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(54) Title: ILLUMINATION SYSTEM COMPRISING A LUMINESCENT ELEMENT WITH A HEAT SINK

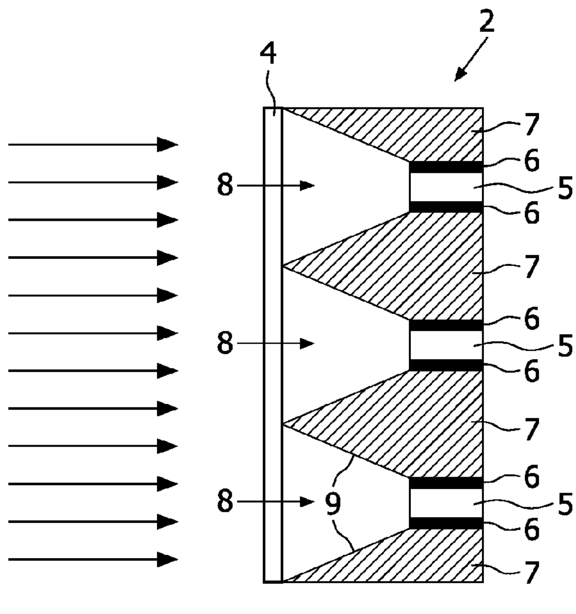

FIG. 2

(57) Abstract: The invention concerns an illumination system, with a light source (1) emitting light of at least a first wavelength, and a luminescent element (2) which is irradiated with the light emitted by the light source (1) and which emits light of at least a second wavelength which is different from the first wavelength, wherein the luminescent element (2) is comprised of a plurality of sub-elements (5) which are each in heat conducting contact with a heat sink (7). This way, an illumination system is provided which can be used as a white light source with high brightness and absence of speckle.

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ILLUMINATION SYSTEM COMPRISING A LUMINESCENT ELEMENT WITH A HEAT SINK

FIELD OF THE INVENTION

The invention relates to the field of illumination systems, especially to illumination systems which provide white light by conversion of laser light in a luminescent element.

BACKGROUND OF THE INVENTION

During the last decades, thanks to the advances of semiconductor technology, LEDs (Light Emitting Diodes) have been becoming more and more important in lighting applications. Technological breakthroughs in high-power LEDs have opened the door to new lighting concepts driven by miniaturization, lifetime, efficiency and sustainability.

Compared to LEDs, the advantage of lasers is their much higher brightness. Semiconductor lasers have started to become available in output powers of several Watts, thus enabling high lumen output. Taking this into consideration, it is expected that lasers are the ultimate light source for several applications and, thus, it can be expected that the next generation of solid-state light sources is based on semiconductor lasers.

If no special measures are taken, the extremely high brightness of a laser is a disadvantage when applied to lighting: lasers usually deliver a divergent beam originating from an extremely small (virtual) spot or a pencil-shaped beam. For lighting purposes, however, the beam has to be reshaped into a distribution that depends on the application. For automotive front lights or UHP-lamp replacements in projection displays, the solid angle the light is emitted into has to be greatly enlarged without spoiling the brightness too much. In other words, the properties of the source should resemble those of the filament of an incandescent lamp or the arc of a gas discharge lamp. The same holds for spotlights. On the other hand, the resulting brightness should not be too high since this would result in problems related to eye-safety. Also the annoying and persistent problem of speckle should be avoided.

From WO 2006/007301 A1 a phosphor-based illumination system including a light source, a light guide including an output surface, emissive material positioned between the light source and the output surface of the light guide, and an interference reflector positioned between the emissive material and the output surface of the light guide is known. The light source emits light having a first wavelength. The emissive material emits light of a wavelength band comprising a second wavelength which is different from the first wavelength when illuminated with light coming from the light source. This way, a white light source can be achieved.

SUMMARY OF THE INVENTION

It is the object of the invention to provide an illumination system which can be used as a white light source with high brightness and absence of speckle.

According to a first aspect of the invention, this object is achieved by an illumination system, with

a light source emitting light of at least a first wavelength, and

a luminescent element which is irradiated with the light emitted by the light source and which emits light of at least a second wavelength which is different from the first wavelength, wherein

the luminescent element is comprised of a plurality of sub-elements which are each in heat conducting contact with a heat sink.

Accordingly, it is an essential feature of the invention to partition the luminescent element into a plurality of sub-elements, which makes it possible to effectively dissipate heat generated in the sub-elements to a heat sink. The sub-elements may be separated from each other. However, it is also possible that the sub-elements are in contact with each other. In the latter case, the sub-elements can be shaped as a mesh where the holes in the mesh are filled with a heat conducting material for dissipating the heat to the heat sink.

Partitioning the luminescent element into a plurality of sub-elements which are each in heat conducting contact with a heat sink is advantageous since by absorbing the light emitted by the light source, the luminescent element heats up. This is due to an effect called "Stokes shift": The luminescent element, e.g. made of phosphor, converts the light emitted by the light source, e.g. blue or near-UV photons produced by a laser, into less energetic photons having a longer wavelength. The energy difference is converted into heat. This causes the luminescent element to heat up and to saturate. This means that at some instant, irradiating the luminescent element with more light from the light source does not result in more converted light. In practice, a luminescent element made of phosphor can become very hot, i.e. above 130 °C, the melting point of plastics such as PMMA.

