reflective surface are diffusively reflective.

14 A surface lighting device according to claim 1, wherein the distance between the masks (18) and the aperture (10) is less than 14 millimeter.

15 A surface lighting device according to claim 1, wherein each light source (16a,b) comprises a plurality of light emitting diodes.

16 A surface lighting device comprising a lighting unit according to any one of the preceding claims, comprising a light modulation device (11) with an input surface located at said aperture (10).

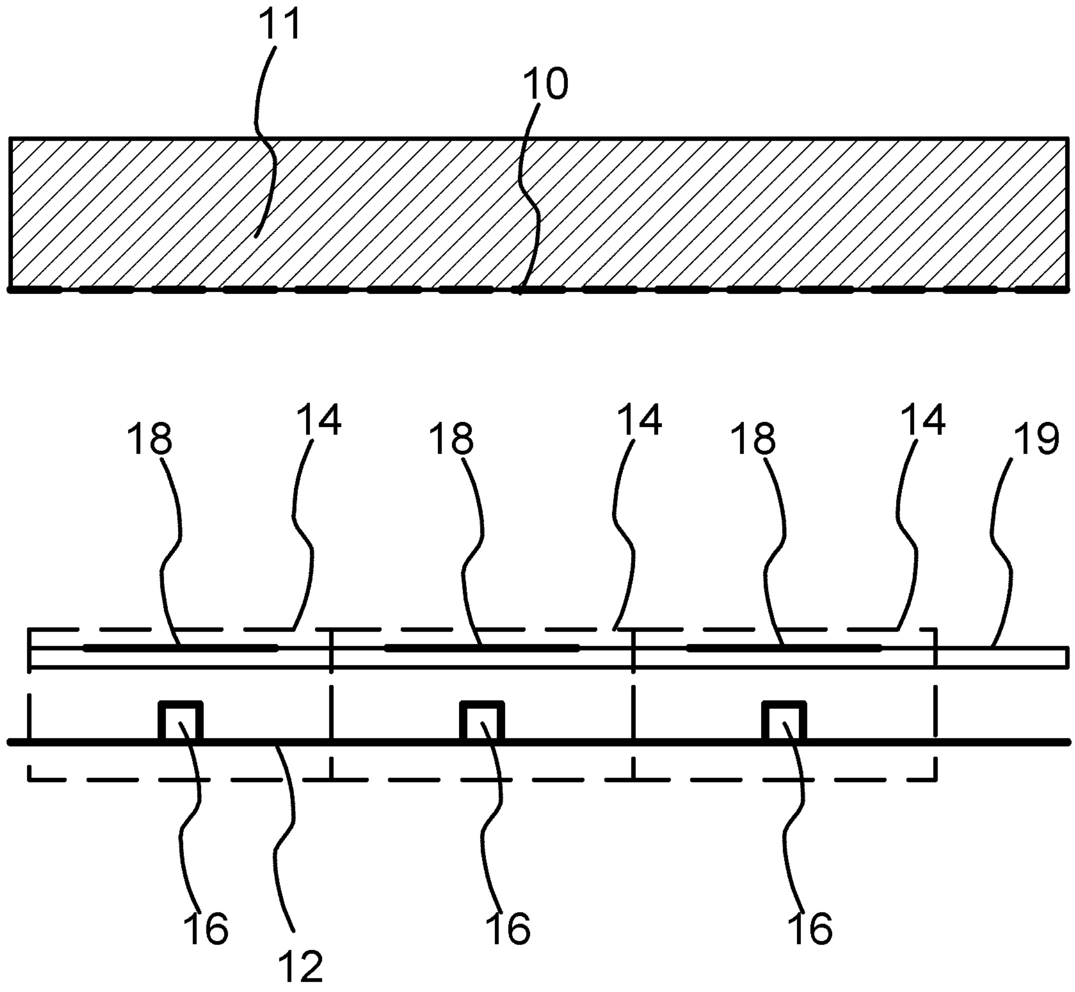