In general, the sub-elements can be connected to the heat sink in different ways. However, according to a preferred embodiment of the invention, the sub-elements are each surrounded by a heat-conducting material which is in contact with the heat sink. Thus, this heat-conducting material can also be used to hold the material of the sub-elements of the luminescent element. Further, according to a preferred embodiment of the invention, the inner side of the conducting material which faces the sub-elements is reflecting. The inner side can be specularly or diffusely reflective, in the latter case being a scatterer.

According to a preferred embodiment of the invention, on the side of the luminescent element facing away from the light source, at least for one sub-element, preferably for all sub-elements, a tapered funnel with reflective side walls is provided for collecting and redirecting light emitted by the luminescent element. This means that according to a preferred embodiment of the invention, the sub-elements are each provided with a collimator for collecting and redirecting the emitted light back to a main emittance direction.

Further, according to a preferred embodiment of the invention, on the side of the luminescent element facing the light source, at least one of the sub-elements is, and preferably all sub-elements are, provided with a pinhole mirror arrangement with a pinhole and a light reflective side facing away from the light source, and a focusing arrangement for focusing light emitted by the light source through the pinhole onto the respective sub-element.

This way, due to the focusing arrangement, essentially all of the light coming from the light source is directed through the pinhole mirror arrangement and reaches a sub-element. However, for the light emitted by the sub-elements of the luminescent element in a direction towards the light source, i.e. in a back direction, the pinhole mirror arrangement essentially acts as a mirror. This means that most of the light which reaches the pinhole mirror arrangement from the side of the luminescent element is reflected back due to the reflective side facing away from the light source. Only the least part of the light which reaches the pinhole mirror arrangement from the side of the luminescent element manages to get through the pinholes and, thus, is lost. Accordingly, a high brightness of the light output by the luminescent element is achieved.

Generally, the sub-elements can all be made of the same material. However, according to a preferred embodiment of the invention, at least two sub-elements comprise different luminescent materials which each emit light with different wavelengths when irradiated with the same light. For example, instead of a “yellow” phosphor as the material for sub-elements of the luminescent element, different phosphors are used. For example, a "red" phosphor, a "green" phosphor and a transparent scattering medium transmitting the light coming from the light source are used. The advantage is that a higher color-rendering-index can be obtained than when use is made of only one material for all the sub-elements.

According to another preferred embodiment of the invention, the light source comprises at least two different sub-light sources which emit light of different wavelengths, wherein the light from each of the different sub-light sources is directed to a different sub-element. This way, optimum wavelengths can be used for different materials of the sub-elements. Further, according to a preferred embodiment of the invention, the light source comprises at least two different sub-light sources which emit light of different wavelengths, wherein the light from the sub-light sources is directed onto at least one common sub-element. According to this preferred embodiment of the invention, by tuning the ratio of the output of the two sub-light sources the color temperature of the resulting converted light can be tuned.

Moreover, according to another preferred embodiment of the invention, a dichroic filter is provided in the optical path of the light emitted by the light source between the light source and the luminescent element, the dichroic filter being transmissive for the light of the first wavelength, i.e. the light from the light source, but being reflective for the light of the second wavelength, i.e. the light from the luminescent element, and a collimator arrangement is provided which is adapted for collecting and redirecting light emitted from the luminescent element in such a way that the collected light is redirected onto the dichroic filter.

Due to the dichroic filter, light emitted from the luminescent element into the "wrong" direction, i.e. in a back direction, is redirected, similar to the embodiment using the pinhole mirror arrangement described above, into the front direction. According to this preferred embodiment comprising the collimator arrangement, this function of the dichroic filter is further improved: The transmission and reflection properties of a dichroic filter are dependent on the angle of incidence of the light. Accordingly, this arrangement makes it possible to provide for an essentially perpendicular angle of incidence, yielding the highest reflection ratio.

The collimator arrangement can be designed in different ways. However, according to a preferred embodiment of the invention, the collimator arrangement comprises at least one tapered funnel with reflective sidewalls, the tapered funnel being provided on the side of the luminescent element facing the dichroic filter and corresponding to one sub-element. Most preferably , each of the sub-elements of the luminescent element is provided with such a tapered funnel.

According to a second aspect of the invention, the above mentioned object is further addressed by an illumination system with

a light source emitting light of at least a first wavelength,

a luminescent element which is irradiated with the light emitted by the light source and which emits light of at least a second wavelength which is different from the first wavelength,

a dichroic filter which is provided between the light source and the luminescent element in the optical path of the light emitted by the light source, and

a collimator arrangement, wherein

the dichroic filter is transmissive for the light of the first wavelength but is reflective for the light of the second wavelength, and wherein

the collimator arrangement is adapted for collecting and redirecting light emitted from the luminescent element in such a way that the collected light is redirected onto the dichroic filter.