Fig.1

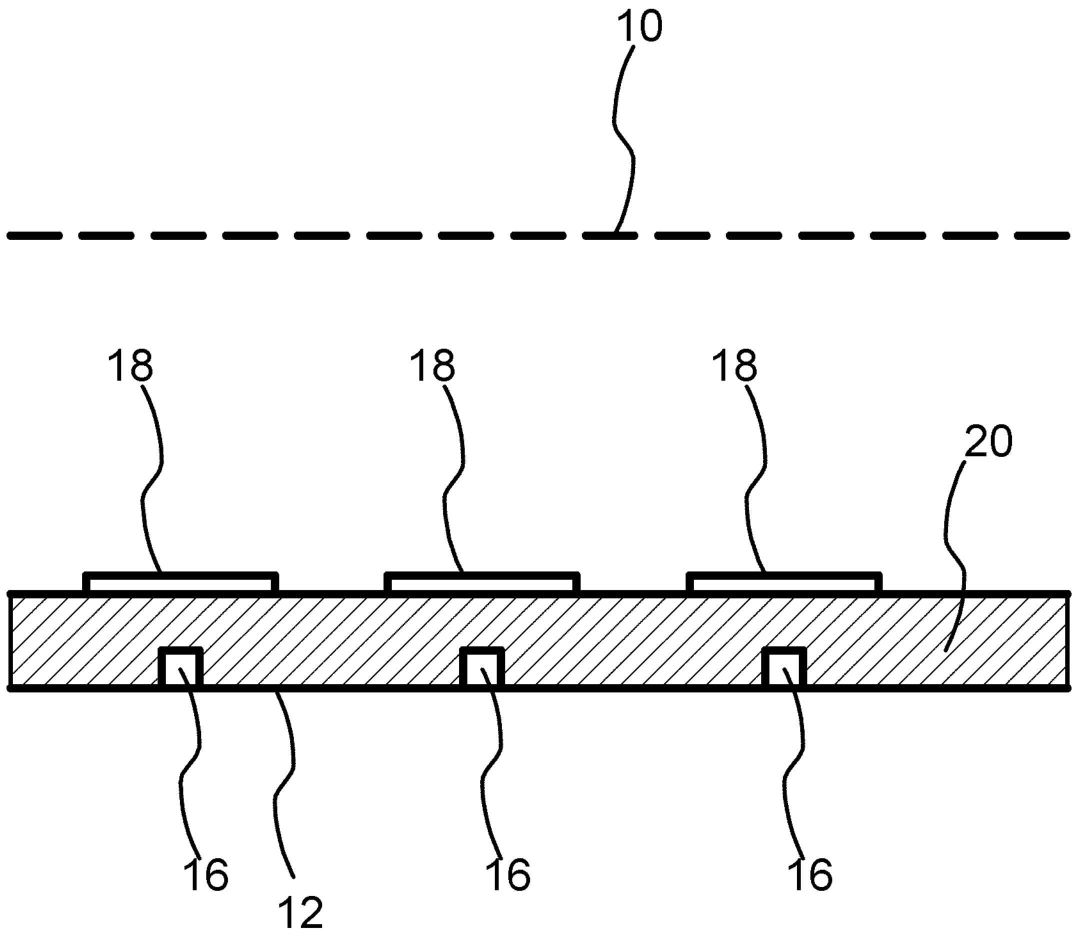


Fig.2

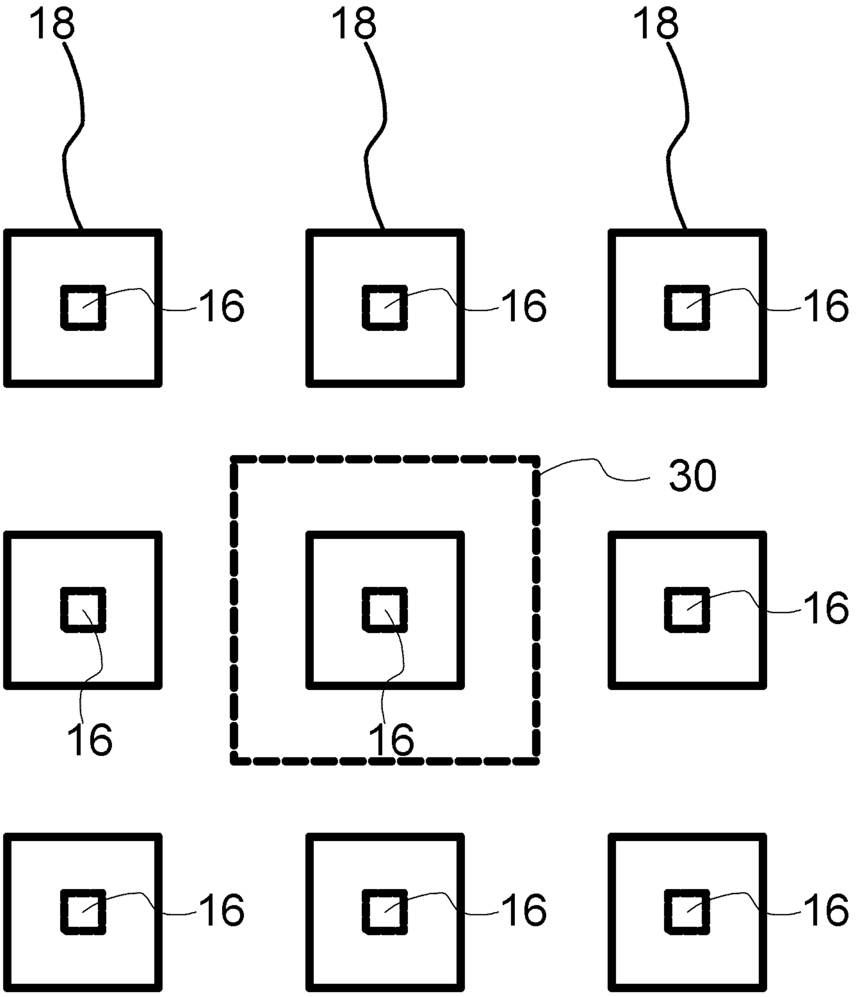
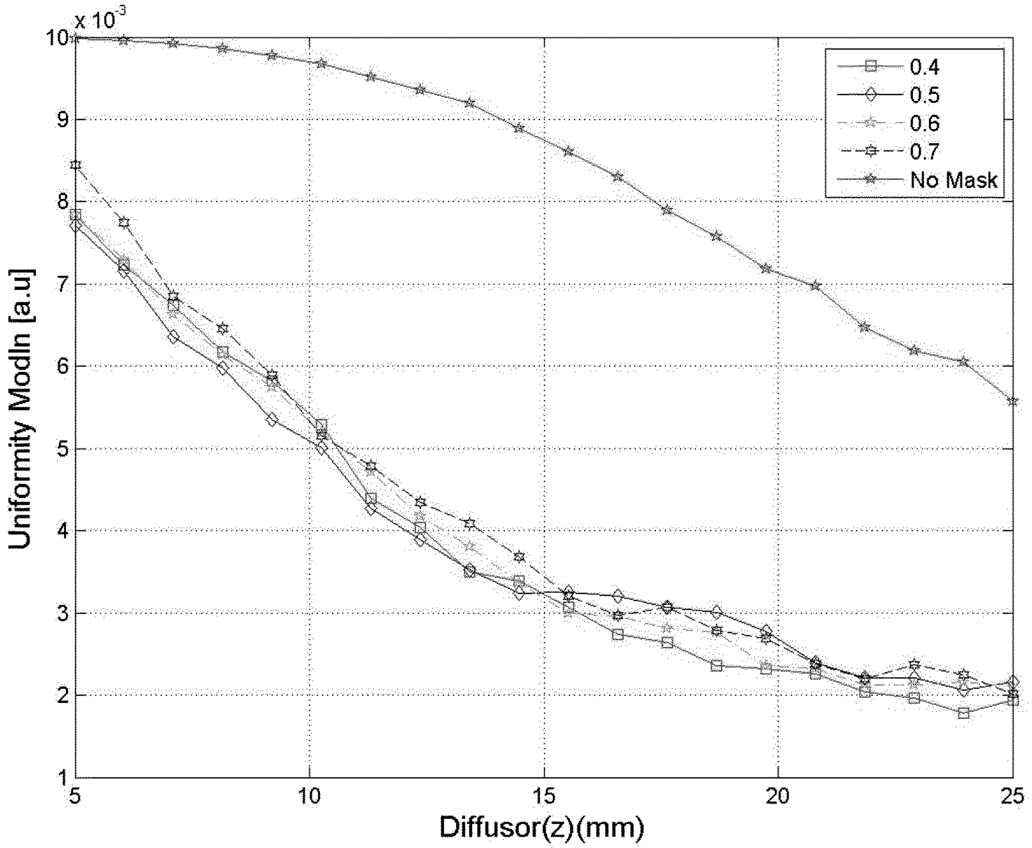


Fig.3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0.7
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Fig. 4