According to this aspect of the invention, similar to the preferred embodiment described further above, the function of the dichroic filter is further improved: Due to the collimator arrangement an essentially perpendicular angle of incidence on the dichroic filter is achieved, thus providing the best reflection ratio.

Further, according to a preferred embodiment of the invention which applies to the first and for the second aspect of the invention, the collimator arrangement is adapted for redirecting the collected light in a predefined range of angles onto the dichroic filter. Preferably, the incidence angle deviates less than 30°, more preferably less than 20°, and most preferably less than 10° from a perpendicular incidence.

Furthermore, as already indicated hereinabove, according to a preferred embodiment of the invention which also applies to the first and to the second aspect of the invention, the luminescent element comprises a luminescent ceramic, preferably comprising phosphor.

In general, the light from the light source can be directed freely onto the luminescent element. However, according to a preferred embodiment of the invention, an optical fiber is provided for guiding the light generated by the light source to the luminescent element. Here, the laser is geometrically separated from the phosphor conversion. The advantage is that in this way the generation of the light by the light source and, thus the generation of heat, is decoupled from the actual light source, i.e. the luminescent element which acts as conversion system.

Finally, in general, different light sources can be used. However, according to a preferred embodiment of the invention, the light source is a laser, especially a blue or near-UV diode laser.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 shows an illumination system according to a first embodiment of the invention,

Fig. 2 shows an alternative layout according to a second embodiment of the invention,

Fig. 3 shows a third embodiment of the invention,

Fig. 4 shows a fourth embodiment of the invention,

Fig. 5 shows a fifth embodiment of the invention,

Fig. 6 shows a sixth embodiment of the invention,

Fig. 7 shows a seventh embodiment of the invention,

Fig. 8 shows an eighth embodiment of the invention,

Fig. 9 shows a ninth embodiment of the invention, and

Fig. 10 shows a tenth embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

An illumination system according to a first embodiment of the invention is shown in Fig. 1. According to this embodiment, the light from a light source 1, which is a blue diode laser, is directed towards a luminescent element 2, which is a thin ceramic-like platelet of phosphor which measures 1 mm x 1 mm x 0.13 mm. The luminescent element 2 converts the blue laser light into a broad band of wavelengths in the yellow part of the spectrum. Most of the blue light is converted by the luminescent element 2 into yellow. Some of the blue light is transmitted by the luminescent element 2. The ratio of converted and transmitted blue light is chosen such that their combination results in white light.

Half of the yellow light generated travels in the wrong direction, i.e. is directed back towards the light source 1. According to the first preferred embodiment of the invention, this light is redirected in the following manner:

A collimator arrangement 3 is used which in this case is a so-called concentric parabolic concentrator (CPC) as shown in detail in Fig. 1, in order to collimate the light directed back to the light source 1. At the exit of the collimator 3, a dichroic filter 4 is located. This dichroic filter 4 is a multilayer stack of thin dielectric layers, designed such as to transmit the blue part of the spectrum and reflect the complementary part, including yellow. In this manner, the dichroic filter 4 reflects the yellow light and sends it back towards the luminescent element 2. The collimator is advantageous in that it ensures that the yellow light hits the dichroic filter 4 nearly perpendicularly: The behavior of dichroic filters in general is very angular-dependant; the angular range of the rays hitting the dichroic filter 4 should therefore be limited to a small range around a perpendicular incidence. In this manner, the light originally sent into the wrong direction is redirected, thereby improving the efficiency by a factor of almost two.

An alternative layout according to a second embodiment of the invention is shown in Fig. 2. It is advantageous that the phosphors of the luminescent element 2 are cooled to avoid thermal quenching, i.e. saturation due to overheating. To this end, the total volume of phosphor is divided into sub-elements 5. Each sub-element is surrounded by a heat-conducting material 6, e.g. a metal such as copper, gold, diamond, graphite, or ceramic that is heat-conducting and opaque or optically transparent. The heat accumulating in the heat-conducting material 6 is guided to a heat sink 7. The laser-light is guided to each sub-element of phosphor by a tapered funnel 8 with reflecting sidewalls 9. These tapered funnels 8 collimate the phosphor-converted yellow light going back in the direction of the light source 1. Again a dichroic filter 4 is used to redirect this yellow light. The heat-conducting material 6 surrounding the phosphors and holding it in place may be specularly reflecting or diffusely reflecting, e.g. a scatterer.

Another embodiment of the invention is shown in Fig. 3. The sub-elements 5 of phosphor are located at the end of the tapered funnel 8. In other words, the geometry of the surroundings of the phosphor can be straight as can be seen from Fig. 2, or tapered and funnel-shaped as can be seen from Fig. 3. Further, other different shapes are possible too, giving more design freedom.

Yet another embodiment according to the invention is shown in Fig. 4, demonstrating that also at the exit side of the sub-elements 5 of phosphor there is a tapered funnel 10 with reflective side walls 11. The tapered funnel 10 at the exit collimates the light and seamlessly couples the light of different sub-elements 5 of phosphors. In other words, the light leaving the illumination system as a whole is collimated and has a homogeneous emission pattern.

Another embodiment of the invention is shown in Fig. 5. In this case, there is no dichroic filter to redirect the yellow light going backwards. Its function is taken over by a pinhole mirror arrangement 15. With the aid of a focusing arrangement 20 which comprises a plurality of lenses 21, each corresponding to one respective sub-element 5, the laser light is focused through pinholes 13 in a mirror 14 onto the sub-elements 5 of phosphor. In this manner, all the blue light is directed onto the phosphor.

However, most of the phosphor-converted yellow light going backwards will be reflected by the reflective side 12 of the pinhole mirror arrangement 15 and, thus, only a small fraction will escape through the pinhole 13.

Fig. 6 depicts yet another embodiment of the invention. Instead of a “yellow” phosphor, different phosphors are used. For example, a "red" phosphor 16, a "green" phosphor 17 and a transparent scattering medium 18 transmitting the blue laser light. The advantage is that a higher color-rendering-index can be obtained than when only a "yellow" phosphor is used. Further, according to this embodiment of the invention, on one side the sub-elements, i.e. the phosphors 16, 17 and the transparent scattering medium 18, are in optical contact with elements 41, 42, 43 of a transparent medium with, preferably, a high index of refraction. Further, it is preferred that this medium is a transparent heat-conducting ceramic. It may also be for example a silicone material that can withstand relatively high temperatures. The purpose of this extra transparent medium is that it is easier for the light generated inside the phosphors 16, 17 to escape towards a medium with a high index of refraction than it is to escape towards air. Preferably, this transparent medium has a convex shape to ensure that most of the light leaves this medium at near normal angles with respect to its surface. In this case the chance of being reflected back is lowest. The second purpose of this extra medium is to conduct heat away from the sub-elements. Of course, such elements 41, 42, 43 can also be provided for embodiments of the invention other than those shown in the other Figures.

Fig. 7 and 8 show further embodiments of the invention. As shown in Fig. 7, for each sub-element 5 of phosphor a different sub-light source 22, 23, 24, i.e. a different laser, is used. Alternatively, as shown in Fig. 8, different types of phosphor 25, 26, 27 are used for the respective sub-elements 5 in such a way that each phosphor 25, 26, 27 is illuminated by a laser 28, 29, 30 with an optimum pump wavelength. An optimum pump wavelength for each phosphor 25, 26, 27 is advantageous since this is the most efficient way of producing light and at the same time minimizes heating of the phosphors 25, 26, 27. Also, the color can be tuned by tuning the output of the individual lasers 28, 29, 30.

Yet another embodiment is shown in Fig. 9. Each sub-element 5 of phosphor is illuminated by two different lasers 31, 32 and, thus with different pump wavelengths. By tuning the ratio of the output of the two beams from laser 31 and laser 32, the color temperature of the resulting phosphor-converted light can be tuned.

Finally, another embodiment is shown in Fig. 10. Here, the light source 1 is geometrically separated from the phosphor conversion. The laser light is guided towards the phosphor conversion system by means of a fibre 19. The advantage is that in this way the generation of laser light and heat is decoupled from the actual light source, i.e. the phosphor conversion system.

As a result, as described above, possibilities of using blue or near-UV diode lasers to create speckle-free white or colored or color-adjustable light sources are provided. The light sources, based on phosphors that convert the light from blue or near-UV pump lasers, have the following characteristics:

By combining a dichroic filter and a collimator, the light converted by the phosphors and going in the wrong direction, i.e. backwards, is redirected, thereby almost doubling the brightness. Further, by the use of an entrance mirror with a pinhole or a tapered funnel, the light converted by the phosphors and going in the wrong direction, i.e. backwards, is redirected, thereby almost doubling the brightness. Furthermore, an array of sub-light-sources, i.e. the sub-elements of the luminescent element, are provided with a collimator at the exit and seamlessly combined into one light source. Heat is conducted away from the phosphor by using small sub-elements of phosphor in combination with a heat conductor. Combining different pump lasers and different phosphors, a color-adjustable or color-temperature-adjustable light source is obtained by adjusting the relative power of the different pump lasers.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

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. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. An illumination system, with

a light source (1) emitting light of at least a first wavelength, and

a luminescent element (2) which is irradiated with the light emitted by the light source (1) and which emits light of at least a second wavelength which is different from the first wavelength, wherein

the luminescent element (2) is comprised of a plurality of sub-elements (5) which are each in heat-conducting contact with a heat sink (7).

2. The illumination system according to claim 1, wherein the sub-elements (5) are each surrounded by a heat-conducting material (6) which is in contact with the heat sink (7).

3. The illumination system according to claim 1 or 2, wherein the inner side of the heat-conducting material (6) which faces the sub-elements (5) is reflecting.

4. The illumination system according to any of claims 1 to 3, wherein, on the side of the luminescent element (2) facing away from the light source (1), at least for one sub-element (5) a tapered funnel (10) with reflective side walls (11) is provided for collecting and redirecting light emitted by the luminescent element (2).