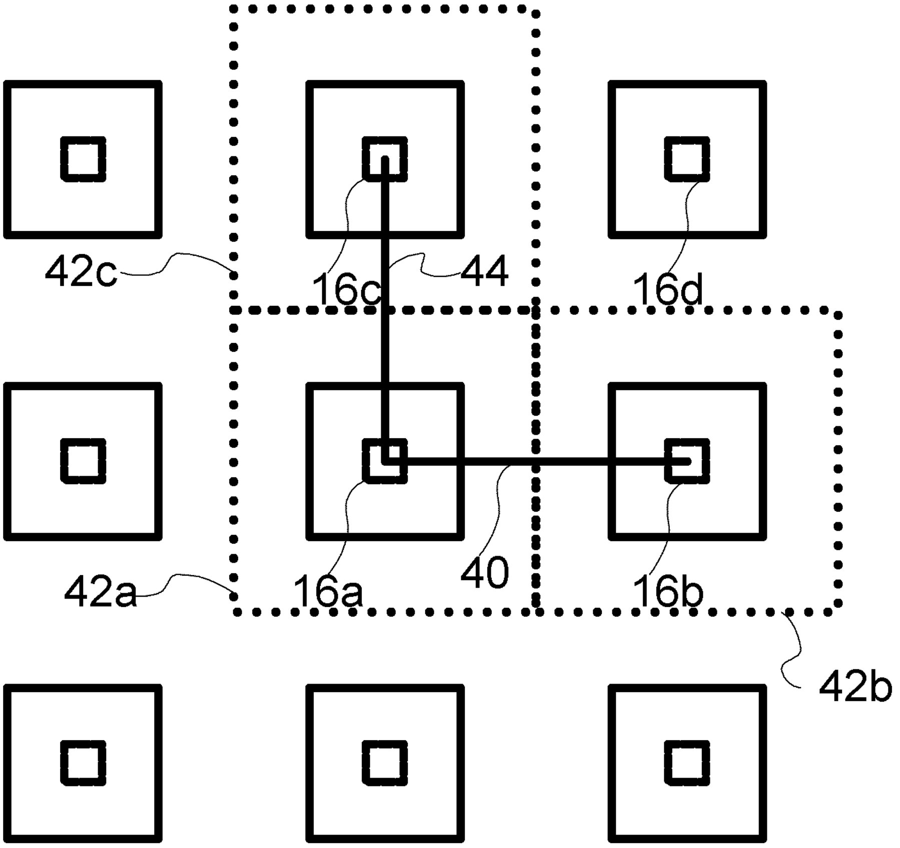

Fig.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/070527

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02F1/13357
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)
G02F

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 2009/003002 A1 (SATO EIICHI [JP]) 1 January 2009 (2009-01-01) paragraphs [0013], [0172] - [0196], [0200] - [0204]; figures 2,4,7 -----	1-16
X	US 2011/205448 A1 (TAKATA YOSHIKI [JP]) 25 August 2011 (2011-08-25) paragraphs [0061] - [0066]; figure 4 -----	1
X	US 2010/102743 A1 (HOU WEI HSIN [US] ET AL) 29 April 2010 (2010-04-29) paragraphs [0041], [0042], [0045] -----	1
X	WO 2011/059100 A1 (OPTO DESIGN INC) 19 May 2011 (2011-05-19) paragraphs [0025], [0086] - [0091]; figures 5,6 ----- -/--	1

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/070527

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/050556 A1 (BAE SEUNG CHOON [KR] ET AL) 3 March 2011 (2011-03-03) paragraph [0102]; figure 12 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/070527

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009003002 A1	01-01-2009	JP 4280283 B2	17-06-2009
		JP 2008027886 A	07-02-2008
		KR 20080099281 A	12-11-2008
		KR 20090061682 A	16-06-2009
		TW I320838 B	21-02-2010
		TW 200946819 A	16-11-2009
		US 2009003002 A1	01-01-2009
		US 2010061096 A1	11-03-2010
		WO 2007086347 A1	02-08-2007
US 2011205448 A1	25-08-2011	US 2011205448 A1	25-08-2011
		WO 2010035566 A1	01-04-2010
US 2010102743 A1	29-04-2010	NONE	
WO 2011059100 A1	19-05-2011	CN 102612622 A	25-07-2012
		EP 2503215 A1	26-09-2012
		JP 2011151002 A	04-08-2011
		KR 20120103590 A	19-09-2012
		US 2012268688 A1	25-10-2012
		WO 2011059100 A1	19-05-2011
US 2011050556 A1	03-03-2011	US 2011050556 A1	03-03-2011
		US 2011050735 A1	03-03-2011
		US 2011051397 A1	03-03-2011
		WO 2011025095 A1	03-03-2011
		WO 2011025099 A1	03-03-2011
		WO 2011025100 A1	03-03-2011