5. The illumination system according to any of claims 1 to 4, wherein at least two sub-elements (5) comprise different luminescent materials which each emit light of different wavelengths when irradiated with the same light.

6. The illumination system according to any of claims 1 to 5, wherein the light source (1) comprises at least two different sub-light sources which emit light of different wavelengths, wherein the light from each of the different sub-light sources is directed to a different sub-element (5).

7. The illumination system according to any of claims 1 to 5, wherein the light source (1) comprises at least two different sub-light sources which emit light of different wavelengths, wherein the light from the sub-light sources is directed onto at least one common sub-element (5).

8. The illumination system according to any of claims 1 to 7, wherein, on the side of the luminescent element (5) facing the light source (1), at least one of the sub-elements (5) is provided with a pinhole mirror arrangement (15) with a pinhole (13) and a light-reflective side (12) facing away from the light source (1), and a focusing arrangement (20) for focusing light emitted by the light source (1) through the pinhole (13) onto the sub-element (5).

9. The illumination system according to any of claims 1 to 7, wherein a dichroic filter (4) is provided in the optical path of the light emitted by the light source (1) between the light source (1) and the luminescent element (2), the dichroic filter (4) being transmissive for the light of the first wavelength but being reflective for the light of the second wavelength, and wherein a collimator arrangement (3) is provided which is adapted for collecting and redirecting light emitted from the luminescent element (2) in such a way that the collected light is redirected onto the dichroic filter (4).

10. The illumination system according to claim 9, wherein the collimator arrangement (3) comprises at least one tapered funnel (8) with reflective sidewalls, the tapered funnel (8) being provided on the side of the luminescent element (2) facing the dichroic filter (4) and corresponding to one sub-element (5).

11. An illumination system with

a light source (1) emitting light of at least a first wavelength,

a luminescent element (2) which is irradiated with the light emitted by the light source (1) and which emits second light of at least a second wavelength which is different from the first wavelength,

a dichroic filter (4) which is provided between the light source (1) and the luminescent element (2) in the optical path of the light emitted by the light source (1), and

a collimator arrangement (3), wherein

the dichroic filter (4) is transmissive for the light of the first wavelength but is reflective for the light of the second wavelength, and wherein

the collimator arrangement (3) is adapted for collecting and redirecting light emitted from the luminescent element (2) in such a way that the collected light is redirected onto the dichroic filter (4).

12. The illumination system according to any of claims 9 to 11, wherein the collimator arrangement (3) is adapted for redirecting the collected light in a predefined range of angles onto the dichroic filter (4).

13. The illumination system according to any of claims 1 to 12, wherein the luminescent element (2) comprises a luminescent ceramic, preferably comprising phosphor.

14. The illumination system according to any of claims 1 to 13, wherein an optical fiber (19) is provided for guiding the light generated by the light source (1) to the luminescent element (2).

15. The illumination system according to any of claims 1 to 14, wherein the light source (1) is a laser, especially a blue or near-UV diode laser.

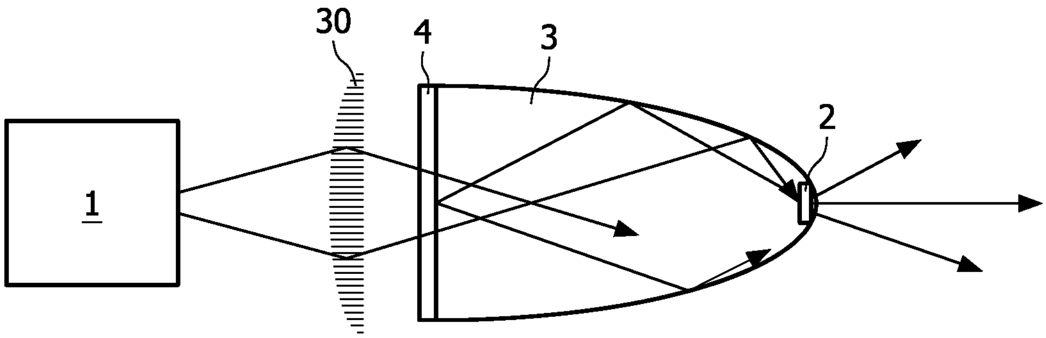

FIG. 1

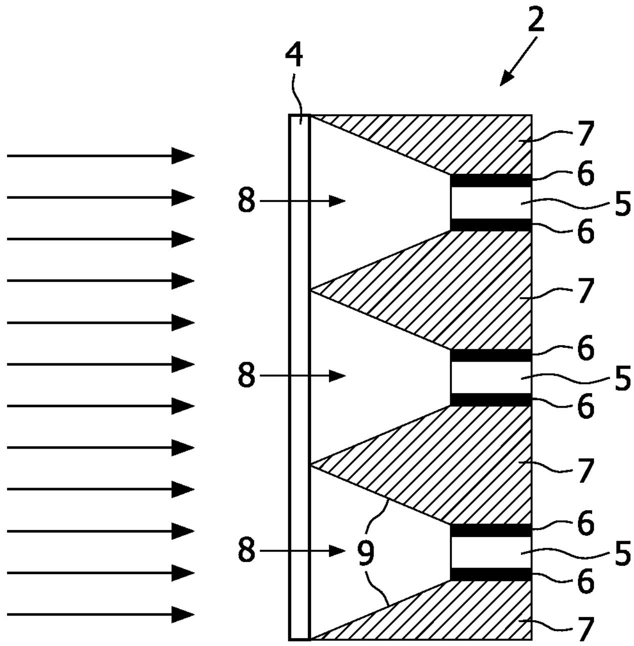

FIG. 2

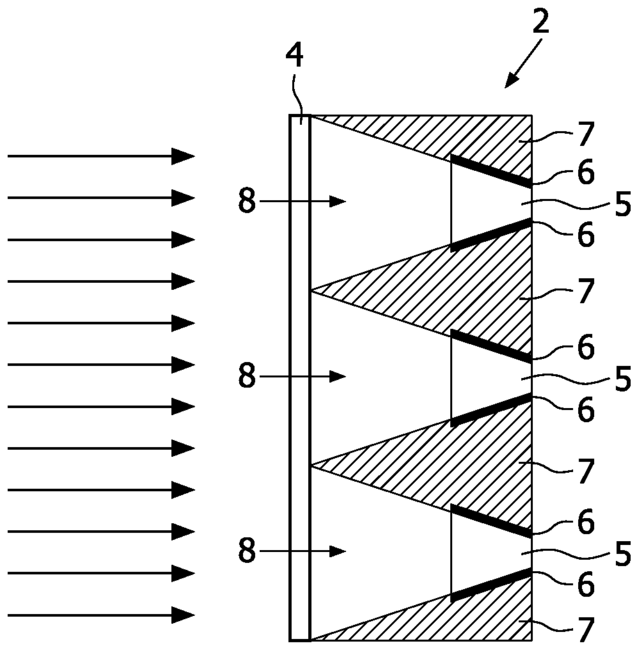

FIG. 3

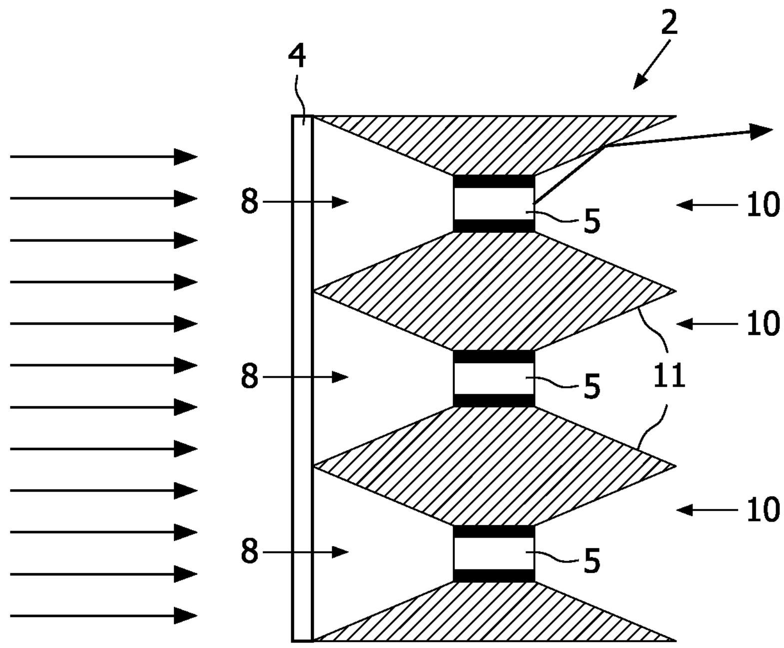

FIG. 4

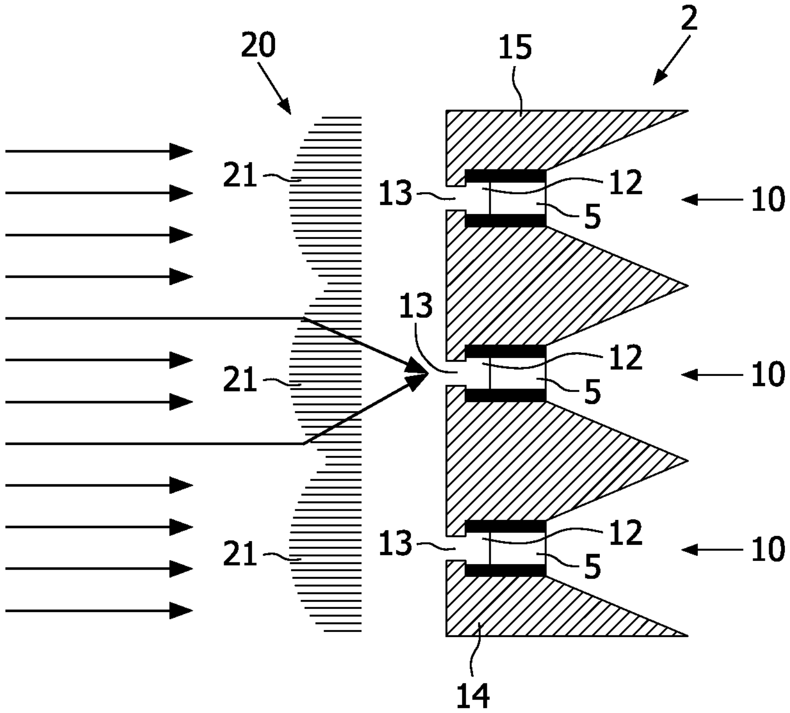
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FIG. 5

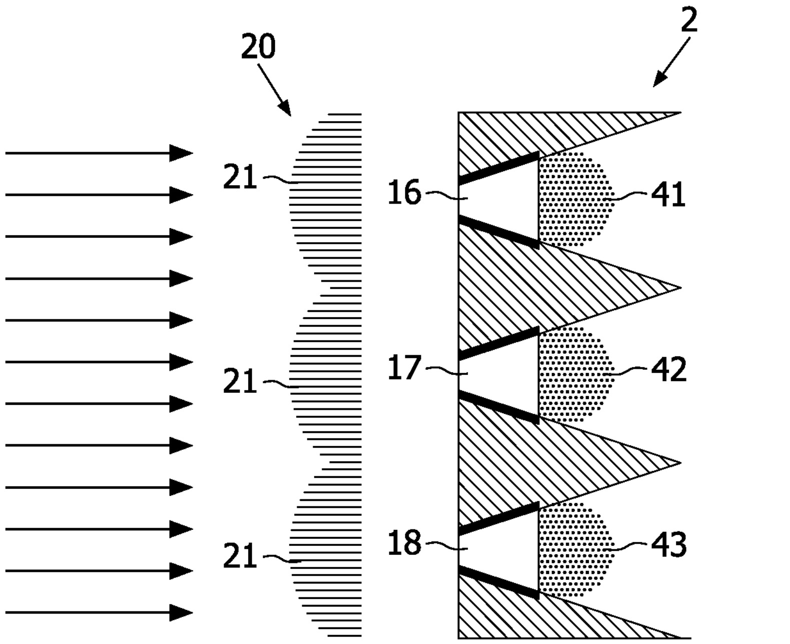
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FIG. 6

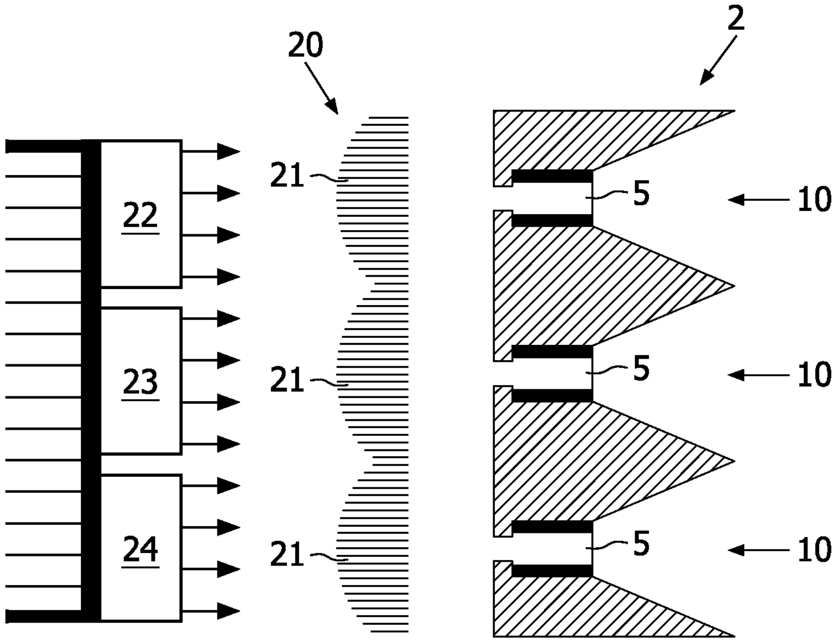

FIG. 7

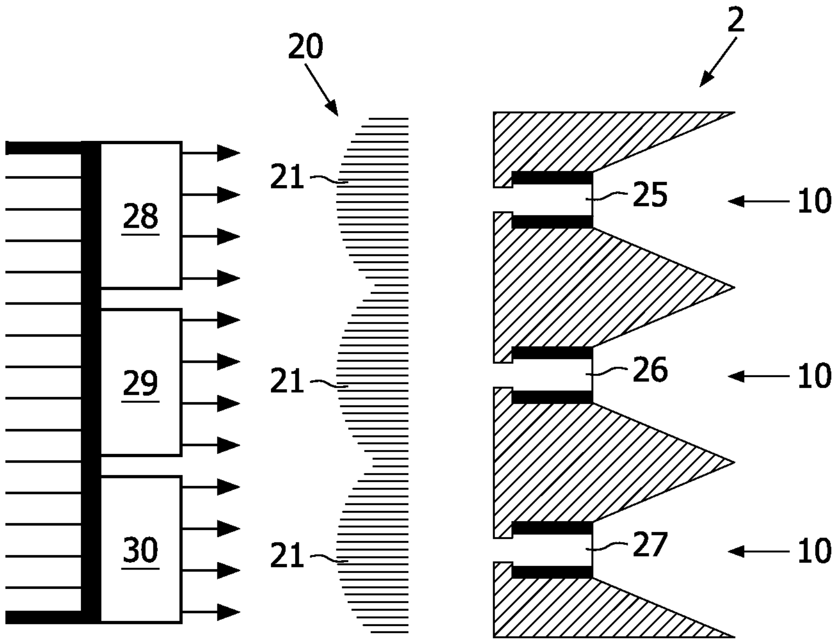

FIG. 8

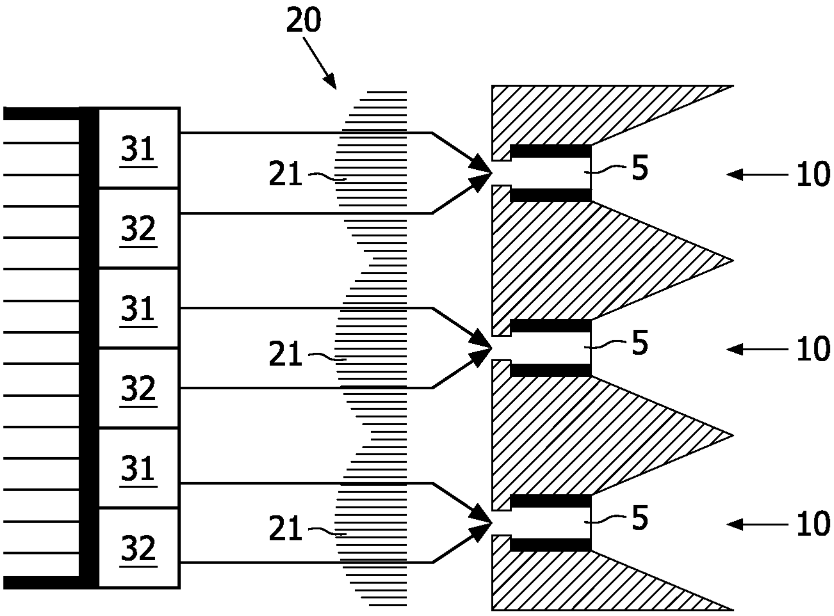

FIG. 9

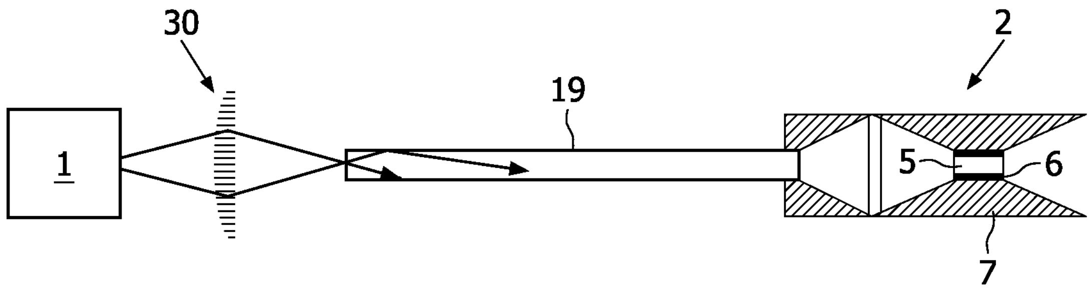

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2009/051075

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21K7/00 G02B17/08

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)
G03B F21K H05B G02B 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 practical, 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 Y	US 2005/270775 A1 (HARBERS GERARD [US] ET AL) 8 December 2005 (2005-12-08) paragraphs [0022] - [0049] paragraph [0055] paragraphs [0061] - [0063] figures 1-5,7,8,12	1,4-7, 9-12 14,15
X	WO 2008/018002 A (KONINKL PHILIPS ELECTRONICS NV [NL]; PHILIPS LUMILEDS LIGHTING CO [US]) 14 February 2008 (2008-02-14) paragraphs [0026], [0032], [0033], [0038], [0041] - [0053] figures 1,7,10-16	1-3,8,9, 11,13
Y	US 6 350 041 B1 (TARSA ERIC J [US] ET AL) 26 February 2002 (2002-02-26) column 4, line 53 - column 5, line 4	14

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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
2 July 2009	09/07/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Breccia, Luca

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2006/002101 A1 (WHEATLEY JOHN A [US] ET AL) 5 January 2006 (2006-01-05) cited in the application paragraphs [0060], [0062] -----	15
A	US 4 646 210 A (SKOGLER BRIAN I [US] ET AL) 24 February 1987 (1987-02-24) column 8, line 61 - column 9, line 5 -----	1-3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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